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Manjunath Patel G. C.
Ganesh R. Chate
Mahesh B. Parappagoudar
Kapil Gupta

Machining of Hard Materials

A Comprehensive Approach to Experimentation, Modeling and Optimization

Springer

Contents

Chapter 1
Introduction to Hard Materials and Machining Methods

1.1 Introduction

Machining is most widely used to transform the material into the product of desired shape and size by the mechanism of removing excess material. Machining involves group of processes, wherein the excess material is removed from the work specimen in sequential steps with the help of cutting tools (either single point or multi-point). It is to be noted that machining with a single-point cutting tool uses well-defined tool geometry (i.e. cutting edges (honed, sharp, chamfered) possessing different faces (rake, flank, etc.), whereas grinding process uses abrasive wheel with multi-point micro-cutting edges having undefined geometry [1–3]. Machining processes are widely used to finish parts of both metallic (ferrous, non-ferrous, and their alloys) and non-metallic materials (polymers, composites, wood, glass, etc.) to the desired complex geometries possessing high structural integrity and surface finish [4]. Hence, machining process is widely used in industries for manufacturing moulds and dies of casting; injection moulding, extrusion, forging, and so on; automotive, hydraulic, and other power transmission and aircraft parts [4–9].

Machining operations account approximately 15% of the total manufacturing cost, and the survey report shows that the annual expenditure associated with machining and machine tools will be around several billion euros in industrially developed countries [10, 11]. It is worthy to note that the trend shows an increase of 20–30% machining applications of aeronautical parts [12]. Rapid development in machining technology has enabled the machining industries to manufacture the products with high accuracy and precision. These technologies are broadly categorized as traditional and non-traditional machining processes. Each process has its own distinct advantages and limitations [13, 14]. Slow material removal rate, part size (i.e. thickness limitations), multi-pass machining even for thin sections, high tooling and capital investment cost, low productivity, restriction to a wide variety of materials are few shortcomings of non-traditional machining technology [14]. Indeed, for manufacturing or design engineers, the major concern is with regard to functional

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Chapter 2
Studies on Machining of Hard Materials

Over the years, machining industries are continuously striving to manufacture the parts at reduced cost and improved quality. This can be achieved by selecting appropriate set of tool–work materials and effective modelling and optimization of the process. Optimized grades of high-speed steel (HSS) are used to be treated as ultimate tool material till the 1930s [1]. However, American metalworking industry had shown three-time improvement in productivity with the use of same machines and manpower during the period 1939–1945. These revolutionary changes in machining were attributed to the development or invention of cemented carbide tools. The cemented carbide tools, possessing superior properties (improved tool life, ability to cut at faster rate, high hot strength, and so on), reduced the manufacturing costs of various machining processes (i.e. turning, milling, drilling). In addition to an appropriate choice of tool–workpiece material, the improvement in product quality and processes directs the economic growth of industries [2]. Many research efforts were made to improve the process/product quality with the use of traditional try-error method, classical engineering experiments, and analytical, numerical, and optimization approaches [3–11]. The above methods were employed by distinguished researchers focussed mainly on establishing input–output relationships in machining with an objective to optimize the product quality and cost. In view of the above, the present chapter discusses various research works carried out in hard turning process.

2.1 Hard Turning Process

Hard turning is a process of machining metals with hardness greater than 45 HRC, by employing a single-point cutting tool on the lathe or turning centre. Chapter 1 describes the process capabilities, technical difficulties, and applications of hard turning process. Surface finish of turned parts is still challenging, although the process has proved significant technological and economic benefits over grinding

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Chapter 3
Experimentation, Modelling, and Analysis of Machining of Hard Material

Planning and conducting experiments is the key in effective monitoring of system, which leads to success in manufacturing. The traditional approach of experimental study (i.e. one factor at a time, OFAT) requires more number of experiments and consequently consumes more resources. Moreover, the interpretations and analysis that can be made from the experimental data are also limited. Design of experiments (DOE) is a statistical tool, which uses well-planned set of experiments to collect the input–output data. Further, DOE can be used to analyse the experimental data, establish input–output relations, and optimize the process. Figure 3.1 shows the general steps followed in designing a statistical-based experiment.

It is essential to select the process to apply DOE. General guidelines referred in selecting the process for DOE application are mentioned below:

i. Existing process with low productivity.
ii. Required to upgrade or modify the existing process, where changes are required to improve the process efficiency.
iii. The applications especially reverse modelling and online monitoring of the system through feedback and dynamic adjustments. The input–output relations developed via DOE may be used to generate huge amount of data that can be used in reverse modelling through soft computing tools.

The application of DOE needs well-defined responses (output) that can be measured and expressed quantitatively. Further, all parameters influencing the output (response) must be identified along with their operating range. The information on input parameters (variables) and their operating range may be finalized by consulting literature and industry personnel. However, for new process, brainstorming process can be used. It is required to include all parameters initially and screening may be done by applying Plackett and Burman (PB) design. The PB design is able to provide information on important parameters influencing the process. It is important to note that PB design requires very little number of experiments even with huge number of input parameters. The general framework of developing the process or system modelling is presented in Fig. 3.2.

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Chapter 4
Intelligent Modelling of Hard Materials Machining

In the Mid of 1950s, artificial intelligence was emerged to solve practical problems in engineering domain by using tools, developed based on human intelligence. Genetic algorithm 'GA', artificial neural network 'ANN', and fuzzy logic are some AI-based soft computing tools used to predict and assist in control of manufacturing processes. Today, huge money is spent throughout the globe on development of AI technology to assist manufacturing industries. The Artificial Intelligence (AI) has found successful applications in engineering [1] such as selection of materials (i.e. tool and workpiece) [2], tool and vibration monitoring [3, 4], machine and process control [5], fault diagnosis [6], machine design or designing of machine elements [7], production planning and scheduling [8, 9], inspections [10], automatic remeshing using finite element analysis of forging deformation [11], control of welding process [12, 13], motion of aircraft [14, 15], robot [16], laser machining [17], and prediction of properties or responses [18–22].

4.1 Advantages of Artificial Intelligence Over Statistical Methods

The main advantages of AI tools (ANN, fuzzy logic, GAs) over statistical methods are listed below [23, 24]:

1. ANN models do not require prerequisite knowledge about a process.
2. ANN learn with data patterns where the information is incomplete and noisy data.
3. ANN possess good generalization capability.
4. Fuzzy logic models are capable to handle the data with a lot of uncertainty or vagueness to solve the objective functions, which are subjected to practical constraints.

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Chapter 5
Optimization of Machining of Hard Material

In real-life engineering problems, conducting practical experiments and collecting experimental data for analysis and evaluation in order to attain optimal solutions are difficult as compared to data-driven optimization of mathematical functions. In particular, the numerical modelling and simulation process yield solutions and the duration may vary from few seconds to hours depending on the complexity of problems to be solved. Moreover, the solution obtained may or may not be the global optimal solution. Numerical modelling and simulation task can only predict the outputs for set of inputs and needs many try-error runs, which may not yield optimal solutions. On the other hand, optimization tools are capable to locate the global solutions with very less computational efforts, iterations, and time.

Optimization is the process of identifying or determining the most effective solution for an individual or multi-objective function under particular set of constraints. There are two major types of optimization algorithms, namely stochastic and deterministic algorithms. Deterministic search procedure is employed in conventional optimization tools (statistical methods) to move one solution with reference to another, which results in many local solutions. Stochastic algorithms conduct heuristic search in many distinct locations at multi-dimensional search space to locate the optimal solutions. The heuristic search algorithms are generally more suitable to locate the global solutions, although there may be high computation cost due to many local minima or maxima. The technical advantage of stochastic optimization tools is that it will not require exact mathematical formulation and software to optimize the given task. The system works like a black box and does not require high computation efforts (i.e. calculation of derivatives) and time.

Stochastic optimization algorithms are developed based on the idea inspired by natural or biological phenomenon, namely the evolution of species, teacher–learner phenomenon, and behaviour of animals or features of insect colonies. Further, these algorithms have excellent tools for optimization [1]. The technical benefits associated with the structured stochastic search include generating, modifying, and updating the solutions in the wide search space with the collective information carried from the

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Contents

Analysis and Optimization of Metal Injection Moulding Process

C. Veeresh Nayak, G. C. Manjunath Patel, M. R. Ramesh, Vijay Desai and Sudip Kumar Samanta

Abstract Near net shape metal injection moulding (MIM) process is employed to manufacture the complex shaped metal parts and can readily be used without the requirement of secondary processes. Appropriate control at various stages (i.e. feed-stock preparation, injection moulding, binding, debinding, and sintering) of the MIM process is essential to obtain pore-free structure that yield good compact in MIM parts. In MIM process, the outputs (such as, surface roughness, micro-hardness, and ultimate tensile strength) of injection molded parts is influenced majorly by injection speed, feedstock flow velocity, injection temperature and mold temperature. The present work is focused to study and analyse the effect of influencing variables of nickel based (Cr_3C_2-NiCr + NiCrSiB) metal injection moulded parts using statistical Taguchi method. Taguchi method is employed to conduct actual experiments and Pareto analysis of variance is conducted to analyze and estimate the significant contribution of input variables on different outputs. Taguchi and Pareto ANOVA methods determine the different set of optimal levels for each output, separately. Determining single optimal level for all the outputs is often difficult due to the conflicting requirements (maximize: MH, UST; minimize: SR) in injection moulded parts. Therefore, Principal component analysis (PCA) is applied to determine the relative importance (weight fraction) for individual outputs. Grey relational analysis (GRA) is applied to convert the multiple objective functions with different set of weight fractions determined using PCA to single objective function through suitable mathematical formulation. The grey relation grading has been determined and single optimal levels for satisfying the conflicting requirements are solved in the present work. The hybrid Taguchi-GRA-PCA method determined optimal solutions are tested with practical

C. Veeresh Nayak · M. R. Ramesh · V. Desai
Department of Mechanical Engineering, National Institute of Technology Karnataka, Surathkal 575025, India

G. C. Manjunath Patel (✉)
Department of Mechanical Engineering, PES Institute of Technology and Management, Shivamogga 577204, Karnataka, India
e-mail: manju09mpm05@gmail.com

S. K. Samanta
Near Net-Shape Manufacturing Group, CSIR-Central Mechanical Engineering Research Institute, Durgapur 713209, India

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Contents

Modelling and Optimization of Alpha-set Sand Moulding System Using Statistical Design of Experiments and Evolutionary Algorithms

G. C. Manjunath Patel, Ganesh R. Chate and Mahesh B. Parappagoudar

Abstract The traditional trial-and error method applied to derive empirical relation and optimize the process is time consuming and results in reduced productivity, high rejection and cost. Hence, current research in foundries focussed towards development of statistical modelling and optimization tools. The present research work is focused on modelling and optimization of Alpha-set moulding sand system. The variables such as percent of resin and hardener, and curing time will influence the sand mould properties, namely, compression strength, permeability, mould hardness, gas evolution and collapsibility. Experimental data is collected as per CCD design matrix and non-linear models have been developed for all responses. The behaviour of all responses is studied by utilizing surface plots. The statistical adequacy of all models is tested with help of ANOVA. All responses are tested for their prediction capacity with the help of test cases. The predictive non-linear models, developed for the process resulted in average deviation of less than 5%. The optimization (GA, PSO, DFA and TLBO) tools are applied to optimize the process for conflicting requirements in sand mould properties. Six case studies with different combination of weight fractions assigned to sand mould properties are considered. The optimum solution correspond to highest composite desirability value is selected. TLBO outperformed other optimization tools (i.e. GA, PSO, and DFA) while determining the highest desirability value and resulted in optimized sand mould properties. Experiments are conducted for the optimized and normal (i.e. lowest desirability) sand mould conditions. Castings are prepared by pouring molten LM20 alloy to the prepared moulds. The casting obtained for the optimized sand mould condition resulted in a better casting quality.

G. C. Manjunath Patel (✉)
Department of Mechanical Engineering, PES Institute of Technology and Management, Shivamogga 577204, Karnataka, India
e-mail: manju09mpm05@gmail.com

G. R. Chate
Department of Industrial and Production Engineering, K.L.S. Gogte Institute of Technology, Belgaum, India

M. B. Parappagoudar
Department of Mechanical Engineering, Padre Conceicao College of Engineering, Verna, Goa, India

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Optimization of Abrasive Water Jet Machining for Green Composites Using Multi-variant Hybrid Techniques

G. C. Manjunath Patel, Jagadish, Rajana Suresh Kumar and N. V. Swamy Naidu

Abstract Traditional machining of polymer matrix composites (PMCs) possesses difficulties as they exhibit excellent specific strength and stiffness. Superior properties led PMCs parts were extensively used in structural, aviation, construction and automotive applications. The advanced machining process abrasive water jet machining (AWJM) has been explored to machine PMCs. The AWJM factors namely abrasive grain size, working pressure, standoff distance, nozzle speed, and abrasive mass flow rate affect the final outcome of surface quality (i.e. surface roughness, SR) and productivity (i.e. material removal rate 'MRR' and process time 'PT') are studied. Taguchi L_{27} orthogonal array of experimental design is employed for conducting practical experiments. Taguchi method limit to optimize multiple conflicting outputs (maximize: MRR, and minimize: PT and SR), simultaneously. In general, multiple outputs may have many solutions and are dependent on the tradeoff (relative importance or weights) assigned to each output. Traditional practices such as engineer judgement, expert suggestion and customer requirements may lead to local solutions (i.e. superior quality for one output, while compromising with the rest). Principal component analysis (PCA) method overcomes the said shortcomings of traditional practices and determines weight fractions for each output based on the experimental data. Multi-objective optimization on the basis of ratio analysis (MOORA), Grey relational analysis (GRA), Technique for order preference by similarity to ideal solution (TOPSIS) and Data Envelopment Analysis based Ranking (DEAR) are the four methods employed for the purpose of multi-objective optimization. MOORA, GRA and TOPSIS methodologies require assigning weight fractions for each output by the problem solver. Note that, solution accuracies vary with the weight fractions assigned to each output. The aggregate (composite values of all responses) values determined by PCA-MOORA, PCA-TOPSIS, PCA-GRA and DEAR method were

G. C. Manjunath Patel
Department of Mechanical Engineering, P.E.S. Institute of Technology and Management, Shivamogga 577204, Karnataka, India

Jagadish (✉) · R. S. Kumar · N. V. S. Naidu
Department of Mechanical Engineering, National Institute of Technology Raipur, Raipur 492010, Chhattisgarh, India
e-mail: jagadishbaridabad.s@gmail.com

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Feature Extraction and Recognition Information System for Manufacturing Prismatic Part

Vinod V. Rampur and Sachhidanand Reur

Abstract Feature extraction and recognition information systems are now widely located as a foundation for formulating an automated process planning system. Many methods have been reported in the kinds of literature, but a few of them acquired a status of generic methodology. In this research work explains the concept of automatic feature recognition system using CAD model neutral file in the format of ISO 10303 Standard for Exchange of Product model data (STEP) AP-214 to identify the hole feature of the CAD model. The geometrical information of the part design is analyzed by a feature recognition procedure that is created specifically to extract the features from the 3D CAD model based on geometric reasoning approach. Finally, a sample application description for a workpiece is presented for demonstration purposes.

Keywords STEP AP-214 · CAD · CAPP · CAM · Features · B-rep

1 Introduction

Automation of production activities for achieving manufacturing flexibility is becoming a major significant issue for manufacturing industries, as it leads to an improvement in production efficiency. The utilization of computer integrated manufacturing (CIM) approach is considered as a most doable approach to achieve efficiency. In such undertakings, computer-aided systems collaborate with a fused method to manage all through the product life cycle of a given part. As needs are the fundamental combination between CAD with CAPP and after that CAPP with CAM is perceived as the key zone of core interest. The integration of CAD and CAM through CAPP is

V. V. Rampur (✉)
Department of Mechanical Engineering, PESITM, Shivamogga, Karnataka, India
e-mail: vinod.rampur@pestrust.edu.in

S. Reur
Department of Industrial and Production Engineering, PDACE, Kalburgi, Karnataka, India
e-mail: sr.chidu1@gmail.com

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Experimental investigation on the effects of fiber orientation on translaminar fracture toughness for glass-epoxy composite under mixed Mode I/II load

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Abilash Desai, C. M. Sharanaprabhu, and S. K. Kudari

Experimental Investigation on the Effects of Fiber Orientation on Translaminar Fracture Toughness for Glass-Epoxy Composite Under Mixed Mode I/II Load

Abilash Desai[1,a) , C.M. Sharanaprabhu[2,b) and S.K. Kudari [3,c)

[1]*Asst. Professor, Department of Mechanical Engineering, SDMCET, Dharwad, Karnataka, India*
[2] *Professor, Department of Mechanical Engineering, PESITM, Shivamogga, Karnataka, India.*
[3] *Professor, Department of Mechanical Engineering, CVR College of Engineering, Hyderabad, India*

[a)]Corresponding author: abilashdesai@gmail.com
[b)]cmsharanaprabhu@rediffmail.com
[c)]s.kudari@rediffmail.com

Abstract. In this paper, the effects of fiber orientation on translaminar fracture toughness of a glass–epoxy composite laminate were evaluated using a compact tension shear (CTS) mixed mode (I/II) fracture specimen. Unidirectional (UD) glass fiber laminates of 0° and 0/90° orientation were considered for the experimental work. The fabrication of the CTS mixed mode (I/II) fracture specimen plates of thickness 9mm for various fiber orientations were done using hand lay-up technique. The CTS specimens of various fiber orientations are machined to form composite plates. The experimental study conducted for CTS specimen was of seven loading angle varying from 0° (mode-I) to 90° (mode-II) with an increment of 15° for various fiber orientation. Experimentally evaluated peak loads from CTS mixed mode (I/II) fracture specimen for various fiber orientations and loading angle are utilized to estimate the translaminar fracture toughness. The experimental results of translaminar fracture toughness of unidirectional (UD) glass fiber shows higher for 0/90° as compared with 0° fiber orientation and highly dependent on loading angle. The factography study clearly indicates that the crack initiation/direction depends on the loading angle.

Key words: translaminar fracture toughness, CTS mixed mode (I/II) fracture specimen, unidirectional glass fiber laminate, factography

INTRODUCTION

The translaminar fracture toughness of glass-epoxy composite, where fracture toughness related to longitudinal tensile failure is observed, is an important parameter which helps in controlling damage initiation and propagation in longitudinal loading. Hence, structures can be made more damage resistant by increasing the translaminar fracture toughness. In glass-epoxy laminates, fiber pull-outs are common type of translaminar fracture failure, which can be observed by visual inspection [1,2]. Most of the authors agree that the translaminar fracture toughness in composite laminates is directly related to the energy dissipated by debonding and by friction during the formation of these surfaces [3-6]. Materials are properly chosen for engineering applications based on their physical or mechanical properties, including mass, strength, stiffness and toughness. The ability to take advantage of the lightweight potential of glass-epoxy polymer composites is dependent, in many applications, on the ability to calculate their fracture behavior. Unidirectional (UD) fibers as of late rose as a new class of materials that can conceivably prompt weight decrease in composite structures. They exhibit improved resistance against delamination, fiber pull outs and matrix cracking [2].

The longing for effective structure, combined with a consistently expanding comprehension of composite failure, is moving the manufacturing industry towards a more damage tolerant way to deal with composites. Strategies for anticipating the damage resistant composites are profoundly alluring. In the meantime, as the

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Dr. Girisha L.	**Dr. Basavarajappa Y. H.**	**Dr. Chaitanya Kumar M. V.**
Coordinator, NCMPC-19	HOD, Mechanical Dept.	Principal, PESITM

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Coordinator, NCMPC-19	**HOD, Mechanical Dept.**	**Principal, PESITM**

Effect of TiC Addition on Fracture Toughness of Al6061 Alloy

M S Raviraj[1,a)] , C M Sharanprabhu[2,b)], G C Mohankumar[3,c)]

[1] Department of Mechanical Engineering, Government Engineering College, Chamarajanagar 571313, India
[2]Department of Mechanical Engineering, PES Institute of Technology and Management, Shimoga, India
[3]Department of Mechanical Engineering, National Institute of Technology Karnataka,Surathkal 575025, India

[a)]Corresponding author: ravirajsunkapur@gmail.com
[b)]cmsharanaprabhu@rediffmail.com
[c)]mkumargc@gmail.com

Abstract: Al 6061 matrix was reinforced with different proportions of TiC particles such as 3wt%, 5wt% and 7wt% and the effect on fracture toughness was studied. Al-TiC metal matrix composites were produced by stir casting method to ensure uniform distribution of the TiC particulates in the Al matrix. LEFM (Linear Elastic Fracture Mechanics) has been used to characterize the fracture toughness using various specimen geometries. The compact tension (CT) specimens with straight through notch were machined as per ASTM E399 specifications. All the specimens were machined to have constant a/W=0.5 and B/W was varied from 0.2 to 0.7. A sharp crack initiation was done at the end of notch by fatigue loading using servo- hydraulic controlled testing machine. Load v/s crack mouth opening displacement (CMOD) data was plotted and stress intensity factor, K_Q determined. Critical stress intensity factor K_{IC} was obtained by plotting K_Q v/s thickness of specimen data. The fracture toughness of the composites varied between 16-19 MPa√m as compared to 23MPa√m for base alloy Al6061. Composites with 3wt% and 7wt% TiC showed better fracture toughness than 5wt% TiC reinforced Al metal matrix composites.

INTRODUCTION

Extensive investigations are made on the mechanical behavior of particle reinforced aluminum metal matrix composites since they exhibit enhanced strength and stiffness over their monolithic alloys and are relatively isotropic and easier to fabricate compared to other fiber- reinforced metal matrix composites. However certain studies revealed that addition of particles can significantly degrade the ductility and fracture toughness of these materials. The role the characters of particles play is important in controlling the toughness of the composites, and the impairing of toughness is considered to be due to cracking of particles, non uniformity of particles and changes in matrix flow behavior [1-3]. Much of the research is carried out by additions of SiC and Al_2O_3 into the Al matrix and studying their properties. But the effect of TiC additions into the Al matrix particularly on the fracture toughness is not investigated as referred from the literature. It has been established that TiC particles grain refine Al and Al alloys [4] and in the Al-TiC system there is thought to be sufficient lattice matching for the direct nucleation of solid Al to occur on the particle surfaces [5]. The Al-TiC composites occupy a unique position in the family of metal matrix composites due to their excellent wear/stiffness, strength to weight ratio with good mechanical properties. The most common applications of these composites are in commercial aerospace, space technology, automobile, general industrial and engineering structures. Typical examples are found in helicopter blade, automotive piston, engine block, cylinder liners, brake discs and valve engines [6]. Solidification characteristic of TiC particulate reinforced Al alloy matrix composites have been studied [7]. Some of the mechanical properties and microstructures of the Al6061 alloy matrix reinforced with various proportions of TiC particulates have been published in our earlier reports [8]. In this paper fracture toughness of composites of Al6061 alloy reinforced with 3wt%, 5wt% and 7wt% TiC particulates have been presented.

MATERIAL

The Al-TiC metal matrix composites were produced by stir casting method so as to achieve uniform distribution of TiC particulates in the Al matrix. Commercially available Al6061alloy was melted in the graphite crucible and

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Experimental processing and the effects of cenosphere on some mechanical properties of Al6061-SiC composites

E. Ashoka, C. M. Sharanaprabhu, G. Kodancha Krishnaraja, and S. K. Kudari

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Experimental Processing and the Effects of Cenosphere on Some Mechanical Properties of Al6061-SiC Composites

E Ashoka [1,a)], C M Sharanaprabhu [2,b)], G Kodancha Krishnaraja [3,c)], S K Kudari [4,d)]

[1] Research Centre, Mechanical Engineering Department, Bapuji Instiute of Engineering and Technology, Davangere 577004, India.
[2] Research Centre, Mechanical Engineering Department, P E S Institute of Technology and Management, Shivamogga 577204, India.
[3] Research Centre, Mechanical Engineering Department, B V B College of Engineering, Hubli-580031, India.
[4] Research Centre, Department of Mechanical Engineering, CVR College of Engineering, Hyderabad 500 029, India

b)Corresponding author: cmsharanaprabhu@rediffmail.com
a)ashokamech06@gmail.com
c)kgk252785@yahoo.com
d)s.kudari@rediffmail.com

Abstract. In this paper, stir casting technique was utilized to fabricate the hybrid Aluminium alloy (Al 6061) metal matrix reinforced with silicon carbide (SiC) and cenosphere particulates. An Al6061-SiC-Cenosphere hybrid composite is selected with 3wt% of silicon carbide and 3wt%, 6wt% and 9wt% proportions of cenosphere particulates. The uniform distribution of these two reinforcement particulates in Al6061matrix was achieved by stirring and pouring the hybrid composite mixture into the steel mould to accomplish the rectangular shaped casting. These various hybrid composites were studied with respect to its microstructure and some mechanical properties. The rectangular shaped casting of various hybrid composites was machined according to ASTM tensile specimens standards to estimate some mechanical properties. For various cast hybrid composites a comparative study is done with respect to modulus of elasticity, yield stress, percentage elongation and microhardness. Finally, the distribution of particulates and the nature of the tensile specimen fractured surface of various hybrid composites were understood using scanning electron microscope.

Keywords: Cenosphere, Silicon Carbide, Al6061 metal matrix, Stir casting, Tensile strength.

INTRODUCTION

Now a day's owing to low density, better wear resistance, tensile strength composite material increases growth in aerospace, industrial and automotive sectors. Matrix and reinforcement are constituted of composite material. Among matrix Aluminium and its alloy have sustained to maintain their demand due to the class of lightweight high performance [1]. Authors [2,3] selected SiC particulate due to low density, high elastic modulus, *etc*. as a reinforcement material for Al metal matrix and showed some modification in mechanical properties. Also related to low density, least expensive and available on huge quantities fly ash is used as particulates for Al metal matrix composites [4-5]. The Al based metal matrix composites with various reinforcement are fabricated by different techniques such as: stir casting [6], liquid metal infiltration [7], squeeze casting [8] and spray co-deposition [9]. In the above mentioned fabrication techniques, stir casting process involve the mixing of particulate reinforced into the molten metal matrix form. Using the stir casting technique, Yang *et.al*.[10] experimentally conducted peel tests, tensile tests, and bend tests for Al3003-SiC composites and demonstrated an effective of SiC fiber reinforcements using ultrasonic consolidation. Mohan *et.al*. [11] experimentally carried out work on the effects of SiC particles on tensile properties of Al6061-SiC composites and analyzed the modulus of elasticity and yield strength increases with an increase in weight proportions of SiC particles in Al6061-SiC composites. Related to fly ash particulates reinforced with pure Al, Rao *et.al*. [12] explained good bonding between them using stir casting technique. Rao *et.al*. [13] experimentally studied the fly ash effects on mechanical properties for AA2024-fly ash (ALFA)

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Performance and emission characteristics of a CNG-Biodiesel dual fuel operation of a single cylinder four stroke CI engine

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Performance and emission characteristics of a CNG-Biodiesel dual fuel operation of a single cylinder four stroke CI engine

Basavarajappa Y H[1*], N.R. Banapurmath[2], Pradeep G[3], Vinod R[4], V.Yaliwal[5]
[1]Department of Mechanical Engineering, PESITM, Shimoga,
[2]School of Mechanical Engineering, KLE Technological University, Hubballi,
[3]Department of Mechanical Engineering, KLEIT, Hubballi,
[4]School of Mechanical Engineering, REVA University, Bengaluru,
[5]Department of Mechanical Engineering, SDMCET, Dharwad,India

* Corresponding Author: basavarajappa_yh@pestrust.edu.in

Abstract: The introducement of stringent emissions norms like Euro V and Euro VI is diverting the research to develop new technologies to reduce the engines exhaust emissions. Many researchers have adopted different techniques for lowering the tailpipe emissions from the engines where oxides of nitrogen (NOx) and smoke are mainly formed. In this study a diesel engine having single cylinder is converted into dual-fuel engine to operate with pilot injection of Diesel/biodiesel ethanol blend and Compressed natural gas (CNG). The engine was operated on both single fuel(SF) and dual fuel(DF) mode. The CNG was inducted into the inlet manifold through a gas carburettor on purpose designed for this application. The injection timings was optimized for CNG- biodiesel. The optimum injection timing was 27°BTDC. The pilot fuel injection pressure was maintained at 230 bar. Engine was operated with optimum Compression ratio of 17.5 and CNG flow rate was optimized and found to be 0.5 kg/h. The effect of CNG induction on combustion and emissions characteristics of a compression ignition engine with a dual fuel was studied and compared with single fuel operation. Comparative results revealing the effect of dual fuel combustion on the engine performance, combustion and exhaust emissions. Based on the performance, combustion and emission characteristics it is concluded that, use of CNG in the dual fuel mode in a diesel engine improves the performance and reduces the exhaust emissions from the engine except for HC and NO_X emissions.

1. Introduction

Continuous pressure on emission control through tightened and stringent emission norms is directing the researchers to design new methods to control engine tailpipe emissions. Due to stringent restrictions laid down by government agencies on tail pipe emissions from internal combustion engines and worldwide shortage of fossil fuels, alternative fuels have gained popularity [1-3]. Continued efforts towards reducing pollutant emissions from diesel engines especially particulate matters and nitrogen oxides, many researchers recommended a dual fuel engines for utilising CNG as a partial substitute along with liquid biodiesel [4-6] which paves the way for replacement of neat diesel. In such engines a variety of combination of biodiesel fuels and gaseous fuels have been utilized. In this context natural gas has become a most widely used alternative gaseous fuel for a variety of reasons including its ready availability and its low emissions [7-8].

2. Majority of the transport vehicles are driven by Compression Ignition (CI) engines and they can effectively use variety of fuels that are alternatives to diesel and hence possible to meet stringent emission norms besides conserving energy as well [1, 9-14]. Research on highly efficient diesel engines, using various alternative and renewable fuels has been reported in the literature [10, 15-16]. Different methods have been adopted by researchers for controlling the tailpipe emissions from the engines in order to address smoke and oxides of nitrogen emissions [19-23]. It is possible to convert existing CI engines to run in dual fuel mode with natural gas as primary fuel and diesel/biodiesel as pilot fuel. In

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Tensile and flexural properties of areca sheath fibers

Ashok R. Banagar[a*], Srinivasa Chikkol Venkateshappa[b], Sakshi Shantharam Kamath[c], Basavaraju Bennehalli[c]

[a]*Department of Mechanical Engineering, PES Institute of Technology, Shivamogga-577204, Karnataka, India*
[b]*Department of Mechanical Engineering., GM Institute of Technology, Davangere-577006, Karnataka, India*
[c] *Department of Chemistry, Alva's Institute of Engineering and Technology, Mijar-574225, Karnataka, India*
**Corresponding Author: Email: jnnashok@gmail.com*

Abstract

In the current work, the effect of surface modifications of areca sheath fiber by chemical modifications such as alkylation, permanganate treatment, benzoylation and acrylation on the tensile and flexural behavior of areca sheath was studied. Both the surface modified and raw areca sheath fibers are studied in this investigation. It was found that the tensile and flexural strength are greatly influenced by surface modifications. From this study, it is concluded that chemical treatment of areca sheath will result in increasing the tensile strength and will reduce the bending strength. Further, the tensile strength increases with the surface modification and flexural strength decreases. It is concluded that the composites utilizing areca strands are promising elective materials, which can be effectively utilized in automobiles, packaging industry, parcel/panel boards, and so on

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Keywords: Areca sheath; Tensile strength; flexural strength; Surface modification;

1. Introduction

The areca nut palm, Areca catechu L. is the source of the common masticatory nut, popularly known as areca nut. Areca is a commercial/profit-oriented crop and is mainly grown southern parts of India [1]. Areca leaf sheath is shed intermittently from the tree and it can be conceivably utilized as dry grub in ruminants. Around four lakh hectares of land is under Areca development and it is evaluated that 500,000 tonnes of the potential availability of areca leaf sheaths annually [2]. Each areca leaf sheath weighs about 250 g and the total annual availability of areca sheath is about 0.14 million tons. Few of the studies have high lightened the measurable quantity of studies on arecanut,

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