MATHEMATICAL MODELLING FOR SURFACE ROUGHNESS OF STIR CAST Al-RHA REINFORCED COMPOSITE USING REGRESSION ANALYSIS

A DESSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

AWARD OF THE DEGREE OF

MASTER OF TECHNOLOGY

IN

PRODUCTION ENGINEERING

Submitted by :

SNIGDHA

(2K17/PIE/13)

Under the supervision of

DR. VIPIN

PROFESSOR

DEPARMENT OF MECHANICAL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

(FORMERLY DELHI COLLEGE OF ENGINEERING)

CANDIDATE'S DECLARATION

I, SNIGDHA , Roll No. 2K17/PIE/13 student of M. Tech. (Production & Industrial Engineering), hereby declare that the project Dissertation titled "Mathematical modeling for surface roughness of stir cast Al-RHA reinforced composite using regression analysis " which is submitted by me to the Department of Mechanical Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

Place : Delhi SNIGDHA

Date :

CERTIFICATE

I hereby certify that the project Dissertation titled which is submitted by SNIGDHA , Roll No. 2K17/PIE/13 Department of Mechanical Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of degree of Master of Technology, is a record of the project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi — DR. VIPIN

Date : — PROFESSOR

DELHI TECHNOLOGICAL UNIVERSITY

ACKNOWLEDGEMENT

It is a matter of great pleasure for me to present my dissertation report on "**MATHEMATICAL MODELLING FOR SURFACE ROUGHNESS OF STIR CAST Al-RHA REINFORCED COMPOSITE USING REGRESSION ANALYSIS**". First and foremost, I am profoundly grateful to my guide **Dr. VIPIN, Professor, Mechanical Engineering Department** for his expert guidance and continuous encouragement during all stages of thesis. I feel lucky to get an opportunity to work with him. Not only understanding the subject, but also interpreting the results drawn thereon from the graphs was very thought provoking. I am thankful to the kindness and generosity shown by him towards me, as it helped me morally complete the project before actually starting it.

I would like to thank, **Sh. Roshan Kumar** (Metrology Lab.) and **Sh. Sunil Kumar** (Machine Shop, CWS) for all their assistance during execution of this project work, without their support it would be almost impossible to complete my thesis work on time.

Last, but not the least, I would like to thank **my family members** for their help, encouragement and prayers through all these months. I dedicate my work to them .

SNIGDHA

(Roll No. 2K17/PIE/13)

M. Tech. (Production Engineering)

Delhi Technological University, Delhi, India

ABSTRACT

Surface Roughness and Material removal rate are the important characteristics affecting quality of a material. Surface roughness is a product quality index which is employed to check the quality of a product . As surface finish increases, mechanical properties of a product also become strengthened. Therefore , surface roughness factor decides the quality of a product. Surface Roughness affects the product life as well as other factors like friction, heat transmission, temperature etc. By analyzing the parameter called surface roughness, we are tending towards the optimal level of machining parameters which leads to low production cost by reducing production time.

In the study, focus is being based on the fabrication of aluminium 6061 metal matrix composite reinforced with RHA(rice husk ash). 8wt% RHA is incorporated to the matrix by using stir casting technique. This study investigates the effect of input variables like cutting speed , feed rate , depth of cut on response variable or output variable as surface roughness. Taguchi method has been used to optimize the machining parameters, which is a influential parameter for analyzing optimal level of parameter. The specimen was machined under different parameters and was being measured for surface roughness under varying machining parameters using Taylor Hubson's Surtronic 3+. The optimum parameters are cutting speed (V) ,feed (f), depth of cut (d) which produces minimum surface roughness of material. From the results, it is revealed that high cutting speed and low feed rate causes better surface finish.

KEYWORDS: Surface Roughness, Friction stir casting, Taguchi, Regression analysis, Taylor Hubson Surtronic 3+.

CONTENTS

List of figures

List of Tables

Nomenclature

Parameter	Description
Ra	Parameter of roughness
SR	Surface Roughness
DOE	Design of Experiment
DOC	depth of cut

CHAPTER 1

Introduction

Stir casting is a modern technique to be used for fabrication of aluminium and other composites. It consists of a mechanical stirrer which helps in mixing the dispersed particle with molten matrix. The reinforcing particles are mixing continuously with the help of mechanical stirrer providing homogeneous mixture which reduces porosity and other surface defects. It is the most simplest and cost effective technique being employed to produce composites.

Now-a-days aluminium alloys are becoming demandable material because of having excellent mechanical properties like strength, hardness, toughness, fatigue strength etc. in aeronautical industries, marine industries and automotive industries. Friction stir casting is the effective way to fabricate the aluminium based composites .

The study focusses on the surface roughness prediction of composite being fabricated by using stir casting technique while machining on lathe. The controllable variables like speed , feed , depth of cut has signficant effect on the surface roughness. Moreover the mechanical properties like hardness, toughness, creep life, corrosion resistance etc. greatly affects the roughness. Therefore S.R cannot be ignored completely. It plays significant role in achieving better surface finish to enhance the product life.

Lathe is the mother of all machine tools. It can cut workpieces when they are rotating. To get better surface finish , definite machining parameters are to be needed such as feed, speed ,and depth of cut , nose radius, rake angle etc. Lathes are capable of doing fast cuts through maintaining accuracy and precision and also effective in other operations like drilling and indexing which can effectively be machined by lathes.

The present study involves the following steps:

- First fabrication of aluminium alloy reinforced with RHA using friction stir casting .

- In the present work, there is an establishment of relationship between input parameters (in this resarch work: speed, feed, idepth of cut) and output or response parameter(in this study : roughness).

- To obtain the optimum level of cutting parameters for achieving minimum surface roughness.

A well-known formula has been used to calculate surface Roughness theoretically is given by $f^2/32r$. The terms which are used in above formula are defined as f is fead rate and r is nose radious. Surface roughness is greatly influenced by nose redius and fead rate. Surface finish increases the life of a product . Surface roughness is a quality characteristic which plays an important role in obtaining a product with good life, fatigue strength. In manufacturing industries, surface finish has become a vital part of product being produced at the minimum cost.

SR is one among the most vital parameters among manufacturing parameters. It does affect the quality of a w/p which is the main consideration in the name of production cost. Therefore surface roughness could become the main aspect in research field. As we go forward in field of research, surface roughness would play significant role in determining quality of a product. It makes a product life longer, strengthen it too. Researchers are trying hard to get the effective and strong relationship between the manufacturing parameters and their affect on surface roughness. By focusing on surface roughness(SR), researchers could make it possible to achieve quality of a product at minimum cost.

Nishant Verma (2019) studies the machining and fabrication of Aluminium alloy -7075, AA 7075/B_4C composite and AA7075/B_4C/RHA hybrid composite. stir casting technique is used to make composites. The hardness values which is revealed from the results is 72% higher than the pure AA 7075. Reinforcement distribution in AA7075 is confirmed by Energy dispersive spectroscopy (EDS). In this study, response surface methodology (RSM) is used for the analysis and optimizing the cutting parameters. From the results, speed was the best powerful parameterin SR and material removal rate.

1.1 Composite Materials

Composite materials are comprising of equal and more than two distinct constituents. To make metal matrix composites, reinforcements are added .Composite materials consists of two components: one is irregular phase which is called as reinforcement and the other component is unbroken phase which is referred to as matrix (Tudu,2009). As compared to the pure alloy, metal matrix composites are having more mechanical advantages as they have much improved mechanical properties (Shiv Prasad, 2012).

The material can be said to be composite if it follows the following conditions:

- It is produced.
- It consists of minimum two properly set and distributed phases which have man dissimilarities on the basis of chemical interface.
- It is having many features which are different from other components.

1.2 Classification of Composites

Composites can be categorised on the basis of matrices as polymer, ceramic, metal and reinforcement as oxides, carbides and nitrides , continuous fibers, short fibers, whiskers and particulates are being classified on the basis of shapes and lastly as orientations (Senthilbabu et al.,2015).

1.2.1 Polymer matrix composites

This composite consists of polymer resin and fibers. Polymer resins include polyesters, vinyl esters, PEEK, PPS etc. Some common fibers are glass, carbon, and aramid. Polymer matrix composites such as Glass Fiber Reinforced Polymer (GRPF) is used in storage containers, piping, automotive and marine bodies and industrial floorings. Another type of Polymer matrix composite is Carbon Fiber Reinforced Polymer is used in pressure vessels, aircraft structural parts, rocket and motor equipments.

1.2.2 Ceramic Matrix Composites

Ceramic –based matrix materials which are having high melting point, better corrosive resistance, used for applications rendering structural material above 1600°C.Special type of ceramic matrix composites are made up of ceramic matrix and ceramic fiber which is acting as reinforcement. Ceramic matrx composits are used in medical industry, aeronautical industry.

1.2.3 Metal Matrix Composites (MMC)

Metal matrix composites are made up of alloy made of metal matrix (Al, Mg, copper, titanium) and ceramic phase (in form of particulates, whiskers , ash, short fibers , continuously aligned fibers). Metal Matrix Composites are being fabricated by a technique in which there is homogeneous dispersion of reinforcement into matrix. MMCs are having very high wear ressistance, high thermel and electrical properties, erosive resistance etc.

1.2.4 Aluminum metal matrix composites (AMMC)

Aluminium metal matrix composites are made up of mainly aluminium alloy which acts as matrix part and ceramics includes (SiC), (Al_2O_3), B_4C, boron nitrate and aluminium nitrate (Sharma et al.,2014).

AMMCs can be classified on the basis of reinforcement types:

- Particles-reinforced AMMCs (PAMMCs)
- Whiskers- reinforced AMMCs(SFAMMCs)
- Continous fiber-reinforcad AMMCs(CFAMMCs)
- Mono filamant-reinforcad AMMCs(MFAMMCs)

1.2.4.1 Particulate Reinforced Aluminum Metal Matrix Composites

Particulates Reinforced Aluminium MMC are fabricated by mainly two techniques: solid state technology or powder metallurgy, liquid state or stir casting methodology etc. processes..The mechanical proparties of Particulete Reinforcad MMC are far better than pure aluminium alloy.

1.2.4.2 Short fiber and Whiskers Reinforced Aluminum Metal Matrix Composites

The reinforcement of those composites are having aspect ratio greater than five. These are fine grained polycrystalline fibers. Melt infiltration is used to produce the composite. They have high tensile strength values .On the other hand, a significant disadvantage of whisker particles is that they can be easily caught in air and could attack lungs severely.

1.2.4.3 Continuous Fiber Reinforced Aluminum MMC

Fiber materials such as Silicon carbon, carbon, and various oxides are used for the manufacturing of continuous fiber. Continuous fiber is manufactured by melt infiltration. The usage of composites depends upon various properties like toughness, stiffness and creep. The reinforcement used is carbon fiber as it is long and thin fiber of very less diameter. These reinforcements are very flexible in nature and they can be used as a single pattern long fibers. Their main use is when the temperature corresponding to application is very large.

1.3 Methods of Fabrication of MMC

Mainly there are three methods of fabrication of MMC: 1) liquid state Processing technique 2) Solid state processing technique and 3) Vapour state processing technique.

1.3.1 Liquid State Processing Technique

In this technique , particulates or ceramic particles are mixed homogeneously into liquid metal .Later on ,the liquid is cast into any shape which is needed by conventional methods of casting .Some of the important liquid state processing technique are :

1.3.1.1 liquid metal infiltration

This is one of the best techniques of liquid state processing. The is done by penetrating the fiber in liquid metal, infiltration wires are fabricated using it. The next step is to collect them and perform the diffusion bond in liquidus and solidus region. This process is very useful for making small size composites which are anisotropic in nature.

1.3.1.2 Squeeze Casting

As we have studied it is a metal casting process in which very précised quality products are fabricated .Firstly the metal is melted and placed in the die cavity which is preceeded by hydraulic press with a very high pressure and it solidfy with a very high solidification rate till the hydraulic press is fully overlapped with the die cavity. The temperature in this process is very high and used for producing aluminium and magnesium castings. It is used in large scale manufacturing .The advantage of this process is improved mechanical properties .complex shapes are made by this process

1.3.1.3 Stir casting

This is one the best methods for casting, mainly used for the aluminium alloys .It is built with a mechanical stirrer which works at high frequency . This method involves utilizing ceramic particles which are being dispersed into the matrix. This method is the easiest fabrication technique which is also called as vortex technique. Then the liquid slurry was being cast into various shapes accordingly Maximum percentage which is allowed to get significant composite is upto 30% and size of the particles lies between 5to100.

1.4.2 Solid State Processing

Some of the techniques are as follows:

1.4.2.1 Powder Metallurgy

In this method, matrix used is in powder form and it is blended with the reinforcement ,after that the powder is compacted in a given shape ,then binding oils are injected to get a proper bond. After that sintering is done, workpiece is heated to elevated temperature and constant pressing is done. In powder metallurgy, the particle size is in nanometers due to the fineness of particles the bond is very strong and it improves after the heat treatment .It is very useful method used to fabricate MMC.

1.4.2.2 Diffusion bonding method

It can also be referred as foil-fiber-foil method .This technique is chiefly used to manufacture titanium based fiber reinforced composites. For e.g. Al 6061/ boron fiber composites are fabricated by using diffusion bonding technique. This method is basically used for manufacturing of intricate shapes and highly fibrous volume reinforced composites.

1.4.3 Vapour State Processing

The processes relating to vapour state processing are discussed below:

1.4.3.1 Physical vapour deposition technique

It is one of the best methods used to make composites but it is relatively slow. A high vapor pressure electron beam is directed onto the solid bar producing vapors. This method is used to fabricate the monofilament reinforced Ti composites. This method is very significant in which fibers have a diffusion barrier layer, and a tailored surface chemistry.

1.5 Applications of ALMMC

AMMCs have wide applications in aircraft technology, electronic engineering, space engineering field. Some of the important AMMCs are:

.

- Al_2O_3 reinforced ALMMC are used in manufacturing of piston ring and piston crown because of high wear resistence and very high running temperature.
- Graphite reinforced ALMMC are used in cylinder, piston bearing.
- TiC reinforced aluminium metal matrix composites are used in manufacturing of connecting road and piston due to improved strength and wear resistance.

Applications of AMMCs are significantly useful in the field of electronics management, in chemical industries, in aerospace engineering, tennis rackets, golf club shafts, fishing rods, bicycle frame works.

1.6 Surface Roughness

SR is referred to as the peaks and velleys produced on the surface of the element. Surface Roughness creates resistance to movement during machining.

1.6.1 Types of Surface Roughness:

a) Ideal Roughness

Ideal Roughness is the best possible roughness which is being produced using machining. As we cannot remove the various factors completely, ideal roughness is obtained. Ideal roughness is mathematically calculated by:

$$R\ max = f / (\cot \varphi + \cot \beta)$$

Average Roughness is calculated by:

$$R_a = R_{max}/4$$

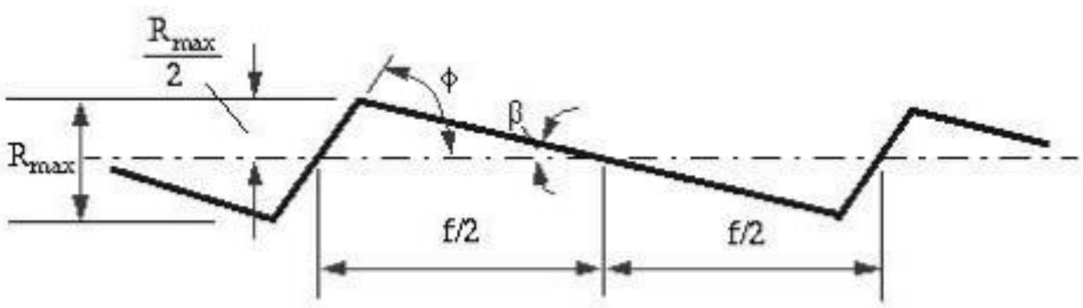

Fig1: Surface Profile

f= feed

Φ= higher cutting angle

B= upper cutting angle

b) Normal Roughness

It is the naturally sustaining roughness which mostly affect the surface roughness .By providing additives to the matrix, we can minimize the surface roughness.

1.7 Cutting Parameters

Various machining parameters like S, F.R, DOC. etc. which affects the machining .In this research work, we are optimizing the machining parameters like S, F.R, DOC to get the optimal level of parameters and its effect on surface roughness parameter.

1.7.1 Cutting Speed

It may be defined as the movement of tool in one minute (mm/min). Cutting speed need to be optimized to get the optimal parameters for the study. It is mathematically calculated by :

V_c=πDN/1000

Where V_c= cutting speed , D= diameter, N=rpm

1.7.2 Feed Rate

It is referred to as the radial movement of tool in one revolution of work piece. A hard material has given less feed in the range of 1.1mm/rev because of chances of chatter and vibrations. On the other hand, a soft material has given comparatively more in the range of 1.5mm/rev.

1.7.3 Depth of Cut

Doc is stated as the metal removed in one pass of machining .Depth of cut should be optimized to obtain the optimal level of parameters. Value of feed is 1-5mm to obtain better surface finish and for finishing operation, its value is kept less than 1mm.

1.7.4 Effect of machining parameters on SR

Cutting parameters affect the SR greatly as we know product. Surface roughness greatly influences the surface finish of a material and hence the quality. Cutting parameters like feed rate also plays a vital role in getting good SR. As it decreases, surface finish would get better.

Surface finish also depends upon the working material whether it is ductile or brittle. The value of SR highly depends upon the nature of material. The value of SR also depends upon the types of chips produced like continuous or discontinuous chips . Therefore cutting parameters affect the surface roughness followed by better surface finish .

1.8 Taguchi Method

Taguchi method is an efficient system of method which proposes a robust and effective design of optimal consequences at a relatively low cost. Design of experiment in Taguchi method is used for observing the effect of machining factors on surface roughnesss of composite material being machined with carbide tool and also obtaining the optimal level of these parameters/ factors which are resulting into better and improved surface finish. There are three steps approach system to carry out optimization of process parameters such as system design, parameter or process design, tolerance design.

1.8.1System Design

An Engineer creates a basic and functional model design through application of scientific and engineering knowledge . A model or prototype design involves the product design and process design step. Product design includes the selection of materials, components, etc . In case of process design, processing sequence, process parameters values are involved. System design is full of creativity and innovation . It is the design of initial level having techniques relating to the application of basic knowledge leading to the fundamental pillar of the fumctional design.

1.8.2Parameter Design

The objective of the parameter design is to increase the parameters values for nurturing the performance and also for the identification of the product parameter values under the optimal parameter conditions. It is the method for attaining process parameters under ideal condition which are unresponsive for environmental factors and other noise factor. Hence this method is used for obtaining good quality characteristics without being increment in cost. When the number of machining parameters are increased then the no of experiments are also get affected ie increases. To manage the work, one uses Taguchi optimization tool which is using an orthogonal array to study all the parameter values in a single table or small interval. Taguchi orthogonal array suggested the technique of modeling the parameter values through employment of loss function for computing the deviation between experimental and desired value. Loss function is being changed into signal to noise ratio which are commonly of three types for the optimization technique .

1)Smaller- the-better :

n = -10Log$_{10}$(mean of sum of square of measured data)

This particular type is defined for the defects characteristics having ideal value is 0. But when the ideal value is finite then the difference between the measured and the ideal values which is expected to be small as possible. Then the equation becomes

n= -10Log$_{10}$[mean of sum of squares of (measured - ideal)]

2)Larger-the-better :

n= -10Log$_{10}$[mean of sum of squares of reciprocal of measured data]

3)Nominal-the-best:

n= 10Log10[Mean^2/variance]

If the number of parameters or factors are increased , this method will become uneasy to conduct. Therefore Taguchi's orthogonal array was being suggested in the case of more number of factors to be taken. Then taguchi involves the use of loss function measuring the performance measure which are deviating from the desired output values. The loss function is being changed into signal to noise ratio .There are three types of signal to noise ratio : nominal-the-best, larger-the-better, and smaller-the-better.

3)Tolerance Design

In tolerance design, several parameters are being optimized upto the level of few dimensions within controlling limits.

1.8.3 Design of Experiment(DOE)

Design of experiments is a competent mathematical modeling and analyzing tool which is used for the analysis of process parameter's over the desired value function. Design of experiment is one of the best statistical tool using for the product and process development by providing a analytical knowledge of complex variables to short trials.

Analysis of Variance (ANOVA)

ANOVA is a statistical analysis of the experimental values of important parameters influencing the process design rather than involving all the factors. ANOVA is an estimation of comparative studies over the overall measured values. It signifies the process parameters when there are more number of variable input values. It is used for defining the impact of any process parameter through design of experiment and also used for understanding the data.

It offers a mathematical tool which offers whether or not all averages are all equal. Results from a ANOVA table are not depend upon constant bias and scaling errors and other environmental factors.

1.8.4 Regression Analysis

It is one of the best optimizing techniques for the analysis of cutting parameters. It is a good technique to set up a relation between independent and dependent variables. In this study, independent variables like S, F.R, DOC. Response variable is surface roughness.

To find out the relation between input and output parameters, various techniques are used to predict the output or response parameter. In this work, regression analysis is being used to optimize the process parameters for the prediction of surface roughness.

Categorization of regression method is as follows:

- Linear Regresion
- Polynomial Regresion
- Simple Regresion
- General linear model
- Discrete
- Binomial Regresion
- Binary Regresion

- Logistic Regresion
- Multiple Regresion

By plotting values of dependent and independent values, we have drawn a scatter plot and then a best fit line is obtained helpful in prediction of surface roughness .

1.9 OBJECTIVE

This study mainly focusses on the finding out the optimal parameters of machining and search out variation of surface roughness corresponding to the cutting parameters (S, F.R, DOC) of a metal matrix composite in which rice husk ash (RHA) is used as a reinforcement and aluminium 6061 is used as matrix .We are adding 8% RHA to make composite which is being fabricated by using stir casting technique in which a mechanical stirrer makes homogeneous dispersion of particulates into matrix up to nanoparticles.

In this study, after the fabrication of composite using friction stir casting technique, we need to optimize the machining parameters . Firstly, Work piece is turned on lathe to get the surface for measurement of roughness. For measurement of surface roughness, Taylor Hobsen Apparatus is being used. Further to find out the relationship between input and output parameters, regression optimization is applied for best fit curve to forecast the S.R value. Therefore, this method is used to make a model providing easy way for prediction of surface roughness value.

CHAPTER 2

LITERATURE REVIEW

A significant number of studies have examined the effects of the cutting parameters like S, F.R, DOC, nose radius , forces and other parameters on the S.R . These studies have been briefly discussed for the variations observed experimentally.

2.1 Literature survey

***Suresh et al.*(2013)** focusses on the study which resulted that the addittion of TiB_2 which improves the wear resistence and micro hardness value of aluminium composites. In this paper, aluminium alloy AI6061 was reinforced with titanium bromide by stir casting method . Titanium bromide is more attractive to the particular study because it is having high modulus (315-401GPa) , low density (4.5 g/cm^3), superior Vickers hardness (3400HV) , great thermal conductivity (~110W/m k at 25^{o} C), high electrical conductivity (22×10^6 Ω cm). In this study, titanium bromide is added in 0, 4,8 and 12% by weight . With the increase in the amount of Tibr in the ALMMC, an improvement in the wear resistance attribute and enhancement in the strength of the aluminium composite .

Vipin et.al. (2013) focusses on the investigation of parameters which are affects the S.R attribute manufactured during the turning of aluminium alloy AI6061 . Taguchi design is used for analyzing the effect of the turning parameters on the surface roughness function. The results obtained from the machining experiments for aluminium 6061 are used to illustrate the main parameters which are affecting surface roughness by ANOVA method . . The optimum parameters for minimum SR is obtained at 2100rpm , 0.1 mm/rev and 0.2 mm . A regression model is constructed for surface roughness which is aacurate resonably and can be used for prediction within limits. Taguchi gives simple and robust approach but difficult method for the optimum operating conditions.

Embark et.al **(2013)** focusses on the investigation of optimization of the machining parameters for the prediction of SR in CNC turning machining with AI6061 material . In this research work ,L-9 orthogonal array, S/N ratio, analysis of variance(ANOVA) , are incorporated to study the performance attributes in the turning operations of AI6061 . The machining parameters involving cutting speed , feed rate and depth of cut. This study shows that feed rate , cutting speed and depth of cut are affecting the MRR and surface roughness by using ANOVA method . .

The effect of cutting speed in turning process is the most noteworthy parameter on surface roughness than on MRR. Faster cutting speed resulting in improving surface roughness . Feed rate is affecting both MRR and surface roughness .

Selvam et al. (2013) focusses on the fabrication and characterization of Aluminium Matrix Composite reinforced with Sic and weight percentage of Fly ash using stir casting . The study analyses the microstructural and mechanical properties of the fabricated aluminium matrix composite. The homogeneous dispersion of fly ash and silicon carbide revealed under Scanning Electron Micrograph (SEM). With the help of SEM , the addition of flyash helps to prevent dissolution of silicon carbide and formation of aluminium carbide . The AL-Sic-FA comparises of 7.5wt % FA and varying weight percentage 7.5 and 10.5 wt % of SiC of reinforcement. From the study, the macro and micro hardness of the reinforced composite varies from 61.53 HV to6.8 HV and39.4 BHN to 47.21 BHN with respect to constant weight percentage of SiC and fly ash particles. Moreover, the tensile strength has been increased from 153 MPa to 203 MPa . Also the formation of aluminium carbide is being prevented by the addition of fly ash .

Kılıckap et al(2013) Now –a – days metal matrix composites are attracting attention due to good and achieving engineering properties and abrasive behavior nature of the reinforced particles (SiC).In this paper, 5% SiCp of aluminium alloy is taken to look into observation of tool wear and surface roughness. In this study, K10 grade uncoated and tin coated cutting tools are being used at different cutting speeds (50,100,150 m/min), feed rates (0.1,0.2,0.3mm/rev), and depth of cuts (0.5, 1 ,1.5mm). It has been concluded from the paper that tin –coated cutting tool would give best results, it decreased wear and good S.R Cutting speed is the most powerful parameter , with the increasing cutting speed tool wear increases. Feed is having the same effect on tool wear and SR as that of cutting speed.

Poria et al.(2014) studied the ALMMC reinforced with titanium bromide using friction stir casting . Varying weight percentages of microparticles of titanium bromide having sizes 5-40micron are added into aluminium matrix composite through friction stir casting. Block-on-roller tribotester is being used to test the friction and wear properties of titanium bromide reinforced aluminium matrix composite at room temperature. From the study , with the increase in titanium bromide there is an decrease in friction and wear . On the contrary, friction and wear increase with the load and speed. Abrasive and adhesive wear mechanism are both present which are revealed under scanning electron

Savanna et al(2014) focusses on the possibilities of most inexpensive rice husk as a reinforcement to form a new composites . A rice husk ash particulates of 3, 6, 9 & 12% by weight are used to fabricate metal matrix composites by using a liquid metallurgy method which is one of the liquid state processing. The surface geometry was studied using scanning electron microscope(SEM) for analysing the dispersion of RHA particulates homogeneously into the matrix. The mechanical properties like tensile strength, compressive strength, hardness and percentage elongations are considered for reinforced RHA composites. The outcomes are resulting in the % addition of reinforcement of RHA will increase ultimate tensile strength, compressive strength and hardness of the composite etc.

***Kalyankar et al* (2014)** focusses on the fabrication of aluminium metal matrix composite .Silicon carbide is used as a reinforcement . It also focusses on the addiction of silicon carbide with varying weight percentage of properties like strength, hardness, compressive strength, yield strength etc.

Rao et al (2015)studied the aluminium silicon alloy LM6 reinforced with boron carbide with varying wt percentage (2.5, 5,7.5%) using stir casting route. Scanning electron microscopy (SEM) reveals that there is homogeneous distribution of particulates in the matrix. Hardness and ultimate compressive strength of the composites are increased . Density was increased with the addition of boron carbide in the matrix.

Kumar et al (2015) studied that the pure Aluminium matrix was reinforced with graphite and boron carbide . Varying volume fraction of boron carbide ie 2.5%, 5%, 7.5% is incorporated in the alloy by maintaining constant volume fraction of graphite ie 2% using stir casting route. Optical microscope and scanning electron microscopy reveals that there is homogeneous dispersion of particulates into matrix. With the increase in reinforcement from 2.5% to 5% ,there will be a drastic increase in hardness ie by 48% as compared in case of reinforcement value 5%to 7.5% ie by 11.83% . The wear rate increases with the volume fraction of reinforcement. Ultimate stress, breaking load, maximum displacement is higher for 5% as observed from the compression test on UTM after that it reduces.

Shanmughasundaram et al.*(2015)* focusses on the fabrication of Aluminium alloy reinforced with fly ash for the proper utilization of fly ash into the matrix using two step stir casting . Fly ash is a waste of coal during combustion of coal in thermal power plants. In this study , author is trying to investigate the microstructural , mechanical properties and the wear

Gladston et al.(2016) focusses on the fabrication of aluminium metal matrix composite reinforced with rice husk particles with varying mass fraction (2,4,6,8,10%) by using compocasting technique. The composites were specialised using X-ray diffraction and scanning electron microscopy (SEM). The scanning electron micrographs(SEM) revealed a homogeneous distribution of RHA particles into the aluminum alloy. The reinforcement of RHA particles increased the microhardness and ultimate tensile strength of the AMCs.

Anil kumar et al(2016) investigated the experimental procedure comprising the fabrication of flyash reinforced aluminium composite (Al-6061) using stir casting technique. In this paper, the mechanical properties of composites are being studied . 3-25, 46-50 and 77-100 μm particle sizes of flyash are being used in this study .Moreover , 10, 15, 20 % be the weight fraction of reinforcement chosen respectively. The mechanical properties which were studied for the experiment were tensile strength , hardness, ductility etc. From the results obtained ,it is revealed that when we increase the particle size of the reinforcement , tensile strength ,hardness and ductility were decreased . secondly when we increase the weight fraction of the reinforcement , the mechanical properties were also increased but decrease the ductility.

Venkatesan et al(2017) studied the machining properties of the aluminium composites reinforced with SiC and TiB_2 . Optical microscopy was viewed to study the geometry of the surface of the composites. Vickers hardness test is conducted to measure the hardness of the composite which reveals that the hardness is increasing on the addition of SiC and TiB_2 reinforcement. Tensile testing is done on the samples and the results reveals that on addition of silicon carbide, 21% strength is increased or imparted to the composite . On the other hand, 50-60% hardness is imparted to the composites from addition of TiB_2. The effect of cutting parameters(in this study s, doc, f) on surface roughness is also studied in this research work. With the help of ANOVA table , the contribution of reinforcement titanium bromide is significant ie 36.65% on the surface quality. Tool wear mechanism is also studied .TiB_2 reinforcement affects tool causing built up edge formation , chipping and hence affects surface quality.

Bhushan et al(2017) studied the effect of cutting parameters ie speed, doc, feed on the surface roughness while machining aluminium 7075 reinforced with 10% silicon carbide . The machining was conducted on the CNC with polycrystalline diamond insert and tungsten carbide as a cutting tool. The surface roughness is searched out to be lower in case of tungsten carbide as cutting tool as compared to the PCD for the feed range of 0.2 to 0.4 mm/min and depth of cut in the range 0.5 to 1.5 mm . Tool wear mechanism is being studied under SEM (scanning electron microscope). Carbide tool and PCD both are increases with the increase in cutting speed .

Moses et al (2017) studied the fabrication of aluminium reinforced with 15% (mass fraction) TiC as reinforcement. In this study , empirical relationship is developed to study the effects of stir casting on the tensile strength . The process parameters which were considered are stirring time , casting temperature, stirring speed. All the parameters have considerable effect on tensile strength which is studied by microstructural properties. Central composite design is incorporated in it for design of experiments.

Umanath et al(2017) studied the wear behavior of aluminium 6061-T6 reinforced with silicon carbide and aluminium oxide. Pin on disc wear tester is being used to study the wear mechanism . Mathematical relation is being developed using regression analysis and ANOVA ie analysis of variance for the estimation of wear. The frature surfaces of the composites shows the tear ridges.

Karthikeyan et al (2018) studied the sliding wear behavior for aluminium 6063 reinforced with SiC by using pin- on-disc wear testing instrument. The fabrication of lauminium reinforcing with different varying proportion of SiC ie 6,7,8% using stir casting methodology .SEM module is used to examine the wear behavior on the composites. From the experimental results, it was revealed that with increasing the sliding velocity ,wear increases but on the addition of reinforcement wear decreases.

Kumar et al. (2016) Studied the fabrication of AA6351 aluminium matrix composite by using stir casting technique. The aluminium metal matrix AA6351 is reinforced with Al_2O_3 and Gr as reinforcement. The microstructural and mechanical behavior of the pure alloy and the composite is being studied and compared. Optical microscopy is being used to examine the wear behaviour and the particles dispersion into the matrix. Mechanical properties are improving on the addition of reinforcement . on the addition of reinforcement ie hardness, tensile strength etc.

Phanibhushana et al(2018) studied the wear characteristics of hematite ore reinforced with aluminium 6061. The fabrication technique being used is liquid metallurgy. The reinforcement size is in pariculates form with a increment of 1% from 0 to 7 % weight fraction . The microstructural study reveals that the particulates are properly dispersed into the matrix. The results shows that there will be increase in wear resistance as we add reinforcement.

Kandpal et al(2018) studied the fabrication of aluminium alloy 6061 reinforced with aluminium oxide (Al_2O_3) with varying weight percentage ie 6, 10, 15, 20% by using stir casting . The microstructural characterization is done by electron microscopy. The results revealed the homogeneous dispersion of particulates of aluminium oxides. The reinforcement added improves the microhardness and ultimate tensile strength of the composite being fabricated.

Gargatte et al (2018) studied the fabrication of AA5083 reinforced with silicon carbide being fabricated by using stir casting technique . Different weight fraction of Sic ie 4, 5, 6% being used for fabrication of the aluminium AA5083 composites . Sliding wear test is conducted for the wear test by using wear testing machine. On the account of studying the influence of wear parameters like applied load, perecentage of reinforcement on the aluminium based composites. Taguchi orthogonal array (L_9) and signal to noise ratio was chosen for the design of experiments. ANOVA was used to find out the contribution of parameters . Regression analysis was used to find out the correlation between the parameters.

2.2 Conclusion:

From the above research papers, it is concluded that

- With increase in RHA percentage ,there is significant increase in surface finish and wear properties.
- RHA is organic matter obtained from paddy fields and can be used as reinforcement for metal matrix composites.
- Analysis of variance is useful for determining the optimal machining parameters for the turning of aluminium MMC.
- L27 array is significant to frame a relationship between dependent and independent variables.

CHAPTER 3

EXPERIMENTAL SETUP

3.1 INTRODUCTION

There will be discussion on materials used, experimental processes as well as equipment used. Firstly, the composition and properties of aluminium alloy and the reinforcement (RHA) are studied. The second step includes the fabrication of composites specimens. Then the third step involves the procedures evaluating the surface roughness by optimizing the cutting parameters. In this research work, cutting parameters are taken as cutting speed, feed rate, depth of cut. Finally Regression modeling is done to achieve the best fit curve for response parameter.

3.2 EXPERIMENTAL PROCEDURE

3.2.1 Composite Preparation

The production of the composites used in the present study was conceded out by using friction stir casting. The Al alloy was placed into the crucible and heated up to 800°C till the entire alloy was melted (fig 3.2) . Before mixing the reinforcement (RHA) into the melted alloy, it is being preheated to 600°C for 3h to remove the carboneous particles completely. A mechanical stirrer which is an important part of the stir casting was depressed into the matrix slowly up to certain height of the molten metal and it was rotated at 450 rpm.

The preheated Rice Husk Ash was added in the liquid metal at a steady rate of 2-3 gm to make sure the homogeneous dispersion of the particulates into the matrix slowly by increasing 450 to 750rpm. It was observed that the separate solid layer was formed over the molten metal. Therefore, to improve the wettability between the rice husk particulates and the metal alloy, 1.2% magnesium is added. The stirring is continued for 3-4 mins after completion of the addition of particulates. Finally the mixture was taken into mould of desired shape and then preheated again up to 500°C for 30mins to get uniform solidification.

Fig2: Stir Casting Furnace with ultrasonic stirrer

Table 1 Specifications of stir casting

Model	**Stir casting furnace with ultrasonic stirrer**
Capacity	1.5 to 5 kg
Motor	3 phase AC
Blade	4
Speed	1000rpm
Working temperature	900
Mechanical stirrer	Ultrasonic
Frequency	0 to 20 kHZ

3.3 Conventional Lathe

Fig2 Lathe

Lathe has two important components: head stock and Tailstock. Headstock consists of three jaw chuck which is used to hold the work piece in position. Tailstock is also used to hold the work piece for performing cutting operation, can also hold drill, boring drill etc.

Table 2: Specifications of lathe

Model	Wm210v
Capacity	
Swing over bed	520mm
Swing over carriage	350mm
Admit between centres	420mm
Maximum Length	330mm
Turning dia	263mm
Maximum Turning Diameter	330mm
Chuck size	230 (8”)mm
Spindle	
Spindle Nose	A2-6
Spindle Inside Taper	MT-7

Hole through Spindle	64mm
Maximum Bar Capacity	53mm
Spindle speed range	3600rpm
Maximum Torque in Spindle	150Nm

3.3.1 Working Principle

In lathe, there is a chuck which holds the work piece in position and is rotating with a specified Rpm. Chuck is referred to as headstock technically. Tool is fixed into the toolpost which holds the tool tightly in position and is kept stationary. The principle of lathe is very simple. Now the tool is fed to the work piece with a specified feed, depth of cut at specified rpm.

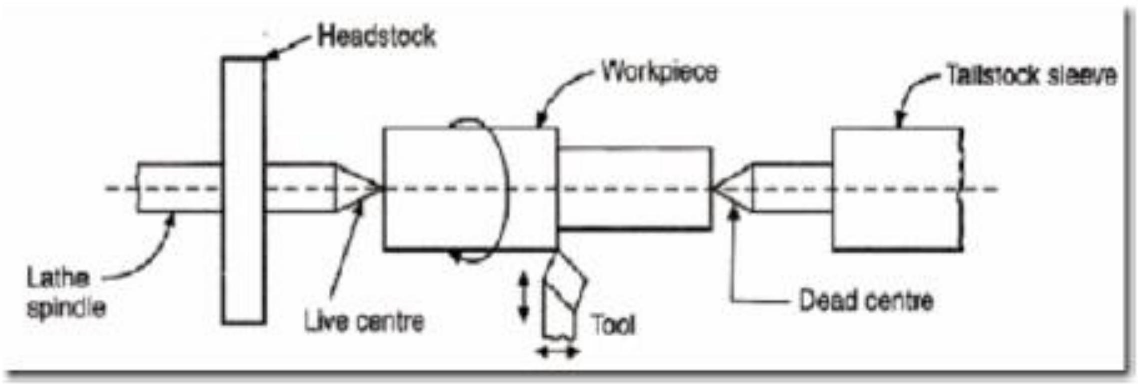

Fig 4 : Schematic diagram of conventional lathe

3.3.2 Components of Lathe

The main components of lathe are : Headstock, Tailstock, Lathe bed, Carriage, Gear box, Tool post.

1. Lathe bed: It is the base of the lathe on which it is resting. It absorbs all the vibrations, damping etc. produced .It is made up of grey cast iron which has damping characteristics.
2. Headstock: It mainly consists of spindle, chuck, gear box, motor , pulley etc. It is mainly used to hold the work piece in position.
3. Tailstock: It is a movable component of the lathe. It can hold drill, boring drill, cutting tool etc.

4 Gear Box : It basically controls the torque, speed. It changes the speed of the spindle accordingly, giving the various speed ratio.

5 Lead screw: It is also termed as “master thread”. It is a long threaded rod in succession with the front of the bed. Lead screw helps in translating turning motion into translatory motion.

3.4 SURFACE ROUGHNESS(taylor hobsen)

The surtronic 3+ is a simple measuring unit for the surface roughness measurement that can measure multiple roughness parameters. Roughness measurement process parameters are R_a, R_z, R_p, R_v and R_t are displayed on the 2.4” LCD colour display. It is very easy and robust technique performing fast, easy and precise measurements in almost any environment and surface. The instrument is mainly equipped with the alkaline non rechargeable battery. Sometimes nickel cadmium based rechargeable battery is used. The instrument gives the variable output with great accuracy. The results are displayed on the screen and there will be another computer for the further results. We can plot the curve from the results obtained.

Fig5: Surface Roughness measuring instrument

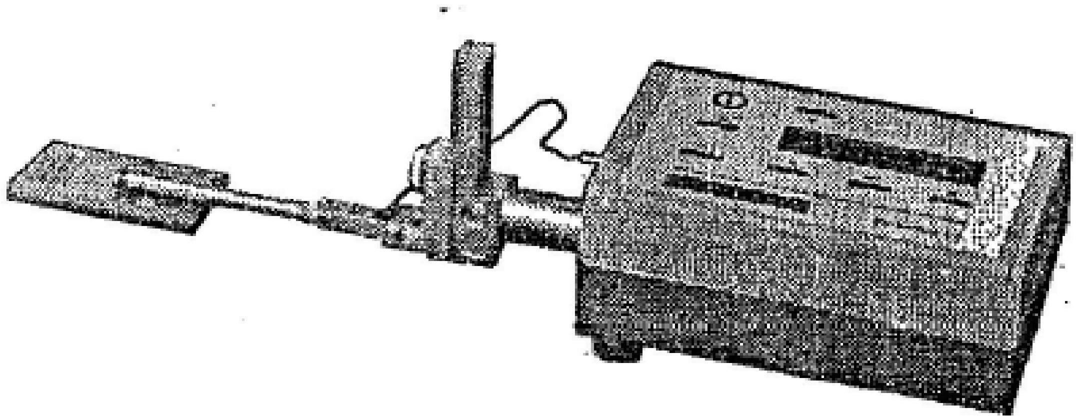

Fig6: Schematic Diagram of surface roughness instrument

This instrument is used to plot the graph of roughness and to find out the value of surface roughness. It consists of a DIP switch, Connector, pick up holder. Stylus is used to convert the analog signal to a desired output signal. This machine has a very high resolution in the order of 3-4 seconds, which is very fast. The accuracy and precision of the machine is very high

SPECIFICATIONS:

Table 3: specifications of surtronic 3+

Battery	Alkaline: Minimum 500 Measurement of 4mm Measurements Length. Ni-Cad: Minimum 350 Measurement of 5mm Length Size: 6 LR 60 (USA/Japan), Fixed Battery External Charged (Ni-Cad) 110/240V, 50Hz
Traverse Unit	Cross Speed: 1mm/Sec
Measurement	Metric Preset by using DIP-Switch
Cut-Off Values	0.24mm, 0.82mm, and 2.60mm
Traverse Length	1, 3, 6, 10, Or 25.5 + 0.1mm At 0.9mm Cut-Off.
Display Unit	LED-Matrix. 2lines * 18 Characters
Keyboard	Membrane Switch Panel

3.5 Surface Roughness Measurement

Inspection and measurement of surface roughness of a turned work piece is mainly done by following three methods:

1.Direct method

2.Comparison –based method

3.Non contact methods

$$R_a = \frac{1}{L}\int_0^L |Y(x)|dx,$$

Figure 7: Mean roughness

Where R_a= arithmetic average deviation from the mean line

L= sampling length

Y= the ordinate of the profile curve

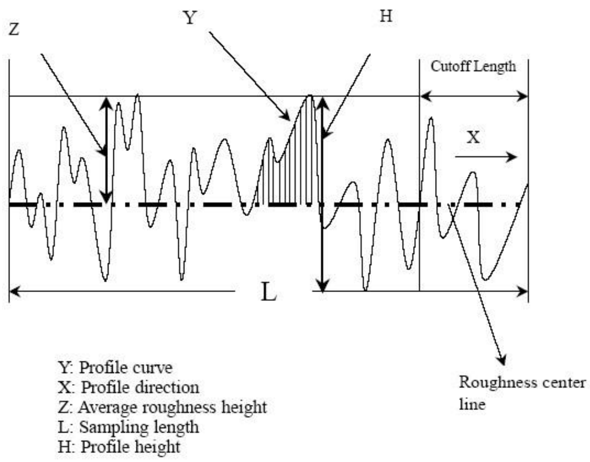

Fig 8: Measurement of roughness by stylus

CHAPTER 4

DATA COLLECTION

In this study, the collection of data is done through the experiment being conducted on the lathe machine. includes the fabrication of composites specimens. Then the third step involves the procedures evaluating the surface roughness by optimizing the cutting parameters. In this research work, cutting parameters are taken as cutting speed, feed rate, depth of cut. The specimen was machined under different parameters and was being measured for surface roughness under varying machining parameters using Taylor Hobson's Surtronic 3+

4.1 Process parameters and their levels:

The cutting parameters and their levels are chosen on the basis of tool, work piece material, machining parameters such as [in this study: cutting speed(s), feed(f) , depth of cut(d)]. And also decided by studying various research papers and data hand books. Different cutting parameters and their levels are shown below:

Table4: Factors and their levels

Symbols	Cutting parameters	Units	Level1	Level2	Level3
A	Speed	m/min	36.33	80.29	125.66
B	Depth of cut	mm	0.6	0.9	1.2
C	Feed	mm/rev	0.1	0.2	0.3

4.2 Roughness values

Table 5: surface roughness values

Experiment no.	Cutting speed(m/min)	Feed Rate (mm/rev)	Depth of cut (mm)	Surface Roughess (micro meter)
1	36.39	.1	0.6	1.27
2	36.39	.1	0.9	1.32
3	36.39	.1	1.2	1.51
4	36.39	0.2	0.6	1.65
5	36.39	0.2	0.9	1.72
6	36.39	0.2	1.2	1.84
7	36.39	0.3	0.6	2.04
8	36.39	0.3	0.9	2.11
9	36.39	0.3	1.2	2.27
10	80.29	0.1	0.6	.87
11	80.29	0.1	0.9	.95
12	80.29	0.1	1.2	.98
13	80.29	0.2	0.6	1.12
14	80.29	0.2	0.9	1.24
15	80.29	0.2	1.2	1.29
16	80.29	0.3	0.6	1.34
17	80.29	0.3	0.9	1.43

18	80.29	0.3	1.2	1.63
19	125.66	0.1	0.6	.68
20	125.66	0.1	0.9	.77
21	125.66	0.1	1.2	.82
22	125.66	0.2	0.6	.89
23	125.66	0.2	0.9	.97
24	125.66	0.2	1.2	1.11
25	125.66	0.3	0.6	1.15
26	125.66	0.3	0.9	1.16
27	125.66	0.3	1.2	1.23

4.3 Minitab 17

MINITAB, as a statistical software system which is designed for easy and integrated study of analyzing the research data. It provides many statistical analyses such as regression, ANOVA, S/N ratio etc. It becomes easier to analyse and validate the experimental results through Minitab software for improving process/product developments. Some steps which are followed in minitab are as follows:

- Open the sample space
- Choose stat > Taguchi (DOE) .
- In Response, enter Surface roughness.
- In input variables ,enter speed, feed, depth of cut.
- Enter OK

Taguchi's orthogonal array is designed for the optimization of process parameters of having more number of variables into few trials. Since it makes the calculations and graphs easier which becomes more focused on analyzing and interpreting the data. Initially, the data or sample space is summarized for further optimization. After design of experiment is being done on the experimental values, analysis of data using regression analysis is formulated.

CHAPTER 5

ANALYSIS

5.1 INTRODUCTION

It describes about measurement of surface roughness, a model based on the values of S.R using taguchi method. This helps to optimize the machining parameters i.e. speed, depth of cut, feed for the minimum value of surface roughness. The work piece of Al+Rha composite is turned on conventional lathe at different speed, depth of cut, feed and its roughness is measured and by using MINITAB 17, regression model is mathematically made.

5.2 MACHINING TEST

Work piece of dimension Diameter = 30mm, Length = 100mm, is turned on lathe at different machining parameters and 27 such readings are marked , then roughness is measured on Subtronic + and readings are noted.

5.3 REGRESSION MODEL

A regression model gave the relation among an independent and dependent variable by plotting a line closer to observed data. The regression equation then make a correlation between the significant parameters, namely cutting speed, feed rate, depth-of-cut and their dependency. The regression equations established for surface roughness using MINITAB-19 software is as follows:

Table 6: Regression analysis for surface roughness

Sn	Log s	logd	Log f	Log r_a
1	3.59429	-2.30259	-0.510826	0.239017
2	3.59429	-2.30259	-0.105361	0.277632
3	3.59429	-2.30259	0.182322	0.412110
4	3.59429	-1.60944	-0.510826	0.500775
5	3.59429	-1.60944	-0.105361	0.542324
6	3.59429	-1.60944	0.182322	0.609766
7	3.59429	-1.20397	-0.510826	0.712950
8	3.59429	-1.20397	-0.105361	0.746688

9	3.59429	-1.20397	0.182322	0.819780
10	4.38565	-2.30259	-0.510826	-0.139262
11	4.38565	-2.30259	-0.105361	-0.051293
12	4.38565	-2.30259	0.182322	-0.020203
13	4.38565	-1.60944	-0.510826	0.113329
14	4.38565	-1.60944	-0.105361	0.215111
15	4.38565	-1.60944	0.182322	0.254642
16	4.38565	-1.20397	-0.510826	0.292670
17	4.38565	-1.20397	-0.105361	0.357674
18	4.38565	-1.20397	0.182322	0.488580
19	4.83358	-2.30259	-0.510826	-0.385662
20	4.83358	-2.30259	-0.105361	-0.261365
21	4.83358	-2.30259	0.182322	-0.198451
22	4.83358	-1.60944	-0.510826	-0.116534
23	4.83358	-1.60944	-0.105361	-0.030459
24	4.83358	-1.60944	0.182322	0.104360
25	4.83358	-1.20397	-0.510826	0.139762
26	4.83358	-1.20397	-0.105361	0.148420
27	4.83358	-1.20397	0.182322	0.207014

5.4 Graphs obtained from Regression analysis

5.4.1 Normal probability plot

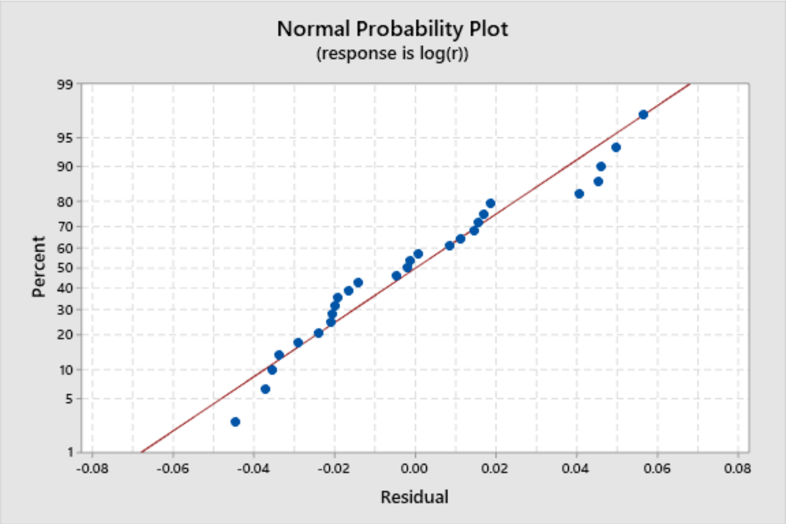

Fig9: Normal probability plot of Residuals for log Ra

From the normal probability plot ,the points usually form a straight line if the residual distribution is normal. If the points got dispersed from the straight line , the assumption might be invalid for the given project work. This curve shows bending in the tail due to the less number of observations in this project work even if the residual distribution is normal.

5.4.2 Residual v/s fitted value for log Ra

This plot represents the random pattern of residuals with respect to mean value or we can say the deviation of points from the mean. If in case , a point lies far away from the group of points then it may not be further inclusion of the value .

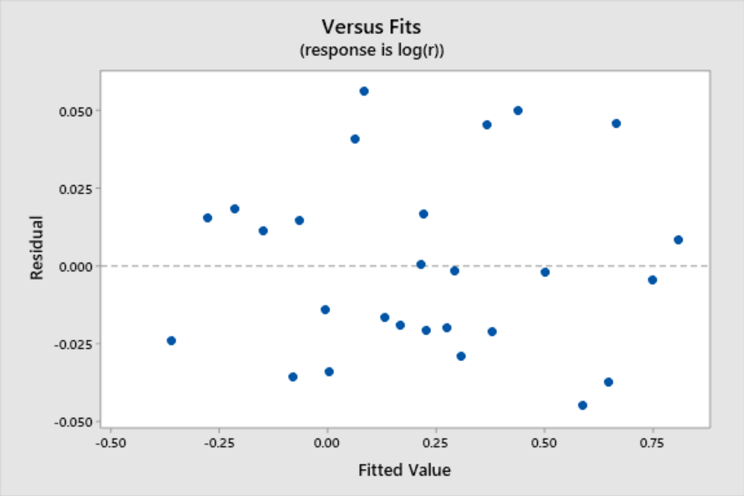

Fig 10: Residual v/s fitted value for log Ra

This can be concluded that the values should be in range which indicates that there si no sign of unusual pattern and structure. This plot detects the nonlinearity, outliers . It is a scatter plot of residual lies on the y axis v/s fitted values on the x axis. The residual plot is random then it would be said that the data is meaningful. If the points are above the mean line then the residual is said to be positive .On the other hand if the points are below the mean line ,the residuals are negative.

5.4.3 Frequency v/s residual plot

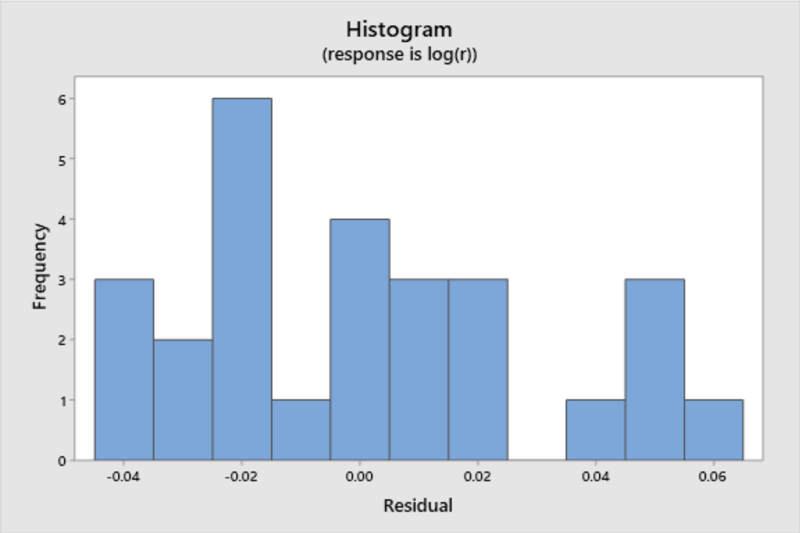

Fig11: Frequency v/s residual plot

The plot shows the bar trend of the pattern . If the bars are away from the other group of values then it is said to be outlier . The plot shows the frequency on the vertical axis and residual on the x axis. Histograms are also called frequency bar graphs which are used to determine whether the data are skewed or include outlier. Histograms are used for approximately 20 or more points .

5.4.4 Residual v/s order for log Ra

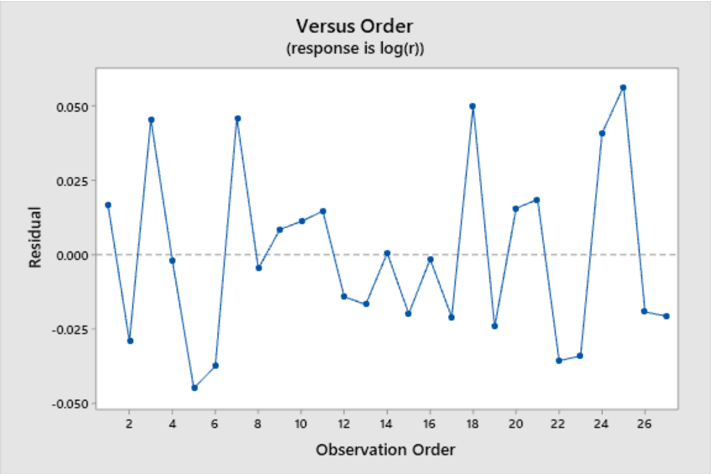

Fig12:Residual v/s order for log Ra

Plotting between residual against the observation order shows the validity of the regression analysis. If the plot shows no trend in its range then the regression is fully satisfied. On the other hand , if the plots shows trend then there is likely violation of regression analysis being done.

5.4.5 Graph of roughness v/s speed

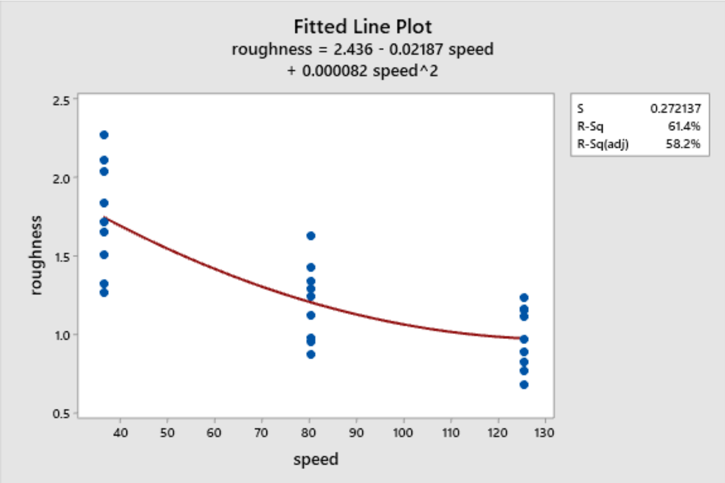

Fig13: Graph of roughness v/s speed

As shown from the graph , as the speed increases roughness decreases. By plotting all the values of roughness with corresponding to the speed gives a curve as shown in the above plot. This plot also gives the equation which relates the roughness and the speed . R^2 is given by the plot showing 61% which tells the best fit curve measurement of the regression models. R squared is a mathematical tool which measures the closeness of data to the best fit line in regression model for analyzing the data.

5.4.6 Graph between roughness and feed

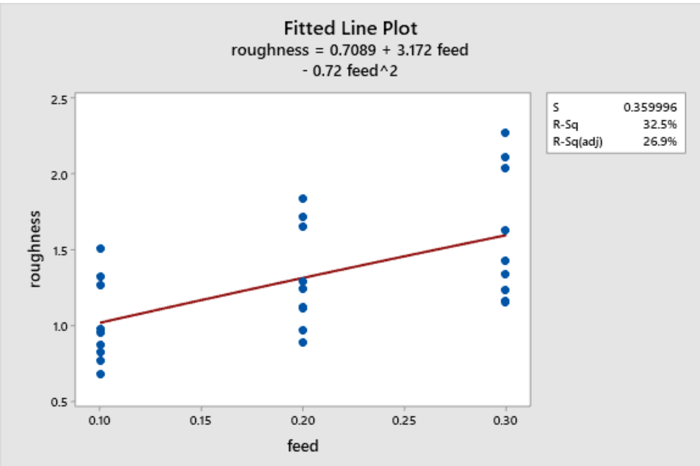

Fig14: Graph between roughness and feed

The variation between roughness and feed is somewhat different than what we have through roughness and speed. As the roughness increase ,feed also increases.

5.4.7 Roughness vs depth of cut

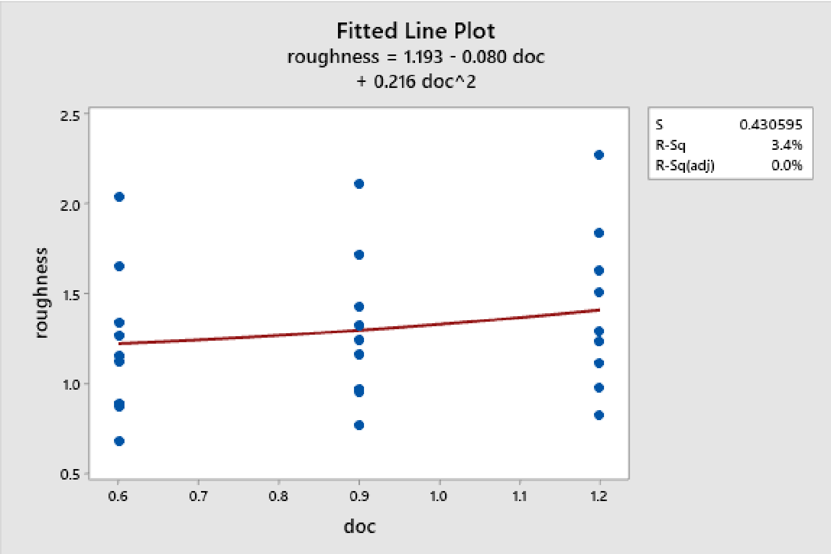

fig15 : Roughness vs depth of cut

This plot shows the effect of depth of cut on roughness .Here R^2 value is very low ie 3.4% therefore the roughness is not much affected by the depth of cut parameter during machining.

5.5 Interaction plots

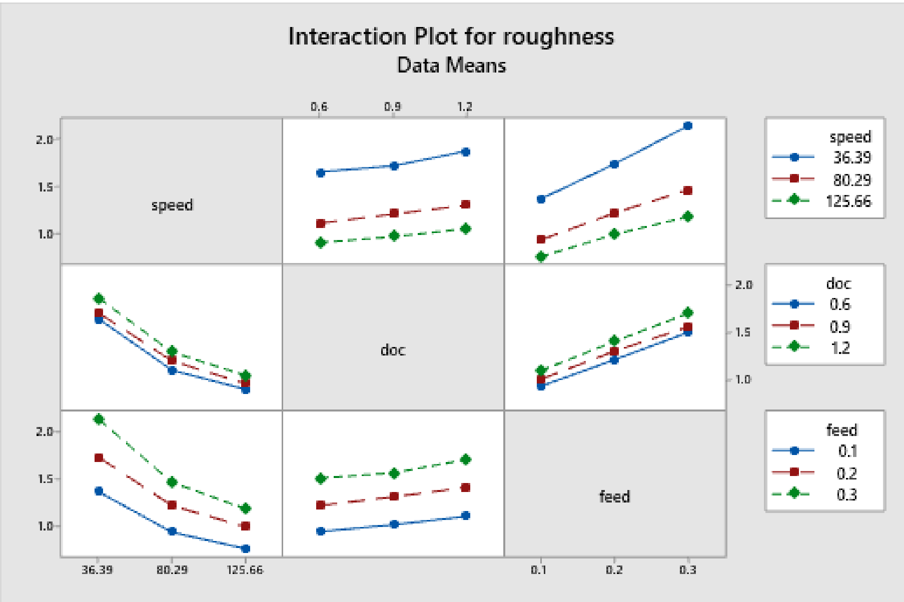

Figure 16 Interaction plot of roughness vs speed, feed

From the plot, it is clearly concluded that when speed is 125.66m/min, roughness speed is minimum at the feed 0.1mm/rev.

5.6 Main effect plot for Roughness

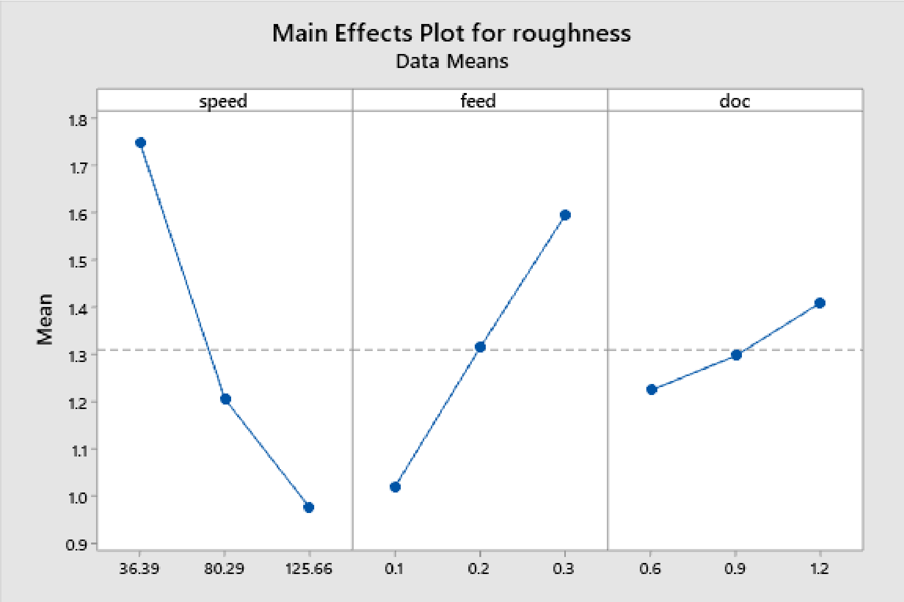

Fig 17: Main effect plot for Roughness

The main effect plots are used to determine the optimal design conditions to obtain the optimal surface finish. According to this main effect plot, the optimal conditions for minimum surface roughness is .68 which cutting speed (125.66 m/min), feed rate (0.1 mm/rev), and depth of cut (0.6 mm),

Table 7 Analysis of variance

Symbol	**Cutting parameters**	**DF**	**AdjSS**	**AdjMS**	**F**	**P**	**Contribution (%)**
	Regression	3	2.57712	0.85904	887.73	0.000	
A	Log S	1	1.57226	1.57226	1624.7	0.000	60.49%
B	Log f	1	0.91010	0.91010	940.5	0.000	35.01%
C	Log d	1	0.09477	0.09477	97.93	0.000	3.65%
Error			0.02226	0.00097			0.86%
Total							100%

Where DF is degree of freedom, SS is sum of square, MS is mean square. From the above table speed has the most contribution on surface roughness among cutting parameters ie 60.49%.

Table 8 : S/N ratio and Mean

S.N	DIAMETER	RPM	SPEED (m/min)	FEED(mm/rev)	DOC (mm)	RA (mm)	S/N Ratio (db)	Mean
1	30	289	36.39	.1	0.6	1.27	-4.6599	1.710
2	30	289	36.39	.1	0.9	1.32	-8.1425	2.325
3	30	289	36.39	.1	1.2	1.51	-13.8039	4.900
4	30	289	36.39	0.2	0.6	1.65	-12.3154	3.524
5	30	289	36.39	0.2	0.9	1.72	-15.3875	5.880
6	30	289	36.39	0.2	1.2	1.84	-6.3154	4.254
7	30	289	36.39	0.3	0.6	2.04	-3.2274	1.450
8	30	289	36.39	0.3	0.9	2.11	-6.2171	5.355
9	30	289	36.39	0.3	1.2	2.27	-9.9937	3.160
10	30	639	80.29	0.1	0.6	.87	-11.2349	2.552
11	30	639	80.29	0.1	0.9	.95	-13.7327	4.860
12	30	639	80.29	0.1	1.2	.98	-10.4978	5.325
13	30	639	80.29	0.2	0.6	1.12	-5.8007	1.950
14	30	639	80.29	0.2	0.9	1.24	-11.4678	1.255
15	30	639	80.29	0.2	1.2	1.29	-13.9620	4.990
16	30	639	80.29	0.3	0.6	1.34	-15.3427	1.368
17	30	639	80.29	0.3	0.9	1.43	-12.8096	4.370
18	30	639	80.29	0.3	1.2	1.63	-9.3457	1.258
19	30	1000	125.66	0.1	0.6	.68	-0.6369	1.520
20	30	1000	125.66	0.1	0.9	.77	-4.31278	2.325
21	30	1000	125.66	0.1	1.2	.82	-12.7298	4.330

22	30	1000	125.66	0.2	0.6	.89	-8.3446	1.551
23	30	1000	125.66	0.2	0.9	.97	-13.6248	4.800
24	30	1000	125.66	0.2	1.2	1.11	-4.2354	5.325
25	30	1000	125.66	0.3	0.6	1.15	0.2915	0.967
26	30	1000	125.66	0.3	0.9	1.16	-8.3259	4.325
27	30	1000	125.66	0.3	1.2	1.23	-15.1327	5.710

Table9: Coefficients of the Regression model

Term	**Coef**	**SE Coef**	**95% CI**	**T-value**	**P-value**	**VIF**
Constant	2.9534	0.055	2.83,3.06	53.55	0.000	
Log(s)	-0.471	0.0117	-0.495,-0.44	-40.3	0.023	1.00
Log(f)	0.4047	0.0132	0.377, 0.432	30.67	0.011	1.00
Log(d)	0.2084	0.0211	0.164,0.251	9.90	0.007	1.00

5.6 Regression Equation

Log(r) = 2.9534 – 0.4710 log(s) + 0.4047 log(f) + 0.2084 log(d)

$$R_a = 19.17\, s^{-0.4710} f^{0.4047} d^{0.2084}$$

Table 10: Actual roughness v/s theoretical roughness

No of experiments	Speed (m/min)	Feed (mm/rev)	Doc(mm)	Actual Ra µm	Theoretical Ra	Error%
1	36.39	0.1	0.6	1.27	1.248724	-1.67531
2	36.39	0.1	0.9	1.32	1.358826	2.941329
3	36.39	0.1	1.2	1.51	1.442783	-4.45147
4	36.39	0.2	0.6	1.65	1.653077	0.186494
5	36.39	0.2	0.9	1.72	1.798832	4.583241
6	36.39	0.2	1.2	1.84	1.909975	3.803011
7	36.39	0.3	0.6	2.04	1.947858	-4.51677
8	36.39	0.3	0.9	2.11	2.119604	0.455153
9	36.39	0.3	1.2	2.27	2.250567	-0.85609
10	80.29	0.1	0.6	0.87	0.860188	-1.12784
11	80.29	0.1	0.9	0.95	0.936032	-1.47031
12	80.29	0.1	1.2	0.98	0.993866	1.414922
13	80.29	0.2	0.6	1.12	1.138728	1.672172
14	80.29	0.2	0.9	1.24	1.239132	-1.07001
15	80.29	0.2	1.2	1.29	1.315694	1.991755
16	80.29	0.3	0.6	1.34	1.341789	1.33515
17	80.29	0.3	0.9	1.43	1.460097	2.104678
18	80.29	0.3	1.2	1.63	1.550311	-4.88888
19	125.66	0.1	0.6	0.68	0.696574	0.437296
20	125.66	0.1	0.9	0.77	0.757992	-1.55952
21	125.66	0.1	1.2	0.82	0.804825	-1.85056
22	125.66	0.2	0.6	0.89	0.922134	3.61052
23	125.66	0.2	0.9	0.97	1.00344	3.447391
24	125.66	0.2	1.2	1.11	1.065439	-4.01452
25	125.66	0.3	0.6	1.15	1.086571	-5.51559
26	125.66	0.3	0.9	1.16	1.182375	1.92892
27	125.66	0.3	1.2	1.23	1.25543	2.067513

From the table , the optimum parameters obtained are speed : 125.66 m/min, feed :0.1mm/rev, and depth of cut :0.6 mm ,corresponding to the cutting parameters , surface roughness obtained as 0.68 µm.

.

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

It concludes the experimental work with the future scope. As experiments shows the variation of cutting parameters and surface roughness. Experiment concludes to optimum parameters for minimum surface roughness and this model gives us a medium to predict surface roughness with a good accuracy.

6.1 CONCLUSION

Following observations are made as follows:

- Cutting speed has highest contribution (60.49%) toward the surface roughness and with increase in speed, roughness decreases.
- With increase in feed rate, surface roughness increases.
- Depth of cut has least contribution on the surface roughness and with increase in doc surface roughness increases with a smaller slope
- Cutting parameters, like cutting speed (125.66 m/min), feed rate (0.1 mm/rev), and depth of cut (0.6 mm), are observed to have minimum surface roughness ie 0.68 μm in machining of AL6061 + RHA composites.
- Rice husk is a waste of Paddy and it can be used as a reinforcement for a composite and it turns out to be very progressive as it gave better results, So we can use this waste for industrial purpose.

6.2 SCOPE FOR FUTURE WORK

The scope of this work depicts the area of future research

- The further experiment can be carried out to find the wear rate, sliding velocity, MRR.
- The fabrication of composite can be carried out on squeeze casting, power matullurgy.
- A further experiment can be carriedout to find the wear rate, sliding velocity, MRR.

- The fabrication of composite can be carried out on squeeze casting, power matullurgy.

- A further experiment can be carried out to see effect of % RHA increase on Roughness.
- Tool life, Cost optimization can be done on the different RHA % and its optimization can be done.

REFERENCES

[1] Suresh, Aksoy, M., & Inan, A. (2005). Study of tool wear and surface roughness in machining of homogenised SiC-p reinforced aluminium metal matrix composite. Journal of Materials Processing Technology, 164

[2] Ranganath, M. S., & Vipin, R. S. (2013). Optimization of Process Parameters in Turning Operation of Aluminium (6061) with Cemented Carbide Inserts Using Taguchi Method and Anova. *International Journal*, *1*(1), 13-21.

..[3] Abdallah, A., Rajamony, B., & Embark, A. (2014). Optimization of cutting parameters for surface roughness in CNC turning machining with aluminum alloy 6061 material. *Optimization*, *4*(10).

[4] Selvam, J. D. R., Smart, D. R., & Dinaharan, I. (2013). Synthesis and characterization of Al6061-Fly Ashp-SiCp composites by stir casting and compocasting methods. *Energy Procedia*, *34*, 637-646.

[5] Kılıckap, E., Cakır, O., Aksoy, M., & Inan, A. (2005). Study of tool wear and surface roughness in machining of homogenised SiC-p reinforced aluminium metal matrix composite. *Journal of Materials Processing Technology, 164,* 862-867.

[6] Poria, S., Sahoo, P., & Sutradhar, G. (2016). Tribological characterization of stir-cast aluminium-TiB 2 metal matrix composites. *Silicon*, *8*(4), 591-599.

[7] Srivastava, V. S., Srivastava, A. K., Nag, A., Singh, R. K., Yadav, D. K., & Madheshiya, S. K. Surface roughness a measurement of in-situ metal matrix composite Al7075/B4C.

[8] Saravanan, S. D., Senthilkumar, M., & Shankar, S. (2013). Effect of particle size on tribological behavior of rice husk ash–reinforced aluminum alloy (AlSi10Mg) matrix composites. *Tribology transactions*, *56*(6), 1156-1167.

[9] Kalyankar, N., Shelke, R., & Barkul, D. (2016). A review on effect on properties of al-sic composites fabricated by stir casting method. *Int. J. Res. Eng. Technol.*, *5*(2), 283-287.

[10] Rao, S. R., & Padmanabhan, G. (2012). Fabrication and mechanical properties of aluminium-boron carbide composites. *International journal of materials and biomaterials applications*, *2*(3), 15-18.

[11] Senthilkumar, N., Tamizharasan, T., & Anbarasan, M. (2014). Mechanical characterization and tribological behaviour of Al-Gr-B4C metal matrix composite prepared by stir casting technique. *Journal of Advanced Engineering Research*, *1*(1), 48-59..

[12] Patidar, D., & Rana, R. S. (2017). Effect of B4C particle reinforcement on the various properties of aluminium matrix composites: a survey paper. *Materials Today: Proceedings*, *4*(2), 2981-2988.

[13] Shanmughasundaram, P., Subramanian, R., & Prabhu, G. (2011). Some studies on aluminium–fly ash composites fabricated by two step stir casting method. *European journal of scientific research*, *63*(2), 204-218.

[14] Narasaraju, G., & Raju, D. L. (2015). Characterization of hybrid rice husk and fly ash-reinforced aluminium alloy (AlSi10Mg) composites. *Materials Today: Proceedings*, *2*(4-5), 3056-3064.

[15] Prasad, D. S., Shoba, C., & Ramanaiah, N. (2014). Investigations on mechanical properties of aluminum hybrid composites. *Journal of Materials Research and Technology*, *3*(1), 79-85.

[16] Gladston, J. A. K., Sheriff, N. M., Dinaharan, I., & Selvam, J. D. R. (2015). Production and characterization of rich husk ash particulate reinforced AA6061 aluminum alloy composites by compocasting. *Transactions of Nonferrous Metals Society of China*, *25*(3), 683-691.

[17] Verma, N., & Vettivel, S. C. (2018). Characterization and experimental analysis of boron carbide and rice husk ash reinforced AA7075 aluminium alloy hybrid composite. *Journal of Alloys and Compounds*, *741*, 981-998.

[18] Anilkumar, H. C., Hebbar, H. S., & Ravishankar, K. S. (2011). Mechanical Properties of Fly Ash Reinforced Aluminium Alloy (Al6061) Composites. *International journal of mechanical and materials engineering*, *6*(1), 41-45.

[19] James, S. J., Venkatesan, K., Kuppan, P., & Ramanujam, R. (2014). Hybrid aluminium metal matrix composite reinforced with SiC and TiB2. *Procedia Engineering*, *97*, 1018-1026.

[20] Bhushan, R. K., Kumar, S., & Das, S. (2010). Effect of machining parameters on surface roughness and tool wear for 7075 Al alloy SiC composite. *The International Journal of Advanced Manufacturing Technology*, *50*(5-8), 459-469.

[21] Moses, J. J., Dinaharan, I., & Sekhar, S. J. (2016). Prediction of influence of process parameters on tensile strength of AA6061/TiC aluminum matrix composites produced using stir casting. *Transactions of Nonferrous Metals Society of China*, *26*(6), 1498-1511.

[22] Umanath, K. P. S. S. K., Palanikumar, K., & Selvamani, S. T. (2013). Analysis of dry sliding wear behaviour of Al6061/SiC/Al2O3 hybrid metal matrix composites. *Composites Part B: Engineering*, *53*, 159-168.

[23] Karthikeyan, A., & Nallusamy, S. (2017). Experimental analysis on sliding wear behaviour of aluminium-6063 with SiC particulate composites. In *International Journal of Engineering Research in Africa* (Vol. 31, pp. 36-43). Trans Tech Publications.

[24] Phanibhushana, M. V., Chandrappa, C. N., & Niranjan, H. B. (2017). Study of Wear Characteristics of Hematite Reinforced Aluminum Metal Matrix Composites. *Materials Today: Proceedings*, *4*(2), 3484-3493.

[25] Kandpal, B. C., & Singh, H. (2017). Fabrication and characterisation of Al2O3/aluminium alloy 6061 composites fabricated by Stir casting. *Materials Today: Proceedings*, *4*(2), 2783-2792.

[26] Gargatte, S., Upadhye, R. R., Dandagi, V. S., Desai, S. R., & Waghamode, B. S. (2013). Preparation & characterization of Al-5083 alloy composites. *Journal of Minerals and Materials Characterization and Engineering*, *1*(01), 8.