

Modelling and optimisation of natural fibre reinforced polymer nanocomposite: application of mixture-design technique

Optimising the composition of nanocomposite

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Abstract

Purpose – The aim of this article is to demonstrate the development of environment friendly, low cost natural fibre composites by robust engineering approach. More specifically, the prime objective of the study is to optimise the composition of natural fibre reinforced polymer nanocomposites using a robust statistical approach.

Design/methodology/approach – In this research, the material is prepared using multi-walled carbon nanotubes (MWCNT), Cantala fibres and Epoxy Resin in accordance with the ASTM (American Society for Testing and Materials) standards. Further, the composition is prepared and optimised using the mixture-design approach for the flexural strength of the material.

Findings – The results of the study indicate that MWCNT plays a vital role in increasing the flexural strength of the composite. Moreover, it is observed that interactions between second order and third order parameters in the composition are statistically significant. This leads to proposing a special cubic model for the novel composite material with residual analysis. Moreover, the methodology assists in optimising the mixture component values to maximise the flexural strength of the novel composite material.

Originality/value – This article attempts to include both MWCNT and Cantala fibres to develop a novel composite material. In addition, it employs the mixture-design technique to optimise the composition and predict the model of the study in a step-by-step manner, which will act as a guideline for academicians and practitioners to optimise the material composition with specific reference to natural fibre reinforced nanocomposites.

Keywords Polymer nanocomposite, Cantala fibre, Design of experiments, Mixture design, Composition optimisation, Flexural strength, Residual analysis, Special cubic model

Paper type Research paper

1. Introduction

The intensification in environmental perception, interest towards community, novel environmental guidelines and unmanageable consumption of petroleum has persuaded the development of ecologically friendly resources across the globe (Cheung *et al.*, 2009). Many floras, pods and crops, which are sources of agriculture are being considered as significant sources of feasible natural fillers for the manufacture of polymer composites (Ramamoorthy *et al.*, 2015). Considerable enhancement in the application of natural fibres as bio-filler/reinforcement materials in industries for the preparation of composites can lead towards a greener society and increase environmental safety concepts because of the utilisation of renewable materials (Huzaifah *et al.*, 2017). Composites prepared from natural fibres have less biological and health complications for the workforces employed in the production of these composites, compared with composites prepared from carbon fibres, glass fibres and other synthetic fibres (Joshi *et al.*, 2004). In this regard life-cycle assessment (LCA) of these bio-based composites has gained prominence, to gauge the environmental benefits and its



Effect of Compression Ratio on Engine Performance, Combustion and Emissions in an CI Engine Fueled By VIOME, WCOME and W10V10

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Abstract: Benefit for mankind is the key for intensive scientific innovation. In this belief, the research in field of biofuels is one such to create an ecofriendly environment. The work presented here includes the study on the influence of variation of compression ratio(CR) on engine performance, combustion and emissions for the selected biodiesel fuels namely Vateria Indica Oil Methyl Ester (VIOME) B20, Waste Cooking Methyl Ester(WCOME) B20 and W10V10 (Hybrid of VIOME B10 and WCOME B10)along with neat diesel. The main focus is on VIOME due to the reason being very little research is done on the same. The compression ratio levels selected are 17, 17.5 and 18 where 17.5 is standard for the engine design to work on diesel. The increase of the compression ratio favored to increase the brake thermal efficiency (BTE) and reduction in brake Specific fuel consumption (BSFC). The combustion characteristics enhanced at CR 18 due to the temperature assistance. The emissions did not show a significant improvement. The NO_x levels were observed to be high whereas the CO levels dropped due to the better combustion.

Keywords: Compression Ratio (CR), Brake Thermal Efficiency (BTE), Combustion and Emission.

I. INTRODUCTION

It is well recognized truth by all concerning the fossil fuel diminution and also the harm to the nature by the use of the same. The fast-moving world, development of science, expansion of the economy necessitates the use of engines and fuels to run the same. The scientist community along with the environmentalists have reported on the adverse effect of the pollutants emitted from the engines or burning of the fossil fuel. [1]–[3]. This concern has raised the young researchers to work on the alternative fuels and also those fuels which are environmentally friendly. Biodiesel is commonly yielded from the vegetative and animal resources. Here while selecting the feedstock utmost care has to be taken such that the food cycle is not disturbed. This has made the policy makers and the associated officials to prepare the governing rules in wise selection of the edible bio stock [4]–[6].

The main focus is given on the preparation of biodiesel from Vateria Indica being the new biofuel and very less research is done. In search of the non-edible feedstock and availability in local areas, Vateria indica found to be the suitable one and also meagre research is done on this feedstock. Vateria indica is yielded in the parts of south zone within Asia and majority in western Ghats of Karnataka, the seeds are commonly called by name Dhupa. These trees yield once in two years around 400 to 500 kg per hectare[7], [8]. The Vateria indica has few medicinal benefits too and studies have revealed the presence of 20 to 22% oil [8]. Gowda et.al stated in their research the existence of the FFA levels more than 6 in oil borne through Vateria indica seeds. Also, the want of two step transesterification is presented so as to make the oil feasible for use, which reduced the tendency to solidify at room temperatures[9]. Awolu and Layokun too reported on the oil yield from neem oil, which demanded the want of two step transesterification as it acquired the FFA levels greater than 4.5, also the procedure helped in reduce of the fuel viscosity [10].

Noting on the handling of the biodiesel in the engine the essential concern for the researchers is on the subject of lesser need towards engine alterations, combustion characteristics, performance, and the emissions. During the factors considered in concern to application of bio diesel preference weightage is offered for the fuel which needs lesser engine modifications. Bio oil yielded from the Jatropha by pramanik et al demonstrated by working the CI engine devoid of physical modifications. Literature is obtainable stating, 45 to 50% of the bio diesel is in capability to switch over diesel fuel deprived of the need to physical engine modifications. Adding to it the engine performance too improved [11]. The biodiesel viscosity is higher which result in difficulty for atomization during the fuel injection and also the vegetative oils cause the clogging of the fuel lines and sticky valves. The oxidization stability and the cold flow properties are the other associated problems which challenges the researchers [12][13]. Blended biofuels in similarity to the neat diesel found to possess short ignition delay. The existence of the abundant oxygen levels resulted in higher combustion temperature[13]. Studies have shown interaction of the biodiesel with the materials of engine owing to the chemical attributes. The characteristics



Production optimization of *Vateria Indica* biodiesel and performance evaluation of its blends on compression ignition engine

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ABSTRACT

The rapid depletion of fossil fuels and the increasing levels of exhaust gas emissions have paved the way for researchers to focus their attention on alternative fuels. One such potential alternative source of fuel is biodiesel. In the light of the search for newer fuels, the present work focuses on *Vateria Indica* biodiesel that is found widely in Western Ghats of India and Srilanka. The work reports on the extraction of *Vateria Indica* oil, preparation of its biodiesel and performance testing of biodiesel blends on compression ignition engine (diesel engine). The oil and biodiesel yields have been optimized by Response Surface Methodology (RSM) and are found to be 23% and 85% respectively. The performance test results of *Vateria Indica* biodiesel blends on diesel engine have indicated that the brake thermal efficiency (BTE) was found to be lower and the brake specific fuel consumption (BSFC) was found to be higher for B10 (90% diesel+10% biodiesel), B20 (80% diesel+20% biodiesel) and B30 (70% diesel+30% biodiesel) blends compared to neat diesel. The performance characteristics of B10 blend were very close to neat diesel. The combustion characteristics of biodiesel blends were found to be superior compared to neat diesel. The B30 blend has better combustion characteristics compared to B10 and B20 blends. The emissions of unburnt hydrocarbons (UBHC), carbon monoxide (CO) and smoke were lower, and oxides of nitrogen (NO_x) were higher for all the blends of biodiesel compared to neat diesel.

1. Introduction

The ever increasing demand for energy will pose challenges to security of supply as the resources are dissipated around the world. Biodiesels boost and safeguard energy security by minimising the world's dependence on fossil fuels (Simsek, 2020; Gad and Jayaraj, 2020; Shrivastava et al., 2020; Krishnamoorthi et al., 2020). Also combating the climate change compels the world to search for alternative, low carbon sources of energy and fuel. Since traffic is one of the largest sources of greenhouse gas such as carbon emissions, replacing fossil fuels with renewable energy sources such as biodiesels is an effective way to minimize the harmful emissions. Besides, it is expected that the world population may reach to 10.5 billion by 2050 combined with significant economic growth in emerging economies will result in a drastic increase in energy consumption. To meet the growing demand, the use of renewable energy sources such as biodiesels should be enhanced (Devarajan et al., 2020; Rajak et al., 2020; Aydin et al., 2020; Mishra et al., 2020; Shrivastava and Verma, 2020; Babu et al., 2020). Extensive research work has been carried out on various biodiesels to

explore their suitability as fuels for diesel engine (Mahlia et al., 2020; Raju et al., 2020; Tacias-Pascacio et al., 2019; Hoseini et al., 2018, 2019; Pathak et al., 2018; Yatish et al., 2018; Aboelazayem et al., 2018; Chandra Sekhar et al., 2018; Das et al., 2018; Baskar et al., 2018; Nair et al., 2017). In the search for newer fuels among the vegetable oils, *Vateria Indica* oil has drawn its attention as a potential source of biodiesel. The *Vateria Indica* is a large evergreen tree belonging to the Dipterocarpaceae family and is endemic to India. It is commonly called as Indian copal or dhupa. The *Vateria Indica* seeds yield 20–27% of oil. It is a multipurpose tree that finds its use in food industry, medical field and its resin is used as incense and for candles (Rao et al., 2019). In order to substantiate the suitability of biodiesel obtained from *Vateria Indica* oil as an alternative to diesel the following literature review on biodiesels has been carried out.

Shrivastava et al. (2020), have investigated the performance characteristics of *Roselle* and *Karanja* biodiesel blends on diesel engine. They have reported that the brake thermal efficiency (BTE), oxides of nitrogen (NO_x) and smoke emissions of biodiesel blends are less compared to diesel. Shrivastava & Verma (2020), have conducted experiments on

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Numerical investigation of hydrogen absorption in a metal hydride reactor with embedded embossed plate heat exchanger

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ABSTRACT

In this paper, a Metal Hydride (MH) reactor integrated with an Embossed Plate Heat Exchanger (EPHX) was studied for the first time for its hydrogen absorption rate and thermal performance. A detailed numerical analysis of the various flow-field designs in the EPHX such as parallel-type, pin-type, and serpentine types (vertical and horizontal) was performed. The serpentine flow-field EPHX presented better heat transfer and faster hydrogen storage ability. Also, it showed more uniform temperature distribution in the bed compared with parallel and pin-type flow-fields. Next, the vertical-serpentine flow-field EPHX was compared with the most commonly used Helical Coil Heat Exchanger (HCHX) and the outcomes were discussed. Although, EPHX showed slightly lower overall heat removal from the reactor, it presented similar hydrogen absorption rate and remarkable uniformity in temperature distribution in the reactor.

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1. Introduction

In a Metal Hydride (MH) reactor, the heat transfer phenomena plays a significant role in regulating the time it takes to reach the equilibrium pressure of the hydride and hence the absorption rate. The heat transfer governs the temperature the hydride reach during the absorption, thus may have an influence on disproportionation. It is reported in a patent document [1], that cycling at high temperature can make the metal powder more likely to disproportionation. Many interesting strategies have been employed by various researchers to facilitate effective heat transfer from/to the reactor. In the last two decades, several investigators have proposed MH reactors integrated with different heat exchanging systems. These can be broadly classified as internal heat exchanger system, techniques to supplement effective thermal conductivity, and phase change materials. Some of the internal heat exchanger designs are spiral tubes [2,3], tube with fins [4–8], coiled tubes [9,10], helical coils [11–14], capillary tube bundles [15], double-layered annulus MH reactor [16–19], and heat pipes [20,21]. The techniques used to augment operative thermal conductivity of the reactor were metal wire matrix [22], multilayer sheet structure [23], MH powder composites [24], metal foam [25,26], and porous

expanded graphite [27]. Several scholars devised MH reactors with phase change materials [28,29]. Hui et al. [30] developed a method to improve hydrogen absorption by physical moving of the powder by tilting the tank back and forth by 90° to enhance heat transfer rate. The results showed that larger MH reactors benefited more from the physical moving of the powder than the small sized reactors. A honeycomb structure heat exchanger with a resistive heater placed at the center was used by Claudio et al. [31] to study the desorption behavior of hydrogen in MOF-5® adsorbent material.

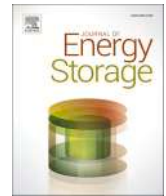
It is known that metal powder undergoes fragmentation into smaller particles upon repeated cycles of hydriding and dehydriding. This results in variation in the contact conditions between the alloy particles. A study by Kenta et al. [32] reveals the effect of pulverization on contact conditions between the alloy particles and hence its effective thermal conductivity. The major factors influencing the effective thermal conductivity of the particles are their contact ratio of point contact & plane contact, mean gap, and Biot number. After the charging and discharging cycles, although the increase in contact ratio of point contact increase the heat conduction, the significant effect of decrease in contact ratio of plane contact, mean gap and Biot number decrease the effective thermal conductivity of the alloy particles. The fine grains due to pulverization may gradually settle at lower portion of the cylinder under gravity forming a densely packed region. The denser zones are mainly due to segregation, ratcheting and followed by

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Analysis of Heat and Mass Transfer During Charging and Discharging in a Metal Hydride - Phase Change Material Reactor

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ABSTRACT

This paper presents the heat and mass transfer study during charging and discharging processes in a metal hydride reactor (MHR) equipped with phase change material (PCM). The PCM numerical model is newly developed and incorporated into the metal hydride (MH) model, which was presented earlier [1]. It is based on the enthalpy-porosity formulation and considers source/sink terms in energy and momentum conservation equations. The study explores the effects of metal foam incorporated into PCM, and the variation of its porosity and pore density towards better heat transfer, and hydrogen charging and discharging rates. Detailed performance analysis of the MHR-PCM system with and without metal foam is performed, and the results show a significant improvement in performance with the PCM having metal foam embedded in it. The study on the effect of metal foam porosity reveals an interplay between effective PCM thermal conductivity and PCM amount on the hydrogen charging rate. The study clearly illustrates the limitation posed by the MH powder thermal conductivity on heat transfer and optimizes the metal foam morphology for improved hydrogen charging and discharging rates. The natural heat convection in the PCM is found to be negligible due to its high density. A brief study on the influence of hydrogen inlet and exit pressures, and the amount of PCM on charging and discharging rates is also performed. The study provides an in-depth insight into the formation of liquid and mass fraction fronts in the PCM and MH regions, respectively, under different operating conditions and PCM configurations.

1. Introduction

Recent research works have demonstrated the potential candidacy of solid-state metal hydrides (MH) for hydrogen storage due to their high gravimetric and volumetric density, moderate operation temperature, pressure, and substantial hydrogen sorption rates [2]. Despite the significant advancement in the development of solid-state materials, the inherent heat problem is still remaining. The formation and dissociation of hydride are exothermic and endothermic, respectively, with an enthalpy of reaction typically greater than 33 kJ/mol H₂ (heat of 16.5 MJ/kg). For instance, if 5 kg of hydrogen is to be stored in 3 minutes, the generated heat of 82.5 MJ will need to be removed at a rate of ~0.46MW, which is a highly exacting engineering problem and demands an exceptional heat management system. To exacerbate this, the dissociation of hydride requires substantial heat to be supplied to meet the supply pressure requirement of the fuel cell [3].

From the thermodynamic point of view, the hydrogen absorption and desorption reaction rates on metal are strongly dependent on temperature. The metals are relatively stable at high temperatures;

therefore, lowering the temperature is needed to facilitate metal-hydrogen reaction to form metal hydride. The converse is valid for the hydrogen desorption process. Therefore, there have been significant research and development efforts devoted in the literature to improve heat transfer in the MH tanks. These research works can be broadly classified into three main categories: internal/external heat exchange methods, methods to improve the effective thermal conductivity of the MH bed, and the use of phase change materials (PCM). A thin double-layered annulus MH bed was studied by several researchers, via both experimental and numerical approaches [4–9]. The MH bed had two thin annulus layers of metal powders with hydrogen supply between them. Filters were provided to avoid the flow of metal particles from the MH bed. Several cooling channels were provided in the outer and inner MH walls, and heating means were provided at the inner and outer sides of the MH walls. In [7], fins were provided in the MH bed to improve the effective thermal conductivity of the bed. The MH beds used for ITER storage and delivery employed helium loops for active cooling. Several experimental and simulation works have proved the feasibility of the use of such MH beds for hydrogen storage and delivery. The literature

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Spatial analysis of CO poisoning in high temperature polymer electrolyte membrane fuel cells

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HIGHLIGHTS

- The effects of CO poisoning on HT-PEM fuel cell performance were investigated.
- Simulations were conducted on 49.4 cm² fuel cell at various operating conditions.
- Spatial variation of CO coverage and current density in the cell were studied.
- Even current distribution with reformat at total current lower than with pure H₂.
- The effect of the reformat feed rate on cell performance was studied.

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ABSTRACT

The improved tolerance of the High Temperature-Polymer Electrolyte Membrane Fuel Cell (HT-PEMFC) to CO allows the use of reformat as an anode feed. However, the presence of several per cent of CO in the reformat, which is inevitable particularly in on-board reformation in automobiles, which otherwise demands complex systems to keep the CO level very low, will significantly lower the cell performance, especially when the HT-PEMFC is operated at 160 °C or below. In this study, a three-dimensional, non-isothermal numerical model is developed and applied to a single straight-channel HT-PEMFC geometry. The model is validated against the experimental data for a broad range of current densities at different CO concentration and operating temperatures. A significant spatial variation in current density distribution is observed in the membrane because the CO sorption is a spatially non-homogeneous process depending on local operating conditions and dilution of the H₂ stream. To investigate the local spatial effects on HT-PEMFC operation, the model is applied to a real cell of size 49.4 cm² with an 8-pass serpentine flow-field at the anode and the cathode. The membrane and anode catalyst layer are segmented into 5 × 5 array to investigate the spatial resolution of the polarization curves, H₂ concentration, current density, and anode polarization loss. The simulation results show that the presence of CO in the anode feed reduces cell performance, however, the results reveal that uniformity in current density distribution in the membrane improves when the cell is operated in

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A Numerical Investigation on Thermal Gradients and Stresses in High Temperature PEM Fuel Cell During Start-up

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ABSTRACT

The High Temperature Polymer Electrolyte Fuel Cell (HT-PEMFC) stacks using polybenzimidazole (PBI) based membranes have an inability to internally heat up at low temperatures to their nominal operating temperature (160°C–180°C) during the start-up process. Several strategies, such as direct electrical heating, coolant/gas channel heating, catalytic hydrogen-oxygen combustion, etc., are proposed in the literature to assist the heating for quick start-up situations. However, little knowledge exists on the transient thermomechanical stresses induced during the start-up heating process due to non-uniformity in heat supply and disparity in thermal properties of the cell components. The objective of the present research is to analyze the thermal gradients and thermal stresses developed in the HT-PEMFC structure during the start-up with various heating methods discussed in the literature, as well as during the cell operation by exploiting the Fluid-Structure Interaction (FSI) approach. The use of polyalkylene glycol (Fragoltherm S-15-A) based Heat Transfer Fluid (HTF) in the coolant channel has substantially improved the start-up time due to the high Nusselt number. However, a significant gradient in temperature distribution is observed during the preheating process, which resulted in great inhomogeneous stresses in the membrane, particularly in the in-plane direction. Interestingly, the degree of uniformity in membrane current density distribution during cell operation is increased. A detailed heat analysis in the cell showed that the heat generated in the cell due to electrochemical reactions is sufficient to raise the cell temperature from 120°C to operating temperature in a short time. Being subjected to a compressive stress of above 40 MPa, which is higher than the ultimate strength of a typical acid doped PBI membrane, the electrolyte is the most vulnerable component during the start-up. Hence, to inhibit the concomitant effect on cell performance and degradation, a novel start-up strategy should be implemented.

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1. Introduction

Over the past couple of decades, the phosphoric acid doped polybenzimidazole (PBI)-based High Temperature Polymer Electrolyte Fuel Cells (HT-PEMFCs) have received considerable attention compared to Low Temperature Polymer Electrolyte Fuel Cells (LT-PEMFCs) based on perfluorosulphonic acid (PFSA) polymer electrolytes, especially for portable power supply, Auxiliary Power Units (APU), backup power and micro-Combined Heat and Power (μ CHP) [1] applications. The LT-PEMFCs are not recommended to operate above 80°C due to the loss of mechanical stability and proton conductivity, which is a strong function of the water content of the membrane [2]. On the other hand, the significant benefits

of HT-PEMFCs are derived mainly from its higher operating temperature, i.e., typically in the range of 160°C–180°C. The benefits of HT-PEMFC are: it allows the use of reformat fuel with better tolerance to carbon monoxide poisoning, easy water management as it exists in the vapor phase, simplified flow-field design, better heat management, and improved electrode kinetics. It should also be mentioned that the major challenges of HT-PEMFCs are also derived from its high operating temperature. Some of them include longer start-up time, the demand for good thermal and mechanical stability of components [3], increased carbon corrosion [4], and electro-catalyst degradation.

In a review of phosphoric acid doped PBI-based HT-PEMFC, Araya et al. [5] rightly pointed out that significant research is being carried out on fuel cell components level since Wainright et al. [6] proposed the use of acid doped PBI membranes in fuel cells. However, what hurdles the successful commercialization of HT-

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Numerical Study of Hydrogen Absorption in a Metal Hydride Tank Embedded with multiple U-Shaped Cooling Channel

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ABSTRACT. In the present paper, a three-dimensional hydrogen absorption model is applied to a cylindrical LaNi₅ hydride bed embedded with multiple U-shaped cooling channels having fins fitted in different orientations. Four number of cooling channels are placed radially at equal distances to achieve uniform heat removal from the bed. The fins are fixed to the coolant channel in transverse and radial directions. The fins volumetrically collect heat from the bed and deliver to the coolant channels. Three metal hydride bed cases are numerically studied, they are with: only coolant channels - case 1, coolant channels fitted with transverse fins - case 2 and coolant channels with transverse and radial fins - case 3. From the simulation results, it is revealed that the presence of fins in the coolant channels significantly improves the heat transfer and hydrogen absorption rate in the bed. The hydrogen absorption in the bed approaches 90% of saturation in 998 s, 867 s and 656 s for case 1, 2 and 3, respectively. Detailed multi-dimensional contours of temperature and hydrogen to metal ratio distributions in the bed are presented for different cases. This study provides a better understanding of heat and mass transfer during the hydrogen absorption in a metal hydride bed.

Keywords: Metal hydride, Hydrogen storage, U-shaped coolant channel, Fins

1. INTRODUCTION

Depletion of non-renewable energy sources like fossil fuels has been a major concern around the world and this led to significant advances in R&D on alternative fuels. Among the several, hydrogen being a pollution free gas and high energy density is recognized as an alternative fuel in many onboard applications. Despite hydrogen being a high potential energy carrier, high flammability and low density have made the storage and transportation a major bottle neck in onboard applications. Conventional hydrogen storage methods such as compression and liquefaction require lot of storage space, energy and safety requirements. Solid state storage of hydrogen gas in elemental metal/intermetallic alloys has recently gained much attention due to low operating pressure & temperature, economical, compact and safe [1]. The hydrogen absorption (hydriding) and desorption (dehydriding) in a metal hydride (MH) are exothermic and endothermic reactions, respectively. The difference between the line pressure and equilibrium pressure is the driving force for the sorption process in the reactor. Therefore, effective heat removal and supply during the absorption and desorption, respectively plays a significant role. To add to this, the thermal conductivity of the metal alloy is very low and with the hydriding it decreases further. Therefore, understanding the heat & mass transfer within the bed and developing an effective heat exchanging system is very essential to improve the hydrogen storage[2].

Jemni and Nasrallah [3] developed a two-dimensional numerical model to investigate the thermal phenomena in the MH reactor during hydrogen absorption. The model was used to study the effect of inlet pressure & temperature,

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A numerical study of metal hydride reactor embedded with helical coil heat exchanger

Hydrogen charging and discharging in a metal hydride reactor

Abstract: The critical challenge of heat management in a Metal Hydride (MH) reactor necessitates comprehensive research and development towards an effective heat transfer system to enhance its hydrogen charging and discharging rates. Several interesting strategies were reported in the literature to assist effective heat transport from and to the reactor. In this report, a comprehensive three-dimensional numerical model accounting for reaction kinetics and, heat and mass transfer is developed for hydrogen charging and discharging in a LaNi₅ based MH reactor. The model is compared with the experimental data, and the simulation results agree closely with the experimental data. A detailed parametric study is carried out to optimize the operating conditions of the reactor and the geometry of the Helical Coil Heat Exchanger (HCHX) to improve the hydrogen charging and discharging rates. The effect of essential parameters such as supply/exit pressures, Heat Transfer Fluid (HTF) temperature, and helical coil pitch/turns on the thermal performance and sorption rate of the MH bed are analyzed systematically. The hydrogen charging simulation results show that increasing the inlet hydrogen pressure and reducing the HTF temperature significantly improves the charging rate. From the HCHX design point of view, it is observed that increasing the number of coils turns benefits the hydrogen storage performance due to improved heat transfer from the MH bed to the helical coil. The influence of the exit pressure and the HTF temperature on the hydrogen discharge rate is also discussed in detail. The present study with multi-dimensional contours of temperature and hydrogen mass fraction will improve the fundamental knowledge of the MH reactor and shed light on the development of an effective heat exchanger.

Keywords: Heat transfer; Helical coil heat exchanger; Hydrogen storage; Metal hydride.

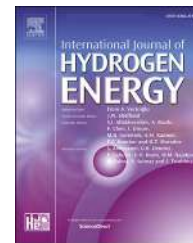
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Optimization of graded catalyst layer to enhance uniformity of current density and performance of high temperature-polymer electrolyte membrane fuel cell

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HIGHLIGHTS

- Performance of HT-PEMFC comprising a graded cathode catalyst structure is studied.
- Multiple graded CLs improve performance but leads to uneven current distribution.
- High Pt loading downstream greatly improves uniformity in current distribution.
- Proposed hybrid CL structures improve both performance and current distribution.
- Study shows the importance of a rational design of CL based on cell application.

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ABSTRACT

The optimal use of catalyst materials is essential to improve the performance, durability and reduce the overall cost of the fuel cell. The present study is related to spatial distributions of current and overpotential for various graded catalyst structures in a high temperature-polymer electrolyte membrane fuel cell (HT-PEMFC). The effect of catalyst gradient across the catalytic layer (CL) thickness and along the channel and their combination on cell performance and catalyst utilization is investigated. The graded catalytic structure comprises two, three, or multiple layers of catalyst distribution. For a total cathode catalyst loading of 0.35 mg/cm^2 , higher loading near the membrane presents improved cell performance and catalyst utilization due to reduced limitations caused by oxygen and ion diffusions. However, non-uniformity in the current distribution is significantly increased. The increase in the catalyst loading along the reactant flow provides a substantially uniform current density but lower cell performance. The synergy of varying catalytic profiles across the CL thickness and along the cathode flow direction is investigated. The results emphasize the importance of a rational design of cathode structure and mathematical functions as a strategic tool for functional grading of a CL towards improved uniform current distribution and catalyst utilization.

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Effectiveness of Collaborative Learning Among Gen Z Engineering Students

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Abstract: Collaborative learning helps to get the most out of students' academic as well as intellectual capabilities by engaging a team of students in self-regulated learning activities under the supervision of course coordinators. At the swipe of a screen, Generation Z (Gen Z) has the solutions to every problem. The need to promote interactive and productive learning and to cater to the needs of current Generation Z (Gen Z) engineering students, collaborative learning is considered to be one of the most profound approaches which can be incorporated in the teaching and learning process on the campuses. The aim of this research is an attempt to understand the engineering students' insights towards collaborative learning and its effectiveness. The study population of this action research is the second-year electronics and communication engineering students (N=60; males=33; females=27) on a core course at St Joseph Engineering College, Mangaluru, Karnataka, India. They were selected on the basis of their performance in the previous test. The collaborative activity was conducted in two phases. Six Thinking Hats activity was adopted for collaborative learning activity. A detailed research design with a structured

questionnaire has been used to measure the effectiveness of the activity. Collaborative learning is found to be an effective method in enhancing learning among Gen Z engineering students, with a positive correlation between collaborative learning and student performance and the assessment parameters of the presentation indicate that the students participated actively.

Keywords: Collaborative learning, Group presentation, Generation Z, Student engagement, Student understanding.

1. Introduction and Literature Review

Technology is life and breath for Gen Z engineering students and they live amid information and entertainment. Unlike traditional learners, Gen Z engages with information to tackle challenges and come up with their solutions. Collaborative learning is one of the effective teaching learning tools. When we analyse the Engineering education, it demands lot discussions, demonstrations, presentations, brainstorming and participative sessions. Collaborative teaching tool is more comprehensive and best suited to meet these requirements compare to other tools. More over engineering is more of team work where collaboration is inevitable and collaborative learning tool prepares them for their work place conditions as well. As we look into the literature there are considerable work have been

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EMBEDDING OF CONCEPT LATTICE INTO ITS MIXED CONCEPT LATTICE

H. S. RAMANANDA AND A. J. HARSHA¹

ABSTRACT. Formal Concept Analysis (FCA) is a method of analysis of object-attribute relational data and knowledge representation. In this paper, the foundations of FCA are extended and in particular mixed concept lattices are studied in depth. We mainly focused on embedding property of a given lattice with respect to its mixed concept lattice. At the end of the article, we characterized the types of lattices which can be embedded in the corresponding mixed concept lattice.

1. INTRODUCTION

Formal Concept analysis (FCA) method was introduced by R.Wille, a German mathematician. Theoretical foundations of FCA are built on applied lattice theory [1, 2]. FCA constitutes a very successful mathematical approach to knowledge representation with a rich theory as well as numerous practical application. FCA is a method of analysis of object-attribute relational data and knowledge representation. For the last two decades, FCA has been used extensively in various disciplines such as software engineering, linguistics, information retrieval, bioinformatics and data mining [3–7].

FCA gives the fundamental data model in a binary relation between a set of objects and attributes, which indicates the presence of a property in an object.

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Key words and phrases. Concept lattice, atomistic lattice, \vee -irreducible elements, \wedge -irreducible elements.

A FRAMEWORK FOR STUDENT'S RESULT ANALYSIS USING FORMAL CONCEPT ANALYSIS

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ABSTRACT: For any educational institute, outcome based education (OBE) is the key tool of growth and success. To achieve this goal, it requires the performance of the students and analysis of their results. An independent analysis of students result gives precisely what is to be achieved through the proper attributes (subjects) and which helps to monitor progress towards those objectives (students).

Formal Concept Analysis (FCA) is a method of analysis of object-attribute relational data and knowledge representation. In this paper a clear cut framework is established using the concept of FCA and lattice structure. This analysis provides the performance of students, which helps the institutes about their learning outcomes.

KEYWORDS: formal concept analysis, concept lattice, attribute implication

I. INTRODUCTION

FCA method was devised in the early 1980s by R.Wille, a German mathematician. Theoretical foundations of FCA are built on applied lattice theory [1, 2]. FCA is a method of analysis of object-attribute relational data and knowledge representation. For the last two decades, FCA has been used extensively in various disciplines such as software engineering, linguistics, information retrieval, bioinformatics and data mining [3, 4, 5, 6, 7].

Universe can be considered as a large collection of objects. Each object is associated with some information with it. In order to find the knowledge about the universe we need to extract some information about these objects, which requires various method of data analysis in a scientific way. When dealing with large sets of data we inevitably need to address the problem of data representation. Many different approaches for tackling that problem have been proposed and applied over years. A framework for medical diagnosis, business marketing is already done using FCA [8, 9]. With reference to these work, we focused on one such type of data analysis of students result using the concept of FCA. Which gives important and sensitive conclusions. The implementation of these analysis gives an quality output for the academic institutions.

In this paper we considered class of students and analyzed their performance with various decisions. In this article, Section II provides basic notations and definitions, Section III divides the data in a structured way to make analysis simple and convenient. In Section IV, we have taken different decision classes to analyse the result. This further followed by a conclusion and future work in Section V.

Notations And Definitions

A formal context or simply a context $T=(G, M, I)$ consists of two sets G and M and a relation I between G and M . The elements of G are called objects of T , the elements of M are called attributes of T . If an object a has attribute m , we denote it by aIm . A 1 in row a and column m means that the object a has attribute m . A context is represented in terms of binary matrix. For a set $A \subseteq G$ of objects and $B \subseteq M$ of attributes, $A' = \{m \in M \mid aIm \text{ for all } a \in A\}$; $B' = \{g \in G \mid bIg \text{ for all } b \in B\}$. A formal concept of the context $T = (G, M, I)$ is a pair (A, B) with $A \subseteq G$, $B \subseteq M$, $A' = B$ and $B' = A$. $L(G, M, I)$ denotes the set of all concepts of the context T . The set of all concepts, when ordered by set-inclusion, satisfies the properties of a complete lattice. The lattice of all concepts is called concept lattice. The formal concept lattice of the context in FIGURE 1 (Context T) is shown in FIGURE 2 (Concept of T).

How Admixtures Affect Yield Stresses of Cement

by Chandrasekhar Bhojaraju, Malo Charrier, and Claudiane M. Ouellet-Plamondon

A factorial experimental design plan was used to compare admixtures (high-range water-reducing admixture, viscosity-modifying agent, accelerator, CSH seeds, and nanoclay) in a cement and silica fume blend. Two methods were tested to measure the structuration rate: the constant velocity method and the creep recovery method. The measurements were performed with a rotational rheometer with a double-helical spiral geometry to reduce slippage. The evolution of yield stress and thixotropy of the mixtures at four resting times was evaluated, providing insight into the stress that the recently printed structure can withstand. The creep recovery method generally provides a higher static yield stress than the constant velocity method, except for the stronger mixtures, raising additional questions on the effect of the paste history on microstructural buildup mechanisms. When the extruder begins, shear is applied and the microstructure is broken, causing the dynamic yield stress to be lower than the static yield stress. The effect of the admixtures on thixotropy is discussed.

Keywords: admixtures; creep recovery method; CSH-seed; thixotropy; yield stress.

INTRODUCTION

The growing interest in large-scale additive manufacturing processes in construction is stimulating research in computer-controlled placements of cementitious materials to create structures. This has prompted a fresh look at rheology to describe the early behavior of cement paste that is required: flowability for extrusion and material structuration for buildability. Admixtures affect the buildability of a paste. The microstructure of a cement paste can resist certain stress before it is broken down and starts to flow. At rest, the microstructure strengthens due to colloidal flocculation during the first 5 minutes. After the hydration products begin to fill, the volume and the admixtures change the cement dormancy period and the rate of structural buildup.

The yield stress can be defined in many ways. A definition common to many materials is that yield stress is the change from elastic to plastic behavior of materials. Cementitious materials are visco-plastic Bingham materials. They flow only when a critical stress value is reached—that is, the yield stress.¹ The static yield stress is the critical stress that allows a paste to flow from rest. The dynamic yield stress is the critical stress when the paste is in motion. These yield stresses will change with time due to the following intrinsic forces to the cement. There is competition between the attractive colloidal forces in the network of cement particles and viscous dissipations during the dormant phase, which resists the flow.¹ Pumping and extrusion happen at this stage, and the material yield stress and viscosity should be as low as possible. The yield stress of cement increases over time as more hydrates bridge the particles. For three-dimensional

(3D) printing, the structuration rate must be fast. High static yield stress is required to ensure the stability of the extruded layers after deposition.²

Static yield stress is the stress required to initiate the flow of an undisturbed microstructure. The characterization of the static yield is essential to define the printing parameters, and the methodology remains a subject of debate. Static yield stress is measured at the flow onset and depends on the network of colloidal interactions between the cement particles.² The small-amplitude oscillatory shear (SAOS) test is linked to CSH formation at the contact point between cement grains.³ This paper focuses on the static yield stress at the flow onset. Three types of measurements have been suggested. The most common method is to apply a constant, very low shear rate. At first, the microstructure deforms elastically, and then the elastic limit is reached and the paste flows. The constant speed varies among studies, from 0.001 to 0.01 to 0.2 s⁻¹.⁴⁻⁹ The shear rate affects the paste deformation, which means that the results are comparable only for the same velocities. The second method is to use a constant deformation rate to determine the structuration rate for 3D printing, which was recommended by a study of the static yield stress with varying constant shear rate levels between 0.08 and 0.24 rad/s.² This constitutes the second measurement type. The third method, known as the creep recovery method, is to control the torque of the rheometer. By gradually increasing the angular velocity, the microstructure breaks and deforms rapidly, and the static yield stress is determined from the rapid change in torque.¹⁰ Thus, the challenge later becomes selection of experimental parameters that are representative of the printing system.

Concrete must be in movement during transportation to prevent the formation of a 3D network. In general, the maximum shear rate experienced by concrete is approximately 10 to 60 s⁻¹ during mixing and 20 to 40 s⁻¹ during pumping.¹¹ The dynamic yield stress is measured from a paste in rotation. In this context, the dynamic yield stress is also the stress that keeps the paste flowing, as described in the steady-state models, such as the Bingham model. In the measurement procedure, the rotational speed is increased, then reduced to 0. The upward change in speed brings the particles into a more neutral state. The decreasing trend is used to determine dynamic yield stress with the rheological parameters. The shear rate varies from 0 to 100 s⁻¹ for

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Bioleaching of iron from fly ash using a novel isolated *Acidithiobacillus ferrooxidans* strain and evaluation of catalytic role of leached iron in the Fenton's oxidation of Cephalexin

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Iron is the sole energy source for the acidophilic bacterium *Acidithiobacillus ferrooxidans*. Feeding indirect iron source to this bacteria results in leaching of iron from complex minerals. In this study fly ash, a waste is fed to the isolated bacteria under stress condition and is made to recover the traces of iron present in the fly ash for its application as a Fenton's catalyst to degrade Cephalexin. The investigation evaluates the leaching potential of a novel isolated strain *Acidithiobacillus ferrooxidans* BMSNITK17 in leaching iron from fly ash. About 89 mg/L of iron is recovered within the initial five days of inoculation. It is observed that the rate of metabolism of bacteria is very slow with fly ash as source. Catalytic efficiency of recovered iron was investigated to degrade Cephalexin, a major waste found in pharmaceutical and hospital discharge. About 87.98% of Cephalexin is degraded in first two hours with COD reduction of 74.21%. Reaction follows pseudo-first order kinetics with rate constant 0.017/min.

Keywords: Bioleaching, *Acidithiobacillus ferrooxidans*, fly ash, Fenton's process, Cephalexin.

Introduction

Effluent from pharmaceutical industries and hospital are of more concern to the environmentalist for its toxic and hazardous compounds which pose direct threat to the environment on its disposal¹. Many of these compounds sustain the degradation even at the final stage of treatment and manage to persist for a long period in the environment posing hazard to life. Cephalexin is a group of cephalosporin drug synthesized from penicillin sulfoxide by its ring expansion². This antibiotic drug has its application in the treatment of wide variety of disease. In spite of its beneficial use Cephalexin may cause diarrhoea, nausea, skin irritation etc. On its way to environment through household drug usage, pharmaceutical and hospital discharge these are resistant for biological degradation³⁻⁵. Hence biological methods to treat Cephalexin fails in this concern⁶. Advance oxidation is the chemical method of treatment which is effective for the wide variety of organic pollutants with short duration of treatment. Among

advance oxidation process Fenton's oxidation is of very much interest to the environmentalists. Fenton's oxidation to degrade Cephalexin has been tried by few researchers^{7,8}.

Resource recovery from the waste and zero discharge is the topic of concern that has been in research from decades. Fly ash has its application as reinforcement in concrete and soil studies giving rise to core strength to materials. Environmental concern towards fly ash has been neglected for many decades. Fly ash by virtue of its composition contains silicon dioxide, aluminium oxide, magnesium oxide and iron oxide. Iron content of fly ash is comparatively very low marking its content up to 10–15% of its overall composition^{9,10}. Fenton's oxidation in the treatment of water and wastewater has got importance for its efficient degradation capability of vast number of organic pollutants. Use of iron as a catalyst reduces the treatment time and increases the efficiency¹¹⁻¹⁴. Iron from the fly ash was recovered by some of the researchers using conventional methods⁵⁵. Valeev and co-workers succeeded



Review Paper

A critical review of the effect of concrete composition on rebar–concrete interface (RCI) bond strength: A case study of nanoparticles

Seyed Sina Mousavi¹  · Seyed Soheil Mousavi Ajarostaghi^{2,3} · Chandrasekhar Bhojaraju¹

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Abstract

Minimum concrete cover for rebar, rebar diameter, concrete compressive strength, embedded length of rebar, and lateral reinforcement by stirrups are the crucial factors considered in existing predicting equations and regulations for predicting rebar–concrete interface (RCI) bond strength. However, considerable effects of concrete composition on RCI are ignored in design codes and investigations. This paper intends to comprehensively highlight the critical aspects of this research gap. Additionally, a practical experimental approach is described in the present study to efficiently consider the effect of the new generations of concrete on RCI bond strength. Finally, nano-concrete is considered as a case study to show the importance of nanoparticle types on RCI bond strength. Overall results show that studying the microstructure of the transition zone at RCI is essential to accompany with the RCI bond strength for considering new generations of concrete in reinforced concrete structures. Additionally, the current study emphasizes that more investigations are necessary to be conducted by future works to fill the existing research gaps in RCI.

Keywords Bond–slip · Concrete composition · RCI · Calcium hydroxide · Nano-concrete

Abbreviations

CSH	Calcium silicate hydrate
EDS	Energy dispersive spectroscopy
LWC	Lightweight aggregate concrete
NC	Normal concrete
OPC	Ordinary Portland cement
PPC	Portland pozzolana cement
PSC	Portland slag cement
RAC	Recycled aggregate concrete
RC	Reinforced concrete
RCI	Rebar–concrete interface (RCI)
rebar	Reinforcing bar
SCC	Self-consolidating concrete
SEM	Scanning electron microscopy
TEM	Transmission electron microscopy

List of symbols

c	Concrete cover
d_b	Rebar diameter
f_c	Concrete compressive strength
f_y	Rebar yield strength
K_{tr}	Confinement index
l_d	Development length
w/c	Water-to-cement ratio
λ	Lightweight concrete factor
α	Rebar location factor
β	Epoxy coating factor
γ	Rebar size parameter
τ	Bond stress
τ_{NC}	Maximum bond strength of normal concrete

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Application of Superabsorbent Polymer as Self-Healing Agent in Self-Consolidating Concrete for Mitigating Precracking Phenomenon at the Rebar–Concrete Interface

Seyed Sina Mousavi¹; Lotfi Guizani²; Chandrasekhar Bhojaraju³; and Claudiane M. Ouellet-Plamondon, M.ASCE⁴

Abstract: Improved autogenous healing capacity of concrete using superabsorbent polymers (SAPs) was used as an efficient approach for mitigating damage between steel rebar and self-consolidating concrete (SCC). The results for normal concrete (NC) and those for SCC mixtures were compared. Two SAPs with different particle sizes and chemical compositions were used in the experimental program. Results showed that despite the greater reduction effect of SAP with a smaller particle size on compressive strength, SCC containing this type of SAP had the highest bond strength in uncracked specimens, compared with SAP with larger particle sizes, for SAP-modified NC and SCC mixtures. Moreover, results showed that SCC and NC containing SAP had considerably greater healing improvement factors for large crack widths ($w \geq 0.30$ mm) compared with mixtures without polymers; almost 46%, 30%, and 24% healing improvement factors were obtained for average bond stress, bond strength, and residual bond stress of SAP-containing concrete mixtures, respectively. Furthermore, complete strength recovery (100% healing improvement factor) was obtained for SCC mixture with $w = 0.10$ mm after a 28-day healing period. DOI: [10.1061/\(ASCE\)MT.1943-5533.0003881](https://doi.org/10.1061/(ASCE)MT.1943-5533.0003881). © 2021 American Society of Civil Engineers.

Author keywords: Bond strength; Superabsorbent polymer (SAP); Self-consolidating concrete (SCC); Self-healing.

Introduction

Propagating cracks parallel to the reinforcing bar (rebar) direction causes a considerable reduction in bond strength of steel rebar embedded in normal concrete (NC), which is called the precracking phenomenon (Brantschen et al. 2016; Mousavi et al. 2019a, 2020b). Only a few studies proposed a practical solution, such as the self-healing method, to mitigate internal damage due to the precracking phenomenon (Mousavi et al. 2019b, 2020c). Further hydration of unhydrated cement particles inside concrete mixtures along with precipitation of calcium carbonate are the main healing products used to seal and heal cracks in hardened concrete. Unhydrated cement particles and an internal reservoir of water inside concrete mixtures are needed to provide appropriate conditions for the self-healing method. Different healing agents were used in

concrete mixtures to provide water resources necessary to activate the self-healing method, such as lightweight aggregates and polymers. Among them, superabsorbent polymer (SAP), a hydrogel material, was found to be effective because of its excellent ability to absorb and retain a large amount of water relative to its mass. Hygroscopic materials are categorized into two main groups based on the water absorption mechanism: (1) chemical absorption, and (2) physical absorption (Zohuriaan-Mehr and Kabiri 2008). Chemical absorbers, such as metal hydrides, catch water by chemical reactions, changing their whole structure, whereas physical absorbers maintain water by different mechanisms of reversible modifications of their crystal structure and physical entrapment of water through capillary forces in their macroporous structure (Zohuriaan-Mehr and Kabiri 2008). SAP is a physical organic material absorber with an ultrahigh capability for water absorption. Common hydrogels can absorb water or aqueous solution up to 1 g/g, whereas ultrahigh absorbing materials (such as SAP) can absorb 10–1,000 g/g. This is the reason for the use of the prefix super for this type of hydrogel with extraordinary water absorbency. For example, as reported by Zohuriaan-Mehr and Kabiri (2008), the water absorption of Whatman No. 3 filter paper, facial tissue paper, soft polyurethane sponge, wood pulp fluff, and cotton ball are 180%, 400%, 1,050%, 1,200%, and 1,890% by weight, respectively. They reported a value of 20,200% by weight for an agricultural SAP, which is significantly greater than that of common absorbent materials. Additionally, unlike the traditional absorbent materials, the swollen SAP gradually releases the absorbed water into the matrix as relative humidity in a concrete mixture decreases due to cement hydration. This water absorption–water release cycle by SAP particles is efficient for improving the self-healing (or autogenous healing) of concrete. Mousavi et al. (2020c) used superabsorbent polymers (SAP) in NC mixtures as a healing agent. They obtained promising results for healing cracks at the steel rebar–concrete interface after exposure to the precracking phenomenon. Bond properties of the precracked specimens were partly recovered (regained) after wet–dry healing cycles.

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Experimental study on residual properties of thermally damaged steel fiber-reinforced concrete containing copper slag as fine aggregate

Binaya Patnaik¹ · Chandrasekhar Bhojaraju² · Seyed Sina Mousavi²

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Abstract

This study intends to investigate the effect of copper slag (CS) on the hardened properties of thermally damaged steel fiber-reinforced concrete. Two water-to-cement ratios of 0.5 and 0.55 are considered for the concrete mixture. Different volume fractions of 0, 0.5, 1.0, and 1.5 are considered for steel fiber. Thermal cycles of 28 and 56 are considered in the experimental program. Ultrasonic pulse velocity technique is used to monitor internal damages due to the thermal cycles. Overall results show that concrete mixtures containing copper slag have considerable thermal resistance compared to the reference mixtures. However, results recommend the optimum content of 1% for steel fiber, while further addition causes lower thermal resistance of CS-modified concrete. Also, regression equations are proposed for residual compressive and tensile strengths of thermally damaged CS-modified concrete. Results show good agreement between the experimental database and the proposed regression equations.

Keywords Copper slag · Thermal cycle · Steel fiber · UPV · Compressive strength

Abbreviations

CS	Copper slag	FR _t	Fire resistance factor for splitting tensile strength
COV	Coefficient of variation	HPC	Slip of steel bar in cracked concrete
CSRC	Copper slag-reinforced concrete	HSC	High-strength concrete
(f _c) ₀	Compressive strength of concrete at normal temperature	IAE	Integral absolute error
(f _c) _n	Compressive strength of concrete after <i>n</i> thermal cycles	<i>n</i>	Number of thermal cycles
(f _t) ₀	Splitting tensile strength of concrete at normal temperature	OPC	Ordinary Portland cement
(f _t) _n	Splitting tensile strength of concrete after <i>n</i> thermal cycles	SCC	Self-compacting concrete
FR _c	Fire resistance factor for compressive strength	SR _c	Strength reduction of compressive strength after <i>n</i> thermal cycles
		SR _t	Strength reduction of splitting tensile strength after <i>n</i> thermal cycles
		UPV	Ultrasonic pulse velocity
		UPV ₀	Ultrasonic pulse velocities after 0 thermal cycle
		UPV _n	Ultrasonic pulse velocities after <i>n</i> thermal cycle

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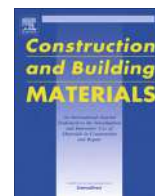
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Introduction

Recently, due to technological progress, industrial development, and population growth, the consumption of natural resources is increasing so more sustainable construction materials need to be produced [1, 2]. Hence, there is a growing tendency in using waste materials and by-products, as partial substitution of natural aggregate, fiber, and filler in conventional concrete [2-5]. The high consumption of river aggregates results in exhaustion of the natural resources



Fresh and hardened properties of GGBS-contained cementitious composites using graphene and graphene oxide



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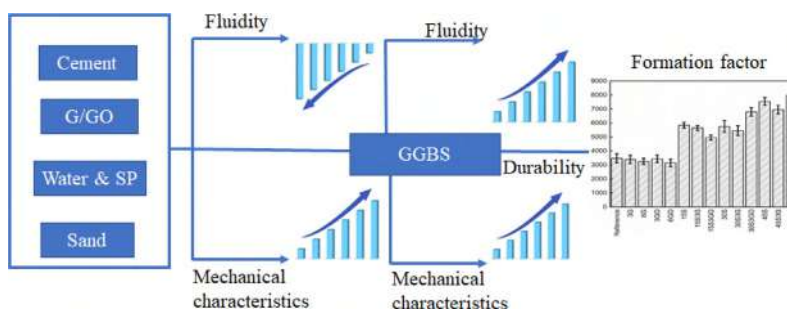
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HIGHLIGHTS

- GGBS increases fluidity and workability of nano-based cement paste.
- Shear rates, shear stress, yield stress and plastic viscosity of GGBS-nano-cement paste are improved.
- GGBS increases the mechanical and durability properties of nano-based cement paste.

GRAPHICAL ABSTRACT



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ABSTRACT

The addition of nanomaterials affects the workability of cementitious composites by reducing the free water available within the mixtures. In order to address this issue, the present study intends to study the addition of ground granulated blast furnace slag (GGBS) in cementitious materials containing graphene (G) and graphene oxide (GO). An experimental program is considered to measure fresh properties, compressive strength, and service life of cementitious composites. Dosages of 0.03% and 0.06% (by weight of cement) of G and GO are tested in cement pastes and mortars. GGBS in three different dosages of 15%, 30%, and 45% is investigated. A constant water/cement ratio of 0.35 is used in all mixtures. Results show that GGBS improves the yield stress and plastic viscosity of G- and GO-modified cementitious composites. Moreover, GGBS dosages of 30% and 45% compensate the reduced fluidity of 0.03 wt% of G- and GO-modified cementitious composites, respectively. The thixotropy of the composite paste containing GO decreases with the addition of GGBS. Moreover, comparable and slightly improved compressive strengths are obtained for mixtures containing GGBS. The results from the nomogram show a promising trend for the service life of mixtures containing G, GO, and GGBS.

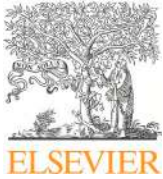
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1. Introduction

The addition of nanomaterials to cementitious materials presents an opportunity to achieve highly durable and long-lasting materials. This can significantly increase the structural performance of building materials [1]. Recent research has focused on the reliability-based durability design of the nano-based cementitious material used in the construction industry [2–5]. To achieve

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Hybrid steel/glass fiber-reinforced self-consolidating concrete considering packing factor: Mechanical and durability characteristics

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Self-consolidating concrete
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Hybrid fiber
Durability
Packing factor

ABSTRACT

This study intends to determine the effect of fiber type and aggregate content on hardened and durability properties of self-consolidating concrete. Steel, glass, and steel/glass hybrid fibers are tested in the present experimental program. Additionally, the effect of aggregate content is considered by using different packing factors and sand-to-all aggregate ratios. Moreover, normal and high strength concrete grades are prepared. Compressive, splitting tensile, flexural, and impact tests are conducted for measuring hardened properties of concrete mixtures. Absorption, desorption, acid attack, resistivity, potential, and chloride diffusion are also durability tests carried out in the present study. Results show that 1.0% and 0.05% are the optimal dosage of steel and glass fibers respectively. Results show that packing factor plays a major role in mechanical characteristics of fiber-reinforced self-consolidating concretes so that an optimal value of 1.12 and 1.14 is obtained for mechanical properties. Also, experimental results reveal that for 1.12 packing factor, the sand-to-all aggregate ratio needs to be equal to the value of 0.50, while 0.57 is achieved as an optimum value for packing factor of 1.14. Overall, results show that hybrid-reinforced self-consolidating concrete is promising for mechanical and durability performance as compared to other mixtures.

1. Introduction

Mechanical properties of normal concrete can be considerably improved by using different types of fiber [1–3]. Among the commonly used fibers, steel has the highest elastic modulus, and stiffness, thereby using steel fibers can be very useful in the improvement of mechanical properties of concrete [4,5]. However, it is also known that steel fiber rusts easily, and increases the structure's weight of the concrete, which causes a balling effect in mixing, and therefore consequently has lower function [6]. Synthetic fibers also, have low elastic modulus, low melting point, and weak interfacial bonding with cementitious matrixes, so to compensate this weakness, fibers reinforced polymers such as carbon, glass, aramid were used widely, to reinforce concrete. Glass fiber-reinforced concrete (GRC) consists basically of a cementitious matrix composed of cement, sand, water, and admixtures, in which short-length glass fibers are dispersed [7].

Extensive studies have performed on the mechanical performance of

glass fiber-reinforced concrete (GFRC). Griffiths and Ball [8] have conducted experimental tests to study the mechanical properties of glass fiber reinforced polyester polymer concrete. Their results show that the addition of about 1.5% chopped glass fibers (by weight) increases the modulus of rupture by about 20% and the fracture toughness by about 55%. Chandramouli et al. (2010) [9] have observed a reduction in bleeding by the addition of glass fibers in concrete mixes. They have also reported the percentage increase of 20 to 25% for various grades of glass fiber concrete mixes compared to normal concrete. A similar trend was observed by Tassew and Lubell [10] where the flexural strength of ceramic concrete increased with increase in the glass fiber volume fraction irrespective of the mix composition or fiber length. Choi and Yuan [11] have reported that the addition of glass fibers to concrete increased the splitting tensile strength of concrete by approximately 20–50%, and the splitting tensile strength of GFRC ranged from 9% to 13% of its compressive strength. Vijai et al. [12] have shown that the addition of 0.03% volume fraction of glass fibers in

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RESEARCH ARTICLE

Bioleaching of iron from laterite soil using an isolated *Acidithiobacillus ferrooxidans* strain and application of leached laterite iron as Fenton's catalyst in selective herbicide degradation

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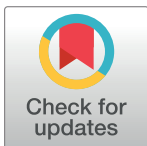
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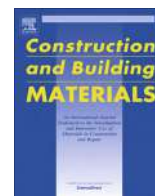
Competing interests: The authors have declared that no competing interests exist.

Abstract

A novel isolated strain *Acidithiobacillus ferrooxidans* BMSNITK17 has been investigated for its bioleaching potential from lateritic soil and the results are presented. System conditions like pH, feed mineral particle size, pulp density, temperature, rotor speed influences bioleaching potential of *Acidithiobacillus ferrooxidans* BMSNITK17 in leaching out iron from laterite soil. Effect of sulfate addition on bioleaching efficiency is studied. The bioleached laterite iron (BLFe's) on evaluation for its catalytic role in Fenton's oxidation for the degradation of ametryn and dicamba exhibits 94.24% of ametryn degradation and 92.45% of dicamba degradation efficiency. Fenton's oxidation performed well with the acidic pH 3. The study confirms the role of *Acidithiobacillus ferrooxidans* in leaching iron from lateritic ore and the usage of bioleached lateritic iron as catalyst in the Fenton's Oxidation.

1. Introduction

Worldwide application of herbicide to increase the significant yield of agricultural production by controlling weeds and pests may in turn have an adverse effect with environmental pollution. It is the bioaccumulation, lipophilic property, long half-life and large range transport that make herbicide more persistent in the environment. Persistent Organic Pesticides (POP's) are the class of herbicides which includes organochlorides that pose hazard to the environment. Pesticides like aldrin, isobenzane, pentachloro phenol are likely to be classified as highly hazardous exposure to which pose neurotoxicity and DNA damage. Most of the herbicides are likely to present for a longer period deteriorating environmental quality [1–3]. Ametryn, an herbicide belongs to triazine class have an adverse effect on environment in spite of its vast application for sugarcane, corn and pineapple crops. Dicamba is another class of benzoic acid herbicide formulated to substitute atrazine compounds for the control of woody plants and



On mitigating rebar–concrete interface damages due to the pre-cracking phenomena using superabsorbent polymers



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HIGHLIGHTS

- Low dosage of SAP has comparable bond strength in uncracked concrete.
- Large-size SAP has similar bond strength, as compared to the smaller size.
- High dosage of SAP has considerable effect on self-healing at rebar-concrete interface.
- Self-healing at rebar-concrete interface has no effect on splitting bond failure.
- EDS test confirms a considerable mass percent of calcium in the healed products.

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Bond-slip
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Self-healing,
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ABSTRACT

This study intends to determine the effects of incorporating superabsorbent polymers (SAP) within concrete on the bond properties of steel reinforcing bars (rebar) embedded in uncracked and pre-cracked concrete. An experimental program is conducted to check the performance of SAP, as a healing agent inside the concrete, in mitigating internal damage at the rebar-concrete interface due to the pre-cracking phenomena. Two types of SAP with different particle sizes (0.15 and 0.50 mm) and chemistries are considered in the experimental program. Pull-out test results show improved bond properties of steel rebars embedded in uncracked and healed concrete containing lower dosages of SAP. However, concrete containing a high dosage of SAP shows lower bond strength, compared to normal concrete, due to the presence of macro voids. A considerable healing effect is observed for the initial bond-slip curve portion, the bond strength, and the energy absorbed by the bond mechanism, within the cracks of pre-cracked SAP-modified concrete subjected to wet-dry cycles. This study shows that SAP can significantly increase the autogenous healing performance of concrete at rebar-concrete interfacial damage sites.

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1. Introduction

Pre-cracking phenomena, which illustrates the occurrence of cracks along the axis of steel rebar in the surrounding concrete, is a common issue in reinforced concrete structures, especially in steel-congested regions such as beam-column joints and shear walls extremities [1]. Various situations, including corrosion-caused pre-cracking [2,3], mechanical preloading [4,5], biaxial load transfer [6–8], multiaxial stress states [9,10], and transverse tension [11], are at the root of the pre-cracking phenomena. The

pre-cracking mechanism is similar to bond-splitting cracking and mainly affects the bond-slip behavior of the rebar. However, no fully efficient solution is available to tackle this inherent problem in reinforced concrete members (itself comprised of anchorage problems of flexural reinforcement in slabs [12], loop connections subjected to combined tension and bending [13], arch-shaped members without transverse reinforcement [14], and reinforced concrete members without transverse reinforcement [15]), which causes a significant reduction in maximum and residual bond stress [4,5]. One of the main objectives of this study is, therefore, to consider an accelerated self-healing method to mitigate damages due to the pre-cracking phenomena. This proposal could provide new insight into a strategy for healing damages due to the pre-cracking phenomena at critical interlayer sections of reinforced concrete members.

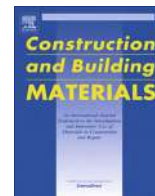
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The effect of air-entraining admixture and superabsorbent polymer on bond behaviour of steel rebar in pre-cracked and self-healed concrete

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ABSTRACT

This paper intends to study the effect of air-entraining admixture (AE) on self-healing method at rebar-concrete interface using superabsorbent polymer (SAP). AE with a constant dosage of 0.83 kg/m³, and 0.25% and 1.0% SAP dosages are considered. Two types of superabsorbent polymer with different chemical compositions and particle sizes are considered for the experimental tests. Pull-out test results of mixtures containing AE admixture are compared with those in non-AE concrete. Scanning electron microscopy/energy dispersive X-ray spectrometry (SEM/EDS) along with microscopic analysis is performed to study the healing products at crack surface and SAP macro voids around the rebar. Overall, results indicate that AE admixture has a considerable impact on the performance of the self-healing method at the rebar-concrete interface especially for higher dosage of SAP (1.0%). This can be attributed to the internal voids networks around the rebar generated by AE admixture, which can ease the water transfer between SAP macro voids to participate in healing cracks after wet-dry cycles. SEM analysis shows that stalactites, healing products at the external surface of crack, are composed of a large amount of calcium and oxygen.

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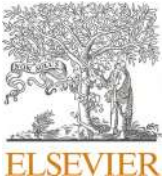
1. Introduction

The interaction between reinforcing bar (rebar) and surrounding concrete, known as the “bond-slip” phenomenon, plays a crucial role in the structural behaviour of a reinforced concrete (RC) member. The bond-slip phenomenon affects the structural efficiency of different sub-elements in an RC frame including column [1,2], beam [3], interior and exterior beam-column joints [4,5], and slab [6,7]. Improving bond characteristics can considerably affect the structural performance of these sub-elements along with the integrity of RC frame. Previous studies have shown that concrete composition has a considerable influence on bond properties including water-to-cement ratio [8,9], mineral admixture [10,11], aggregate type [12,13], and chemical admixture [14]. Among these variables, there is no specific study on the effect of air-entraining (AE) admixtures on bond characteristics of steel rebar in uncracked and pre-cracked specimens.

Air-entraining (AE) admixtures are organic surfactants which entrain a controlled quantity of air in concrete that is a uniformly dispersed discrete bubbles [15]. Content, size, spacing and specific surface of air voids are important parameters for AE concrete mixture. Regarding the size distribution of air voids, a wide range of values for different types of AE admixtures was obtained by previous studies. For instance, air void sizes with ranges of 0.25–1.0 mm [16], 0.10–2.0 mm [17], and air voids with a diameter larger than 0.1 mm (without specifying the max diameter) [18] were reported by the literature for AE concrete mixtures. Initial water-to-cement ratio, type of AE admixture, and dosage of AE admixture considerably affect the size distribution of the air-void system [19]. AE admixtures, as a surfactant, reduce the surface tension of water, resulting in bubble formation and stabilization [20]. Uniform dispersion and appropriate stability are obtained by the mutual repulsion of the negatively charged air-entrainer molecules and the attraction of the air-entrainer molecules for the positive charges on the cement particles [21]. AE increases the workability and consistency of concrete [22–24], so that mixtures with AE admixture have a higher slump value as compared to normal concrete (NC) at the same water content. On the other hand, the presence of air bubbles acts as a lubricant. AE concrete is less sensitive to bleeding and segregation than is non-AE concrete [15]. AE admixtures have

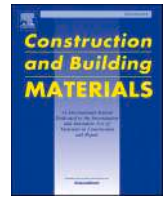
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The impact of carbon-based nanomaterial additions on the hydration reactions and kinetics of GGBS-modified cements

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Graphene

ABSTRACT

Carbon-based nanomaterials have been identified as a viable additive to cement for making high performance binders with exceptional properties. However, on a few studies have considered the impact of these additives in combination with the environmentally motivated use of supplemental cementitious materials. In this work, the effect of two carbon-based nanomaterials, graphene and graphene oxide, on the hydration kinetics of cement modified with various levels of ground granulated blast furnace slag has been documented. The hydration was characterized with in-situ calorimetry measurements and thermogravimetric analysis over 28 days. The analysis monitors the phase development and degree of hydration during the cement curing period. The results show a strong synergy between choice of nanomaterial chemistry and the use supplemental cementitious material. High confidence correlations between the degree of hydration and compressive strength, with R^2 greater than 0.9, across the various combinations of additives, showing the importance of hydration analysis for predicting the cement properties.

1. Introduction

Concrete is used worldwide and accounts for 4 – 8% of global CO₂ emissions [1,2]. Cement material research can increase the sustainability of cement through the development of improved volume efficiency which reduces the effective quantity of cement required. The addition of nanomaterials presents an opportunity to improve volume and cost efficiency of cement. However, the interactions between nanomaterials, such as graphene, and other common additives to cement are not well understood [3,4]. To better characterize the chemistry of nanomaterial interactions, this work addresses a research gap in the understanding of the hydration kinetics of nanomaterial-modified cements containing blast furnace slag.

Ground granulated blast furnace slag is among the most common supplementary cementitious materials [5]. The use of such supplementary cementitious materials can improve the environmental footprint of civil construction by reducing the cement requirements of binders. Many studies have been conducted to understand the influence of different supplementary cementitious materials on the properties of the resulting binder, including the crystalline morphology [6] and the degree of hydration [7]. Supplementary cementitious materials are typically

characterized by their position on a CaO-SiO₂-Al₂O₃ ternary phase diagram, which can be used to estimate their chemical reactivity in a plain cement matrix [8]. Supplementary cementitious materials are important advancement to the development of sustainable concretes. However, to date, few studies have considered the reactivity in the presence of nanomaterials. This absence in the literature limits the capability of applying nanomaterial-modified binders to practical applications which involve supplementary cementitious materials.

The addition of nanomaterials to cements has been studied as an avenue for improving the binder performance and volume efficiency. Both graphene and graphene oxide have been shown to impact the hydration of cement and the evolution of the cement paste. Graphene oxide has been observed to promote the nucleation of calcium-silica-hydrates through a seeding effect [9,10]. This can lower the energy barrier for the chemical evolution of the cement paste and create an accelerating effect, which has been documented [11,12]. This has been employed to improve the sustainability of cement composites by reducing the cement requirements [13] and counteract strength reduction from undesirable recycled aggregates [14]. However, other researchers report that the hydration kinetics are unaffected by the addition of graphene oxide [15]. This inconsistency in the literature indicates the sensitivity of the

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A Reward-based Active Learning Approach for Motivating and Engaging Students in a Large Classroom

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Abstract: Student engagement activities in the teaching-learning process have shown drastic developments and have helped not only in the exchange of information among students but also in the creation of knowledge. Active learning activities in teaching will allow students to participate in the learning process by reflecting on what they have learned. This can also include students working cooperatively in pairs or groups.

Whether it is about understanding concepts from the lectures or the implementation of concept-related information from the textbooks, group activities are of great use, especially while handling large classes. Group activity like in-class teams helps students to exchange information among their peers.

The purpose of the activity is to motivate the students and keep them engaged for the entire session. The in-class group activity proposed here is a reward-based approach which was a major motivation for the students and the competitive spirit among the teams kept them engaged in noting down the points being discussed in class and gathering information throughout the session.

The students of the class showed a better understanding of the concepts and good performance during the assessment. This paper describes the effective deployment of active learning to enhance the attention span of the students and keep them engaged for the entire session and thereby provides effective Outcome-Based Education (OBE). The results show that the attainment of the students' performance is enhanced. Moreover, it improves team spirit and team performance through cooperative learning.

Keywords: Active learning, cooperative learning, student engagement, student motivation.

1. Introduction

"To teach is to engage students in learning." This quote, from Education for Judgment by Christensen et al. [1], captures the essence and practice of this activity of engagement which is the focus of this paper. It highlights the fact that engaging students in learning have become the principal responsibility of the teacher, who has now become not as much an imparter of knowledge but more a designer and facilitator of learning experiences and opportunities for the students.

The focus of this paper is mainly student engagement through a group activity. In large classrooms, the students are distracted quite easily. Hence it becomes the responsibility of the teacher to keep them engaged for the entire session. Group activities often come in handy in such scenarios, whether it is about understanding the concepts or implementing it, especially while handling large classes. It promotes student engagement as well as the exchange of information among them and hence results in improved learning.

Edgerton, in his white paper [2], goes on to cite four strands of pedagogical reform that are moving in the same broad direction: problem-based learning, collaborative learning, service learning, and undergraduate research. This paper looks at a class of pedagogies of engagement, namely, those that are classroom-based. We focus particularly on cooperative learning and problem-based learning

The purpose of the activity proposed here is to motivate the students and keep them engaged throughout the session. In this paper, we have proposed an in-class group activity which is a reward-based approach. The reward was a major motivation for the students. It also encouraged them to make a note of the topics being discussed in class and kept them engaged for the entire session.

2. Literature Review

Edgerton introduced the term "pedagogies of engagement" in his 2001 Education White Paper [2], where he reflected on the projects on higher education. He mentioned the core issue, in my view, is the mode of teaching and learning that is practiced. Learning 'about' things does not enable students to acquire the abilities and understanding they will need for the twenty-first century. We need new pedagogies of engagement that will turn out the kinds of resourceful, engaged citizens".

The publication called The Seven Principles for Good Practice in Undergraduate Education [3] also stressed the

Enhanced Learning and Improved Productivity of Students' using Project Based Learning Approaches for Programming Courses

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Abstract: Active learning techniques surpassed traditional teacher-centric approaches owing to their benefits of better learning from the stakeholders. The selection of a specific learning strategy varies from one course to another for productive results. Many students face difficulties in understanding programming subjects especially when it comes to applying it practically for application developments, since the curriculum permits only a certain number of specific programs to be implemented and some courses will have only theoretical subjects without a practical component. Thus, it becomes a need of the hour to make students productive in order to be confident in applying concepts learnt to the application development. The proposed method of applying a combination of project based learning involving collaborative learning will prove to be an effective platform for the students to enhance their design & development skills. This experimentation has been applied to a total of about 420 engineering students and the average performance in the university examinations as well as their demonstration/oral presentation, viva answering skills are considered as metrics for measurement. Apart from this, students' ability to face challenges is gauged through their ability to excel in placement drives for selection to various companies. This approach has resulted in a significant improvement in students' performance in the university examinations with upto 54% of the students securing higher grades. Apart from this, it has been estimated that there is an improvement in placement rate of upto 10 - 15% along with increase in no. of offerings for the individual students.

Keywords: Active Learning, Project Based Learning, Performance, Application, Development

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1. Introduction

The technological advancements have led to a drastic shift from the traditional teacher centred learning approach to the student centred approach. The task of mastering the students with new competencies and the skills to enable them enriched with higher knowledge is a must to be competitive in the current context. Thus, Project based

learning would prove to be an effective tool to bridge [1] the gap between the universities educational activities and the actual needs from the industrial perspectives.

Project based learning (PBL) technique explores students' knowledge through techniques involving critical thinking and self-regulations [2]. PBL helps to engage the students in deep inquiry and in the construction of knowledge. PBL also supports collaborative learning thereby enabling better learning from the students' perspective. PBL involves the roles of the teachers to be modified as well as the environment in which they work. Teachers will be required to employ new classroom management strategies as well as scaffolding abilities to measure the effectiveness by assessing individual learning by the students. It also requires the beliefs from the teachers that their students are fully capable of learning through this approach.

PBL enables more participation from the students allowing them to acquire knowledge, skills, and personal as well as inter-personal skills. Through inquiry, students gain inter-disciplinary and multi-disciplinary knowledge which builds their design thinking, problem solving, information retrieval and analysing ability [3] making them confident enough to work in any engineering team.

2. Related Work

G. E., Veselov et al. [1] have described that project based method is built upon a foundation of profound integration of project based practices into the traditional educational process from the first year engineering course. They have shown that using this approach, there was an increase in the students' employment status as well as the academic performance. They mentioned that this practice will also enable students to develop their own start-ups thereby becoming an entrepreneur.

Dimitra Kokotsaki et al. [4] have shown that PBL is a student-centered instruction which facilitates students' autonomy, constructive investigations, goal-setting, collaboration, communication and reflection with real-world practices. They have also mentioned that in the modern context, teacher's ability to effectively scaffold students' learning and providing guidance and support, balance between didactic instruction with in-depth inquiry

Effective Usage of Gamification Techniques to Boost Student Engagement

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Abstract:

As the engineering education fraternity is getting accustomed to the new normal amidst the global COVID-19 pandemic, online teaching has been gaining much attention in the recent past. While teachers are getting adjusted to this new way of teaching, it is paramount that the teaching-learning process caters to the needs of our millennial learners. Considering all these factors, the teacher must continuously work towards always keeping the students motivated. The authors of this paper brought in a series of innovative gamification constructs throughout a semester across multiple courses to gauge the level of involvement of students during the online lectures as well as the Learning Management System (LMS). The motive was to ensure that the students actively participate in all deliberations, thereby positively impacting the online learning process. The participants of the study were 56 second year Post Graduate students who were undergoing online classes. Several tasks, as well as assessments, were assigned to the students. While doing so, students were introduced to new gamification tools like Mentimeter, Edpuzzle, Kahoot, Quizizz and many more at regular intervals to break the monotony and keep them on their feet waiting for the next task to be performed. This not only meant that the students started participating in the classes more actively but also kept them engaged with a variety of innovative tools. The results clearly showed that the students started learning the concepts better while keeping competitive spirits. When it came to individual activities, there was an urge in students to outperform each other, which meant that the students would go that extra mile to get the things done. At the same time, team tasks had a high level of collaboration resulting in effective learning and building camaraderie. The students prefer learning through multiple sources and multiple platforms. By leveraging technological advancements and bringing in gamification in learning, the overall teaching-learning process gets highly benefited.

Keywords: Gamification, Technology, Online Teaching-Learning, Student Engagement and Motivation

1. Introduction

Student engagement is known as an essential attribute to influence students' achievement. Students' prior learning (readiness), enthusiasm for learning, and the way the input is introduced to them are some of the factors that influence their ability to learn (Elteгани and Butgereit, 2015). Diverse learning styles among the students also contribute to the way they engage in the activities conducted by the educators. Sustaining the students' interest and participation is a struggle that leaves the educator in a quandary. This is because students' involvement plays an essential factor in their achievement and performance (Handelsman et al., 2005) measured during either the formative or summative assessment. (Mohd et al., 2016) found that active students are more likely to perform well as they retained more knowledge during learning activities. Several studies referred to gamification as a technique to increase the students' engagement (Hanus and Fox, 2015), (Kuo and Chuang, 2016), (Sanmugam et al., 2016). Gamification is the use of game design elements in non-game settings to engage participants and encourage desired behaviours. Technological developments allow the use of game elements in a non-game context by extending the methods that can be employed by educators in developing lesson plans. Not all educators are creative enough to include gamification in their lessons. Thus online platforms such as Kahoot!, Quizizz, Socrative, and Quizalize provide excellent options for educators to choose from in diversifies lesson plans and activities that can captivate and inspire students' motivation and increase students' engagement during lessons in the classroom.

The dynamic of games has influenced the popularity of gamification in the effort to enrich students experience in their learning journey, especially in a classroom. This paper explores the effectiveness of gamification technique to improve the students' engagement in database subject implemented in Polytechnic Muadzam Shah Pahang, Malaysia. Following the introduction, Section "Related Study" presents related studies on students' engagement and gamification. This is then followed by Section "The Research Framework and Model" that elaborate on the research framework and model. Sequentially, Section "The

Comprehensive Strategy to Inculcate Professional Skills among First-Year Students: A Collaborative Learning Approach

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Abstract: Inculcating teamwork, communication skills, and lifelong learning are essential metrics of Outcome Based Engineering (OBE). Ensuring these in early professional courses will enhance the ability of the students to adopt the OBE effectively in the forthcoming semesters. Effective planning and deployment of pedagogy of engagement will aid the students and faculty members to attain the desired outcomes with effective utilization of resources. This article unearths the challenges and documents the lessons learned in deploying collaborative learning in the First Year (FY) engineering education. It establishes a comprehensive assessment methodology from OBE perspective. Further, it addresses professional skills such as teamwork, communication skills, and lifelong learning in a structured manner. The Action Research methodology is adopted by taking into account the OBE approach enshrined in the Programme Outcomes (POs) as suggested by the Indian statutory bodies. The collaborative learning approach of 'Student, Teams, Achievement, Division' (STAD) is utilized by establishing a heterogeneous group. The Define-Measure-Analyze-Improve-Control (DMAIC) approach is used for project deployment and sustainment. Statistical analysis is used to interpret the results effectively. The study shows that the desired outcomes are achieved with a minimum duration of the teaching-learning process. Moreover, statistical analysis shows that even weaker students can reach the set attainment target due to heterogeneous group formation and collaborative learning. Eventually, the structured approach assists in developing a framework for the effective

within the optimal duration, provided a structured approach is embraced. It is also observed that heterogeneous group formation assists slow learners to elevate themselves to progressive learners due to teamwork and the influence of wiser students.

Keywords: Professional Skills, Collaborative Learning, Outcome Based Education, First Year Engineering Education.

1. Introduction

Technical Education everywhere in the world is picking up significance daily due to the quick headways in Science and Technology, which leads to the developments of different disciplines through continuous and ceaseless research. To achieve the social and economic goals of any nation, Engineering and Technical education have become a prerequisite, thereby maintaining the complex structure of the entire modern society. Engineering education should not be just about taking a degree after four years. Instead, it should be about training the students in various facets of life such as team player, being a leader, entrepreneur, ability to conduct oneself in critical situations, problem-solving skills (Buke et al., 2015). It has also been mentioned in "Washington Accord", accreditation bodies like NBA, NAAC and ABET that these aspects of should be given equal importance along with curriculum and pedagogy (Mohanty and Dash, 2016). Basic tenets of Outcome Based Engineering (OBE) is to inculcate critical thinking, and thus to bridge the gap between the facets and technical education provided in the colleges (Bhat et al., 2020a).

A. Outcome Based Education (OBE)

The OBE deployment in Engineering Education is made obligatory for all the Engineering programme to attain accreditation as per the Washington Accord (Bhat et al., 2020a). The concept of OBE developed by sociologist William Spady focusses on the assessment and evaluation of the best practices so that the attainment of learning

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deployment of collaborative learning by establishing robust assessment tools to address the POs related to professional skills. The study shows that collaborative learning can be effectively deployed in FY engineering education with specific reference to POs related to professional skills

Dynamic Classroom Strategies to Address Learning Diversity

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Abstract: Diversity is inevitable in every walk-of-life, and rightly in the learning process. Lack of strategies to address the need for diversified learning style is one of the stumbling-blocks for achieving the desired outcome among the students. The purpose of the research is to dwell deeper into the pedagogies of engagement to establish the strategies to accommodate diversity in learning style withing each session. The objective is to create a framework for resolving the issues of learning diversity through dynamic classroom strategies. Action Research Methodology is adopted to deploy and unearth the feasibility of strategies to resolve issues of learning styles. Silverman-Felder's learning style approach is used to create a dynamic classroom. Also, statistical techniques are used to draw the inference and to determine the effectiveness of the established strategies to resolve the learning issues. The study indicated that learning styles could be effectively addressed in every session through meticulous planning and deployment of active learning methodology. The dynamic classroom approach has resulted in the achievement of the desired outcome, which was validated through the assessment at the end of the session. Besides, the strategies adopted are validated by comparing the outcome of the other section through the internal test. Also, feedback of the students substantiated the methodology adopted to resolve the issues of diversity in learning styles. The study culminates that learning diversity can be addressed effectively only when the tutor is aware of learning styles and active learning strategies. Also, it is ascertained that the meticulous planning assists the faculty in ensuring value-added activities in the session. In addition, well-established

determined that the scientific planning of the session brings socio-technical changes among the students and in the system.

Keywords: Learning Diversity, Dynamic Classroom, Outcome Based Education, Active Learning

1. Introduction

Formulating a comprehensive plan of action is of paramount importance about students' learning styles in deploying student-centric pedagogy of engagement (Tickle, 2001; Yousef, 2016). The mismatch between the learning styles of students and pedagogy of engagement may lead to demotivation in continuous learning (Gilakjani, 2012). The Outcome Based Education (OBE) demands comprehensive understanding and deployment of effective active learning strategies to address the learning styles of all the students (Binu et al., 2020). Also, effective management of individual learning differences and associated tools, more specific application of Felder-Silverman Learning Style models is need of the hour to attain desired outcome OBE framework (Graf et al., 2007). In addition, it is vital to adopt better active learning methodologies which completely change the environment in the classroom to transform lethargic personalities into a brimming student (Bhat et al., 2020a). Moreover, 'Lowman's 2-D Model of Teaching' need to be dwelled deeper not only to comprehend teacher's teaching styles but also to ascertain out teaching style to cater the needs of diversified learning styles among the students. Eventually, it will assist the tutor to differentiate the 'Good Teacher' and the 'Bad Teacher' from students' perspective and ensures better pedagogies of engagement from spectrum students learning styles (Lowman, 1995).

The tutor should not impose their learning styles on to the students, rather must comprehend the students learning styles for effective deployment of OBE. Assessment of students learning styles is the very essence of the OBE. It must be the first step in the design of dynamic classroom

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rubrics helps the students to understand the framework within which they need to participate in the session. Besides, motivation connected to the emotions helps the students participate proactively. Eventually, it is

Constructive Methodologies to Overcome the Technological Barriers in Online Teaching-Learning Process

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Abstract:

Over the past few years, technology-driven learning has gained a lot of momentum in every spectrum of education, more so in the field of engineering education. Most of the engineering educators often get inclined towards technology to deliver their courses effectively. While teachers have started leveraging Learning Management Systems (LMS) effectively, some of the technological innovations still need a little refinement. This study intends to explore the limitations of Canvas which is one of the popular LMSs being used today. Although Canvas is an excellent tool to manage the course content effectively and has proved to be very user friendly, it still has some nagging issues which have been analyzed through this study. The ways to overcome these limitations have also been put forth to ensure that the potential adopters of Canvas may have a seamless experience. The participants of the study were 56 second year Post Graduate students who were undergoing the course titled Professional Communication and Report Writing. A handful of students ran into unknown issues while taking up the Multiple-Choice Questions (MCQ) based quiz designed in the second module of the course. The issue was then traced, and corrective measures were incorporated to ensure that all students can take up the quiz. The analysis proved that MCQ quizzes developed on Canvas were not compatible with older versions of Android. Hence, students using such phones were unable to take up quiz-based assessments. To overcome this issue, the quizzes were dished out using tools like Google Forms, Kahoot, Quizizz, etc., and the links were posted on Canvas for the students to take up the quiz. While this approach worked relatively well, it was observed that each of these tools had their own set of limitations. In a nutshell, there is no technology that is perfect in all situations. In such circumstances, it is imperative that the course instructor takes centre stage and selects the technology that best suits a situation.

Keywords: Engineering Education, Learning Management System, Assessment, Technology, Online Teaching-Learning

1. Introduction

In recent times, technology has been a gamechanger in the field of education. Although technology-based tools were being leveraged pre-pandemic times, the prevailing pandemic situation and resultant restrictions on offline teaching have opened up many avenues for teachers to switch entirely to online teaching. While online teaching is challenging for even an expert, the beginners have had to go through many struggles to get used to the online mode of teaching-learning. The reasons for this are quite obvious. Teachers all over the world have been asked to just jump into online teaching without adequate experience or training.

Technology plays a significant role in online teaching. The dependency on electronic gadgets and the internet has risen quite considerably over the past few months. However, harnessing the power of technology in education means much more than just the usage of gadgets and the internet.

While live lecturing is one facet of online teaching, this method has its own set of limitations. Live lectures demand the students be online and attend the lectures irrespective of their whereabouts. Most of the times, students tend to be at places with limited or no connectivity which makes it that much more difficult for the student to attend the live lecture. Even if there are no connectivity issues, the fickle reception of mobile internet compounds the problem even further. Moreover, students, as well as teachers who are dependent on their mobile internet connection, often run into issues with the amount of data available on their devices.

Recorded lectures are a counterpart of live lectures where a teacher is expected to record the lectures offline and make the recording available to the students who can then watch the recorded lecture at their own pace and space. While this approach seems quite reasonable, it requires a mechanism by which the teacher could share the video resources with the students. Although sharing the same via email or a messenger application like WhatsApp is an option, these are still not the most optimum methods. It is such situations where a Learning Management System (LMS) comes in handy (Rhode et al., 2017) and has proven to be the best fit



Affective database for e-learning and classroom environments using Indian students' faces, hand gestures and body postures



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ABSTRACT

Automatic recognition of the students' affective states is a challenging task. These affective states are recognized using their facial expressions, hand gestures, and body postures. An intelligent tutoring system and smart classroom environment can be made more personalized using students' affective state analysis, and it is performed using machine or deep learning techniques. Effective recognition of affective states is mainly dependent on the quality of the database used. But, there exist very few standard databases for the students' affective state recognition and its analysis that works for both e-learning and classroom environments. In this paper, we propose a new affective database for both the e-learning and classroom environments using the students' facial expressions, hand gestures, and body postures. The database consists of both posed (acted) and spontaneous (natural) expressions with single and multi-person in a single image frame with more than 4000 manually annotated image frames with object localization. The classification was done manually using the gold standard study for both Ekman's basic emotions and learning-centered emotions, including neutral. The annotators reliably agree when discriminating against the recognized affective states with Cohen's $\kappa = 0.48$. The created database is more robust as it considers various image variants such as occlusion, background clutter, pose, illumination, cultural & regional background, intra-class variations, cropped images, multipoint view, and deformations. Further, we analyzed the classification accuracy of our database using a few state-of-the-art machine and deep learning techniques. Experimental results demonstrate that the convolutional neural network based architecture achieved an accuracy of 83% and 76% for detection and classification, respectively.

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1. Introduction

Learning is an affectively charged experience where the affective states continually occur throughout the learning process [1]. An effective learning agent (human or tutor) fosters the affective states which are beneficial to learning [2]. Synchronous and asynchronous learning are the two types of learning events based on students' engagement and medium of learning. Classroom-based learning is a synchronous learning which deals with a group of students taught by an instructor in an indoor or outdoor environment. On the other hand, most of the online education systems (e-learning) are asynchronous learning, where each student can learn the subject using electronic education technologies like massive open online courses (MOOCs). In both synchronous and asynchronous learning environments, the students' affective states can be recognized using video recorded data or image frames. The video recorded data with respect to (w.r.t.) classroom

environment consists of a group of students (multi-person) in each image frame, whereas the e-learning scenario contains a single person in a single image frame.

The students' emotional engagement can be analyzed using intrusive and non-intrusive techniques. Intrusive techniques such as survey-based methods and the use of physiological sensors for each student present in a large classroom are time-consuming [3, 4]. Speech/voice recognition for the students' engagement analysis in a large class is not feasible as each student may not get the opportunity to interact with the teacher all the time [5]. In a synchronized learning environment, the non-intrusive students' engagement can be effectively recognized using non-verbal cues captured from the video image frames of the classroom data [6–9].

Human affective states can be recognized from a multitude of modalities. There are many research studies on the human affective state recognition [10–12]. There exist several state-of-the-art machine & deep learning and computer vision methods for affective state recognition and its analysis [13–15]. These methods require a proper database to train, test, and validate. The accuracy of affective state recognition is dependent on the

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Surveillance video analysis for student action recognition and localization inside computer laboratories of a smart campus

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Abstract

In the era of smart campus, unobtrusive methods for students' monitoring is a challenging task. The monitoring system must have the ability to recognize and detect the actions performed by the students. Recently many deep neural network based approaches have been proposed to automate Human Action Recognition (HAR) in different domains, but these are not explored in learning environments. HAR can be used in classrooms, laboratories, and libraries to make the teaching-learning process more effective. To make the learning process more effective in computer laboratories, in this study, we proposed a system for recognition and localization of student actions from still images extracted from (Closed Circuit Television) CCTV videos. The proposed method uses (You Only Look Once) YOLOv3, state-of-the-art real-time object detection technology, for localization, recognition of students' actions. Further, the image template matching method is used to decrease the number of image frames and thus processing the video quickly. As actions performed by the humans are domain specific and since no standard dataset is available for students' action recognition in smart computer laboratories, thus we created the STUDENT ACTION dataset using the image frames obtained from the CCTV cameras placed in the computer laboratory of a university campus. The proposed method recognizes various actions performed by students in different locations within an image frame. It shows excellent performance in identifying the actions with more samples compared to actions with fewer samples.

Keywords Human action recognition · Smart campus · Object detection · Object localization · Neural networks · Computer enabled laboratories

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A Multi-Protocol Home Automation System Using Smart Gateway

Journal: Wireless Personal Communications

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Important notes

Abstract

Smart Home is one of the most established applications of the Internet of Things. Almost every equipment we use in our daily life—appliances, electric lights, electrical outlets, heating, and cooling systems—connected to a remotely controllable network, giving the user's ability to remotely control and monitor the house, save energy without compromising on comfort and ultimately improve the quality of experience of staying in the house. We present a cost-effective system and address a major challenge that the industry faces today—Protocol Compatibility. To address the challenge, we make use of separate gateways/bridges for each network and an open-source home automation framework called OpenHAB, where each bridge links with a single master Wi-Fi gateway, providing a single window of control through an Application or a web interface for an integrated Smart Home. We integrate an elderly health monitoring device—Beehealth with OpenHAB; addressing the paramount need of a portable, accurate, and efficient health monitoring and fall detection device. We present two methods for fall detection, namely: threshold-based and Neural Network-based, with the latter resulting in 94% accuracy for fall detection. We evaluate the Smart Home devices on parameters like syncing time, battery life, recharge time, deployability, and cost.

Video Description Based YouTube Comment Classification

Applications of Artificial Intelligence in Engineering pp 667-678 | Cite as

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Conference paper

First Online: 11 May 2021

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Part of the [Algorithms for Intelligent Systems](#) book series (AIS)

Abstract

A classifier-based tool for segregation of comments in YouTube video sharing website is discussed. Comments are classified into one of the four categories such as relevant, irrelevant, positive and negative based on the relevance of the comments to the video content given by description associated with the video posted. For the comments taken from Natural Language Processing, Sports and Movies domains, we report an average accuracy of 90.58% in recognizing relevant comments and 97.02% in recognizing irrelevant comments. Further, classification accuracy for positive and negative comments are 95.68% and 97.88% respectively in the specified domains.

Keywords

Comment classification YouTube comments Video description Bag of words

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Mining Morphological Similarities for Translation Lexicon Augmentation

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Conference paper

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Abstract

Bilingual subword correspondences have been proven to be significant in tackling the problem of out-of-vocabulary terms. In this paper, we present results of our study focused on automatic learning of bilingual subword units for translation lexicon augmentation. Experiments involve official Indo-Aryan languages including Hindi, Konkani and Sanskrit each of which are resource-poor and characterized by highly inflectional morphology. Bilingual subword units comprising of stem and suffix pairs are first learnt using morphologically similar surface translation forms and subsequently used in suggesting word-word translations. Bilingual subword units thus learnt are employed in generating phrase translations.

Keywords

Translation Lexicon OOV terms Resource-poor languages

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Notes

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IMPULSE BUYING BEHAVIOUR AT THE RETAIL CHECKOUT: AN INVESTIGATION OF SELECT ANTECEDENTS

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Abstract. The remarkable growth of the Indian retail landscape over the last decade is reflected in the proliferation of supermarkets, departmental stores and hypermarkets in India. Evolving consumption patterns, raising living standards has sparked a huge demand in the food and grocery retailing. Impulse buying is a time-tested tactic by which retailers grab customer's attention and boost average purchase value. Prior research has deliberated extensively on impulse buying in the store and its determinants. However, little effort has been made to examine the impulse buying behaviour, particularly at the retail checkout. To bridge this gap, we conducted an empirical study in the leading food and grocery modern retail stores in selected Tier I and Tier II cities in the state of Karnataka, India. The data was collected from 385 respondents using a structured questionnaire. The responses were analysed using confirmatory factor analysis and multiple regression. Our study shows that impulse buying at the store checkout area is minimal and sporadic for most of the product categories at the checkout. Impulse buying at the checkout is instigated by factors such as store environment, credit card availability, momentary mood, in-store promotion, offers and discounts and large merchandise. The study has important implications for retail stores by emphasising on the choice of merchandise offered for sale at the checkout area. Further, the investigation reveals that Indian shoppers are health-conscious and cautious about their purchase at the checkout rather than being impulsive.

Keywords: impulse buying, grocery retailing, in-store promotion, situational factors, external factors, retail checkout.

JEL Classification: D91, L21, L81, M31.

Introduction

Indian retail industry is the fifth-largest in the world and is one of the most preferred, fast-growing global destination for retail space (FICCI, 2020; IBEF, 2019). The organised retailing share is anticipated to grab a market share of 22% by 2021, while the share of organised grocery stores and departmental chain stores is expected to touch 18% during the same period (Suneera, 2019). The modern food and grocery retail in India largely comprise of supermarkets and hypermarkets formats and are fast expanding due to evolving consumer preferences (Sandoval & Sawant, 2019). Most of the Indian department stores have shared checkout at the entrance/exit area of the store (Pataskar, 2011; Fatima, 2013, p. 44). The efficiency of the checkout was observed to be poor in western Maharashtra, a highly developed urban zone in India (Pataskar, 2011, p. 202).

Researchers in the past often attributed checkout as a compelling, unavoidable and common experience in retail

service encounters (Maister, 1985; Taylor, 1994; Van Riel et al., 2012; Schimmel & Bekker, 2013; Weiss & Tucker, 2018; Ullal & Hawaldar, 2018; Hawaldar et al., 2019). Waiting at the checkout area is usually alleged as an unproductive time that does not create any value for the customer (Nethravathi et al., 2020; Van Riel et al., 2012). The checkout lane is flanked by the attractive product displays having a low cost, high margin to stimulate impulse buying (Nathanson, 2013). From the store's perspective, waiting at the checkout is an opportunity to raise additional revenue (Weiss & Tucker, 2018; Ullal et al., 2020).

Pugliese (1998) reported about 69% of the magazines bought as an impulse buy at the checkout counter and perceived as a "want" by the customers in the U.S. A drop in impulse buying of candies and magazines were observed in Quincy, Massachusetts when the customers availed self-checkout over staffed counters (Vinish et al., 2021; Adams, 2006). Hilliard (2014) shared evidence of impulse buying

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Introspective Parameter on Talent Management for Service and Manufacturing Industry Introduction

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Abstract


Talent acquisition and management as a part of HR analytics is getting transformed with the emerging technology landscape, mobility, big data analytics, artificial intelligence and machine learning which are expected to cause a colossal shift in the way Talent management will be handled in future. Expectations and aspirations of the employees are increasing. There is severe competition between the companies to attract and retain the best talent irrespective of the situation. Thus, talent management acts as a vital HR tool in the organizations to reduce the cost and increase the efficiency. This paper takes interest in introspective parameter on talent management for service and manufacturing industry. The study has chosen Mangalore Chemicals and Fertilizers Limited (MCF) in manufacturing category and Diya Systems, Mangalore in software services category. The paper makes an effort to understand understand the relevant components responsible for talent acquisition and management in Diya Systems Mangalore and MCF Mangalore. Talent management in both the companies was not influenced either by the age or the gender of the employees. Present paper proposes a model of Talent Acquisition and Management followed by the observations and the findings.

Key words: Talent acquisition, HR tool, Talent management, Manufacturing sector, Introspective, Software services


Organizations that focus maximizing their investment in people will have a significant competitive advantage as they support for managing the talents of the people in a positive way. Organizations are continuously seeking new ways of improving workforce productivity and in this regard the Talent management forms an important part of Human resource Management. Since the market factors are subject to changes fiercely the talent management supports individual development to adapt to changing and complex operating environment. Acquiring the Talent is a methodology of finding and fixing capable individuals for an organization. Talent acquisitions is concerned with the task of HR section and are responsible for discovering, obtaining, evaluating, and engaging candidates to meet organization's goals. Current system of procuring the talent is a tactical role of an organization, which includes talent requirement for future and planned aptitude evaluation and growth. Since Talent Management refers to searching and grooming human resources on a continuous basis it is referred as proactive function of Human Resource Management. The identification of people who have future growth prospects in an organization is a primary function of Talent Management (Creelman D., 2004). Succession planning, HR Development and employee performance management take precedence from Talent management. Talent management deals with allocation of resources in the form of reward, guidance, instruction, and actual work to the people on the basis of their present performance and future prospects (Berger & Berger, 2004).

Competitive Advantage and Risk: Impact on Indian Stock Market


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Abstract

The current study examines the performance of top 40 companies based on market capitalization for the period of 5 years (2015-2019). Competitive advantage is measured using asset turnover ratio and profit margin and risk is measured using financial leverage. Book to market ratio is used as a measure of market performance of the firms. The results indicate that profit margin has the most significant impact on the market performance in the Indian stock market.

Keywords: Competitive advantage, Asset turnover ratio, Book-Market ratio, Risk, Market performance, Profit margin

Introduction

A firm is said to have competitive advantage when it has established a method of offering the same benefit as a competitor but at lower cost or when it can provide additional benefits at the same cost as a competitor. The two forms of competitive advantage are cost advantage or differentiation advantage. In order to retain competitive advantage, a firm must have resources and skills that outweigh that of competitors

Risk has always been a part of financial activity. Risk can be defined as the probability of an unpredictable or negative outcome. Any action or operation which results in any form of loss can be called as risk. Market performance of companies provides a basis for success of firms. The book to market ratio (BMR) is one of the measures of market performance. Firms analyse their book to market ratio with that of their peers as well as other companies outside the industry to obtain a sense of the size of the performance.

THE IMPACT OF HUMAN RESOURCE ACCOUNTING ON THE FINANCIAL PERFORMANCE OF CONSUMER DURABLE COMPANIES LISTED ON NSE**Ms. Vinola Preemal D Souza¹ and Dr Babitha Rohit²**Student¹ and Associate Professor², St Joseph Engineering College, Mangaluru

ABSTRACT

This paper examines the impact of Staff and training cost on the firm's financial performance based on the indicators of Net profit margin and Return on Equity. This study establishes human resource cost has significant effect on the financial performance of consumer durable companies listed on National Stock Exchange (NSE). Investment in human assets in the area of training and development become more crucial for the success of the firm's in today's highly competitive environment.

Keywords – Human Resource Accounting (HRA), Net Profit (NP), Return on Equity (ROE)

I. INTRODUCTION

People are considered as an asset to the organisation by the management. They are more of a dynamic asset. Nothing can happen in an organisation without people, money, machineries and equipment, technology. Hence, the management has now realized the importance which has stressed the need of human resources in an organisation. Efficiency can be achieved through humans and not the machines.

With the dynamics in the business environment, the needs of the business change every now and then and it becomes difficult for the HR professionals to manage and measure the employees' goals. The main objective of HR function is to attract, retain and motivate the best employees, make them feel that they are the leaders of their own company. The basic HR function involves a lot of activities recruiting, selecting, hiring, training, promoting, retention, separation and supporting of faculty, and staffing. It also includes all decisions, strategies, processes, principles and functions related to managing people in any organization. Organizations are increasingly finding it imperative to improve returns on investment, in order to stay competitive. Traditionally, accounting norms were viewed only from the financial perspective and were applied to all departments ranging from marketing, production distribution etc. HRM was limited to salary and administration and, while doing so, it was analyzed from the perspective of balancing performance management across all organizations (Mahapatro, 2010).

II. LITERATURE REVIEW

- **Khan, 2020** investigated the impact of HRA on the overall performance of the organisation. Various aspects such as human capital efficiency, profitability, return on asset and return on equity were implemented. The data was collected from 268 respondents of human resource and finance departments. The study showed a positive evidence of the HRA benefits in the organisation.
- **Akinjare, Idowu, & Sule, 2019** analysed the impact of human resource accounting on the financial performance of the Nigerian companies through the secondary data sources from the year 2012-16. The staff, training and development cost had a positive impact on the financial performance of oil and gas companies. The health and safety cost did not reveal a significant relationship between health and safety cost.
- **Sharma & Khatik, 2017** scrutinized the human resource accounting disclosure practices in Indian companies during a specified period. A comparison was made between public and the private sector companies and the data on Human Resource Accounting was selected from the annual reports. The analysis revealed that ONGC was having a better performance while HPCL, ACC and TCS had concerns in disclosure practices of HRA.
- **Edom, Inah, & Adanma, 2015** examined the impact of human resource accounting on the profitability of Access Bank of Nigeria from 2003 to 2012. They used ordinary least square analytical technique and also relied on the secondary data. The results showed a positive relation of the indicators oh human resource with the profitability of the bank.

III. RESEARCH DESIGN**Objectives of the study**

- To determine the relationship between Staff and training cost and the financial performance of the consumer durable companies.



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ANTECEDENTS OF BEHAVIORAL INTENTION TO USE ONLINE FOOD DELIVERY SERVICES: AN EMPIRICAL INVESTIGATION

Abstract

The online food delivery market in India perseveres to grow at a sustained pace. The business has unique dynamics and challenges with the spike in orders during week-ends, meeting delivery schedules during peak demand, offering deep discounts to address wavering customer loyalty, reducing cash burns, and managing food quality inconsistency. In contrast, the fast-paced life and the rise of millennials in the workforce is likely to assure a promising future for the food aggregators. The above backdrop has led the researchers to pursue this study. An empirical study was carried out to explore the consumption occasion and the antecedents of online food ordering in the select cities in Karnataka, India. The data was collected from 385 respondents through telephonic and mail survey using a structured questionnaire. The responses were analyzed using exploratory factor analysis and multiple regression. The result of the study indicated a positive association between the constructs ‘buying motives’, ‘aggregator attractiveness’, and customer satisfaction. The variation in customers’ satisfaction is largely attributable to the convenience of order placing, food quality, availability of food and restaurant reviews, offers and discounts, faster home delivery, and the wide choice of restaurants listed on the aggregator’s website. Additionally, the aggregator attractiveness showed a higher impact on customer satisfaction as compared to buying motives.

Keywords

online food ordering, customer satisfaction, buying motives, aggregator attractiveness, food aggregator, India

JEL Classification

L81, L83, L87, M31

INTRODUCTION

Online food ordering and discovery platforms have transformed the way Indian customers eat. Outsourcing in the food and restaurant business gained wide acceptance among business owners primarily due to prospects of earning additional revenue, broader customer reach, and growing the customer base. In contrast, the convenience of shopping became the primary motive for customer’s inclination towards online purchases. Customers could save more time by purchasing online and divert the available time to other endeavors.

As reported by IMARC (2019), the online food delivery market touched USD 2.9 billion in 2019 and cited factors such as the rapid internet penetration, growth of smartphones, rise in disposable income, speedy process of urbanization, rise in disposable income, and increase in the number of working women responsible for the growth. The industry is expected to reach USD 8 billion by 2022, growing at a compound annual growth rate of 25-30%, dominated by Zomato and Swiggy (IANS, 2020). Variety in foods, peer advocacy, and advertisements drive steady growth in online food delivery. The report further stated that the ordering frequency is projected to grow by 18-20%, al-



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Conflict of interest statement:
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FORECASTING ARECA NUT MARKET PRICES USING THE ARIMA MODEL: A CASE STUDY OF INDIA

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Abstract

India is the major producer of Areca nut in the world. Volatile demand and price are the major challenges for the Areca nut growers in India. The use of time series models to manage the price risk has become the interest of academicians today. This paper deals with developing an appropriate model to predict the prices of a new variety of Areca nut in Karnataka using monthly price data for the period January 2009 to December 2018. Box Jenkins ARIMA methodology is used to develop the model. Along with ARIMA estimates, log-likelihood, Akaike's information criterion (AIC) and Bayesian (BIC) information criterion statistics are also estimated to decide on the appropriate model. ACF and PACF correlograms for residuals of ARIMA are used to do the diagnostic check of the selected ARIMA model. Appropriate model to forecast the new variety Areca nut price is ARIMA (3, 1, 3).

Keywords: investment behavior, Areca Nut, price forecasting, ARIMA models, volatility, time series, ACF, PACF, stock market forecasting

Classification JEL: C22, G11, G17

EXPERIMENTAL ANALYSIS OF INFLUENCE OF INJECTION PRESSURE ON COMPRESSION IGNITION ENGINE WITH BIODIESEL AND NANOPARTICLES BLEND

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Abstract

The scarcity of conventional fuel and stringent emission norms made researchers to look after alternative fuels to run an internal combustion engine. One of the possible alternatives for the Compression Ignition engine is biodiesel. Although there are some challenges such as high viscosity, low calorific value, carbon deposit on the injector nozzle, etc. To overcome these challenges nanoparticles are added which will bring most properties near to virgin diesel. Simarouba a non-edible biodiesel feedstock used and aluminum oxide nanoparticles are added with 50 nm size. Using a probe-type Ultrasonication process nano-biodiesel blend is prepared. To improve stability SDS surfactants are added. The characterization of nanoparticles studied using SEM image. The performance of the engine tested for different dosage levels of nanoparticles mainly 25 ppm, 50 ppm, and 75 ppm. The injection timing, injector pressure, and speed kept constant, whereas injection pressure is varied 200 bar, 225 bar, and 250 bar. There is found a 5.2% increase in brake thermal efficiency for nanoparticles added blend biodiesel at 250 bar compare to 200 bar pressure. For the same thing brake specific fuel consumption decreased by 9%. Most of emissions such as Carbon monoxide, unburnt hydrocarbons decreased, whereas there is a significant amount of increase in oxides of nitrogen emission found.

Keywords : Biodiesel, nanoparticles, transesterification, stability

Notations

CI- Compression Ignition

SEM-Scanning Electronic Image

SDS- Sodium Dodecyl Sulfate

BTE-Brake Thermal Efficiency

BSFC-Brake Specific Fuel Consumption

B20-Diesel(80%)+Simarouba(20%)

1. Introduction

To travel people or to take goods from one place to transportation is required. For transportation most of vehicles uses chemical energy in the form fuel. There are different types of fuels are used to run the engines. High octane number fuels are used in Spark Ignition engines, whereas high Cetane number fuels are used in Compression Ignition engines. Due to many reasons in India, most of the heavy vehicles use Compression Ignition Engines. Due to rapid depletion of fuel it is the need of the hour to shift from conventional fuels to alternative fuels. One of the possible alternatives for diesel is biodiesel because it has most of the properties identical to diesel. The of the major disadvantage in biodiesel is its low calorific value and high viscosity to overcome this challenge biodiesel is used as blend with diesel[1]. Injector deposit is another major challenge to overcome. Injector deposit is another major challenge to overcome. Endurance test on engine after using biodiesel shows in SEM image there is a greasy type of deposition. The higher level of carbon deposits observed at the injector tip after usage of biodiesel without much modification[2]. The biodiesel has prospective to replace conventional diesel fuel[3].

With recent development of nanotechnology, a lot of researchers is using nanoparticles in different applications. The usage of nanoparticles in diesel engines in biodiesel tends to reduce toxicity, improves stability. Application nanoparticles tend to improve performance characteristics and decrease the major pollutions[4]. The major challenge in nanoparticles characterization is in relevance with physical conditions.[5].

Simarouba one of the non-edible oil feedstock used to produce biodiesel from transesterification process. The brake thermal efficiency is found to be increased by 9.14% for biodiesel nanoparticles blend SME2040 (20% biodiesel+40 PPM nanoparticles), this is because graphene nanoparticles having higher thermal conductivity increases combustion efficiency which in turn increases heat transfer coefficient. As a heat transfer coefficient increases, it has directly related with convection heat transfer. As the load increased, there will be an increase in smoke because fuel to air ratio becomes lean to richer. But with the addition of surfactant, smoke is decreasing because there will be an increase in atomization. Also with the addition of surfactant carbon



EXPERIMENTAL ANALYSIS OF INFLUENCE OF INJECTION TIMING ON COMPRESSION IGNITION ENGINE WITH BLEND OF BIODIESEL AND NANOPARTICLES

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ABSTRACT

Discovery in nanoparticles has opened up new options in fuel additive. The conventional diesel fuel blended with biodiesel is dispersed in aqueous aluminium oxide nanoparticles using an Ultrasonicator. The nanoparticles used are in the size range of 0-50nm. The engine performance and emission characteristics are measured for 3 different dosing levels of aqueous aluminium oxide nanoparticles with simarouba biodiesel blend. Injection timing plays a vital role in CI engine performance and emission characteristics. Therefore, the influence of injection timing is also studied experimentally. The delay in injection timing reduces most of the emissions along with slight increase in performance characteristics.

I. INTRODUCTION

The developing index of any country is measured by how much energy is developed and used. India happens to be the world's fourth leading energy end user and a end user of crude and petroleum products after the United States, China, and Japan[1]. Like most countries, India also depends on petroleum oil producing nations. In India, petroleum resources are very less, so the need of the hour is look for alternatives like wind, solar, and geothermal. Biodiesel energy is derived from vegetable oils. Biodiesel either can be produced one of the feedstock's, they are edible oil, Non-edible oil, animal fat, waste cooking oil and algae[2]. According to the Indian government's bio-fuel policy, edible oil cannot be used for producing biodiesel because there is a lot of domestic need. If edible oil is used for the purpose of biodiesel production, then there will be a huge gap between demand and supply. According to the Indian bio-fuel policy, the best feedstock for the production of biodiesel is non-edible oils such as-jatropha, neem, mahua, cotton seed, cashew nut, simarouba glauca, etc. Some of the important things to remember while selecting the best feedstock are availability, percentage oil extraction from seeds, and cost[3].

Oil can be extracted from seeds using any process, but; in general, the mechanical extraction process is used. After the extraction, it is required to find the Free Fatty Acid (FFA) of the oil. If it is lower than 10, then by a single step, the non-edible oil can be converted into biodiesel[4]. If the FFA is more than 10, then the two- step esterification process is required. The conversion of oil in to biodiesel using alcohol and a catalyst like potassium hydroxide (KOH) or sodium hydroxide (NaOH) is called transesterification process. The products of this process are biodiesel and glycerin[5]. The biodiesel produced from this process cannot be directly used in diesel engines because it has more viscosity and cloud point. To overcome this problem, diesel can be added to it as a blend. The increase in the blend of biodiesel causes an increase in NO_x emission mainly due to high viscosity and surface tension, which causes change in droplet size. When the viscosity increases, the fuel droplet size also increases[6]. The recent development in nano sized particles has added a new dimension to engine fuel additives. One of the main characteristics of nanoparticles is its higher surface-volume ratio. The major challenge to the addition of nanoparticles to the fuel is its stability issues. Stability is very crucial while-considering nanoparticles for the engine. Stability mainly depends on its HLB value and zeta potential value[7]. The size of the nanoparticles has direct relation with fuel properties[8]. Studies show that the addition of nanoparticles decreases the formation of carbon monoxide due to the availability of more oxygen for the purpose of combustion [9].

II. METHODS AND MATERIALS

A. BIODIESEL-NANOPARTICLES BLEND PREPARATION

The biodiesel used for the current investigational work is non-edible oil, simarouba. The main reason for using simarouba seeds for the production of biodiesel is its higher free unsaturated fatty acid, which leads to long-term stability[10].The properties of aqueous aluminium oxide nanoparticles are shown in Table 1.The properties of diesel, simarouba biodiesel, and B20 (diesel 80%+ simarouba 20%) are shown in Table 2. The properties were found using the apparatus in the laboratory, while the Cetane value was taken from the literature. One of issues is the aggregation of nanoparticles in the fuel after some time. This relates to the stability of the nanoparticles. It may be overcome by different processes like Ultrasonication by; adding surfactants to the mixture. Anionic surfactants have better thermal conductivity compared with-cationic surfactants[7].

Effect of CuO Nanofiller on PVA/PVP Blend

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Abstract. Polyvinyl alcohol (PVA)/Polyvinylpyrrolidone (PVP) (50/50) blends filled with various concentrations of Copper Oxide (CuO) nanofiller (0, 2 and 4 wt %) were prepared using solvent casting technique. The structural properties were carried out using XRD. The UV Visible studies reveal that the direct energy gap values declines with an increase in CuO nanofiller concentration in the blend. The surface morphology studies were carried out using atomic force microscope (AFM). The photoluminescence spectra measured at an excitation wavelength of 220 nm reveals that the intensity of the spectra increases with filler concentration. The mechanical properties measured using Universal testing machine (UTM) indicates enhancement in the properties upon addition of CuO nanofiller. These significant enhancements in the optical and mechanical properties of the blend upon addition of CuO nanofillers make it a potential material for device applications.

INTRODUCTION

Blending of various polymers is an exclusive method to transform the properties of a polymer. This method is used to obtain a polymer composite with desired properties. This procedure depends on the extent of miscibility of polymers in appropriate solvents [1]. In the present study, we have considered PVA and PVP as the basic polymers. Poly Vinyl Alcohol (PVA) is a nontoxic water-soluble, biodegradable, semi crystalline polymer with good dielectric strength and charge storage capacity. Poly vinylpyrrolidone(PVP) is an amorphous water soluble polymer with high polarity, good dielectric constant, biodegradable, low toxic, transparent polymer with good film forming capabilities. The interaction between the OH group of PVA and C=O group of PVP helps in the formation of hydrogen bonding resulting in the blend formation [1-3]. Further enhancement in the properties of these polymer blends can be achieved by the addition of suitable nanofillers. In the present work CuO nanoparticles are selected as nanofillers since they have large applications in photonics, optics, and electronics. Copper oxide (CuO) is a metal oxide semiconductor with an energy gap of 1.2 –2.1eV. It has good electronic and thermal properties, chemical stability, low production cost and non-toxic in nature [4, 6].

EXPERIMENTAL DETAILS

Preparation of nanocomposite

Polyvinyl Alcohol (PVA-average molecular weight, Mw=89000-98000) and CuO nanopowder (particle size <50 nm) were procured from Sigma Aldrich and Sisco labs respectively. Poly vinylPyrrolidone (PVP, molecular weight, Mw=1,300,000) was procured from Alfa Aeser. 1.5g of PVA and PVP were taken in two beakers separately and 90ml of distilled water was added to it. The solution so obtained was stirred continuously using a magnetic stirrer at temperatures of 90°C and 50°C respectively until a homogeneous solution was obtained. The resulting solutions were mixed at room temperature. Stirring continued for two more hours. The resulting solution was divided into three equivalent parts and Copper oxide nanoparticles were added in the wt percentages of 0, 2, and 4. These

Advancement in Structural, Morphological and Dielectric Studies of PVA filled TiO₂ and ZnO Nanocomposites

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Abstract: In this article, we report advancement in structural, morphological and dielectric studies of PVA encapsulated titanium dioxide (TiO₂) and zinc oxide (ZnO) nanoparticles. PVA/(x)TiO₂(15-x)ZnO nanocomposites are prepared using solvent casting ex-situ technique for x= 0wt%, 1wt%, 5wt%, 7.5wt%, 10wt%, 14wt% and 15wt% filling concentrations. FTIR spectroscopy reveals the formulation of complexes between the PVA main chain and nano fillers is due to inter/intra molecular hydrogen bonding. The AFM picture shows the uniform grain structure for pure PVA and changes in surface morphology for prepared PVA nanocomposites. The morphological and homogeneous distribution of nano fillers in PVA nanocomposites was observed using SEM and EDAX. AC conductivity studies spectacles that the conductivity increases for different filling concentrations with increase in frequency. The frequency dependent dielectric constants with different filling concentrations are recorded.

INTRODUCTION

Polymer based metal oxide nanocomposites creates a heavy demand in the field of science and technology. It deals new prospects for fabricating the present/next generation electronics and optoelectronics devices [1]. Features of nanocomposites material depends on properties of their individual constituents, morphology and interfacial characteristic [2]. The interfacial interaction between the nano fillers and PVA matrix enhances the dielectric, optical and electrical properties of nanocomposites [3]. PVA nanocomposites have several attractive properties and hence it is a potential candidate for fabricating device with enhanced performance.

EXPERIMENTAL DETAILS

Synthesis of PVA/(x) TiO₂ (15-x) ZnO Nanocomposites Using Ex-Situ Technique

TiO₂ and ZnO nanoparticles were prepared as reported in our earlier work [4]. To prepare PVA nanocomposites, 180ml of distilled water is added to 8g of PVA, kept in a temperature controlled (80°C) mechanical stirrer (1200rpm) till a clear viscous solvent of PVA is achieved. By reducing the stirring rate to 250rpm the PVA solvent is cooled to lab temperature. Then share the PVA solvent into eight equal parts and for each share TiO₂ and ZnO nanoparticles are filled as per the scheme PVA/(x)TiO₂(15-x) ZnO for x=0wt%, 1wt%, 5wt%, 7.5wt%, 10wt%, 14wt% and 15wt%. For uniform distribution, the PVA nanocomposites solvent is sonicated using a probe ultrasonicator (15 minutes) and then poured into a petri dish. The PVA nanocomposites are allowed to dry at 50°C in a muffle furnace (1day). The films are then peeled off and kept in vacuum desiccator for advance study.

Enhancing the tensile strength of SiC reinforced aluminium- based functionally graded structure through the mixture design approach

Mixture design
to enhance
tensile strength

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Abstract

Purpose – This article aims to study the tensile properties of a functionally graded composite structure with Al–18wt%Si alloy as the matrix material and silicon carbide (SiC) particles as the reinforcing element. More specifically, the study's primary objective is to optimize the composition of the material elements using a robust statistical approach.

Design/methodology/approach – In this research, the composite material is fabricated using a combination of stir casting and the centrifugal casting technique. Moreover, the test specimen required to study the tensile strength are prepared according to the ASTM (American Society for Testing and Materials) standards. Eventually, optimal composition to maximize the tensile property of the material is determined using the mixture design approach.

Findings – The investigation results imply that the addition of the SiC plays a crucial role in increasing the tensile strength of the composite. The optical microstructural images of the composite show the adequate distribution of the reinforcing particles with the matrix. The proposed regression model shows better predictability of tensile strength. In addition, the methodology aids in optimizing the mixture component values to maximize the tensile strength of the produced functionally graded composite structure.

Originality/value – Little work has been reported so far where a hypereutectic Al–Si alloy is considered the matrix material to produce the composite structure. The article attempts to make a composite structure by using a combination of stir casting and centrifugal casting. Furthermore, it employs the mixture design to optimize the composition and predict the model of the study, which is one of a kind in the field of material science.

Keywords Functionally graded material, Composite structure, Centrifugal casting, Al–Si alloy, Design of experiments, Mixture design, Composition optimization, Tensile strength, Residual analysis

Paper type Research paper

Nomenclature

DF Degree of freedom
Seq SS Sequential sum of squares
Adj SS Adjusted sum of squares
Adj MS Adjusted mean squares
F-value Fisheries test value
p-value Probability value

Coef Coefficient
SE Coef Standard error of the coefficient
T-value *T*-distribution value
S Standard error
R-sq *R*-square
R-sq(adj) *R*-square (adjusted)



Ten commandments for successful implementation of Design for Six Sigma

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Abstract

Purpose – This article aims to provide Design for Six Sigma (DFSS) practitioners, researchers and academicians with Ten Commandments to successfully deploy projects.

Design/methodology/approach – The commandments are the brainchild of four authors' experience and expertise for more than 15 years of DFSS deployment in the spectrum of fields as a consultant, researcher, academic and Master Black Belt in Six Sigma and general quality management and engineering disciplines. Thus ascertained commandments were validated and classified through the "Delphi Study" to ensure its applicability.

Findings – The Ten Commandments from authors' perspective include: alignment of DFSS with organisational strategy; top management support and involvement; listening to the voice of the customers (VOC); effective training programme for right project teams; project selection and prioritisation; linking DFSS with ISO international standards; linking DFSS with organisational learning and innovation; linking DFSS with the 4th Industrial Revolution; effective use of DFSS methodology and the integrated tools within the methodology and reward and recognition schemes.

Research limitations/implications – The commandments presented in this article are the authors' personal experience in different industrial scenarios and settings and demographical locations. The authors are planning to conduct a longitudinal survey to understand further insights of these commandments with the input of several DFSS Black Belts and Master Black Belts, academicians and leading researchers from various countries.

Originality/value – All the organisation's stakeholders can use this article as general guidelines to ensure effective deployment of the DFSS approach.

Keywords DFSS, Continuous improvement, KPIs, Product and service development, Ten commandments

Paper type Conceptual paper

1. Introduction

In the era of disruptive technologies, ever-changing customer preferences, surging costs, market turmoil and competition from counterparts, the companies need to establish a nimble-footed system that not only adapts to the situation but also benchmarks the best practices to reap the reward in the global market (Ghobakhloo and Fathi, 2020). Companies often eye on launching the product/services on time to the market, but the need of the hour is to launch it ahead of time to take a competitive advantage (Florén *et al.*, 2018). In the quest of product/service realisation and launch to the market, often companies are confronted with challenges such as high cost of quality, product recalls, rework rates, warranty payments and doom in brand name. This situation leads the companies back to square one quickly, without much opportunity to bounce back to the market place (Vlahinos, 2008). These challenges are mostly due to the lack of robust design and development approach towards new product/services,



QUALITY PAPER

Performance and service quality enhancement in a healthcare setting through lean six sigma strategy

Performance
and service
quality
enhancement

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Abstract

Purpose – The article intended to excavate the Lean Six Sigma (LSS) deployment challenges, Critical Success Factors (CSF), tools and techniques, and managerial implications in an Indian healthcare setting.

Design/methodology/approach – The article illustrates a case study established using Action Research (AR) approach. Further, the case study is based on the Define, Measure, Analyze, Improve, Control (DMAIC) phases of LSS. The performance and service quality of the Endodontics department of a dental college attached to a hospital is enhanced and sustained through the LSS strategy.

Findings – The processing time of Root Canal treatment is reduced by determining the root causes for delay and implementing sustainable solutions. The structured deployment of the LSS strategy helped the Endodontics department to reduce the processing time from an average of 116 min–84 min. Thus, the process's sigma level is enhanced from 0.06 to 4.17 and assisted in sustaining the results.

Research limitations/implications – The case study's findings are based on the single AR carried out at an Endodontics department of a dental college hospital based on LSS strategies. Even though this study's results cannot be generalized, the deliverables of the case study can be used to develop the LSS roadmap for the dental colleges to enhance the service quality and safety of the patients.

Originality/value – The article provides step-by-step details for implementing LSS in dental college hospitals with critical analysis based on robust statistical tools and techniques. The case study provides evidence of the adoption of LSS in medical college education and provides the confidence to adopt the same through novice users. The study's findings may persuade the policymakers to add LSS in the medical education curriculum to reinforce safety and reduce errors in the healthcare system.

Keywords Lean six sigma, Dental hospital, Endodontics department, Dental education, India

Paper type Case study



Lean Six Sigma competitiveness for micro, small and medium enterprises (MSME): an action research in the Indian context

Lean Six Sigma
competitiveness
for MSME

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Abstract

Purpose – The aim of the article is to ascertain the challenges, lessons learned and managerial implications in the deployment of Lean Six Sigma (LSS) competitiveness to micro, small and medium Enterprises (MSME) in India and to establish doctrines to strengthen the initiatives of the government.

Design/methodology/approach – The research adopts the Action Research methodology to develop a case study, which is carried out in the printing industry in a Tier III city using the LSS DMAIC (Define-Measure-Analyze-Improve-Control) approach. It utilizes LSS tools to deploy the strategy and to unearth the challenges and success factors in improving the printing process of a specific batch of a product.

Findings – The root cause for the critical to quality (CTQ) characteristic, turn-around-time (TAT) is determined and the solutions are deployed through the scientifically proven data-based approach. As a result of this study, the TAT reduced from an average of 1541.2–1303.36 min, which in turn, improved the sigma level from 0.55 to 2.96, a noteworthy triumph for this MSME. The company realizes an annual savings of USD 12,000 per year due to the success of this project. Top Management Leadership, Data-Based Validation, Technical Know-how and Industrial Engineering Knowledge Base are identified as critical success factors (CSFs), while profitability and on-time delivery are the key performance indicators (KPIs) for the MSME. Eventually, the lessons learned and implications indicate that LSS competitiveness can be treated as quality management standards (QMS) and quality tools and techniques (QTT) to ensure competitive advantage, sustainable green practices and growth.

Research limitations/implications – Even though the findings and recommendations of this research are based on a single case study, it is worth noting that the case study is executed in a Tier III city along with novice users of LSS tools and techniques. This indicates the applicability of LSS in MSME and thus, the modality adopted can be further refined to suit the socio-cultural aspects of India.

Originality/value – This article illustrates the deployment of LSS from the perspective of novice users, to assist MSME and policymakers to reinforce competitiveness through LSS. Moreover, the government can initiate a scheme in line with LSS competitiveness to complement the existing schemes based on the findings of the case study.

Keywords Lean six sigma, MSME, India, Printing industry, Design of experiments (DOE), PI controller

Paper type Research paper



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1. Introduction

In India, enterprises are classified as micro (investment on plant and machinery less than Rs. 25 lakh), small (investment on plant and machinery more than Rs. 25 lakhs but less than

Application of Lean Six Sigma in conservative dentistry: an action research at an Indian dental college

Lean Six Sigma
in conservative
dentistry

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Abstract

Purpose – The article evaluates the obstacles, lessons learned and managerial implications of deploying Lean Six Sigma (LSS) in a dental college hospital in India.

Design/methodology/approach – The work adopts the action research (AR) methodology to establish a case study, which is carried out using the LSS define–measure–analyze–improve–control (DAMIC) approach in a dental college. It uses LSS tools to enhance the productivity and performance of the Conservative Dentistry Department of a dental college and to unravel the obstacles and success factors in applying it to the education and healthcare sector together.

Findings – The root cause for high turn-around time (TAT) is ascertained using LSS tools and techniques. The effective deployment of the solutions to the root causes of variation assists the dental college to reduce the TAT of the Conservative Dentistry process from an average of 63.9 min–36.5 min (i.e. 42.9% improvement), and the process Standard Deviation (SD) was reduced from 2.63 to 2 min. This, in turn, raises the sigma level from 0.48 to 3.23, a noteworthy successful story for this dental college.

Research limitations/implications – While the results and recommendations of this research are focused on a single case study, it is to be noted that the case study is carried out with new users of LSS tools and techniques, especially with the assistance of interns. This indicates the applicability of LSS in dental colleges; thus, the adopted modality can be further refined to fit India's education and hospital sector together.

Originality/value – This article explains the implementation of LSS from an aspiring user viewpoint to assist dental colleges and policymakers in improving competitiveness. In addition, the medical education sector can introduce an LSS course in the existing programme to leverage the potential of this methodology to bring synergy and collaborative research between data-based thinking and the medical field based on the findings of this study. The most important contribution of this article is the illustration of the design of experiments (DOE) in the dental college process.

Keywords Lean Six Sigma, Dental college, Conservative dentistry department, Hospital, India, Design of experiments

Paper type Case study

1. Introduction

The healthcare sector is among the fastest-growing industries in India. In the coming years, India, being a significant player among the emerging markets, is expected to relish the competitive advantage of medical tourism (Bhat and Jnanesh, 2013). The healthcare industry in India is facing several challenges like increased cost and fierce competition. To overcome these challenges, it is essential to drive change and innovation quickly (Bhat et al., 2019).



QUALITY PAPER

An evaluation of Lean and Six Sigma methodologies in the national health service

An evaluation
of Lean and Six
Sigma in the
NHS

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Abstract

Purpose – The purpose of this paper is to conduct an empirical study derived from the previous literature from the perspective of benefits, tools and techniques, continuous improvement (CI) and quality improvement (QI) methodologies and critical failure factors (CFFs) of Lean and Six Sigma (SS) in the national health service (NHS).

Design/methodology/approach – A literature review was carried out to identify previous findings, empirical data and critical variables concerning Lean and SS in healthcare for over ten years. Second, primary research in quantitative surveys and qualitative interviews was carried out with 110 participants who have experience using Lean and SS in the NHS.

Findings – Lean and SS have evolved into common practices within the NHS and now have an established list of tools and techniques frequently employed by staff. Lean and SS are considered robust CI methodologies capable of effectively delivering extensive benefits across many different categories. The NHS must overcome a sizable amount of highly important CFFs and divided organizational culture.

Originality/value – This paper has developed the most extensive empirical study ever produced on Lean and SS in the NHS and has expanded on previous works to create new and updated research. The findings produced in this paper will assist NHS medical directors and practitioners in obtaining up-to-date insight into Lean and SS status in the NHS. The paper will also guide the NHS to critically evaluate their current CI strategy to ensure long-term sustainability and deliver improved levels of service to patients.

Keywords Lean, Six Sigma, Lean Six Sigma, NHS, Benefits, Tools and techniques, Critical failure factors

Paper type Research paper



1. Introduction

For the past 2 decades, there has been a growing interest in the healthcare sector that focuses on building a sustainable healthcare system (Sunder *et al.*, 2020; Kroezen *et al.*, 2018). In today's context, the national health service (NHS) in the United Kingdom (UK) is facing an