TAGUCHI ANALYSIS TO OBTAIN OPTIMAL PARAMETERS FOR SURFACE ROUGHNESS ANALYSIS OF STIR CAST ALUMINIUM MMC

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

MASTER OF TECHNOLOGY IN

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July 2019

CANDIDATE'S DECLARATION

I, Rohit Dhiman , Roll No. 2K17/PIE/11 student of M. Tech. (Production & Industrial Engineering), hereby declare that the project Dissertation titled "**TAGUCHI ANALYSIS TO OBTAIN OPTIMAL PARAMETERS FOR SURFACE ROUGHNESS ANALYSIS OF STIR CAST ALUMINIUM MMC**" 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 Associate ship, Fellowship or other similar title or recognition.

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I hereby certify that the project Dissertation titled **TAGUCHI ANALYSIS TO OBTAIN OPTIMAL PARAMETERS FOR SURFACE ROUGHNESS ANALYSIS OF STIR CAST ALUMINIUM MMC** which is submitted by Rohit Dhiman, Roll No. 2K17/PIE/11 Department of Mechanical Engineering, Delhi Technological University, Delhi in partial fulfillment 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.

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ACKNOWLEDGEMENT

It is a matter of great pleasure for me to present my dissertation report on "**TAGUCHI ANALYSIS TO OBTAIN OPTIMAL PARAMETERS FOR SURFACE ROUGHNESS ANALYSIS OF STIR CAST ALUMINIUM MMC**". 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.

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ABSTRACT

In this era of highly growing technology, new advancement in materials is necessary because of requirement of high quality and accuracy. To determine the quality of the product, Surface Roughness is a very important factor. Surface roughness not only enables one to have good surface properties, but gives accuracy to have a desired type of fit. Mechanical properties of composites are also improved like Tensile strength, Fatigue Strength, corrosion resistant, temperature dependent failures (creep). Composite is super material which is having matrix and reinforcement (to improve the quality of matrix), in this research work Al6061 matrix along with SiC (5%) is taken to fabricate the composite. Stir Casting is one of the best composite fabrication process having a mechanical stirrer (Ultrasonic stirrer), it gives mixing up to nanoparticle levels.

A cylindrical Work piece of dimensions Diameter (30mm), Length (100mm) is turned on the lathe and divided into 9 segments to measure roughness by changing the machining parameters like cutting Speed, depth of cut, feed rate. By analyzing various research papers three levels of speed (27.23m/min,60.21m/min,94.24m/min), feed(.04mm/rev,.12mm/rev,.20mm/rev), depth of cut (.1mm, .2mm, .3mm) are taken to perform experimental work. This study focuses on optimizing surface roughness by using taguchi method. subsequently, 27 readings are taken into consideration to make a regression model, and ANOVA is done which helps us to predict the Roughness without doing any experimental work. The optimal parameters obtained are Speed=94.24m/min, Depth of cut=.1mm, feed =.0795 mm/rev.

Keywords: Roughness, stir casting, Lathe, Taguchi analysis

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NOMENCLATURE

Parameter	**Description**
Ra	Parameter of roughness
SR	Surface Roughness
DOE	Design of Experiment
DOC	depth of cut
F	feed rate

CHAPTER 1

INTRODUCTION

1.1 Introduction

A composite material is a widely used advanced material in the field of engineering and science. A composite material gives better properties as enhanced properties are taken into account by minimizing the undesirable properties. They are widely used in every field of engineering like Marine science, Construction and Transportation. They are also used to manufacture aircraft bodies having very light weight, very smooth surface to minimize surface resistance.

This study helps us to understand better relationship between the composition of matrix and reinforcement and composite made by FSC having better physical and mechanical properties. This study has been reported by Dhingra(1986), UPadhay (1992) and study on MMC done by clyne (2000) . Manocha and Bunsell (1980) stated that 12.1% materials out of total which are used in industries are composite

1.2 Composites

A Composite is heterogeneous material made up of two or more materials , one which is having greater percentage is called as Matrix , the additional material in low percentage which is mixed to enhance the properties of matrix . We can physically determine just by seeing because mixing is heterogeneous.

suchetclan (1972) stated that composite materials are made up of two or more solid phases whose composition can be seen clearly on a microscopic scale. Author noted that their composition gives us uniform properties on a much enhanced scale . Difference of properties which are not of individual material and the heterogeneous composition on macro scale makes them different from alloys. Ketty (1963) et.al stated that on a broader scale they do have different properties and can be distinguished easily.

1.2.1 Composites: Composites materials are widely used in every field of engineering like aerospace, super light materials due to their various enhanced properties which makes them different from conventional materials

- Increased machinability and weld ability
- Increased electric and thermal conductivity
- Cheap
- Low thermal expansion
- High strength by weight ratio
- Increased damping characteristics
- Increased toughness and strength
- Increased impact strength, fatigue strength
- Good surface finish
- Light material
- Low coff. Of thermal expansion or contraction
- Good corrosion resistance
- Good electrical conductivity
- Good physical properties
- Good vibrational damping

Further study has been carried out to make composite materials more shock and vibration resistant to resist earthquake destruction. Composite materials are made specifically to be used as vibration Dampers to rectify the purpose.

1.2.2 Components of Composite

There are two main components of composite materials among two ,the one with greater percentage is known as Matrix and one with lower percentage is known as Reinforcement .

Both of them have different properties and made to fulfill the best properties and to eliminate the unfeasible ones.

1.2.3 Matrix

There are many reinforcements which exhibits various properties but only when they are composed with a suitable matrix, matrix plays a vital role as they exhibit good strength, matrix creates an interface between subsequent reinforcement fibers so that they should not have wear or abrasion against each other. A virtuous matrix must possess various properties like good mouldability, good stress distribution.

Table1: Strength of Matrix used in Composite (ASM Handbook)

Fiber	Matrix	Percentage(%)	Density	Strength (Gpa)	Modulus (Gpa)
Carbon	Al6061	4.2	2.44	320	556
Boron	Al6061	4.7	2.93	250	258
SiC	Al6061	5.0	2.14	370	456
Alumina	Al6061	2.4	1.83	265	452
Borsic	Al6061	4.1	3.11	178	654

Various types of matrix used to fabricate composite.

1. Metal matrix composite
2. Ceramic matrix composite
3. Polymer matrix composite

1.2.4 Reinforcement Fiber

Type of Reinforcement enables one to control the mechanical properties of a composite. Mostly used reinforcement fibers are Silicon Carbide, Alumina; also they do have very good bond strength at high temperature.

However, various other type of reinforcement fiber used in MMCs is:

- Continuous fibers (Alumina , boron carbide , carbon, boron)
- Short fibers
- Whiskers
- Particles sized
- Discontinuous fibers

1.2.1 Bonding Interface

It may be defined as the intermediate layer which keeps a connection between matrix and reinforcement fiber. Role of interface is to keep reinforcement away from environmental disturbances and transfer the weight to the best strength reinforcement fiber. It reduces the pressure as it is a layer on which total load acts and distributed uniformly.

1.3 Types of Composite

There are many types of composite, on the basis of type of matrix;

1.3.1 Polymer matrix composite

A polymer is a long chained chains of hydrocarbons mostly which are joined by covalent bond , they are also called as reinforcement polymer fibers , there are propagating chain type materials which have high elastic modulus, which makes it very useful for various used like, electric industries, mechanical parts etc. There are many types of polymer fibers like Teflon, nylon, thermosetting, thermoplastic, poly vinyl.

1.3.2 Ceramic matrix composite

Ceramics are special types of fibers which are used especially to withstand under very large temperatures. They are reinforced with small fibers because they don't have that bonding strength.

1.3.3 Metal matrix composite

They are the most widely used composites which have very high strength, toughness, elastic modulus. They do have very good mouldability, machinability; can be transformed easily into any form. Mostly used MMC is Aluminum which is also widely used with various additives in it. They are very light and have very less relative density and widely used in every field of engineering like Military, aerospace, mechanical parts.

1.4 Surface Roughness

Roughness may be defined as the flaws or disintegrity on the surface of an element. It exhibits various losses which occur during machining of a work piece and it provides resistance to movement.

1.4.1 Types of Roughness:

- **Ideal Roughness**

  Ideal roughness is something which has to be occurred at any circumstances because we can't eliminate the various factors on which roughness depends like if there is no chatter or disturbances. Mathematical formula of ideal roughness without inference of factors is:

  R max = f / (cot φ + cot β)

  Average Roughness is defined as:

  Ra = Rmax / 4

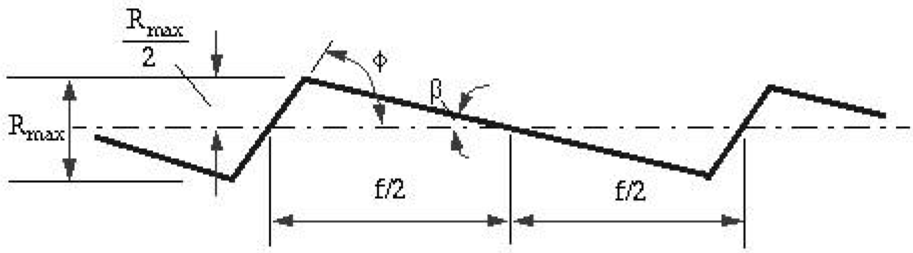


Fig 1: Surface Profile

f = Feed

Φ = Higher cutting angle

B = lower cutting angle

- **Normal Roughness**

  It is defined as the natural occurring roughness which is sustained after various factors like spatter, chatter, wear, cutting fluid, type of material, they mostly affect the surface roughness and to minimize this we provide various additives to the base material.

1.5 Cutting Parameters

There are numerous factors which effect the performance of a machine and the required properties like good surface finish etc., cutting parameters like Speed (s), Depth of cut (doc), feed (f). We need to optimize various parameters to get the desired set of properties and its functions.

1.5.1 Cutting Speed

It may be defined as the movement of tool in one minute (mm/min) ,Hence it defines the power which is required to perform the operation. It should be optimized to get good surface properties.

It is calculated by

Vc= πDN/1000

Where: V_c = Cutting Speed (m/min), D = Dia, N = Rpm

1.5.2 Feed Rate

It may be defined as the radial movement of tool while work piece got one revolution .If a material is very hard it should be given with less feed because there may have chances of chatter and vibrations may cause it is in the range of 1.1mm/revolution, For soft materials if kept large because less vibrations may produce of order 1.1mm/rev.

1.5.3 Depth of Cut

While turning a cylindrical work piece , it is used to give an initial cut into the work piece to reduce its diameter and it should be optimum to obtain a good surface finish, for normal work its value is 1-5mm and for finishing operation it is keep less than 1mm.

1.6 Effect of machining parameters on Surface Roughness

There are several experiments done on various tool materials to specify the effect of cutting parameters , As we know that if we increase the cutting speed the value of surface roughness decreases also by decreasing feed rate the same happens . The depth of cut should be minimum to minimize the vibrations, improving the surface finish. So our aim is to find such a value of cutting parameters which gives us best surface finish, the optimum value is traced by performing experiment under various conditions.

It also depends on the type of material we are working on , like while machining ductile material the types of chips also decides the value of roughness , continuous chips are very large chained and to be broken by using chip breakers , in case of brittle materials chips are very small sized and can be removed easily manually.

1.7 Stir Casting

It is an extension of Friction stir processing, This is a very fine process to make composites with a very good mechanical properties, in FSC we use a mechanical stirrer and in our lab its ultrasonic one, It vibrates with a very high frequency and we easily get mixing up to nanoparticle and the strength of composite is very large as compared to other processes .It is very economical process with a very wide use all over every field of science. The mechanical properties of MMC depend on various factors like solidification rate, mixing ratio etc. It is a two-step mixing process. There are two interface one is liquodous and another is solidus which determine interface bonding.

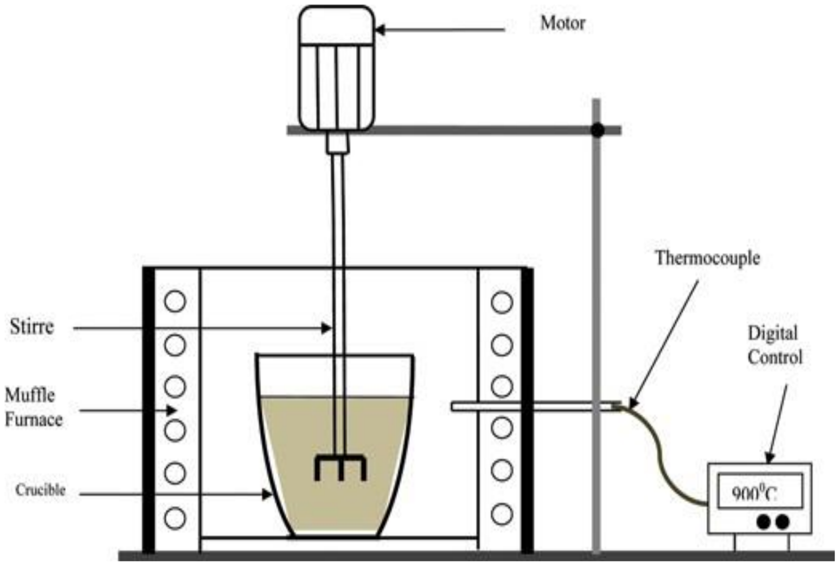


Fig2: stir casting apparatus with mechanical stirrer

1.8 Regression Analysis

Regression analysis is a very good method to predict the relationship between dependent variables and output variable (independent). It is a prediction tool helps to determine the output data. Mainly there are two types of variables

- Dependent Variable: This is variables which are known to us, we can understand them easily.
- Independent variable: these variables are hard to understand and need to be predicted and evaluated

We use various operations to find the relationship between i/p and o/p. In this Research work we are using multiple linear regressions.

There are many types of regression techniques:

- Linear regresion
- Simple regresion
- Polynomial regresion
- linear model
- Discrete
- Binomial regression
- Logistic regresion

  Binary regression
- Multiple regression

This make a scatter plot by plotting values of different variables and independent variables and a Fit line is drawn which covers all the values occurring throughout experiment and variables which affect the process of turning.

1.8.1 Taguchi method

Taguchi method is a very useful tool to determine the good and optimum design at a very low cost. It involves DOE (design of experiment) which is used to determine the factors, degree of freedom, factor and their levels. Taguchi can be used to determine the relationship between S, F, and DOC when an ALMMC is turned on conventional lathe and L_{29} array is used. It involves System design, parametric design, and tolerance design.

1.8.2 Design of experiment

Design of experiments is a dominant analysis tool for modeling the impact of process variables on dependent variable which is an unknown of these variables. The DOE is considered as one of the most extensive approach in product/process developments. It is a statistical approach that efforts to provide a analytical knowledge of a compound, multi-variable process with few number of trials.

1.8.3 ANOVA

Since there are large number of variables observing the process, mathematical models can be made to indicate the process. Though, this models is to be proven using the important parameters which influences the process rather than containing all the limits. In order to have this, arithmetical analysis of the experimental results is to be processed using the ANOVA which is a mathematical procedure that allows the estimation of control variables to the calculated response.

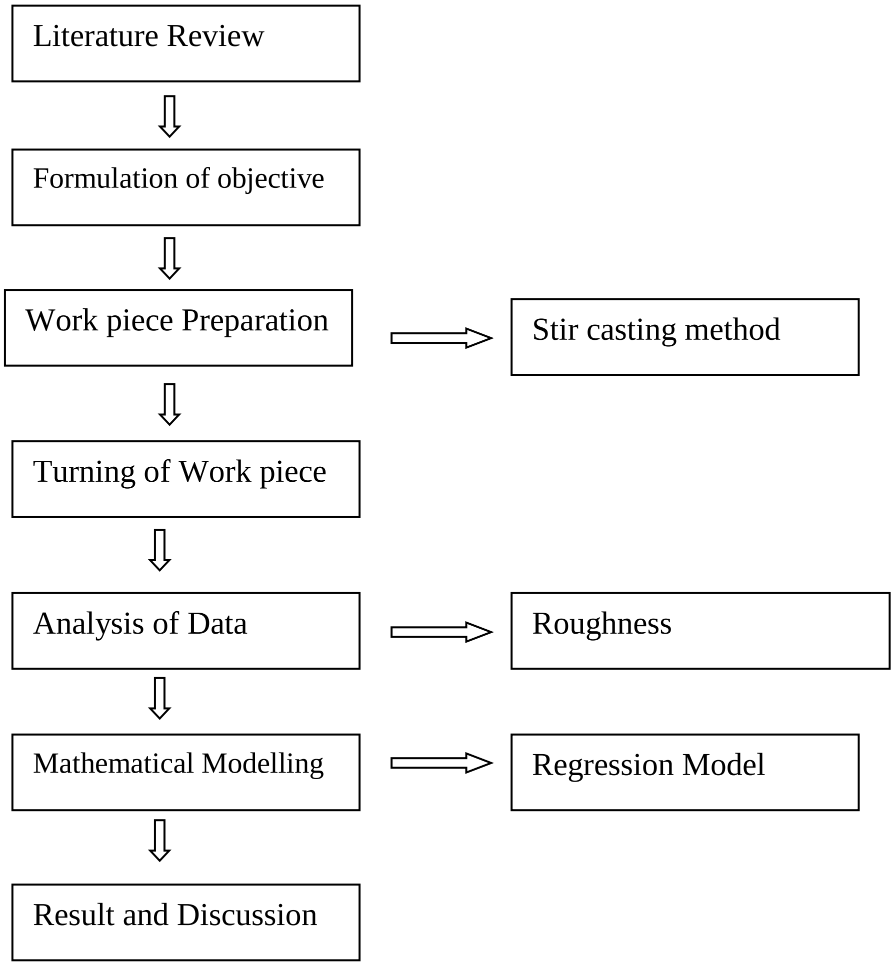
ANOVA can used to frame relationship between i/p and o/p variables using multiple experiments by DOE for machining and it can be used to understand experimental data. ANOVA is an association of stat., and events, in which we can calculate the square of standard deviation and it is means deviation from the average value, this shows the accuracy of the model.

1.9.1 Objective

The objective of this research work is to find out the optimum values of cutting parameters and to find a relationship between S.R. and Machining parameters (cutting speed, depth of cut, feed) of a metal matrix composite reinforced with Silicon Carbide (5%) fabricated by Friction stir casting with mechanical stirrer (ultrasonic)

In this investigation, the fabrication method used is friction stir casting because it is cheap and the chemical composition obtained is very fine at micro levels. We get a uniform mixing. Work piece is turned on lathe at different cutting parameters and easily roughness is calculated by using Taylor Hobson apparatus and mathematical modeling is done to predict the relationship. It may help manufacturing firms to get a brief idea about the quality of the work piece and the cost associated with it. This model will make an easy way to calculate roughness without performing experiments up to some tolerance levels up to some extent.

1.9.2 The overall project methodology is:



CHAPTER 2

LITERAURE SURVEY

2.1 INTRODUCTION

This chapter gives us brief idea about past work which has been carried out by researchers in the field of Composites and the different processes which has been carried out for its manufacturing. As material selection plays an important role in determining mechanical properties and applications. Approximately 23% of Material used in Industries is Composite or it's by parts, they are widely used in every field of research and engineering. While doing Literature Review we get an idea that most of industrial applications need High Strength, High Corrosion Resistance and Low strength/weight Ratio. The main purpose of using composite as a pro material is that they are manufactured cheaply, have very good wear properties and they do have very light weight.

2.2 LITERATURE REVIEW

This section comprises of review on Al-MMC, Manufacturing, Physical and wear properties, Machining of AMMC and optimisation of parameters, Future scope, Objective of present work associated with it as Composites are Well known for their enhanced properties and characteristics.

2.2.1 Use of Al-MMC

- **Warren et.al (2001),** mainly focuses on the use and various properties of Al mmc. These materials possess increased stiffness; wear resistance, fatigue strength, coff. Of thermal expansion, these properties mainly used in aerospace vehicles, automobile parts, industrial parts , integrated chips , thermal resistors.

- **Rosso et.al (2001),** tells about the use of ceramic composites for defence purposes , Aeronauticals and the process parameters like fatigue strength , wear resistance , weight density and coefficient of thermal expansion.

- **Shenqing et.al (2003),** tells us about the preparation of al-sic composite and friction stir casting and its use in manufacturing of pistons of IC engine. It is a good enhanced material, it has good acceptance rate and have good allowance . It is a new generation material used by China is mass manufacturing. It is industry 4.0 material.

- **Xinhe et.al (2004)**, fabricated a Al-sic composite prototype to study the Vibrations and dynamic stability of a satellite involving low to high frequency vibration tests and various physical properties like fatigue strength , impact strength , coff. of thermal expansion ,these tests concludes to enhanced performance of the material.

- **Vukcevic et.al (2005),** studied various factors which are responsible for change in mechanical properties of a Al-Mmc and also gives an idea about its fabrication , application in electronics , aircraft , automated vehicles , defence.

2.2.2 Fabrication of Composite and mechanical properties

- **Mares et.al (2005)**, Studied various mechanical properties of aluminium MMC, it is reinforced with graphite and silicon carbide having 10% by percentage volume. Method use for fabrication is vortex casting with a single phase reinforcement. At NTP various hardness and tensile tests are taken to measure the mechanical properties. This paper tells about variation of temperature, time and reinforcement and corresponding change in properties have been studied.

- **Ramchandra et.al (2005)**, fabricated an aluminium based mmc strengthened with SiC by volume percentage of 15-16% and graphite in a very low quantity by using friction stir casting. Author found a significant change in structural properties, grains are longitudinally distributed and reinforcement is uniformly distributed by using stir casting .thus found very useful results like with increase in silicon carbide leads to increase wear resistance, subsequently wear increases with increase in sliding velocity, hardness also increases with increase in Si-c particles.

- **Singh et.al (2009)**, studied the effect of Si-C as reinforcement by varying its weight percentage on Tensile strength ,fatigue strength , fabricated by using friction stir casting. Also surface metrology is studied to check failure criteria and effect of microstructure on crack propagation.

Shivnand et.al (2009), made a comparison of 2 methods of composite fabrication, took powder metallurgy and friction stir casting and compared their mechanical properties and concluded that Stir casting is best method to make composites.

Dovrzafisk et.al (2011), fabricated a Metal matrix composite with ceramic as reinforcement formed by infiltration method using ceramic powder, author investigated mechanical and wear properties. By using alumina , strength and hardness increases twice as compared to matrix.

Singla et.al (2011), developed an Al6061 Si-C reinforced composite with an aim of cost optimisation and homogeneous distribution of grains, to get this target author uses Stir casting method and a standard percentage of aluminium (98.4%) , Si-C has been chosen as matrix and reinforcement respectively . Six samples are taken into account with different Si-C percentage (5% ,10% ,15%,20%,25%,30%) keeping others constant .With increase in Si-c Percentage Hardness and impact strength increases upto a limit. Best results were obtained at 25% weight percentage of reinforcement as impact strength, Hardness increases.

kumar et.al (2013), investigated the mechanical properties of RHA reinforced aluminium alloy Al6064 , processed by Stir casting method . author used multiple w/ps of fly ash particle having size 4-45, 45-50,75-100 , studied various properties like tensile strangth , compresive strength, hardnes of Composite. Unreinforced Al6061 was also tested. Mechanical properties like tensile strength, compressive strength decreasing as we increase particle size , Mechanical properties increases by increasing weight density of particles.

mandal et.al (2013), studied the wear behaviour of Al6061 with 10% SiC used for rolling purpose, Design of experiment has been carried out to measure the change in stress, speed on wear. A prediction model is made Using Regression analysis to predict the results. The wear is less for hardened steel and moreover rolling speed influences the wear phenomenon is the Aluminium and SiC composite.

Singh and Garg (2015), The presentation of Ti-c tool was described using response surface methodology (RSM) while we turn AISI 1046 steel is done. Cutting tests was performed by taking constant DOC and a under dry cutting conditions. The factors inspected were cutting speed, feed and the side cuting angle (SCEA) of the cutting edge. The cuting force, i.e. the tangential force and surface roughness were the response variables investigated

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Yucel et.al (2016*)* deals with study and development of a SR prediction model for turning of MS, by using a method Response Surface Methodology (RSM). The experimentation was carried out with TiN tungsten carbide cutting tools, for machning mild steel work-piecs covering a wide range of machining conditions. A 2nd order mathematical model, in terms of machining parameters, was developed for surface roughness predction using RSM. This model gives the factor effects of the individual process parameters. An attempt has also been made to optimize the surface roughness predictiion modal using Genetic Algorithms (GA) to optimise the objective function. Surface quality can be greatly controlled using Genetic Algorithms.

Aouici et al. *(*2017*)*,stated that an network is adopted to iconstruct a prediction imodel for surface roughness iand force. This network comprises of ia numberi of functional nodes, i which are self-configureid to form an optimal networki hierrarchy by using a predicted error (PE) critertion. Once the procesis parametersi (speed, feed raite and depith of cut) are given, the surface roughness and cutting force can be predicited by this netwerk. To veriify the accuracy of ithe abductive networki, regression ianalysis.

Antonies et.al(2017), has been adopted to developed a prediction model for surface roughness and force. Relationship of the two models indicates that the predicti on model established by the network is more valueable by using regression analysis. Critical elements that affect SR are the feed, where increasing feed rate will increase the SR value, while a multiplied for the surface roughness demonstrates that the cutting speed does have a significant influence on roughness is very large.

Singh and Rao et al.(2017), developed a model based on artificial neural network which predicts surface roughness. Fuzzy logic system is made to train the data set and to create a relationship between variables, independent, dependent ones. He concludes that accuracy can be increased by increasing the number of training data and reducing the range and standard deviation of the configured values.

Bagci and Isik et al.(2017) focuses on study of various models to predict the acceptable surface roughness . Therefore it determines the reliability of experimental values. According to the presence in the model and agreeing to the analysis results, the speed is the most influential variable for the mrthod. A higher cutting speed results in a smother surface calculated.

Abdullah A. et al.(2017) recognized the need to optimize the cutting parameters (speed, depth of cut, feed) aluminum6061 is used to study the effect of cutting parameters on roughness. L-9 orthogonal array, ANOVA has been used to study the characteristics, and Taguchi method experiment design has used to optimize the cutting parameters. roughness and MRR are found to be maximum at 11.6%and 14%; and minimum at 4.3% and 3.8% respectively. Cutting parameters viz. cutting speed, feed rate and doc are found to be affecting the machining process at 47%, 32% and 15% respectively for minimum surface finish of 0.265 microns with an error percentage of 5.4% which is minimum.

2.3 CONCLUSION

Various observations are concluded by studying various research papers are as follows:

- By adding Silicon carbide as reinforcement, mechanical properties of ALMMC increases in a suitable manner
- By adding 5-8% Silicon carbide Strength increases and surface roughness decreases, better surface finish.
- Multiple linear regression is very suitable tool to calculate the surface roughness having a high accuracy.
- Cutting speed having most important influence on the surface roughness, it decreaes with increase in cuting speed.
- Surface roughness increases with increase in feed and depth of cut.

. CHAPTER 3

EXPERIMENTAL SETUP

In Chapter3 we will discuss about the Experimental Setup and the machine tool we have used throughout the thesis work.

3.1 CONVENTIONAL LATHE

Lathe is one of the oldest and known as mother of all machines, it is very easy to understand and can be used to make cylindrical parts using a single point cutting tool. Lathe can perform various operations like Turning, taper turning, facing, drilling, planning, drilling etc. In lathe Tool is kept stationary and work piece is rotated and it is derived using a motor with variable speed outputs.

Fig4: Lathe machine

Lathe have two important parts that is Tail stock and headstock, headstock contains 3 jaw chuck which is used to hold the work piece and it is rotated by the motor. Tailstock holds tools to perform cutting action ,we can hold drill, boring drill, single point cutting tool to perform feasible operation. Cutting can be done according to the axial or radial feed, axis of rotation is fixed.

Table2: 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
General	

size (Length x Breadth x Height)	2015x1925x1480
Weight	3600kg
Floor Space required	5.0m^2
Power Supply	
Voltage	AC, 435 ±10% V, 400
Frequency	51 ± 1 Hz
Power	23.2kVA
Accuracy	
Positioning of slides - X Axis	0.0051mm
Positioning of slides - Z Axis	0.010mm
Repeatability : X-Axis / A Axis	± 0.003 / ±0.004mm

3.1.1 Working principle

Working of lathe is very simple as it has a chuck where we hold work piece and it is rotated with a given speed, there is a tool post where we can hold the tool, and it is kept stationary and tool is fed to work piece with a given feed rate and depth of cut, cutting tool is fed radially or longitudinally to the workpiece, it depends on type of operation.

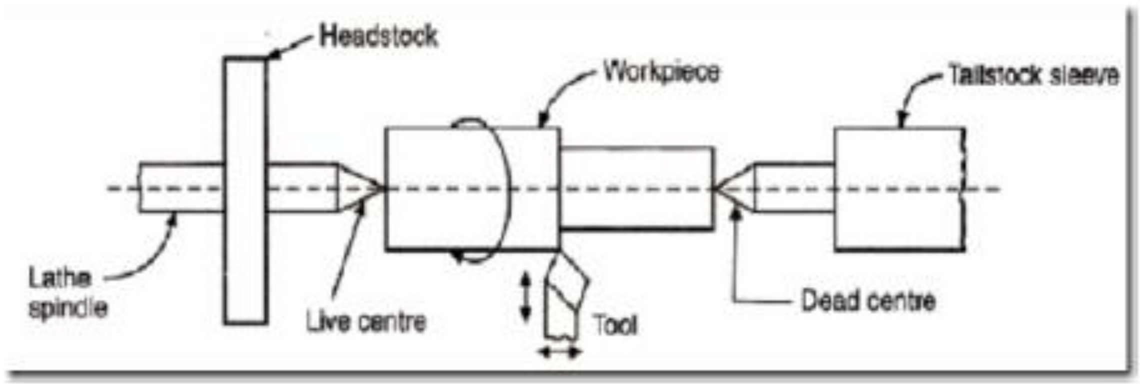

Fig5: Schematic diagram of lathe

3.1.2 Components

The main components of lathe are headstock, tailstock, Bed, carriage, tool post, gear box

1 **Lathe bed:** It is the foundation of the lathe machine and whole machine parts are being rest on it. It is made up of Grey cast iron, as it has very good damping characteristics; it absorbs vibrations and rested on the ground and act as a vibration damper.

2 **Legs:** whole weight of machine is rested on them and they are founded to ground by mean of nuts and bolts.

3 **Headstock:** it contains spindle, chuck, gear mechanism and various drive and pulley mechanisms.

4 **Gear box :** it contains various mechanisms and gear ratios to change the speed of spindle accordingly and it gives us various speed ratios.

5 **Carriage:** it is a machine part using which we can feed the tool, control the transverse movement of work piece, it is used to locate the tool post, guide, and feeding is done using carriage.

6 **Tailstock:** tailstock is a movable component of lathe machine, which can be slide over the bed. It contains tool post and it is directly opposite to the headstock. We can slide the tailstock and work upon the various lengths of work piece.

3.2 STIR CASTING

stir casting is a very précised method to fabricate aluminium composites, It has a ultrasonic stirrer which vibrates with a very high frequency and gives mixing up to Nano level.
Al6061 is taken as matrix and Si-C is taken as reinforcement, the weight fraction is 5%. The workpiece of dimension diameter (30mm), Length (100mm) is fabricated.

Figure 7: Al6061+SiC composite

Table 3: Composition of Al6061

Elements	Si	Fe	Cu	Mn	Ni	Pb	Zn	Ti	Mg	Cr	Al
% by weight	0.43	0.7	0.24	0.139	0.05	0.24	0.25	0.15	0.802	0.25	Balance

It is an extension of Friction stir processing, This is a very fine process to make composites with a very good mechanical properties, in FSC we use a mechanical stirrer and in our lab its ultrasonic one, It vibrates with a very high frequency and we easily get mixing up to nanoparticle and the strength of composite is very large as compared to other processe

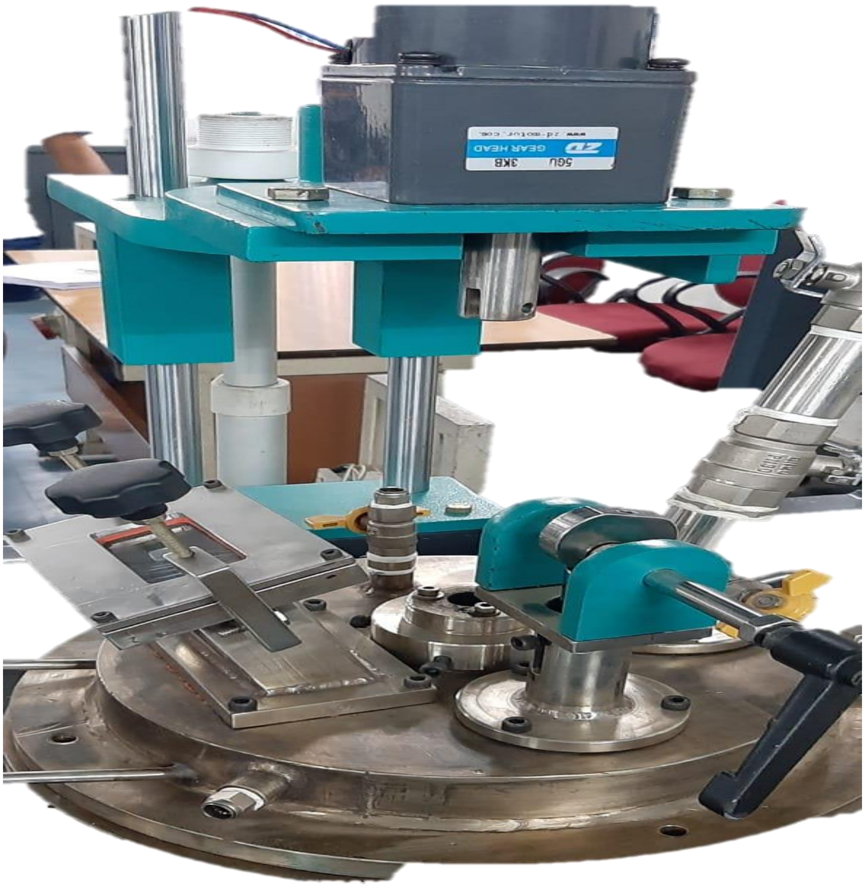

Figure 8: Stir Casting with Ultrasonic Stirrer

Table4: Specifications of stir casting

Model Name	Stir casting 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

Ultrasonic stirrer is a mechanical stirrer which helps to gradual mixing of MMC and reinforcement particles upto nanoparticle levels. It has a star, stop button and a led which is used to turn it off or on.

Figure 9: Ultrasonic stirrer

Controlling system comprises of various functions:

- Power system
- Temp. controller
- Ultrasonic power supply

- Emergency switch

Figure 10: Controlling System

3.3 surface Roughness (Taylor hobson)

The Subtonic 3+ is a movable, self-contained for the measurement of surface texture and is appropriate for use in both the workshop and laboratory. Parameters accessible for surface texture evaluation are: Ra, Rq, Rz (DIN), Ry and Sm.

The parameters evaluations and other functions of the instrument are microprocessor based. The measurement results are displaced on an LCD screen and can be output to a voluntary printer or another computer for further results.

The instrument is normally powered by an alkaline non-rechargeable battery. If preferred, a Nickel cadmium rechargeable battery can be used and its life varies according to the use. This testing machine gives us a variable output with a great functionality and accuracy. We can plot the graph of roughness

Figure 11: Surface roughness measuring Instrument

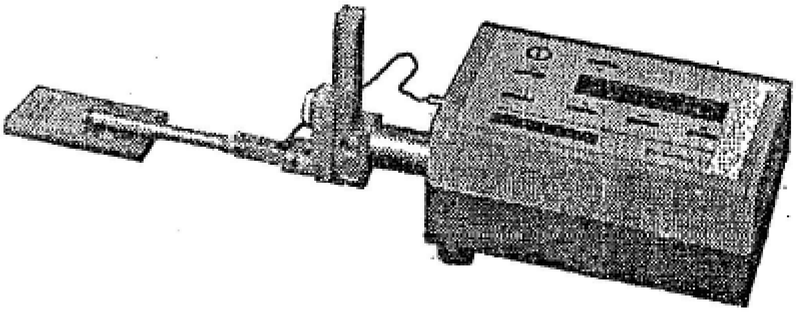

Figure 12: Schematic Diagram (Instrument Manual)

This machine helps us to plot the graph of roughness and to calculate the value of Ra. It has a stylus with variable output which transduces the analogue signal to a very useful output. It has a DIP switch, Connector, pick up holder which have a unique functionality and use **.** The resolution of this machine is very high, with an output rate in order of 3-4 seconds. Which is considered to be very fast **.** the accuracy and precision of this machine is very high and it uses multi dimentional apprach to classify the type of roughness they are deaing with while performing experiment.

Specifications:

Table 5: Specification of subtronic 3+

Battery	Alkaline: Minimum 700 Measurements of 3mm Measurements Lengths. Ni-Cad: Minimum 340 Measurement of 5mm Length Size: 7 LR 61 (Japan), Fixed Battery External Charger (Ni Only) 110/240V, 50Hz
Traverse Unit	Speed: 1mm/Sec
Measurement	Metric Preset by DIP-Switch
Cut-Off Values	0.26 mm, 0.88mm, and 2.70mm
Traverse Length	1, 3, 6, 10, Or 25.1 + 0.1mm At 0.9mm Cut-Off.
Display units	LCD-Matrix. 2lines * 16 Characters
Keyboard	Membrane Switch Panel

3.6 Measurement of Surface Roughness

Inspection and calculation of SR of machined work pieces can be carried out by means of different measurement techniques. These methods can be ranked into the following classes:

- Direct measurement methods
- Comparison based techniques
- Non-contact methods

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

where
R_a = the arithmetic average deviation from the mean line
L= the sampling length
Y= the ordinate of the profile curve

.

Fig13: Mean roughness

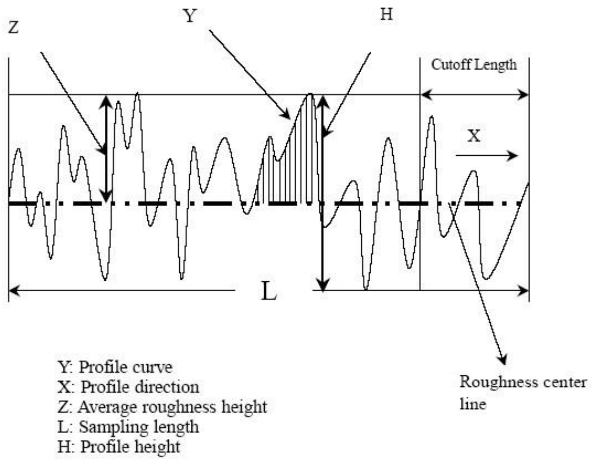

Fig14: Measurement of roughness by Stylus

CHAPTER 4

DATA COLLECTION

This study focuses on optimizing surface roughness by using taguchi method subsequently, 27 readings are taken into consideration to make a regression model, and ANOVA is done which helps us to predict the Roughness without doing any experimental work. Work piece of dimensions Dia =30mm, length = 100mm is fabricated by using Stir casting and turned on conventional lathe at various levels of speed, doc, feed and value of roughness is measured over these 27 readings.

By performing experiments on lathe, values of roughness corresponding to machining parameters are:

4.1 Factors and their levels

By studying different research papers, values of factors and their levels are taken into account as they depend on tool, material type, cutting parameters, mentioned below is cutting parameters and their levels.

Table 6: Factors and their levels

Symbol	Cutting parameters	Units	Level1	Level2	Level3
A	Speed	m/min	27.23	60.21	94.24
B	Depth of cut	mm	0.1	.2	.3
C	Feed	mm/rev	0.04	0.12	.20

Three levels of speed(27.23m/min,60.21m/min,94.24m/min),feed(.04mm,.12mm,.20mm), depth of cut(.1mm,.2mm,.3mm) are taken.

4.2 SURFACE ROUGHNESS VALUES

TABLE 7: SURFACE ROUGHNESS VALUES

S.N	DIAMETER	RPM	SPEED (m/min)	FEED(mm/rev)	DEPTH OF CUT(mm)	R_A (mm)
1	*30*	289	27.23	0.04	.1	1.49
2	*30*	289	27.23	0.04	.2	1.83
3	*30*	289	27.23	0.04	.3	1.98
4	*30*	289	27.23	0.12	.1	2.41
5	*30*	289	27.23	0.12	.2	2.52
6	*30*	289	27.23	0.12	.3	2.59
7	30	289	27.23	0.2	.1	2.58
8	30	289	27.23	0.2	.2	2.78
9	30	289	27.23	0.2	.3	2.83
10	30	639	60.21	0.04	.1	1.62
11	30	639	60.21	0.04	.2	1.70
12	30	639	60.21	0.04	.3	1.79
13	30	639	60.21	0.12	.1	1.42
14	30	639	60.21	0.12	.2	1.67
15	30	639	60.21	0.12	.3	1.73
16	30	639	60.21	0.2	.1	1.35
17	30	639	60.21	0.2	.2	1.43
18	30	639	60.21	0.2	.3.	1.86
19	30	1000	94.24	.04	.1	1.34
20	30	1000	94.24	.04	.2	1.65
21	30	1000	94.24	.04	.3	1.93
22	30	1000	94.24	.12	.1	1.02
23	30	1000	94.24	.12	.2	1.23
24	30	1000	94.24	.12	.3	1.32
25	30	1000	94.24	0.2	.1	1.01
26	30	1000	94.24	0.2	.2	1.17
27	30	1000	94.24	0.2	.3	1.23

CHAPTER 5

ANALYSIS OF DATA

5.1 Graphical Presentation of Roughness at given speed, depth of cut, feed

1. Roughness profile for, Speed=27.23m/min, Depth of cut=.1 mm , feed =.04 mm/rev

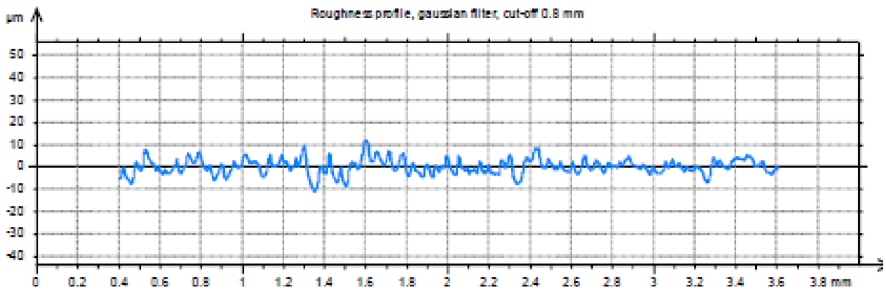

Figure 15.01: R$_a$ =1.49mm profile of AL6061+SiC composite

This is the roughness profile obtained while work piece is measured on subtronic 3+ , this graph is plotted at minimum levels of machining parameters, it shows peaks and valleys on both side of mean line and Avg. peak to valley height =1.49 mm

Max peak to valley height = 11 µm

Min peak to valley height = -10 µm

2. Roughness profile for, Speed=27.23m/min, Depth of cut=.2 mm , feed =.04 mm/rev

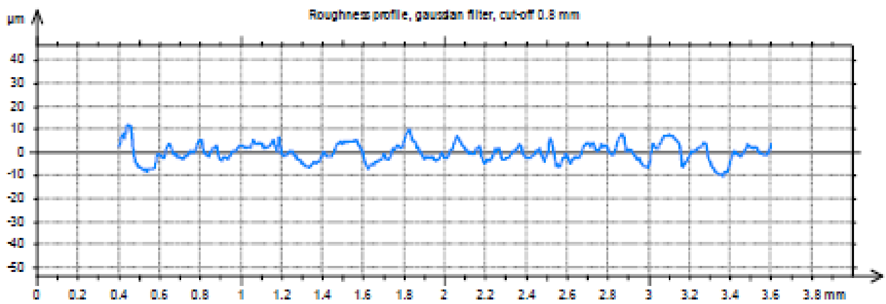

Figure 15.02: R$_a$ =1.82mm profile of AL6061+SiC composite

This graph shows, by keeping speed ,feed constant and increasing depth of cut the value of roughness increase and average peak to valley height =1.82mm

Max peak to valley height = 12 µm

Min peak to valley height = -10 µm

3. Roughness profile for, Speed=27.23m/min ,Depth of cut=.3 mm , feed =.04 mm/rev

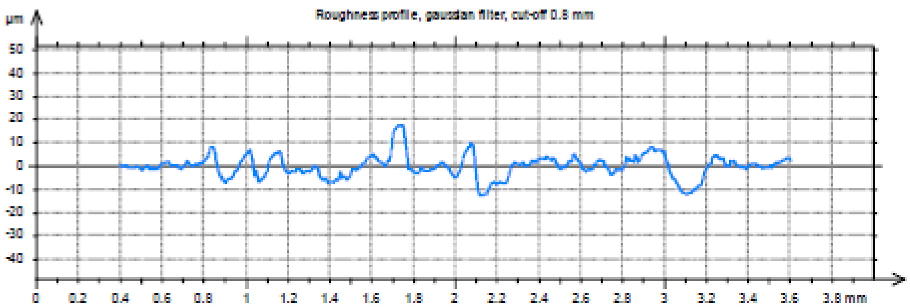

Figure 15.03: $\mathbf{R_a}$ =1.98mm profile of AL6061+SiC composite

This graph shows that by further increasing doc to level3, the roughness value increases and average peak to valley height =1.98mm

Max peak to valley height = 11 µm

Min peak to valley height = -10 µm

4. Roughness profile for, Speed=27.23m/min ,Depth of cut=.1 mm , feed =.12 mm/rev

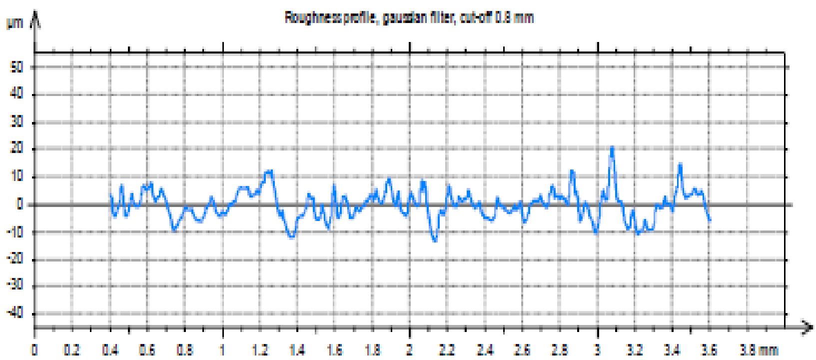

Figure 15.04: $\mathbf{R_a}$ =2.41mm profile of AL6061+SiC composite

This graph shows, by keeping speed ,feed constant and increasing depth of cut the value of roughness increase and average peak to valley height =1.82mm and average peak to valley height =2.41

Max peak to valley height = 20 µm

Min peak to valley height = -11 µm

5. Roughness profile for, Speed=27.23m/min ,Depth of cut=.2 mm , feed =.12 mm/rev

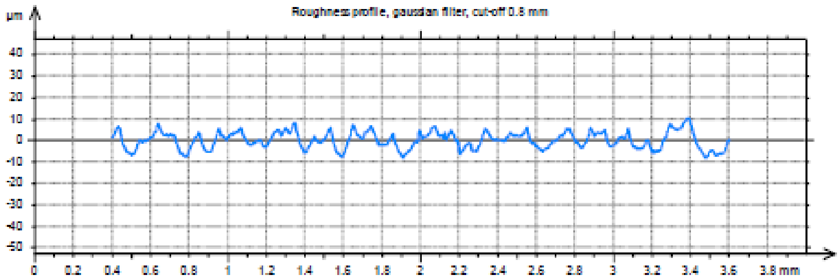

Figure 15.05: R_a =2.52mm profile of AL6061+SiC composite

This graph shows, by keeping speed ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.82mm and average peak to valley height =2.52mm

Max peak to valley height = 10 µm

Min peak to valley height = -9 µm

6. Roughness profile for, Speed=27.23m/min ,Depth of cut=.3mm , feed =.12 mm/rev

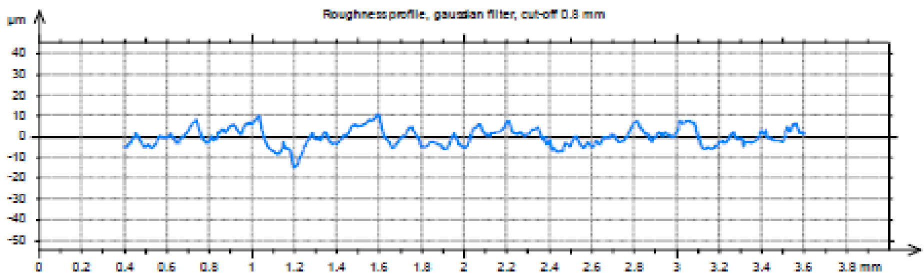

Figure 15.06: R_a =2.59mm profile of AL6061+SiC composite

This graph shows, by keeping speed ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.82mm and average peak to valley height =2.17

Max peak to valley height = 11 µm

Min peak to valley height = -13 µm

7. Roughness profile for, Speed=27.23m/min ,Depth of cut=.1 mm , feed =.2 mm/rev

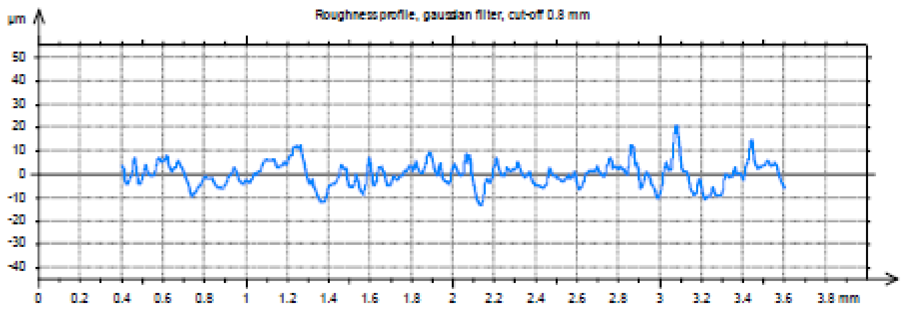

Figure 15.07: R_a =2.58mm profile of AL6061+SiC composite

This graph shows, by keeping speed ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.82mm and average peak to valley height =2.58mm

Max peak to valley height = 20 µm

Min peak to valley height = -12 µm

8. Roughness profile for, Speed=27.23m/min ,Depth of cut=.2 mm , feed =.2 mm/rev

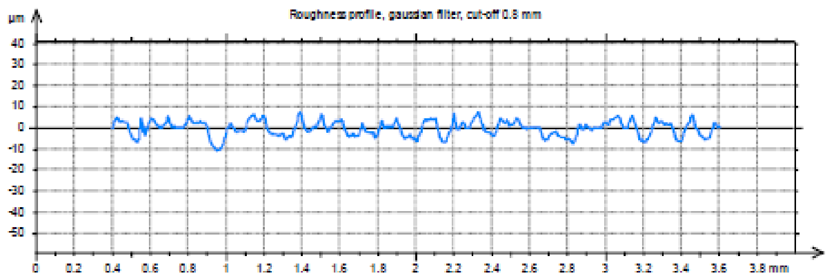

Figure 15.08: R_a =2.78mm profile of AL6061+SiC composite

This graph shows, by keeping speed ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.82mm and average peak to valley height = 2.78mm

Max peak to valley height = 8 µm

Min peak to valley height = -10 µm

9. Roughness profile for, Speed=27.23m/min ,Depth of cut=.3 mm , feed =.2 mm/rev

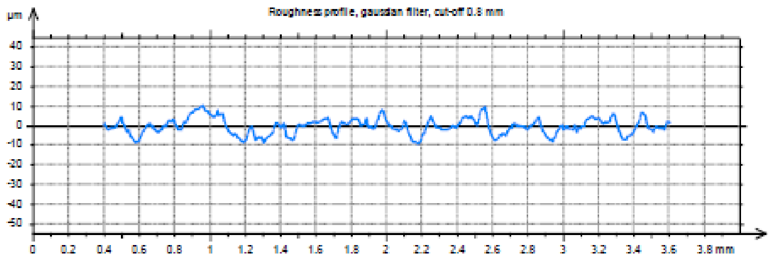

Figure 15.09: Rₐ =3.23mm profile of AL6061+SiC composite

This graph shows, by keeping speed ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.82mm and average peak to valley height =3.23mm

Max peak to valley height = 10 µm

Min peak to valley height = -10 µm

10. Roughness profile for, Speed=60.21m/min ,Depth of cut=0.1 mm , feed =.04 mm/rev

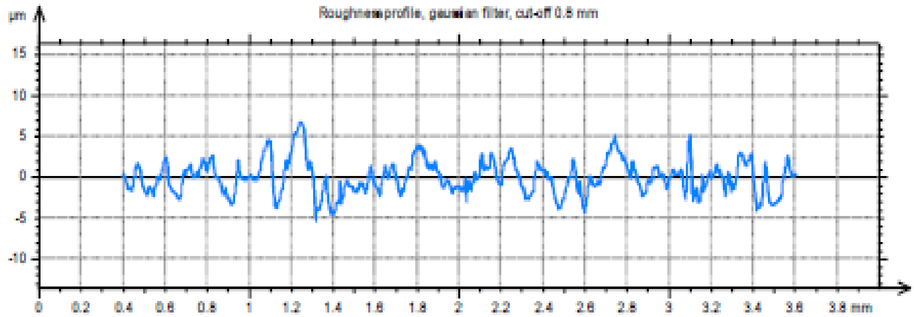

Figure 15.10: Rₐ =1.62mm profile of AL6061+SiC composite

This graph shows, by keeping speed =60.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.62mm

Max peak to valley height = 6 µm

Min peak to valley height = -5 µm

11 Roughness profile for, Speed=60.21m/min ,Depth of cut=.1 mm , feed =.04mm

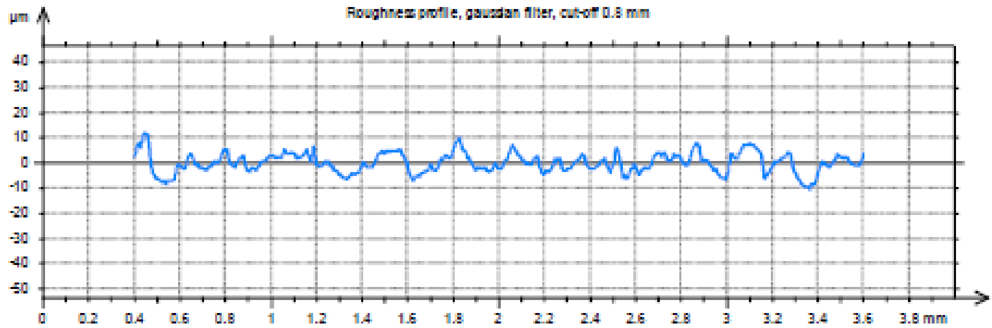

Figure 15.11: R_a =1.7mm profile of AL6061+SiC composite

This graph shows, by keeping speed =60.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.7mm

Max peak to valley height = 11 µm

Min peak to valley height = -10 µm

12 Roughness profile for, Speed=60.21m/min ,Depth of cut=.1 mm , feed =.12 mm

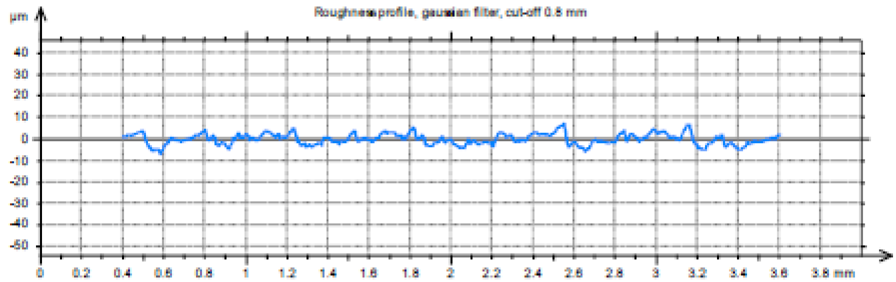

Figure 15.13: R_a =1.72mm profile of AL6061+SiC composite

This graph shows, by keeping speed =60.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.72mm

Max peak to valley height = 6 µm

Min peak to valley height = -7 µm

13 Roughness profile for, Speed=60.21m/min ,Depth of cut=1.0 mm , feed =.2 mm

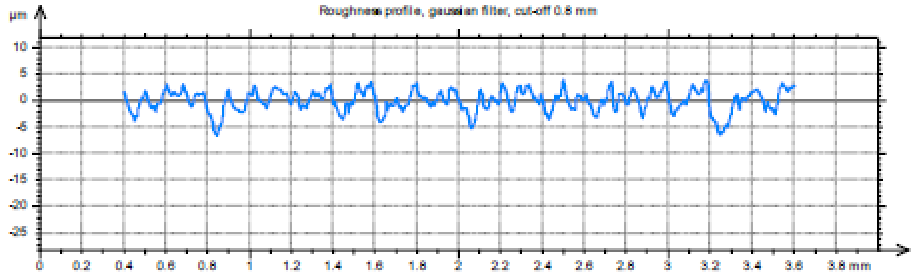

Figure 15.14: R_a =1.67mm profile of AL6061+SiC composite

This graph shows, by keeping speed =60.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.67mm

Max peak to valley height = 7 µm

Min peak to valley height = -12 µm

14 Roughness profile for, Speed=60.21m/min ,Depth of cut=1.1 mm , feed =.04 mm

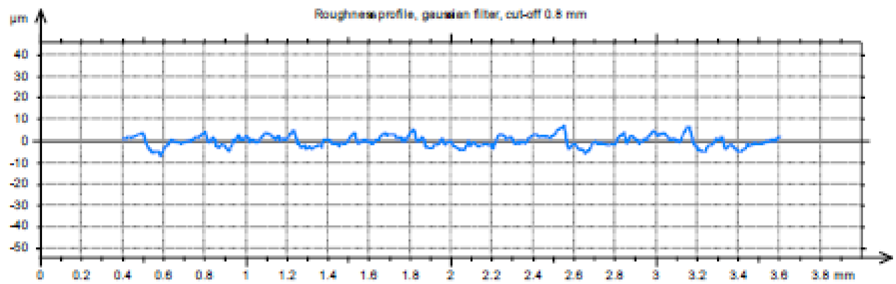

Figure 15.15: R_a =1.67mm profile of AL6061+SiC composite

This graph shows, by keeping speed =60.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.67mm

Max peak to valley height = 8 µm

Min peak to valley height = -5 µm

15 Roughness profile for, Speed=60.21m/min ,Depth of cut=1.0 mm , feed =.12 mm

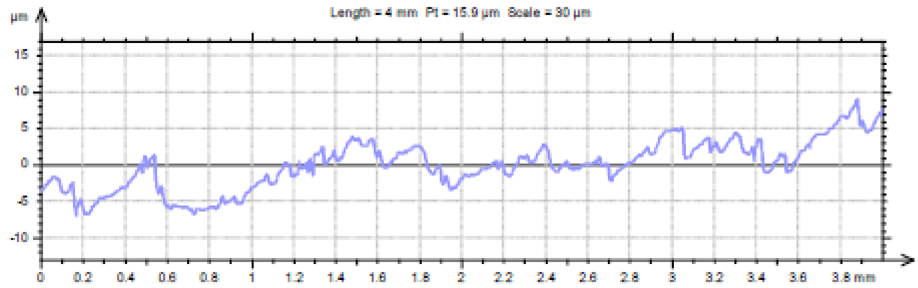

Figure 15.16: R_a =1.83mm profile of AL6061+SiC composite

This graph shows, by keeping speed =60.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.83mm

Max peak to valley height = 8 µm

Min peak to valley height = -6 µm

16 Roughness profile for, Speed=60.21m/min ,Depth of cut=.12mm , feed =.2 mm

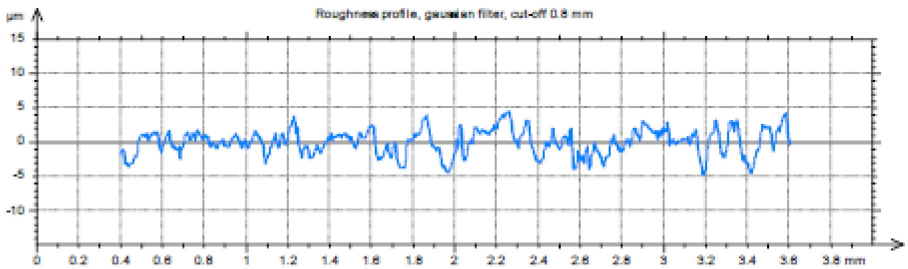

Figure 15.17: R_a =1.43mm profile of AL6061+SiC composite

This graph shows, by keeping speed =60.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.43mm

Max peak to valley height = 4 µm

Min peak to valley height = -5 µm

17 Roughness profile for, Speed=60.21m/min ,Depth of cut=.2 mm , feed =.04 mm

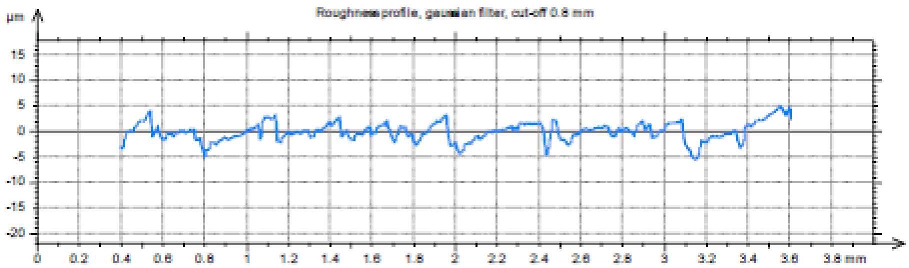

Figure 15.18: Ra =1.85mm profile of AL6061+SiC composite

This graph shows, by keeping speed =60.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.85mm

Max peak to valley height = 5µm

Min peak to valley height = -6 µm

18 Roughness profile for, Speed=94.24m/min ,Depth of cut=.1 mm , feed =.12 mm

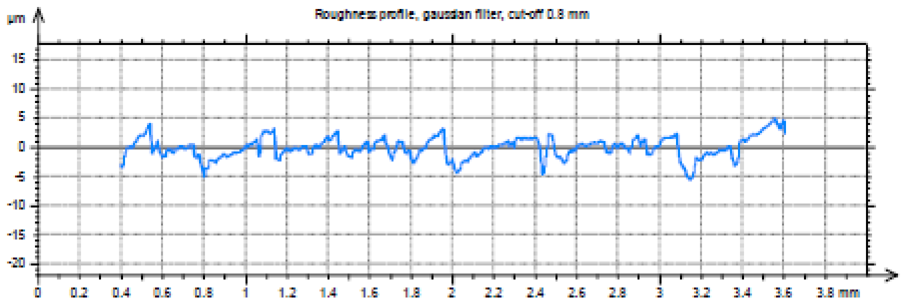

Figure 15.19: Ra =1.34mm profile of AL6061+SiC composite

This graph shows, by keeping speed =94.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.62mm

Max peak to valley height = 5 µm

Min peak to valley height = -6 µm

19 Roughness profile for, Speed=94.24m/min ,Depth of cut=.1 mm , feed =.2 m

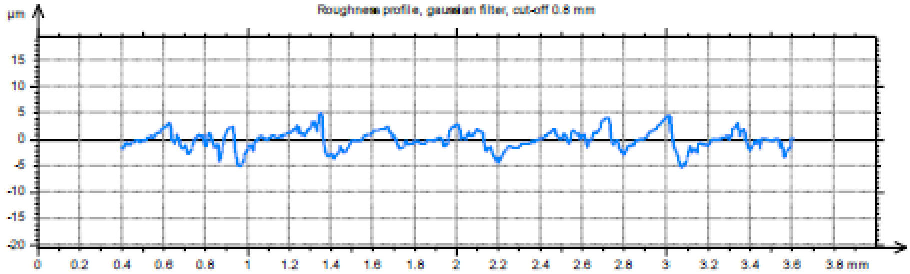

Figure 15.20: R_a =1.62mm profile of AL6061+SiC composite

This graph shows, by keeping speed =94.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.62mm

Max peak to valley height = 5 µm

Min peak to valley height = -5µm

20 Roughness profile for, Speed=94.24m/min ,Depth of cut=1.1 mm , feed =.04 mm

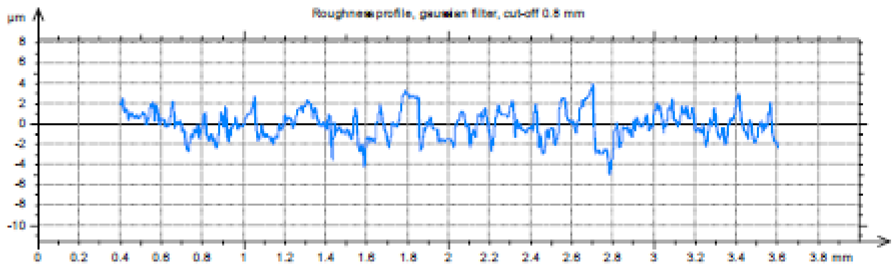

Figure 15.21: R_a =1.93mm profile of AL6061+SiC composite

This graph shows, by keeping speed =94.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.93mm

Max peak to valley height = 4 µm

Min peak to valley height = -5 µm

21 Roughness profile for, Speed=94.24m/min ,Depth of cut=.1mm , feed =.12 mm

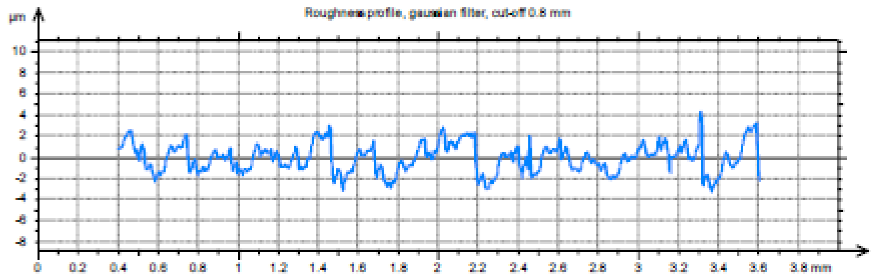

Figure 15.22: R$_a$ =1.23mm profile of AL6061+SiC composite

This graph shows, by keeping speed =94.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.23mm

Max peak to valley height = 4 µm

Min peak to valley height = -3 µm

22 Roughness profile for, Speed=94.24m/min ,Depth of cut=1.0 mm , feed =.2 mm

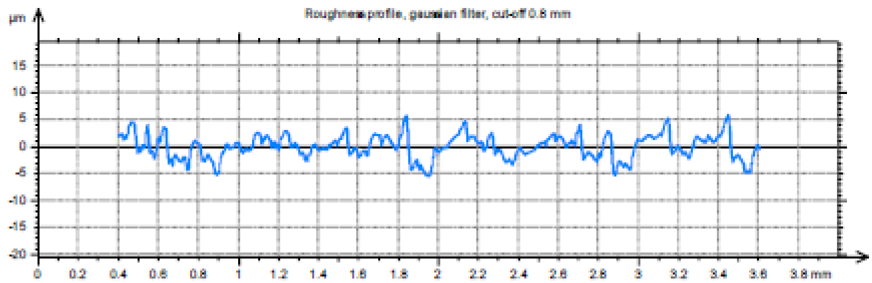

Figure 15.23: R$_a$ =1.23mm profile of AL6061+SiC composite

This graph shows, by keeping speed =94.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.29mm

Max peak to valley height = 5 µm

Min peak to valley height = -5 µm

23 Roughness profile for, Speed=94.24m/min ,Depth of cut=.3 mm , feed =.12 mm

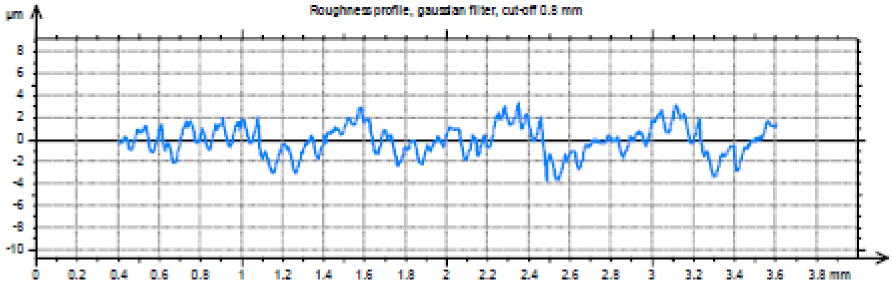

Figure 15.24: R_a =1.32mm profile of AL6061+SiC composite

This graph shows, by keeping speed =94.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.32mm

Max peak to valley height = 3 µm

Min peak to valley height = -4µm

25 Roughness profile for, Speed=94.24m/min ,Depth of cut=.1 mm , feed =.04 mm

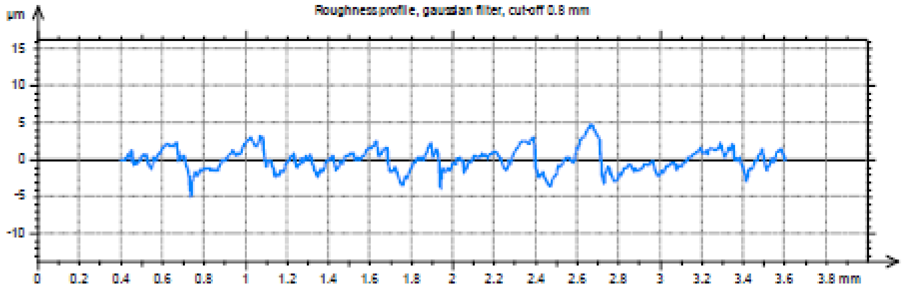

Figure 15.25: This graph shows, by keeping speed =94.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm

R_a =1.44mm profile of AL6061+SiC composite

Max peak to valley height = 5µm

Min peak to valley height = -5 µm

26 Roughness profile for, Speed=94.24m/min ,Depth of cut=.2 mm , feed =.12 mm

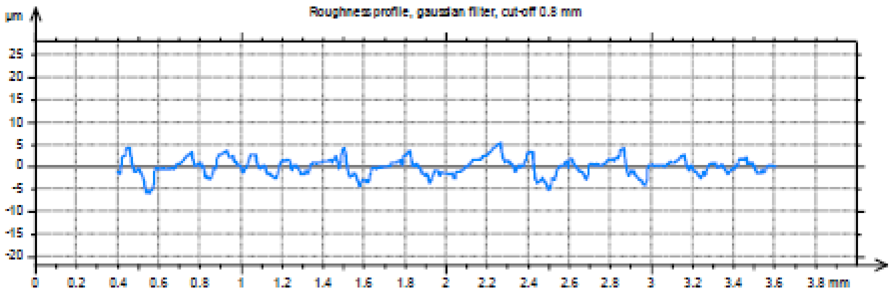

Figure 15.26: R_a =1.17mm profile of AL6061+SiC composite

This graph shows, by keeping speed =94.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.17mm

Max peak to valley height = 5 µm

Min peak to valley height = -5 µm

27 Roughness profile for, Speed=94.24m/min ,Depth of cut=.3 mm , feed =.2 mm

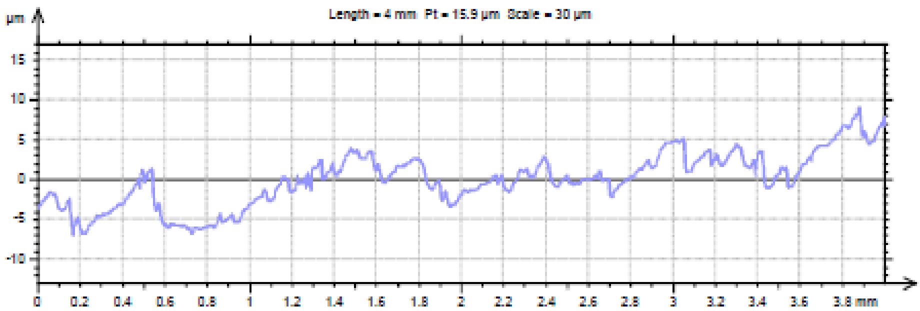

Figure 15.27: R_a =1.30mm profile of AL6061+SiC composite

This graph shows, by keeping speed =94.21m/min ,feed constant and increasing depth of cut the value of roughness increases and average peak to valley height =1.62mm and average peak to valley height =1.30mm

Max peak to valley height = 9 µm

Min peak to valley height = -6 µm

Average Roughness in micro-meters or micro-inches. Ra is the mean deviation of the profile This section explains the main parameters of ISO 4297:1997. Each parameter is classified according to primary profile (P), roughness profile (R), and waviness profile (W) in order to evaluate different aspects of the profile. (When the wavelengths of the waviness and primary profile components are compared, the surface roughness component is the asperity component of that which has the comparatively shorter wavelength.).all the above profile curve explain the different values of different parameter ,all above graph as cut off 0.4mm.with different values of Ra. Ra is by far the most commonly used Surface Finish parameter

5.2 Regression Analysis (Minitab 19)

Table 8: Standardization of data

S.N	**Log S**	**Log d**	**Log f**	**Log R_a**
1	3.30432	-2.3026	-3.21888	0.239017
2	3.30432	-1.6094	-3.21888	0.277632
3	3.30432	-1.2040	-3.21888	0.412110
4	3.30432	-2.3026	-1.60944	0.500775
5	3.30432	-1.6094	-1.60944	0.542324
6	3.30432	-1.2040	-1.60944	0.609766
7	3.30432	-2.3026	-2.12026	0.712950
8	3.30432	-1.6094	-2.12026	0.746688
9	3.30432	-1.2040	-2.12026	0.819780
10	4.09784	-2.3026	-3.21888	-0.139262
11	4.09784	-1.6094	-3.21888	-0.051293
12	4.09784	-1.2040	-3.21888	-0.020203
13	4.09784	-2.3026	-1.60944	0.113329
14	4.09784	-1.6094	-1.60944	0.215111
15	4.09784	-1.2040	-1.60944	0.254642
16	4.09784	-2.3026	-2.12026	0.292670
17	4.09784	-1.6094	-2.12026	0.357674
18	3.30432	-2.3026	-3.21888	0.488580

19	3.30432	-1.6094	-3.21888	-0.385662
20	3.30432	-1.2040	-3.21888	0.261365
21	3.30432	-2.3026	-1.60944	-0.198451
22	3.30432	-1.6094	-1.60944	-0.116534
23	3.30432	-1.2040	-1.60944	-0.030459
24	3.30432	-2.3026	-2.12026	0.104360
25	3.30432	-1.6094	-2.12026	0.139762
26	3.30432	-1.2040	-2.12026	0.148420
27	4.09784	-2.3026	-3.21888	0.207014

Standardization of data is done by taking natural log, excel is used to find all the log values and to be analyzed in Minitab 19

5.3 ANOVA

Table 9 Analysis of variance with different speed feed depth of cut

Analysis of Variance						
Source	D F	Adj SS	Adj MS	F-Value	P-Value	Contribution%
Speed	2	15.5547	7.7774	56.01	0.000	80.69
Feed	2	0.5735	0.2868	2.07	0.153	2.975
Depth of cut	2	0.3696	0.1848	1.33	0.287	1.917
Error	20	2.7774	0.1389			14.40
Total	26	19.2752				

SS-Sum of Squares, D.F. Degrees of freedom, M.S.- Mean Square, C- Contribution

This table illustrates the contribution of cutting parameters (speed, depth of cut, feed rate) on the dependent function i.e. Surface Roughnes

5.3.1 S/N ratio and mean value by Taguchi method

Taguchi suggests the use of the loss function to compute the performance characteristic from the expected value. The significance of the loss function is further altered into a signal-to-noise (S/N) ratio η; usually there are three types of the performance characteristic in the assessment of the S/N ratio, that is, the lower-the-better, the higher-the-better, and the nominal- the-better

Table 10 Experimental results for S/N ratio by Taguchi method

S.N	**DIA**	**RPM**	**SPEED (m/min)**	**FEED(mm/rev)**	**DOC (mm)**	**R_A (mm)**	**S/N Ratio (db)**	**Mean**
1	*30*	289	27.23	0.04	.1	1.49	-4.6599	1.710
2	*30*	289	27.23	0.04	.2	1.83	-6.1121	2.365
3	*30*	289	27.23	0.04	.3	2.61	-13.8039	4.900
4	*30*	289	27.23	0.2	.1	2.41	-13.2435	5.365
5	*30*	289	27.23	0.2	.2	2.18	-15.3875	5.880
6	*30*	289	27.23	0.2	.2	2.17	-11.7811	2.6325
7	30	289	27.23	0.12	.1	3.62	-3.2274	1.450
8	30	289	27.23	0.12	.2	3.19	-6.2487	2.654
9	30	289	27.23	0.12	.3	3.23	-9.9937	3.160
10	30	639	60.21	0.04	.1	1.62	-11.6985	2.3647
11	30	639	60.21	0.04	.2	1.7	-13.7327	4.860
12	30	639	60.21	0.04	.3	1.70	-9.3647	9.952
13	30	639	60.21	0.2	.1	1.42	-5.8007	1.950
14	30	639	60.21	0.2	.2	1.67	-8.6971	2.365
15	30	639	60.21	0.2	.3	1.65	-13.9620	4.990
16	30	639	60.21	0.12	.1	1.83	-9.3254	2.952
17	30	639	60.21	.12	.2	1.43	-12.8096	4.370
18	30	639	60.21	.12	.3.	1.86	-6.5624	3.652
19	30	1000	94.24	.04	.1	1.34	-3.6369	1.520
20	30	1000	94.24	.04	.2	1.65	-5.2488	3.324

21	30	1000	94.24	.04	.3	1.93	-12.7298	4.330
22	30	1000	94.24	.2	.1	1.02	-6.5478	6.632
23	30	1000	94.24	.2	.2	1.23	-13.6248	4.800
24	30	1000	94.24	.2	.3	1.32	-16.6987	9.325
25	30	1000	94.24	.12	.1	1.44	-0.2915	0.967
26	30	1000	94.24	.12	.2	1.17	-23.4514	4.365
27	30	1000	94.24	.12	.3	1.30	-15.1327	5.710

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5.4 GRAPHS FROM TAGUCHI

5.4.1 Signal-to-Noise: In the Taguchi method, the term 'signel' represents the necesary value (mean) for the o/p charactistic and the term 'noise' represnts the undesireble value (S.D.) for the output charactristic. Therefore, the S:N ratio is the ratio of the mean to the S.D. Taguchi uses the S:N ratio to measure the quality charactristic deviating from the desired value

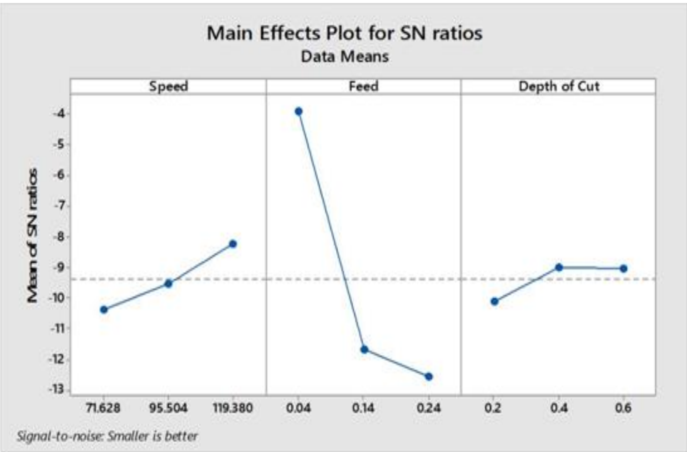
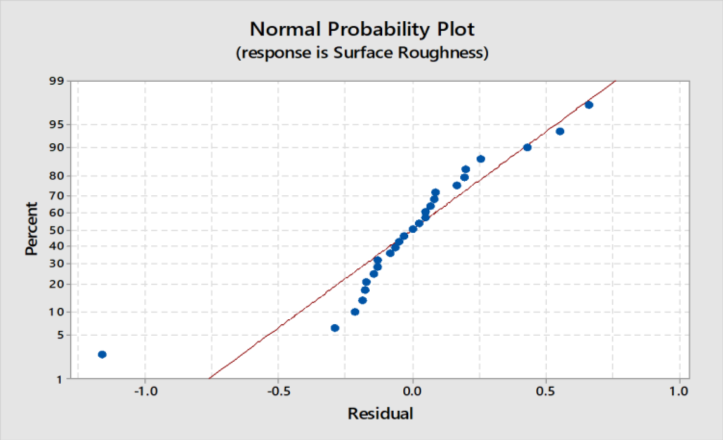


Fig 16 : Mean effective plot for SN ratios

5.4.2 Normal probability plot : It shows the response is surface roughness normal probability plot within the residual and percent ,the blue dotted shows the percentage probability of residual at different stage ,minimum at (-.25) residual and maximum probability at 30 to 75 percent of expected value.



Fig; 17normal probability plot response is surface roughness

5.4.3 Surface roughness versus fits versus residual

It shows the residual values found out in discrete pattern but main values of residual are found at mean value of 0.0 residual of different fitted values. The size of the stud residual should be independent of its predicted value. In other words, the vertical spread of the stud residuals should be approximately the same for each bowler. In this case the plot looks good. The spread from top is not out of line with his competitors, despite their protestations about the highest score

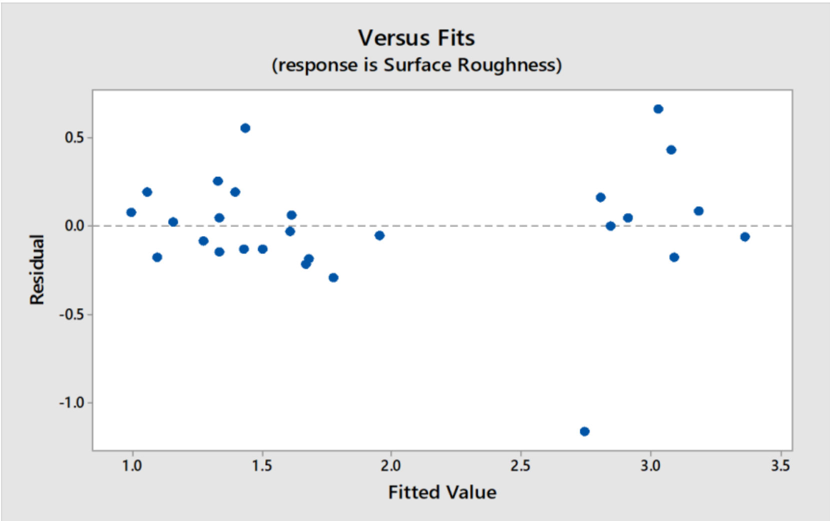


Fig18 (Response is surface roughness versus fits versus residual)

5.4.4 Interaction plots

It shows that speed ,feed,and depth of cut intraction between all three ,it's a form of matrix of 3*3 that shows relation among all three with varying one by one and keeping one as constant.three levels of feed,depth of cut, speed are taken and plotted to measure the interaction.

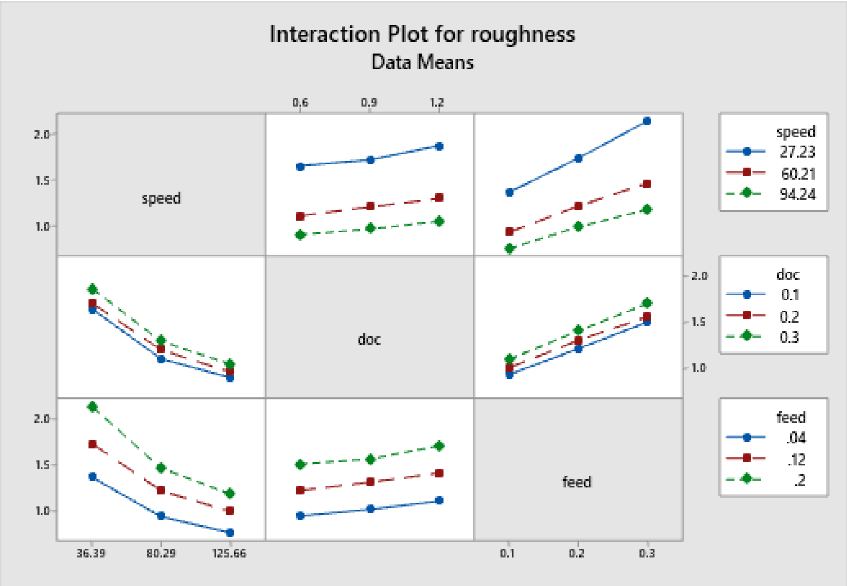


Fig 19: Interaction Plot

It tells the relative behavior of machining parameters to determine the interaction between two variables by making one as constant.

5.4.5 Main effect plot

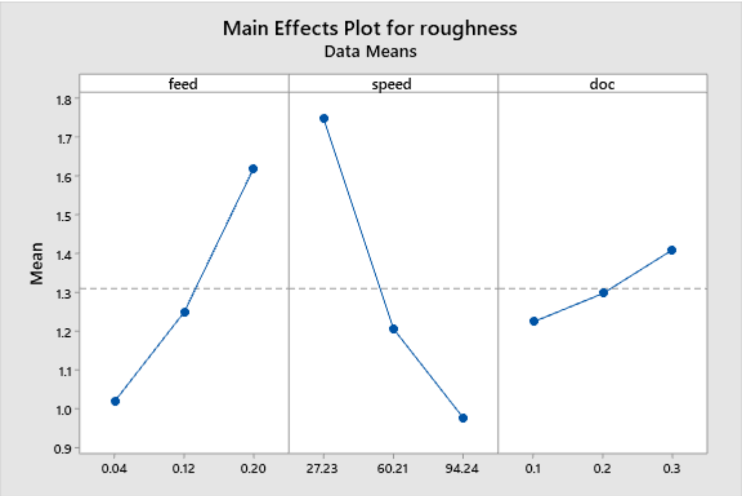


Fig 20: main effect plot

- With increase in feed rate the roughness value increases with a greater slope and minimum at .04mm/rev
- With increase in speed the roughness value decreases with a negative slope and minimum at 94.24 m/min
- With increase in doc the roughness value increases with a less slope and minimum at .1mm

5.4.6 Histogram

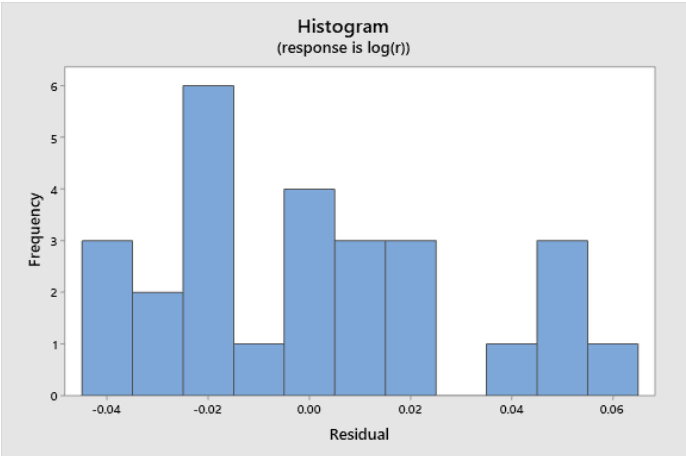


Fig21: histogram of response is surface roughness and frequency relation

- Above histogram shows that (response in surface roughness) ,frequency versus residual
- Different values of frequency at different residual maximum frequency at f (0.0) residual and minimum frequency at (-0.8)and(0.4)

5.4.7 versus order response plot

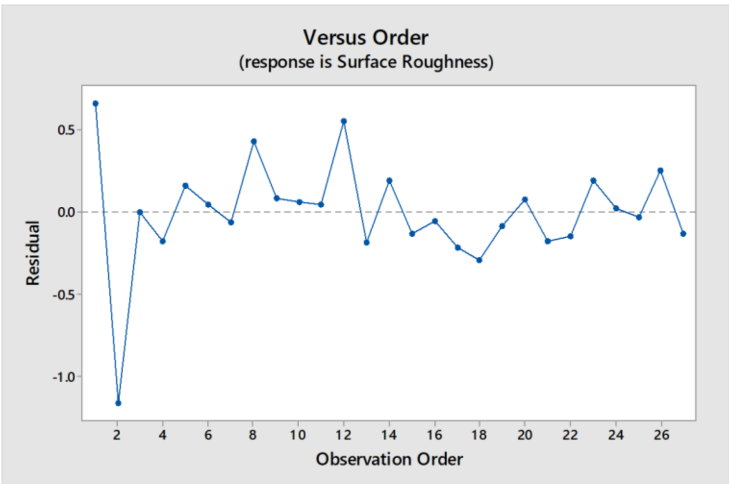


Fig. 25(versus order response of surface roughness against residual related observation order)

Above figure shows that residual versus observation order of (response is surface roughness) versus order at different observation order found different value of residual in above graph maximum residual at 1,and minimum residual at 2

Table 11 Analysis of Variances

Source	DF Adj SS Adj MS F-Value P-Value
Regression	**3 0.707932 0.235977 41.02 0.000**
Log S	**1 0.670250 0.670250 116.52 0.000**
Log F	**1 0.028020 0.028020 4.87 0.038**
Log D	**1 0.009662 0.009662 1.68 0.0208**
Error	23 0.132299 0.005752
Total	26 0.840231

5.4.8 Regression Equation

Log Ra = 1.728 - 0.7061 Log S + 0.1645 Log F - 0.123 Log D

$Ra = 52.12\ S^{(-0.7061)}\ F^{(0.1645)}\ D^{(-0.123)}$

R_a= Surface roughness

F=feed rare

S=speed

D=depth of cut

Table 12: Comparison of Actual and calculated values

S.N	Speed(m/min)	Feed rate (mm/rev)	Depth of cut(mm)	Calculated R_a(mm)	%error
1	27.23	0.04	.1	1.49	15.33
2	27.23	0.04	.2	1.83	12.16
3	27.23	0.04	.3	2.61	-27.36
4	27.23	0.2	.1	2.41	-11.67
5	27.23	0.2	.2	2.18	-6.67
6	27.23	0.2	.2	2.17	9.55
7	27.23	0.12	.1	3.62	44.67
8	27.23	0.12	.2	3.19	-16.97
9	27.23	0.12	.3	3.23	34.33
10	60.21	0.04	.1	1.62	7.21
11	60.21	0.04	.2	1.7	-4.97
12	60.21	0.04	.3	1.70	-9.97
13	60.21	0.2	.1	1.42	12.67
14	60.21	0.2	.2	1.67	-2.97
15	60.21	0.2	.3	1.65	3.97
16	60.21	0.12	.1	1.83	7.35
17	60.21	.12	.2	1.43	-9.64
18	60.21	.12	.3.	1.86	43.45
19	94.24	.04	.1	1.34	34.21
20	94.24	.04	.2	1.65	-16.23
21	94.24	.04	.3	1.93	19.82
22	94.24	.2	.1	1.02	13.11
23	94.24	.2	.2	1.23	-5.65
24	94.24	.2	.3	1.32	-6.64
25	94.24	.12	.1	1.44	1.35
26	94.24	.12	.2	1.17	-19.62
27	94.24	.12	.3	1.30	32.25

From the table above, experimental values and theoretical values are very close to each other. Percentage error is minimum at machining parameter i.e. speed=94.24m/min, feed=.12mm/rev, depth of cut=.1 mm. This concludes the validity of model as experimental results are very close to the theoretical values.

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSION

6.1.1 Surface roughness

- Cutting speed has highest contribution toward the surface roughness and with increase in speed, roughness decreases.
- With increase in feed rate, surface roughness increases with positive slope.
- Depth of cut has least contribution on the surface roughness and with increase in doc surface roughness increases with a smaller slope
- Optimum cutting parameters are Speed=94.24m/min ,Depth of cut=.1mm , feed =.0795 mm

6.2 FUTURE SCOPE

The scope of this work in context to future research:

- This work can be carried out to find MRR, Residual stress etc.
- Different methods can be used to fabricate the MMC and comparative analysis can be done to find out the best one.
- In current research three levels in the factors of combinations in Design of experiment. These levels can be changed in this research by taking different machine and tool for the different material and tool combinations.
- Different modeling technique can be used to predict the effect of machining parameters on the surface roughness.
- Nonlinear regression model may be used and different DOE with more numbers of values for more accuracy

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