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Supporting Documents

Optimization of engine operating variables on performance and emissions characteristics of biogas fuelled CI engine by the design of experiments: Taguchi approach

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Abstract

Biogas obtained from renewable resources is a viable solution for solving energy scarcity and environmental degradation. A single-cylinder 4-stroke natural aspirated variable compression ratio research engine was fuelled with biogas as primary and diesel as a pilot injection in this work. Experiments were designed based on Taguchi L_9 OA (orthogonal array) choosing biogas flow rate, compression ratio, and engine load as input factors, while brake thermal efficiency (BTE), BSEC, CO, HC, NOx, and smoke were targeted responses. The effects level of factors on responses was analysed by using MINITAB software. The higher value of raw data and S/N ratios for BTE was observed with low biogas flow rate, higher compression ratio, and full engine load. On the other hand, lower raw data and high S/N ratio analysis for emissions characteristics (CO, HC, NOx, and smoke) were achieved in the order of rank, that is, engine load > biogas flow rate > compression ratio. With the analysis of results, optimum levels of various factors were evaluated. These results showed that the Taguchi method design was an effective tool for optimizing the elements in terms of combustion performance and emissions characteristics.

KEYWORDS
design, emissions, optimization, performance, Taguchi method

1 | INTRODUCTION

CI engine's cost-effectiveness and reliable nature make them frontier in the transportation, agriculture, construction, and shipping industry. High exhaust ejections caused by high combustion temperature have hazardous influences on the ambient air quality. Increased fossil fuel consumption by diesel engine coupled with the diminishing nature of fossil fuels and their ecological issues create stress on finding clean and alternative fuels.[1,2] Replacement of conventional fuels with clean and renewable energies will help reduce greenhouse gas emissions and reduce imports for developing countries like India. Biogas is considered an enticing clean and alternative fuel owing to its serene and cost-effectiveness under dual-fuel (DF) mode in diesel engine.[3] The DF operation entails the mixing of biogas with air before it enters

Full Length Article

Determination and utilization of optimal diesel/n-butanol/biogas derivation for small utility dual fuel diesel engine

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ABSTRACT

Aggregating pollution along with exhausting fossil fuels throughout the world has enforced the inventors to explore for an alternative fuel that can be utilized in diesel engines. Presently, investigators and professionals have originated that biodiesel in association with higher alcohols and gaseous fuel can be an alternative for the current circumstances. Anterior examinations have rendered that biodiesel and higher alcohol along with gaseous fuels can support in upgrading the performance and denigrating detrimental exhaust emanations of a diesel engine. This research aimed to investigate the impacts of engine load, n-butanol concentration, and biogas quantity on emissions and performance characteristics of a small utility compression ignition engine. The different engine load (20–100% of brake power), n-butanol concentration (0–20%) and biogas flow rate (0.5–2 kg/h) were used as input variables. The multi-criteria decision analysis based on response surface method techniques was employed to find the optimal values of engine working conditions fuelled with diesel/n-butanol/biogas fuel blends. In the optimization process, five objective functions (BTE, NOₓ, CO, UHC, and soot) were considered to be optimized based on the defined criteria. The addition of n-butanol in diesel has shown a favourable impact on biogas operated dual-fuel engine in terms of performance and emissions characteristics. The approach of desirability was applied to obtain the best operating conditions of the engine. The optimum value of engine load, n-butanol concentration, and biogas flow rate were found as 76.59%, 20%, and 1.07 kg/h, respectively. At this condition, the optimal value of BTE, UHC, CO, NOₓ, and smoke emissions were found to be 19.19%, 0.36g/kWh, 0.04%, 14.51g/kWh, and 22.32%, respectively. A high desirability value of 0.77 was obtained for the suggested condition, showing the efficiency of the derived models for response parameters.

1. Introduction

Diesel engines are predominant in the transportation, agriculture, and agriculture industry by the virtue of their reliable and economic nature [1,2]. However, the ejections of toxic compounds due to fossil fuel utilization possess a serious threat for the environment and mankind [3–6]. The escalating fossil fuel prices coupled with severe environmental pollution have urged the researches to look for non-conventional and clean fuels. Dual fuel mode is one of the effective techniques for utilizing gaseous fuel such as biogas through the mixing of gaseous fuel and air before entering the combustion chamber in the CI engines [7]. Biogas is a carbon-neutral fuel and one of the most attractive biofuels which mainly contains methane and carbon dioxide and could be efficiently utilized in the CI engine under dual fuel mode

REVIEW ARTICLE

Separate effect of biodiesel, n-butanol, and biogas on performance and emission characteristics of diesel engine: a review

Sunil Kumar Mahla[1] · Geetesh Goga[2] · Haeng Muk Cho[3] · Amit Dhir[4] · Bhupendra Singh Chauhan[5]

Abstract

Unsustainable energy sources are one of the preeminent supply specks of power generation in the prevailing scenario. The production and utilization of energy have brought about serious ecological effects all over the globe. Exceptionally unpredictable fossil fuel expenses are making increasingly more ambiguity for the worldwide economy while simultaneously giving an ambiguous motivation for putting resources into sustainable power source advancements, which are now accepted as a viable solution. Biodiesel, higher alcohol, and gaseous fuel are considered to be suitable replacements for dwindling natural resources. These substitute fuels not only aid in enhancing the engine performance but also cooperate in contracting the injurious tailpipe emissions. In this review article, a study has been made to evaluate the domination of biodiesel, n-butanol, and biogas on the performance and emission characteristics of the diesel engine in comparison to fossil diesel. Conclusions of empirical analysis considering emission and performance characteristics with different permutation and combination are put forwarded to understand the commuted result on various characteristics of the diesel engine. The comprehensive study recommends that the performance characteristics of the engine degrade with substitute fuels, whereas its emission characteristics are depicted to have abated.

Keywords Biodiesel · n-Butanol · Biogas · Diesel engine

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1 Introduction

Energy has consistently been a crucial asset in the improvement of any country. It reflects a record of monetary development and communal advancement [1]. The success of a country is estimated according to energy consumed by each individual. Although the globe has witnessed excited industrialized action in the former era, it has additionally encountered difficult issues emerging out of indiscriminate usage of the resources of energy [2, 3]. Low fuel costs did not energize effective use of energy. Throughout the industrialization progression, the ecology faced utilization of a dominant part of its energy assets and worldwide natural balance has been defaced.

Renewable energy resources which can be utilized in a compression ignition engine as a fuel consist of gaseous fuels, biodiesel, and alcohols. There is a comprehensive diversity of gaseous fuels accessible in the environment which can be utilized in diesel engines. Among the amenable gaseous fuels, only hydrogen and biogas can be reflected as renewable fuels for the reason that all other gaseous fuels are limited in nature. To procure hydrogen, a lot of energy is required, which is
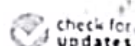
Article

Intervention of Artificial Neural Network with an Improved Activation Function to Predict the Performance and Emission Characteristics of a Biogas Powered Dual Fuel Engine
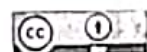
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Abstract: Biogas is a significant renewable fuel derived by sources of biological origin. One of today's research issues is the effect of biofuels on engine efficiency. The experiments on the engine are complicated, time consuming and expensive. Furthermore, the evaluation cannot be carried out beyond the permissible limit. The purpose of this research is to build an artificial neural network successfully for dual fuel diesel engine with a view to overcoming experimental difficulties. Authors used engine load, bio-gas flow rate and n-butanol concentration as input parameters to forecast target variables in this analysis, i.e., smoke, brake thermal efficiency (BTE), carbon monoxide (CO), hydrocarbon (HC), nitrous-oxide (NO_x). Estimated values and results of experiments were compared. The error analysis showed that the built model has quite accurately predicted the experimental results. This has been described by the value of Coefficient of determination (R^2), which varies between 0.8493 and 0.9863 with the value of normalized mean square error (NMSE) between 0.0071 and 0.1182. The potency of the Nash-Sutcliffe coefficient of efficiency (NSCE) ranges from 0.821 to 0.8898 for BTE, HC, NO_x and Smoke. This research has effectively emulated the on-board efficiency, emission, and combustion features of a dual-fuel biogas diesel engine taking the Swish activation mechanism in artificial neural network (ANN) model.

Keywords: bio-gas; dual fuel mode; artificial neural network; swish activation function; emission parameters; engine performance

1. Introduction

Due to higher fuel economy, greater performance and low fuel prices, diesel engines are now favoured in many industries. However, these engines' combustion emissions have long been negatively impacting civilization and habitat. Researchers are now emphasizing alternative fuels due to reduced fossil fuel supplies and concerns about the effect of the use of fossil fuels on ecological concerns, such as environmental pollution. To solve these challenges, diesel engine researchers plan to seek an appropriate, blended fuel that can improve the machine's efficiency and reduce emissions. Since traditional methods are very time-consuming and costly, researchers have turned to methods that could achieve the same performance more easily and efficiently. Artificial Neural Network (ANN) has already been used to develop computational technology for various automotive engineering problems [1].

RESEARCH ARTICLE

Effect of hydrogen-enriched biogas induction on combustion, performance, and emission characteristics of dual-fuel compression ignition engine

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Abstract

Gaseous fuel induction in a compression ignition (CI) engine has picked up much attention over the most recent few years, particularly when it is produced by using renewable sources. In this study, hydrogen-enriched biogas (HEB) was used as a gaseous fuel and co-combusted in dual-fuel CI engine. Experimentation was carried out on a 3.5-kW CI engine test rig in the brake mean effective pressure range between 0 and 3.5 bar, as well as, HEB between 0.1 and 0.5 kg/hr. HEB induction effects on various engine characteristics (combustion, performance, and emission) were studied at rated engine speed (1,500 rpm). Results revealed that the peak cylinder pressure and ignition delay period increased with increasing HEB proportion (0.1 to 0.5 kg/hr) as compared with diesel mode. The calorific value of HEB (57.0 MJ/kg) is higher than diesel (42.0 MJ/kg), which led to improved BTE in dual-fuel mode. The emission results showed that with an increase of HEB rates, the NOx emission mildly decreases, but smoke opacity and hydrocarbon emissions majorly reduce. Thus, the HEB induction has great potential to be a feasible technological solution to overcome low BTE and high hydrocarbon emissions in biogas operated CI engines.

1 | INTRODUCTION

Nowadays, compression ignition (CI) engines are being used for power generation, because it offers high efficiency (thermal) and excellent fuel economy when compared with spark ignition engines.[1] These CI engines are mostly powered by nonrenewable petroleum fuels, which lead to fossil fuel depletion. Worldwide depletion of petroleum reserves encouraged researchers to explore renewable energy resources. Energy resources are categorized as fossil fuels, nuclear resources, and renewable resources.[1] Fossil fuels have been considered as the most prevailing energy source, and its large-scale applications led to deteriorating environmental conditions.[2] India is the most developing nation with an alarming rise in the populace and adding around 5% of the worldwide CO₂ discharge. Beside this, India has proposed to reduce CO₂ emissions by 20% by 2020.[3] Utilization of renewable fuels may provide a great path to meet the CO₂ emission reduction targets. For this, alternative fuels, which are

RESEARCH ARTICLE

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Abstract

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KEYWORDS

Ignition engine, co-combustion, renewable H$_2$-enriched biogas, dual-fuel technology, combustion characteristics, exhaust emission

1 | INTRODUCTION

Nowadays, compression ignition (CI) engines are being used for power generation, because it offers high efficiency (thermal) and excellent fuel economy when compared with spark ignition engines.[1] These CI engines are mostly powered by nonrenewable petroleum fuels, which lead to fossil fuel depletion. Worldwide depletion of petroleum reserves encouraged researchers to explore renewable energy resources. Energy resources are categorized as fossil fuels, nuclear resources, and renewable resources.[1] Fossil fuels have been considered as the most prevailing energy source, and its large-scale applications led to deteriorating environmental conditions.[2] India is the most developing nation with an alarming rise in the populace and adding around 5% of the worldwide CO$_2$ discharge. Beside this, India has proposed to reduce CO$_2$ emissions by 20% by 2020.[3] Utilization of renewable fuels may provide a great path to meet the CO$_2$ emission reduction targets. For this, alternative fuels, which are

Effect of varying biogas mass flow rate on performance and emission characteristics of a diesel engine fuelled with blends of n-butanol and diesel

Geetesh Goga[1] · Bhupendra Singh Chauhan[2] · Sunil Kumar Mahla[3]📧 · Amit Dhir[4] · Haeng Muk Cho[5]

Abstract

Dwindling petroleum products and environment degradation, owing to the gases from the exhaust tailpipe of compression ignition engines, have obligated the investigators to invent some unconventional fuel. Current experimentation aimed to evaluate the combustion, performance and emission characteristics of a dual fuel engine by using blends of diesel and n-butanol as pilot fuel with biogas as primary fuel. Under dual fuel mode, biogas at different mass flow rates (0.5, 1.2 and 2.0 kg h^{-1}) was admitted into the engine through inlet manifold and blends of n-butanol with diesel (D90/nb10 and D80/nb20) were injected as a pilot fuel to initiate the combustion. The fuel properties of the tested fuels were measured as per ASTM standards. The engine testing was carried out at constant speed of 1500 rpm and different engine loads. The experimental results depict that under dual fuel mode, brake-specific fuel consumption increased by 22.6% and brake thermal efficiency of the engine decreased by 11.9% in comparison to conventional diesel. As far as emissions are concerned, carbon monoxide and hydrocarbon emissions increased by 50.8 and 11.9%, respectively, whereas NOx and smoke opacity decreased by 19.8 and 40.9%, respectively, when compared to conventional diesel. Thus, such fuel combinations can be used in existing diesel engines for addressing long term energy needs and solving environmental associated challenges.

Keywords Biogas · n-Butanol · Diesel engine · Mass flow rate · Emissions

List of symbols

CI	Compression ignition
CNG	Compressed natural gas
CH$_4$	Methane
CO$_2$	Carbon dioxide
H$_2$	Hydrogen
N$_2$	Nitrogen
H$_2$S	Hydrogen sulfide
IOCL	Indian Oil Corporation Limited
ASTM	American society for testing and materials
kg h^{-1}	Kilogram per hour
rpm	Revolutions per minute
kW	Kilowatt
BTE	Brake thermal efficiency
BSFC	Brake-specific fuel consumption
CO	Carbon monoxide
HC	Hydrocarbons
NOx	Oxides of nitrogen
D80nB20	Diesel 80% n-butanol 20%
D70nB30	Diesel 70% n-butanol 30%
D60nB40	Diesel 60% n-butanol 40%
D92nB8	Diesel 92% n-butanol 8%
D84nB16	Diesel 84% n-butanol 16%
D76nB24	Diesel 76% n-butanol 24%
nb20	Diesel 80% n-butanol 20%
D90nB10	Diesel 90% n-butanol 10%
nb5	Diesel 95% n-butanol 5%
nb10	Diesel 90% n-butanol 10%

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Multi-objective optimization of performance and emissions characteristics of a variable compression ratio diesel engine running with biogas-diesel fuel using response surface techniques

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ABSTRACT

Rapidly intensifying necessitates of energy and depletion of accessible fossil resources has made a remarkable interest in investigation of the alternative fuels. The current investigational work was performed to examine the use of multi-objective optimization (MOP) based on response surface methodology (RSM) to investigate the impact of compression ratio (CR), biogas flow rate and engine load on the performance of dual-fuel engine. An engine load of 80%, compression ratio of 18, and biogas flow rate of 2.8 kg/h were observed to be optimal condition. According to these optimized parameters, the value of BTE, NO$_x$, UHC, CO and smoke opacity were found to be 18.51(%), 13.5 (g/kW.hr), 0.49 (g/kW.hr), CO (0.08% vol.) and 23.6 (%), respectively. Compared with conventional diesel fuel, dual-fuel operational mode can improve brake specific energy consumption and reduce NO$_x$ as well as Smoke opacity, while producing higher emissions of CO and UHC.

Introduction

Energy has been consistently an indicator of fiscal advancement and social development of any nation (Deepanraj 2017). The planet has endorsed industrial innovation in the former century, and encountered severe issues related to aimless application of the energy assets. This creed was associated with higher utilization of energy to achieve enhanced industrial advancement but it does not contemplate improved and adequate adoption of energy resources. Road transportation also performs an essential part in establishing the wealth of a country and currently, transport sector is based on fossil fuel resources (Deepanraj et al. 2017a; Sharma et al. 2019). Limited fossil fuel reserves, higher crude oil escalation, strict emissions norms, and augmented exigency for energy preservation has initiated attentiveness in supplementary innovative and intelligent combustion technologies along with substitute fuel candidate (Deepanraj et al. 2016; 2017b). Accordingly, there is an exigent requisite to endorse the customization of unconventional fuels as replacements for CI engines (Porpatham et al 2012; Barik and Murugan 2014b; HassanPour, Safieddin, and Sheikhdavoodi 2018, Safieddin Ardebili, Solmaz, and Mostafaei 2019).

Biogas (produced from biomass) inducted dual-fuel diesel engines can solve the problem of energy scarcity and degradation of ambient air quality particularly in developing countries like India (Bora

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Full Length Article

Sampled-data model validation: An algorithm and experimental setup of dual fuel IC engine

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ARTICLE INFO

Keywords:
Dual fuel engine
Biogas
Emission
ANN
Optimization

ABSTRACT

This research work investigates the usage of hybrid based Artificial Neural Network-Harris Hawks and whale optimization algorithm (ANN-HHOWOA) for forecast of emission properties and performance of small utility single cylinder direct injection (DI) diesel engine inlet with rice bran biodiesel blends under dual fuel mode along with biogas. This Artificial Neural Network based hybrid Harris Hawks and whale optimization algorithm was developed and optimized to forecast the values of brake thermal efficiency (BTE), hydrocarbon (HC), carbon monoxide (CO) and carbon dioxide (CO₂) based on the gathered input data from the experimental setup of dual fuel engine by varying engine operating load, blends of rice bran biodiesel, air fuel ratio and injection timings. To experimentally validate the results by using hybrid based Artificial Neural Network-Harris Hawks and whale optimization algorithm (ANN-HHOWOA), 500 trial runs were performed on objective function of gathered data to find optimal solution. 70% of data were used for training, 15% for testing and other 15% were used for validation. It has been concluded that hybrid based Artificial Neural Network-Harris Hawks and whale optimization algorithm (ANN-HHOWOA) gave remarkable results with classification rate 98.6667% which is much better than other meta heuristic algorithms. It is found that Artificial Neural Network based hybrid Harris Hawks and whale optimization algorithm is a very useful tool for prediction and optimization of combustion performance and emissions properties of dual fuel engine fuelled with biogas-biodiesel blends.

1. Introduction

In this era of revolution, the human life is highly influenced by use of mechanical equipment's and motor vehicles. Due to maximum dependency on and utilization of vehicles, noxious gasses such as nitrogen oxides (NOₓ), carbon dioxide (CO₂), sulphur dioxide (SO₂) and carbon monoxide (CO) are released by them. These gasses are contaminating the air to the huge level. Generation of these gasses by industries and vehicles has put an adverse impact on health of human beings. Moreover, the (fossil) fossilized remains of prehistoric plants and animals on which vehicles run are also depleting at an alarming rate. Consequently, it of utmost importance to discover the substitute fuel for operating these vehicles and industrial motors. Improved and cost-effective substitutes can be the used and invented from renewable resources like bio-waste [1–4]. India as a country produces huge amount of bio waste which is capable of generating power for self-reliance and sustainability [2,5].

Goga et al. 2020 [6] used a dual fuel engine to examine its emission properties and performance when biogas at varying mass flow rates was inducted in it together with diesel and biodiesel. The performance characteristics of the engine demonstrated that BSFC augmented whereas BTE diminished by using biogas as a primary fuel in assessment with pure diesel. Concerning emission contents, it was reported that exhalations of HC and CO increased owing to lower amount of oxygen content in biogas. In contrast, there was a simultaneous reduction in NOₓ and smoke emanations. Thus, regardless of having all the optimistic properties biogas is culprit of producing more HC and CO emissions vis-à-vis natural diesel. The reason for the same has been

Research paper

Biodiesel production from *Terminalia bellerica* using eggshell-based green catalyst: An optimization study with response surface methodology

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ABSTRACT

The main aim of this study was to find the possibility of biodiesel production from *Terminalia bellerica* and evaluation of optimal input reaction parameters (molar ratio, reaction temperature and catalyst amount) for maximizing the methyl ester yield with Box-Behnken design. Calcium oxide catalyst synthesized from waste chicken eggshells was used for conversion of *Terminalia bellerica* oil. Highest yield of 97.95% was achieved with optimized parameters: 62.5 °C temperature, 2.25 wt. % catalyst amount and 9:1 molar ratio where the agitation speed of the stirrer during reaction was kept constant at 600 rpm. The fuel properties of *Terminalia bellerica* methyl ester such as acid value 0.030 mg KOH/g, kinematic viscosity 4.722 cSt, flash point 160 °C, pour point 0 °C, cetane number 52 and oxidative stability 2.2h were within the limits of ASTM 6751 and EN14214 specifications.

1. Introduction

The modern world is currently experiencing a continuous clash among various alternative energy technologies to overcome the much-exploited use of fossils. However, such zero carbon or low carbon energy sources are bound to succeed in the global market commercially only when their cost is lower to presently used fossil fuels (Covert et al., 2016). The use of renewable energy has had a lower impact on overall development than expected. Out of the top 38 renewable energy-consuming nations, only 57% had a positive effect on their respective economic output (Bhattacharya et al., 2016). Among various possible alternatives, biofuel industry has been seeing tremendous growth from a long time ago. Government policies have supported various biofuel-related schemes in order to promote low emission fuels. Biofuel programme in India, for instance, includes ethanol (derived from molasses) blended gasoline. But sugarcane farming has led to excess greenhouse gases GHG emissions (Soam et al., 2015). The potential of biofuel industry has not been fully tapped in an effective manner (Luthra et al., 2015).

Mono alkyl esters of fatty acids (vegetable oil or animal fats), better known as, biodiesel is a well-known and commonly used biofuel. It can be used either in pure form, that is B100 or in various blends of petrodiesel. The major advantage of using biodiesel is lower amount of emissions in the form of un-burnt carbons; carbon monoxide and particulate matter (Ranalli, 2007). Non-edible seeds derived oil have been claimed as suitable feedstock for biodiesel production. As these seeds do not affect the food demand and edible crops and also do not require fertile land with maintenance, it is expected to see a growth and demand of non-edible fruit bearing crops (Kumar and Sharma, 2011). Some of the reported literature on rarely used but promising non-edible seeds include Brucea javanica seeds (Hasni et al., 2017), Simarouba glauca (Sivamani et al., 2018), Manilkara zapota (Kumar et al., 2015), rubber seed oil (Onoji et al., 2016), tobacco seed oil (Usta et al., 2011), Pangium edule (Atabani et al., 2015), Acrocomia aculeata (macaúba) (César et al., 2015), Balanites aegyptiaca (Nitiema-Yefanova et al., 2016), Silybum marianum (Takase et al., 2014) and Annona diversifolia (Reyes-Trejo et al., 2014). *Terminalia bellerica* (baheda) oil is one of the possible alternatives in non-edible oil category for low-cost biodiesel production.

The most common and effective method of converting triglycerides to methyl ester is with transesterification method. This method involves a short alkyl group alcohol, like methanol reacting with a long fatty acid chain (triglycerides) and carried by alkoxide anion (R'O⁻), which is generated by base catalyst
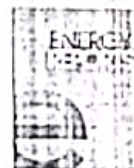
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Research paper

Performance and emission characteristics of diesel engine fueled with rice bran biodiesel and n-butanol

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ARTICLE INFO

ABSTRACT

Due to the depletion of petroleum products and fatal emissions from the tailpipe of diesel engines it has become a need to seek for the alternative of petroleum products for long-term use. Currently, researchers and experts have come to the conclusion that biodiesel along with higher alcohols can be an appropriate substitute for this situation. Former investigations have presented that biodiesel and higher alcohol can help in improving the performance and depreciating harmful exhaust gases in a diesel engine. In the current investigation blends of diesel, rice bran biodiesel and n-butanol were prepared to check its effect on performance and emission characteristics of a diesel engine. Biodiesel was prepared by single stage alkaline transesterification process in this study and after that blends of diesel-biodiesel and diesel-biodiesel-n butanol were prepared as B10, B20, B10 nb10 and B20 nb20. Then these blends were tested in a single cylinder, small utility diesel engine with a rated power output of 3.73 kW to compare them with baseline diesel. Experimental investigation demonstrates that blends of rice bran biodiesel and n-butanol can be used as a fuel in a diesel engine without any change in the engine.

1. Introduction

Diesel engines are one of the dominant prerequisites nowadays in so many sectors owing to the fact that it has better fuel economy, higher efficiency, more reliability, lower fuel cost, and long-lasting capacity. Tailpipe emissions from these engines are very badly affecting the mankind and habitat from so many decades. Moreover, due to the hike in automobiles on roads the fossil fuels are depleting at an alarming rate which may result in its permanent deterioration in few decades. To overcome this, diesel engine specialists, researchers, and combustion analysts are trying to find a substitute fuel which can upgrade the performance characteristics of the engine and cut down exhaust emissions (Mahalingam et al., 2015; Mahla et al., 2018a; Singh et al., 2018; Chauhan et al., 2011). Biofuels is the primary choice of the researchers amidst all alternative fuels due to its properties which help in producing fewer greenhouse gases and soot emissions. Furthermore, these are sustainable in nature and economical than conventional fuels (Singh et al., 2018). Researchers have done experimentation and simulation study on diesel engines by using biodiesel prepared from various vegetable and animal fat oils and found that amidst

reasonable, low grade and renewable vegetable oils Rice bran oil secures top position (Yuan et al., 2013; Chauhan et al., 2010a; Singh et al., 2012; Chauhan et al., 2010b; Sharma et al., 2013; Rai et al., 2013b; Goga et al., 2018; Chhabra et al., 2017). Bora and Saha (2015) explored the opportunity of using Rice bran biodiesel, Palm oil biodiesel and Pongamia oil biodiesel as pilot fuel for a biogas run dual fuel diesel engine and revealed that Rice bran methyl ester was best in performance among all biodiesel oils. Liquid fuel reinstatement was also found maximal for Rice bran biodiesel whereas there was a decrement in HC and CO emissions for Rice bran methyl esters. The emission study also stated that NOx emission declined for Palm oil and Pongamia oil methyl esters. Kaimal and Vijayabalan (2015) performed an experimental investigation on a diesel engine using Rice bran oil biodiesel and plastic oil and concluded that brake specific energy consumption of Rice bran methyl esters is more than plastic whereas the thermal efficiency of the engine was on the lower side with Rice bran biodiesel and plastic oil as compared to that of diesel.

Diesel engine experts have proved that the inclusion of higher alcohol in fuel helps in developing its properties. n-butanol is a dominant priority of researchers as a fuel in diesel engine owing to its inferior viscosity, higher calorific value and finite moisture absorbing capacity (Bora and Saha, 2015; Kaimal and Vijayabalan, 2015; Ndaba et al., 2015). Rakopoulos et al. (2015) mixed various proportions of blends of biodiesel, cottonseed vegetable oil, n-butanol, and ethanol and tested the combustion and emission

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ORIGINAL PAPER

Effect of Metal Contaminants and Antioxidants on the Oxidation Stability of *Argemone mexicana* Biodiesel: Experimental and Statistical Study
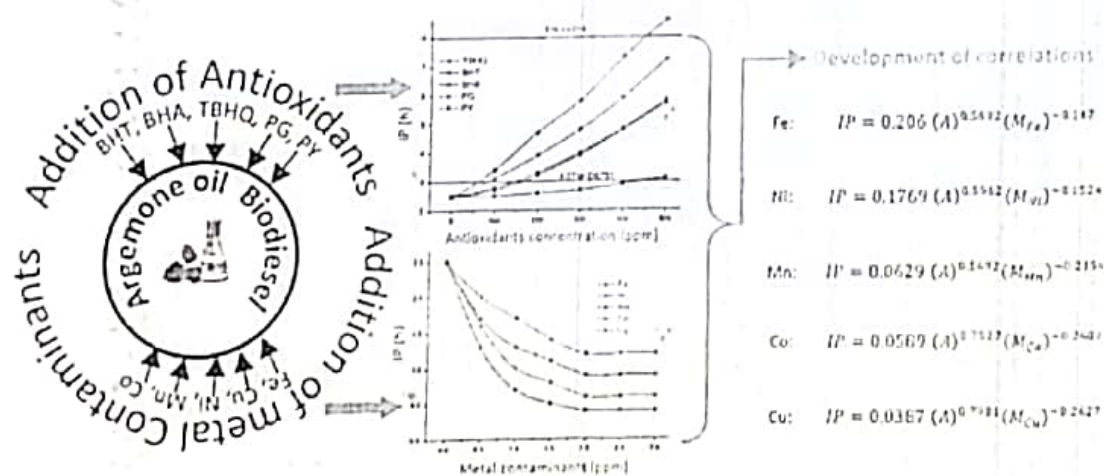
Mandeep Singh[1] · Deepak Kumar Singh[1] · Surjit Kumar Gandhi[2] · Amit Sarin[3] · Sanjeev Saini[4] · Sunil Kumar Mahla[5] · Ajay Gupta[3] · Sarbjot Singh Sandhu[1]

Abstract

Biodiesel's auto-oxidation by metal catalyzed decomposition of hydroxides (ROOH) is a major hurdle restricting the commercial viability of biodiesel. This paper investigates the oxidation stability of argemone biodiesel contaminated with transition metals such as: Fe, Ni, Mn, Cu, and Co. Pure argemone oil biodiesel (ABD) has a rancimat induction period of 2.5 h which does not satisfy the ASTM-D6751 and EN-14214 standard limits of 3 and 8 h respectively. The results show that the presence of a metal in argemone oil results in accelerating the free radical oxidation reaction. To meet the desired standards, present work experimentally investigates the effect of various antioxidants like BHT, BHA, TBHQ, PY, and PG in the range of 100-500 ppm on argemone oil biodiesel. Effectiveness order of antioxidants in pure biodiesel was observed as: PY > PG > BHA > BHT > TBHQ. The 500 ppm of most effective antioxidant pyrogallol (PY) has the potential to enhance the induction period of argemone biodiesel above 8 h which is vital by EN-14214 standard. Based on the results of most effective antioxidant PY and varying concentration of metals (Fe, Ni, Mn, Cu, and Co), several correlations have been developed to calculate the induction period of argemone oil biodiesel, as a function of antioxidant and metal concentration.

Graphic Abstract

Fe: $IP = 0.206\,(A)^{0.5612}(M_{Fe})^{-0.147}$

Ni: $IP = 0.1769\,(A)^{0.5562}(M_{Ni})^{-0.1524}$

Mn: $IP = 0.0629\,(A)^{0.5697}(M_{Mn})^{-0.2154}$

Co: $IP = 0.0569\,(A)^{0.7527}(M_{Co})^{-0.2487}$

Cu: $IP = 0.0367\,(A)^{0.7981}(M_{Cu})^{-0.2627}$

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Dry reforming of methane using various catalysts in the process: review

Rattanvir Singh[1] · Amit Dhir[2] · Saroj Kumar Mohapatra[1] · Sunil Kumar Mahla[3]

Abstract

Dry (CO₂) reforming of methane with its commercial application of syngas production also serves in utilization of greenhouse gases like carbon dioxide and methane. Though the process is well studied, still, there are areas that are being explored in optimizing the process. One of the key areas of research is enhancing the activity and stability of the catalysts used in the reforming reactions. Activity of catalyst depends upon particle size, dispersion on support, support type, synthesis method, etc., whereas deactivation of catalyst is due to carbon deposition and sintering of metal precursor. With noble metals like Rh, Ru, Pt and Pt providing more stability but are not economical, commercialization of dry reforming process has been achieved using Ni-based catalysts. Literature based on optimization of the catalyst performance varying various parameters like type of active metal, support, promoters, and catalyst synthesis procedure has been cited in this review. Review also extends towards various structured catalysts like foams, zeolites, and their performance-enhancing characteristics. With active metals like Ni showing excellent dispersion on well-structured supports like layered double hydroxides; enhanced performance by addition of a second metal usually a noble metal; use of promoters like lanthanides, which induce gasification of carbon species, thus inhibiting deactivation; and methods of introducing promoters, such as controlled adsorption, these catalysts can serve as strong candidates in commercial applications.

Keywords Methane · Reforming catalyst · Supports · Syngas · Promoters · Activity · Coking · Commercialization

1 Introduction

The increasing global energy demand speeds up the depletion of fossil fuel resources, which adds to the motivation of search for alternative resources. It is observed that there have been transitions from solid to liquid and now from liquid to gaseous fuels as major energy sources. There are demands for decarbonization of energy sources due to environmental concerns. Hydrogen is considered an ideal alternative and clean fuel because combustion of hydrogen will produce only water vapors. The other advantage with hydrogen is that it can be obtained for variety of sources. Hydrogen has highest energy content by mass, but its lower density is the major concern. In addition, there is an increasing demand for hydrogen with major applications in refinery use and as a component in synthesis gas for the manufacture of methanol and ammonia. Currently, it is also anticipated that renewed interest in Fischer-Tropsch technology (GTL (gas-to-liquid) CTL (coal-to liquid)/BTL (biomass-to-liquid)) will further enhance the demand of hydrogen [1, 2].

Commercially, production of syngas (hydrogen and carbon monoxide mixture) has an escalating significance worldwide [3] because of the versatile nature of this feedstock; it can be utilized for the production of fuels and chemicals, including Fischer-Tropsch fuels, hydrogen, methanol, ethanol, and dimethyl ether (DME). Production of syngas can be carried out from a variety of primary feedstock, such as petroleum coke, coal, natural gas, and biomass. On the basis of cost, syngas production is the cheapest in the case of natural gas [4].

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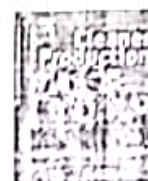
Application of clean gaseous fuels in compression ignition engine under dual fuel mode: A technical review and Indian perspective

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ABSTRACT

The rapid increase in energy demand and the fast depleting environment stresses the exploration of renewable and clean energy sources. Both biogas and hydrogen are considered clean and renewable fuels, and their effective utilisation in engines could reduce harmful emissions. The present review comprehensively investigates the influences of biogas and hydrogen on the performance, combustion, and emission of the compression ignition engine operating under dual fuel mode. In addition, Indian governmental policies related to biofuels are also discussed briefly. The present review showed that biogas utilisation reduces brake thermal efficiency, volumetric efficiency, and exhaust gas temperature, whereas brake-specific fuel consumption increases. Biogas introduction also reduces nitrogen oxides and smoke emissions with an increase in hydrocarbon and carbon monoxide emissions. The review shows that hydrogen supplementation results in better performance at high and moderate loads due to suitable fuel characteristics of hydrogen. The zero-carbon nature of hydrogen reduces all the carbon-based emissions from the climate change perspective. The increase in hydrogen proportion results in the escalated emission of oxides of nitrogen (approximately 30–60%) contrasting to diesel mode by virtue of higher in-cylinder temperature. Additionally, a detailed study is also presented on the bottlenecks in hydrogen application for dual fuel mode.

1. Introduction

The world energy demand is steadily increasing owing to a faster economic process and rapidly growing population. Fossil fuels are the primary energy source; however, their finite nature and emission characteristics have created a doubt on the sustainability of development models. The sources of conventional fuels are also clustered in some specific parts of the world, increasing the import burden on developing countries like India.

Fig. 1 shows the dependency of India and World on the fossil fuels. The combined concerns regarding rapid depletion, fluctuating prices, geopolitical scenario, and environment protection have surged the hunt for non-conventional, clean, and alternative energy resources like solar, wind, hydro, and biofuels. Adequate planning is desired for shifting towards cleaner fuels that do not impair productivity and the environment. Gaseous fuel having a high H/C ratio produces less emission when used in the internal combustion engine and thus regarded as future fuels. Biogas and hydrogen (H2) have been distinguished as possible alternatives to the conventional fuel for various energy applications such as

transportation fuel in prime movers (Rosha et al., 2018; Verma et al., 2019a).

Biogas could be generated by anaerobically digesting the organic matter and sludge of wastewater treatment plants. It is also a carbon-neutral energy source given that the carbon released by its combustion was fixed from the atmosphere CO_2 by plant matter. The yield of biogas and composition mainly depends on the type of feedstock used (Table 1). Biogas is essentially a composition of methane (CH_4) and carbon dioxide (CO_2) with minors of hydrogen, carbon monoxide, ammonia, and hydrogen sulfide (Sharma and Dhir, 2020). Biogas utilisation could elucidate three significant obstacles, i.e. determining a sustainable energy source, mobilising a high greenhouse gas methane, and adequate bio-waste disposal. Biogas has high anti-knocking properties contrasting to diesel, making it suitable for CI engines under DFM (dual fuel mode).

Hydrogen is also a carbon-free fuel and could be generated from diverse sources, essentially natural gas, biogas, water, etc. Its unique physic-chemical properties make it one of the most preferred renewable fuels. It has the highest energy content (120 MJ/kg) and many valuable assets such as high diffusivity, more comprehensive flammability limits,

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Trend and time series analysis by ARIMA model to predict the emissions and performance characteristics of biogas fueled compression ignition engine

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ABSTRACT

Biomass-derived biogas is a very promising alternative energy source because of its renewable and clean combustion characteristics compared to fossil petroleum diesel fuel. The forecasting of emissions and performance characteristics is done by using the autoregressive integrated moving average (ARIMA) model. The R^2, root mean square error (RMSE), and normalized Bayesian information criterion (BIC) are used to test the validity and applicability of the developed ARIMA models revealing adequate accuracy in the model performance. It is inferred from the experimental results that NO_x and smoke opacity emissions were lower at all engine operating loads. There is an increase in CO, CO_2, and HC emissions at all gas flow rates compared to diesel counterparts. The brake thermal efficiency drops with the increase in biogas flow induction at all engine operating modes. This paper explores and highlights the potential of biogas-diesel dual-fuel combustion mode at different engine operating conditions.

Introduction

Depleting fossil fuels, escalating prices, stringent environmental policies, and increased demand for energy conservation have triggered interest in renewable and alternative fuels as energy sources for internal combustion engines (Goga et al. 2019; Rosha et al. 2019; Singh et al. 2019). So, there is an urgent need to promote the use of renewable (liquid and gaseous) alternative fuels as substitutes for compression ignition engines (Bora and Saha 2015; Barik and Murugan 2014b; Porpatham, Ramesh, and Nagalingam 2012). Gaseous fuels are considered good for internal combustion engines because of their good mixing characteristics with air and attainment of higher compression ratios, resulting in an improvement in the brake thermal efficiency and reduction in tailpipe exhaust emissions (Ali et al. 2015; Namasivayam et al. 2010; Palash et al. 2015). Biogas is a potential renewable, abundantly available and environment-friendly fuel produced from a variety of organic substances through the anaerobic digestion process (Barik et al. 2016, Jingura and Matengaifa 2009, Mahla, Das and Babu 2018). Biogas is a low cetane fuel, and it cannot be directly ignited and combusted in conventional diesel engine. It requires an intense source of ignition as the auto-ignition temperature of biogas is high (Barik and Murugan 2013a). CO_2 present in the biogas acts as a diluent for the reduction of NO_x tailpipe emission, when it is used in dual-fuel engine (Yoon et al., 2011; Barik and Murugan 2014c). Brake thermal efficiency of the engine is reduced at low to

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Effects of ternary fuel blends (diesel-biodiesel-n-butanol) on emission and performance characteristics of diesel engine using varying mass flow rates of biogas

Geetesh Goga[a], Varun Singla[b], Sunil Kumar Mahla[c], Bhupendra Singh Chauhan[d], Amit Dhir[e], Dhinesh Balasubramaniam[f], and Neeru Singla[g]

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ABSTRACT

Currently, diesel engine specialists and experts have established that combination of biodiesel higher alcohols and gaseous fuel can be an apposite substitute for the existing conditions. In the present study, an investigation and analysis were done by fueling a dual fuel engine with blends of diesel, rice bran biodiesel, and n-butanol as liquid fuel and biogas as gaseous fuel. Performance and exhaust emissions parameters of the dual-fuel engine energized with ternary blends utilizing diesel-biodiesel-n-butanol along with biogas were evaluated and compared with baseline diesel. Results depicted that brake thermal efficiency (BTE) was reduced by 14.68% on an average in relation to baseline diesel. Emissions characteristics illustrated that CO and HC emissions on average were higher by 45.58 and 17.74%, while NOx and smoke opacity on an average were lowered by 39.06 and 46.85% in relation to pure diesel. Therefore, utilization of cost-effective gaseous fuel, for instance biogas, would be a feasible recommendation to deal with the existing and upcoming complications of energy insufficiency and accompanying conservational apprehensions.

Abbreviations

ASTM	American Society of Testing and Methods
BSFC	Brake specific fuel consumption
CI	Compression ignition
BTE	Brake thermal efficiency
CO	Carbon monoxide
HC	Hydrocarbon
NOx	Oxides of nitrogen
LPG	Liquid petroleum gas
CNG	Compressed natural gas
D70/Bd10/n20 Bio (0.5)	Diesel 70% +Biodiesel 10%+n-butanol 20% +biogas (0.5 kg/h)
D70/Bd10/n20 Bio (1.2)	Diesel 70%+Biodiesel 10%+n-butanol 20% +biogas (1.2 kg/h)
D70/Bd10/n20 Bio (2)	Diesel 70%+Biodiesel 10%+n-butanol 20% +biogas (2 kg/h)
D70/Bd20/n10 Bio (0.5)	Diesel 70%+Biodiesel 20%+n-butanol 10% +biogas (0.5 kg/h)
D70/Bd20/n10 Bio (1.2)	Diesel 70%+Biodiesel 20%+n-butanol 10% +biogas (1.2 kg/h)
D70/Bd20/n10 Bio (2)	Diesel 70%+Biodiesel 20%+n-butanol 10% +biogas (2 kg/h)

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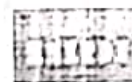
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Effect of compression ratio on combustion, performance, and emission characteristics of compression ignition engine fueled with palm (B20) biodiesel blend

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ABSTRACT

Limited fossil fuel reserves led to focus on alternatives fuels for combustion engines. Several studies reported optimal (20%) biodiesel blend for utility in compression ignition engine at constant compression ratio. Literature lacks on the study of palm-based biodiesel in blended form at varying engine compression ratios. In this study, an initiative was undertaken to study the effect of variable compression ratio (16:1, 17:1 and 18:1) on various engine characteristics by fuelling 20% palm biodiesel blending compression ignition engine. The ignition delay period decreased, whereas the peak cylinder pressure and brake thermal efficiency increased with increase in the engine compression ratio from 16:1 to 18:1. At 3.5 bar bmep, brake thermal efficiency values were observed to be 28.9, 30.8 and 33.8% at 16:1, 17:1 and 18:1 CRs, respectively in B20 fuel. Moreover, Increasing compression ratio from 16:1 to 18:1, the average reduction in emissions of hydrocarbon, carbon monoxide and smoke opacity were observed to be 47.8, 41.0 and 35.7%, respectively whereas, oxides of nitrogen emissions increased by 41.1%. Thus, it is inferred that B20 fuel performed well at high engine compression ratio.

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1. Introduction

Worldwide usages of compression ignition (CI) engine for different applications resulting fossil fuel depletion and environmental degradation. This result in increased worldwide conventional fuel usage and diminishing underground carbon resources on account of indiscriminate extraction of non-renewable energy sources. Apart from that, the widespread use of fossil fuels is also associated with environmental concerns such as global warming and climate change. The harmful emissions emit from diesel engines comprise hydrocarbon (HC), carbon monoxide (CO), particulate matter (PM) and oxide of nitrogen (NOx) [1,2]. Though, every nation is trying to tackle environment-related issues by enforcing stringent emission norms day by day. Widespread applications of non-renewable fuels and the environmental issues related to their use encouraged the researcher to focus on renewable alternative fuels. Moreover, new research endeavors are continuously explored for the production and utilization (in CI engine) of various alternative fuels [3–5]. These investigations inferred that alternative fuels promise a harmonious correlation with energy conservation, sustainable development, environmental preservation, and efficiency.

Biodiesel as an alternative renewable fuel picking up popularity as it is a clean oxygenated fuel derived via transesterification of vegetable oil/animal fat [6]. Biodiesel has been considered as a fuel that adds to energy sustainability, and can be used in CI engines either in pure form or by blending with conventional diesel [7]. It is more eco-friendly and non-toxic fuel when compared to ordinary diesel; moreover, its high lubricant properties improve engine performance as well [8]. Muralidharan et al. [9] utilized biodiesel blends in CI engine and expressed that brake thermal efficiency
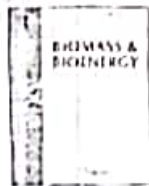
Research paper

Catalytic reforming of synthetic biogas for hydrogen enrichment over Ni supported on ZnO−CeO$_2$ mixed catalyst

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ABSTRACT

Catalytic reforming has been considered as an effective technique to produce hydrogen (H$_2$)/syngas from the various feedstocks. The present study focussed on the dry reforming of biogas with Ni (10 wt %) catalysts supported on ceria (CeO$_2$) and Ni catalyst with mixed support of ceria and zinc oxide (ZnO). The synthesized catalysts were characterized by H$_2$-TPR, FESEM, EDX, XRD and BET techniques. The effect of Zn loading (10 and 20 wt %) on the catalytic activity was assessed with respect to various performance parameters. Increased reaction temperature from 650 °C to 900 °C caused a significant increase in reactant conversion and product yield. At 650 °C, CH$_4$ conversion and H$_2$ selectivity achieved were 15.1 and 5.2%, respectively, whereas, at 900 °C, enhanced CH$_4$ conversion (78.5%) and H$_2$ (35.7%) selectivity was achieved with Ni$_{0.1}$/CeO$_2$ catalyst. Further, it was observed that Ni supported on mixed support exhibited higher reactant conversions when compared to Ni supported with ceria. At 900 °C, Ni$_{0.1}$/(Zn$_{0.1}$-Ce$_{0.8}$) catalyst showed higher CH$_4$ and CO$_2$ conversion of 63.1 and 97.0%, respectively, with 40.3% of H$_2$ enrichment. Carbon deposition rate in mixed support catalyst was observed to be less when compared to single support material after 7 h of continuous dry reforming reaction. Further, in order to reduce carbon deposition on the catalyst bed, dry oxidative reforming was carried out at 650 °C with varying proportions of O$_2$/CH$_4$ ratio which resulted in significantly higher CH$_4$ conversion with low catalyst deposition.

1. Introduction

Currently, worldwide research is focused on renewable gaseous fuels for power or energy generation [1]. At present, the power primarily originates from the combustion of fossil fuels, which are non-renewable and limited. Hydrogen (H$_2$) is envisioned as a clean and appealing energy carrier in the 21st century [2]. H$_2$ is primarily produced by catalytic steam reforming of petroleum derivatives such as natural gas or naphtha [3]. With the increasing demand of H$_2$ and depletion of fossil fuels, renewable resources for H$_2$ production have gained attention. H$_2$ from renewable sources, such as biogas, seems to be a promising route in view of its sustainability and accessibility [4]. Biogas primarily consists of methane (CH$_4$), carbon dioxide (CO$_2$), and traces of hydrogen (H$_2$), carbon monoxide (CO), hydrogen sulfide (H$_2$S) and oxygen (O$_2$) [5]. Moreover, its composition largely depends on the feedstock used during biogas production [6]. Because of the main concerns related to the utilization of biogas directly in compression

ignition (CI) engines, especially due to carbon-based emissions and reduce efficiency, a technique i.e. dry reforming of biogas has been suggested by the various researcher to produce H$_2$-enriched gaseous fuel [7,8].

Dry reforming provides an effective approach to utilize CH$_4$ and CO$_2$ (greenhouse gases) by converting them into H$_2$/syngas [9]. Despite this, dry reforming process is not implemented industrially due to huge energy requirement and carbon deposition, which lead to deactivated catalysts [10]. Also, difficulties of catalyst making for dry reforming reactions are to limit coke formation, while increasing H$_2$ yield [11]. From energy consumption aspect and H$_2$ economy, aforesaid goals must be accomplished at bringing down temperatures than conventional dry reforming. Noteworthy, reducing the reforming temperature comparatively reduces the catalyst activity. Chen et al. investigated the effect of H$_2$S in the biogas dry reforming reactions and stated that the H$_2$S causes server catalyst deactivation [12]. Along these lines, to achieve high H$_2$ yield/selectivity with least carbon deactivation, development of

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Combined impact of varying biogas mass flow rate and rice bran methyl esters blended with diesel on a dual-fuel engine

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ABSTRACT

For fetching day-to-day energy needs, current energy requirement majorly depends on fossil fuels. But ambiguous matter like abating petroleum products and expanding air pollution has enforced the experts to strive for another fuel which can be used as an alternative or reduce the applications of fossil fuels. Considering the issues, the main objective of the present study is to find the feasibility by using blends of rice bran oil biodiesel and diesel which are used as pilot fuels by blending 10% and 20% biodiesel in fossil diesel and biogas, introduced as gaseous fuel by varying its mass flow rate in a dual-fuel engine mode. An experimentation study was carried out to find the performance and emission parameters of the engine relative to pure diesel. The results were very much similar to the majority of researchers who used biodiesel and gaseous fuels in a dual-fuel engine. Brake specific fuel consumption (BSFC) of the engine was noticed to have increased, while brake thermal efficiency was on the lower side in dual fuel mode in comparison with regular diesel. In relation with conventional diesel, it was noticed that combined effect of rice bran methyl esters and varying mass flow rate of biogas showed a decrement in NO_x and smoke emissions, whereas HC and CO exhalations were on higher side when biogas and biodiesel were utilized collectively in dual-fuel engine. Hence, it was concluded that combination of blends of biodiesel and diesel and introduction of biogas in the engine can be a promising combination which can be used as a substitute fuel for addressing future energy needs

Introduction

Need for energy boosts up by 6.5% annually and more than three-fourth petroleum products are imported from other countries to satisfy the increasing demand in India, due to which the country is facing energy crisis and it has become mandatory to minimize the use of conventional resources of energy or to opt for alternative sources (Goga et al. 2018; Kusumo et al. 2018; Patil et al. 2018; Suresh, Jawahar, and Richard 2018). Moreover, the exhaust emissions like carbon monoxide (CO), nitrogen oxide (NO_x), hydrocarbons (HC), smoke etc. emitted by petroleum products are attributing a huge loss to environment and society (Damanik et al. 2017; Kalsi and Subramanian 2017) and Paris pact is a future environmental need. The disaster caused to atmosphere owing to the excessive adoption of petroleum products can be compensated by the use of alternative fuels, based on biomass. The success of sustainable energy process is still limited because of its low production

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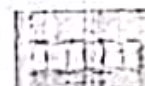
Hydrogen enrichment of biogas via dry and autothermal-dry reforming with pure nickel (Ni) nanoparticle

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ABSTRACT

The present study includes first attempt to assess the performance of bare Ni nanoparticle towards dry and autothermal-dry reforming of synthetic biogas. Influence of reaction temperature was strong on H_2/ CO ratio in both reforming processes, whereas, weight hour space velocity (WHSV) showed variation in products yields. In dry reforming, Ni showed better performance at high temperature and low WHSV. Highest CH_4 conversion and H_2 selectivity of 77.1 and 36.7%, respectively, were observed at 900 °C temperature and 20,000 $NmLg^{-1}h^{-1}$ WHSV, whereas, increased WHSV to 40,000 $NmLg^{-1}h^{-1}$, 21.6 and 26.3% decrement in CH_4 conversion and H_2 selectivity was observed. Autothermal-dry reforming employed at 0.17 O_2/CH_4 ratio with high reaction temperature (≥ 850 °C) showed improved performance in terms of reactant conversion and H_2 yield. At 900 °C, CH_4 conversion and H_2 selectivity of 80.8 and 35.9%, respectively, were obtained at 0.17 O_2/CH_4 ratios in autothermal-dry reforming. Carbon deposition of 0.40 wt% was examined under dry reforming at 900 °C, whereas, negligible carbon deposition (0.003 wt %) was observed in case of autothermal-dry reforming. Thus, autothermal-dry reforming offers better option for H_2 enrichment and effectively addresses the problems of carbon deposition and high energy requirement of dry reforming process.

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1. Introduction

Today's worldwide energy sectors are mainly focused on power generation by using unsustainable fossil fuels. However, in the long-term perspective, power must be produced from the renewable resources because of unpredictability and shortage of worldwide fossil fuel reserves. Over the last few decades, the so-called renewable resources for power or energy generation have already been proposed; including sun, water, wind and biomass [1]. Inspite of this, transition of these resources has slowed down due to the non-availability of wind and solar power, round the clock [2]. Therefore, to address this aforementioned situation, it is fundamental to move towards a renewable resource independent of meteorological conditions. In this context, biogas produced from biomass is envisioned as a viable energy resource that, if managed properly, could be stored and used for power generation. Truth be told, India has officially upgraded the capability of biogas plants by 31.8% from 2014 to 2015 [3]. Methane (CH_4) is the main flammable component present in biogas in addition to CO_2 & H_2S, which are considered as impurities. Biogas is relatively cheaper and cleaner, its utilization to produce energy efficient product like H_2-enriched biogas has attracted attention because of the worldwide availability of biogas [4]. Both CH_4 and CO_2 are the attractive renewable carbon source; thus, exploitation of biogas to produce H_2-enriched gas stream not just uses the two noteworthy ozone depleting gases (CH_4 and CO_2) but can be used for power or energy generation by direct combustion in the compression ignition (CI) engine under dual fuel mode. The gaseous fuel (especially H_2, biogas, syngas) induction in a CI engine and its influence on the combustion, performance and emission characteristics under dual fuel mode has been thoroughly reviewed [5].

Several catalytic reforming processes have been reported in the past for the production of H_2-enriched biogas/syngas viz., steam reforming (SR) [6,7], dry reforming (DR) [8,9], partial oxidation (PO) [10,11], etc. These reforming techniques vary in their oxidant used, product ratio (H_2/CO), energetic and kinetics of the reaction. Among these, only SR has been commercialized for the production

Performance and emission characteristics of CNG-fueled compression ignition engine with *Ricinus communis* methyl ester as pilot fuel

Sunil Kumar Mahla[1] · Amit Dhir[2]

Abstract

Surge in petroleum prices, its drying sources and degradation in air quality focused interest on renewable energy sources as substitute for existing fuels for internal combustion engines. This study highlights the combustion, performance, and emission characteristics of diesel engines fueled with compressed natural gas (CNG) as primary fuel and castor (*Ricinus communis*) oil methyl ester (COME) as pilot fuel. COME was produced from non-edible grade *Ricinus communis* oil. The biodiesel fuel properties and characterization was done as per ASTM D6751 specifications. The CNG was inducted through inlet manifold fumigation at a consistent flow rate of 15 l/min under dual-fuel mode. It is evident from the test results that B20-CNG yields brake thermal efficiency of 23.6% when compared to 25 and 27% for D-CNG and diesel fuel, respectively. The peak cylinder gas pressure was lower in dual-fuel mode when compared to conventional diesel. The emission results show increase in NO, emission by 24.5 and 28.4% for D-CNG and B20-CNG, respectively when compared to baseline diesel fuel at full engine load. There was increase in HC emission by 6.7 and 11% whereas CO emissions decreased by 31.6 and 37.4% for B20-CNG and D-CNG, respectively at similar operating conditions. Reduction in smoke opacity by 49.4 and 59.6% was achieved respectively for D-CNG and B20-CNG under dual-fuel mode. On the whole, COME exhibits a better pilot fuel choice for dual-fuel combustion mode in comparison to conventional fossil petroleum diesel in terms of combustion, performance, and emissions characteristics.

Keywords Dual fuel · Smoke · Biodiesel · Emissions · CNG

Nomenclature

CNG	Compressed natural gas
COME	Castor oil methyl ester
LCV	Lower calorific value
DFM	Dual-fuel mode
ASTM	American Society for Testing and Methods
LPM	Liter per minute
NO,	Oxides of nitrogen
NaOH	Sodium hydroxide
SI	Spark ignition engine
CI	Compression ignition engine
TDC	Top dead center
SOI	Start of injection
BTE	Brake thermal efficiency
BSEC	Brake-specific energy consumption
CO	Carbon monoxide
CO_2	Carbon dioxide
HC	Hydrocarbons
rpm	Revolutions per minute

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Introduction

Scarcity of fossil fuel sources coupled with environmental degradation has led to an intensive research towards alternative renewable clean fuel technologies around the globe. It is always desirable to improve thermal efficiency and reduce exhaust emissions for conserving energy and addressing climate change issues. Diesel has been the major source of fuel for the transportation sector because of

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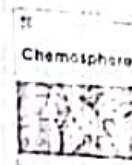
A facile synthesis of Cs loaded TiO₂ nanotube photoelectrode for the removal of 4-chloroguaiacol

Himadri Rajput [a], Rahil Changotra [a], Vikas Kumar Sangal [b], Sunil Kumar Mahla [c], Amit Dhir [a],*

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HIGHLIGHTS

- Novel Cs/TiO₂NTs electrode fabrication by anodization for PEC removal of 4-CG.
- Comparative assessment of photocatalysis, electrocatalysis and photoelectrocatalysis performances.
- Photoelectrocatalytic process was most efficient in terms of % removal, TOC reduction and ·OH generation.
- Identification of degradation intermediates and cytotoxicity assessment.

GRAPHICAL ABSTRACT
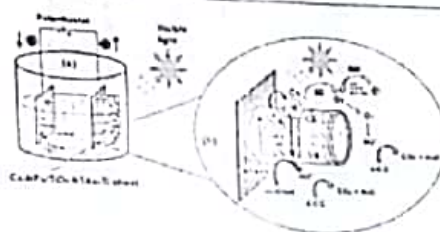
ABSTRACT

In this study, novel Cesium (Cs) doped TiO₂ nanotubes photoelectrode (Cs/TiO₂NTs) were synthesized by simple electrochemical anodization method and characterized by several physicochemical techniques. In particular, the photocatalytic (PC), electrocatalytic (EC) and photoelectrocatalytic (PEC) activity of newly synthesized Cs/TiO₂NTs electrodes was investigated using 4-Chloroguaiacol (4-CG). The effect of operating parameters like Cs concentration, electrolyte concentration, external current and pH on degradation efficacy was examined. PEC oxidation using Cs/TiO₂NTs lead to 92% degradation of 4-CG in 6 h of solar light irradiation under optimized conditions (2.5 mM Cs, 160 mg L⁻¹ Na₂SO₄, 0.03 A current and pH 3). A comparative assessment between PEC, PC and EC process manifested that PEC process was most efficient than the other two processes and Cs/TiO₂NTs exhibited higher PEC activity than bare-TiO₂ electrodes in terms of degradation and mineralization of organic pollutant. The generation of ·OH radicals was found to be highest in PEC when compared to EC and PC process. Possible intermediates/byproducts were identified by GC-MS technique and a corresponding tentative degradation pathway has been proposed. Cytotoxicity study showed that PEC has potential to detoxify 4-CG. Hence, combination of TiO₂ electrodes decorated with Cs metal can act as a highly efficient photoelectrode for the degradation of hazardous pollutants.

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1. Introduction

4-chloroguaiacol is a widespread recalcitrant pollutant present in pulp and paper mill effluents (Kringstad and Lindstrom 1984).

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Review

Waste materials as potential catalysts for biodiesel production: Current state and future scope

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ARTICLE INFO

ABSTRACT

Recent studies on the exploration of eco-friendly approach by utilizing large-scale waste materials as potential catalyst in biodiesel production have attracted much attention. The development of heterogeneous catalysts especially from calcium has gained much awareness due to the large availability of calcium-rich waste materials and their corresponding high catalytic activity in the transesterification of oil. Most of the waste materials employed as heterogeneous catalysts have an abundance of natural Ca content and they have high catalyst activity and selectivity despite being environment-friendly and cost-effective. Heterogeneous catalysts with high activity can be produced from Ca based waste materials when calcined at high temperatures. This review gives a brief overview of the developments of various Ca based catalysts derived from waste materials as an efficient catalyst for biodiesel production with significant yield. Industrial wastes (red mud, slag, ash) and biological catalysts (chicken eggshells, mollusk shells, animal bones) possess enormous potential towards developing as economical catalyst and subsequently, low-cost biodiesel generation. However, future challenges await a better utilization of useless wastes into a useful resource to satisfy human needs.

1. Introduction

The continuous exigency for fossil fuels for industrial, transportation and domestic purposes has led to the exploration of alternative energy sources. Coal, oil, and gas are the main contributors in the energy sector. The literature studies reveal that oil, coal, and gas may last for a further 40, 200 and 70 years, respectively, as per the ongoing consumption of fossil fuel reserves [1]. Sky-high prices of gasoline and diesel have forced the researchers and scientists to develop liquid biofuels as alternative fuels [2]. Bio-diesel, a non-renewable and biodegradable fuel, is a suitable alternative fuel whose properties match the specifications of the ASTM and EN standards [3]. Transesterification process is a widely used method, which involves the conversion of triglycerides to methyl esters (with methanol) or ethyl esters (with ethanol) along with the use of a suitable catalyst, Fig. 1 depicts the transesterification mechanism for biodiesel production.

Homogeneous base catalysts (KOH and NaOH) are not capable to convert used cooking oils and inedible oils due to their high FFA content causing the formation of soaps in the product. Moreover, the extent causing the formation of soaps in the product. Moreover, the separation of biodiesel from the solution is difficult and thus costly. Acid-catalyzed reactions for pre-esterification of high FFA are not suitable

due to the corrosive nature of acid catalysts. Therefore, the studies on the development of solid heterogeneous catalysts have escalated [4,5]. The higher molar ratios, catalyst amount and reaction temperatures required for the heterogeneous catalysis when compared to homogeneous catalysis is a complication for production of low-cost biodiesel. Solid base heterogeneous catalysts relatively require lower reaction conditions when compared to those for solid acid catalysts. Waste materials derived from industries and surroundings can assist in the development of an economical solid base catalyst. Awareness towards an exploration of more waste materials can help in the development of catalysts promoting a sustainable and environment-friendly approach towards biodiesel production [6]. Rice husk as by-product constitutes about 20% in terms of weight of rice when milled. Around 151 million tonnes of rice husk was produced as reported in July 2017 [7].

Calcium oxide (CaO) is one of the most active catalysts in the category of solid base catalysts. Due to its low cost, easy availability and high regenerability, CaO is a widely used catalyst for transesterification of feedstocks. Also, various waste products contain Ca content in huge amounts and are easily available at low cost. CaO as catalyst support is ideal due to its high surface area and a large number of pores available on the surface. CaO is a non-toxic catalyst possessing high basicity and

Review

Waste materials as potential catalysts for biodiesel production: Current state and future scope

Akshey Marwaha[a], Pali Rosha[b], Saroj Kumar Mohapatra[a], Sunil Kumar Mahla[c], Amit Dhir[b,*]

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ABSTRACT

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1. Introduction

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Biogas reforming for hydrogen enrichment by ceria decorated over nickel catalyst supported on titania and alumina

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ARTICLE INFO

ABSTRACT

Catalytic dry reforming of biogas for hydrogen enrichment was studied over cerium oxide promoted nickel catalysts supported on titanium dioxide and aluminium oxide. The catalysts were prepared by wet impregnation method and characterized by H_2-TPR, XRD, BET and FESEM techniques. Their catalytic performance in the biogas dry reforming reaction was studied at temperature ranges from 650 to 850 °C with a CH_4/CO_2 ratio of 1.5:1. The H_2-TPR results revealed that 11 wt % Ni impregnation on TiO_2 support makes the catalyst with strong metal-support interaction which moderates the metal sintering. Also, the addition of CeO_2 effectively improved the CH_4 and CO_2 conversions as well as H_2 enrichment. At 850 °C, 11 wt % Ni/TiO_2 catalyst leads to 70.5% CH_4 conversion with 32.0% H_2 enrichment, whereas, $Ni_{0.11}/Ce_{0.05}$ (Al_2O_3-TiO_2) yielded high CH_4 conversion (84.9%) with 40.6% of H_2 enrichment. No significant change in the activity of the catalyst was observed with 8.8 wt % of carbon deposited on the $Ni_{0.11}/Ce_{0.05}$ (Al_2O_3-TiO_2) catalyst, after 7 h of continuous reforming. Moreover, under combined (dry and oxidative) reforming of biogas, the stoichiometric H_2/CO ratio (1:1) was observed at 0.47 O_2/CH_4 ratios with negligible carbon deposition. Thus, $Ni_{0.11}/Ce_{0.05}$ (Al_2O_3-TiO_2) catalyst exhibited better activity and selectivity with high catalyst stability at 850 °C.

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Introduction

In recent years, excessive use of petroleum fuels for power or energy generation has resulted in their depletion and deteriorated air quality [1]. The worldwide research endeavours have been committed towards the development of clean and energy productive fuels which are being renewable [2]. In this unique situation, H_2 has been emerging as an energy effective and eco-friendly fuel in light of its high calorific value (120 MJ/kg) and carbon neutral gaseous fuel that prompts to produce zero carbon based emissions during combustion [3]. H_2 is currently being produced by various techniques, for example, steam reforming, pyrolysis and gasification using water and

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An overview of solid base heterogeneous catalysts for biodiesel production

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ABSTRACT

The alcoholysis process requires high activity catalysts for biodiesel production. Heterogeneous catalysts have been proven to possess highly active nature and are environment-friendly. The present article emphasizes on various types of solid base catalysts that have been used in the recent past for the production of biodiesel by transesterification of oils. The parameters and conditions affecting the transesterification reaction and biodiesel yield have also been mentioned in the article. Heterogeneous catalysts have the capability to be recycled for many runs in the process without greatly abating the biodiesel yield. Also, such catalysts possess noncorrosive nature, thus making the biodiesel safe to be used in engine without any damage. The exploitation of waste materials as catalysts would reduce the overall production cost of biodiesel. Calcium-based catalysts in the reviewed literature have shown promising outcomes for the future use and would make the process economical for large-scale industrial applications.

1. Introduction

Modern world scenario has changed drastically over the past few decades in terms of energy demand and availability. Humungous use of resources by the mankind will certainly lead to a shortage of resources in the near future. The need to search for alternative sources of energy has massively increased due to the changing lifestyle of humans and necessity of comfort. Power generation industries, agricultural and transportation sector have a huge dependence on fossil fuels for energy requirement. The major drawback of using fossil fuels is the generation of CO_2, which is responsible for the growth of greenhouse gases emission, thus resulting in global warming. CO_2 is the major constituent of greenhouse gases. This has led to anthopogenic climate change which is likely to continue further for several centuries. Climate change has proved to be the greatest future challenge for the mankind.[1–3]

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Optimization of Hydrogen-Enriched Biogas by Dry Oxidative Reforming with Nickel Nanopowder Using Response Surface Methodology

Pali Rosha,[†] Rattanvir Singh,[‡] Saroj Kumar Mohapatra,[‡] Sunil Kumar Mahla,[§] and Amit Dhir[*,†]

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[§]Department of Mechanical Engineering, I.K. Gujral Punjab Technical University, Hoshiarpur Campus, Hoshiarpur, Punjab 146001, India

ABSTRACT: Today, the worldwide research is focused on the development of alternative energy sources for power generation; thus, the present study aims to optimize the dry oxidative reforming (DOR) process parameters for H_2-enriched biogas production by integrating response surface methodology with a three-level, three-factor Box–Behnken design in the presence of commercial Ni nanopowder. First, the effect of CH_4/CO_2 and O_2/CH_4 ratios on the catalytic performance of DOR was assessed in the temperature range of 800–900 °C. The reactant (CH_4 and CO_2) conversions, product (H_2 and CO) yields, selectivities of H_2 and CO, H_2/CO ratio, and specific energy consumption were chosen as responses. The empirical regression models were developed to identify the influential and most significant parameters. More than a 95% value of determination coefficients by analysis of variance proved that the developed regression models were highly satisfactory. Experimentally, a maximum H_2 enrichment of 38.7% with 82.9 and 90.8% CH_4 and CO_2 conversions, respectively, were achieved at optimal reaction conditions of 900 °C, 1.5 CH_4/CO_2 ratio, and 0.10 O_2/CH_4 ratio. The combination of the regression model and dry oxidative technique for biogas reforming could provide an attractive proposition for enhancing the yield of H_2 in product gases with a subsequent increase in energy density and production of environmentally friendly gas.

1. INTRODUCTION

Today, the conversion of biomass to a valuable energy source has significant potential in addressing the scarcity of conventional fuels. In this direction, studies have been linearly shifted toward the production of clean, renewable, and sustainable alternative fuels.[1] Biogas as a gaseous fuel is considered as a very peculiar long-period renewable fuel for a dual-fuel compression ignition (CI) engine. It is produced by anaerobic degradation or fermentation of various organic matter, such as cow dung, agricultural waste, municipal waste, sewage sludge, etc., and its composition largely depends upon the feedstock used.[2] Typically, biogas produced from cow dung normally contains methane (CH_4), carbon dioxide (CO_2), and trace gases in the ranges of 55–65, 35–45, and 0–1%, respectively, and organic waste digesters produce biogas with 60–70% CH_4, 30–40% CO_2, and 0–1% trace gases.[3] Many studies have been reported in the past for exploring the impact of CH_4 and CO_2 percentages in biogas used in a CI engine under dual-fuel mode.[4] Likewise, Jiang et al. revealed that an increased CH_4 content in biogas significantly improves the engine performance, with a slight deterioration in the tailpipe emissions.[5] The higher CO_2 content (up to 40%) in biogas consequently decreases the fuel quality in terms of combustion.[6] Moreover, it has been thoroughly discussed about the influence of gaseous fuel induction on various characteristics of a dual-fuel CI engine.[7]

Therefore, biogas exploitation to produce energy-efficient renewable gaseous fuel, which is so-called hydrogen (H_2)-enriched biogas, would be an attractive proposition for a dual-fuel CI engine. For this, production of H_2-enriched biogas via a

dry-reforming (DR) technique has been chiefly suggested in the previous literature, because it uses the two major greenhouse gases (CH_4 and CO_2).[8] Still, this reforming technique is not yet commercialized, because it offers significant challenges during operation. These include rapid catalyst deactivation and huge energy requirement, which lead to increased operating costs.[9,10] Therefore, to address these issues, it is imperative to hunt out an alternative reforming technique that could make an overall energy-efficient process. In this way, plenty of researchers have been focusing on the utilization of CH_4 and CO_2 along with oxygen (O_2), and the process is called dry oxidative reforming (DOR).[11–13]

Indeed, there is an enormous amount of research published on the DR and DOR techniques, with some papers on biogas DR over a MgO-supported nickel (Ni) catalyst.[14] Zhan et al. reported that Mg added in Ni/Al_2O_3 enhanced the basicity of the catalyst and increased the Ni metal sintering.[15] It has been reported that, when the catalyst is reduced at a higher temperature, a low Ni loading is enough to improve the performance of the catalyst.[16] Furthermore, support plays a key role in catalyst activity, owing to its chemical effect and metal site interaction. Tanios et al. observed that a small amount of Co added to Ni–Mg–Al significantly enhances resistance toward carbon deposition.[17] The effect of the Ni–Co bimetallic catalyst supported over La_2O_3/Al_2O_3 was discussed by Xu et

A

Original Research

Investigations on environmental emissions characteristics of CI engine fuelled with castor biodiesel blends

Authors Info

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Abstract

Aim : Biodiesel is an attractive fuel option for diesel engines in view of issues related to fossil fuel crisis and environmental degradation. The present study aimed to prepare biodiesel from non-edible grade castor Ricinus communis oil and to evaluate the emission characteristics of castor biodiesel fuelled diesel engine at different engine operating loads.

Methodology : The biodiesel was prepared from non-edible grade castor oil by single step alkaline transesterification process at room temperature. The fuel properties like kinematic viscosity, density, calorific value, flash point, pour point, and cloud point were measured as per ASTM D-6751 specifications. The engine used for experimental work is a single cylinder, four stroke, constant speed direct injection diesel engine. The engine testing was performed at different engine loads (0.9, 1.8 and 2.7 bmep) and at constant speed of 1500 rpm with different tested fuel blends i.e. B0, B20, B40 and B60. The emission parameters like nitrogen oxides, hydrocarbons and carbon monoxide were evaluated using flue gas analyzer.

Results : Production yield of 96.5% was obtained using biodiesel synthesis and castor oil based biodiesel was found to possess similar fuel properties when compared to fossil petro-diesel. At full engine load condition of 2.7 bmep, the hydrocarbon emission was lowered by 24.6, 39.6 and 42.1% for B20, B40 and B60 fuels, respectively, and the carbon monoxide emission was reduced by 12.9, 17.1 and 26.2% for tested fuel blends B20, B40 and B60, respectively, when compared to petro-diesel. At 2.7 bmep load condition, the NO_x emissions was higher by 26.2% for B60 fuel when compared to petro-diesel, while, at 0.9 bmep load condition, NO_x emissions increased by 11.8 and 15.1% for B20 and B40 blends, respectively, when compared with petro-diesel.

Interpretation : The non-edible grade of castor oil can be used as a raw material for biodiesel production and its blend with diesel is a suitable fuel candidate for use in diesel engine without modifications, which results in overall low emissions.

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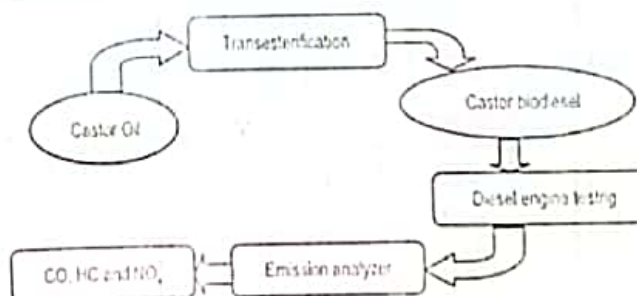
Studies on biogas-fuelled compression ignition engine under dual fuel mode

Sunil Kumar Mahla[1] · Varun Singla[1] · Sarbjot Singh Sandhu[1] · Amit Dhir[1]

Abstract

Experimental investigations has been carried out to utilize biogas as an alternative source of energy in compression ignition engine under dual fuel operational mode. Biogas was inducted into the inlet manifold at different flow rates along with the air through inlet manifold and diesel was injected as a pilot fuel to initiate combustion under dual fuel mode. The engine performance and emission characteristics of dual fuel operational mode were analyzed at different biogas flow rates and compared with baseline conventional diesel fuel. Based upon the improved performance and lower emission characteristics under the dual fuel conditions, the optimum flow rate of biogas was observed to be 2.2 kg/h. The lower brake thermal efficiency (BTE) and higher brake specific energy consumption (BSEC) were noticed with biogas diesel fuel under dual fuel mode when compared with neat diesel operation. Test results showed reduced NO$_x$ emissions and smoke opacity level in the exhaust tailpipe emissions. However, higher hydrocarbon (HC) and carbon monoxide (CO) emissions were noticed under dual fuel mode at entire engine loads when compared with baseline diesel petro-diesel. Hence, the use of low-cost gaseous fuel such as biogas would be an economical viable proposition to address the current and future problems of energy scarcity and associated environmental concerns.

Keywords Biogas · Dual fuel · NO$_x$ · CI engine · Emission

Nomenclature

NO$_x$	Oxides of nitrogen
PM	Particulate matter
rpm	Revolutions per minute
CO$_2$	Carbon dioxide
CO	Carbon monoxide
O$_2$	Oxygen
HC	Hydrocarbon
BTDC	Before top dead center
CI	Compression ignition
BTE	Brake thermal efficiency
BSEC	Brake specific energy consumption
HRT	Hydraulic retention time

Highlights

- Biogas is a promising alternative fuel for CI engine under dual fuel mode (DFM)
- Lower BTE and higher BSEC found with biogas under DFM
- Huge reduction seen in NO$_x$ smoke emission with biogas under DFM

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Introduction

The widespread use of diesel engines in transportation sector, construction machines, and stationary power generation are due to their high fuel efficiency and durability. However, the higher emissions of NO$_x$ and smoke are emitted from diesel engines and there is a trade-off relationship between them (Hotaya et al. 2009; Nwgogusa 2006). Stringent environmental policies, reduction in underground fossil fuel reserves, and increased demand for energy have triggered work on many advanced and novel combustion technologies that use renewable and alternative fuels as energy sources (Kaushik et al. 2017). Regulations on pollutant exhaust
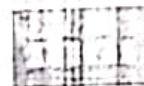
Influence of EGR on the simultaneous reduction of NO$_x$-smoke emissions trade-off under CNG-biodiesel dual fuel engine

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ABSTRACT

Dwindling fossil fuel resources and deteriorating ambient air quality has mandate the search for suitable alternative fuels for diesel engine. Dual fuel engines show remarkable engine performance characteristics at higher engine loads but suffer from high NO$_x$-smoke opacity emissions trade-off. In the present study, an attempt has been made to introduce exhaust gas recirculation (EGR) under compressed natural gas (CNG) fuelled diesel engine using Jatropha biodiesel (B20) blend as pilot fuel. Experimental investigations were carried out in a single cylinder direct injection compression ignition engine, which was suitably modified to operate under dual fuel mode along with EGR. Comparative analysis was made on the basis of combustion, performance and emissions characteristics at different engine operating loads for fossil diesel, CNG and biodiesel blend (B20) with and without EGR. It was evident from the experimental investigations that dual fuel mode with EGR improved the NO$_x$-smoke emission trade-off at higher engine loads without deteriorating engine combustion and performance characteristics.

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1. Introduction

Energy scarcity and environmental degradation led to an intensive research towards alternative clean energy technologies around the globe. Regularly, continuous efforts have been made to improve thermal efficiency for conserving energy and reduce exhaust emissions by using unconventional fuels [1-3]. Diesel engines have proved its utility in transport, agriculture and power sector. However, diesel engine has a problem of higher smoke and NO$_x$ emissions simultaneously when conventional fossil diesel fuel is used [4-6] The use of natural gas fuels in compression ignition (CI) engines through dual fuel technology represents a promising way to reach a good solution among sustainable development,

energy conservation and environmental preservation [7-10]. Although, compressed natural gas (CNG) can be used in diesel engines but, it causes poor performance and emissions characteristics at certain engine operating loads [11-13]. CNG has many prospects as a fuel for power production in I.C. engines because of its high octane number, possible improvement in thermal efficiency and engine power output. CNG (which is mainly methane) has a lower adiabatic flame temperature when compared to diesel fuel and thus leads to lower NO$_x$ emissions at the same combustion rate [14,15]. Methane also has wider flammability limits allowing for leaner operation and increased use of EGR for NO$_x$ control. Its self-ignition temperature is 730°C and it requires intense source of energy through glow plug, spark plug or pilot liquid fuel to enable combustion. It mixes rapidly with air to form homogenous air fuel mixture for efficient combustion inside engine cylinder and substantial reduction in harmful emissions [16] The literature studies on the subject indicate significant reductions in particulate and NO$_x$ emissions with natural gas as secondary fuel [17-20].

It has been proved that biodiesel and its blends, as a better fuel from environmental perspective because it is derived from

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Original Article

Experimental investigations on performance and emission characteristics of variable speed multi-cylinder compression ignition engine using Diesel/Argemone biodiesel blends

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Abstract

The present work explores the use of argemone mexicana (non-edible and adulterer to mustard oil) biodiesel in multicylinder compression ignition, indirect injection engine. Argemone Mexicana biodiesel was produced by transesterification process and the important physico-chemical properties of various blends were investigated. Blends of diesel/biodiesel (AB10, AB20, AB30 and AB40) were prepared and used for analysing the engine performance and emission characteristics at varying loads (0, 25, 50 and 75%) and speeds (2500–4000 r/min). The results show improvement in indicated thermal efficiency and indicated specific fuel consumption with increased proportion of biodiesel in diesel, when compared to conventional diesel. In addition, exhaust emissions such as carbon monoxide, unburnt hydrocarbon and smoke opacity were significantly reduced by AOME/diesel blends. The improvement in engine performance and exhaust emissions were observed up to 30% blending of AOME/diesel. Beyond that, higher blend (AB40) showed deterioration in performance characteristics in contrast to AB30 but still better as compared to conventional diesel.

Keywords

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Life cycle assessment of sustainable concrete by utilizing groundnut husk ash in concrete

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ABSTRACT

The present paper aims to develop sustainable concrete to reduce the impact of concrete on environment of using groundnut husk ash. In the present study, Life Cycle Assessment (LCA) of concrete is evaluated in terms of Global Warming Potential (GWP), Acidification Potential (AP), and Eutrophication Potential (EP) which indicates the impact of Carbon Dioxide (CO_2) and other gases emission on environment during manufacturing of concrete. Six types of concrete mixes i.e. M0, G-0%, G-4%, G-8%, G-16%, G-32% and for 18 designed concrete mix in sustainable mix by spreading the concrete was 1254 by mass and flexure was between loads (0%, 2.5%, 5%, 7.5%, 10%, 12.5% and 15%). Cubes were tested for compressive strength after 7 and 28 days. Results indicated that up to 12.5% replacement of cement with groundnut husk ash (GHA) by mass, the compressive strength of concrete mixes for all mixes tested, strength had M30 grade concrete mix. LCA of cement mix and GHA concrete was done measured for one pore basis level. In control mix concrete, cement has the highest environmental impact of about 65%, 71% and 56% of total impact for GWP, AP and EP respectively. Results indicated that by utilizing 12.5% reduction of 12%, 9.5%, and 5.2% in GWP, AP and EP respectively can accommodate respectively. Therefore, this concluded that the use of groundnut husk ash in concrete will reduce the impact of carbon dioxide and other greenhouse gases (CO_2) on environment and adds to the sustainability aspect by utilizing waste.

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1. Introduction

The construction industry is the most booming industry has a great impact on the economy of any nation. Worldwide, the production of cement is 4.4 billion tonnes and estimated to increase up to 5.5 billion tonnes by 2050, due to the speedy growth of urbanisation in post covid times [1]. The various manufacturing process of cement such as extraction of minerals, crushing of raw material, and manufacturing of clinker consume nearly 15% of total electricity energy. It is estimated that 65% per abatement, respectively. The increasing 12% are heavy fuel, oil, and the gas used during the manufacturing process. All these processes consume energy and emit carbon dioxide into the atmosphere.

The total emission of carbon dioxide is 0.9 to 1.25 tonne for one ton of manufacturing cement [2]. It includes decarbonation of limestone, kiln combustion, and the transportation of raw materials. Since the cement industry to concrete manufacturing also to construction industry, which accelerates the consumption of fuel and emission of gases. Therefore, the need of hour is to use alternative raw materials to reduce the adverse impact of emissions and improve the sustainability of concrete. This can be achieved by using supplementary cementitious materials (SCMs) such as fly ash, slag, cement, and the use of alternative cement based on the fuel during the production process.

The use of fly ash and recycled aggregate in up to 20% in concrete can reduce 24.1% the carbon emission [3]. CO_2 emission reduced from 37% to 1% for low mix grade 10 to higher grade 40 MPa respectively [4]. Biomass fly ash can reduce the carbon footprint by 40% in concrete without compromising the technical and environmental performance [5]. With replacement of slag cement in one cubic meter concrete prevents 25 kg–171 kg CO_2 emission, reduced 42 to 65 of Greenhouse Gases and 102 kg–140 kg of soil and raw material. Ordinary Portland cement can be substituted with other cementitious materials without compromising the

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Utilization of Maize Cob and Rice Husk ash in manufacturing Paver block concrete for low traffic areas

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ABSTRACT

This paper highlights the results of a study which was conducted on M35 grade cast concrete paver blocks using rice husk ash (RHA) and maize cob ash (MCA) partial replaced with Ordinary Portland Cement (OPC). The replacement for rice husk ash was fixed at optimum 10% ash and maize cob ash was varied from 2.5 % to 10%. Control mix concrete was prepared without any replacement and only with ordinary Portland cement. The basic compressive strength was compared for both i.e. with the specimens exposed to sulfuric acid, nitric acid, magnesium sulfate, and sodium sulfate at the ages of 28, 60, and 90 days. The test results confirmed the attainment of requirement of compressive strength with 5% MCA and 10% RHA. While less changes were observed in durable properties of MR concrete than control mix concrete. It was concluded that MR concrete can be used in lawns, open area, parking areas, low traffic areas, houses, and for manufacturing of perforated blocks/grass concrete paving / permeable concrete to be used for vegetation purposes. It can provide good resistance against sulfuric acid produced by the decomposition of organic matter and convert into sulfuric acid after reacting with moisture present in the soil.

Key words: Maize cob ash, Rice husk ash, Sulfuric acid, Nitric acid, Magnesium sulphate

Introduction

Cement concrete paver blocks are easy in molding in various sizes and shapes like I – section, rectangular, round or any other shape. However, the production of cement effects the environment, due to the overutilization of natural resources and the emission of carbon dioxide. The aim of this study was to reduce the cement content in paver block concrete and utilize waste materials i.e. corn cob ash tain required strength and durability.

Paver blocks when used in an aggressive environment and in industrial area face the exposure of sulfuric acid, nitric acid, and sulfate attack during their life cycle. When leaves, litter, and other waste materials pile up on the paved road, hydrogen sulfide (H_2S) gas is produced due to the decomposition of organic matter in suitable conditions which further oxidizes into corrosive sulfuric acid (H_2SO_4) and attacks the paver blocks concrete (Joorabchian,

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Cascade aeration: a promising post treatment of effluent from UASB reactor

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ABSTRACT

Effluents from (i) bench scale 56 L upflow anaerobic sludge blanket (UASB) reactor and (ii) four UASB based sewage treatment plants (STPs) of capacities ranging from 27 to 70 MLd used in containers were pumped to flow over inclined plane at a rate of 200 mL/min. The objective of the project is to evaluate the performance of inclined plane and to find correlation between oxidation reduction potential (ORP), dissolved oxygen (DO), chemical oxygen demand (COD) and biochemical oxygen demand (BOD). The DO after fall was dependant on initial COD whereas increase in ORP was dependent on DO increase after fall. The cascade was designed for increase in DO as 4.5 mg/L. However in DO and ORP increase was 0.5-2 mg/L. The increase in DO has been shown to be dependent on wastewater characteristics. Oxygen transfer efficiency was found to be independent of DO influent. But it showed positive correlation with DO after fall. E20 of 50% was assured when DO after fall was 5.7 mg/L. 60% of DO₂. Overall reduction of COD ranged between 20-40%. The decay rate of COD and ORP ranged between 0.1-0.2 h⁻¹ and 0.6-1.2 h⁻¹ respectively. The empirical equation of SW2 predicted the temporal variation of fraction of COD in four STPs.

Key words: Inclined plane, Anaerobic treatment, Chemical oxygen demand, Wastewater, Oxidation reduction potential

Introduction

In the developing countries there has been shift from treating sewage by the conventional aerobic processes to anaerobic processes. Advantages of high rate anaerobic systems such as up flow anaerobic sludge blanket reactor (UASB) are low cost, simple in operation, biogas recovery, low energy consumption, and low production of sludge (van Haandel and Lettinga, 1994).

A vast variety of post treatment options such as activated sludge process, Trickling filter, down hanging flow system and natural treatment processes have been explored. Polishing ponds are gaining importance in developing countries at several STPs in India, Colombia and Brazil as post-treatment option because of their simplicity in design and operation (von Sperling and Mascarenhas, 2005; M von Sperling et al., 2001; Chernicharo, 2006; Khan et al., 2011a). In India generally post treatment in the form of non algal pond known as polishing ponds (PPs) is provided. However the detention of effluent for 1 day in polishing ponds is not compatible with discharge standards (Khan et al., 2011b). Aeration is process by which the area of contact between water and air is increased. Aeration of liquid is achieved by diffused, surface aeration and gravity aerators. Diffusers aeration is influenced by clogging problem while the surface aerator cost is more because of power consumption. While considering

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Improving material quality management and manufacturing organizations system through Industry 4.0 technologies

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ABSTRACT

In these changing times, Industry 4.0 technologies are being adopted in many parts of the world. These technologies are used to develop smart materials, smart factories, smart logistics, smart manufacturing and smart supply chains in the business sector. It has the potential to solve complex manufacturing problems. This paper provides a thorough study of various Industry 4.0 technologies for improving the material quality and manufacturing systems. We have listed and various available technologies, their characteristics, and benefits of quality management in the operating industries. It helps the businesses take companies optimize their material and cost and hence reduce costs and increase productivity with minimal waste and ... The technologies help properly reduce downtime and help them stay up to date with the information. Smart predictions analysis will help to properly ... the equipment out of the industry using Industry 4.0 technologies. Faults in materials can be detected and resolved at an early stage. Further, this provides the ability of the systems and processes to fulfil the required expectations of the customer.

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1. Introduction

Industry 4.0 technologies are now being used heavily throughout the world. These technologies have good potential and have brought significant changes in almost all industries. A report published by Markets and Markets states that the current market size of Industry 4.0 may be more than USD 71.7 billion and forecasted that it would be more than USD 150 billion by 2024 [1]. Due to the COVID-19 pandemic, this technology's adoption rate has been and shall make them may even be higher than predicted. With such an innovative use of these advanced technologies, a proper management system is needed [2,3]. This paper focuses on Industry 4.0 technologies for proper management system during manufacturing. In the manufacturing industry, technologies like Data Analytics, Cyber Security, Industrial Internet of Things (IoT), Advanced Robotics and Additive Manufacturing (AM) are being used. This industry has changed heavily and it expected to change more in the days to come. With all the new emerging technologies, a proper management system should be kept to manage them. With proper management systems, these technologies can be used to the best of their abilities. Javaid et al. [4] presented the Industry 4.0 technologies useful in combating the COVID-19 pandemic. Bahl et al. [5] discussed telemedicine (TM) applications, which can be very helpful to combat the COVID-19 pandemic. Industry 4.0 technologies are used to enhance the digital information during the COVID-19 outbreak [6,7].

2. Research objectives and methodology

Industry 4.0 technologies are now present everywhere. With the onset of the COVID-19 pandemic, even small businesses and industries have started implementing many of these technologies. Thus, for the best use of these technologies, a proper management system is needed. This paper aims to study the critical technologies of Industry 4.0 that can be adopted for improving the performance of the management systems of a manufacturing-based industry. Initially Google scholar has been utilised to take an initial sample of what types of articles are available. Regarding Google scholar, Several research terms were initially used to establish a list of research articles that were the primary source and peer-reviewed. We used Elsevier, IEEE Xplore, ScienceDirect and NCBI databases to provide

Post-treatment of effluent from UASB reactor by surface aerator

R. Walia[1] · P. Kumar[2] · I. Mehrotra[2]

Abstract

Effluent from full-scale and bench-scale upflow anaerobic sludge blanket reactors (UASBRs) was aerated by surface aerator. The monitoring parameters used for process were oxidation reduction potential (ORP), dissolved oxygen (DO), chemical oxygen demand (COD) and biochemical oxygen demand (BOD). Experiments were conducted on effluents of bench-scale 56-L UASB reactor as well as on the effluents from four UASB-based sewage treatment plants (STPs) of capacities ranging from 34 to 70 ML/d (million liters per day). The linear relationship between DO and ORP indicates the sensitivity of ORP. The rate of DO transfer depends on ORP, DO deficit, nature and concentration of BOD or COD. The ORP values increased with aeration time indicating improvement in redox status. The oxygen demand of anaerobically treated effluent proceeds in three-stage initial S-BOD exertion followed by CBOD exertion and subsequently NBOD exertion. The optimum condition for BOD, COD and sulfide removal was 120–140 min characterized by DO content of 4–5 mg/L. Sulfides removal rate of 80% and BOD of 30 mg/L desired discharge standards were obtained.

Introduction

The treatment of sewage by UASB process is an attractive and appropriate option for developing countries since it involves low initial investment and low energy for operation, easier maintenance than conventional aerobic processes, and an energy recovery through the production of methane gas (Van Haandel and Lettinga 1994). However, effluent from an anaerobic treatment. Energy-intensive post-treatment methods proposed in the literature are the rotating biological contactor (RBC); trickling filters (TF); and activated sludge process (ASP). Von Sperling et al. (2001) investigated the performance of pilot scale UASB-ASP treating domestic wastewater. The result indicated that the variable inflow did not affect the performance of ASP. Torres and Foresti (2001) concluded that COD and TSS removal
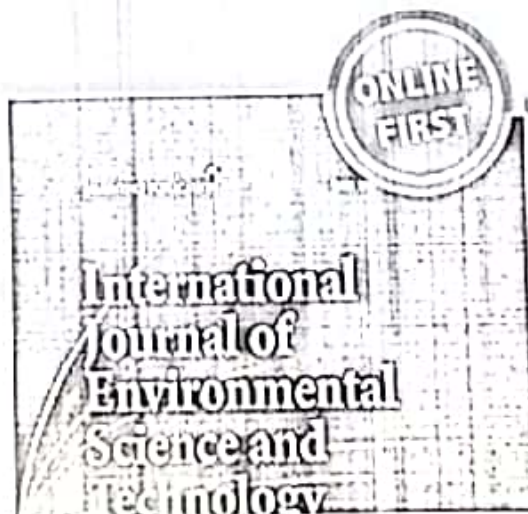
Post-treatment of effluent from UASB reactor by surface aerator

R. Walia, P. Kumar & I. Mehrotra

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Performance of thermal-sprayed coatings to combat hot corrosion of coal-fired boiler tube and effect of process parameters and post-coating heat treatment on coating performance: a review

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ABSTRACT

High-temperature corrosion of coal fired boiler parts such as water walls and superheated tubes poses a serious threat to the efficiency of the thermal power plant. To overcome this, numbers of corrosion control techniques are commonly employed. But, a dense and defect-free coating deposited by the thermal spray technique has shown promising result to combat hot corrosion. Although open or closed porosity in distinct thermal spray coatings can originate from distinct factors such as partial or totally un-molten particles, inadequate flow or fragmentation of the molten particle at impact, non-optimal spray angle and entrapped gas. But, this can still only be prevented by coating post-treatment. Hence, in this paper, authors have reviewed the performance of distinct coatings deposited by diverse thermal spray processes. Then, the effect of distinct process parameters and heat treatments on microstructure and mechanical properties of coatings is described. Finally, the best coatings are suggested to combat maximum hot corrosion of boiler tubes.

Introduction

In the past century, the global energy demand and consumption have enhanced rapidly owing to the population explosion and economic growth [1]. As per the latest statistics mentioned in 'Annual Report 2018–19, Ministry of Power, Govt. of India, the total installed power generation capacity as on 30 December 2019 in India was 367,281 MW, out of which 54.2% (198,495 MW) was supplied by coal-operated thermal power plants. The power supply position in India during the last 12 years (2009–10 to 2020–21) is depicted in Figure 1.

So, in order to fulfil the rapidly increasing energy demand, distinct energy source such as coal, gas, biomass, hydro, wind, solar, nuclear etc. are used. But, in recent years among distinct energy source, low-grade fuel (low rank coal) has received much attention for the production of electric power due to its low cost and abundant availability [1]. The projected share of distinct energy sources for the fulfilment of power requirement in 2030 is represented in Figure 2.

In coal-fired thermal power plant, the metallic components such as superheater tubes, water walls and economizer are subjected to very high temperature, pressure and severe corrosive environment. The corrosive nature of the actual boiler environment comprises sulphur, carbon, oxygen that may cause accelerated material deterioration and result in the premature failure of boiler tubes, particularly in high-temperature region (Figure 3).

However, the major corroded boiler tubes are mostly observed in the coal-fired boilers. Because the coal employed in Indian thermal power plants contains huge quantities of ash (~50%), which comprise abrasive mineral species such as hard quartz (up to 15%), which enhance the erosion tendency of coal [2]. The ash, coal and flue gas analysis data is given in Tables 1–3.

In addition, the gross calorific value of coal used in GGS Thermal Power Plant Ropar was measured to be 4187 and 4055 kcal kg⁻¹ on a fire basis. However, the net gross calorific value of coal was measured to be 3834 kcal kg⁻¹.

Thus, the combustion of coal produces a corrosive film (salt film) on the boiler components at high temperature. These salts (Na_2SO_4, K_2SO_4, V_2O_5, NaCl, KCl etc.) decrease the ability of the boiler steel to withstand very high temperature [3]. This results in hot corrosion of the boiler steel and lead to big economic losses. Although more than 25–30% of yearly corrosion costs can be saved if proper corrosion control techniques are used [4]. Currently, a hot corrosion problem is a major issue in thermal power plants (nuclear power plants, hydro-electric power plants, coal-operated power plants and diesel-operated power plants), gas turbine and I.C. engines. The hot corrosion and erosion-corrosion alone has been

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Prediction of wear resistance model for magnesium metal composite by response surface methodology using central composite design

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Abstract

Purpose – In recent days, friction stir processing (FSP) has emerged as a pioneering approach for the manufacture of composites with enhanced mechanical and tribological properties. The present study aims to examine the impact of process parameters such as tool rotation speed and number of FSP pass on the AZ61A/TiC magnesium metal composite for responses such as hardness and wear resistance.

Design/methodology/approach – To minimize number of experimental runs, design of experiment was configured according to the response surface methodology using central composite design. Analysis of variance has been conducted to develop mathematical and empirical model for studying relationship between tool rotation and number of pass for responses such as microhardness and wear resistance. Microhardness was checked on vickers microhardness testing machine, and tribological behavior were examined on pin-on-disc using tribotester. Wear morphology was analyzed via scanning electron microscopy.

Findings – The responses were predicted using validated mathematical model, and contour plots were generated to study the interaction and influence of process parameters. Wear observations suggest that for the base magnesium alloy adhesive wear mechanism was dominating and for the developed nanocomposites, abrasive wear mechanism is a prominent factor. It was also observed that both the selected parameters significantly influenced the responses.

Originality/value – To the best of the authors' knowledge, no prior work has been conducted with this material and preparation of composites with TiC nanoparticles. Furthermore, no mathematical models have been developed to predict the response values.

Keywords Composite, Wear behaviour, Friction stir processing (FSP), Centeral composite design (CCD), Magnesium metal composite (MMC), Response surface methodology (RSM), Wear morphology

Paper type Research paper

1. Introduction

The concept of using magnesium in manufacture of lightweight automobile vehicles is gaining widespread attention when contrasted with other available metals such as aluminum, titanium and stainless steel. This is mainly because of the fact that magnesium is 77.00% lighter than stainless steel, 61.00% lighter than titanium and 33.00% lighter than aluminum (Gupta and Wong, 2015). Ranking among the most widely occurring metals, it makes up 2% by mass in the earth crust, the eighth-most abundant element in the universe and with density of 1.738 g/cm^3, it is the third most abundant mineral dissolved in seawater (Neite et al., 2006). In addition, magnesium possesses many other benefits like ease to machinability, good electromagnetic shielding, and excellent cast ability. In spite, appealing scope of mass mechanical properties, insufficient hardness, low elastic modulus, ductility, poor creep, high corrosion rate and generally a poor protection from wear is a genuine obstruction against more extensive uses of

magnesium alloys. Most of the limitation have been circumvented by the friction stir processing (FSP) process and the addition of secondary phase particles that creates magnesium metal composite (MMC). Friction stir welding is the predecessor of (FSP), using same method (Mishra and Ma, 2005). The FSP processing involves working on a metal in its solid state below the melting temperatures, and could locally modify the microstructure via plastic deformation resulting in improved local mechanical properties (Chen et al., 2010; Mishra et al., 2003). Recently many researchers concludes that superior mechanical properties of base magnesium alloy can be achieved by addition of secondary phase particles without any significant adverse effect (Asadi et al., 2010; Sharma et al., 2019; Navazani and Dehghani, 2015; Das et al., 2016). A large portion of the distributed research works at lab scale level, which is centered around the influence of FSP parameters on microstructure, hardness and wear resistance responses, is being carried out (Faraji et al., 2011; Khayyamin et al., 2013; Dadashpour et al., 2016; Azizieh et al., 2011). Recently,

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Role of tool rotational speed on the tribological characteristics of magnesium based AZ61A/TiC composite developed via friction stir processing route

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ABSTRACT

Purpose: A new composite material was prepared and Different properties such as hardness and tribological behaviour of the fabricated metal matrix composite (MMC) was investigated and compared with the base AZ61A magnesium alloy.

Design/methodology/approach: For the current research work, state-of-the-art technology, Friction stir processing (FSP) was performed to develop magnesium based AZ61A/TiC composite at optimized set of machine parameters.

Findings: Increasing tool rotational speed ultimately leads in enhanced hardness, which further gives superior tribological properties as compared to base AZ61A alloy. Wear observations suggests a combination of abrasive and adhesive wear mechanism.

Research limitations/implications: More microstructural and mechanical properties can be examined.

Practical Implications: The idea behind selecting AZ61A is mainly due to its increasing use in bicycle pedals and military equipment's where at certain places it needs to encounter friction. In this current work, microhardness study and wear behaviour of AZ61A/TiC composite processed via FSP were examined.

Originality/value: Paper is completely new and no work has been done till date considering this material and preparing composite with nanoparticles TiC.

Keywords: Friction stir processing, AZ61A magnesium alloy, Microhardness, Wear

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Review

A comprehensive review of recent progress in fabrication of magnesium base composites by friction stir processing technique—A review

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Abstract: Metal matrix composites (MMCs) are the next generation materials, globally popular for having numerous potential applications in aircraft, automobile and biomedical industry. Magnesium being continuously replacing other conventional materials however it is a hard to process material. Recently, friction stir processing (FSP) is drawing attention among researchers to fabricate MMCs. Using FSP, superior properties of magnesium based MMCs being successfully achieved. The primary aim of this paper is to review and provide a thorough summary of FSP synthesized magnesium based composites. Additionally the effect of secondary phase particles on the tribological behavior of produced composite materials is also summed up. Mechanical along with microstructural properties produced from stirred process and contribution of strengthening mechanism is addressed, as well.

Keywords: friction stir processing; metal matrix composites; magnesium; strengthening mechanism

1. Introduction

Metal matrix composite (MMC), widely known as the cluster of smartly developed engineered materials, synthesized by adding secondary phase reinforced micro, macro or nano particulates with parent materials of different chemical composition [1]. Continuous phase of metal is called matrix, and depending upon the chemical composition of matrix, composites are classified as metal matrix

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RESEARCH ARTICLE

Erosion corrosion behaviour and mechanical properties of wire arc sprayed Ni-Cr and Ni-Al coating on boiler steels in a real boiler environment

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ABSTRACT

The aim of the current investigation is to evaluate the erosion-corrosion (E-C) performance of wire arc sprayed Ni-20Cr and Ni-5Al coatings on T22 and SA516 boiler steels in a real boiler environment. The microstructure, mechanical properties and high temperature E-C performance of the deposited coatings were investigated. The E-C behaviour of the test samples was determined in the superheater zone of the coal fired boiler at 750°C for fifteen cycles, where each cycle involved 100 hours of heating followed by 1 hour of cooling. Thickness loss data was used to determine the E-C behaviour of the coating. XRD, SEM/EDS were used to analyse the test samples. Ni-20Cr coated SA516 steel decreased maximum E-C rates by 98.05%, while Ni-5Al coated T22 steel reduced E-C by 68.63% than the base steel. This higher E-C resistance is due to the formation of protective phases (Cr_2O_3, NiO and Al_2O_3) and better mechanical properties of the coatings.

Introduction

The wastage of material, especially metals and alloys due to high temperature corrosion and oxidation is a serious issue for equipment operating at high temperature in aggressive environment. This includes boilers, gas turbines, industrial waste incinerators and fluidised bed combustors [1–4]. In thermal power plants, coal is widely used as a fuel due to its economic benefits. However, it contains sodium, sulphur and vanadium as impurities [5]. In coal fired boiler, during combustion, sodium (Na) reacts with sulphur (S) and form sodium sulphate (Na_2SO_4), while vanadium (V) reacts with oxygen (O_2) to form vanadium oxide (V_2O_5) and vanadates. These compounds result in an ash, that accumulates on the surface of the boiler tubes, leading to corrosion. It results in premature failure of boiler tubes, also bringing about increased maintenance, tube replacement, and extra downtime. It accounts for multimillion dollar losses both in power plants and related industries [6,7].

At the present time there are distinct types of boilers such as fire tube boilers, water tube boilers, fluidised bed combustion boilers, packaged boilers, pulverised fuel boilers and waste heat boilers are used in the engineering sector. However, coal fired water tube boilers are most widely used in power plants, paper, and chemical industries [8]. In these, boiler failures due to erosion created by fly ash particles are major problems. The velocity and amount of ash in coal are the main factors responsible for erosion of pressure parts. Here, fly ash erosion is mainly found in the primary super-heater tubes, economiser, and in the inlet portion of the steam reheater tubes. The rate of erosion increases considerably when the flow of flue gas is turbulent. There are many factors that affect fly ash erosion, such as: flue gas velocity, mineral content in coal, flue gas temperature, flue gas direction, layout of the pipe work and air flow rate etc. Out of these factors, the mineral matter in the coal, velocity and temperature of the flue gas are the major factors [9].

According to Electric Power Research Institute (EPRI) failures by corrosion in coal fired boilers area are the major cost of the thermal power plant. Analysis of the 'North American Electric Reliability Council-Generic Availability Data System' (NERC data) demonstrates that the coal-operated boilers are among the largest economic risk parts in any power plant [10]. Hidalgo, V.H. et al. [11] reported that erosion and high temperature corrosion in a coal fired boilers are recognised to be the fundamental cause of downtime, and account for 50% to 75% of the total. The repair and maintenance cost for replacing failed tubes is also very high, and can be calculated up to 54% of overall production cost [12]. Hence, the evolution of erosion and corrosion protection system in coal fired boilers is a major R&D issue.

Specific corrosion prevention techniques include thermal spray coatings. These are one of the most useful and effective way to safeguard boiler tubes from

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Investigation of mechanical properties and hot corrosion behavior of friction welded AISI 304 and AISI 1021 steels

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Abstract. In the current study, friction welding of two different steels, namely low alloy steel and austenitic stainless steel was done. For conducting welding, an in-house experimental set-up was designed and fabricated. The steels were friction welded by using various axial pressures at a uniform circular speed. Influence of axial pressure on the joint strength of the friction welded specimens such as tension, impact toughness, torsion strength and microhardness were evaluated. Moreover, the weldments were also tested for high temperature corrosion resistance. The corrosion testing of the welded joints was carried out in a molten salt environment of $Na_2SO_4 + V_2O_5$ (0)% at 650°C. Weight change data were used to establish the kinetics of corrosion. Based upon this data, the weldments showing best corrosion resistance was identified. Subsequently to understand the composition of oxide scale, the specimen was evaluated using SEM/EDS and X-ray diffraction techniques.

Keywords. Friction welding; dissimilar metals; mechanical testing; hot corrosion; molten salt environment.

1. Introduction

In several industries, there is a need to weld austenitic and ferritic steel to achieve special combinations of properties, for instance, in power generation industry [1]. However, several metallurgical and fabrication limitations arise while joining dissimilar materials, which can lead to in-service failures [2, 3]. The most noticeable welding defects are hot cracks attributed to unintended application of improper C-steel electrodes [4]. Using these electrodes may also lead to the development of extremely hard, crack-pronounced structure towards the stainless-steel side of the dissimilar weldments, whereas interrupted hard and brittle zones along the interface line of ferrite side of weldment [4]. These brittle and hard regions may lead to oxidation attack, localized pitting and failure of the joint due to uneven stresses. Numerous industrial failures are reported within the open literature [4]. Moreover, while studying the literature it has been noticed that in the power generating equipment, high temperature oxidation is a very thoughtful concern which can lead to in-process failures [5–8]. High temperature corrosion is the enhanced corrosion of metals at high temperatures, aggravated by the fluxing of fused salt on the metal surfaces. The need of hot corrosion has aroused as during welding dissimilar materials, different cooling rates were observed [9] and these led to the formation of corrosive layer at the interface with the passage of time and the joint gets failed. It has been concluded from

the literature that most of such failures occur in the weldment region [4]. Therefore, there is a need to investigate the problem to a greater depth. Moreover, it is learnt that no work has been done to investigate the high temperature corrosive behavior of friction weldments AISI 304/AISI 1021 steels.

In the present investigation, a friction welding set-up was fabricated and retrofitted on a heavy-duty conventional lathe for the fabrication of friction weldments. Subsequently, an attempt was made to evaluate the joint behavior of the friction weldments of dissimilar steels, produced by changing the axial pressures at a fixed rotational speed. Furthermore, the performance of the produced friction welded joint was evaluated in a corrosive atmosphere consisting of an eutectic mixture of $Na_2SO_4-V_2O_5$ (0)% at 650°C under cyclic conditions. The combinations of ferritic and austenitic steels are commonly applicable in fabricating boiler tubes, owing to their good mechanical properties along with economy [1]. However, such weldments are usually exposed to serious hot corrosion problems [10].

2. Experimental procedure

2.1 *Experimental set-up*

In the current investigation, weldments of AISI 1021 and 304 steels were made using an in-house developed continuous drive friction welding machine. Figure 1 presents the custom-made friction welding set-up. The experimental

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Materials Research Express

Synthesis of a novel hybrid nanocomposite of AZ31Mg-Graphene-MWCNT by multi-pass friction stir processing and evaluation of mechanical properties

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Abstract

The present work is a focused study of the influence of hybridizing nano-graphene and MWCNT particulates on the microstructural and the mechanical behaviour of AZ31Mg–MWCNT-graphene hybrid composite was investigated by experimentation and its analysis. A novel hybrid nanocomposite was synthesized of AZ31Mg as base material reinforced with MWCNT and graphene nano particulates using multi-pass friction stir processing (FSP) technique. AZ31Mg plates of 6 mm thickness were drilled up to 4 mm depth with 2 mm diameter and compacted with hybrid carbonaceous reinforcements in a ratio 7:1. Multiple FSP passes were used to develop composites of AZ31Mg-MWCNT, AZ31Mg-graphene, hybrid nanocomposite AZ31Mg-MWCNT-graphene and FSP'ed monolithic AZ31Mg sample plates for appropriate comparison of results. The processing parameters were kept constant throughout the process for all the specimens. Microstructural characterization revealed grain refinement credited due to the uniform distribution of graphene nano-particles embedded with MWCNT. Scanning electron microscopy of AZ31Mg-MWCNT-graphene nano-hybrid composite confirmed more localized recrystallized grains and lesser tensile twin fraction, as compared to the other composites under comparison. Mechanical properties assessment specified the dominance of strength and ductility combination in the specimen of AZ31Mg-MWCNT-graphene nano-hybrid composite as compared to other composites specimens. The superior mechanical properties of the developed nano-hybrid composite attributed due to the uniform dispersion of hybridized carbonaceous nano-reinforcements and improved interfacial bonds linking the matrix and the reinforcement particles. The improvement in microhardness of the developed nano-hybrid composite is recorded as 90.6 Hv, which is much superior to other composites. The enhancements of yield strength are recorded as 32.31% and of ultimate tensile strength as 49.23%. In case of compressive strength testing, recorded improvement in 2% yield compressive strength is 50% and in case of ultimate compressive strength, it is 73.13%, whereas improvement in compressive fracture strength is noted as 8.21%, as compared to the unreinforced FSPed.

1. Introduction

Magnesium-based metal matrix composites (Mg-MMCs) have attracted significant research attention in the recent years in the field of aerospace, automobile, and electronics industries due to their low density, good thermal stability, good damping properties, good castability and high specific strength [1–3]. Previous literature revealed that micro and sub-micro-sized reinforced composites are prone to fail prematurely due to crack generation during loading, reflecting they're lacking strength and ductility. This deficiency significantly limits

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PAPER

High temperature oxidation and erosion-corrosion behaviour of wire arc sprayed Ni-Cr coating on boiler steel

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Keywords: wire arc spray, erosion-corrosion, oxidation, Ni-20Cr

Abstract

In the current investigation, oxidation and erosion corrosion performance of wire arc sprayed Ni-20Cr coating on SA516 and T-22 boiler steel was studied at high temperature. The air oxidation kinetics of wire arc sprayed samples was established on the basis of weight change values for 50 cycles at 900 °C. Each cycle consists of 1 h of heating, followed by 20 min of cooling in air. The erosion corrosion performance of samples was determined by exposing them to the super heater zone of coal fired boiler for 15 cycles at 750°, where each cycle consists of 100 h of heating, followed by 1 h of air cooling. Then, the kinematics of erosion corrosion were established using thickness loss and weight change value of the exposed samples. The distinct characterization techniques (XRD, SEM and EDS) were utilized to examine the oxidized and eroded corroded products. Experimental results reveal that both the coated samples offered more oxidation and erosion corrosion resistance. However, Ni-20Cr coating on SA516 steel perform better than T-22 steel. The Ni-20Cr coated SA516 and T-22 steel reduced the weight gain by 99% and 90% respectively in laboratory environment. Moreover, the Ni-20Cr coating reduced the erosion corrosion rate of SA516 and T-22 steel by 98.04% and 88.23% respectively in terms of thickness loss. The higher resistance against erosion corrosion and oxidation is due to the development of Cr_2O_3 phase, higher micro hardness and less porosity of the coating.

1. Introduction

To increase the efficiency and reduce the emission of coal fired boiler is one of the major challenge for thermal power plant [1]. Therefore, steam at high temperature and pressure is required to attain higher efficiency. However, this leads to different types of material degradations like high temperature oxidation, erosion-corrosion (E-C), solid particle abrasion, wear and overheating etc High temperature corrosion (hot corrosion) of boiler tubes has been recognized as a serious problem, resulting in the tube wall thinning and premature failure [2]. However, the degraded or worn out parts (boiler tubes) can be replaced, which enhance the cost and decrease the efficiency of the plant. Thus, to diminish these big economic losses, mainly in boiler tubes, coating by thermal spray techniques is one of the best and most effective method. Since, thermal spray coatings have the ability to safeguard the material of desired type without changing other characteristics of the base material [3]. In addition, it provides excellent mechanical properties like high strength, hardness, scratch resistance and improve wear resistance [4, 5].

In the past decade, a distinct thermal spray coating (Ni-Cr-Mo, Ni-Cr-B-Si, Ni-Cr-Ti, Ni-Cr, Cr3C2/ Ni-Cr and Ni-Cr-Al-Y) have been sprayed using Plasma Arc Spray, Detonation—Gun Spray, High Velocity Oxy Fuel and Wire Arc Spray etc to prevent the boiler tubes from E-C and oxidation [6—12]. Among distinct aforementioned coating techniques, wire arc spray (WAS) is gaining higher potential owing to its low power input, low cost, high deposition efficiency, feasibility to spray two dissimilar wires, high spraying rate, flexibility, simplicity, offers more coarse coating than Plasma or HVOF coating method and imparts an on-site solution for restoration of corroded parts. Due to these characteristics, wire arc spray coating technique is most

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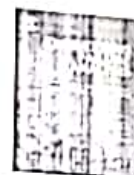
Comparative study of high temperature oxidation behavior and mechanical properties of wire arc sprayed Ni–Cr and Ni–Al coatings

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ABSTRACT

In the present investigation, Ni–20Cr and Ni–5Al wires were used to deposit coatings on T22 and SA516 boiler steels for protection in high temperature environment. The microstructure, mechanical properties and high temperature oxidation behavior of the deposited coatings were studied. The coatings were found to have a uniform thickness (250–300 μm) and well intact with the substrate steels. The weight change study was conducted to ascertain the high temperature oxidation behavior of the coatings at 900 °C under laboratory conditions. The kinetics of oxidation was established using weight change values for the uncoated and the coated steels. The oxidation products of the coated and uncoated samples were analyzed using X-ray diffraction (XRD), scanning electron microscopy/energy dispersive spectroscopy (SEM/EDS) and X-ray mapping analysis. The results showed that Ni–20Cr coating on SA516 steel reduced the weight gain by 97%, whereas the Ni–5Al coating on T22 steel decreased weight gain by 83% than the bare steel. This higher oxidation resistance is due to the presence of a protective phases in the oxide scale (Cr₂O₃, NiCr₂O₄, NiO, and Al₂O₃), lower porosity (2%), and higher micro hardness of the coating.

1. Introduction

Hot corrosion and erosion recognize as serious issues in coal based thermal power plants in India. In power plants, the overall economic loss due to solid erosion is predicted to be US$150 million annually [1]. In most of the thermal power plant, coal is burnt to change water into steam, which has been expanded through a turbine for the generation of electricity. Since, Indian coal contains large amount of ash (abrasive mineral species) and other constituents like sulphur, carbon, hydrogen etc. [2]. During operation, fly ash particles impact on boiler tubes resulting in erosion (material removed due to striking off) of the boiler tubes. Simultaneously the corrosive compounds are deposited on boiler tubes (super-heater tubes and water walls) that not only thinning and curtailing the heat transfer rate but also triggering corrosion mechanisms [3,4]. During burning, sulphur (S) which is present in coal gets partially oxidized to sulphur trioxide (SO₃). After that at combustion temperature, the sulphur trioxide (SO₃) and water vapour (H₂O) react with sodium chloride (NaCl) which is present in air or fuel as impurities to yield sodium sulphate (Na₂SO₄). Also during combustion, the small quantity of vanadium (V) which exists in coal, forms vanadium oxide (V₂O₅) during combustion. Subsequently, this sodium

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ARTICLE

High-temperature corrosion behavior of some post-plasma-spraying-gas-nitrided metallic coatings on a Fe-based superalloy

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Abstract

The objective of the present study is to propose a cost-effective process for modifying commercially available coatings by gas nitriding using commonly available equipment and starting materials. Al-Cr and Ti-Al metallic coatings were deposited on Superfer 800H (Fe-based superalloy) using a plasma spray process. Then the gas nitriding of the coatings was done in the lab and the parameters were optimized after conducting several trials on plasma-sprayed-coated specimens. Characterization and high-temperature corrosion behavior of coatings after exposure to air and molten salt at 900°C were studied under cyclic conditions. Techniques like XRD, SEM/EDX, and X-ray mapping analysis were used for the characterization of the coatings and analysis of the oxide scale. Both the coatings successfully protected the substrate and were effective in decreasing the corrosion rate when subjected to cyclic oxidation (Type-I hot corrosion) at 900°C for 50 cycles in air and molten salt (a salt mixture of Na_2SO_4-60%V_2O_5 dissolved in distilled water). Based on the findings of the present study, the coatings under study are recommended for tapplications to super-heater and reheater tubes of boilers and all those surfaces that face fireside corrosion, such as fluidized beds, industrial waste incinerators, internal combustion engines, gas turbines or steam turbines, to provide protection against degradation in these environments. The cost of the product/process is approximately Rs. 0.62 per mm^2 in case of Al-Cr coating and Rs. 1.86 per mm^2 in case of Ti-Al coating.

KEYWORDS

characterization, corrosion, gas nitriding, oxide scale, plasma spray

1 | INTRODUCTION

In the last few decades, the development of protective coatings has become an active area in the field of materials engineering.[1] Coatings provide a way of extending the limits of use of materials at the upper end of their performance capabilities, by allowing the mechanical properties of the substrate materials to be maintained while protecting them against wear or corrosion.[2,3] Today, numerous Ni- and Fe-based super-alloys are used as structural components in various applications, such as gas turbines, steam boilers, heat exchangers, aero engines, and industrial springs, as they possess superior mechanical properties along with

Full Length Article

Influence of tool rotation speeds on mechanical and morphological properties of friction stir processed nano hybrid composite of MWCNT-Graphene-AZ31 magnesium

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Abstract

The ever-increasing demand for light weighted hard materials for transportation industries encouraged researchers to develop composites with excellent mechanical properties which can transform it into more economical and eco-friendly. Reinforcing the metals with carbonaceous nanomaterials are progressively in focus due to their excellent capability to inculcate and tailor the properties of MMCs. In the present research, a hybrid nanocomposite of MWCNT-Graphene-AZ31 Mg alloy has been developed by using variable tool rotation speeds with friction stir processing (FSP). Optimized reinforcement ratio of 1.6% vol. MWCNT and 0.3% vol. of graphene have been used with variable tool rotation speeds, whereas other processing parameters are kept constant. The developed specimens were investigated using standard testing equipment for evaluating and comparing the mechanical properties on the basis of the microstructure of the processing regions and their morphological analysis, according to the ASTM standards. The obtained results revealed an improvement of 19.72% in microhardness and 77.5% of compressive strength in comparison with the base metal AZ 31 Magnesium alloy, with a tool rotational speed of 1400rpm. The values of tensile stress and percentage area reduction were recorded as less than that of the base metal matrix, but an increasing trend has been observed in the values of both with the improvement on rotational speeds of the tool. The effectual strengthening mechanisms are analyzed on the bases of SEM images and observed that discussed and found that grain refinement strengthening is the major contributor to the strength of the nanocomposite.

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Keywords: MMCs (Metal Matrix composites); Friction stir processing (FSP); Multi-walled carbon nanotubes (MWCNT); Graphene Nano Particulates (GNP); Stir Zone (SZ); Thermo mechanically affected zone (TMAZ); Heat Affected Zone (HAZ).

1. Introduction

Metal matrix composites (MMCs) generally contain one part as a reinforcement which can be metal, nonmetal, ceramic or organic compounds. When more than one reinforcements are added to enhance the properties, the composite is called a hybrid composite [1]. In case of Magnesium, many researchers have studied various materials as reinforcements using different methods to develop Magnesium MMCs, such as Al2O3 [2], CNTs [3–5], graphene nanoplatelets (GNPs) [6,7], SiO2 [8], SiC [9,10], and Y2O3 [11]. But recent researches show an increasing trend of reinforcing Mg using carbonaceous nanomaterials, such as CNTs, Graphene, and other carbon fibers have gained more focus and became an emerging class of reinforcing material used to enhance various mechanical, physical, electrical and thermal properties in MMCs [12–16]. Especially, CNTs and Graphene [17–19] have exceptional mechanical properties which makes

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Review

Combating hot corrosion of boiler tubes – A study

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Keywords:
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Boiler environment
Oxidation

ABSTRACT

The premature failure of boiler tubes, especially in coal fired boilers poses serious threat to the efficiency of the Indian boilers. In coal fired thermal power plant boilers, hot corrosion and erosion is the primary reason behind downtime, which leads to huge economic losses. So the consolidated results of the various researchers working in the area of combating hot corrosion of boiler tubes, especially in context with Indian boilers (both actual and simulated environment) are presented in this article. These results help the researchers in selecting an appropriate and accurate coating material composition, coating process and parameters for a particular boiler steel to improve the life of boiler tubes. So, that, any unwanted damage of boiler tubes due to hot corrosion could be minimized.

1. Introduction

Overall economic loss due to all the types of corrosion in India, accounts to US\$ 6500 million annually [1]. Corrosion under high temperature environment known as hot corrosion is the oxidation of materials under accelerated conditions. This is induced by a thin film of fused salt deposit [2]. The fireside corrosion of boiler tubes occurs due to the reaction of sulphur species in the gas phase with surface of metal [3]. The presence of sulphur content in low-grade coal produces SO_2 due to combustion, which is partly oxidized to SO_3. This SO_3 further reacts with NaCl and water vapour to give Na_2SO_4 (melting point 884 °C), at combustion temperatures [4]. A small amount of vanadium may also be present in coal, which on combustion forms V_2O_5 (melting point 670 °C). This may further react with Na_2SO_4 to form sodium vanadate's having a low melting point. These sodium vanadates are extremely corrosive to high temperature materials used in the combustion system [5, 6].

As reported by Shih et al. [7] when metals and alloys confined with a thin layer of liquefied salt at elevated temperature in gas environment, then oxidation appears at higher rates. This category of oxidation is known as hot corrosion. Due to high temperature corrosion rapid erosion/deterioration of metal and alloy take place which is commenced by liquid salt deposits (Na_2SO_4). There are number of deposits such as sulfates of Na, Ca, and K, as well as vanadates and carbonates that have been shown to cause hot corrosion of alloys. Fig. 1 shows the condition that causes hot corrosion of metals and alloys [8].

Viswanathan, R. et al. [9] reported that in the U.S, 70% of the electricity is produced in fossil power plants, 15% in nuclear power plants, 12% in hydraulic power plants and the rest from other types of sources. In steam power plant, the fossil fuel may be pulverized coal or natural gas. Due to the low cost and availability, coal is most commonly used in steam turbine plants. The layout of various elements of a coal fired steam power plant is shown in Fig. 2.

In Indian coal fired boiler, the coal contains 50% ash, which contains nearly 15% abrasive mineral species (hard quartz) that

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EXPERIMENTAL EVALUATION OF MECHANICAL PROPERTIES OF FRICTION WELDED DISSIMILAR STEELS UNDER VARYING AXIAL PRESSURES

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Abstract: The present study emphasizes on joints two industrially important materials AISI 304 with AISI 1021steels, produced by friction welding have been investigated. Samples were welded under different axial pressures ranging from 75MPa to 135MPa, at constant speed of 920rpm. The tensile strength, torsional strength, impact strength and micro hardness values of the weldments were determined and evaluated. Simultaneously the fractography of the tensile tested specimens were carried out, so as to understand the failure analysis. It was observed that improved mechanical properties were noticed at higher axial pressures. Ductile failures of weldments were also observed at 120MPa and 135MPa axial pressures during fractography analysis.

KEYWORDS: Friction Welding; Tensile Strength; Torsion Strength; Impact Strength; Micro Hardness; Scanning Electron Microscopy.

1 Introduction

Dissimilar joints between austenitic stainless steel and low alloy steel are extensively used in many high temperature applications in the energy conversion system (Handa & Chawla, 2013 a). There is an extensive need for dissimilar metal joints in power plant components, due to the severe gradients in mechanical and thermal loading. In central power stations, the parts of the boiler that are subjected to lower temperatures, are made of low alloy steel for economic reasons. The other parts, operating at higher temperatures, are constructed with austenitic stainless steel. Therefore, transition welds are needed between these two materials. The joining of dissimilar materials is generally more challenging than those of the similar materials due to difference in thermal, metallurgical and physical properties of the parent materials. The specific problems associated with welding of austenitic stainless steel are formation of delta ferrite, sigma phase, stress corrosion cracking, and sensitization at the interface. Friction welding is one such solid state welding process widely employed in such situations (Meshram et al 2008, Sathiya et al 2007). Main advantages of friction welding are high material saving, low production cost, and ability to weld dissimilar materials (Sahin, 2004). Friction welding is one of the versatile and well established welding processes (Meshram et al 2008) that are capable of giving good quality welds; it gives solid state joining of the materials through the controlled rubbing of the interfaces. Due to thus produced heat softens the material and brought the localized faces into the plasticized form which results in good quality welds (Sathiya et al, 2007) In this process heat energy is produced by the

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Predicting the effect of fiber orientations and boundary conditions on the optimal placement of PZT sensor on the composite structures

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Abstract

In this paper, the modal-model of the composite structure is predicted and viewed to decide the optimal position of the PZT sensors on the composite structures. The novelty of this work is to systematically study the effect of fiber orientations and boundary conditions on the modal-model and the optimal location of the PZT sensors on the composite structures. The glass fibers are reinforced in a polyester matrix at different fiber orientations such as 0°, 30°, 45°, 60° and 90°. It is used for various engineering applications, especially in the aerospace and automobile sector, and it is very important to measure its dynamical response. The PZT patches can be embedded on the composite structures to measure their vibrational response. In this paper, ABAQUS software is used to build the finite element model of the PZT-composite structure. The composite structure is modeled with different boundary conditions. It is observed that the orientation of the fibers as well as the boundary condition directly put their effect on the modal-model of the composite structure and also on the selection of the optimal position of the PZT patches. It is found that the optimal position of the PZT directly depends upon the fiber orientation.

1. Introduction

Composite materials have distinct properties from other conventional and metallic materials such as high fatigue life, corrosion resistance, specific strength, specific stiffness, wear resistance, acoustical insulation, and many more. Inherent properties like high specific strength and durability have immense the use of composite material in various naval, aerospace and automobile applications [1, 2]. The extensive use of composite materials opens a wide range of failures caused in a static and dynamic mode. In this regard, both static and dynamic analysis of the composite structures is essential to study to avoid failure of the structure. The composite structure may fail because of its resonance condition, so it is very important to predict or measure the modal characteristics (spatial model, modal-model, and response model) of the structure. Researchers studied the vibrational analysis of the composite structures in which they analyzed the importance of prediction of the modal-model (natural frequencies, mode shapes and viscous damping coefficients) for effective dynamic analysis. The study of natural frequencies and their corresponding mode shapes of the structure are combined to term as modal analysis. Modal analysis of any structure depends upon the physical properties of the material, structure-dimensions, and boundary conditions. In the case of composite materials, there are two or more different materials combined at the homogenous level that may affect the modal analysis separately. In composite materials, mostly fibers are embedded at different orientations in the matrix or resin. The orientation of reinforced fibers into the matrix may affect the modal-model of the system.

Review

A systematic review on recent progress in advanced joining techniques of the lightweight materials

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Abstract: We are living in a time where the emphasis is given on the development of new and improved materials having high strength and are correspondingly light in weight for application in fields such as transportation, aerospace, medical and other such related areas. These new materials developed need to be processed and joined with oneself and other materials as well. The paper presents a brief understanding of the advanced joining processes namely friction stir welding, microwave hybrid heating, electron beam welding, laser beam welding, thermo-hydrogenated diffusion bonding, electromagnetic welding and ultra sonic welding. The purpose of these advanced joining techniques is to increase the efficiency of the joining process and prevent failure. The objective of this review paper is to provide an insight into the principles, current trends and research gaps in advanced joining techniques.

Keywords: friction stir welding; microwave hybrid heating; electron beam welding; laser beam welding; electromagnetic welding; ultra sonic welding

1. Introduction

Joining is the process of combining a broad spectrum of materials using three basic techniques of temporary or permanent fastening, adhesive bonding and welding. Generally, the products which

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Review

Finite element model updating of metallic and composite structures—A state of the art review

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Abstract: Finite element model updating (FEMU) is a technique to improve the analytical finite element (FE) model of any structure from its experimental modal test data. The main purpose to apply FEMU on structures is to remove the uncertainties or errors present in the analytical FE model. The main objective of this paper is to present a review on the various FEMU techniques which can be applied to remove the uncertainties present in the FE model of the actual engineering structures. Applications of various FEMU techniques on the metallic and the composite structures have been discussed in this review paper. FEMU is applied on the metallic and the composite structures to remove the error present in their FE models. The main objective of the FEMU is to accurately predict the modal analysis characteristics such as the spatial-model, modal-model and the response model of the structures. The uncertainties present in the analytical or simulated FE model of any structure may be due to its material properties, dimensions and most probably due to the uncertainties present in the boundary conditions of the structure. However, to provide a sufficient strength to this review paper, the different updating methods are applied on the three degree of freedom spring mass system, on a 1-D aluminum beam, 2-D aluminum panel and on a graphite-epoxy composite material laminate. It is found that the updating algorithms are fast and reliable enough to remove error present in the numerical or simulated FE model of the structures and deliver the accurate estimation of the spatial-model, modal-model and response model of the different material structures.

Keywords: finite element model updating; direct updating method; composite structures; uncertainties; modal analysis; spatial-model

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Electricity Generation Through Water Supply Pipes in High Rise Buildings

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Abstract. Day by day, with the improved per capita demand and increasing population, energy requirements are increasing globally. Big organizations are trying to develop zero energy establishments by using solar rooftop systems and by following green building norms. This paper proposes to utilize the kinetic energy of water falling in high-rise buildings for the generation of electricity. This study proposes the idea of extracting electric power from falling water in high-rise buildings. A 15 m high building is considered for the study, having sufficient water head to run a micro-hydro turbine. Hydraulic turbines are stationed at each storey of the building, which employs the water energy for the generation of electricity. Analytically, the suggested setup is commercially propitious for several major cities of the country. The economic review of the suggested setup is discussed for possible commercialization of the idea.

Keywords: Water head; energy; hydroelectricity; high rise buildings; micro-hydro turbine.

1. Introduction

Globally, hydropower generation accounts for about 70% of all renewable electricity. In 2015, it was 16.6% of the world's total electricity, and it is supposed to increase by 3.1% every year up to the next 25 years. In 2013, the Asia-Pacific region produced 33% hydropower of the world. China produced 920 TWh hydroelectricity in 2013, which accounts for 16.9% of its domestic demand. Hydroelectricity is a competitive source of renewable energy/electricity due to its relatively low cost. No water

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1

3D Printing Technology and its Significant Applications in the Context of Healthcare Education

Ilma Tasneem, Aleena Anz, Devyani Bharti, Abid Haleem, Mohd Javaid and Shashi Bahl

Abstract

Next

3D printing applications help solve challenges in the field of healthcare. These technologies evolved to produce custom-made medical devices and implants for patients and enhance medical education and research. This paper aims to make readers aware of the role of 3D printing in the field of medical education. 3D printing technologies are part of additive manufacturing (AM) technologies. 3D printing shows excellent potential with unconventional materials like different types of plastic, ketones, wood, human cells, metal powder, ceramics, composites, smart material, etc. This manufacturing method is suitable for producing complex and intricate shaped medical objects of the required property with lesser wastage of material. This paper introduces 3D printing technology and the need to carry out this study related to medical education and research. A brief literature review of 3D printing has been carried out. The paper further discusses the capabilities of 3D printing in the field of medicine. Patient-specific 3D models are being designed and then manufactured and implanted. 3D models of defective body parts help surgical planning and better part designing. Finally, the paper discusses significant roles of 3D printing in healthcare education in a tabular form. For the future, this technology has immense potential in medical education, surgical planning and support including for a clear understanding of the disease.

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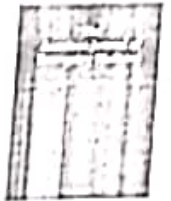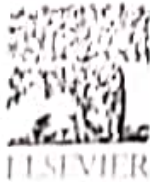
Can open access publishing be made 'JUST' for authors from low-middle income countries?

Medical innovation, scientific research and ultimately academic publication are vital for clinicians as they progress in their professional career [1]. All these three elements are necessary to enhance medical knowledge. This allows clinicians to be abreast with evidence-based medicine that can be applied to enhance patient care in a multitude of conditions.

However, academic publishing has seen a change as it makes a transition from traditional print publishing model to an electronic format. Publishing journals can be divided into three categories: subscription-model, open-access, and hybrid (combined model with open-access by choice).

In the traditional subscription model, readers must pay a subscription fee to access scholarly information either personally or through institutional access and libraries. Cost of printing, download charges, innate conservativeness and difficulty in accessibility of 'paywall' articles in the subscription model of publishing has led to search for alternate modes of publishing [2].

Internet revolution with digital technology which began at the end of 20th century has allowed rapid scholarly distribution of research and paved a broader way for academic publication [3]. With the search for broader access to information, combined pressure of budget cuts at universities, increased costs for journals and transition to more open, internet-based alternatives to conventional publishing appear inevitable [4].

Open Access (OA) publishing model makes research information available free to readers on the web and the internet but comes at a cost for the author. In the OA model, authors or their funding organisation pay as an article processing charge (APC), for publishing their work. Since publications are freely available online to readers, it is supposed to remove the legal, financial and technical obstacles associated with subscription model.

OA applies the principles of 'FAIR' in its publishing model. Proposed in March 2016 and endorsed by the European commission and the G20, 'FAIR' is an acronym for 'findable, accessible, interoperable and reusable', intended to more clearly define what is meant by the term 'open access' and make the concept easier to discuss [5]. We wondered if the 'FAIR' concept can be supported by the philosophy of 'JUST' as well, to empower authors especially from the low and middle-income countries (LMICs).

J- Jargon friendly, U- Universal, S- Sharing, T- Transparent.

OA contents are published under certain licenses. The most common licenses used in open access publishing are Creative Commons (CC) licenses [6]. One of the criticisms of traditional subscription journals are the stringent copyright laws. To overcome this obstacle, CC a non-profit body, offers customized licenses free of charge in a variety of formats depending on the author's preference to make their work available for commercial use or not and the allowance for derivative works or not. Attribution is a mandatory obligation in all licenses. However, a wide range of CC licenses exist with some restrictive ones e.g. CC BY-ND, CC BY-NC and CC BY-NC-ND licenses to name a few. These are confusing to an unaccomplished author submitting on a journal's manuscript submission portal. There is possibility of making a mistake and inadvertently incurring an APC.

The OA movement advocates worldwide access to all scientific publications free of charge. The Internet and electronic technology revolution can make this possible. Researchers have long argued that wider dissemination facilitates progress, but does this apply to scholars and researchers from LMICs? Universal, unrestricted accessibility is the key for such advancement. OA under the FAIR principle already allows fair amount accessibility to readers, however unconfined access may be determined by how restrictive the CC license the article is published under or if it is deposited in a repository held by institutions e.g. in a dedicated archive such as arXiv or bioRxiv with its inherent pitfalls [7]. Scientists, health care professionals, and institutions in developing nations and LMICs often do not have the capital necessary to access scholarly literature, although schemes exist to give them access for little or no cost.

Sharing of data allows rapid dissemination of scientific progress and reduces unnecessary duplication of scientific effort. OA licensing allows re-usability, especially in certain situations. In fact, proponents of OA publishing suggest it is the only fair way to make research accessible to all and researchers have a collective responsibility to embrace it [3]. However, we feel it can be simplified to allow scientific publications to be shared amongst researchers from LMICs as an equitable and at the best a low -cost process.

Publishers charge an APC in the Gold open-access business model. The APCs are waived off partially or even fully by many publishers to support the authors financially. But these waiver policies are not always transparent. Sometimes, the researchers come to know about the APC only after their paper is accepted for publication in the journal. Eligibility for the APC waivers varies considerably which makes it quite cumbersome for the authors to understand the policies and even discourages them. If waiver policies can be made more transparent, then researchers can take the full advantage of these policies. There is a requirement to evolve the publishing and business models to equally help authors from LMICs.

Inherently, OA model appears to be a great publishing model for the research community. However, shifting the burden of cost of scholarly publishing to an author and APC may itself be a barrier to academic publishing apart from other causes of rejection of articles including lack of command of English language and poor editing skills [8,9]. It can also open opportunities for deceitful online websites to exploit authors for profit leading to Predatory Publishing [10].

Justice is the notion of things being morally balanced. Enabling authors and readers to access, read, distribute and publish knowledge from LMICs without barriers for the scientific benefit of the world at

large is morally a JUST thing. An OA publishing model is probably the futuristic model of scientific publication. Empowering and supporting authors from LMIC's in this endeavour will only enhance medical knowledge and benefit our patients and researchers.

Contributors

VJ and KPI involved in Conceptualization, literature search, manuscript writing and editing. SB in literature search, manuscript writing and editing. KV involved in review of manuscript, supervision of the project and approved the final draft. All authors read and agreed the final manuscript submitted.

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Declaration of Competing Interest

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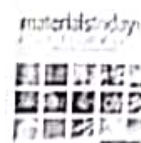Raju Vaishya
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Axisymmetric finite element analysis of single fiber push-out test for stainless steel wire reinforced aluminum matrix composites

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ARTICLE INFO

ABSTRACT

An axisymmetric cylindrical finite element (FE) model with wire-matrix interface is presented with the objective of evaluating the interfacial properties of stainless steel wire reinforced aluminum matrix composites. It consists of a wire of stainless spring steel 1.4310 (X10CrNi18-8), a matrix of aluminum alloy AA6060 and the interface. The FE model used to model the push-out test which has been developed over a number of years as a mean of quantifying the interfacial properties. The interface with a specified thickness is modeled using the cohesive layer concept where, in addition to the elastic parameters, a damage criterion based on the maximum nominal stress is also defined for the interface. Fracture energy is used to define the damage evolution which describes the rate at which material degrades, once the damage initiation criterion is met. The interface parameters are varied to adopt the model according to the experimental results reported in the past. The simulation results are in qualitative agreement with experimental results regarding the force-displacement graph. The simulation results obtained show the presence of compressive stresses at the top and tensile stresses at the bottom of the interface caused by the bending of the specimen. It indicates that, during fiber push-out test of metal matrix composites where thin-slice geometries are used, interfacial failure initiation favoured by tensile stress field, probably occurs at the bottom of the specimen even in the absence of thermally induced shear stresses. However, modeling the stepwise debonding of interface requires the more sophisticated implementation of interface behaviour concerning failure evolution and the friction between wire and the matrix.

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1. Introduction

The properties of the fiber-matrix interface have a significant influence on the mechanical properties of composites. These interfacial properties include the interfacial shear strength, interfacial frictional stress after debonding and matrix shrinkage pressure on the fiber. Recognition of the importance of interfacial properties has led to the development of a number of experimental techniques and theoretical models for assessing these properties. The commonly used tests are the push-out test and the pull-out test [1,2]. The internal load transfer between matrix and fiber is a crucial factor for the composite's performance. The single fiber push-out test allows for the quantitative evaluation of the fiber-matrix debonding shear strength as well as for receiving a qualitative impression of the interface. The push-out test is based on an indentation technique which was originally developed by Marshall [3]

for testing ceramic matrix composites. It is a method used for measuring the debonding shear strength for fiber reinforced composites where the reinforcing element is completely surrounded by matrix material. The fiber is loaded by applying an indenter until the interface fails and the reinforcement is pushed out from the specimen. Ideally, this impact is considered as pure shear load. In fact, the transversal expansion of the fiber induces a compressive stress on the interface. The debonding shear strength can be calculated from the maximum applied load [4]. Numerous experimental investigations have been carried out regarding the push-out test in order to get a quantitative evaluation of the fibre-matrix debonding shear strength as well as for receiving a qualitative impression of the interface. Du et al. [5-7] carried out the investigations for different interfaces which were based on erbium oxide, zirconia oxide, copper and carbon. The shear strength values determined for the oxides were found to be comparable but the fracture energy of interface for the coating with erbium oxide was found to be almost three times more than that of the zirconia oxide. Mao
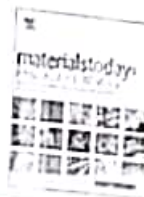
An experimental study to measure the acoustical properties of natural fibers at real case broadband excitations

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ABSTRACT

The acoustical properties such as sound transmission loss (STL) and A-weighted equivalent continuous sound level (LA_{eq}) of natural fibers are measured experimentally in this paper. The acoustical properties are measured for various real case acoustic broadband disturbances such as white noise, pink noise, road traffic noise, train noise, ambulance siren noise, aircraft noise, and construction and machinery noises. The above acoustic excitations are passed through the specimens of natural fiber material in order to measure their acoustical properties. The natural fibers used in this study are banana, coconut coir, hemp, jute and kenaf. It is observed in the experimental investigations that kenaf is the best noise absorbing material. The sound reduction of kenaf varies from 5.67 dB to 7.82 dB. The second best material is jute whose sound reduction varies from 4.5 dB to 6.28 dB. Third best material is hemp whose sound reduction varies from 2.88 dB to 5.51 dB followed by the banana fiber. The coconut coir is found to be the worst noise absorbing material among the five natural fibers considered for experimental investigation.
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1. Introduction

Noise is an undesired or unwanted sound. Different noise sources such as white noise, pink noise, colored noise, leisure noise, road traffic noise, train noise, construction noise, machinery noise, aircraft noise etc. are responsible for noise pollution. The continuous exposure to noise pollution can create severe effects on the human health [7,12,14]. Passive and active noise control methods can be used to control the noise. The passive noise control methods do not require a power source to reduce the unwanted sound rather it uses the material properties (acoustical properties) for attenuation of unwanted sound. In these methods, sound absorbing or sound isolating materials are used. Passive methods are effective for medium and high frequency noises. On the other hand, the active noise control technique requires a power source for attenuation of noise. In this method another source of sound is used, called as anti-noise. The anti-noise makes the destructive interference with the source noise and reduces its amplitude. Active noise control (ANC) methods are mostly effective for low

frequency sounds [6]. Ulrich et al. [11] presented a simulation approach to control the noise emission of car engine. Authors used ANC technique for this. In this paper, the passive methods are explored to measure the acoustical properties such as sound transmission loss (STL) and equivalent continuous A-weighted sound pressure level (LA_{eq}) of natural fiber materials at broadband excitations.

Parikh et al. [4] fabricated a floor covering of automobiles by needle punch technique. They used natural fibers such as kenaf, jute, waste cotton and flax in blends with polypropylene and polyester binders. Authors found that as the frequency increases the sound absorption coefficient of floor covering also increases. Arenas and Crockett [10] suggested different types of sound absorbing natural fibers such as cotton, kenaf, hemp, wood, flax, jute for passive sound reduction applications. Thilagavathi et al. [5] reinforced different natural fiber materials such banana, jute and bamboo into polypropylene (PP) matrix. Sound absorption test was conducted by using impedance tube transfer function technique. The results showed that the bamboo/PP blend has the highest sound absorption coefficient. Fatima and Mohanty [16] measured the sound absorption coefficient and sound transmission loss (STL) of natural rubber latex jute. They observed higher sound

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Industry 4.0 technologies and their applications in fighting COVID-19 pandemic

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ABSTRACT

Background and aims: COVID-19 (Coronavirus) pandemic has created surge demand for essential healthcare equipment, medicines along with the requirement for advance information technologies applications. Industry 4.0 is known as the fourth industrial revolution, which has the potential to fulfil customised requirement during COVID-19 crisis. This revolution has started with the applications of advance manufacturing and digital information technologies.

Methods: A detailed review of the literature is done on the technologies of Industry 4.0 and their applications in the COVID-19 pandemic, using appropriate search words on the databases of PubMed, SCOPUS, Google Scholar and Research Gate.

Results: We found several useful technologies of Industry 4.0 which help for proper control and management of COVID-19 pandemic and these have been discussed in this paper. The available technologies of Industry 4.0 could also help the detection and diagnosis of COVID-19 and other related problems and symptoms.

Conclusions: Industry 4.0 can fulfil the requirements of customised face masks, gloves, and collect information for healthcare systems for proper controlling and treating of COVID-19 patients. We have discussed ten major technologies of Industry 4.0 which help to solve the problems of this virus. It is useful to provide day to day update of an infected patient, area-wise, age-wise and state-wise with proper surveillance systems. We also believe that the proper implementation of these technologies would help to enhance education and communication regarding public health. These Industry 4.0 technologies could provide a lot of innovative ideas and solution for fighting local and global medical emergencies.

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1. Introduction

COVID-19 (Coronavirus) pandemic has affected almost all countries and has made a significant effect on the available healthcare facilities and treatment systems. There is a requirement for the introduction of various advance technologies to tackle various problems related to this viral pandemic. Industry 4.0 is also known as the fourth industrial revolution, which consists of advance manufacturing and information technologies, to fulfil the customised requirement of different areas of the human being in lesser time. These technologies provide wireless connectivity in the manufacturing and service sector to enhance automation. In the

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https://scholar.google.co.in/citations?user=2lu3gQ0AAAAJ&hl=en (R. Vaishya),
https://scholar.google.co.in/citations?user=A3LEW9tAAAAJ&hl=en (R. Suman)

Review Article

Sustainability of Coronavirus on Different Surfaces

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Coronavirus disease 2019 (COVID-19) is the name of the disease supposedly manifested in December 2019 from Wuhan, from the virus named SARS-CoV-2. Now, this disease has spread to almost all other parts of the world. COVID-19 pandemic has various reasons for its dramatic worldwide increase. Here, we have studied coronavirus sustainability on various surfaces. Various disinfectants and their roles are discussed from the available literature. The infection capabilities of SARS-CoV-1 and SARS-CoV-2 for different materials and finally studies on infection decay for SARS-CoV-1 and SARS-CoV-2 are discussed. (J Clin Exp Hepatol 2020,10:386–390)

The global disaster COVID-19 pandemic has various reasons for its dramatic increase worldwide. Some researchers opine that the SARS-CoV has its origin from bats and the prevalence of this virus to humans was through palm civets: the intermediate source between bats and human population.[1,2] The most responsible reasons for it include the large human population gathering and human intervention which have violated the ecosystem globally. The population of the world intrudes the various untouched ecologies and put themselves before the unknown viruses and bacteria without knowing their threat or impact of exposure to humankind.[3,4]

The coronavirus can travel beyond species boundaries. The earliest infection of SARS-CoV-2 was in Wuhan (China), and the World Health Organization (WHO) has called this pandemic as Coronavirus disease 2019 (COVID-19). Initially, it was thought that this virus also has its origin from the animals to humans, as some of the infected people were from a wholesale seafood market in Wuhan. At a later stage, infections were found in humans, those who have not even visited that particular market, thus making it clear that this virus can also spread by human-to-human exposure.[5-7]

There can be various ways of transmission for this virus to infect the human population. Spreading or transmission of COVID-19 can be through close contact of human beings or by touch or the aerosol spreading of the virus.[8-10] The most common way of spreading of this virus is through respiratory droplets as the infected one coughs or sneezes. These microdroplets containing the virus can infect a healthy human by settling on the face (mouth, nose, ears, eyes) or hands.[11] This virus can sustain for a long time on various surfaces which is also considered as a significant reason for its transmission. Frequent touching of the facial area, handshake and unavoidable touch to different surfaces while travelling (through various transport means) are also a significant threat to humans. In addition, the transmission is known as "hidden transmission" as the carrier unknowingly spreading the infection to other population exists.[12]

CORONAVIRUS SUSTAINABILITY ON VARIOUS SURFACES

Coronavirus can last for long durations on different metal surfaces, ranging from hours to days.[13,14] Recent studies show that the coronavirus can last about three days on a plastic surface as well as on stainless steel surface, it can also sustain for a period of whole one day on cardboard, while it can only sustain only for about four hours on a copper surface.[15]

DISINFECTANTS/SANITISERS AND THEIR ROLE

The use of disinfectants decimates microorganisms such as virus or bacteria on inner layers or inert surfaces by acting as an antimicrobial agent. Disinfectants are not always impressive against all kinds of microorganism such as bacterial spores unlike sterilisation, which kills all types of microorganisms by the use of extreme physical or chemical procedures.[16] Disinfectants play a critical role in decimating microorganisms outside the human body or on various surfaces. This fact distinguishes disinfectants from antibiotics and antiseptics, which act inside the human body or on living tissues, respectively. The mechanism of disinfection involves the destroying of the cell wall of microbes and the disinfectant enters into their metabolism to destroy or inactivate them.

Numerical simulation of the debonding behavior of fiber reinforced metal matrix composites

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ARTICLE INFO

ABSTRACT

Finite element analysis (FEA) is performed for investigating the debonding behavior of fiber reinforced metal matrix composites (MMCs). An Axisymmetric cylindrical and three dimensional solid finite element (FE) models without interface are constructed which consist of a stainless spring steel wire as fiber reinforcement and an aluminium alloy as matrix. Numerical simulation is carried out with both the spherical and cylindrical indenters. The simulation results obtained in this work are compared with the experimental findings reported in the past. The initial part of load–displacement curve for cylindrical indenter is linear in nature as compared to the non linear behaviour with the spherical indenter. This shows that the non linearity is because of the shape of the indenter and not due to other reasons such as incorrect modeling. The coefficient of friction does not affect the response regarding the load–displacement curve. A large gap between the experimental and simulation curves for the elastic region is due to stiffness of the experimental setup. The simulation curve shows continuous increase in the value of load which is due to the absence of definition of failure criterion. The axisymmetric FE model presented in this study shows the capability to simulate the debonding behaviour of fiber reinforced MMCs. However, it can be improved further with the implementation of cohesive layer concept for modeling the fiber-matrix interface. In future work, the FEA of the axisymmetric model with interface using the cohesive zone modeling (CZM) for the interface will be carried out.
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1. Introduction

Fibre-matrix bonding is a key factor in the effective transmission of load from the matrix to the fiber. It is essential that this bond is strong for the composite to develop the desired properties. Otherwise, on the onset of stress, the fibers could potentially slide within the matrix, and thus not carry any of the loads [1]. The mechanical properties of composites are greatly influenced by the properties of the interface between the fiber and the matrix material such as interfacial shear strength etc. A large number of experimental methods and theoretical models such as push-out test and pull-out test have been developed in order to investigate these interfacial properties [2,3]. The indentation technique on which the push-out test is based was developed by Marshall [4] in order to perform the testing composites where ceramic was used as a matrix material. The push-out test is employed to determine the debonding shear strength for fiber reinforced composites.

Here, the matrix material completely surrounds the reinforcement [5]. The load is applied on the fiber with the help of an indenter until the failure of the interface. Finally, the fiber is pushed out of the specimen. A compressive stress is induced on the interface by the transversal expansion of the fiber. The value of the debonding shear strength can be determined from the values of applied load, diameter of the fiber and the specimen thickness [5-7].

Janczak et al. [5] used a push-out-technique which involved preparing polished, thin specimens of Ti-matrix (SiC/Ti₆Al₄V) and Al-matrix (SiC/Al) composites in which the fibers were oriented perpendicular to the composite surface. It was concluded that push-out technique can be used for the interfacial investigation of a wide range of MMCs in their temperature application range. Galbraith et al. [8] performed the fiber push-out tests on the sapphire reinforced NiAl thin-slice specimens to study the interface failure process. The results indicated that in sapphire/NiAl system, interfacial failure initiates at the specimen back face and propagates towards the indenter during thin-slice fiber push-out-tests. Furthermore, it was found that the interfacial failure sequence is

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Exploring the significant applications of Internet of Things (IoT) with 3D printing using advanced materials in medical field

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ABSTRACT

This article explores how 3D printing and the Internet of Things (IoT) can provide a solution to the medical industry's various challenges and what materials can be used for different medical industry requirements. Cranial and maxillofacial constructs require a material with high strength whereas tissue generation does not require hard materials, so the material choice is important for maximum success. IoT can compensate for some of the limitations of 3D printing. The two mentioned technologies' applications are studies from IEEE, ScienceDirect, ResearchGate and PubMed databases. Medical 4.0 is to be implemented where 3D printing and IoT form its core. This paper presents ideas related to the technologies mentioned above to provide solutions to some significant challenges currently being faced by the medical field. However, the ideas presented are entirely theoretical and have not been verified practically and there is a need for more research on the topics. These two technologies together can provide a faster and reliable solution to urgent medical situations.
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1. Introduction

Additive Manufacturing (AM) provides a platform of technologies wherein different materials are added layer by layer to form a physical model from digital data. It complements subtractive manufacturing and helps manufacture complex and optimized parts with new material sets. AM involves much less wastage of materials and allows for the formation of more cost-effective items with lesser risk factors if the right kind of process is chosen depending upon the item's usage to be manufactured. This process also gives much scope for customization because designing in AM is less restrictive than traditional methods. It is one of the most critical technologies that make the core of industry 4.0 and medical 4.0. The upper layer of skin, liver and bio-scaffolds are now successfully designed and 3D printed, and research is on to print other organs as well. Apart from this, it also finds usage in target-specific drug deliveries and for developing models for better knowledge of the anatomy [1,2]. Internet of Things (IoT) is a network of devices that can communicate with each other over the Internet. It involves sensors, transmitters and actuators to name a few. Their

function of recording, transferring, and storing data has changed healthcare's face in unimaginable ways. They have provided relief to patients suffering from chronic illnesses by allowing them to take proper medical care from their homes' comfort. Patients suffering from serious illnesses want to be treated from their homes and IoT has provided them with the comfort they needed. Also, it acts as a boon for patients with mobility problems susceptible to falls by notifying the caretakers about the new development [3,4]. Though much of the work has been done on these two technologies' individual roles in the medical industry, there has been less work on these two technologies' combined potential and their contribution to medical 4.0. This paper aims to provide insights into these two technologies' applications together, how IoT can compensate for some of the shortcomings of 3D printing and what challenges the medical industry faces can be solved by these two technologies in unison [5,6]. The problem of the short life of 3D printed organs has been told by many experts not being able to provide adequate healthcare in remote locations for illnesses such as cancer, organ transplantations being too expensive, complicated surgeries requiring assistance and special customized tools to the limitation of the physical presence of a specialized surgeon during a complicated surgery. The solution lies in using these two technologies together for better and safe outcomes making medical

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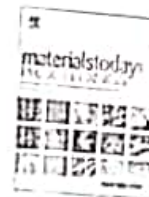
Experimental investigations on brass material and pin–fin based heat transfer system and its modeling by using adaptive neuro-fuzzy inference system

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ABSTRACT

The objective of this paper is to predict the behavior of brass material and pin fin based thermal convection system with the help of a model which is based on adaptive neuro-fuzzy inference system (ANFIS). The effects of change in input parameters like voltage and current on the response parameters like temperature at different locations of heat transfer system can be imitated by the ANFIS model. The results which are achieved by employing the ANFIS model are then compared with the experimental results in terms of graphs and also numerically by evaluating the error norms. The predictions obtained by using the ANFIS model are found to be very close to the experimental findings which prove that the model proposed in this study is capable to accurately predict the behavior of heat transfer system. The temperature at the location of sixth temperature sensor where the temperature level is low is best predicted by the ANFIS based model. A control system can be further developed with the help of proposed ANFIS model for controlling the temperature at various locations of the heat transfer system by varying the input parameters like current and voltage.
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1. Introduction

The modeling and simulation based on the adaptive neuro-fuzzy inference system (ANFIS) is considered preferable over a classical mathematical model of the system [1]. It has the advantage of saving time and energy to identify the systems which have complex governing equations involving number of input and response parameters and having the possibilities of uncertainties in the parameters which are involved in the processing of the system [2]. The fuzzy logic and artificial neural network (ANN) methods are used in combination in ANFIS for dealing with system identification problems. During the development of ANFIS model, the designing of fuzzy membership functions is done by employing the hybrid learning algorithm. The hybrid learning algorithm is based on the combination of least-square method and back-propagation gradient descent method. The ANFIS model incorporates a humanistic approach during rules evaluation due to the presence of fuzzy logic effects. Artificial neural networks help in adapting to the changing working conditions during the evaluation of the fuzzy rules. A robust model and hence controller for very complex systems can be developed by employing ANFIS.

The modeling based on ANFIS has been used in the past in the number of applications. Some of these applications include the polymers reinforced with glass fiber [3,4], the system of photo-voltaic power supply [5], wire-electric discharge machining (WEDM) [6] and the turning operation which is required for stainless steel [7]. ANFIS based modeling has also been employed earlier for friction stir welding (FSW) [8], processing of rubber [9,10], monitoring of bearing condition [11], simulation for water quality of reservoirs [12] and various other applications. It can also be employed for the different applications related to finite element model (FEM) updating [13-22].

ANFIS exhibits the capability to be used in future applications for modeling the various latest methods of manufacturing which includes microwave hybrid heating (MHH) processes and other traditional machining processes where we don't have the easy availability of theoretical classical models of the processes [23-31]. The approach based on ANFIS has been employed very effectively for the purpose of modeling required in various applications

Smart materials types, properties and applications: A review

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ABSTRACT

Future developments of smart materials for domains such as self-sustainable wireless sensor networks, self-tuned vibration energy harvesting devices, seismic applications etc. is the need of an hour. Such smart materials have the potential to build smart structures and materials. Smart materials are stimuli-responsive which constituted a broad range of materials to exploit vibration control such as piezoelectric, shape memory alloys, electro-rheological fluid and magneto-rheological fluid. Smart materials show a certain amount of analogy with respect to biological systems. For instance, piezoelectric hydrophones that show similarity as that of ears with which fish senses vibrations, piezoelectric with an amalgamation of electromechanical coupling, shape-memory materials with a potential to recollect the original shape and electro-rheological fluids with manipulative viscosity strength etc. Such potential grabbed the attention of research and allow them to think and integrate varied advanced technologies into compact, diverse functional packages with an ultimate aim to develop advanced smart materials and revolutionize the research field of smart materials. This review initially discusses a brief summary of the aforementioned stimuli-responsive smart materials following a complete description of some of the smart materials.

1. Introduction

Thousands of years ago humans used materials for different causes due to which there was an enhancement in their living standards. Even civilizations were divided on the basis of their discovery of materials like the first age was the Stone Age. The most revolutionary age was the Bronze Age because bronze was more durable and harder. The discovery of bronze was the beginning of new metallurgy era after that many materials discovered. From the past two decades, science and technology have made great improvements in synthesizing the new materials. They are divided mainly into four categories which are polymers, ceramics, metals, and smart materials. Among them, smart materials are becoming more popular because they have various applications as compared to standard materials. The special materials that can change their properties such as materials which can change its shape just by adding some heat or can change its phase instantly when placed near magnet are called smart materials. This new era of smart

materials will have a great impact on mankind, for example, some of them can change their properties according to the environment and some of them have sensory capabilities some of them can repair automatically and some of them have self-degradation, these extraordinary capabilities of smart materials will have an impact on all aspects of civilization. Various smart materials already exist like piezoelectric materials, shape memory alloys, magneto-rheological materials, and electro-rheostat materials and many more to be discovered. This paper concentrates on the introduction to different types of smart materials and their potential applications in various areas.

2. Classification of smart materials

Smart materials are also known as advanced materials or intelligent materials. They cannot be defined by a single specific definition. They can be defined as materials that can recoil their original shape to specific stimuli, or it can be defined as advanced materials that can respond smartly to environment changes [1]. Smart materials are categorized on the basis of their properties such as active and passive [2], passive smart materials have ability to transfer a

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Impact of the coronavirus pandemic on the supply chain in healthcare

As the coronavirus pandemic spreads worldwide, the effect on global healthcare systems has been profound. One of the key challenges in managing this public health crisis has been the production and distribution of medical devices, surgical supplies and pharmaceuticals to those on the clinical frontline. This article assesses the impact of the coronavirus outbreak on the supply chain in healthcare and evolving solutions.

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Introduction

Healthcare supply chain management is a dynamic process that integrates manufacturing resources and vendors, and delivers goods and services to providers and patients (Figure 1). It is a complex, fragmented process that requires a constant flow of product, orders, information and fund transfers between different stages. Since supply chain management is a staged process, the coronavirus pandemic has affected most, if not all, parts of the chain for numerous reasons, resulting in a lack of various medical devices and personal protective equipment at the clinical frontline. The disruption to the flow of medical goods and services from the manufacturer to the patient and clinicians has affected daily life with far-reaching consequences (Haleem et al, 2020).
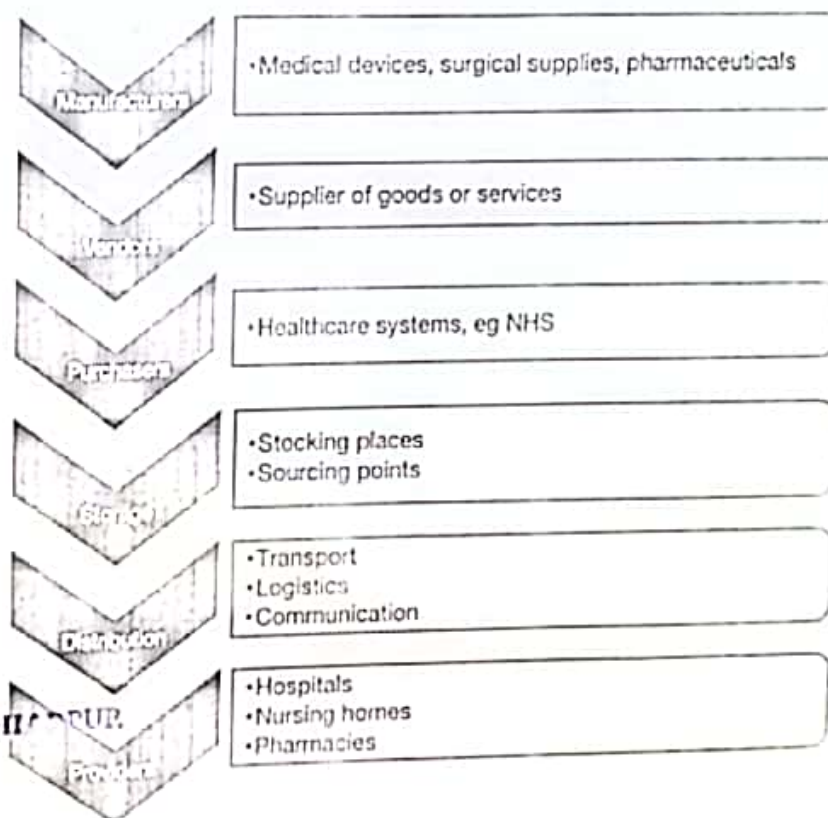

- Medical devices, surgical supplies, pharmaceuticals
- Supplier of goods or services
- Healthcare systems, eg NHS
- Stocking places
- Sourcing points
- Transport
- Logistics
- Communication
- Hospitals
- Nursing homes
- Pharmacies

Figure 1. Supply chain management process in healthcare systems.

Challenges and solutions in meeting up the urgent requirement of ventilators for COVID-19 patients

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ABSTRACT

Background: Severely affected patients in the COVID-19 pandemic need Ventilators, we chart the challenges faced by the health care systems in procuring these machines and the role of 3-D printing technology in building ventilators.

Aims: We tried to find the current role, availability and need of ventilators in the COVID-19 pandemic and the role of applied innovative technologies is assessed.

Methods: We have done a comprehensive review of the literature using suitable keywords on the search engines of PubMed, SCOPUS, Google Scholar and Research Gate in the second week of April 2020.

Results: We found in our review that there is an acute shortage of the ventilators and the manpower to operate these sophisticated machines. There is significant deficiency in the production and supply chain of the ventilators. Many of the seriously ill patients who require hospitalization may need ventilator support. Non-invasive ventilation is not recommended in these patients.

Conclusion: As the respiratory illness due to COVID-19 pandemic spreads worldwide, health care systems are facing the tough challenges of acquiring ventilators to support patients. All steps involved in the supply chain management of ventilators are being escalated to produce more ventilators for the coronavirus frontline. Innovative applications of Additive medicine like 3-D printer technology may play key role in delivering sufficient ventilators.

1. Introduction

COVID-19 pandemic is an infectious disease which is caused by novel coronavirus. It is a highly contagious disease which begun in Wuhan in China at the end of December 2019 [1] and now has spread across the globe to around 200 countries, in a short period of three months and has affected more than 2.1 million individuals and has caused death in more than 145 thousand patients [2]. It can present as a mild infection (such as common cold) to a serious respiratory illness (such as pneumonia). The droplets of saliva and the discharge from the nose of the infected person while sneezing are the main sources for the spreading of coronavirus. There is no particular treatment or vaccine available for this disease at present. The seriously ill patients suffering from COVID-19 need respiratory support, as their lungs get damaged by the coronavirus leading to breathing difficulties. Ventilators are needed in such cases for supplying adequate oxygen (O_2) into their lungs and also removing the carbon dioxide (CO_2), as a lifesaving supportive measure. The ventilators are one of the most vital medical devices needed to keep these critically ill COVID-19 patients alive. There has been a drastic increase in the number of patients struck by COVID-19 pandemic in the hospitals and ICUs worldwide. However, sufficient ventilators are not available in the hospitals at present. An influential report from Imperial College London estimates that 30% of patients admitted in hospitals due to COVID-19 are expected to need the mechanical ventilation [3]. In a recently published study, Yang et al. [4] described their experience from Wuhan, China of the COVID-19 patients who were admitted in the ICU. 56% of their patients required non-invasive ventilation at admission and out of these 76% further required invasive mechanical ventilation. The mortality rate in the individuals who were on non-invasive ventilation was 79% and 86% in those who required invasive mechanical ventilation. They advised against the use of non-invasive ventilation for the

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Finite element analysis of VGCF/pp reinforced square representative volume element to predict its mechanical properties for different loadings

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ABSTRACT

Composite structures whose characteristic dimensions are found at the nanoscale are called nanocomposites. In this paper, vapor grown carbon fibers (VGCF) are reinforced in a polypropylene matrix, termed as nanocomposites. A square representative volume element (RVE) is taken in this analytical study to predict the storage modulus, loss modulus and strain energy of the nanocomposites. The diameter of the VGCF is 200 nm and length is 3800 nm. A longitudinal loading is applied along the length of the nanofibers to predict the modulus in the fiber directions. However, a transverse pressure is applied on the RVE to predict the modulus in the transverse direction of the fibers. In this work, two types of arrangement of the fibers are taken inside the RVE. These types are VGCF through the RVE and VGCF inside the RVE. Finite element (FE) analysis software termed as nnumerically integrated elements for system analysis (NISA) is used to predict the mechanical properties of the nanocomposites. The predicted results from FE method/ strain energy method are compared with conventional rule of mixtures. It is observed that there is considerable improvement in longitudinal modulus of the VGCF/pp nanocomposite for addition of small amount of nanofiber.

1. Introduction

Many researchers across the globe started working in the field of nanotechnologies and nanomaterials since the advent of this century. As suggested by Guz et al. [1], a unique characteristic of many nanomaterials is that the mostly their atoms lies on the periphery as compared to regular materials, where atoms are spread throughout the particle. Daniel et al. [2] recommends that surface area of the support substances is the structural property of utmost value in the interpreting of the structural connection between nanocomposites. Finegan et al. [3] used dynamic mechanical thermal analyzer for measuring the storage modulus and damping of nanocomposites. The fiber injection direction is the preferred direction corresponding to which predicted and measured results are validated by the authors. The researchers proposed that even anticipated and evaluated damping values lies

in similar domain, the expected rates do not yield the evaluated reduction in damping by rising fiber volume proportion. Forecasts depict the mixture with less fiber aspect proportions must have more prominent damping compared to others with high fiber aspect proportions. Liu and Chen [4] evaluated the relevant characteristics of carbon nanotube-based composites with the 3-D nanoscale representative volume element (RVE) derived from 3-D elasticity approach and worked out with the finite element method (FEM). Patterns to calculate the material constants from results of the RVE for triple load instances are demonstrated with the elasticity. Numerical results demonstrate that the reinforcing capabilities of the carbon nanotubes (CNTs) in a matrix are significant.

Odegard et al. [5] presented the two approaches, equivalent-continuum modelling and the self-similar approach for predicting the elastic properties of SWCN/polymer composites. Here, the framework comprises data of the atomic contacts at the nanoscale level to a time relevant mechanics framework. Liu and Chen [6] measured the relevant characteristics of CNT- founded mixture

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Finite element modeling and simulation of the fiber–matrix interface in fiber reinforced metal matrix composites

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ABSTRACT

The properties of fiber-matrix interface in the fiber reinforced metal matrix composites (MMCs) have been investigated in the past with the use of push-out test. The finite element (FE) analysis which is used to model the push-out test helps the composite's designer in optimizing the interfacial properties. A two dimensional planar FE model is presented for investigating the properties of interface. Cohesive layer concept is used to model the interface with a specified thickness. The initial response of the cohesive element is assumed to be linear elastic. The maximum nominal stress criterion is used to define the damage initiation and the damage evolution is defined in terms of fracture energy. The simulation results show that the cohesive layer behaves almost like the matrix for the linear elastic deformation prior to damage. It is concluded that the values of Young's modulus and shear modulus for the cohesive layer can be taken equal to that of the matrix material for the finite element simulation of the debonding behavior of these MMCs. Furthermore, it is observed that the shear stress at which damage initiates can be determined by using the cohesive layer concept for the interface. Once a damage initiation criterion is met, material damage occurs in accordance with the defined damage evolution law. The complete failure of the interface takes place when the stress becomes zero. However, the interface behavior needs to be defined in a more sophisticated way so as to model the stepwise debonding and failure evolution once the complete debonding has occurred.

1. Introduction

The mechanical properties of fiber reinforced composite materials have been investigated in the past [1–4]. They are greatly affected by the properties of the interface between fiber and the matrix. The interfacial shear strength is one of the important properties of the interface. A number of experimental and theoretical methods have been developed in order to study the properties of the fiber–matrix interface. Among them, push-out and pull-out test are considered as most important [5–7]. The pull-out-test has been extensively used in polymer composites. This involves extraction of a single fiber half embedded within a matrix, under an axial stress. But, owing to problems of sample preparation and inconsistent experimental results, the pull-out test is not widely used. Instead, the push-out test is often used for ceramic matrix composites and is gaining importance in the area of fiber reinforced MMCs [8]. The fiber–matrix debonding shear strength can be evaluated quantitatively and the behavior of interface can be studied qualitatively with the use of single fiber push-out test. The basis of push out-test is the indentation technique. This technique was developed by Marshall in order to investigate the ceramic matrix composites [9]. The push-out test is employed for determining the debonding shear strength in case of fiber reinforced composites which consist of matrix material surrounding completely the reinforcement [10]. Singh and Sutcu [11] developed a simple concentric cylinder model to predict analytically the experimental observations in fiber push-out tests performed on specimens of zirconium matrix composites uniaxially reinforced with either uncoated or BN-coated SiC filaments. A slope change in the load-displacement data was predicted for composites in which the fiber–matrix interface was initially chemically bonded. In contrast, a very small slope change was predicted for composites in which the fiber–matrix interface was frictionally coupled. Inter-

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Diabetes & Metabolic Syndrome: Clinical Research & Reviews

Redefining diabetic foot disease management service during COVID-19 pandemic

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ABSTRACT

Background & aims: Diabetic Foot Disease (DFD) management had to be redefined during COVID-19. We aim to evaluate the impact of this on diabetic foot care services and the strategies adopted to mitigate them.

Methods: We have performed a comprehensive review of the literature using suitable keywords on the Search engines of PubMed, SCOPUS, Google Scholar and Research Gate in the first two weeks of May 2020. We have reviewed how the diabetic foot service in the hospital and community setting has been affected by the current Coronavirus outbreak.

Results: We found considerable disruption in diabetic foot service provisions both in the primary care and in the hospital settings. Social distancing and shielding public health guidelines have impacted the delivery of diabetic foot services.

Conclusion: As the COVID-19 pandemic spreads worldwide, health care systems are facing the tough challenges in delivering diabetic foot service to patients. Public health guidelines and the risk of virus transmission have resulted in reconfiguration of methods to support and manage diabetic foot patients including remote consultations.

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1. Introduction

The novel Coronavirus (2019-nCoV) crisis started in Wuhan, China in December 2019 [1] and has spread globally. At the World Health Organisation latest report, there were over 6.5 million confirmed cases of COVID-19 in over 210 countries accounting for more than 397,000 deaths (06 June 2020) [2].

The global outbreak of this disease has led to the suspension of most routine clinical work as all healthcare resources are mobilised to fight the pandemic. There have been significant efforts made to enforce social distancing and to reduce attendances to primary and secondary care facilities. This has had a significant impact on patients with significant co-morbidities, in particular for those with diabetes mellitus (DM) and associated foot involvement. We wanted to ascertain the affect this has had on Diabetic Foot Disease (DFD) services and the steps taken by health care organisation to support these patients.

2. Overview of diabetic foot disease (DFD)

Diabetic foot is defined as; infection, ulceration or destruction of tissues of the foot associated with neuropathy or peripheral artery disease in the lower extremity of a person with diabetes mellitus [3]. It is characterised by the classic triad of neuropathy, ischaemia and infection [4]. This is usually a chronic and late complication of DM, which is feared by the most patients and clinicians caring for them. For many, this condition causes a significant reduction in quality of life; with repeated hospitals stays, disability and a profound socio-economic impact. It is estimated that the roughly half a billion people worldwide were living with DM in 2019 and this number is projected to increase by 25% in 2030 [5]. Out of the reported nearly 62 million diabetics in India alone, 25% develop diabetic foot ulcers resulting in around 100,000 associated leg amputations a year [6]. This only highlights the significant burden of this disease.

Progressive reduction in protective sensation to the lower limb

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Mechanical and microstructural behaviour of weldment of two low alloy steels using MIG

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ABSTRACT

In industrial applications, various types of materials are used and strength of weldment of two alloys is a major cause of interest among engineering community. In this study P11 and P22 steels were welded using ER −70 - SG wire electrode with metal inert gas (MIG) welding process using CO_2 as shielding gas. The strength of the weldment was tested by impact testing, Hardness by Micro Vicker hardness and Microstructure of weldment before and after the failure was examined using a metallurgical microscope. The results of experiments performed on the specimen on impact testing machine showed that the impact energy of welded specimen was 49 J in Charpy impact test, whereas, that of parent metal P11 was 48 J and for P22, it was 61 J. The result of impact test shows that the impact energy of weldment of P11 and P22 lies between the impact energy of parent alloys. The microhardness at Heat affected zone (HAZ) was highest and at base metal, it was lowest whereas, at weldment microhardness value lies in between microhardness value of base metal and HAZ. Specimen were heat treated in a furnace in an air environment at 700, 800 and 900 °C for 2 h and subsequently cooled in the furnace. The results of impact test show increased strength of weldment after post weld heat treatment (PWHT) at all temperatures however, the strength was found to decrease with increase in temperature of PWHTs.
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1. Introduction

Welding is a permanent joining procedure of like or different materials, which is carried out by the using heat, pressure or both. The filler metal in form of wire, rod or powder may be required. Some of the welding types do not require even filler material for making joints. Types of welding include some processes mentioned here but not limited to: Resistance/ Tungsten/ Metal/ Submerged arc and Flash welding. In addition to this, Spot, Butt, Stitch, and Projection welding are used as per requirements. Deployment of inert gas atmosphere during welding has been used nowadays for achieving faster and better joint as compared to traditional methods. It can produce cleaner, longer continuous welds without undesired inclusions and oxidation of metal under consideration. The major processes that uses inert environment include Tungsten

Inert Gas Welding (TIG) [1,2] and Metal Inert Gas welding (MIG) [3,4]. Alloy Steel referred in MyreRutz [5] such as ASTM A335 P22, ASTM A335P11, contains Cr and Mo as alloying elements. This composition delivers good capability to weld along with increased resistance to scratch. Presence of Cr improves resistance to oxidation and corrosion, while Mo is helpful in enhancing strength at raised temperatures [6]. The combination of these two is also helpful in enhancement of high temperature hydrogen attack and creep. ASTM specifies various combinations of Cr and Mo as alloying element to get a variety of steel [7,8]. Similarly, the reinforcement of some material in the matrix of base material is utilized to enhance its mechanical properties. Calcium carbonate up to 6 wt% is reinforced in banana fibre alongside epoxy adhesive to enhance mechanical properties of the banana fibre. The result showed increase in tensile strength of the composite as reported by Srinivasan et al. [9]. Similar result of improvement in strength and stress relieving is reported by many researchers [10-12]. Improve-

ELSEVIER

Experimental study of electroless plating on acrylonitrile butadiene styrene polymer for obtaining new eco-friendly chromium-free processes

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ABSTRACT

The current metallization process requires chromium in both stages of electroless and electrolytic plating. It is well-known that trivalent and hexavalent chromium are hazardous chemicals and are carcinogenic to humans. They are harmful to both human beings and the environment. Hence an alternative method must be designed to reduce or eliminate this harm to humans and the environment. The demand for light-weight, cheap, durable and good-looking products are growing, and metallization is the only available method. So, it is imperative to discontinue the use of carcinogenic chemicals in the process and achieve the same results. This research cites an initial study of different processes as compared to the commonly used etching procedure. Here in the proposed work surface is prepared without using chrome in the etching solution. In the present work, eco-friendly chromium-free electroless plating is performed on ABS plastic specimen. After etching the surface of the specimen with the sulphuric acid, we observe microscopic holes on the surface. These pores enhance the process of bonding of plastic with deposited metal. The presence of micro-pores and formation of the metallic layer over the plastic substrate indicates the success of the new chromium-free metallization process. The study concludes that this new eco-friendly chromium-free etching could substitute the trivalent and hexavalent chromium during etching in the electroplating industry. It will help the avoidance of health problems at existing workplaces and reduce the toxicity of generated waste.

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1. Introduction

Techniques of chemical processing, plating on plastics started commercially, as a result of multifarious technological advancements in mid-twenties. Today, a large number of industries, including automobiles, electronics, plumbing and appliances use plastics that are plated [1]. Plating on plastics is done through two differentiated stages, electroless stage and electrolytic stage. The samples are immersed in different solutions to get metalized. It requires adequate immersion times and working temperature for each solution to attain metallization. The conventional metallization procedure is: initially, samples should be washed in a solution.

This first stage is optional and is used to clean the surface from dirt, oil and grease. The next step is etching. The etching solution is a mixture of chromium hexavalent, sulphuric acid and some additives that remove some part of the plastic surface to increase the area and create some micro-holes on the plastic surface by the reduction of chromium hexavalent.

Next process is activation. Activation solution is a mixture of palladium and tin complex in chloride acid and additives. The palladium solution feature is being deposited as palladium metal in these micro holes created in the acrylonitrile butadiene styrene (ABS) surface. And it also becomes a catalyst agent for the chemical nickel deposition. Therefore, the following stage is the accelerator solution. The accelerator is a mixture of the hydrochloric acid-based solution. It has the role of removing the excess of hydrolyzed tin hydroxide. Activator solution is a mixture of palladium and tin complex in chloride acid and additives. The palladium solution

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Comparative study of silicon dioxide and kaolinite ratio for temperature and humidity variations of earth energy enabled cooling system and traditional cooler

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ABSTRACT

The earth energy enabled (EEE) cooling system is designed in order to utilise the heat capacity of the earth effectively. For buildings, the EEE cooling systems are an effective passive heating and cooling medium. All countries opt for different types of solutions in order to decrease the consumption of residential building energy. In light of this, a new device called earth-air heat exchanger is under the development stage for achieving the increased efficiency and hence the improvement in economic competitiveness. This paper presents the comparative studies of silicon dioxide and kaolinite ratio for temperature and humidity variations of EEE cooling system and traditional cooler with some modifications in order to explore some new aspects by using water in place of air and the basic cooling principle of a simple cooler or cooling tower for cooling in summer season. A comparison of cooling effect produced by the traditional cooler and the EEE cooling system for different conditions has also been made. Results show that proposed EEE cooling system is much more efficient than the traditional cooler. It is shown that the EEE cooling systems are realistic approach towards energy consumption. They are the future of heating–cooling technologies.

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1. Introduction

In the present scenario of world energy, the sources of conventional energy are depleting very fast. Non-conventional energy sources provide a better option of clean and sustainable energy. Air conditioning is common in residential places, buildings, offices and industries in order to achieve comfort conditions. Ozone layer is depleted by the chlorofluorocarbons (CFCs), which are being used as refrigerants, and this is further leading to global warming. In order to minimize depletion of the ozone layer and global warming and to reduce the consumption of high-grade energy, various techniques are explored. The earth energy enabled cooling system is one of the promising techniques [1,2]. The schematic diagrams of earth energy enabled (EEE) cooling system and traditional cooler are shown in Figs. 1 and 2. In the traditional cooler, transparent

PVC pipe delivers water from the sink to the water trap fitted in the main body of the cooler. Through these holes, the water goes to the drainage compartment via khus (the traditional wooden coolant/ moisture trap). The exhaust fan sucks the cool air from air pockets (above water trap) and delivers it to the room through a rectangular-shaped duct. Main disadvantages of the traditional cooler are that it can function only in dry regions where humidity is less and cannot be used in coastal and highly polluted areas. It consumes more electrical power and needs water to operate. It creates noise during the operation. It can become unhygienic quickly; therefore, it needs regular cleaning of the water tank and water pads [3,4]. In the earth energy enabled cooling system; the water tank of the traditional cooler is used as a sand reservoir.

The ratio of silicon dioxide and kaolinite is 2:0.5. This ratio is selected to increase the thermal capacity of the soil so that soil can take more time to heat up. Water collected at the bottom of the chamber starts flowing through the pipeline when the suction pump is started. During summer the temperature of groundwater

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3D scanning of a carburetor body using COMET 3D scanner supported by COLIN 3D software: Issues and solutions

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ABSTRACT

Nowadays, the industry uses 3D Scanners for reverse engineering, new product design, rapid manufacturing, multimedia, architecture, inspection, and quality control. The scanning process converts a real object into a digital format. This paper's essential purpose is to show the use of a 3D blue light Scanner/COMET 3D to redesign a carburetor body. The paper identifies different issues involved in the processes to help future users. COMET 3D does scanning of the carburetor body by which COLIN 3D software is used for measurements, editing, and analyzing of the acquired point clouds data. This paper also identifies the necessary steps to undertake 3D Scanning and part dimensioning for a carburetor body. It also discusses the error/problems that occurred during the process. The applications of non-contact blue light 3D Scanners are many as they can be innovatively used to redesign an existing part, architecture designing, and reducing production cycle time, biomedical and associated applications. This paper's contribution lies in achieving a step-by-step procedure of scanning any three-dimensional object as this helps in understanding the 3D scanning hardware and support software. It provides good knowledge of how to resolve the issues that can cause an error during the measurement of the surfaces and scan objects.

1. Introduction

The primary function of the 3D Scanner is to convert a real-life object into digital form. This Scanner collects information about the exact shape and size of the object and records these data [1]. In the fourth industrial revolution, there is an essential requirement for digital manufacturing. A 3D scanner captures the physical object's image by using the concept of the white or blue light without making any contact with the surface of the object. This technology does not disfigure the object surface and is a non-contact device, and even the light (blue/white) is harmless to the human body. 3D scanners develop clouds of data from the object surface. These scanners have sensors and are equipped with one/two cameras, which take several images of the physical object during the measurement. These images are analyzed through a high-end computer, where 3D scanning software calculates point coordinates throughout the visible area under scan [2–4]. This technology's applications are for industrial design, documentation of cultural artifacts, quality control/inspection, reverse engineering, and prototyping. 3D Scanner technologies have a wide range of applications. Its range starts with designing the smallest tooth gear to one of the national monument [5–7]. Many product development/manufacturing companies are implementing the concept of reverse engineering to reduce the cost and time associated with their product development cycle [8]. In the product design and development process: a designer tries to understand and observe the market, the requirement of the customer and their limitations; quick synthesis of this information to develop some new concept or making further improvement in already existing products; then redesigns, generate prototypes and analyses the same; lastly implements changes in the design step with technologically advanced procedures. This goes on as iteration until we obtain a satisfactory product. Fig. 1 shows the above steps of the product development process, and we analyzed that it requires more time & associated costs to develop a new product. Hence, to reduce the cost, and excess time, it needs a digital data of the product, which is quite convenient for redesigning and analysis through available customized software.
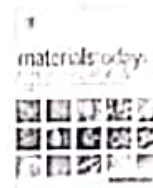
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Experimental study to measure the sound transmission loss of natural fibers at tonal excitations

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ABSTRACT

In this paper, the acoustical sound absorbing property such as Insertion Loss (IL) or sound transmission loss (STL) of natural fibers is measured experimentally. The STL is measured for tonal acoustic excitations (one-third octave band harmonic frequencies). The tonal acoustic excitations are generated by using acoustic transducer (loudspeaker) and passed through the various natural fiber samples. The primary objective of this work is to measure the absorption properties of available natural fibers so that they may be replaced with glass material or other synthetic fibers (such as glass, carbon, graphite etc.) for various engineering and architectural applications. The natural fibers used in this study are banana fibers, coconut coir fibers, hemp fibers, jute fibers and kenaf fibers. The diameter and the thickness of the natural fiber specimens are 0.160 m and 0.03 m respectively. It is observed from this experimental study that the sound absorption by the kenaf fibers is more as compared to other natural fibers at tonal one third-octave band harmonic acoustic excitation frequencies.
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1. Introduction

Different noise sources such as harmonic noise and broadband acoustic excitations are responsible for noise pollution. The harmonic noises come from engine like structures, where the source of excitation is generating sound at single or tonal frequencies. Train noise, traffic noise, construction noise, machinery noise, aircraft noise, ambulance siren noise etc. all sources are responsible for broadband or random acoustic noise excitations. It is seen that the reduction of the tonal noise is easy as compared to broadband excitations. The continuous exposure to noise pollution can create severe effects on the human health [1-3]. Passive and active noise control methods can be used to control the noise. The passive noise control methods do not require a power source to reduce the unwanted sound rather it uses the material properties (acoustical properties) for attenuation of unwanted sound. In these methods, sound absorbing or sound isolating materials are used. Passive methods are effective for medium and high frequency noises. The acoustical properties of porous, synthetic and natural fiber materi-

als can be used to attenuate the unwanted sound energy. The most important issue to control the noise by using passive methods is the size of the absorbing materials. Various factors such as type of the material, its dimensions, and its properties directly influence on the reduction of unwanted sound using passive methods.

2. Literature review

In this section, a detailed literature review is presented. Parikh et al. [4] with the help of needle punch technique constructed a floor covering of automobiles. Natural fibers such as kenaf, jute, waste cotton in blends with polypropylene and polyester binders were used by the authors. It was observed that the sound absorption coefficient of floor covering increases with the increase in frequency. Arenas and Crockert [5] presented the sound absorbing natural fibers such as cotton, kenaf, hemp, wood, flax, jute suitable for the applications of passive sound reduction. Thilagavathi et al. [6] studied the natural fibers such as banana, jute and bamboo reinforced into polypropylene (PP) matrix. The impedance tube transfer function technique was used to test the sound absorption. It was observed that the bamboo/PP blend has the highest sound absorption coefficient. Fatima and Mohanty [7] investigated the natural rubber latex jute. The sound absorption coefficient and

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Significance of Health Information Technology (HIT) in Context to COVID-19 Pandemic: Potential Roles and Challenges

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Abstract. Health information technology (HIT) refers to the concept of applying cloud-based services, internet, connected network, etc. in healthcare. It mainly utilizes electronic health records, information, and data related to the patients for providing the treatment and services in a more effective and advanced manner. This study attempts to propose roles and applications and identify the impact of the concept of HIT on serving the patients during the ongoing COVID-19 pandemic period. This paper also assesses the significant impact of HIT in the healthcare sector during the COVID-19 crisis. The medical decision support, e-sign-off tools, bar-coding approach, advanced medicine dispensing, e-patient portals, etc. are numerous data-sharing and network system-based HIT services. It has many capabilities to shift the working culture of medical facilities while serving and treating patients with a higher care level and impressive satisfaction, especially so during this COVID-19 pandemic. Interoperability and tele-healthcare have also become practicable with the proposed HIT approach.

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Letter to Editor

Corona warriors under risk during COVID-19 pandemic

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Dear Editor,

COVID-19 has emerged as a pandemic for the world population, especially for so-called corona warriors, i.e. doctors, nurses, healthcare professionals, police/army personnel and media.[1] Movement of most of the persons was restricted because of lockdown arising out of COVID-19 pandemic.[2-4] However, it was corona warriors who have to bear maximum social, mental, physical and economic pressure as of COVID-19. These brave hearts were left with direct and indirect contact with COVID-19 patients with or without proper personal protective equipment.[7] whereas others were required to follow the physical distancing norms and other guidelines issued by Government and other health organisations. Corona warriors worked for long hours, touched the articles and stayed away from the families due to which their immediate family members suffered from the feeling of extreme anxiety. The precious life of warriors and their immediate family members were at a high risk of transmitting MERS-CoV.[8,9] Moreover, the lack of support at the levels of governments, hospitals and other places even added to their stigma.

The situation had been worsening day by day in India as the number of reported positive cases and the deaths as a result of COVID-19 is increasing. The positive cases have been reported for the upfront workers/officials, celebrities, politicians, bureaucrats, etc. There has been acute shortage of ventilators required for supporting patients.[10] As seen from the recent trends, persons who are cautious enough and have comparatively lesser public dealings are not getting infected. A number of technologies have been reported for early detection of coronavirus and providing healthcare

facilities to the COVID-19 patients from the remote place.[11-13] A recent study conducted by MIT reported that it is predicted that India would have around 0.287 million cases daily in the starting months of the year 2021. In the wake of this worsening situation, a serious thought is needed at all levels to defend and protect these corona warriors from getting infected quite frequently as they get in touch with the public to further deteriorate the situation in the country.

We personally believe that this is a wake eye call for all of us to give a preference to health and education to devise some ways and methods to compensate these warriors in the form of allowances, leaves, travel and other benefits who were made to fight this war-like situation without proper equipment after the country/world gets out of this pandemic.

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Conflicts of interest
There are no conflicts of interest.

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Letter to Editor

Advancement of multi-agent system in healthcare during COVID-19 pandemic

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Dear Editor,

A multi-agent system (MAS) is an efficient approach to combat the complex structure of the e-medicine system The main features of the MAS are decentralization, flexibility, personalization, proactivity and security, which enable this platform of a patient to combat the pandemic. This system consists of a set of agents that divide a problem into sub-problems, which may be solved by these autonomous entities, for example, CARREL.[1] Based on the degree of the interdependency of tasks, agents may be concurrently running in various computers. The general performance of the system is improved; for example, health agents. MAS can change dynamically at runtime, for example, K4care. Personal agents associated with each patient may continuously monitor his/her medical information and raise the appropriate alarms when a problem is detected; for example, GerAmi and Aingeru.[2,3]

Figure 1 represents the MAS process for the treatment of COVID-19 patients. Figure 1 also shows how the patient goes through the admission and treatment process. If the patient does not have a badge, the data recorded during its transition at bed reservation service are verified and completed. A hospitalisation badge is then given to the patient, this contains data related to his/her stay, and then, all the data will be displayed on healthcare worksheets. If the patient has a valid hospitalisation badge, then he/she will go to the concerning care units (CUs). Medical staff indicates all the related information regarding a patient,
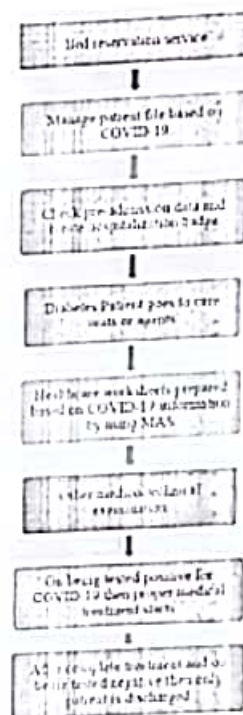
Figure 1: Multi-agent system enabled process for the treatment of patients during COVID-19 pandemic

his/her symptoms and all the necessary test reports for COVID-19 on designed healthcare worksheets. Once the treatments in the CU are finished, then the patient

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Finite element analysis for predicting the vibration characteristics of natural fiber reinforced epoxy composites

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ABSTRACT

Modal analysis is a tool to predict the vibration characteristics such as natural frequencies, mode shapes and viscous damping coefficients of the structures. These characteristics play an important role in engineering design and analysis. In this paper, the prediction of vibration characteristics or modal-modal of cantilever beam made of neat epoxy and various natural fiber composites carried out by using finite element analysis software ANSYS 20.0. In this study, the natural fibers such as jute, banana, coconut coir, hemp and kenaf fibers are used as reinforcement in the epoxy matrix. The size of beam is 160 mm × 20 mm × 3 mm. The volume fraction of fiber is 33.33% taken for all natural fiber composite materials. The natural frequencies, damping factor and frequency response function bode plot are obtained with the help of ANSYS software. The damping factor is found out using half power bandwidth method from frequency response function bode plot. The natural frequency and damping factors of different natural fiber composites are compared with epoxy material. It is found from this analytical study that the damping factor values for each natural fiber composite material have higher values corresponding to each mode than that of epoxy material. Hence, it is concluded that the natural fiber composites have better damping properties than epoxy material. Hemp and kenaf fiber composite materials have similar values of natural frequencies for lower modes (1st mode and 2nd mode) and at higher modes (5th mode and 6th mode) respectively.

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1. Introduction

Natural fibers are gaining the remarkable value in the field of engineering due to their frequent availability, low density, low weight, better thermal, and acoustic insulation properties. Natural fiber also used in composite material as reinforcement. So, it is important to predict the vibration nature or damping properties of natural fibers. Natural fibers like hemp, jute, banana, coconut coir, and kenaf fibers have identified due to their high mechanical properties and can be used as reinforcement in the matrix like epoxy. Natural fibers like hemp, jute, banana, coconut coir, and kenaf fibers also show the good acoustical properties to attenuate the unwanted noise. In order to attenuate the higher frequency unwanted sound, the natural fibers in the combination like jute-air-banana and jute-air-kenaf are very effective [1]. The natural fiber shows effective reduction in noise for broadband disturbances such as pink noise, white noise, traffic noise, construction noise, train noise and machinery noise. An acoustical property increases with increase in the thickness of natural fiber panel. Especially kenaf fiber shows exceptionally great acoustical properties than other natural fibers [2,3]. Kenaf is one of the environmental friendly materials with great mechanical properties.

Kenaf fiber treated with 6% of sodium hydroxide shows improved tensile properties. The kenaf fiber used as reinforcement in composite materials shows better structural damping properties [4]. To find out the damping factor form frequency response function (FRF) plot, the half power bandwidth method is used. Half power bandwidth method predicted the better results for acceleration frequency response transfer function [5]. LabVIEW software is used to find out the damping ratio of structure. This software generates the FRF curve for cantilever beam and the damping factor and natural frequencies are found out corresponding to each peak of FRF curve [6,7]. Vibration-based damage detection is a

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Biodegradation of plastics: A state of the art review

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ABSTRACT

Plastics are unquestionably superior materials in terms of their costs, process ability and functional properties. Human lives starts with the use of plastics and more and more plastics are being employed on daily basis. Since polymeric materials do not decompose easily, considering their abundance in the environment, accumulation of plastics in landfill and ocean has been increasing from decades. Most of the plastics waste enters into water which is consumed by sea creatures destroy their habitat. To overcome the problem researchers have researched about the biodegradation of plastics by the degradable enzymes. This review is about biodegradable plastics and the microorganisms which help in degrading the synthetic and natural plastics. Industries have started manufacturing biodegradable plastics using additives like prooxidant and starch etc. Micro-organisms show rapid action on thermoset plastics like polyester polyurethane and some organisms have been segregated or isolated to utilize polyurethane as a sole source of carbon and nitrogen. This review is an attempt to understand the recent development in biodegradation of plastics by enzymes to reduce the impacts of plastic and make the environment safe.
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1. Introduction

Plastics are usually synthetic or semi synthetic organic compounds of high molecular mass and made of long chain polymeric molecules [1]. Plastics generally include a main chain organic link, side linked molecular groups and some organic and inorganic blends added as additives, plasticizers and fillers etc. [2]. Plastics are composed of elements like carbon, hydrogen, nitrogen, oxygen, chlorine and bromine. Plastics are inert that show resistance to decompose but durable because of light weight, low cost and malleable. They can be used in a wide range because of its moldability into different size and shapes [2]. Application of plastics has been increasing every year in every aspect of life and technology. Most abundantly used plastics are polyethylene, polystyrene, polyvinyl chloride, polypropylene and polyethylene terephthalatete [3,4]. Its usage is almost in every sector such as health care industries, building constructions, transportations and households and for disposals items, such as wraps, cups, spoons, trays plate etc [5]. The total amount of plastics manufactured in the world from 1950 through 2019 is 8100Mt. The production of plastics increased from 2 Mt in 1950 to 450 Mt in 2019 [6]. Bio-based or biodegradable plastics currently have a global production capacity of only 4 Mt. The vast majority of monomers are used to make plastics, such as ethylene and propylene, which are derived from fossil hydrocarbons [6]. None of the commonly used plastics are biodegradable resulting in accumulation of plastics in landfills and dispose into water, which do not decompose in the environment and thus threatening the environment and its diverse ecosystems. Plastic pollution in the sea is global concern and found everywhere and throughout the ocean with concentration about 580,000 plastic pieces per square kilometer [7]. A recent review for the United Nation convention on biological diversity document over 600 species ranging from microorganism to whales, affected by marine plastic waste largely through ingestion [8]. To overcome this problem many procedures and methods are being tried. Now many local industries are manufacturing different types of degradable plastic bags or partially degradable bags with the use of additives. Carbohydrates have been using by many industries to synthesis plastics which degrade under U.V radiation and which also degrades by micro-organisms [3].
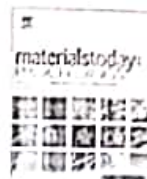
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Fiber reinforced metal matrix composites - a review

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ARTICLE INFO

ABSTRACT

Modern technology has placed increasing demands on materials. The need of hour is to develop the new materials so as to overcome the limitations of the materials existed presently regarding applications in different fields. The materials with properties such as better wear resistance, high specific strength and stability at high temperatures have been in great demand in the past few decades. The properties of conventional materials can be improved by the method of reinforcing whiskers, fibers and particles in to polymers, metals and ceramics. This has resulted in the manufacturing of composite materials. The mechanical properties of fiber reinforced metal matrix composites (MMCs) make them the suitable choice for applications in the fields of automotive and aerospace etc. The paper outlines the overview of fiber reinforced MMCs. The applications, manufacturing methods and mechanical properties of these composites are discussed. Furthermore, this review describes the single fiber push-out test which is developed in the past years so as to measure quantitatively the properties of the interface between the fiber and the matrix in these fiber reinforced MMCs.

1. Introduction

This section discusses the fundamentals, definition, classification, and advantages of fiber reinforced metal matrix composites. In metal matrix composite (MMC), at least one constituent is a metal or alloy which forms at least one percolating network. The other constituent is embedded in the matrix material. It is called the reinforcement. A high strength material which is called reinforcement is dispersed into the matrix material to make a metal matrix composite material. In order to prevent the chemical reaction of the reinforcement with the matrix, the coating of the reinforcement surface can be done [1]. Fiber-matrix interface is defined as the bounding surface between the reinforced and the matrix. A discontinuity in some parameter occurs across the interface. This discontinuity can be sharp or gradual. Practically, the interface has a finite thickness. Some of the material properties such as crystal structure, elastic modulus etc. change from one side to the other in the region of interface. The combination of the behaviors of reinforcement, matrix and the interface provides the resultant behavior of the MMCs. The interface between the reinforcement and the fiber occupies the extensive internal surface area due to which

the interface is considered to be extremely important in the MMCs. The value of internal surface area occupied by the interface can go up to about 3000 cm^2/cm^3 in a composite which contains a good reinforcement volume fraction [2]. Depending upon the reinforcement form, the MMCs can be grouped in to four categories [3]: (a) fiber reinforced MMCs which contain either continuous or discontinuous fiber reinforcements, the reinforcement can be in the form of whiskers which have diameter approximately in the range of 0.1–0.5 μm and the length to diameter ratio can go up to 200; (b) particulate-reinforced MMCs which contain either particles or platelets of size varying from 0.5 to 100 μm; c) dispersion-strengthened MMCs which contain particles of diameter less than 0.1 μm; and (d) in situ MMCs for example directionally solidified eutectic alloys. The main advantages of MMCs when compared with the unreinforced materials such as steel are [4]: better specific strength, better specific stiffness, better wear resistance, better damping capabilities and better resistance to corrosion. These properties have resulted in the increased interest in fiber-reinforced metal matrix composites [5]. However MMCs have some disadvantages when compared with the monolithic metals. These disadvantages are the higher cost; technology is relatively immature, complex manufacturing methods and limited service experience.

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Letter to the Editor

Letter to the editor in response to: Telemedicine for diabetes care in India during COVID19 pandemic and national lockdown period: Guidelines for physicians

Dear Editor,

We were delighted to read a recently published article on the use of telemedicine for diabetic patients during COVID-19 pandemic [1]. The authors have duly elaborated the importance of telemedicine in the clinical practice management of the diabetic patients, but its applications can be applied to many other medical specialties. The telemedicine takes an edge over other technologies, as it offer the medical like facility at the door steps for the needy ones. The patients can have regular interaction sessions with their corresponding physician in such critical time. Secondly, telemedicine offers the patients the necessary and timely medical regarding their ailment while they are stuck in a remote location [2] and that too without putting much efforts.

Chronic diseases such as Diabetes are highly responsible worldwide in an increased death rate due to COVID-19 pandemic. This virus has the ability to sustain on various surfaces [3]. This may be decreased by having the good glycemic control. The situation of worldwide lockdown due to COVID-19 disease has resulted in the deteriorated health of diabetic patients. The real time health condition of these patients can be monitored by employing the telemedicine technology as a response in times of restrictions imposed on the movement of people due to the spread of COVID-19. The medical record and information related to the patients is exchanged between the places located far from each other with the help of advanced technologies for the purpose of providing health care services to their patients, by the doctors [1].

The universal availability and the use of smartphones are a boon for using telemedicine technology. The major advantage of this technology is in helping the patients to connect with the doctors while being at home thereby avoiding the risk of being getting infected with the Coronavirus while visiting the hospitals for the treatment. It is however, necessary that the doctors undertake several instructions for using this technology, which is rather easy and user friendly and not a 'rocket science'.

With its capability of digital platform, this technology is successfully used for chronic care and proper management of health. Proper monitoring of vital sign like blood pressure, blood sugar levels, and other required activities can be performed from home during this COVID-19 outbreak. The diabetic patients can schedule their visit from homes which also helps to save transportation cost. It has ability to effectively interact with patient to improve the clinical outcome [4]. The patients can therefore be remotely managed by the physician with proper management of condition in daily basis.

We believe that this technology can change the way how we manage diabetes to improve the quality of treatment. This also provides alternative approaches to manage high risk infected patient. In future, this technology could seem innovative to manage diabetes during COVID-19 pandemic. The major caveat to the use of this technology are making wrong clinical decisions (at times), due to non examination of the patient and relying on their investigation reports and history. Secondly, many patients may not feel satisfied without having a face-to-face contact with the treating doctor. But, due to the pandemic situations, the telemedicine is perhaps the best way out for both the patients and the doctors. Different alternative solutions are also provided to sort out the shortage of ventilators required for COVID-19 patients [5].

We agree with the authors that there may be some legal issues related to telemedicine consultations, but the recent approval by the Medical Council of India and the legal courts have given a respite to some extent in this regard. However, we feel that despite an availability of telemedicine facilities in India and abroad for many years, the use of it has not been adequately used so far. This pandemic has given us the golden opportunity to explore using this facility for our patient effectively, not only in this pandemic but also later on!

Declaration of competing interest

The authors declare that they have no conflict of interest in the publication.

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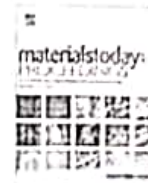E-mail address: shashi.bahl@ptu.ac.in (S. Bahl).

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Automation and manufacturing of smart materials in additive manufacturing technologies using Internet of Things towards the adoption of industry 4.0

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ABSTRACT

Mass customization and personalization are the significant implications of Industry 4.0. Even though additive manufacturing (AM) technologies possess the capability to personalize final products, they cannot be used for mass production of the 3D printed job on a large scale. Their inability to perform production processes for large-sized objects adds to the disadvantages. Consequently, the industries are hesitant regarding the idea of AM techniques to carry out commercial productions. Therefore, this research-based study aims to efficiently identify and utilize Industry 4.0 technologies to improve AM processes' reliability and mass 3D print smart materials for manufacturers globally. We explore the requirement for Industry 4.0 technologies for AM processes and study the advantages of the application of information technologies (IT) in AM. Further, we analyze how the Internet of Things (IoT) additive manufacturing integrated techniques will benefit the industries and material manufacturers. However, the paperwork is confined to theoretical work. Since automation in AM is a fledgling concept, the available material for research-based study is limited. We conclude that IoT application in AM improves production processes' efficiency followed by reduced manufacturing waste and fulfilled customer specifications. AM has become an essential industrial technique for product innovation and development, therefore, it is necessary to bring reforms to make this technology customer-friendly.
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1. Introduction

The fourth industrial revolution also known as Industry 4.0 has changed the manufacturing industry's face. Industries worldwide are adapting to the ongoing mechanical automation trend in conventional manufacturing processes which has led to the rise of intelligent manufacturing [1], one of the most widely researched topics these days. Cyber-physical systems and integration of physical processes, storage systems and production facilities that coordinate, exchange information autonomously and monitor each other form the basis of Industry 4.0 [2]. The manufacturing industries are availing opportunities that follow Industry 4.0, the emerging networking technologies being machine to machine (M2M) communication, 5G and software designed Networking (SDN) [3]. Devices embedded with software, sensors and similar computer technologies can communicate with each other, enabling data transfer and real-time monitoring. For instance, mobile phones are used not just for communication purposes nowadays; they can also be connected to machines to control specific machining processes, obtain data and resolve machining errors in real-time [4]. The management of supply chain processes through ERP cloud interfaces is also taking several supply chain industries by storm. Digitization of manufacturing processes has numerous advantages associated with it, including increased time efficiency, improved productivity and enhanced quality. The ability of devices to communicate without human intervention has reduced the amount of human effort required subsequently reducing error chances [5–10].

In 2014, the Internet of Things had started to evolve rapidly which marked the advent of Industry 4.0. Technologies worldwide had started to adapt to this reality leading to the Internet of Things hitting Gartner's hype cycle's 'Peak of Inflated Expectations' in the same year. A research report published by Pew Research Centre in

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Magneto-rheological abrasive finishing (MAF) of soft material using abrasives

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ABSTRACT

Magnetorheological finishing is highly developed unconventional machining process used for nanometer range surface finishing with the help of magnetic abrasive particles. The cutting forces are generated and controlled by the magnetic field in this process, which is developed between the electromagnetic poles and magnetic abrasives. Excellent process capabilities were attained by this technology. But one of the major limitation or drawbacks is in the wide utilization of the process in industries. This is due to the huge cost of magnetic abrasives, which act as cutting tool in these processes. Very few studies have been performed in the direction of development of new or alternative magnetic abrasives. The present research mainly focuses on the development of magnetic abrasives and performance of these magnetic abrasives. This investigation aims to develop magnetic abrasives by different techniques i.e. Simple Mixing, Adhesive bonding, Microwave sintering and Mechanical alloying, then investigating the performance on brass work piece with SiC abrasives and to find the best technique. The surface topography was done through the x-ray diffraction (XRD) and scanning electron microscope (SEM) to analyze the surface obtained after finishing. The Mechanical Alloying is the best technique concluded through this work to prepare the magnetic abrasives, which further gives the best results in terms of Material removal rate (MRR) and percentage improvement in surface finish (PISF) upon the internal surface of hollow cylindrical brass pipes.

1. Introduction

There is a higher demand for the precise components in today's highly competitive scenario; the components with better quality surface finish are always demanded in advanced engineering industries like automotive, semiconductor, aerospace and biomedical. The properties like "wearing resistance", "corrosion resistance", etc. are the most affected properties due to the surface finish, thus the surface finish proves to be the important functional requirement of the component. But, it has been observed, that the modern engineering materials were tough to finish economically by the traditional finishing methods like grinding, lapping and honing. This results in the development of advanced finishing methods in today's scenario for accomplishing the better surface finish and dimensional accuracy of the components. In the last few decades, many of the modern finishing processes have been developed to cover up the drawbacks of conventional finishing processes, i.e. requirement of the harder tool and accurate control over finishing forces. The surface finish of the order of nanometres can be achieved by the modern machining process as it has the ability to remove a small amount of material [1,2]. The surface finish in the range of nanometre could be attained because of extremely small material removal in these modern finishing processes with low dimensional tolerance [3].

Some of the modern machining methods make use of the magnetic or electric field to regulate the finishing forces performing on abrasive molecules. Few finishing processes that use the magnetic field are Magnetic Abrasive Flow Machining (MAFM), Magnetic Float Polishing (MFP), Abrasive Flow Machining (AFM), Magnetorheological Abrasive Flow Finishing (MRAFF), Magnetorheological Finishing (MR Fluid), and Magnetically Assisted Abrasive Finishing (MAAF). In MAAF process the surface of the work pieces

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Improving material quality management and manufacturing organizations system through Industry 4.0 technologies

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ABSTRACT

In these changing times, Industry 4.0 technologies are being adopted in many parts of the world. These technologies are used to develop smart materials, smart factories, smart logistics, smart warehousing and smart supply chains. In the business aspect, it has the potential to solve complex manufacturing problems. This paper provides a thorough study of various Industry 4.0 technologies for improving the material quality and manufacturing systems. We have listed out various available technologies, their characteristics, and benefits of effective management in the upcoming industries. Digital technologies help companies optimize their material wastage and inventory which ends up in cost reductions. With remote collaboration, on-site and off-site employees can easily collaborate as and when needed. These technologies ultimately reduce communication gaps and help them stay up to date with the information. Smart predictive analysis will help to properly monitor the equipment in the industries using Industry 4.0 technologies. Faults in materials can be detected and resolved at an early stage. Further, this provides transparency in the systems and processes and fulfills the required expectation of the customer.
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1. Introduction

Industry 4.0 technologies are now being used heavily throughout the world. These technologies have great potential and have brought significant changes in almost all industries. A report published by Markets and Markets states that the current market share of Industry 4.0 may be more than USD 71.7 billion and forecasted that it would be more than USD 150 billion by 2024 [1]. Due to the COVID-19 pandemic, this technology's adoption rate has increased, and market share may even be higher than predicted. With such an immersive use of these advanced technologies, a proper management system is needed [2,3]. This paper focuses on Industry 4.0 technologies for proper management system during manufacturing. In the manufacturing industry, technologies like Data Analytics, Cyber Security, Industrial Internet of Things (IoT), Advanced Robotics and Additive Manufacturing (AM) are being used. This industry has changed heavily and is expected to change more in the days to come. With all the new emerging technologies, a proper management system should be kept to manage them. With proper management systems, these technologies can be used to the best of their abilities. Javaid et al. [4] presented the Industry 4.0 technologies useful for confronting the COVID-19 pandemic. Bahl et al. [5] discussed telemedicine (TM) applications, which can be very helpful to combat the COVID-19 pandemic. Industry 4.0 technologies are used to enhance the digital information during the COVID-19 outbreak [6–11].

2. Research objectives and methodology

Industry 4.0 technologies are now present everywhere. With the onset of the COVID-19 pandemic, even small businesses and industries have started implementing many of these technologies. Thus, for the best use of these technologies, a proper management system is needed. This paper aims to study the critical technologies of Industry 4.0 that can be adopted for improving the performance of the management systems of a manufacturing-based industry. Initially, Google scholar has been utilized to take an initial sample of what types of articles are available. Regarding Google scholar, broad search terms were initially used to establish a list of research articles that were the primary source and peer-reviewed. We used Emerald, IEEE Xplore, ScienceDirect and NCBI databases to provide

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Advancements in Biosensor Technologies for Medical Field and COVID-19 Pandemic

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Abstract. World health organization (WHO) has declared the COVID-19 outbreak as a public health emergency of international concern and then as a pandemic on 30th of January and 11th of March 2020, respectively. After such concern, the world scientific communities have rushed to search for solutions to bring down the disease's spread, fast-paced vaccine development, and associated medical research using modern technologies. Biosensor technologies play a crucial role in diagnosing various medical diseases, including COVID-19. The present paper describes the major advancement of biosensor-based technological solutions for medical diagnosis, including COVID-19. This review-based work covers the biosensors and their working principles in the context of medical applications. The paper also discusses different biosensors and their applications to tackle medical issues, including this ongoing pandemic.

Keywords: Biosensors; biosensor applications; COVID-19; medical applications; pandemic.

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Bioengineering Technology in Context of COVID-19 Pandemic: Potential Roles and Applications

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Abstract. Bioengineering (BE) technology has significant influence on the healthcare environment. This has grown steadily particularly since the medical practice has become more technology based. We have tried to assess the impact of bioengineering in tackling the COVID-19 pandemic. The use of bioengineering principles in healthcare has been evaluated. The practical implications of these technologies in fighting the current global health pandemic have been presented. There has been a shared drive worldwide to harness the advancements of bioengineering to combat COVID-19. These efforts have ranged from small groups of volunteers to large scale research and mass production. Together the engineering and

Strain energy and finite element analysis to predict the mechanical properties of vapor grown carbon fiber reinforced polypropylene nanocomposites

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ABSTRACT

In this paper the mechanical properties of the nanocomposite materials are predicted by using the finite element and strain energy method. The Numerically Integrated elements for System Analysis (NISA) software is used to make a representative volume element of vapor grown carbon fiber reinforced nanocomposite material. The predicted mechanical properties are storage modulus, loss modulus and loss factor. The fiber is aligned unidirectional and the load is applied at one end of the representative volume element. In this numerical study, the fiber is inside the representative volume element. The diameter of the vapor grown carbon fiber is 200 nm and length is 3800 nm. The aspect ratio is 19. The predicted results are compared with the extended rule of mixture and with the results reported in the past. It is observed that the storage modulus is increasing with respect to aspect ratio. However, the loss factor is showing decrement in its behavior. Also, the loss modulus is increasing as the fiber aspect ratio increases but sudden drop is found at the higher values of the aspect ratio.

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1. Introduction

One of the applications of the nanotechnologies is the study of materials or particles at nanoscale. Finite element method (FEM) is one of the important tools that can be used to predict the mechanical and other properties of nanomaterials or nanocomposites. Ruoff and Lorents [1] used known elastic properties of graphite sheet to derive the mechanical properties of single and multi-walled carbon nanotubes. Schadler et al. [2] studied the mechanical behavior of multiwalled carbon nanotube/epoxy composites in both tension and compression and observed that the load transfer to the carbon nanotubes is higher in compression mold. The value of the compression modulus is higher as compared to tensile modulus because during the load transfer in multiwalled nanotubes only the outer layer is seen to be in tension whereas other layers in compression. Finegan et al. [3] used dynamic mechanical thermal analyzer for measuring the storage modulus and damping of vapor grown carbon fiber nanocomposites. Wetzel et al. [4]

introduced nano and micro scale particles into the epoxy matrix to enhance its various properties such as impact energy, flexural strength, dynamic mechanical thermal properties and wear.

Liu and Chen [5,6] used finite element based model of representative volume element (RVE) to predict the mechanical properties of carbon nanotube-based composites. Authors applied an extended rule of mixtures (ERM) to estimate the young's modulus of the RVE in the longitudinal or axial direction. Papanikos and Tserpes [7] proposed a three-dimensional finite element model for armchair, zigzag and chiral single-walled carbon nanotubes to predict its mechanical properties. Gojny et al. [8] studied different types of CNTs such as single-walled CNTs, multi-walled CNTs, double-walled CNTs, to find their influence on the mechanical properties of nanocomposites and surface functionalization of fillers. The authors studied the effect of filler contents, the varying dispersibility, aspect ratio, the specific surface area and an amino-functionalization on the properties of nanocomposites. Seidel and Lagoudas [9] predicted the effective elastic properties of CNT/polymer nanocomposites using different micromechanical techniques. Ashrafi and Hubert [10] used FE method along with strain energy method to predict the elastic properties of

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Removing uncertainty in the boundary condition of five degree of freedom spring mass vibratory system using direct updating method

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ABSTRACT

In this paper, direct updating algorithm is used to update or correct the analytical mass and stiffness matrix of the five degree of freedom spring mass system. In the analytical model, there are assumed values of the material properties, dimensions and most importantly the boundary conditions. The material properties of any system can be approximately measured by doing experiment on the same material and treated it as a free-free beam. The dimensions of the simple structures can be measured by using mechanical equipment's such as scales or vernier calipers. However, it is very difficult to estimate the correct boundary condition in the analytical model. In this work, the analytical mass and stiffness matrices are updated by using the Eigen values and the Eigen vectors of the experimental model. The experimental model is named as 'simulated-experimental model' in this study. The direct updating method is used to update the mass and the stiffness matrices of the analytical five degree of freedom model from the simulated-experimental model. It is assumed that the error is in the boundary condition of the analytical model. For analytical model the assumed boundary condition is cantilever type. However, for the simulated-experimental model the boundary condition is clamped-clamped type. The experimental modal model is always correct and it is our duty to modify the analytical model accordingly. It is found that the application direct updating method on the five degree of freedom system has updated the modal-model of the analytical model. The maximum percentage error in the natural frequencies of the analytical model is 45% that reduces to 0% after applying the updating algorithm on the analytical model. The frequency response function curve is also plotted to validate the results.
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1. Introduction

Any recurring movement of an object in to and fro direction is called vibration. Motion of guitar string, drums, building vibrations due to earthquakes is typical examples of vibrations. The system in which the output relies upon the input and characteristics of system is known as vibratory system [1]. However, there are many errors in the vibratory system e.g. boundary errors, property errors and errors in the dimensions. These errors can be removed by using various updating methods. Friswell et al. used direct updating (DU) method to update damping and stiffness matrices [2]. Carvalho et al. also worked with direct updating method to update the system matrices [3]. Yang et al. proposed a new method to update

structural models [4]. Jahani and Nobari identified shear and young's modulus with the help of modal bases direct updating method [5]. Yang et al. used direct updating method for structural models [6]. Bagha et al. updated a composite beam using the approach of direct updating method [7]. Arora et al. proposed a damped finite element model updating technique to update damping matrices [8]. Steenackers and Guillaume used finite element method updating to update uncertain modeling parameters [9]. Modak et al. used finite element model updating for the dynamic design of a structure [10]. Finite element modeling and simulation can be employed to determine the mechanical properties of the engineering materials [11-19]. It was observed from the literature review that no one has been done earlier to remove boundary uncertainty for five degree of freedom (DOF) vibratory system using DU Method. In this paper, uncertainty of boundary condition in five DOF mass-spring systems is removed by applying direct

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Telemedicine Technologies for Confronting COVID-19 Pandemic: A Review

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Nanomedicine Technology and COVID-19 Outbreak: Applications and Challenges

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Abstract. The coronavirus (COVID-19) pandemic is one of the biggest challenges in the field of healthcare. Nanomedicine is a developing area that has the potential to treat various diseases and control infections. Now, its applications are open for the treatment of COVID-19. We have studied relevant papers through Scopus, Google Scholar, Science Direct and ResearchGate on nanomedicine in context of COVID-19. This paper provides detailed information about nanomedicine in the context of healthcare. It further identifies the primary challenges faced in the current situation. This study provides details about the advancements in the area of nanomedicine in healthcare for fighting the COVID-19 pandemic. Finally, we have identified and discussed various significant applications of nanomedicine in solving challenges thrown by the COVID-19 pandemic. Researchers can work on developing applications of nanoparticles with the size of the novel Coronavirus. Nanomedicine is helpful to repair the cells of an infected patient the help of repair proteins. It also plays a vital role in testing medicine and helps many clinical trials get approval from healthcare agencies. In the future, nanomedicine will be helpful for fighting against this pandemic and creating advancements in healthcare.

Keywords: Nanomedicine; nanotechnology; COVID-19; drugs; testing; healthcare.

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Nanomedicine Technology and COVID-19 Outbreak: Applications and Challenges

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Abstract. The coronavirus (COVID-19) pandemic is one of the biggest challenges in the field of healthcare. Nanomedicine is a developing area that has the potential to treat various diseases and control infections. Now, its applications are open for the treatment of COVID-19. We have studied relevant papers through Scopus, Google Scholar, Science Direct and ResearchGate on nanomedicine in context of COVID-19. This paper provides detailed information about nanomedicine in the context of healthcare. It further identifies the primary challenges faced in the current situation. This study provides details about the advancements in the area of nanomedicine in healthcare for fighting the COVID-19 pandemic. Finally, we have identified and discussed various significant applications of nanomedicine in solving challenges thrown by the COVID-19 pandemic. Researchers can work on developing applications of nanoparticles with the size of the novel Coronavirus. Nanomedicine is helpful to repair the cells of an infected patient the help of repair proteins. It also plays a vital role in testing medicine and helps many clinical trials get approval from healthcare agencies. In the future, nanomedicine will be helpful for fighting against this pandemic and creating advancements in healthcare.

Keywords: Nanomedicine; nanotechnology; COVID-19; drugs; testing; healthcare.

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Experimental investigations into sound transmission loss by different materials at aircraft noise

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ABSTRACT

In this paper, the sound transmission loss by different materials at aircraft noise is measured experimentally. The main objective of this paper is to measure the acoustical or sound absorption properties of glass material, polypropylene material and glass fiber reinforced composite material. The composite material is manufactured at three different fiber volume fractions. The fiber volume fractions are 10%, 20% and 30%. A three dimensional wooden sound proof duct is manufactured in which a long duct is enclosed. An acoustic source is used to generate an aircraft noisy signal. The generated signal is passing through the samples of the different material to measure their sound absorption properties. It is observed that for each fiber orientation, glass material is absorbing more aircraft sound than neat polypropylene and composite specimens. It is concluded that composite material with 10% volume fraction of fiber is performing better than the rest of specimens. This is due to the fact that with the increase in volume fraction of fiber, porosity decreases due to which sound transmission loss decreases. Also, the sound transmission loss of composite specimen with 10% volume fraction of fiber is comparable with that of the glass material.
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1. Introduction

Sound is a form of energy that is transmitted by pressure variations which the human ear can detect. When one plays a musical instrument say a guitar, the vibrating chords set air particles into vibration and generate pressure waves in the air. A person nearby then hear the sound of the guitar when the pressure waves are perceived by the ear. Sound can also travel through other media such as water or steel. Noise is one of the major environmental problems in urban and rural areas. The World Health Organization (WHO) has also acknowledged that the undesirable sound is one of the main contributors to noise pollution. The road traffic noise, ambulance siren noise, train noise, aircraft noise, construction and machinery noise radiates low and high frequency noise components. It puts the psychological and physiological effects on the human beings [1–3]. So, there is a need to control the noise. Passive and active noise control methods can be used to attenuate this noise. In this paper, the passive noise control methods will be explored. The passive methods use the sound absorbing properties of various materials. The porosity is the main contributor.

Casalino et al. [4] discussed some important models such as Gust-airfoil interaction models, Gust-cascade interaction models, Rotor-stator reflection/transmission models and Nacelle noise transmission models etc. to model and attenuate the aircraft noise. The main objective of the present work is to measure the sound reduction by the composite materials for aircraft noise acoustic disturbances. Yuan et al. [5] investigated the convenient and accurate means for predicting the fuselage transmission loss (TL), the fuselage is modeled as a composite cylinder and its TL is predicted with the analytical, the statistic energy analysis (SEA) and the hybrid FE & SEA method. The TL results predicted by the three methods are compared to each other and they show good agreement but in terms of model building the SEA method is the most convenient one. Therefore, the parameters including the layup, the materials, the geometry and the structure type are studied with the SEA method. Lee and Kim [6] investigated the effects of structure on sound absorption and sound transmission loss of a composite sheet. Non-woven polyethylene terephthalate fabrics were bonded to the top side and the bottom side of the polypropylene

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Big data applications to take up major challenges across manufacturing industries: A brief review

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ABSTRACT

Growing population and depleting resources are forcing the manufacturers to become more competent and sustainable. Customers are becoming more and more informed about the product they consume, and therefore, manufacturers need to be flexible and open to new changes taking place. Big Data Analytics (BDA) is one such technology that has transformed the manufacturing sector. Organizations have now become more flexible with regards to their processes and, at the same time, have also improved their product quality. Here in this paper, we have analyzed various advantages of Big Data that manufacturing organizations can exploit for their betterment. We have also discussed examples of certain leading manufacturers and how they can lead to big data-enabled manufacturing. Lastly, we discuss certain shortcomings that need to be addressed to make big data analytics viable for organizations of all sorts and not just for top manufacturers.

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1. Introduction

Big data is one of the nine pillars of Industry 4.0. Though it has been around for quite some time now, it is in recent years that its importance and usage are being explored and analyzed to make it suitable for carrying out predictive analysis for businesses. Gartner in 2001 simply described big data as 'high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making and process automation' [1]. Some analysts consider big data as the electricity for the 21st century due to its importance in powering businesses to make executive decisions based on the data they have analyzed. Big data has three attributes (3Vs) used to understand the nature and characteristics of big data. They are namely: volume, variety and velocity. Volume is the most common attribute as big data is synonymous with a massive, unprecedented amount of data. According to a survey, approximately 2.5 quintillion bytes of data are being generated every day. In fact, in the last couple of years, more data has been generated than the total data generated since the beginning of time. Moreover, in 2020 there was approximately 1.7 MB of data generated per human per second. It is an unfathomable amount of data, and therefore nowadays, companies have data storage capacities of hundreds of petabytes which is to help them in future decision making. The first companies to make optimum use of this data are the tech giants-Facebook, Google. They have an unimaginable amount of data stored on their servers, and this data enables them to improve the system and thereby pave the way for complete automation and artificial intelligence.

Variety is the characteristic of big data that makes it quite different from the traditional data collection techniques for making excel sheets or CSV files. Today data and the old techniques have various varieties and there are images, sensor data, encrypted packages, tweets, posts, videos, etc. The data, thus being generated, is highly varied and unstructured; it is not specific data that could be transformed into an excel sheet. Therefore, to analyze this data and create a bigger picture, sophisticated tools like deep neural networks are required, analyzing the data's hidden pattern to help predict the results [2]. Velocity is another crucial aspect of big data. Velocity is not merely the speed at which the data is being generated, but also differentiates entities. For example, Facebook has to deal with the unlimited amount of real-time data (photos, videos, post) each day. It has over 250 billion photos stored in it has severs,

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Data science applications for predictive maintenance and materials science in context to Industry 4.0

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ABSTRACT

With the revolutionising of the industry to the next generations, machines have become more complicated. If they are not put to regular maintenance then there is more breakdown and disruption in the production line. These days, data science techniques have applications over almost every field and likewise are being applied to Industry 4.0. In this advanced setup, massive data is created and stored every second. Experts with expertise in advanced mathematical and computational skills are in demand to identify root causes of failures and quality deviations of a machine, contributing to minimising a loss in time and money. Moreover, new elements with tailored properties can be discovered with material theories and computational skills. The integration of data science with Industry 4.0 will increase efficiency and will be helpful to predict the quality of material minimising the production line cost and time. Different research articles on industry 4.0, data science and predictive maintenance are identified and studied. This paper identifies five critical processes of data scientists for predictive maintenance and discussed briefly through a literature review. Data science uses various processes, scientific methods, and algorithms to extract knowledge from a large amount of data. It can collect a massive amount of industrial data, which is further used to improve the manufacturing systems' efficiency and reliability. It helps analyse the data and become essential for Industry 4.0.

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1. Introduction

The contemporary industry is undergoing the fourth revolution, where the challenge is integration between industries' physical and digital systems. Through this integration, a massive amount of data is created by the industrial system, which contains real-time events, maintenance logs, and Internet of Things (IoT) data that occur along the production line. Availability of data and customisation are critical features of industry 4.0 [1,2]. With advancements in industries, machines have become complicated, resulting in breakdowns. Thus, machine failure must be identified and resolved, thereby avoiding stoppage and improving the production line's efficiency. According to Harward's business review, data science is the most demanded job of the 21st century [3]. A data scientist manipulatesthe raw data using computational power, statistics, and domain knowledge to identify meaningful patterns.

When advanced computational power is applied to this massive data can, one can bring out valuable information and knowledge, which helps in strategic decision-making, reduces maintenance cost and time, and increases production activities and efficiency while maximising the machine life. These outcomes are known for predictive maintenance and are also called Predictive maintenance (PdM) 4.0. PdM offers the potential to predict failure that had been unpredictable up to now. This term is not entirely new. People have been doing this for many years without realising it. For example, a technician decides when a machine part must get maintenance or repair based on his knowledge, experience and institutions. Javaid et al. [4] discussed the applications of Industry 4.0 technologies to the COVID-19 pandemic. It helps analyse the status of the virus and the research and development process. Bahl et al. [5] presented telemedicine's major applications (TM) technology for confronting the COVID-19 pandemic. TM is a cost-effective technology and provides a safer healthcare delivery solution during difficult times, like in the COVID-19 pandemic. Advanced manufacturing technologies of Industry 4.0 are used to fulfill the

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REVIEW

Blockchain technology and its applications to combat COVID-19 pandemic

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Abstract

Background and aims The world is currently facing multifaceted problems due to the emergence of the COVID-19 (coronavirus) pandemic. Blockchain technology (BT) plays a vital role in creating a platform for adequately managing the COVID-19 pandemic. **Methods** The latest information on the blockchain and its application in solving challenging problems due to the COVID-19 pandemic are collected and discussed from the available literature searched through PubMed, Scopus, and Google scholar. **Results** In this paper, we propose a blockchain-based platform to combat this pandemic. Furthermore, we have identified and discussed nine significant applications of blockchain in solving the problem arising from the COVID-19 pandemic. **Conclusions** The severity of COVID-19 was so tremendous that the World Health Organization (WHO) had to declare it as a pandemic within a month of its full-scale expansion. The greatest challenge most governments are suffering from is the lack of a precise mechanism to detect the newly infected cases and predict coronavirus infection risk. So, we need a technology-empowered solution to fight during this COVID-19 crisis. The various features of blockchain technology, such as decentralization, transparency, and immutability, can help control this pandemic by early detection of outbreaks, fast-tracking drug delivery, and protecting user privacy during treatment.

Keywords Blockchain technology (BT) · COVID-19 · Coronavirus · Healthcare

Introduction

In this worldwide health crisis, the medical industry is looking for newer technologies to monitor and control the COVID-19 (coronavirus) pandemic. Thus, to monitor and control the spread of any virus, accurate and trustable data are required or essential. However, in the present scenario, the existing technology lacks the trustable data that may provide the

Highlights
· Blockchain technology (BT) provides a better platform for effective management of the COVID-19 pandemic.
· Blockchain technology helps create decentralization, transparency, immutability, and early detection of infected cases.
· Blockchain technology is useful for disease control, patient traceability, and improved management of the healthcare system.

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Tissue Engineering and its Significance in Healthcare During COVID-19 Pandemic: Potential Applications and Perspectives

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Significant Applications of Machine Learning
for COVID-19 Pandemic

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Abstract. Machine learning is an innovative approach that has extensive applications in prediction. This technique needs to be applied for the COVID-19 pandemic to identify patients at high risk, their death rate, and other abnormalities. It can be used to understand the nature of this virus and further predict the upcoming issues. This literature-based review is done by searching the relevant papers on machine learning for COVID-19 from the databases of SCOPUS, Academia, Google Scholar, PubMed, and ResearchGate. This research attempts to discuss the significance of machine learning in resolving the COVID-19 pandemic crisis. This paper studied how machine learning algorithms and methods can be employed to fight the COVID-19 virus and the pandemic. It further discusses the primary machine

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Soft Computing (SOCO) <em@editorialmanager.com>
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Rule-based multi-view human activity recognition system in real time using skeleton data from RGB-D sensor

Neeraj Varshney[1] · Brijesh Bakariya[2] · Alok Kumar Singh Kushwaha[3] · Manish Khare[4]

Abstract
Identification of human activity with decent precision is a challenging task in the field of computer vision, especially when applying for surveillance purpose. A rule-based classifier method is proposed in this paper, which is capable of recognizing a view-invariant multiple human activity recognition in real time. A single Kinect sensor is used for the input of RGB-D data in real time. Initially, a skeleton-tracking algorithm is applied. After tracking the skeleton, activities are recognized from each individually tracked skeleton independently. Different rules are defined to recognize discrete skeleton positions and classify a particular order of multiple postures into activities. During the experimentation, we examine about 14 activities and found that the proposed method is robust and efficient concerning multiple views, scaling and phase variation activities during different realistic acts. A self-generated dataset in the controlled environment is used for the experiment. About 2 min of data was collected. Data from two different males were collected for multiple human activities. Experimental results show that the proposed method is flexible and efficient for multiple view activities as well as scale and phase variation activities. It provides a detection accuracy of 98%.

Keywords Activity recognition · Microsoft Kinect · Multi-view · Rule-based classifier · Tracking skeleton

1 Introduction

Human activity recognition is one of the key research areas in the vision domain because of its promising applications like healthcare monitoring, surveillance system, education

Important cues about human behavior can be identified through the recognition of activity. Earlier methods use colored images captured by RGB camera, although the availability of sensors like Kinect makes it possible to capture the information about the depth of the image

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Human activity recognition using deep transfer learning of cross position sensor based on vertical distribution of data

Neeraj Varshney[1] · Brijesh Bakariya[2] · Alok Kumar Singh Kushwaha[3]

Abstract

Sensor-based human activity recognition and health monitoring are attaining great interest in the eye of the researcher as it maintained the privacy of an individual. A model based on the transfer learning for the vertical distribution of cross position sensor data is proposed in this paper. The whole human body participates during an activity like walking, jumping, running, etc. When someone walk, run, jump, upstairs downstairs his hands and lags both act as per the activity. Existing methods of human activity recognition using sensor data learn from one dataset and transfer that learning for another one but in the proposed work combine learning of accelerometer, magnetometer and gyroscope placed at ankle of the body is used as starting point for the lower arm of the body. combination of sensor data from three sensors (accelerometer, gyroscope, magnetometer) obtain better result as compare to an individual and other combinations. Two publically available datasets are used, i.e. mHEALTH and PAMAP2. The proposed

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Human Activity Recognition by combining external features with Accelerometer sensor data using Deep Learning Network model

Neeraj Varshney[1], Brijesh Bakariya[2], Alok Kumar Singh Kushwaha[3] Manish Khare[4]

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Abstract

Various Human Activities are classified through time-series data generated by the sensors of wearable devices. Many real-time scenarios such as Healthcare Surveillance, Smart Cities and Intelligent surveillance etc. are based upon Human Activity Recognition. Despite the popularity of local features-based approaches and machine learning approaches, it fails to capture adequate temporal information. In this paper, the deep convolutional neural model has been proposed by combining external features, i.e. orientation invariant ($\|v\|$) and consecutive point trajectory information ($\|\Delta v\|$) with tri-axis data of the accelerometer. The proposed external features based approach experimented on three different deep learning architecture, namely Long-Short Term Memory (LSTM), Convolutional Neural Networks (CNN) and Convolution Long-Short Term Memory (ConvLSTM). Accuracy of the algorithms radically improve with the additional input

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Deep convolutional neural model for human activities recognition in a sequence of video by combining multiple CNN streams

Neeraj Varshney[1], Brijesh Bakariya[2]

I K Gujral Punjab technical University, Kapurthala[1], I K Gujral Punjab Technical University, Hoshiarpur Campus[2], Hoshiarpur,

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1. Abstract

The video file is a collection of image sequential; this image sequence holds both spatial and temporal information. Optical flow and motion history images are two well-known methods for the identification of human activities. Optical flow describes the speed of every individual pixel point in the picture. Still, this information about the motion cannot represent the complete action and different movement speeds. The durations of Local body parts show almost similar intensity in the Motion history image. Therefore, similar actions are not identifying with good precision. In this paper, a deep convolutional neural model for human activities recognition video has been proposed in which multiple CNN streams are combined. The model combines spatial and temporal information. Two fusion schemes, i.e. Average fusion and convolution fusion of spatial and temporal stream, are discussed in this paper. The proposed method

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Efficient Approach of Analyzing and Generating Intrinsic Information from Weblog

Brijesh Bakariya

Abstract

The weblog data have unstructured data, and due to this extraction, the desired information from it is a very challenging task. This kind of data is rapidly growing with huge volume. In this paper, the weblog analysis through Pyspark (WAP) algorithm is proposed to analyze the complete weblog dataset and extract useful information from it.

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An Efficient Algorithm for Extracting Infrequent Itemsets from Weblog

Brijesh Bakariya[1] and Ghanshyam Thakur[2]

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[2]Department of Computer Applications, Maulana Azad National Institute of Technology, India

Abstract: *Weblog data contains unstructured information. Due to this, extracting frequent pattern from weblog databases is a very challenging task. A power set lattice strategy is adopted for handling that kind of problem. In this lattice, the top label contains full set and at the bottom label contains empty set. Most number of algorithms follows bottom-up strategy, i.e. combining smaller to larger sets. Efficient lattice traversal techniques are presented which quickly identify all the long frequent itemsets and their subsets if required. This strategy is suitable for discovering frequent itemsets but it might not be worth being used for infrequent itemsets. In this paper, we propose Infrequent Itemset Mining for Weblog (IIMW) algorithm; it is a top-down breadth-first level-wise algorithm for discovering infrequent itemsets. We have compared our algorithm IIMW to Apriori-Rare, Apriori-Inverse and generated result in with different parameters such as candidate itemset, frequent itemset, time, transaction database and support threshold.*

Keywords: *Infrequent itemsets, lattice, frequent itemsets, weblog, support threshold.*

1. Introduction

The collection of minimum frequent itemset might be important. An example can be drowning in drug analysis, market basket analysis, business analysis, etc. Most of the criteria are based on support and confidence, here the support consists number of times pattern occur in the transaction databases, moreover it's a frequency of itemset in a transactional database and the confidence determines the proportion value that shows how frequently a part of the pattern (premise), occurs among all the records containing the whole transaction dataset. For example, if the pattern has to satisfy the minimum support then that pattern is considered as frequent pattern or frequent pattern on the contrary, these patterns have to satisfy maximum support then that pattern considered as in frequent pattern or infrequent pattern [1, 2]. Infrequent patterns can be used in different domains such as biology, medicine and security [9, 15], etc. For example, in a clinical database analysis one can discover infrequent patterns that will help doctors to make decisions about the clinical care. As one can observe, each type of patterns expands the data seeking for specific types of knowledge. In other types of patterns 'infrequent and frequent' patterns that can be mined. Any item set is found interesting only when its frequency is less than the maximum threshold or more than the minimum

infrequent patterns in NP-Complete time or we can say it's solved such problems in polynomial time. The algorithms which efficiently search the 'frequent patterns' are not necessarily be searching for 'infrequent patterns too'. Algorithms to search for both the patterns are infrequently available apart from the 'Rarity' these are many such problems which exist in different data mining algorithms. We have taken log data is collected which gets available at the Internet traffic archive [16]. This log data later partitioned on the basis of its attributes and we have chosen two field timestamp and web page after applying preprocessing techniques [4, 5].

2. General Terms and Definitions

2.1. Power Set

Let A be a set, then the power set of A is P (A) give by P (A) = {S: S (A}. Here A is the set of n elements then the number of elements in P (A) is 2^n or n [P (A)] $=2^n$. For example, if {a, b, c} the P (S) = {o, {a}, {b}, {c}, {a, b}, {b, c}, {a, b, c}}. Here S has 3 elements so p (S) has $2^3 = 8$ elements.

2.2. Lattice

A non empty set P, together with binary relation R is said to from a partially ordered set or a post if the

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Pattern Mining Approach for Social Network Services

Brijesh Bakariya[1] · G. S. Thakur[1]

Abstract Social networking service (SNS) is one of the most encouraging directions of web applications. It is one of the services where people may communicate with one another; and may also exchange messages even of any multimedia communication. In this paper, we proposed practical approach by applying data mining techniques in SNS. Three parameters are considered here viz. user, time and image. This approach generates strong patterns among these parameters. This is a very efficient technique for identifying user's behavior in a SNS environment. Most frequently used pattern can be identified using these three parameters in SNS. Through this approach advertisement recommendation is possible in SNS.

Keywords Social network service · Strong pattern · Data mining · Advertisement recommendation · Frequent pattern

Nowadays the SNS are growing day by day. The term of a social network is a social structure made of individuals (or organizations) called "nodes," which are tied (connected) by one or more specific types of interdependency, such as friendship, financial exchange, dislike or relationships of beliefs, knowledge or prestige [1, 2].

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Social networking is the grouping of individuals into specific groups, like small rural communities or a neighborhood subdivision [3]. Generally, some social services focus on the privacy issue. Due to which one person could not see the friend link of another one. In social networking services, if one user interact another user then all activities performed by the user are maintained on the social network servers. Weblog analyzers of Social network servers will take log data. After taking log, they can be applied some statistics and data mining techniques for extracting user's information. For doing, we have downloaded the dataset from NASA-HTTP [4] Before extracting a strong pattern, log preprocessing is required for removing irrelevancy of data. This log data later partitioned on the basis of its attributes such as IP address, timestamp, etc. [5, 6]. There has been a lot of work in the area of frequent pattern mining. However, all current research in this area is designed for static datasets and not able to log data for SNS.

Agrawal and Srikant [7] proposed Apriori-like algorithm, this algorithm is used for random data generation. The Apriori-like algorithm exhibited the Apriori nature of solving the problem of mining information. In this algorithm the first pass of the algorithm simply counts item occurrences to determine the large 1-itemsets. A subsequent pass, say pass k, consists of two phases. First, the large itemsets L_{k-1} found in the $(k-1)$ pass are used to generate the candidate itemsets C_k. Next, the database is scanned and the support of candidates in C_k is counted.

In this paper, we have calculated related intensity (RI) value among U, T and I. Various terms and definitions are used to calculate RI value.

User $(U) = \{u_1, u_2, u_3, \ldots, u_n\}$ is the set of web users. Each web user can interact with the Social Networking website or access any stuffs from that.

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SHORT COMMUNICATION

Mining Rare Itemsets from Weblog Data

Brijesh Bakariya[1] · G. S. Thakur[1]

Abstract Weblog is unstructured data and therefore mining relevant information from weblog is a very challenging task. Present study proposes a Rare Itemset Mining from Weblog Data (RIMWD) algorithm to extract rare itemset. Most of the algorithms follow a bottom-up strategy, but those strategies are only suitable for discovering frequent itemsets. In contrast RIMWD algorithm is a top-down breadth-first level-wise algorithm to identify all the rare itemsets and their subsets. RIMWD adopts power set lattice strategy and it is the top and bottom levels of the lattice that contains full set and empty set respectively. The proposed RIMWD algorithm was compared with the state-of-the-art algorithms for generating rare itemset.

Keywords Lattice · Frequent Itemsets · Rare itemsets · Weblog · Unstructured data

Data mining plays an important role to find unknown patterns and hidden information. There are different techniques in data mining like classification, clustering and association rule mining to extract the hidden information from heterogeneous database. Association Rule Mining (ARM) was first introduced and is one of the most important and well researched techniques of data mining [1, 2]. ARM aims to extract interesting correlations, frequent patterns, associations or casual structures among sets of items in the transaction databases or other data repositories [3, 4]. But traditional pattern mining techniques focus on mining frequent patterns from the dataset. However infrequent or rare itemsets may be interesting. An itemset is said to be frequent only when its frequency is more than the minimum threshold, otherwise itemsets are infrequent or rare [5]. The present study aims at discovering rare itemsets from weblog data. For that a clear understanding of the weblog data with regards to its contents and formats is a prerequisite.
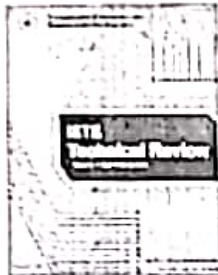
The weblog data contains different attributes, as shown in Table 1. For acquiring relevant dataset from weblog data several operations are needed to be performed. The weblog dataset is downloaded from the Internet Traffic Archive sponsored by ACM SIGCOMM [6]. Before applying the proposed algorithm, weblog data must be preprocessed. For which preprocessing techniques for weblog dataset were applied [7]. Table 1 shows preprocessed weblog containing all attributes.

There has been a lot of work in the area of rare pattern mining. However, all current research in this area is designed for static datasets and not able to handle a weblog data and clickstream environment. Haglin and Manning [8] proposed Minimal Infrequent Itemset (MINIT) algorithm for mining rare itemset. In this algorithm they prove that MINIT takes NP-complete time to solve the problem. Cagliero and Garza [9] proposed Infrequent Weighted Itemset (IWI) Miner algorithm, where they have constructed prune FP-tree for extracting infrequent itemset on the basis of IWI-support value. They have used a property by identifying the support value of an itemsets. Following problems are available in state-of-the-art algorithm. The complexity of state-of-the-art algorithms [8, 9] is high for finding minimal frequent itemset. Searching frequent itemset is a slow process because these algorithms do not

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An Efficient Algorithm for Extracting High Utility Itemsets from Weblog Data

Brijesh Bakariya[a] & G.S. Thakur[a]

[a] Department of Computer Applications, Maulana Azad National Institute of Technology, Bhopal, India

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An Efficient Algorithm for Extracting High Utility Itemsets from Weblog Data

Brijesh Bakariya and G.S. Thakur

Department of Computer Applications, Maulana Azad National Institute of Technology, Bhopal, India

ABSTRACT

High utility itemset refers to those set of items which has high utility such as profit in a database. High utility of itemset plays a crucial role in real life. In recent years, various algorithms have been proposed for finding high utility itemset but unfortunately they are not completely relevant at the time and space point of view. In the data mining field, high utility itemset can be found in different categories of data like time series, categorical, etc. Log data is useful for finding behaviour of the user in different aspects. In this paper, we have proposed an algorithm named HUM (High Utility Itemsets Mining) and construct HUI-FP (High Utility Itemsets Frequent Pattern) Tree for efficiently mining high utility itemsets from log database. The behaviour of the user can be predicted through the high utility of every visited page. We have also proposed pattern generation technique based on cosine similarities among itemsets. These techniques generate strong patterns, and customized users profile according to that pattern. The proposed algorithm is better than the previous state of the art algorithm for high utility itemset generation.

Keywords:

Complexity, Cosine similarity, Frequent pattern, High utility itemset, Weblog

1. INTRODUCTION

Web-mining aims to discover useful information or knowledge from the web hyperlink structure, page content, and usage data [1]. Data mining plays an important role to find unknown patterns and hidden information[2]. There are different techniques in data mining such as classification, clustering, and association rule mining to extract the hidden information from a heterogeneous database. One of the most important and researched techniques of data mining is Association Rule Mining [3,4]. It aims to extract interesting correlations, frequent patterns, associations, or casual structures among sets of items in the transaction databases or other data repositories [5,6]. The relative importance of every item cannot be considered to overcome such problems, a rule called Weighted Association Rule Mining (WARM) [7-9]. In WARM, a weight is considered for every transaction. But there are certain problems that exist in WARM since some infrequent items have a heavy weight [10] and in this technique the quantity of items is not taken into consideration. Utility itemset mining is an important field of data mining; its aim to extract high utility itemset from databases and those itemsets, which have high project, are founded [11]. Here, the utility of itemset means profitability importance and interestingness of the item [12,13]. In a transactional database, the utility of an item depends on two types of utility: internal utility and external utility as we are shown in Figure 1.

Internal utility consists importance to some item in every transaction and external utility consist importance of distinct item [14,15]. An itemset is called high utility itemset, when its utility is not less than the minimum desired utility. Mining of high utility itemset from the database is a very important task. There are various applications of high utility itemset mining, such as website clickstream analysis, marketing, web usage mining, user behavior prediction, e-commerce, mobile-commerce environment, genes prediction in bioinformatics, drug-prediction in medical, etc. [16,17]. Many such techniques of frequent pattern mining such as sequential pattern mining, sequential pattern mining based on common sites [18,19], mining of clickstream data, and mining of relational data have been proposed [20]. Out of all these techniques of frequent pattern mining, a technique called association rule mining is a very important one [21].

The two very famous algorithms of association rule mining are a-priori algorithm and Frequent Pattern Growth (FP-Growth) mining [3,5,22]. The performance point of view, Apriori algorithm is not very efficient as it demands database to be scanned again and again in turn increases the time complexity. To overcome this

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Classification of malignant lung cancer using deep learning

Abstract

In the automatic detection of suspicious cancer regions in CT images viewed from the LIDC-IDRI dataset, the diagnostic system plays a significant role. This paper introduces an automatic segmentation method for lung nodules of the regions of interest (ROI). The lung regions are segmented from DICOM image size 512 × 512 by adding a median filter, Gaussian filter, Gabor filter and watershed algorithm. Alexnet uses 227 × 227 × 3 with "fc7" (fully connected) layers and GoogLeNet uses 224 × 224 × 3 with "pool5-drop 7 × 7 s1" layers. Here, the authors explain what is better about Alexnet and GoogLeNet through its performance analysis, feature extraction, classification, sensitivity, specificity, detection and false alarm rate with time.
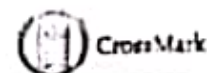
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SHORT COMMUNICATION

Mining Rare Itemsets from Weblog Data

Brijesh Bakariya[1] · G. S. Thakur[1]

Abstract Weblog is unstructured data and therefore mining relevant information from weblog is a very challenging task. Present study proposes a Rare Itemset Mining from Weblog Data (RIMWD) algorithm to extract rare itemset. Most of the algorithms follow a bottom-up strategy, but those strategies are only suitable for discovering frequent itemsets. In contrast RIMWD algorithm is a top-down breadth-first level-wise algorithm to identify all the rare itemsets and their subsets. RIMWD adopts power set lattice strategy and it is the top and bottom levels of the lattice that contains full set and empty set respectively. The proposed RIMWD algorithm was compared with the state-of-the-art algorithms for generating rare itemset.

Keywords Lattice · Frequent itemsets · Rare Itemsets · Weblog · Unstructured data

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of items in the transaction databases or other data repositories [3, 4]. But traditional pattern mining techniques focus on mining frequent patterns from the dataset. However infrequent or rare itemsets may be interesting. An itemset is said to be frequent only when its frequency is more than the minimum threshold, otherwise itemsets are infrequent or rare [5]. The present study aims at discovering rare itemsets from weblog data. For that a clear understanding of the weblog data with regards to its contents and formats is a prerequisite.

The weblog data contains different attributes, as shown in Table 1. For acquiring relevant dataset from weblog data several operations are needed to be performed. The weblog dataset is downloaded from the Internet Traffic Archive sponsored by ACM SIGCOMM [6]. Before applying the proposed algorithm, weblog data must be preprocessed. For which preprocessing techniques for weblog dataset were applied [7]. Table 1 shows preprocessed weblog containing all attributes.

There has been a lot of work in the area of rare pattern mining. However, all current research in this area is designed for static datasets and not able to handle a weblog data and clickstream environment. Haglin and Manning [8] proposed Minimal Infrequent Itemset (MINIT) algorithm for mining rare itemset. In this algorithm they prove that MINIT takes NP-complete time to solve the problem. Capiero and Garza [9] proposed Infrequent Weighted Itemset (IWI) Miner algorithm, where they have constructed prune FP-tree for extracting infrequent itemset on the basis of IWI-support value. They have used a property by identifying the support value of an itemsets. Following

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Pattern Mining Approach for Social Network Services

Brijesh Bakariya[1] · G. S. Thakur[1]

Abstract Social networking service (SNS) is one of the most encouraging directions of web applications. It is one of the services where people may communicate with one another, and may also exchange messages even of any multimedia communication. In this paper, we proposed practical approach by applying data mining techniques in SNS. Three parameters are considered here viz. user, time and image. This approach generates strong patterns among these parameters. This is a very efficient technique for identifying user's behavior in a SNS environment. Most frequently used pattern can be identified using these three parameters in SNS. Through this approach advertisement recommendation is possible in SNS.

Keywords Social network service · Strong pattern · Data mining · Advertisement recommendation · Frequent pattern

Nowadays the SNS are growing day by day. The term of a social network is a social structure made of individuals (or organizations) called "nodes," which are tied (connected) by one or more specific types of interdependency, such as friendship, financial exchange, dislike or

Social networking is the grouping of individuals into specific groups, like small rural communities or a neighborhood subdivision [3]. Generally, some social services focus on the privacy issue. Due to which one person could not see the friend link of another one. In social networking services, if one user interact another user then all activities performed by the user are maintained on the social network servers. Weblog analyzers of Social network servers will take log data. After taking log, they can be applied some statistics and data mining techniques for extracting user's information. For doing, we have downloaded the dataset from NASA-HTTP [4]. Before extracting a strong pattern, log preprocessing is required for removing irrelevancy of data. This log data later partitioned on the basis of its attributes such as IP address, timestamp, etc. [5, 6]. There has been a lot of work in the area of frequent pattern mining. However, all current research in this area is designed for static datasets and not able to log data for SNS.

Agrawal and Srikant [7] proposed Apriori-like algorithm, this algorithm is used for random data generation. The Apriori-like algorithm exhibited the Apriori nature of solving the problem of mining information. In this algorithm the first pass of the algorithm simply counts item

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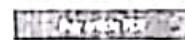# Efficient Approach of Analyzing and Generating Intrinsic Information from Weblog

Rajesh Kumar

Abstract

The weblog data have unstructured data, and due to this extraction, the desired information from it is a very challenging task. This kind of data is rapidly growing with huge volume. In this paper, the weblog analysis through Pyspark (WAP) algorithm is proposed to analyze the complete weblog dataset and extract useful information from it. In the proposed approach is used Resilient Distributed Dataset (RDD) for running and operating on multiple nodes to do parallel processing on a cluster for achieving these concepts is used apache pyspark and implemented on Jupyter notebook. WAP extracts different results such as host count, path count, status count, etc. This approach also generates patterns and track user behavior. The recommendation is also possible by the proposed algorithm based on user behaviors.

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Dear Dr. Parmar:

We are pleased to inform you that your manuscript, "Prediction of COVID-19 Pervasiveness in Six Major Affected States of India and Two-Stage Variation with Temperature", has been accepted for publication in Air Quality, Atmosphere & Health.

You will be contacted by Author Services in due course with a link to complete the grant of rights. Please note that you will receive your proofs after the publishing agreement has been received through our system.

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With best regards,

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Soft computing model coupled with statistical models to estimate future of stock market

Sarbjit Singh[1,3] · Kulwinder Singh Parmar[2] ○ · Jatinder Kumar[3]

Abstract

Almost every organization around the globe is working with uncertainty due to inevitable changes and growth in every sphere of life. These changes affect directly or indirectly the stock market prices which makes forecasting a challenging task. So, the need for reliable, cost-effective, and accurate forecasting models significantly arises to reduce risk and uncertainty in stock market investment. Different time series models have been proposed by data scientists and researchers for accurate prediction of the future with the least errors. Econometric autoregressive time series models such as autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models have established forecasting models capable of generating accurate forecasts. Wavelet methods, being capable of handling nonlinear data, combined with autoregressive models generate more accurate forecasts. In this present study, soft computing models of discreet wavelet transformation and wavelet denoising combined with autoregressive models are developed to forecast the weekly and daily closing prices of the BSE100 S&P Sensex index. Statistical error analysis of the forecasting outcomes of coupled models has been made to evaluate the performance of the prediction of these models. The prediction results reveal that soft computing methods coupled with autoregressive models (wavelet-ARIMA and wavelet denoise-ARIMA) generate considerably accurate forecasts as compared to baseline models (simple regression, ARMA and ARIMA models) and coupled models (wavelet-ARMA and wavelet denoise-ARMA models).

Keywords Closing prices · BSE time series data · Discrete wavelet transformation · Wavelet denoising · ARIMA model · ARMA model · Forecasting

1 Introduction

The stock market plays a vital role in the growth and development of industry and affects the economy of a country to a great extent. Some important functions of the stock market include the economic condition of a country, valuation of securities and to provide a ready market for sale and purchase of securities. For this reason, the government, industry, and investors continuously keep a close watch on the activities of the stock market. BSE (Bombay Stock Exchange) is the 11th largest stock exchange across the globe consisting of 30 well established and financially sound partner companies. BSE 100 S&P measures the performance of 100 largest and most liquid Indian companies. It was launched in 1989 with 1983–1984 as the base year. The BSE Sensex, earlier known as BSE National Index, efficiently records the pulsation of stock prices and stock markets in India.

Forecasting is an approach to estimate the future by understanding past events and is needed by almost every organization for optimum growth. Accurate prediction of the future is one of the major issues in numerous real-life problems, it helps to reduce the degree of uncertainty and develop new policies to earn high profits. Stock market prediction is a challenging task due to the risk and uncertainty involved in an investment. So, accurate prediction of stock market prices helps in reducing risk and making

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Soft computing model coupled with statistical models to estimate future of stock market

Sarbjit Singh[1,3] · Kulwinder Singh Parmar[2] ○ · Jatinder Kumar[3]

Abstract

Almost every organization around the globe is working with uncertainty due to inevitable changes and growth in every sphere of life. These changes affect directly or indirectly the stock market prices which makes forecasting a challenging task. So, the need for reliable, cost-effective, and accurate forecasting models significantly arises to reduce risk and uncertainty in stock market investment. Different time series models have been proposed by data scientists and researchers for accurate prediction of the future with the least errors. Econometric autoregressive time series models such as autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models have established forecasting models capable of generating accurate forecasts. Wavelet methods, being capable of handling nonlinear data, combined with autoregressive models generate more accurate forecasts. In this present study, soft computing models of discreet wavelet transformation and wavelet denoising combined with autoregressive models are developed to forecast the weekly and daily closing prices of the BSE100 S&P Sensex index. Statistical error analysis of the forecasting outcomes of coupled models has been made to evaluate the performance of the prediction of these models. The prediction results reveal that soft computing methods coupled with autoregressive models (wavelet-ARIMA and wavelet denoise-ARIMA) generate considerably accurate forecasts as compared to baseline models (simple regression, ARMA and ARIMA models) and coupled models (wavelet-ARMA and wavelet denoise-ARMA models).

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 dr.kulmaths@ptu.ac.in

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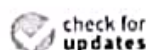
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Article

Suspended Sediment Modeling Using a Heuristic Regression Method Hybridized with Kmeans Clustering

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Abstract: The accurate estimation of suspended sediments (SSs) carries significance in determining the volume of dam storage, river carrying capacity, pollution susceptibility, soil erosion potential, aquatic ecological impacts, and the design and operation of hydraulic structures. The presented study proposes a new method for accurately estimating daily SSs using antecedent discharge and sediment information. The novel method is developed by hybridizing the multivariate adaptive regression spline (MARS) and the Kmeans clustering algorithm (MARS-KM). The proposed method's efficacy is established by comparing its performance with the adaptive neuro-fuzzy system (ANFIS), MARS, and M5 tree (M5Tree) models in predicting SSs at two stations situated on the Yangtze River of China, according to the three assessment measurements, RMSE, MAE, and NSE. Two modeling scenarios are employed; data are divided into 50–50% for model training and testing in the first scenario, and the training and test data sets are swapped in the second scenario. In Guangyuan Station, the MARS-KM showed a performance improvement compared to ANFIS, MARS, and M5Tree methods in term of RMSE by 39%, 30%, and 18% in the first scenario and by 24%, 22%, and 8% in the second scenario, respectively, while the improvement in RMSE of ANFIS, MARS, and M5Tree was 34%, 26%, and 27% in the first scenario and 7%, 16%, and 6% in the second scenario, respectively, at Beibei Station. Additionally, the MARS-KM models provided much more satisfactory estimates using only discharge values as inputs.

Keywords: estimating discharge–sediment relationship; MARS–Kmeans; MARS; ANFIS; M5 model tree

1. Introduction

The rapidly growing global population has made freshwater resources scarce and compelled hydrologists to explore methods for better river management and water resource conservation [1]. Accurate modeling of suspended sediment load (SSL) plays a vital role in river restoration, pollution, and soil erosion reduction, thus solving challenges related to water quality, channel design, and the operation of hydraulic structures [2,3]. However, precise forecasting of SSL is challenging due to the concurrent effects of many meteorological and hydrological factors on sediment processes, such as wind speed, evaporation, precipitation, river discharge, water temperature, and ice packs. The variations of these parameters in space and time make the sediment dynamics highly complicated and nonlinear [4,5]. Many SSL estimation models have been developed in the literature, ranging from physically based to data-driven models. Physically based models require a large

Chaos, Solitons and Fractals

Development of new hybrid model of discrete wavelet decomposition and autoregressive integrated moving average (ARIMA) models in application to one month forecast the casualties cases of COVID-19

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ABSTRACT

Everywhere around the globe, the hot topic of discussion today is the ongoing and fast-spreading coronavirus disease (COVID-19), which is caused by the severe acute respiratory syndrome coronavirus 2 (SARS-COV-2). Earlier detected in Wuhan, Hubei province, in China in December 2019, the deadly virus engulfed China and some neighboring countries, which claimed thousands of lives in February 2020. The proposed hybrid methodology involves the application of discreet wavelet decomposition to the dataset of deaths due to COVID-19, which splits the input data into component series and then applying an appropriate econometric model to each of the component series for making predictions of death cases in future. ARIMA models are well known econometric forecasting models capable of generating accurate forecasts when applied on wavelet decomposed time series. The input dataset consists of daily death cases from most affected five countries by COVID-19, which is given to the hybrid model for validation and to make one month ahead prediction of death cases. These predictions are compared with that obtained from an ARIMA model to estimate the performance of prediction. The predictions indicate a sharp rise in death cases despite various precautionary measures taken by governments of these countries.

1. Introduction

In Dec 2019, Wuhan, China, witnessed the start of an epidemic, which is just a period of two months overpowered the entire world and took the form of a pandemic named COVID-19 [20,46,68]. The novel coronavirus disease (COVID-19) pandemic caused by the virus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has engulfed the entire world within a short period of time [4,12,26,30,32,56,60,61,65,67]. Being highly contagious in nature, it poses a massive threat to people's health as till 10:00 CET, 30 March 2020 a total of 693,282 confirmed cases and 33,106 deaths were reported globally as per World Health Organization (WHO) [26,55,56,61].

The outbreak of new infection has created an emergency situation that raises many important questions related to its transmission dynamics, mitigation, and control measures. Researchers are taking the help of mathematical modeling in order to provide answers to such urgent queries [10]. For instance, to contain the spread, strategies such as social distancing, quarantine and contact tracing of the infected or suspected people, the complete lockdown of the area or countries dealing with it and screening international travelers are the results of model predictions ([19,43]; Mandal et al. 2019; [11,63]). Early modeling results by Kucharski et al. based on the stochastic transmission model told about the variation of COVID-19 over a certain period of time, probability of an outbreak in other areas outside Wuhan and observed a decline in reproduction number from 2.35 to 1.05 after the introduction of travel restrictions [24,37]. In another study by Chen et al. [10], a Bats-Hosts-Reservoir-People transmission network model was developed to simulate the probable transmission from bats to human beings. They also simplified the above model and found that majorly the transmission occurred from person to person relying on

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Study of ARIMA and least square support vector machine (LS-SVM) models for the prediction of SARS-CoV-2 confirmed cases in the most affected countries

Sarbjit Singh[a,c], Kulwinder Singh Parmar[b,*], Sidhu Jitendra Singh Makkhan[d,e], Jatinder Kaur[b,f], Shruti Peshoria[g], Jatinder Kumar[c]

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ABSTRACT

Discussions about the recently identified deadly coronavirus disease (COVID-19) which originated in Wuhan, China in December 2019 are common around the globe now. This is an infectious and even life-threatening disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). It has rapidly spread to other countries from its originating place infecting millions of people globally. To understand future phenomena, strong mathematical models are required with the least prediction errors. In the present study, autoregressive integrated moving average (ARIMA) and least square support vector machine (LS-SVM) models are applied to the data consisting of daily confirmed cases of SARS-CoV-2 in the most affected five countries of the world for modeling and predicting one-month confirmed cases of this disease. To validate these models, the prediction results were tested by comparing it with testing data. The results revealed better accuracy of the LS-SVM model over the ARIMA model and also suggested a rapid rise of SARS-CoV-2 confirmed cases in all the countries under study. This analysis would help governments to take necessary actions in advance associated with the preparation of isolation wards, availability of medicines and medical staff, a decision on lockdown, training of volunteers, and economic plans.

1. Introduction

The world was running very smoothly, and all countries were engaged in improving their gross domestic product (GDP). Suddenly, the novel coronavirus disease (Covid-19) knocked Wuhan, China, in December 2019, which was viewed as the start of an epidemic however it overwhelmed the entire world in a very short span of time and took the form of a pandemic. Covid-19 is highly contagious in nature and is caused by the virus severe acute respiratory syndrome coronavirus, 2 (SARS-CoV-2) [14,19,34,35,43,48,55]. In the starting phase, it was considered as the spread of viral pneumonia, linked to the exposure to the seafood market [46,51,53]. On January 7, 2020, the virus was isolated, and it confirmed the identity of 2019-nCoV (novel coronavirus) by the Chinese health agencies, which on February 11, 2020, was termed as COVID-19 by the World Health Organization [43]. Till date, COVID-19 has led to the death of 2,86,353 individuals around the globe and affected more than 41,78,156 people as on May 12, 2020, reported by the World Health Organization [43]. Deaths caused by COVID-19 are expected to increase far more than the previous two coronaviruses, namely SARS-CoV and MERS-CoV. [10,24].

The emergency situation caused due to the outbreak of a new infection raises many important questions related to its transmission dynamics, mitigation, and control measures. Researchers are taking the help of mathematical modeling in order to provide answers to such urgent queries [7]. As the medicine is not yet discovered, Governments make efforts to control situations by instructing strategies such as social distancing, quarantine and

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Improvements in the explicit estimation of pollutant dispersion coefficient in rivers by subset selection of maximum dissimilarity hybridized with ANFIS-firefly algorithm (FFA)

Hossien Riahi-Madvar[1], Majid Dehghani[2], Kulwinder Singh Parmar[3], NarjesNabipour[4], ShahaboddinShamshirband[5,6]

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ABSTRACT A new hybrid model is proposed using Subset Selection by Maximum Dissimilarity (SSMD) and adaptive neuro-fuzzy inference system (ANFIS) hybridized with the firefly algorithm (FFA) to predict the longitudinal dispersion coefficient (K_x). The FFA is used to derive the optimum ANFIS parameters. The K_x data set includes 503 cross-sectional data point from small to large rivers. For pre-processing of the data set, the SSMD method is used, which is superior to the classical trial and error method. The database covers a wide range of river width (0.2- 867m), and depths (0.034- 19.9 m). Fifteen different combinations of river width (B), depth (H), flow velocity (U) and shear velocity (U*) are implemented as inputs to create fifteen estimative models. The output of the ANFIS-FFA model is compared with the ANFIS and previously published equations to check the performance of the proposed model. The results show that the highest accuracy is attained by the M1 model, with all geometric and hydrodynamic parameters as input variables in comparison with ANFIS and previous equations. The R^2 value, RMSE), MAE and NSE for ANFIS-FFA model are 0.67, 113.14 m²/s, 48 m²/s, and 0.63 for proposed dimensional model, and 0.53, 520.8, and 0.1 in non-dimensional ANFIS-FFA model, respectively, while these are 0.37, 463.34 m²/s, 85.69 m²/s, and -5.19 for dimensional ANFIS model, and 0.11, 3269.88, 1932.09 and -11.54 for non-dimensional ANFIS model, respectively. Overall, hybridization caused 81%, 75%, 76% improvements in R^2, RMSE and MAE. In another contribution of the paper, by using the matrix form of developed ANFIS-FFA optimized parameters, a novel explicit calculation procedure for estimation of K_x is derived. Based on the results, the proposed ANFIS-FFA model exhibits significant improvements than the classical ANFIS and highlights that optimizing by nature-inspired optimization algorithms plays a critical role in strengthening the ANFIS estimations generality.

INDEX TERMS Longitudinal dispersion coefficient, ANFIS-FFA, Maximum dissimilarity method, Natural Rivers, Revised discrepancy ratio (RDR).

I. Introduction

Water is a necessary element in the world, for human life and survival. Most rivers are polluted nowadays, and these pollutants are transported in the river flow. River flow and pollutant transport studies are necessary for several applications such as analysis of water intake, sediment deposition, contamination control, and pollutant risk assessment [1-4]. The fundamental law of mass diffusion in water was first introduced by Fick (1855) [5] as $q = -D\frac{\partial c}{\partial x}$,

where q is the mass flux of pollutant, D is the diffusion coefficient, and $\frac{\partial c}{\partial x}$ is the gradient of the mass concentration (c) in x distance along the longitudinal direction [6,7]. The diffusion coefficient is generally referred to the longitudinal dispersion coefficient [6,8]. The injected pollutants are dispersed by advection and dispersion processes in longitudinal, vertical, and transverse directions [9,10]. The longitudinal dispersion process becomes the main mechanism, when the mixing process in the lateral direction

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Modeling monthly streamflow in mountainous basin by MARS, GMDH-NN and DENFIS using hydroclimatic data

Rana Muhammad Adnan[1] · Zhongmin Liang[1] · Kulwinder Singh Parmar[2] · Kirti Soni[3] · Ozgur Kisi[4,5]

Abstract

Accurate estimation of streamflow has a vital importance in water resources engineering, management and planning. In the present study, the abilities of group method of data handling-neural networks (GMDH-NN), dynamic evolving neural-fuzzy inference system (DENFIS) and multivariate adaptive regression spline (MARS) methods are investigated for monthly streamflow prediction. Precipitation, temperature and streamflows from Kalam and Chakdara stations at Swat River basin (mountainous basin), Pakistan, are used as inputs to the applied models in the form of different input scenarios, and models' performances are evaluated on the basis of root mean square error (RMSE), mean absolute error (MAE), Nash–Sutcliffe efficiency (NSE) and combined accuracy (CA) indexes. Test results of the Kalam Station show that the DENFIS model provides more accurate prediction results in comparison of GMDH-NN and MARS models with the lowest RMSE (18.9 m³/s), MAE (13.1 m³/s), CA (10.6 m³/s) and the highest NSE (0.941). For the Chakdara Station, the MARS outperforms the GMDH-NN and DENFIS models with the lowest RMSE (47.5 m³/s), MAE (31.6 m³/s), CA (26.1 m³/s) and the highest NSE (0.905). Periodicity (month number of the year) effect on models' accuracies in predicting monthly streamflow is also examined. Obtained results demonstrate that the periodicity improves the models' accuracies in general but not necessarily in every case. In addition, the results also show that the monthly streamflow could be successfully predicted using only precipitation and temperature variables as inputs.

1 Introduction

Water is one of the most essential natural resources on the earth and has an important association with the earth's constituent. The physical properties, for example, morphology, soil and land use, affect the constituents of water balance in a basin. The hydrological cycle can be disturbed owing to changes in land use by the varying the base flow [1] and yearly average release of the basin [2]. Streamflow modeling is of high significance to water resources planning and management. Simulation of weekly, monthly, seasonal and annual streamflows has been extensively studied in the last ten decades, and due to their importance, numerous parametric and nonparametric models have been established in the past.

Streamflow forecasting is very important in water resource management in any country around the globe as floods are most common expected disasters and which

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ORIGINAL ARTICLE

Correlation and time-series analysis of black carbon in the coal mine regions of India: a case study

Sidhu Jitendra Singh Makkhan[1,3] · Kulwinder Singh Parmar[2] · Sachin Kaushal[1] · Kirti Soni[4]

Abstract

In recent times, black carbon (BC) has attracted the interest of the researchers due to its adverse effect on human health, climate, rainfall, and global heating causing the melting of ice in the poles due to carbon deposition on it. Coal industry is the backbone of Indian economy and India being the world's third largest producer of coal. Various mining activities are leading to spontaneous emission of black carbon in the atmosphere, especially in the IGP (Indo-Gangetic plain) region. Long-term studies related to black carbon emission in the coal regions of India are very rare. In the present study, a long-term datum of 38 years (1980–2018) for the amount of black carbon emission among the three important coal mines of India, namely Bokaro, Jharia, and Raniganj, is studied using correlation analysis, and time-series analysis along with a few other mathematical parameters. The comparison and forecast obtained using this study will be beneficial in the upcoming years, so as to gather the interest of the government, NGOs, and researchers in this area, so that new policies and preventive measures could be taken to curtail the black carbon concentration from the coal mines.

Keywords Mathematical modeling · Black carbon · Correlation · Time-series · ARIMA · RMSE

Introduction

Black carbon has received a great attention of the researchers during the past decade due to its major role in climatic disturbances and various health-related issues. Black carbon (BC) is a black sooty particulate matter even smaller than $PM_{2.5}$, released during incomplete combustion of fossil fuels, petroleum products, agricultural wastes, and various other carbon containing products (Bond et al. 2004; Haque et al. 2018). Black carbon has severe impacts on the climate, as it absorbs the solar radiations along with those emitted from the earth's surface during various combustion activities

thus leading to global warming (Menon et al. 2002; Ramanathan and Carmichael 2008; Jacobson 2010). Various studies describe BC as the key factor for global heating after CO_2 (Horvath 1993; Wang 2004; Tsakiri et al. 2011). It has a great impact on the rainfall mechanism as it disturbs the micro-physical properties of the clouds which influences cloud formation and the precipitation process, leading to serious problems like drought and floods (Twomey 1984; Tzanis and Varotsos 2008). Due to air and water, BC is transported to distant places causing it to deposits on the snow in Artics, mountain peaks like the Himalayas, and leads to the melting of glaciers and rise of sea level, which is an alarming signal for the entire world (Highwood and Kinnersley 2006).

BC has severe adverse effects on the health of living beings, as it leads to several health disorders, respiratory problems like asthma and chronic bronchitis, various cardio vascular and lung diseases, cancer, and loss of eye sights, and these problems may further worsen leading to birth defects (Japar et al. 1986; Penner et al. 1993; Varotsos et al. 1995; Liousse et al. 1996; Jansen et al. 2005; Venkataraman et al. 2005; Guttikunda and Kopakka 2014). In indoor conditions, the major sources of BC emissions are burning of agricultural wastes, and combustion of biofuels and fossil fuels (Ganguly et al.

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ORIGINAL ARTICLE

Neuro-fuzzy-wavelet hybrid approach to estimate the future trends of river water quality

Kulwinder Singh Parmar[1] © · Sidhu Jitendra Singh Makkhan[2,3] · Sachin Kaushal[2]

Abstract

Water is the basic need for life to exist on this planet earth; rivers play a vital role to fulfill this need for the supply of freshwater. Due to spontaneous growth of industrialization and urbanization near the important rivers, most of them have been polluted to a severe extent and the future of these rivers and living organism depending on the water from them is on threat. Thus, various prediction models have been developed by researchers to build an accurate forecasting model to access the future quality of rivers with least forecasting error. Time series models have been developed to form such prediction, but most of them were unsuccessful in handling nonlinear problems. Artificial neural network (ANN) and adaptive neuro-fuzzy interface system have proven to be an efficient tool to handle such nonlinear situations. In this study, in addition to the above methods, wavelet transformation has been used to develop a forecasting model to generate forecasts close to actual values. The biochemical oxygen demand of river Yamuna at sample site of Nizamuddin (Delhi) is predicted using the past monthly averaged data. Statistical analysis has been used to study the nature of the wavelet domain constitutive series considered. The results obtained indicate that the neuro-fuzzy-wavelet-coupled model leads to considerably superior outcomes compared to neuro-fuzzy, ANN and regression models.

Keywords Hydrological model · River water management · Neural network · Fuzzy logic · Wavelets · Mathematical modeling

1 Introduction

Various hydrological processes exist in nature that sustain the water cycle such as the river water systems, groundwater process and rainfall-runoff process. Modeling of these processes is needed for predicting the future expectation of natural calamities by using the past observations of such events. Rivers are the most vital source, for the supply of drinking water, groundwater level and have great impact on the climate of surrounding areas. To maintain a good health and sanitary condition, sufficient supply of pure water is very necessary. Suspended and dissolved substances of mineral and organic are contained in water [34]. In India, Yamuna is the largest tributary of river Ganga. It originates from lower Himalayas of Uttarakhand at a height of 6387 m from the Yamunotri glacier [7] in the south western slopes of Banderpooch peaks (38°59′N 78°27′E). It passes through some major states of India viz. Delhi, Haryana, Himachal Pradesh, Uttarakhand and Uttar Pradesh travelling an overall length of 1376 km and mixing with 366,233 km^2 of the drainage system before mixing with river Ganga at Allahabad which amounts to an aggregate of 40.2% of entire Ganga Basin. Sample site, Nizamuddin is situated at a distance of nearly 410 km from Yamunotri, leads to a continuous increase in river water pollution due to population growth, urbanization, industrialization, etc. Majority of rivers are fading due to the increase in pollution level, which is an alarming situation. Industrialization, domestic discharge and sewerage from

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Trend and time series analysis by ARIMA model to predict the emissions and performance characteristics of biogas fueled compression ignition engine

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ABSTRACT

Biomass-derived biogas is a very promising alternative energy source because of its renewable and clean combustion characteristics compared to fossil petroleum diesel fuel. The forecasting of emissions and performance characteristics is done by using the autoregressive integrated moving average (ARIMA) model. The R^2, root mean square error (RMSE), and normalized Bayesian information criterion (BIC) are used to test the validity and applicability of the developed ARIMA models revealing adequate accuracy in the model performance. It is inferred from the experimental results that NO_x and smoke opacity emissions were lower at all engine operating loads. There is an increase in CO, CO_2, and HC emissions at all gas flow rates compared to diesel counterparts. The brake thermal efficiency drops with the increase in biogas flow induction at all engine operating modes. This paper explores and highlights the potential of biogas-diesel dual-fuel combustion mode at different engine operating conditions.

Introduction

Depleting fossil fuels, escalating prices, stringent environmental policies, and increased demand for energy conservation have triggered interest in renewable and alternative fuels as energy sources for internal combustion engines (Goga et al. 2019; Rosha et al. 2019, Singh et al. 2019). So, there is an urgent need to promote the use of renewable (liquid and gaseous) alternative fuels as substitutes for compression ignition engines (Bora and Saha 2015; Barik and Murugan 2014b; Porpatham, Ramesh, and Nagalingam 2012). Gaseous fuels are considered good for internal combustion engines because of their good mixing characteristics with air and attainment of higher compression ratios, resulting in an improvement in the brake thermal efficiency and reduction in tailpipe exhaust emissions (Ali et al. 2015; Namasivayam et al. 2010; Palash et al. 2015). Biogas is a potential renewable, abundantly available and environment-friendly fuel produced from a variety of organic substances through the anaerobic digestion process (Barik et al. 2016, Jingura and Matengaifa 2009, Mahla, Das and Babu 2018). Biogas is a low cetane fuel, and it cannot be directly ignited and combusted in conventional diesel engine. It requires an intense source of ignition as the auto-ignition temperature of biogas is high (Barik and Murugan 2013a). CO_2 present in the biogas acts as a diluent for the reduction of NO_x tailpipe emission, when it is used in dual-fuel engine (Yoon et al., 2011; Barik and Murugan 2014c). Brake thermal efficiency of the engine is reduced at low to

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Pan evaporation modeling by three different neuro-fuzzy intelligent systems using climatic inputs

Rana Muhammad Adnan[1] · Anurag Malik[2] · Anil Kumar[2] · Kulwinder Singh Parmar[3] · Ozgur Kisi[4]

Abstract

Modeling pan evaporation (Epan) estimation is a vital issue in water resources management because it directly affects water reservoir and water supply systems. In the developing countries (e.g., India), Epan data are generally limited, and in such a circumstance, theoretical estimates from available climatic data could be beneficial. The study investigates the capability of three adaptive neuro-fuzzy methods, adaptive neuro-fuzzy inference system (ANFIS)-embedded grid partition (GP), subtractive clustering (SC), and fuzzy c-means clustering (FCM), in estimation of monthly pan evaporation using climatic inputs of minimum and maximum air temperatures, wind speed, sunshine hours, and relative humidity obtained from two stations, Uttarakhand, India. Cross validation method is applied by dividing data into three equal parts, and methods are tested using each part. Methods are evaluated by applying various combinations of inputs and using root mean square error (RMSE), mean absolute error (MAE), Nash–Sutcliffe efficiency (NSE), and determination coefficient (R^2) criteria. The ANFIS-FCM is found to be superior to the ANFIS-GP and ANFIS-SC methods in Epan modeling. Cluster-based proposed neuro-fuzzy method increases performance of the best ANFIS-GP and ANFIS-SC models with respect to RMSE by about 9–14% for the both stations. The three ANFIS methods are also compared with each other and Stephen Stewart (SS) method by dividing data into three stages, training, validation, and test. The results indicate the superior accuracy of the ANFIS methods to SS for the same input variables. The ANFIS-FCM generally produces better Epan estimates than the other two ANFIS methods.

Keywords Pan evaporation estimation · Neuro-fuzzy · Grid partition · Subtractive clustering · Fuzzy c-means

Introduction

Evaporation as a nonlinear, stochastic, and complex process occurs due to vapor pressure deficit between the earth surface and atmosphere, when energy sources are available (Penman 1948; Sanikhani et al. 2012; Shiri et al. 2014). Air temperature, relative humidity, solar radiation, and wind speed are important climatic parameters that affect the rate of evaporation. Thus, accurate estimation of pan-evaporation is essential for water budgeting, and modelling crop water responses under different weather conditions (McCuen 1998; Sanikhani et al. 2012; Majidi et al. 2015). Daily pan-evaporation (Epan) has been commonly used as an index for reservoir and lake evaporation, reference or potential crop evapotranspiration and scheduling irrigation (Snyder 1993; Guven and Kisi 2010). Various studies have been conducted on Epan modeling using empirical equations based on meteorological data in different regions (Stephens and Stewart 1963; Priestley and Taylor 1972; Jensen et al. 1990), but the application of such equations is based on certain assumptions. Stephens and

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Long-term aerosol climatology over Indo-Gangetic Plain: Trend, prediction and potential source fields

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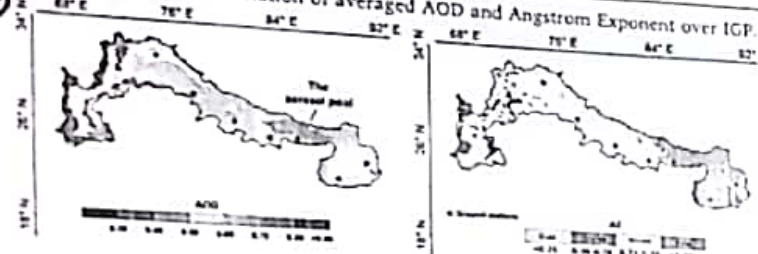[b] Department of Mathematics, Punjab Technical University, Jalandhar, Kapurthala, India
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GRAPHICAL ABSTRACT

Decadal (2006–2015) variation of averaged AOD and Angstrom Exponent over IGP.

ARTICLE INFO

ABSTRACT

Long-term aerosol climatology is derived using Terra MODIS (Collection 6) enhanced Deep Blue (DB) AOD retrieval algorithm to investigate decadal trend (2006–2015) in columnar aerosol loading, future scenarios and potential source fields over the Indo-Gangetic Plain (IGP), South Asia. Satellite based aerosol climatology was analyzed in two contexts: for the entire IGP considering area weighted mean AOD and for nine individual stations located at upper (Karachi, Multan, Lahore), central (Delhi, Kanpur, Varanasi, Patna) and lower IGP (Kolkata, Dhaka). A comparatively high aerosol loading (AOD: 0.50 ± 0.25) was evident over IGP with a statistically insignificant increasing trend of 0.002 year^{-1}. Analysis highlights the existing spatial and temporal gradients in aerosol loading with stations over central IGP like Varanasi (decadal mean AOD $\pm$ SD, 0.67 ± 0.29) and Patna (0.65 ± 0.30) exhibit the highest AOD, followed by stations over lower IGP (Kolkata: 0.59 ± 0.21; Dhaka: 0.60 ± 0.24), with a statistically significant increasing trend (0.0174–0.0206 year^{-1}). In contrast, stations over upper IGP reveal a comparatively low aerosol loading, having an insignificant increasing trend. Variation in AOD across IGP is found to be mainly influenced by seasonality and topography. A distinct "aerosol pool" region over eastern part of Ganges plain is identified, where meteorology, topography, and aerosol sources favor the persistence of airborne particulates. A strong seasonality in aerosol loading and types is also witnessed, with high AOD and dominance of fine particulates over central to lower IGP, especially during post-monsoon and winter. The time series analyses by autoregressive integrated moving average (ARIMA) indicate contrasting patterns in randomness of AOD over individual stations with better performance especially over central IGP. Concentration weighted trajectory analyses identify the crucial contributions of western dry regions and partial contributions from central Highlands and north-eastern India, in regulating AOD over stations across IGP. Although our analyses provide some attributes to the observed changes in aerosol loading, we

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ORIGINAL ARTICLE

Modeling of air pollution in residential and industrial sites by integrating statistical and Daubechies wavelet (level 5) analysis

Kirti Soni[1] · Kulwinder Singh Parmar[2] · Sanjeev Agrawal[3]

Abstract Air pollution is a major issue in all around world, it directly impact on human health, which affecting the lungs and respiratory system. This deposited on soil, plants and in the water, further contributing to human exposure and It mixes in the blood and pumped all-around the body. The most important air pollutants found over Delhi were sulfur dioxide (SO_2), nitrogen dioxides (NO_2) and suspended particulate matter (SPM). Statistical and wavelet analysis of these air pollutants at three different sample sites two residential namely Janakpuri, Nizamuddin, and one industrial namely Shahazada Bagh over Delhi for the more than 20 year period from 1987 to 2010 in India have been studied. The results shown that the mean concentration of SO_2 decreased for both residential (Janakpuri, Nizamuddin) as well as industrial (Shahzada Bagh) area, whereas NO_2 increased but it is under the prescribed limits of National Ambient Air Quality Standards (NAAQS). Janakpuri and Nizamuddin represent almost equal but lower mean values of SO_2 concentration than Shahzada Bagh. SO_2, NO_2 and SPM at all sites depicts symmetrical and platykurtic behaviour except Shahzada bagh, for that it follows leptokurtic. Discrete wavelet analysis of air pollutants using Daubechies wavelet (level 5) have been calculated for the study. It is also observed that the values at five different levels of signal data for all air pollutants varies between −225 and +225.

Introduction

Air pollution is a major environmental health problem affecting the emerging and the established countries. Air pollutants contain gaseous pollutants (SO2, NO2, CO etc), suspended particulate matter (SPM) and odours like as dust, mist, fumes and smoke. Urban areas and its surroundings pollution is directly due to the concentration of these pollutants (Goyal 2003; Soni et al. 2014, 2016; Karimi et al. 2016; Adarsh and Shyma 2017). Varotsos et al. (2005) applied detrended fluctuation analysis to the Athens air-pollution time-series. The main sources of human-created air pollution are energy generation, construction, waste generation, domestic cooking & heating, transportation, and industries. In the last two decades, Delhi was expanding rapidly by both means population and pollution. This made, Delhi in list of the top 10 polluted cities of world. The Central Pollution Control Board (CPCB) of India in March, 2009, stated Delhi as "India's Asthma Capital". Delhi's air pollution mainly developed from a combination of factors including industries, power plants, domestic combustion of coal, biomass and transport (direct vehicle exhaust and indirect road dust). The major air pollutant, which could cause potential harm to human health has been included are SO_2, NO_2 and particulate matter (SPM) etc. (Daneshvar and Abadi 2017; Balyani et al. 2017).

Wavelet analysis is becoming an important tool for analysing the localized variations of power in a time series (Daubechies 1992; Can et al. 2005; Dökmen and Aslan 2013; Diodato et al. 2014). In wavelet, we can use the both information regarding time and frequency, as here signal is

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Modeling of air pollutants using least square support vector regression, multivariate adaptive regression spline, and M5 model tree models

Ozgur Kisi[1] · Kulwinder Singh Parmar[2] · Kirti Soni[3] · Vahdettin Demir[4]

Abstract This study investigates the applicability of three different soft computing methods, least square support vector regression (LSSVR), multivariate adaptive regression splines (MARS), and M5 Model Tree (M5-Tree), in forecasting SO_2 concentration. These models were applied to monthly data obtained from Janakpuri, Nizamuddin, and Shahzadabad, located in Delhi, India. The models were compared with each other using the cross validation method with respect to root mean square error, mean absolute error, and correlation coefficient. According to the comparison, LSSVR provided better accuracy than the other models, while the MARS model was found to be the second best model in forecasting monthly SO_2 concentration. Results indicated that the applied models gave better forecasting accuracy in Janakpuri station than the other stations. The results were also compared with previous studies and satisfactory results were obtained from three methods in modeling SO_2 concentrations.

Keywords Soft computing techniques · Regression methods · Prediction modeling · Environmental management

Introduction

Soft computing consists of different techniques, which are helpful to solve uncertain and complex problems (Corchado et al. 2011; Corchado and Herrero 2011; Vaidya et al. 2012; Kisi and Parmar 2016). It is used to investigate, simulate, and analyze complex issues and phenomenon in an attempt to solve real-world problems. Soft computing is useful where the precise scientific tools are incapable of giving analytic, low cost, and complete solution. The problem of air pollution is one of the most important problems among all, and it had come into play since the beginning. Air pollution affects both the developing and the developed countries alike. Air pollutants consist of gaseous pollutants (SO_2, NO_2, CO, etc.), odors, and suspended particulate matter (SPM) such as fumes, dust, smoke, and mist. The high concentration of air pollutants in and near the urban region causes severe pollution to the surroundings. Sulfur dioxide is a pungent, toxic gas that is in the atmosphere. Moreover, it harms the society, as it causes acid rain which affects the environment (Rizwan et al. 2013). Sulfur dioxide reacts in the atmosphere to form aerosol particles, which can create outbreaks of haze and other climate problems. The main sources of SO_2 are volcanic and anthropogenic emissions from burning sulfur-contaminated fossil fuels and the refinement of sulfide ores (Seinfeld and Pandis 2006). According to the new analysis of data from NASA's Aura satellite, the emissions of sulfur dioxide from power plants in India increased by more than 60% between 2005

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ELSEVIER

Statistical variability comparison in MODIS and AERONET derived aerosol optical depth over Indo-Gangetic Plains using time series modeling

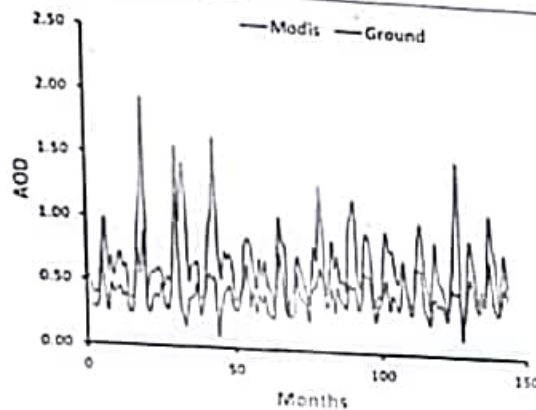Kirti Soni [a], Kulwinder Singh Parmar [b,*], Sangeeta Kapoor [c], Nishant Kumar [d]

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HIGHLIGHTS

- Ground and satellite AODs data for the 2001–2012 period is modeled.
- Statistical variability is compared to assess the performance of the model.
- Time Series Model is applied to assess the future variation in both cases.
- ACF and PACF shows the six monthly patterns.
- Some features of the past carry on to influence the future AOD values.

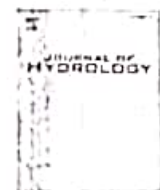## GRAPHICAL ABSTRACT

ARTICLE INFO

ABSTRACT

A lot of studies in the literature of Aerosol Optical Depth (AOD) done by using Moderate Resolution Imaging Spectroradiometer (MODIS) derived data, but the accuracy of satellite data in comparison to ground data derived from AERosol RObotic NETwork (AERONET) has been always questionable. So to overcome from this situation, comparative study of a comprehensive ground based and satellite data for the period of 2001–2012 is modeled. The time series model is used for the accurate prediction of AOD and statistical variability is compared to assess the performance of the model in both cases. Root mean square error (RMSE), mean absolute percentage error (MAPE), stationary R-squared, R-squared, maximum absolute percentage error (MAPE), normalized Bayesian information criterion (NBIC) and Ljung-Box methods are used to check the applicability and validity of the developed ARIMA models revealing significant precision in the model performance. It was found that, it is possible to predict the AOD by statistical modeling using time series obtained from past data of MODIS and AERONET as input data. Moreover, the result shows that MODIS data can be formed from AERONET data by adding 0.251627 ± 0.133589 and vice-versa by subtracting. From the forecast available for AODs for the next four years (2013–2017) by using the developed ARIMA model, it is concluded that the forecasted ground AOD has increased trend.

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ELSEVIER

Application of least square support vector machine and multivariate adaptive regression spline models in long term prediction of river water pollution

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ARTICLE INFO

SUMMARY

This study investigates the accuracy of least square support vector machine (LSSVM), multivariate adaptive regression splines (MARS) and M5 model tree (M5Tree) in modeling river water pollution. Various combinations of water quality parameters, Free Ammonia (AMM), Total Kjeldahl Nitrogen (TKN), Water Temperature (WT), Total Coliform (TC), Fecal Coliform (FC) and Potential of Hydrogen (pH) monitored at Nizamuddin, Delhi Yamuna River in India were used as inputs to the applied models. Results indicated that the LSSVM and MARS models had almost same accuracy and they performed better than the M5Tree model in modeling monthly chemical oxygen demand (COD). The average root mean square error (RMSE) of the LSSVM and M5Tree models was decreased by 1.47% and 19.1% using MARS model, respectively. Adding TC input to the models did not increase their accuracy in modeling COD while adding FC and pH inputs to the models generally decreased the accuracy. The overall results indicated that the MARS and LSSVM models could be successfully used in estimating monthly river water pollution level by using AMM, TKN and WT parameters as inputs.

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1. Introduction

Water is an essential element for life, but we are living in a water starved world. River water and ground water play an important role to fulfill the requirement of quality water around the globe. The quality river water also affects the quality of ground water (Parmar and Bhadwaj, 2013). In old times, numerous civilizations developed on the river banks just for the availability of fresh and pure water, but unfortunately now the rivers are influenced by urbanization, industrialization and other human activities. Contamination in stream water draws consideration of government, public, NGO's and environmentalists in India and the world over. Numerous rivers have been dying at an alarming rate because of the quality of water (Parmar et al., 2009; Kisi et al., 2012). Water quality and its enhancement have a close connection with the presence of chemical oxygen demand (COD). Oxygen concentration act as an important indicator of the water quality (Hanbay et al., 2009).

There are many forecast models, which have been developed for prediction of long-term precipitation (Doyle and Barros, 2011; Dokmen and Aslan, 2013). In these methods, time series modeling on the ground of statistics has been used. Statistical modeling has many advantages over mathematical models. But the shortcomings of the statistical approach include handling nonlinear characteristics of data because the statistical models are usually based on the linear correlations of the data can be expressed with a correlation coefficient. To overcome the shortcomings of the statistical methods, least square support vector machine (LSSVM), multivariate adaptive regression splines (MARS), M5 model tree, models are developed to address the nonlinearity of data (Nayak et al., 2004; Partal and Kisi, 2007; Wieland and Mirschel, 2008; Hanbay et al., 2009; Kisi, 2009, 2013; Alves et al., 2011; Maheshwaran and Khosa, 2012, 2013; Kisi and Tombul, 2013; Soni et al., 2014; Cheng and Cao, 2014; Bhardwaj and Parmar, 2013, 2015).

LSSVM model is based on kernel methods, which have proved capable of estimating more accurate than different techniques, for example, linear models ARIMA, neural networks, ANFIS, neuro-fuzzy systems, in terms of various different assessment measures during both the validation and test stages (Hong and Pai, 2006; Xu et al., 2006; Liu et al., 2007; Wang et al., 2009). The

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