TO STUDY THE EFFECT OF DIFFERENT REINFORCEMENTS ON VARIOUS PARAMETERS IN ALUMINUM MATRIX COMPOSITE DURING CNC TURNING

A DISSERTATION

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

OF

MASTER OF TECHNOLOGY

IN

[**PRODUCTION ENGINEERING**]

Submitted by:

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CANDIDATE'S DECLARATION

I, SONI KESARWANI, 2K17/PIE/14 student of M.Tech, PRODUCTION AND INDUSTRIAL ENGINEERING hereby declare that the project Dissertation entitled "**TO STUDY THE EFFECT OF DIFFERENT REINFORCEMENTS ON VARIOUS PARAMETERS IN ALUMINIUM MATRIX COMPOSITE DURING CNC TURNING**", which is submitted to the **Department of MECHANICAL ENGINEERING**, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of 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 herby certify that the Project Dissertation entitled "**TO STUDY THE EFFECT OF DIFFERENT REINFORCEMENTS ON VARIOUS PARAMETERS IN ALUMINIUM MATRIX COMPOSITE DURING CNC TURNING**" which is submitted by **Ms. SONI KESARWANI**, **2K17/PIE/14, Mechanical Engineering,** Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the 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 — Supervisor

Date: — Dr. M. S. Niranjan

(Associate Professor)

ACKNOWLEDGEMENT

It is a matter of great pleasure for me to present my major project report on "**TO STUDY THE EFFECT OF DIFFERENT REINFORCEMENTS ON VARIOUS PARAMETERS IN ALUMINIUM MATRIX COMPOSITE DURING CNC TURNING**". First and foremost, I am profoundly grateful to my guide **Dr. M. S. NIRANJAN, Associate Professor, Mechanical Engineering Department, DTU** for their expert guidance and continuous encouragement during all stages of report. I feel lucky to have an opportunity to work with them. Not only was their understanding towards the subject, but also their interpretation of the results drawn from the graphs very thought provoking. I am thankful to the kindness and generosity shown by them towards me, as it helped me morally in completing the project before actually starting it.

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ABSTRACT

Metal matrix composites are emerging as advance engineering and structural materials and their demand are continuously growing in various sector with higher pace. Among all the metals matrix composite, aluminum matrix composite are coming out as a tough potential competitor for the conventional materials for having large number of applications in aerospace , manufacturing ,transportation ,defence ,sports and count goes on. Handpicking AMC over other metals is due to its ductility ,toughness ,strength and being less expensive .In this study, Aluminum Metal Matrix composite (AMC) has been fabricated using aluminum alloy Al 6063 T6 as base matrix material as aluminum characterizes the property of being light weight ,durable and strengthening it by adding two different type of reinforcements-one is hard ceramic particle Boron Carbide (B_4C) which the third hardest material known and the other is a natural one-Egg shell powder which is easily accessible.B_4C & Egg shell have been incorporated in the aluminium melt with the micro size of 104µm by creating vortex. Stir casting technique has been used to synthesize aluminum metal matrix composite because of being simple, cost-effective , convenient to use ,suitable for mass production and one of the proven process. Solidified composites were subjected to CNC turning in which process parameters like cutting speed, feed rate and depth of cut were kept constant for all. Evaluation of MRR, surface roughness, residual stress and temperature between tool-work piece interface were considered as responses. The experimental study revealed that MRR of hybrid and egg shell AMC's were maximum. Analyzing surface roughness Ra through surface responses graph, minimum Ra was recorded for Hybrid AMC.Base alloy showed up a higher value for residual stress. Temperature measurement for Hybrid composite was recorded as maximum among all the AMC's and base alloy.

Keyword-Al alloy 6063-T6, Boron Carbide, Egg shell, Stir Casting, Material Removal Rate, Surface roughness, Residual stress, Temperature

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

In current framework, there is a demand of a material that has superior and unusual combinations of properties which can satisfy the need of large sector industries like automobile, production, construction etc which can't be met by the metal alloys, ceramics, and polymeric materials. For example, aircraft engineers are increasingly searching for materials that have low densities, are strong, compact and impact resistant, and are light weight. The best material created by researches in order to fulfil the above requirement is composite. Recording a massive demand, one can consider composite as a next generation materials.

Defining composite as materials which are made by combining two or more components such that the final properties of which are different from the properties of individual components from which it is made.

It is a material in which the mixing of components is homogenous at macroscopic scale but gets heterogeneous at microscopic scale. Each of the components should have distinct properties from the prepared composite.

To annotate a certain materials as a composite, following requirements should be fulfilled.

1. Combination of materials should result in notable property changes
2. Amount of each constituent should be generally more than 10 %
3. In general, property of one constituent is much greater (≥ 5) than the other

Generally a composite comprise of two components-one is known as reinforcement and the other one is known as matrix. Reinforcement is that component which is discontinuous in nature, stronger and harder. The main functions that are performed by the reinforcements are that it imparts the desired propertied into the composite, helps in bearing the load that is applied over the composite and transfers the required strength to the matrix. Reinforcing constituents in composites, as the word indicates, provide the strength that makes the composite what it is.

The other component matrix is continuous in nature and perform functions such as it help to hold the reinforcement fibres together and protects it from environment and abrasion (among itself). It also helps to maintain the dispersion of fibres and distributes the loads evenly between fibres. There are some properties in respect of material and structure such as impact resistance, better finish and transverse strength of the lamina that cannot be imparted by the reinforcement itself, hence in that case matrix plays a significant role. Now there are some of the reasons that provide an edge to composites over other materials during selection of materials at any industrial level like-low weight, stiffness and strength, low coefficient of expansion, resistance against fatigue, ease in manufacturing complex shapes, simple repair of damaged structures, resistance to corrosion.

The biggest advantage of modern composite materials is that they are light as well as strong. By picking a proper combination of reinforcement and matrix material, a new composite can be made that unequivocally meets the necessities of a particular application despite of the fact that the resulting product is progressively proficient, the raw materials are regularly costly.

1.1 CLASSIFICATION OF COMPOSITES

There are two category according to which composite are classified-

The first classification is made on the basis of the type of matrix material used in the composite. The main materials that are being used as matrix are- Metal, Ceramics and Polymers and Carbon. So according to these matrixes, various composites can be prepared such as Organic Matrix Composites (OMCs), Metal Matrix Composites (MMCs) and Ceramic Matrix Composites (CMCs). The term organic matrix composite is commonly expected to incorporate two classes of composites, in particular Polymer Matrix Composites(PMCs) and carbon matrix composites generally known to as carbon-carbon composites.

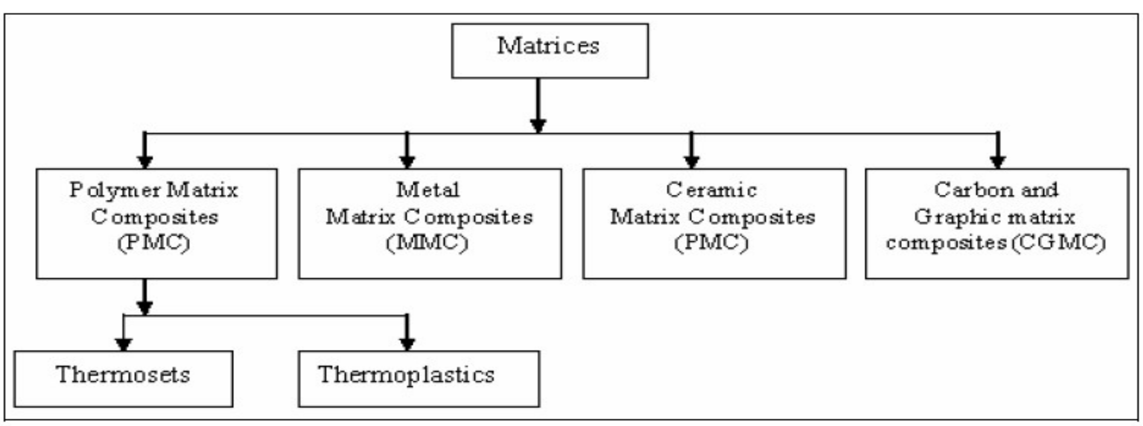

Figure 1-1 Classification on the basis of matrix material [2]

• The second classification is done on the basis of reinforcement form which can be of fibre, laminar or particle form. According to this various composites are prepared such as fibre reinforced composites, laminar composites and particulate composites. Fibre Reinforced composites (FRP) can be further sub classified into those containing discontinuous or continuous fibres.

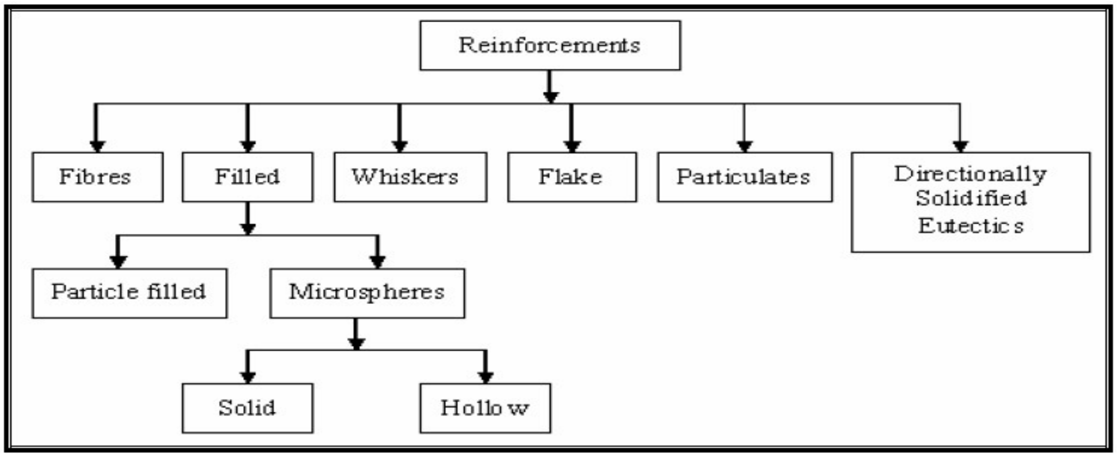

Figure 1-2 Classification on the basis of reinforcement [2]

Fibre Reinforced Composites are made of fibres that are embedded in matrix material. Fibre composite can further be divided into continuous and discontinuous fibres. Continuous fibres reinforced are those in which any further increase in length of the fibre does not affect the elastic modulus of the composite while discontinuous fibres reinforced are those in which its properties vary with the change in the length of the fibre. Fibres are small in diameter and when pushed axially, they bend easily although they have very good tensile properties. These fibres must be supported to keep individual fibres from bending and buckling.

• **Laminar Composites** are composed of layers of materials that are held together by matrix. Sandwich structures come under this.

• **Particulate Composites** are the composites in which reinforcements are present in the form of particles such that they are distributed all over the matrix. The particles may be flakes or in powder form. Concrete and wood particle boards are some good example of this.

Taking about composite prepared from metal matrix and containing reinforcement in particle form-

Metal Matrix Composites (MMC)

Metal network composites, at present however producing a wide enthusiasm for research society, are not as broadly being used as their plastic partners. High quality, break durability and solidness are offered by metal frameworks than those offered by their polymer partners. They can withstand raised temperature in destructive condition than polymer composites. Most metals and alloys could be used as matrix and they require proper reinforcement materials which should be steady over a scope of temperature and non-receptive as well. Anyway the directing angle for the decision depends basically on the matrix material. Light metals form the matrix for temperature application and the reinforcements in addition to the aforementioned reasons are characterized by high moduli.

Most metals and alloys provide great frameworks for matrix. In any case, for all intents and purposes, the choices for low-temperature applications are very few. Only light metals are responsive, with their low density demonstrating a favorable position. Titanium, Aluminum and magnesium are the prominent network metals as of now in vogue, which are especially helpful for aircraft applications. If metallic matrix materials have to offer high strength, they require a reinforcement that has high value of modulus. The strength-to-weight ratios of resulting composites can be higher than most alloys.

The melting point, physical and mechanical properties of the composite at various temperatures determine the temperature of composites at which fulfill desired needs or applications. Most metals, ceramics and compounds can be used with matrices of low melting point alloys. The selection of reinforcement turns out to be increasingly hindered with increment in the liquefying temperature of matrix materials.

Particulate Reinforced Composites

Microstructures of metal and ceramics composites, which show particles of one phase strewn in the other, are known as particle reinforced composites.

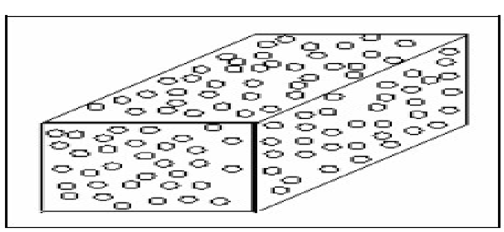

Figure 1-3 Particulate Composite [2]

CHAPTER 2

LITERATURE REVIEW

This study has investigated the effect of variation of various cutting parameters on the micro-hardness and residual stress during CNC turning of Aluminum Alloy 7075.Machining has been done by varying the value of cutting speed and depth of cut. Micro hardness and residual stress is measured by Micro-hardness Vickers's machine and X –ray diffraction method respectively. Cutting speed has an inverse relationship with the residual stress whereas depth of cut has direct relationship on the residual stress. Micro hardness shows a decreasing pattern as the value of cutting speed and depth of cut increases.[1]

In this it was studied the effect of varying the value of spindle speed and feed rate on the surface roughness during the CNC turning of Carbon Alloy Steels. One factor at a time approached has been used in this experiment. Five alloy SAE8620, EN8, EN19, EN24 and EN47 has been for the experiment. Results revealed that surface roughness increases as the feed rate increases and show decreasing trend on increasing the value of cutting speed keeping the feed rate constant.[2]

In this investigation, fabrication a composite of Al 2219 as base matrix and used B_4C and MoS_2 as two reinforcement using stir casting technique and studied the effect of cutting speed with constant depth of cut on cutting force and surface roughness during CNC turning was done. Composite has been prepared from Al-2219 with the percentage of B_4C (3% wt) and varying the percentage of MoS_2 (3% to 5% wt).TiN Coated carbide insert has been used as an cutting tool insert. It is concluded that with increasing the cutting speed both cutting force and surface roughness decreases for both Al 2219 alloy and its hybrid composite.[3]

In this work, it was studied the optimum parameters while turning of aluminum alloy 6063 using carbon nitride tool. Design of experiment was used to study the various parameters such as feed, depth of cut and cutting speed in order to reduce surface roundness error and better surface finish. Taguchi method L27 orthogonal array based experiment was conducted. The conclusion was that the responses were mainly predominated by the feed rate, followed by speed.[4]

In this work, it was studied on surface roughness of machining INCONEL 718 by using Titanium (DNMG 15-06-04) and Carbide (TNMG 15-06-04). CNC Lathe heavy duty SPRINT - 16 TC was used for machining. Taguchi's L9 orthogonal array based nine experiments were performed. Spindle Speed, Feed and Depth of cut were the input parameters and the output response is surface roughness .The predication models are developed using ANOVA was used for prediction model and MATLAB tool box GA is used to find the optimal value of the regression model. Result revealed that Titanium tools and Carbide tools are preferred for low speed application and high speed applications respectively.[5]

In this ,it was investigated the effect of various process parameters on the composite prepared from aluminum casting alloy LM6 as matrix and alumina (Al_2O_3) and molybdenum disulphide (MoS_2) as reinforcement. Input parameters were cutting speed, feed and depth of cut and resultant force of cutting forces in three directions, Specific Cutting Pressure (SCP) and surface roughness Ra were taken as output responses. Results revealed that the most dominating parameter were cutting speed and feed that affects the machining force and SCP.[6]

In this work, it was performed a comparative analysis on composite prepared from aluminum alloy as base metal and reinforcements with varying weight proportion of Egg shell , Waste Carbonized Egg shell, Silicon carbide-snail shell ash with and without heat treatment were used. Results revealed that by adding egg shell at 12.5 % wt there is a increase of tensile strength, hardness, fatigue strength but decrease in corrosion rate, fracture toughness and ductility. In order to improve the mechanical properties, heat treatment was done. 7.5 wt.%, 3000C and 5000C were optimum value for WCE and SiC. Composite containing 7.5 wt.% SiC + 7.5 wt.% SSA showed maximum hardness which reduced when (10 wt.% SiC + 10 wt.% SSA) was used as reinforcements..It was concluded that when composite prepared using WCE as reinforcement gave better properties at a much cheaper rate than uncarbonized egg shells(ES) and SiC+SSA.[7]

In this work, fabrication of prepared composite using Al-6061 as base metal and SiC as reinforcement and found effect of various turning parameters on the surface roughness. Values for cutting speed were 300m/min, 450m/min and 600m/min, feed rate values were 0.08

mm/revolution, 0.16 mm/revolution, 0.24 mm/revolution and depth of cut was kept constant to a value of 1.5 mm.It was concluded that Surface roughness reduces when 600 m/min & 0.08 mm/revolution were used for machining. When feed rate is 0.08 mm/rev for various cutting speed ,the cutting edges were subjected to high build up edges(BUE).[8]

In this work , it was performed experiment to studied the effect of dry and wet machining on the surface roughness of mild steel.HSS tool was used for straight training of mild steel. Optimization of multiple surface roughness parameters and material removal rate (M.R.R.) looking for an ideal parametric mix (great procedure condition) equipped for creating required surface nature of the turned item in a moderately lesser time. Results revealed that wet turning produce better surface than the dry machining.[9]

In this investigation, it was performed experiment on Al-6061 and used high speed steel (HSS) with and without application of coolant at different values of machining parameters and temperature and value of surface roughness was evaluated. In order to analyze the effects of cutting parameters like Speed, Feed and Depth of Cut on recorded responses of machining, Regression models for Cutting Temperature and Surface Roughness are developed .It was determined that turning trials are effectively directed and ideal cutting parameters values are resolved for limiting cutting temperature and surface roughness utilizing Genetic Algorithm at dry and MQL condition.[10]

In this work, it was studied that by modifying the design of the stirrer of the stir casting equipment like the geometry of the stirrer and increase in the stirring force helps in getting homogenous distribution of the reinforcement particle and reduce the formation of cluster respectively. By modifying the feeding mechanism improves in the uniformity of the reinforcements and controlled spraying of particulates helps in enhancing the properties of composite.[11]

In this, fabrication of a composite of Al 6061 as base matrix and TiC as reinforcement by enhancing some of the factors that affect in the mechanical properties of the final prepared composite was done. In order to have a proper melting of the base alloy, the temperature of the furnace was initially increased to 30°C above the melting temperature of the base alloy and during stirring the temperature was further increased to 50°C in order to compensate for the cooling effect of the stirring. The reinforcement was wrapped in the aluminum foil in order to insert into the molten base alloy present in the crucible. To increase the wettability of TiC with the aluminum alloy, magnesium was added to it and to avoid the oxidation of the composite, inert gas argon was passed. After enhancing all the above factors, SEM shows the proper distribution of the reinforcement in the composite and hence a defect free composite was prepared.[12]

In this work, it was studied metal SAE 1020 with carbide cutting tool. In this paper an optimization approach using orthogonal array (L25) has been used for the maximization of MRR. This examination additionally delivered a predictive equation for deciding MRR with a given arrangement of parameters in CNC turning. Hence, with the proposed ideal parameters it is conceivable to expand the effectiveness of machining procedure and lessening production cost in a mechanized manufacturing condition.[13]

In this research, it was studied effect of cutting parameters on material removal rate(MRR) using Taguchi analysis. For the turning operation , AISI 321 Austenitic Stainless steel is used and CVD ,PVD being used as the cutting tool. Cutting speed of 80 m/minified rate of 0.2mm/rev and depth of cut 1mm has been found to give the optimum result with respect of MRR in both case of CVD & PVD.[14]

In this work, it was prepared a teal matrix composite of Al 6061 alloy with Al2 O3 as the reinforcement using stir casting technique. SiC crucible was used to melt aluminium at 800°C.Al2O3 was preheated before mixing into the molten state of aluminum to remove gases and reduce temperature drop. Adding of reinforcement was done in three steps. Stirrer was also preheated and put inside the crucible at depth of two-third for proper mixing with 200rpm.Optical microscopy showed uniform distribution of reinforcement in the composite . Tensile, hardness and yield strength increases with wt % of reinforcement while ductility decreases.[15]

In this work , it was investigated an aluminum composite having Al-6061 as base metal and heated at a temperature of 900°C.Reinforcemnet has been blended with a flux(alkaline K-AL-F, scum powder)for proper dispersion before mixing it with the molten alloy. For degassing, Hexachloro ethane tablets has been used. Mixing is kept undisturbed for 2-5 minute so that a liquid flux is formed in the surface which can be removed from ladle. Then stirrer was applied at 700 rpm .Study revealed that adding flux provide a homogeneity in the distribution of reinforcement in the composite.[16]

In this work, it was proposed a two way mixing of the reinforcement into the metal matrix composite. In first step, matrix metal is heated above its liquidus temperature and then its melt is cooled down in the range which is in between of liquidus and solidus temperature. After preheating the reinforcement it is added to the molten metal and again its temperature is increased to liquidus temperature. After this, hot casting is poured in the desired shaped mould. It was concluded that two step mixing break the gas which surround the reinforcement particles and helps in its proper mixing in the molten metal.[17]

In this research work, it was fabricated a composite usingAl-6063 as base matrix and SiC as the reinforcement. Dehydrated borax was heated at 250°C for 20 min and used for wetting and mixed with SiC in 1:2 ratio. Matrix material was heated to liquidus temperature of 750°C and cooled down to 600°C and then Borax and SiC was added to the melt and stirrer is rotate for 20 minute. And then stirring is done mechanically for 20 min at 300 rpm and temperature of the melt is increased to 750°C.Strength of the composite increases as the volume % increases from 9 to 12 but no effect is seen on the ductility of the composite. [18]

In this investigation, it was studied the effect of deposition of coating materials and various cutting parameters on the surface roughness and material removal rate by using Taguchi Analysis. Cutting parameters are cutting speed, feed rate and depth of cut. It was concluded that depth of cut has tha most influence on surface roughness. The ideal parameters for surface roughness was obtained at Medium cutting speed (550 m/min), low depth of cut (1 mm), low feed rate (0.05 mm/rev), high flow rate of cutting fluid and Multilayer deposition from the selected levels. The ideal parameters for material removal rate was obtained at high cutting speed (600 m/min), medium depth of cut (1.5 mm), high feed rate (0.15 mm/rev).[19]

In this work, implemented CNC turning operation through online platform for mitigation of inspection time and reduction of cost, cutting force signals were transmitted based on wavelet packet transform (WPT) which is further classified as G-WPT, E-WPT, SE-WPT. In the process G-WPT was responsible for the calculation meant for cutting force analysis, whereas E-WPT and SE-WPT is responsible for the reduction of signal processing time.[20]

In this work, it was used high carbon high chromium steel (HCHCr) material and performed CNC turning operation taking the input parameters for analysis as Spindle speed, depth of cut and feed rate , while the output parameters selected for the optimization purpose are the Surface Roughness maintained after turning and the rate of material removal during turning operation using the Tagauchi Technique. The tool handled for the turning operation are the carbide inserts. Optimization is achieved using the regression and the variance analysis and finally L9 orthogonal array was used.[21]

RESEARCH GAP

On the basis of literature survey the following research gap have been identified

- The experimental analysis on composite material has not been explored in the literature.
- The machinability in CNC turning has not been investigated.
- Chip tool interface temperature during machining has not been studied thoroughly.

OBJECTIVE OF PROJECT

On the basis of detailed study of research survey the following research objective have been drawn

- Development of metal matrix composite by using stir casting process.
- To study the effect of process parameter such as cutting speed, feed rate and depth of cut on the surface roughness, material removal rate, residual stress and temperature between tool-work piece interfaces during CNC turning of the composite.
- Statistical analysis of process parameters in CNC turning.

CHAPTER 3

RESEARCH METHODLOGY

3.1 ALUMINIUM

Aluminium is a silvery-white metal which comes at the 13th place in the periodic table. Aluminium is the most widespread metal on Earth, present at level more than 8% of the Earth's core mass. After oxygen and silicon it is the third most common chemical element on earth. Due to its binding nature with other elements, it is pure form cannot be found in nature. The most common form of aluminium that is found in nature is aluminium sulphates which are minerals that combine two sulphuric acids: one based on an alkaline metal (lithium, sodium, potassium rubidium or caesium) and one based on a metal from the third group of the periodic table, primarily aluminium.

The origin if the name aluminium was from aluminium sulphates which stands for alumen in Latin. Aluminum offers an uncommon blend of profitable properties. Since aluminum can easily form compounds with other elements so a wide variety of its alloy can be developed. In order to achieve the required properties to be used in new areas, even a small amount of mixture can provide that. A large amount of such examples cab be seen in daily life such as the mixture of silicon and magnesium with aluminium can be seen on the road in the form of aluminium alloy wheels, in the engines, chassis and other parts of modern vehicles.

It is impossible to imagine big industries like construction, automotive, aviation, energy, food and other industries without aluminium. In addition to this, aluminium has become a symbol of development: all cutting edge devices and vehicles are made from it.

There are many ways to combine aluminum with other materials in order to form a new material that is known as composite (hybrid materials made from two or more materials that retain their identity without chemically combining or mixing). In most of the composite, aluminum is used as a base matrix material and is reinforced with particles of different properties in order to produce a material, which are strong, light weight and can be used in wide applications.

3.1.1 The Benefits of Aluminum and its alloy

1. Light metal
2. Has good corrosion resistance to common atmospheric and marine atmospheres.
3. Has high reflectivity and can be used for decorative applications.
4. Some aluminum alloys can match or even exceed the strength of common construction steel.
5. Retains its toughness at very low temperatures, without becoming brittle like carbon steels.
6. A good conductor of heat and electricity.
7. Readily worked and formed using a wide variety of forming processes including deep drawing and roll forming.
8. Non-toxic and is commonly used in contact with foodstuffs.
9. Can be readily recycled.

3.2 WROUGHT ALUMINUM ALLOY DESIGNATION SYSTEM

6xxx series-Magnesium and Silicon

6XXX Series Alloys -These are aluminium alloy containing silicon and magnesium up to 1% and have wide applications in welding fabrication industry, used predominantly in the form of extrusions, and in many structural components. Adding magnesium and silicon to aluminum forms a compound of magnesium-silicide, that provides this material its ability to become solution heat treated which increase its strength. These alloys are naturally solidification crack sensitive and this is the reason that they are not arc welded autogenously (without filler material).Adding sufficient amounts of filler material while arc welding process is essential in order to provide dilution of the base material, in order to prevent the hot cracking problem. They are welded with both 4xxx and 5xxx filler materials, dependent on the application and service requirements.

3.2.1 THE BASIC TEMPER DESIGNATIONS

While designating the aluminium alloys, T stands for Thermally Treated means the products that are being heat treated in order to produce stable temper where "T" is always followed by one or more digits like **T6** here it stands for solution that is heat-treated and artificially aged.

3.3 ALUMINIUM ALLOY 6063 T

AA 6063 is an aluminium alloy, in which magnesium and silicon are main alloying elements. Aluminium alloy 6063 is an alloy having medium and commonly known to as an architectural alloy. It is normally used in intricate extrusions. It has a decent surface completion, high corrosion resistance, is promptly fit to welding and can be effectively anodized. It has commonly great mechanical properties and is heat treatable. Most generally accessible as T6 temper.

3.3.1 COMPOSITION OF AA 6063 T6

Table 3-1 Composition of Al 6063[5]

Element	% Present
Magnesium (Mg)	0.45 - 0.90
Silicon (Si)	0.20 - 0.60
Iron (Fe)	0.0 - 0.35
Others (Total)	0.0 - 0.15
Chromium (Cr)	0.0 - 0.10
Copper (Cu)	0.0 - 0.10
Titanium (Ti)	0.0 - 0.10
Manganese (Mn)	0.0 - 0.10
Zinc (Zn)	0.0 - 0.10
Other (Each)	0.0 - 0.05
Aluminium (Al)	Balance

3.3.2 SUPPLIED FORMS

Alloy 6063 is can be found in various forms such as-

- Extrusions
- Tube

• Bar

• Rod

3.3.3 PROPERTIES OF AA 6063-T6

Table 3-2 General properties of Al 6063 [5]

Property	Value
Density	2.70 g/cm³
Melting Point	655 °C
Thermal Expansion	23.5×10^{-6} /K
Modulus of Elasticity	69.5 GPa
Thermal Conductivity	201 W/m.K
Electrical Resistivity	52 % IACS
Electrical Resistivity	0.033×10^{-6} Ω .m

Table 3-3 Mechanical properties of Al 6063 [5]

Rod & Bar Up To 150mm Dia. & A/F	
Property	Value
Proof Stress	170 Min MPa
Tensile Strength	215 Min MPa
Elongation A50 mm	8 Min %
Hardness Brinell	75 HB
Elongation A	10 Min %

3.3.4 APPLICATIONS

6063 has wide applications in

- Rail and road transport
- Extreme sports equipment
- Architectural applications
- Extrusions
- Window frames and Doors

- Shop fittings
- Irrigation tubing

3.4 BORON CARBIDE

Boron carbide is an extremely hard boron–carbon ceramic and covalent material utilized in tank defensive layer, impenetrable vests, motor damage powders and various other mechanical applications. With a Vickers Hardness of >30 GPa, it is one of the hardest known materials, behind cubic boron nitride and precious stone diamond.

Nickname - Black diamond for its extreme hardness.

Chemical Formula - B_4C

Preparation-

In order to prepare boron carbide, boron trioxide is treated with carbon or magnesium in an electric furnace having a presence of carbon. While using carbon, reaction take place at temperature higher than the melting point of boron carbide and carbon monoxide is liberated.

$2\ B_2O_3 + 7\ C \rightarrow B_4C + 6\ CO$

After granulating, the dark powder is hardened by squeezing at temperatures surpassing 2,000° C (3,630° F).

Some of the properties of B_4C are-

- At normal state, it is a dark black powder
- Have no odour
- Insoluble in water
- Have molar mass equal to 55.255 g/mol
- Hardness of about 9 to 10 oh mohs scale
- Melting and Boiling point are 2763°C and 3500°C respectively.
- Density of around 2.52 g/cm^3
- Specific gravity is 2.52.
- Have a rhombohedral crystal structure.

Uses-

- Having a good hardness along with very low density, it is used as reinforcement with aluminum in military armor and high-performance bicycles

- Used in wear and tear resistant coatings as being a wear resistant ceramic.
- It is a grating substance utilized for forming and cleaning work-pieces produced using metal and other hard materials.
- This artistic substance is utilized in Metal Matrix Composites.
- Boron Carbide is utilized in ballistic missile destroying plating of body reinforces for human and vehicles. These defensive layer plates can oppose the effect of weapons like projectiles, shrapnel and rockets.

Table 3-4 Particle mesh size conversion chart [8]

Particle Size		U.S. Std. Sieve		Tensile Bolt Cloth			Market Grade		
Inches	Microns	Std Sieve	Opening In Inches	Mesh TBC	Opening		Mesh MG	Opening	
					Inches	Microns		Inches	Microns
0.0083	210	70	0.0083	84	0.0084	213			
0.0079	200			88	0.0079	201			
0.0076	193			90	0.0076	193			
0.0070	177	80	0.0071	94	0.0071	180	80	0.0070	178
0.0065	165			105	0.0065	165			
0.0059	149	100	0.0059	120	0.0058	147	100	0.0055	140
0.0049	125	120	0.0049	145	0.0047	119	120	0.0046	117
0.0041	105	140	0.0042	165	0.0042	107	150	0.0041	104
0.0035	88	170	0.0035	200	0.0034	86	170	0.0035	89
0.0029	74	200	0.0030	230	0.0029	74	200	0.0029	74
0.0025	63	230	0.0025				250	0.0024	61
0.0021	53	270	0.0021	300	0.0022	56	270	0.0021	53
0.0017	44	325	0.0018				325	0.0017	43
0.0015	38	400	0.0015				400	0.0015	38
0.0010	25	500	0.0010				500	0.0010	25
0.0008	20	635	0.0008				635	0.0008	20

3.5 EGG SHELL

The exterior covering of a hard-shelled egg and some types of eggs with smooth outer coats is an eggshell. The Egg Shell is a product-by-product aviculture that is one of the worst environmental issues in the world, particularly in nations where the egg product sector is well established. Egg Shell includes approximately 95% carbonate of calcium and 5% organic materials. Although in many applications there have been many attempts to use egg shell, it has been a potential filler in polymer composites. The shell of the egg has a comparatively small density compared to the carbonate of mineral calcium. The shell of the egg includes 95% by weight of Calcium Carbonate and 5% by weight of components such as Al2O3, SiO2, S, P and Cr2O3, MnO. The overall egg shell structure is a protein-lined mineral crystal, mostly calcium carbonate, these features suggest that egg shell is a excellent material for cheap, light weight and low-load composite applications in the automotive, home, office and factory industries.

Figure 3-1 Egg shell[12]

3.5.1 PREPARATION OF EGG SHELL POWERED

• White eggshells from local shops in Delhi City, India are used.

• The gathered egg shells have been carefully cleaned in water and each shell removes the exterior layer.

• Then it was dries in the sun for about 32 hours.

• The dried egg shell was milled in a ball milling machine at 300 rpm for 4 hours.

• Powdered egg shells were put on a sieve with a mesh size of 150 and vibrated for about 20 minutes after being pulverized.

The above step was repeated approximately 3 times and a good particulate egg shell from the sieve was gathered. The size of the shell used in the experiment was 104 µm.

3.6 BALL MILLING

A ball mill also known as a pebble mill or spinning mill is a sort of grinder used for grinding and mixing materials used in procedures of mineral dressing, painting, pyrotechnics, pottery and selective laser sintering. It operates on the principle of effect and attrition: size decrease is accomplished by effect as the balls fall off close the shell's top. A ball mill is a hollow cylindrical shell that rotates around its axis. The shell axis can be either horizontal or horizontal at a tiny angle. The grinding media is the balls that can be produced of steel (chrome steel), stainless steel, ceramic, or rubber. The stacks with distinct diameters occupy 30% to 50% of the volume of the unit and their size depends on the size of the supply and the mill. The big balls tend to break down the coarse feed materials and the lower balls assist to create the fine product by decreasing the gaps between the balls. The cylindrical shell's internal surface is generally lined with an abrasion-resistant material like manganese steel or rubber. Less wear occurs in lined factories of rubber.

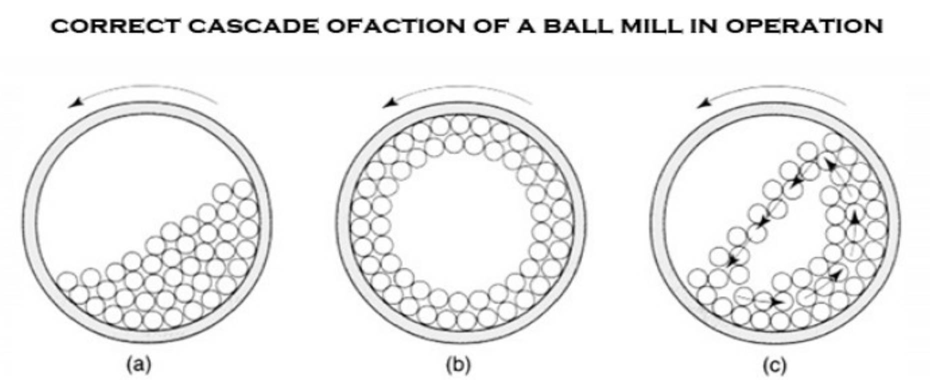

Figure 3-2 Procedure of Ball Milling[16]

The material to be ground is fed from the left through a 60 ° cone in the case of a continuously operated ball mill and the product is discharged through a 30 ° cone to the right. As the shell rotates, the shell lifts the balls up on the shell's growing side and then cascades down (or drops down to the feed) from near the shell's top. This reduces the size of the strong particles between the balls and the floor by effect.

The degree of friction in a ball mill is affected by-

• Material residence time in the chamber of the mill.

• Ball size, ball density and number.

• Ball character (hardness of the grinding material)

• Vessel feed rate and feed level.

• The cylinder rotation velocity.

There are several ball mill kinds. In their working principle, they vary to some extent. The maximum capacity of the milling vessel also differs from 0.010 litres for planetary ball mill, mixer mill or vibration ball mill to several 100 litres for horizontal rolling ball factories.

3.7 STIR CASTING TECHNIQUE

Metal matrix composites processing-

These metal matrix composites have many benefits over monolithic materials as mentioned above, so their applications are growing day by day in different areas. Different procedures are used in the production of MMCs outlined here. These procedures are categorized during processing on the grounds of the metallic matrix temperature. The procedures can therefore be categorized into five categories: (1) liquid-phase processes, (2) solid-liquid processes, (3) deposition methods, and (4) in situ procedures. (5) Processes in two phases (solid-liquid).

3.7.1 Liquid state fabrication of Metal Matrix Composites – It includes incorporating the dispersed phase, followed by its solidification, into a molten matrix metal. Good interface bonding (wetting) between the dispersed stage and the fluid matrix should be achieved in order to provide a high amount of mechanical characteristics of the composite. Wetting enhancement can be accomplished by coating the particles (fibers) of the dispersed phase. Not only does proper coating reduce interfacial energy, it also avoids chemical interaction between the dispersed phase and the matrix. Metal Matrix Composites fluid state manufacturing techniques: stir casting, infiltration such as infiltration of gas pressure, squeeze casting infiltration, or pressure die infiltration.

3.7.2 Stir Casting- It is a liquid state technique of manufacturing composite materials in which a distributed stage (polymer particles, brief polymers) is blended by mechanical stirring with a frozen matrix metal. Stir casting is the liquid state manufacturing technique that is easiest and most price efficient. The liquid composite material is then casted using standard modelling techniques and can be handled using standard metal forming techniques as well.

3.7.3 Process parameters of stir casting process

This method of liquid metallurgy is the most economical of all accessible paths for the manufacturing of metal matrix composite, and enables the manufacture of very big parts. The price of preparation composite material using a cutting technique is also approximately one-third to quarter that of competing techniques, and it is expected that the price will drop to one-tenth for large mass manufacturing. There are several variables that need significant scrutiny in the preparation of metal matrix composites by the cold turning technique, including (a) the challenge of obtaining a uniform distribution of the strengthening material;(b) Wettability between the two primary materials (C)Porosity in the composite pressed metal matrix ; and d) Chemical responses between the matrix alloy and the reinforcing substance.

Proper distribution of reinforcement materials in matrix

During the building process, it is essential to correctly distribute the strengthening ions in the frozen matrix stage. During this stage, problems sometimes arise due to the distinction in density between the pieces of strengthening and the melting of the matrix alloy. In the process of stir winding, it can be prevented by vortex technique. In this method, it is vigorously stirred to form a vortex at the surface of the melt after the matrix material is melted, and then the reinforcement material is inserted at the side of the vortex. Before casting the slurry, the stirring will continue for a few minutes**.**

Proper wettability between reinforcement material and matrix alloy

To attain the performance in deposited MMC samples, there is adequate wetting between the strengthening droplets and the matrix alloy. Wettability can be described as a liquid's capacity to stretch over a solid surface. Successful integration into production of strong ceramic components needs the foam to dry the strong ceramic stage.

Porosity in cast metal matrix composites

Porosity is an issue in the samples of MMC heat milling samples. By adequate stirring, such as using mechanical mixing, it can be minimized. It also reduces castings ' corrosion strength. Porosity is generally caused by three triggers: (a) oil trap during blending, (b) hydrogen development, and (c) solidification shrinkage. Process parameters of keeping moments, mixing velocity, and impeller volume and location will impact porosity development. The performance of the samples casted in the stir painting method relies on different stir processing system parameters such as processing velocity, mixing moment, keeping moment, mixing temperature andvolume.And the impeller's location. Wettability in shaped metal matrix composites can be en hanced by regulating the porosity of these parameters following variables that most influence the stir turning method. They are

1. Speed of stirring
2. Time duration of stirring
3. Stirring temperature

A. SPEED OF STIRING

Several writers report the need for uniform distribution of strengthening ions to improve the characteristics of particulate MMCs such as hardness, toughness, tensile strength, etc. The stirrer's small rpm provides less shear force to the matrix metal and there is no room for the strengthening materials (distributed stage) to be distributed evenly throughout the matrix. In addition, the distributed stage tends to agglomerate and shape clusters. This is owing to the lack of the power needed to withstand it. At greater stirrer rates, the shearing force introduced to the matrix metal is greater, resulting in the transition to the dispersed phase of moving inside through the stirring vortex. The energy provided by the stirrer's high-speed rotation is powerful enough to spread the dispersed phase droplets that cause the dispersed phase to be distributed evenly into the matrix. Researchers also found that there is a possibility for the fluid droplets to migrate inside the box and boost porosity on enhanced stirrer rates.

B. TIME DURATION OF STIRRING

The uniform distribution of the dispersed phase into the matrix performs a very significant part. Less stirring moment creates the strengthening particle clustering. It is also seen that certain parts of the matrix have been discovered without strengthening particle inclusions. As it is evident from the picture that the allocation of the dispersed phase also increases as the stirring period rises, this in addition improves the composite material’s mechanical characteristics.

C. STIRRING TEMPERATURE

It is also one of the most prominent parameters affecting the method of stir turning. Viscosity declines and particle production is impacted by raising the temperature of the metal matrix. The chemical reaction between the pieces of strengthening and the metal matrix is enhanced by raising the salt temperature.

3.7.4 Fabrication

Al 6063 –T6 alloy was used as the matrix and B_4C and egg shell were used as reinforcement in the AMCs.

Liquid metallurgy stir casting method was adopted for composite fabrication, which essentially included following steps , i.e. melting of matrix alloy, preheating of reinforcement particulates, mixing of preheated particulates into molten alloy, solidification

Step 1. A graphite crucible of cylindrical in shape ,having a maximum working temperature of 2700°C and required dimension,220 V, 3-phase electrical resistance furnace (maximum working temperature 1500°C) was used for melting of the matrix alloy and composite slurry preparation. It was mounted with a K-type thermocouple with a maximum range of 1200°C and speed regulated motorized stirring system.

Step 2.The B4C were heated to 350°C for 45 min using muffle furnace of maximum working temperature 0C and, before mixing with the molten alloy. Preheating of B4C is necessary to oxidize their surface remove moisture and

Improve wettability in matrix material

Step 3. Before addition of preheated B4C, vortex was created on the surface of molten alloy by motorized stirring at stirring speed of 400rpm. The particulates were added at slow rate (approximately 10 g/min) using a funnel and rod, into the vortex of molten alloy. The stirrer speed was then slowly increased to 220 rpm and stirring was continued for 10 minutes more. The stirrer blades were positioned at one-third of the depth of the molten slurry from its surface, to enable proper mixing.

Step 4.After mixing the reinforcement for about 15 min with the help of stirrer ,stirrer is taken out and composite slurry is allowed to get cool and solidify and then the cast AMC was removed out of the graphite crucible

3.8 MUFFLE FURNACE

A muffle furnace is a furnace with an externally heated chamber, whose walls heat the chamber's contents radiantly, so that the heated material has no contact with the flame.Muffle furnaces are most commonly used as a compact way of generating incredibly high-temperature atmospheres in laboratories. They are used to evaluate material features at exceptionally elevated and precise pressures. Also regarded as a retort furnace is a muffle furnace.

3.8.1 CONSTRUCTION OF MUFFLE FURNACE

Furnace consists of:

- a vented heating chamber
- a temperature controller
- a door safety switch for operator safety

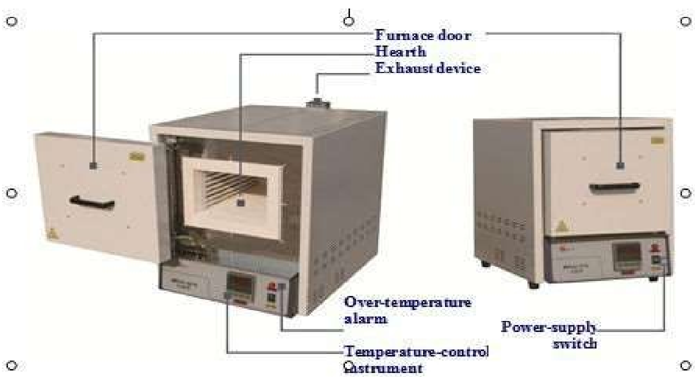

Figure 3-3 Muffle Furnace parts[29]

3.8.2 WORKING OF MUFFLE FURNACE

A muffle furnace is a item of furnace machinery capable of reaching elevated altitudes. It generally operates by placing an insulated fabric with a high-temperature heating coil. Effectively, the insulating fabric functions as a muffle to prevent heat from fleeing.

Usually the furnace is powered by:

• Conduction

• Convection

• Black body radiation from thermal components with electrical resistance

A precious metal thermocouple measures the room temperature and transmits this data in mill volts to the temperature control. The segment of command comprises of a temperature sensor, a present sensor, a transformer, a contact (relay), a circuit breaker. The temperature sensor controls the temperature of the furnace (through the thermocouple) and the present system adjusts electricity to the heating elements. The present system regulates electricity to the heating elements by changing the magnitude of the electrical current (instead of fully switching on or off the electricity). This is the desired technique for regulating heating elements from electricity to molybdenum disilicide. When all the necessary work is done and the current is controlled, the sample will be heated to the desired temperature and removed afterwards. The temperature control of the scheme generally does not involve combustion, which enables for much higher regulation of temperature uniformity and ensures separation of the hot product from the petrol combustion by-products.

3.9 CNC TURNING

Machining is essentially the extraction from the workpiece of fabric, most often metal, using one or more cutting tools to obtain the required sizes. There are various procedures of machining, such as spinning, milling, drilling, etc. Metal is removed through a shearing process in all these cases, which occurs due to the relative motion between the workpiece and the tool. Generally speaking, one of the two rotates at a specified and usually fast velocity, allowing the workpiece to shear fabric (referred as chips). The other passes comparatively gently throughout the workpiece to influence metal extraction.

Cutting velocity, supply, and reducing length are significant parameters for all metal cutting procedures. The following picture demonstrates the significant geometry for the method of transformation. The cutting speed, a test of the ground velocity of the sliced portion compared to the instrument. Speed is a translational motion speed device, which can be specified in meters / min. The cutting range, DOC is the water that plunges the device into the ground. Feed describes the comparative horizontal motion of the cutting tool to the workpiece. Thus, feed determines the cross section of the material removed for each rotation of the job or the tool, as the case may be, together with the cutting depth.

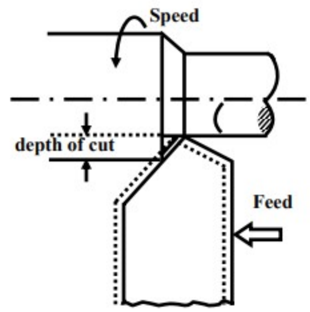

Figure 3-4 Turning Operations[26]

It is recognized as numerical control, or NC, to automatically command a machine tool relying on a collection of pre-programmed machining and motion guidelines. The movement and machining directions and the associated numerical data were published on a punched tape in a typical NC scheme together called a component program. In a sequence of operations needed to produce a mechanical component, the part program is arranged in the form of information blocks, each related to a particular operation. One section at a moment was downloaded from the punched tape. In a specific syntax, each section provided data necessary to process a specific machining command such as the duration of the section, its cutting speed, supply, etc. These pieces of information related, as per the drawing, to the final dimensions of the workpiece (length, width, and circle radii) and the contour forms (linear, circular, or other). Motion instructions were provided individually for each vector of movement on the basis of these measurements. Other guidelines and associated parameters of machining, such as turning velocity, load frequency as well as additional features linked to coolant stream, spindle speed, portion clamping, are also given in component programs based on requirements of manufacture such as tolerance and surface finish. Punched tapes are now largely outdated, replacing them with magnetic disks and optical drives.

Computer Numerically Controlled (CNC) tool instruments, current NC computer variants have an embedded system that includes multiple microprocessors and associated electronics such as the Machine Control Unit (MCU). Multiple microprocessors and programmable logic controllers operate in CNC devices in conjunction for concurrent servo location and speed control of various parts of a contour milling device as well as tracking of the drawing method and machine tool.

3.9.1 ADVANTAGES

• Increased efficiency

• Quality improvement

• Reduced waste frequency

• Reliable and safe service

• Smaller footprint:

3.9.2 DISADVANTAGE

- Relatively greater price opposed to manual variants
- Due to the complex complexity of the techniques, more complicated servicing
- Skilled component programmers are needed.

CNC machine tool systems can be classified in various ways such as:

1. Point-to-point or contouring: depending on whether the machine cuts metal while the workpiece moves relative to the tool

2. Incremental or absolute: depending on the type of coordinate system adopted to parameterise the motion commands

3. Open-loop or closed-loop: depending on the control system adopted for axis motion control.

3.9.3 G & M CODES

G Codes

G00 - Rapid move (not cutting)

G01 - Linear move

G02 - Clockwise circular motion

G03 - Counter clockwise circular motion

G04 – Dwell

G05 - Pause (for operator intervention)

G08 – Acceleration

G09 - Deceleration

G17 - x-y plane for circular interpolation

G18 - z-x plane for circular interpolation

G19 - y-z plane for circular interpolation

G20 - turning cycle or inch data specification

G21 - thread cutting cycle or metric data specification

G24 - face turning cycle

G25 - wait for input to go low

G26 - wait for input to go high

G28 - return to reference point

G29 - return from reference point

G31 - Stop on input

G33-35 - thread cutting functions

G35 - wait for input to go low

G36 - wait for input to go high

G40 - cutter compensation cancel

G41 - cutter compensation to the left

G42 - cutter compensation to the right

G43 - tool length compensation, positive

G44 - tool length compensation, negative

G90 - absolute dimension program

G91 - incremental dimensions

G92 - Spindle speed limit

G93 - Coordinate system setting

G94 - Feed rate in ipm

G95 - Feed rate in ipr

G96 - Surface cutting speed

G97 - Rotational speed rpm

G98 - withdraw the tool to the starting point or feed per minute

G99 - withdraw the tool to a safe plane or feed per revolution

M Codes

M00 - program stop

M01 - optional stop using stop button

M02 - end of program

M03 - spindle on CW

M04 - spindle on CCW

M05 - spindle off

M06 - tool change

M07 - flood with coolant

M08 - mist with coolant

M08 - turn on accessory (e.g. AC power outlet)

M09 - coolant off

M09 - turn off accessory

M10 - turn on accessory

M11 - turn off accessory or tool change

M17 - subroutine end

M20 - tailstock back

M20 - Chain to next program

M21 - tailstock forward

M22 - Write current position to data file

M25 - open chuck

M26 - close chuck

M30 - end of tape (rewind)

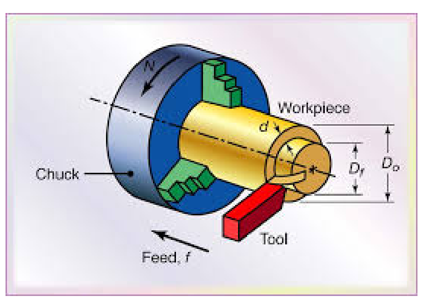

Figure 3-5 CNC Chuck[22]

A lathe moves the workpiece in a spindle while the workpiece is approached by a set cutting tool to cut off chips. Due to this geometry, lathes are perfect for components with symmetry around some core that could be chucked into the spindle.

"Turning" is the process of turning a workpiece on a lathe.

Typically, a CNC lathe is intended to use contemporary carbide tooling and procedures variants. A part can be customized and the tool paths of the machine are often programmed using the processes of CAD or CAM. A programmer can also model a portion or tool path digitally, however. The resulting coded computer file will then be uploaded to the CNC machine and the machine will then automatically produce the desired parts to be designed for.

CNC Lathe Main Parts

- 1 – Headstock
- 2 – CNC Lathe Bed
- 3 – Chuck
- 4 – Tailstock
- 5 – Tailstock Quill
- 6 – Foot Switch or Foot Pedals
- 7 – CNC Control Panel
- 8 – Tool Turret

Figure 3-6 CNC Lathe[21]

3.10 SURFACE ROUGHNESS

Surface roughness is a element of surface texture, often reduced to roughness. It is quantified from its optimal shape by the deviations in the path of a true surface's normal vector. The texture is harsh when these deviations are big; if they are tiny, the texture is soft. In surface metrology, roughness is typically regarded as the element of a weighed soil that is high-frequency, short-wavelength. In practice, however, to ensure that a surface is fit for a purpose, it is often necessary to know both the amplitude and the frequency. There are many distinct parameters of roughness in use, but it is by far the most prevalent, although this is often for historical reasons and not for specific value Ra, as the old roughness meters could only assess. Rq, Rt, and Rz are other popular parameters. Some parameters are only used in some sectors or in some nations.

Surface finish is the form of a ground, also recognized as surface texture or topography. It includes a surface's tiny local deviations from the completely smooth optimal (a real plane). Surface roughness is a element of surface texture, often reduced to roughness. It is quantified from its optimal shape by the deviations in the path of a true surface's normal vector. The texture is harsh when these deviations are big; if they are tiny, the texture is soft. Waviness is the metric of the surface texture's larger spaced element.

It is a wider perspective of roughness because it is more exclusively described as "the artefacts whose spacing is higher than the duration of the roughness testing" lay is the orientation of the ground structure usually determined by the technique of manufacturing.

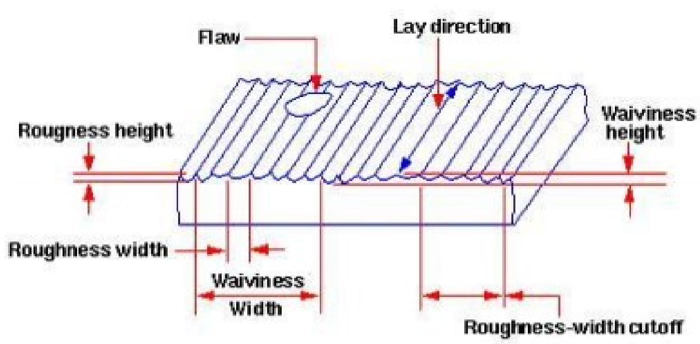

Figure 3-7 Surface Characteristics[11]

3.10.1 METHODS TO CALCULATE ROUGHNESS

1. Root -Means -Square roughness (Ra or RMS)

• Closely linked to the median roughness (Ra)

• Square the lengths, count them, and determine the count base of the consequence

• The subsequent valuation is a ground fabric comparative coefficient that is generally 11% greater than the Ra score.

2. Maximum Peak -Valley Roughness (Rmax or Rt)

• Determine the gap between the rows contacting the profile's maximum exterior and middle limit

• Second most common technique in sector

3. Ten -Point Height (Rz)

Means the range within the recording duration between the five highs and five lowest villages.

3.10.2 Taylor Hobson Talysurf

A skid or shoe traced over the layer of the workpiece so that it matches as closely as necessary the overall contours of the ground. The skid also offers the stylus A stylus datum that passes along with the skid over the ground, so that its movement is close to the skid vertically. This variable allows the stylus to record surface roughness contours regardless of surface waviness. An amplifier to magnify the motions of the stylus A tracking machine to generate a trace or track of the ground image.

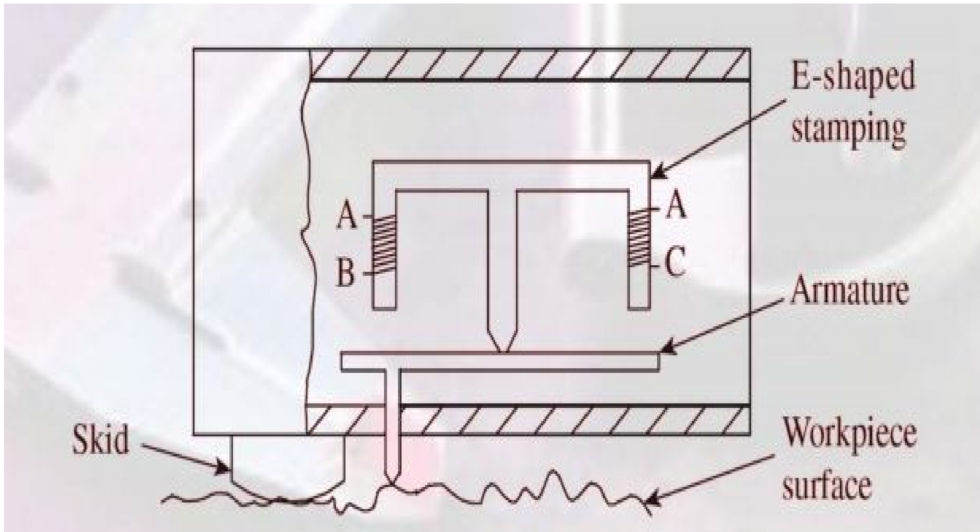

Figure 3-8 Schematic diagram of Talysurf instrument[11]

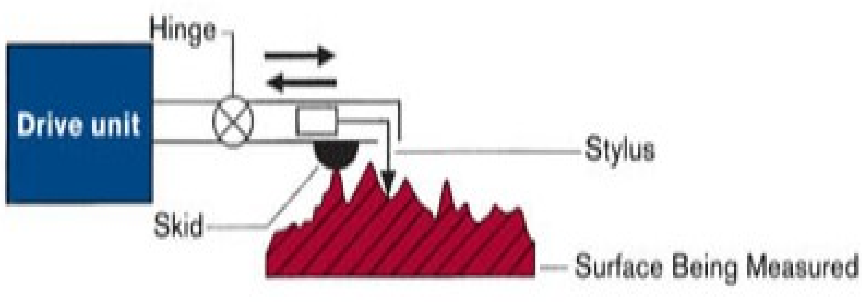

Figure 3-9 Surface Roughness measurement[11]

A stylus is connected to an armature rotating around the center of the part of a stamping formed' E.' E-shaped stamping's exterior feet are wounded with electrical coils. The coils are provided with a pre-determined price of alternating present (excitation current). The coils are component of a loop of a bridge. A skid or shoe gives the data to map the roughness of the ground. An electric motor can traverse the test rod in a linear route. Because of ground abnormalities, the armature is also squeezed as the stylus travels up and down. This creates wind gap variability and creates a link loop imbalance. The subsequent performance of the bridge loop comprises only of compression.

3.10.3 Analysis of Surface Traces

Centre Line Average (Ra) Value

Ra is the roughness parameter that is widely acknowledged. Roughness median Ra is the arithmetic average of the standard numbers of the ordinates of roughness analysis.

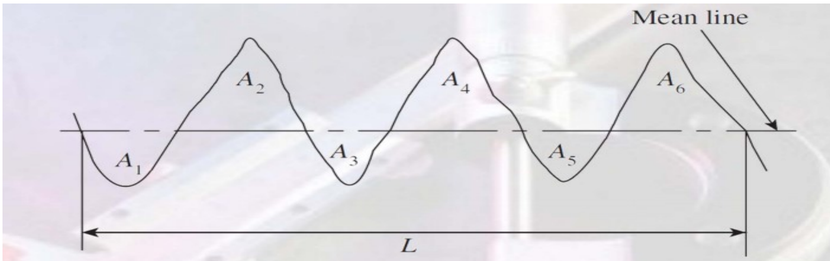

Figure 3-10 Graph for calculation of Ra[15]

$$Ra = \frac{A_1 + A_2 + \ldots + A_N}{L}$$

Figure 3-11 Formula for calculation of Rap[15]

• Roughness Average, Ra, is the arithmetic average of absolute profile height values over the length of the assessment.

• RMS Roughness, Rq, is the root mean square average of the profile heights over the assessment length

• Maximum heights within the sampling length, Rti, the vertical distance between the highest and lowest profile points within the sampling length.

• Average Maximum Profile Height, Rz, is the average calculated over the evaluation length of the successive Rti values. This parameter is the same as Rz (DIN) if within the duration of the assessment there are five sampling times.

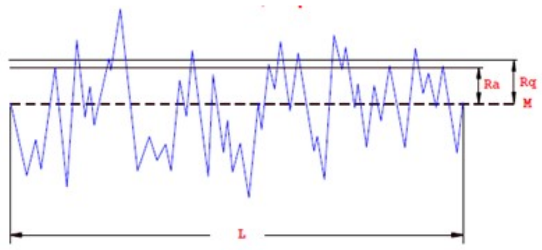

Figure 3-12 Calculation for Ra,Rq[18]

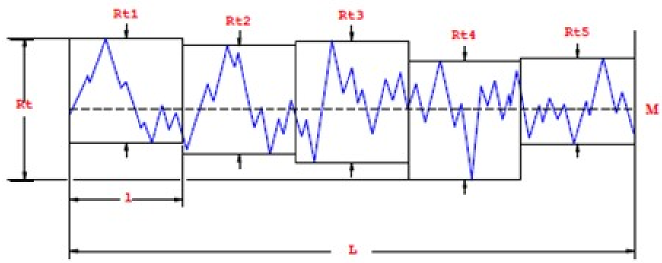

Figure 3-13 Calculation for Rt, Rti, Rz,Rz(DIN),Rmax[18]

3.11 MATERIAL REMOVAL RATE

The MRR is a variable that impacts the frequency and price of machining of the machining hour. Turning is one of the procedures of machining that involves removing extra / unwanted content from a spinning job piece's ground. A single point cutting tool is used. In converting activities, the resource reduction frequency (MRR) is the amount of material / metal that is collected in mm3/sec per variable moment. A ring-shaped coating of fabric is separated for each job item revolution. The parameters that are carried into account are feed prices, spindle speed, trimmed length. The greater the parameters you cut, the greater the MRR.

Material Removal Rate (MRR) is calculated from the multiplication of cutting speed, feed rate and depth of cut by using the relation:

Material Removal Rate (MRR) for Turning:

MRR= Volume removed/cutting time

Where

Volume removed = (initial mass-final mass)/density of material

3.12 TEMPERATURE MEASUREMENT

THERMAL IMAGING CAMERA

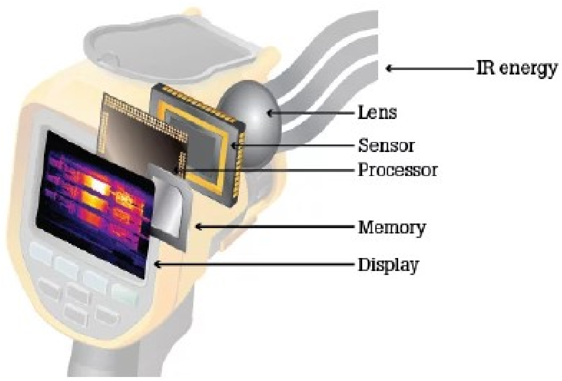

Figure 3-14 Infrared Imaging Camera[25]

All items, recognized as a heat mark, emit infrared energy. The infrared energy of objects is detected and measured by an infrared camera (also known as a thermal imager). The camera transforms that infrared information into an electronic picture that demonstrates the obvious surface temperature of the item being measured. An infrared camera includes an optical system that relies on an infrared power panel (sensor panel) that includes thousands of detector pixels organized in a grid. The camera processor requires the message from each pixel to generate a colour map of the object's apparent temperature by applying a mathematical calculation to it. A distinct colour is allocated to each temperature range. As a colour picture (heat image) of that object, the corresponding colour matrix is sent to the memory and camera screen. Many infrared devices also include a visible light camera that automatically captures a normal digital image with each trigger pull. By mixing these pictures, it is simpler to correlate issue regions with the real machinery or region you are checking in your infrared picture.

3.13 X-RAY DIFFRACTION

The remaining forces are evaluated up to the altitudes of 30μm by evaluating the inter-atomic spacing of the fabric using the mobile devices μ-X360n. X-rays have the same order of wavelength as material inter planar ranges. When X-rays strike the surface of materials it gets scattered to form constructive to destructive interference of a diffracted beam. The equipment also measures the angle of maximum diffraction interference. The angles measured from interferences will be used to measure inter planar distances (d0). The presence of residual stress in sample changes the d spacing which can be measured with the help of bragg's law. The difference of d-spacing according to bragg's law is directly proportional to strain which can be used to calculate residual stress.

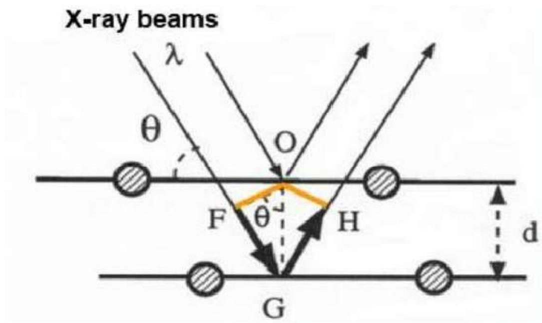

Figure 3-15 Schematic diagram of X-Ray diffraction[17]

3.13.1 Cos α Method

The conventional Sin2ψ case method with a point detector (diffract meter) needs a sequence of readings with distinct sample orientations with regard to the diffract meter in order to achieve the projection of the strain tensor along the various distinct scattering vector orientations, and these guidelines are selected to simplify later evaluation.

Since each object in the Debye loop arises from a distinct angle of the resulting matrix for a specified test profile in studio locations, the entire Debye loop can be used when using a 2D sensor and a range of propagation matrix orientations are concurrently tested in a separate test.

Because of its convenience of use, the use of mobile residual stress analyzers has now risen. The cosα technique has emerged as a quicker and simpler technique of experimentally assessing remaining stress by using mobile equipment because of its capacity to detect a whole Debye loop at once from the two-dimensional sensor, thus needing no various test tilts as in the event of Sin2ψ technique.

3.13.2 Portable X-Ray Device to Measure Residual Stress by using Cos α method

A mobile Pulstec Industrial Co. Ltd. X-ray instrument (μ-X360 remaining pressure analyzer) installed on a solid panel is used to assess remaining pressure after TIG 6063 burning. Different marks on longer and narrower plates on both the compression and strain hand are labelled across the length of the sample after swinging along the tube shaft. The stress analyzer's detector gun is inclined for the aluminum at an angle of 25 ° to obtain the precise outcomes.

The specimen is placed on the adjustable table exposing the surface to be assessed for the residual stress establishing a red laser spot (about 2 mm) on the mark where the X-ray beam is to be applied**.**

Figure 3-16 Experimental set-up for residual stress measurement using portable X-ray machine (μ-X360)

Table 3-5 Specifications of the X-ray machine (μ-X360)

X-ray Tube Voltage, Current	30 KV, 1.0 mA
Target Material	Chromium (Cr)
Beam Wavelength (Energy)	λ= 2.29 Å (E = 5.4 KeV)
Collimator and Beam Spot Size	1 mm and 2 mm diameter
Sample to Detector Distance Approx.	35-40 mm
Typical Data Acquisition + Readout Time	90 seconds

3.13.3 Principle of residual stress by the Cos α method

This method acquires the full Debye-Sherrer ring. A Debye-Scherre ring is obtained by using an image plate (IP) and the data obtained from image as analyzed for determining the value of stress. The translation of the laboratory system (diffractometer system) to the sample system is inherently more complex due to the 2D planar geometry of the measurement.

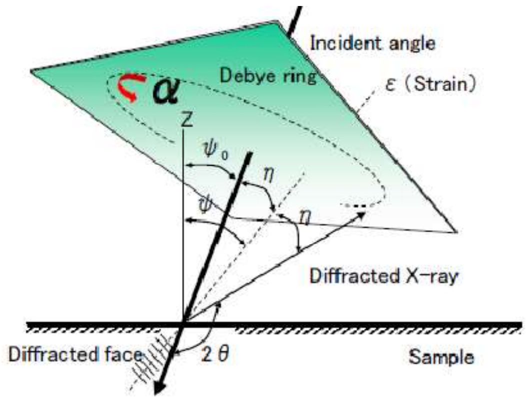

Figure 3-16 Geometric representation of the angles α, Ψ, η and 2θ on the Debye ring[17]

The expression for the translation of strain,

$\varepsilon_\alpha = n_i n_j \varepsilon_{ij}$

Where n is the diffraction vector, which can be expressed in the form

$$n = \begin{bmatrix} \cos\eta \sin\psi_o + \sin\eta \cos\psi_o \cos\alpha \\ \cos\eta \sin\psi_o \sin\emptyset_o + \sin\eta \cos\psi_o \sin\psi_o \cos\alpha + \sin\eta \cos\emptyset_o \sin\alpha \\ \cos\eta \cos\psi_o - \sin\eta \sin\psi_o \cos\alpha \end{bmatrix}$$

Now this value of n can be inserted into Hooke's law to form

$$\varepsilon_\alpha = \frac{1+\upsilon}{E} n_i n_j \varepsilon_{ij} - \frac{\upsilon}{E}\sigma_{kk}$$

The magnitude of strain is determined from the detected position of the Debye-Scherrer ring. Calculate using the following formula.

$$\varepsilon_{\alpha 1} = \frac{1}{2}\{(\varepsilon_\alpha - \varepsilon_{\pi+\alpha}) + (\varepsilon_{-\alpha} - \varepsilon_{\pi-\alpha})\}$$

$$\varepsilon_{\alpha 2} = \frac{1}{2}\{(\varepsilon_\alpha - \varepsilon_{\pi+\alpha}) - (\varepsilon_{-\alpha} - \varepsilon_{\pi-\alpha})\}$$

Hence the value of stress is calculated from the strain using proper elastic and other constants.

$$\sigma_x = -\frac{E}{1+\upsilon} \cdot \frac{1}{\sin 2\eta} \cdot \frac{1}{\sin 2\psi_o} \cdot \left(\frac{\partial \varepsilon \alpha_1}{\partial \cos\alpha}\right)$$

CHAPTER 4

EXPERIMENTATION

4.1 FABRICATION OF COMPOSITES

Al 6063 –T6 alloy was used as the matrix and two different reinforcement are being used-one is synthetic-$B_4C$of mesh size 150 6 wt% and the other is antural one-Egg shell with 6% wt and mesh size 150 in the AMCs.

Liquid metallurgy stir casting method was adopted for composite fabrication, which essentially included following steps , i.e. melting of matrix alloy, preheating of reinforcement particulates, mixing of preheated particulates into molten alloy, solidification

Step 1. A graphite crucible of cylindrical in shape ,having a maximum working temperature of 2700°C and required dimension,220 V, 3-phase electrical resistance furnace (maximum working temperature 1500°C) was used for melting of the matrix alloy and composite slurry preparation. It was mounted with a K-type thermocouple with a maximum range of 1200°C and speed regulated motorized stirring system.

Step 2.The B4C were heated to 350°C for 45 min using muffle furnace before mixing with the molten alloy. Preheating of B4C is necessary to oxidize their surface remove moisture and Improve wettability in matrix material

Step 3.Similarly as in step 2,egg shell powder was heated to a temperature of 250 for about 15 min using muffle furnace. Preheating of egg shell is necessary to oxidize their surface remove moisture and Improve wettability in matrix material

Step 4 Three types are composite has to be prepared by adding the reinforcement one by one and simultaneously.

Step 5 -Before addition of preheated B4C and egg shell, vortex was created on the surface of molten alloy by motorized stirring at stirring speed of **400rpm**. The particulates were added at slow rate (approximately 10 g/min) using a funnel and rod , into the vortex of molten alloy. The stirrer speed was then slowly increased to 220 rpm and stirring was continued for 10 minutes more. The stirrer blades were positioned at one-third of the depth of the molten slurry from its surface, to enable proper mixing.

Step 6-Reinforcemnt is added to the molten state of Al-6063 T6 in three steps.

6.1 In the First composite, eggshell powder in added to the molten state of Al-6063 T6 and stirrer made to rotate into it.

6.2 In the second composite, B4C is added to the molten state of aluminum alloy and stirrer is made to rotate.

6.3 In the third composite, a hybrid composite is made by adding B4C and egg shell simultaneously to the molten state of Al-6063 T6 present in the crucible and stirrer is made to rotate.

Step 7.After mixing the reinforcement/s for about 15 min with the help of stirrer ,stirrer is taken out and composite slurry is allowed to get cool and solidify and then the cast AMC was removed out of the graphite crucible

After casting out the all the composite out of the crucible, proper turning and finishing is done on its outer surface on the lathe machine using carbide tip cutting tool.

Figure 4-1 Fabricated composite

Figure 4-2 Stir Casting equipment

Figure 4-3Egg shell

Figure 4-4 Ball Milling Machine

4.2 ANALYSIS OF PARAMETERS

4.2.1 CNC TURNING

In order to calculate the MRR for each composite, each composite is placed in the cnc machine for the turning operation.

First the total weight of each composite was measured using weighing machine and was noted down. After this, each composite was individually placed in the CNC machine for being turned. During turning, the values of different parameters were taken care of such that the value of each parameter was kept constant during the turning operation which are as follows-

Table 4-1Parameters values for CNC turning

PARAMETERS	**VALUES**
Cutting speed (rpm)	500
Feed rate(mm/rev)	0.1
Depth of cut(mm)	0.5

After being turned according to the above parameters, the samples were taken out of the CNC machine and again being weighed on the weighing machine.

On the basis of weights being measured before and after the turning operations, following formula are being used to calculate the MRR

MRR= Volume removed/cutting time Where Volume removed = (initial mass-final mass)/density of material

Figure 4-5 Base alloy Al 6063 T6

Figure 4-6 AMC with egg shell

Figure 4-7 AMC with B_4C

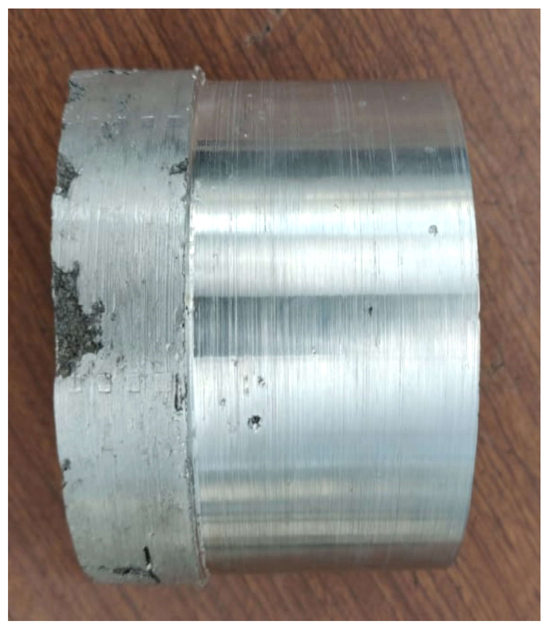

Figure 4-8 Hybrid AMC

4.2.1.1 HORIZONTAL LATHE SPECIFICATIONS

LMW LL20T L3

Figure 4-9 CNC LATHE

CAPACITY

- Swing Over bed=510 mm
- Chuck dia. Max=210 mm
- Max. Turning diameters=320 mm
- Max. Turning Length=310 mm
- Admit between Centers=420 mm

SPINDLE

- Spindle nose type=A2-6
- Hole through spindle mm=61
- Spindle speed rpm=3000(3500)
- Spindle motor power=15 min/Cont.(S6-40%/Cont.) kW=11 / 7.5 (10.5 / 7)

FEED

- Cross travel X-axis mm=185
- Longitunal travel Z-axis mm=370

- Rapid traverse rate X/Z axes m/min=30

TURRET

- No. of stations nos.=8
- Tool shank size mm=25 x 25
- Max. Boring bar dia mm=40
- Turret Indexing type=Bi-directional
- Turret Indexing time sec=1.0

TAILSTOCK

- Quill dia mm=75
- Quill stroke mm=100
- Quill taper=MT-4

CNC SYSTEM

- Controller=Fanuc / (Siemens)

MACHINE SIZE

- Front x Side mm=2065 x 1650 x 1920
- WeightKg=3200

4.2.1.2 CNC PROGRAMMING

G28 U0 W0;

T0707;

G99 M 03 S 500;

G00 X 80.0 Z 2.0;

G01 X 74.0 F 0.1;

Z -50.0;

```
;
G0 X 90.0;
Z 2.0;
G 28 U0 W0;
M 05;
M 30;
```

4.2.2 TEMPERATURE MEASUREMENT USING INFRARED CAMERA

- For the experiment, FlukeTI-400 Handheld thermal infrared camera has been used for the non contact measurement of temperature at the tool-workpiece interface.
- To begin with first set the emissivity of the camera which is Emissivity(ε)can be defined as the ratio of the energy radiated by an object at a given temperature to the energy emitted by a perfect radiator, or blackbody, at the same temperature. The emissivity of a blackbody is 1.0. All estimations of emissivity fall somewhere in the range of 0.0 and 1.0.
- So the value taken was ε=0.95
- After this, particular composite was mounted on the CNC lathe machine and turning operation were performed on it.
- During turning, the thermal imaging camera is projected towards the tool-work piece interface from beginning till end such that temperature being measured at various steps.
- While measurement some of the critical consideration has to be considered such as- field of view (target size and distance), kind of surface being estimated (emissivity considerations), temperature range and mounting (handheld convenient or fixed mount,) and environment.
- The measured temperature is stored in the camera in the form of three reading-maximum temperature, minimum temperature and average temperature.
- These reading will used for the comparison later on.

4.2.2.1 Fluke Ti400 PRO Thermal Camera

Figure 4-10 Thermal Imaging Camera

- Infrared resolution=640 x 480 (307,200 pixels)
- Super Resolution=No
- Minimum focus distance=15 cm (approx. 6 in)
- Built-in digital camera (visible light) =5MP
- Frame rate=60 Hz or 9 Hz versions
- Laser pointer=Yes
- Temperature measurement range (not calibrated below -10 °C)=-20 °C to +650 °C
- Accuracy=±2 °C or 2 % (at 25 °C nominal, whichever is greater)
- On-screen emissivity correction=Yes (both value and table)
- Color alarms (temperature alarms)=High temperature, low temperature, and isotherms (within range)
- Infrared spectral band=7.5 μm to 14 μm (long wave)
- Operating temperature=-10 °C to +50 °C (+14 °F to +122 °F)
- Storage temperature=-20 °C to +50 °C (-4 °F to +122 °F) without batteries
- Relative humidity=10 % to 95 % non-condensing
- Center-point temperature measurement=Yes
- Spot temperature=Hot and cold spot markers User-definable

4.2.3 SURFACE ROUGHNESS

- For the measurement of the surface roughness, Taylor Hobson handheld instrument is being used.
- To take reading, four points are being marked on the best finished surface of each composite.
- Sample are placed between the V-blocks for the proper support and stability.
- A typical surface measuring instrument will consist of a stylus with a small tip, a gauge or transducer, a traverse datum and a processor.
- The surface is measured by moving the stylus across the surface which moves to and fro along the surface in the straight line , the transducer converts this movement into a signal which is then exported to a processor which converts this into a number and usually a visual profile.
- For correct data collection, the gauge needs to pass over the surface in a straight line such that only the stylus tip follows the surface under test.
- After the completion of the test R_a value is collected for each sample and average is taken out.

SURTRONIC S-100 SERIES

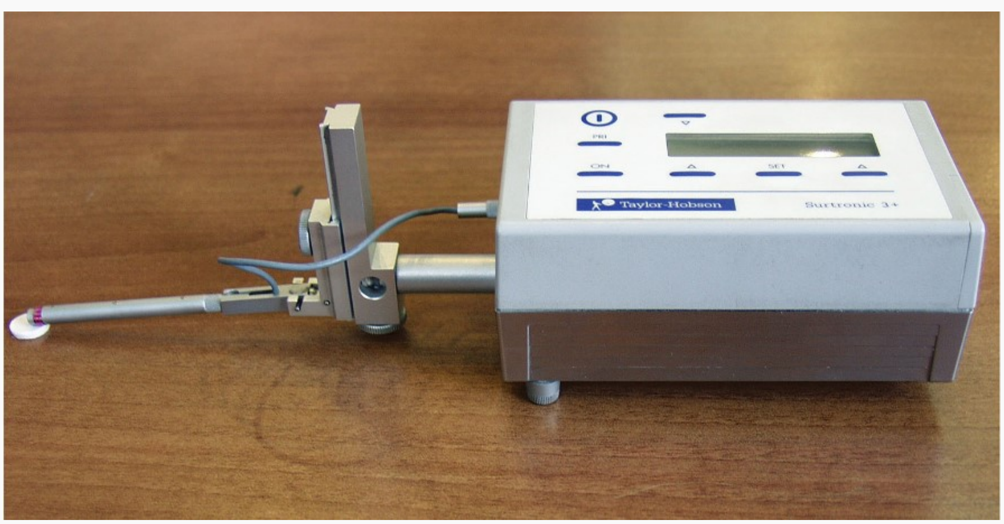

Figure 4-11Taylor Hobson Talysurf instrument

- Measurement capability
- Gauge Range=200 µm / 100 µm / 10 µm
- Resolution=100 nm / 20 nm / 10 nm
- Noise floor (Ra)=250 nm / 150 nm / 100 nm
- Repeatability (Ra)=1 % of value + noise
- Pickup type=Inductive
- Gauge force=150-300 mg
- Stylus tip radius=5 µm (200 µin)
- Measurement type=Skidded
- Calibration Process=Automated software calibration routine
- Standards=Able to calibrate to ISO 4287 roughness standards
- Evaluation length=0.25 mm - 17.5 mm (0.01 in - 0.70 in)
- Measuring speed=1 mm / sec (0.04 in / sec)
- Returning speed=1.5 mm / sec (0.06 in / sec)
- Analysis capability
- Standards=ISO 4287, ISO 13565-1, ISO 13565-2, ASME 46.1, JIS 0601, N31007
- ISO basic=Ra, Rv, Rp, Rz, Rt, Rq, Rsk, Rmr, Rdq, Rpc, RSm, Rz1max
- Units=µm / µin

4.2.4 RESIDUAL STRESS

- Residual stress measurement is done using portable X-ray machine (µ-X360)
- In order to measure the residual stress in the prepared sample, four marking are done on the surface of the sample
- Sample is placed on the V-block under the laser
- Focus of collimator is done on specimen using laser in order to Irradiated the marked point.
- After a particular time , diffraction-peak location and stress values are detected and recorded.

Figure 4-12Experimental set-up for residual stress measurement using portable X-ray machine (μ-X360)

Table 4-2 Specifications of the X-ray machine (μ-X360)

X-ray Tube Voltage, Current	30 KV, 1.0 mA
Target Material	Chromium (Cr)
Beam Wavelength (Energy)	λ= 2.29 Å (E = 5.4 KeV)
Collimator and Beam Spot Size	1 mm and 2 mm diameter
Sample to Detector Distance Approx.	35-40 mm
Typical Data Acquisition + Readout Time	90 seconds

CHAPTER 5

RESULT AND DISCUSSION

This chapter deals with the analysis of the data collected for the various tests conducted on the alloy Al-6063 T6 and three composites prepared with Boron Carbide and egg shell powder individually and in hybrid.

1) EVALUATION OF MRR

Material removal rate of base alloy Al 6063 T6 and three AMC's has been calculated br recording the weight of the specimen before and after truning it on the CNC lathe and keeping the process parameters constant for all the specimen.

Sample 1:Aluminum Alloy 6063 T6

- Mass before turning=1.319 kg
- Mass after turning=1.3153 kg
- Volume=1370.3703 mm^3
- Time=60 sec
- MRR=22.8395 mm^3/sec

Sample 2: Composite of Egg shell

- Mass before turning=1.143 kg
- Mass after turning=1.1377 kg
- Volume=1962.9629 mm^3
- Time=60 sec
- MRR=32.7160 mm^3/sec

Sample 3: Composite of Boron Carbide

- Mass before turning=1.004 kg
- Mass after turning=0.9992 kg
- Volume=1777.7778 mm^3
- Time=60 sec

- MRR=29.6296 mm^3/sec

Sample 4: Composite of Egg shell and Boron carbide

- Mass before turning=1.087 kg
- Mass after turning=1.0817 kg
- Volume=1962.9629 mm^3
- Time=60 sec
- MRR=32.7160 mm^3/sec

Based on above readings, a bar graph has been plotted below.

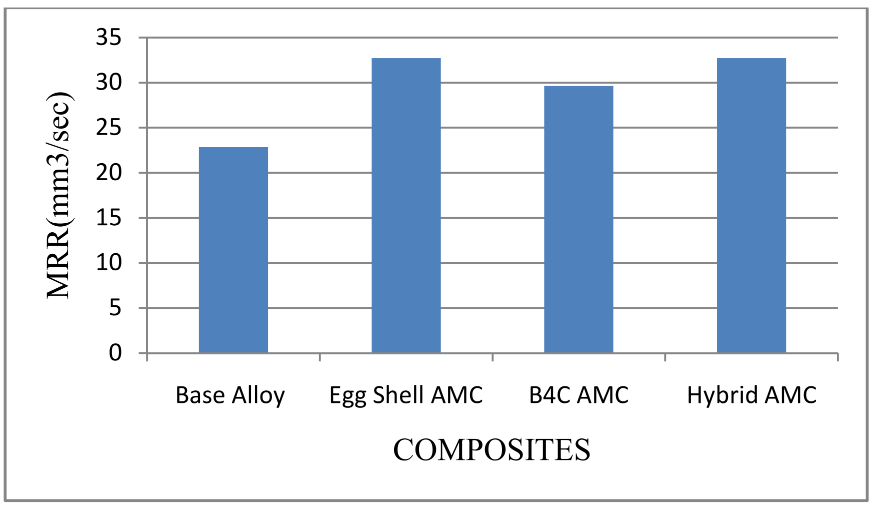

Figure 5-1 Bar graph between MRR and AMC's

From the above graph, it is concluded that among all, Base alloy has the minimum MRR whereas the MRR for Eggshell AMC and Hybrid AMC are near by neck to neck having a same value.

2) Evaluation of Residual Stress

Residual stresses are the stress which always generate mainly during machining process. Having a tensile residual stress have a damaging effect on the component whereas compressive stress can be proved advantageous in many case. In this experiment, residual stress has been measured at four points on each three AMC’s and base alloy and their average has been calculated.

(a)Base Alloy Al 6063

Point 1

Figure 5-2 Camera image of point1

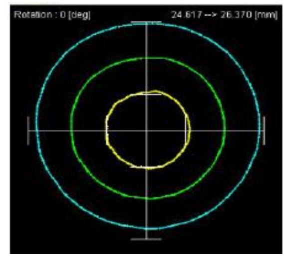

Figure 5-3 Distortion graph of point 1

Residual Stress

Normal stress=(-)60 MPa

Shear stress=(+)16 MPa

Point 2

Figure 5-4Camera image of point 2

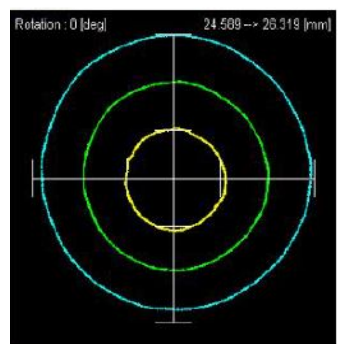

Figure 5-5 Distortion graph of point 2

Residual Stress

Normal stress=(-)33 MPa

Shear stress=(+)15 MPa

Point 3

Figure 5-6 Camera image of point 3

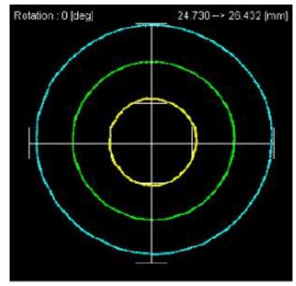

Figure 5-7 Distortion graph of point3

Residual Stress

Normal stress=(-)45 MPa

Shear stress=(+)20 MPa

Point 4

Figure 5-8 Camera image of point 4

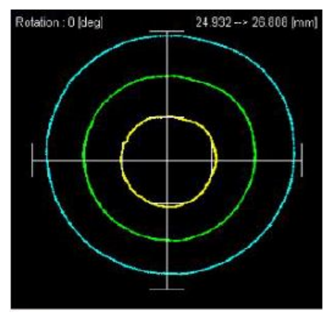

Figure 5-9 Distortion graph of point 4

Residual Stress

Normal stress=(-)56 MPa

Shear stress=(+)31 MPa

Average of Normal=(-)48.5 MPa and Shear=(+)20 MPa

(b)AMC with Eggshell

Point 1

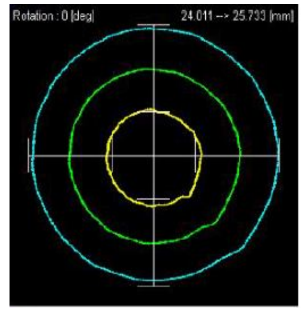

Figure 5-10 Camera image of point1

Figure 5-11 Distortion graph of point1

Residual Stress

Normal stress=(+)14 MPa

Shear stress=(+)3 MPa

Point 2

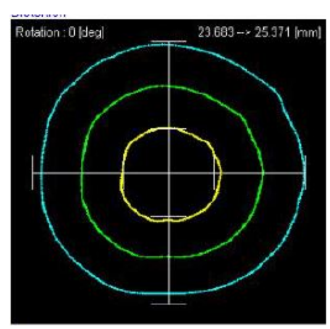

Figure 5-12 Camera image of point2

Figure 5-13 Distortion graph of point2

Residual Stress

Normal stress=(+)13 MPa

Shear stress=(+)10 MPa

Point 3

Figure 5-14 Camera image of point3

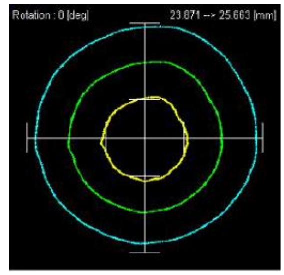

Figure 5-15 Distortion graph of point3

Residual Stress

Normal stress=(-)18 MPa

Shear stress=(+)12 MPa

Point 4

Figure 5-16 Camera image of point4

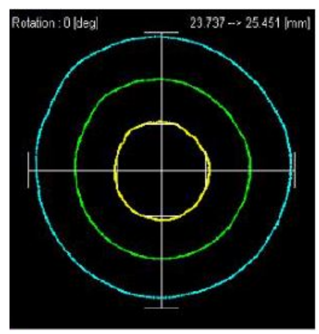

Figure 5-17 Distortion graph of point4

Residual Stress

Normal stress=(-)20 MPa

Shear stress=(-)5 MPa

Average of Normal=(-)11 MPa and Shear=(+)20 MPa

(c)AMC with B4C

Point 1

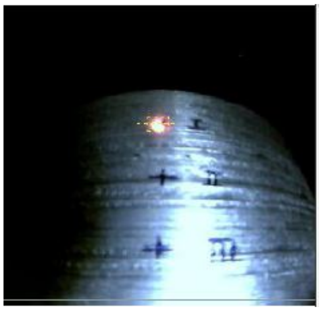

Figure 5-18 Camera image of point1

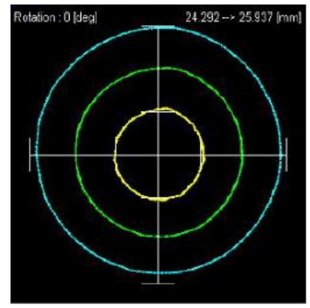

Figure 5-19 Distortion graph of point1

Residual Stress

Normal stress=(-)35 MPa

Shear stress=(+)5 MPa

Point 2

Figure 5-20Camera image of point2

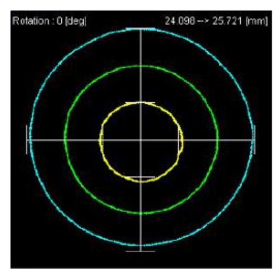

Figure 5-21 Distortion graph of point2

Residual Stress

Normal stress=(-)7 MPa

Shear stress=(-)0 MPa

Point 3

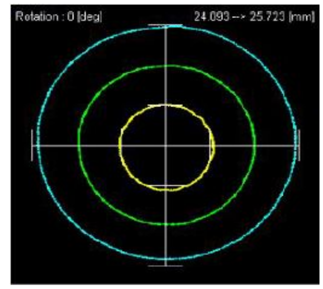

Figure 5-22Camera image of point3 Figure 5-23 Distortion graph of point3

Residual Stress

Normal stress=(-)13 MPa

Shear stress=(+)5 MPa

Point 4

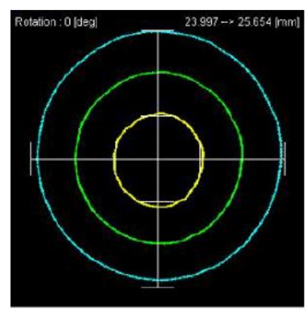

Figure 5-24 Camera image of point4 Figure 5-25 Distortion graph of point4

Residual Stress

Normal stress=(-)17 MPa

Shear stress=(+)20 MPa

Average of Normal=(-)18 MPa and Shear=(+)4.5 MPa

(d)Hybrid AMC

Point 1

Figure 5-26Camera image of point1

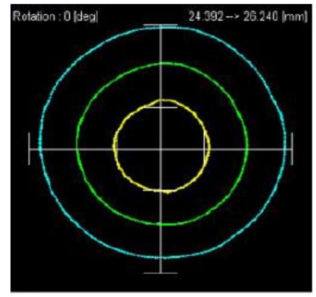

Figure 5-27 Distortion graph of point1

Residual Stress

Normal stress=(-)67 MPa

Shear stress=(+)17 MPa

Point 2

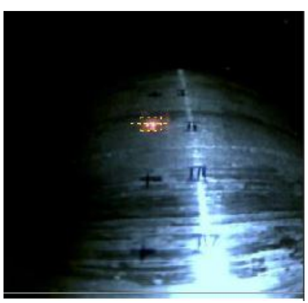

Figure 5-28Camera image of point2

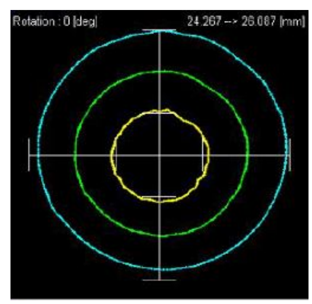

Figure 5-29 Distortion graph of point2

Residual Stress

Normal stress=(-)26 MPa

Shear stress=(+)18 MPa

Point 3

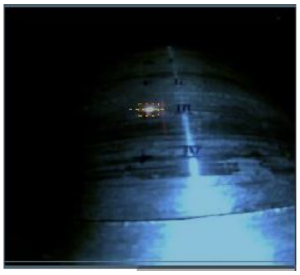

Figure 5-30 Camera image of point3

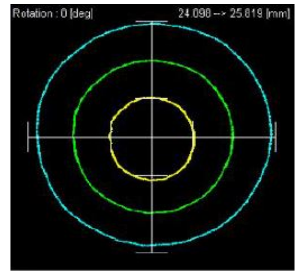

Figure 5-31 Distortion graph of point3

Residual Stress

Normal stress=(-)13 MPa

Shear stress=(+)9 MPa

Point 4

Figure 5-32 Camera image of point4

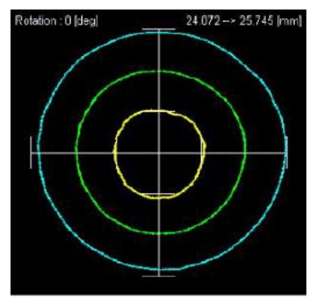

Figure 5-33 Distortion graph of point4

Residual Stress

Normal stress=(-)18 MPa

Shear stress=(+)12 MPa

Average of Normal=(-)31 MPa and Shear=(+)14 MPa

From the above calculated average value and analyzing the graphs, it is revealed that after performing CNC turning operation on Base alloy and prepared AMC's by keeping process parameters constant for all, that the normal residual stress is of compressive nature whereas shear residual stress is of tensile nature. Base alloy has the maximum value of both -normal residual stress with value equal to (-)48.5 MPa as well as shear residual stress with value (+)20.5 MPa as compared to fabricated aluminum metal matrix composites. The reason for being this is that base alloy has the maximum value of surface roughness Ra=4.7925 µm among all the AMC's .This same trend can be seen in other AMC's.

3) Evaluation of Surface Roughness

In this study ,Taylor Hobson's Talysurf surface roughness tester has been used to analyze the roughness of the turned parts surface where roughness tester comes in contact with turned surface for a couple of seconds and shows the roughness profile and Ra and other values through computerized data. Analysis has been done on four points on the surface of each specimen and their average value has been calculated.

a)Base Alloy Al 6063

Point 1

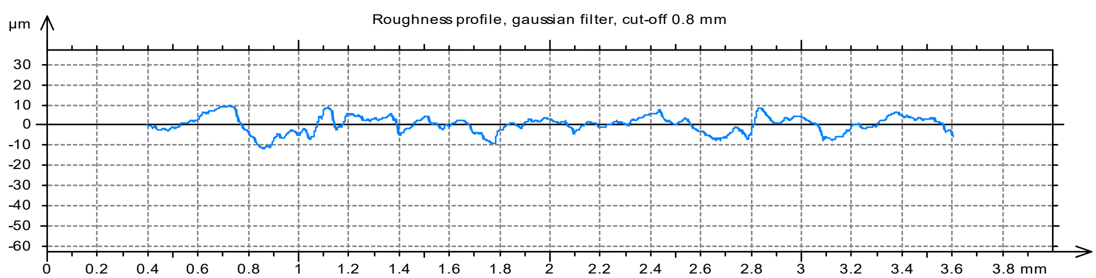

Figure 5-34 Roughness Graph for point 1

Ra=3.35 µm

Point 2

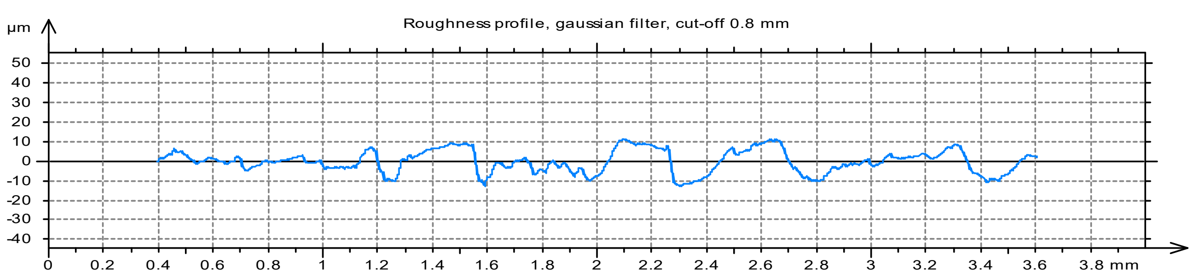

Figure 5-35 Roughness Graph for point 2

Ra=4.87 µm

Point 3

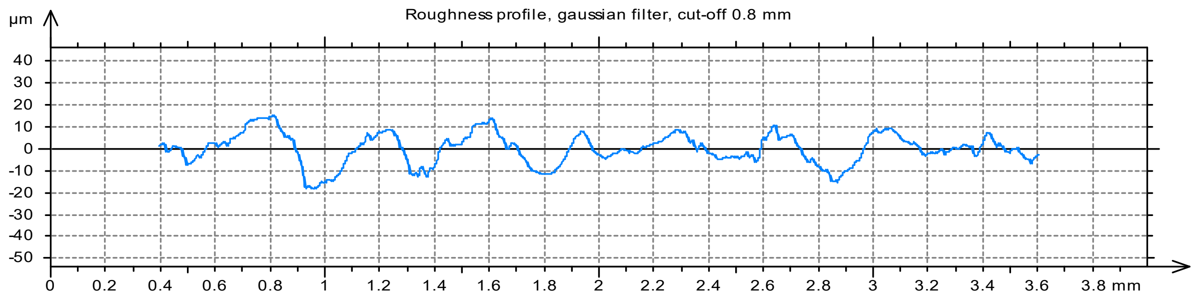

Figure 5-36 Roughness Graph for point 3

Ra=5.87 µm

Point 4

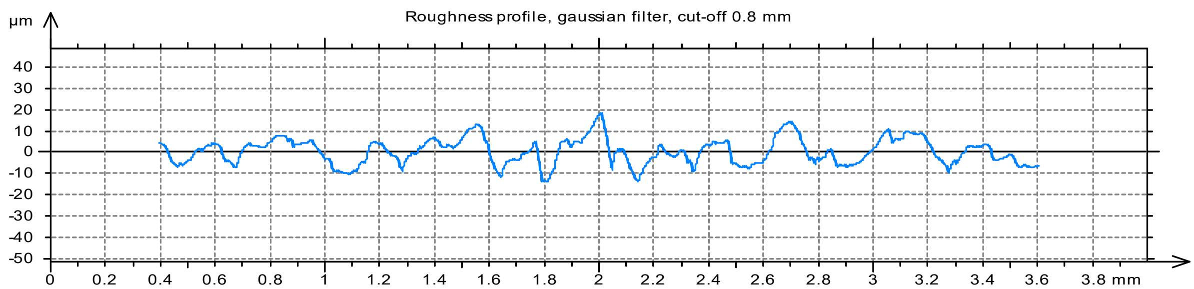

Figure 5-37 Roughness Graph for point 4

Ra=5.08 µm

Average value of Ra=**4.7925 µm**

b)AMC with Eggshell particles

Point 1

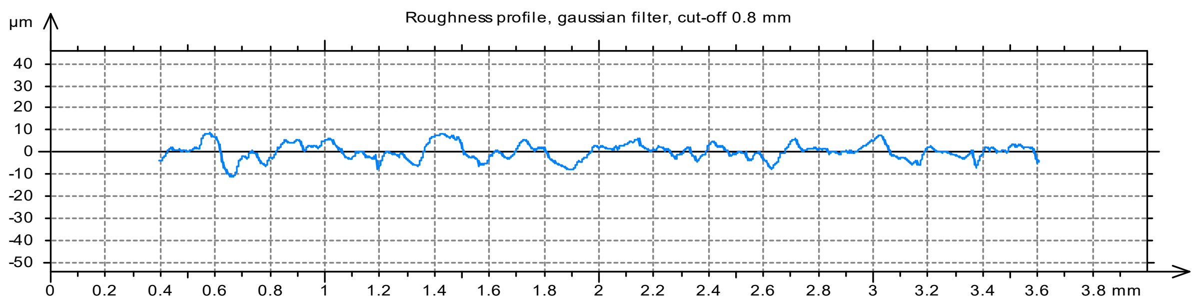

Figure 5-38 Roughness Graph for point 1

Ra=3.08 µm

Point 2

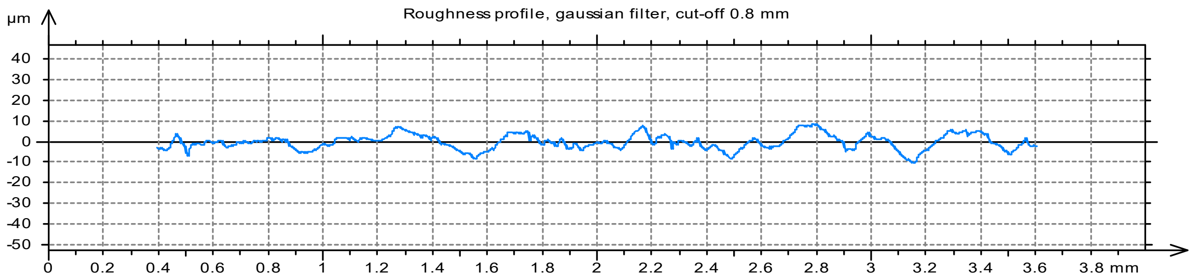

Figure 5-39 Roughness Graph for point 2

Ra=2.64 µm

Point 3

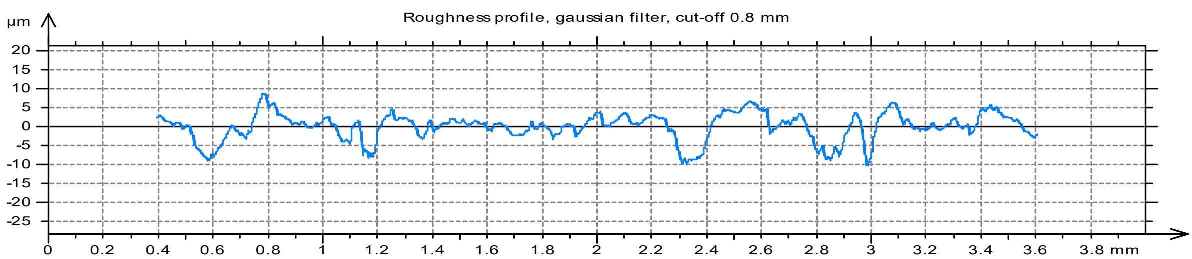

Figure 5-40 Roughness Graph for point 3

Ra=2.56 µm

Point 4

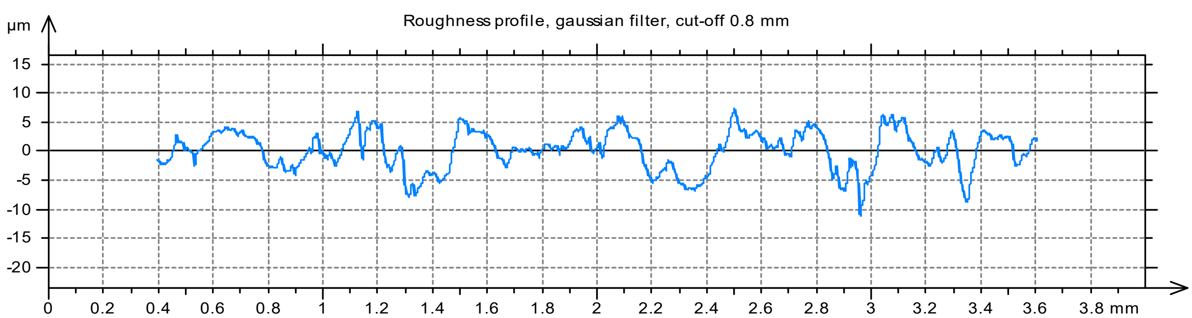

Figure 5-41 Roughness Graph for point 4

Ra=2.61 µm

Average value of Ra=**2.7225 µm**

c) AMC with B_4C particles

Point 1

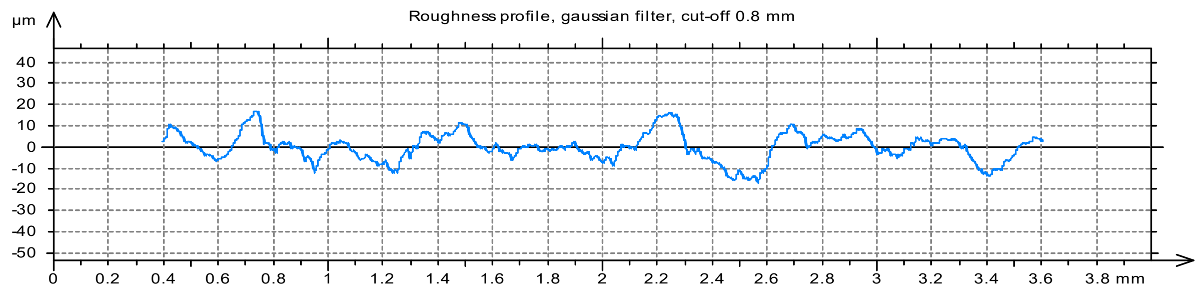

Figure 5-42 Roughness Graph for point 1

Ra=5.29 µm

Point 2

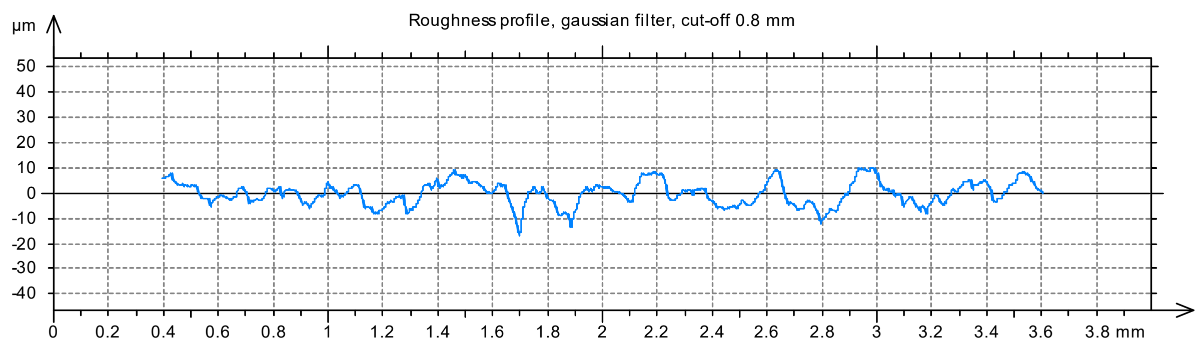

Figure 5-43 Roughness Graph for point 2

Ra=3.59 µm

Point 3

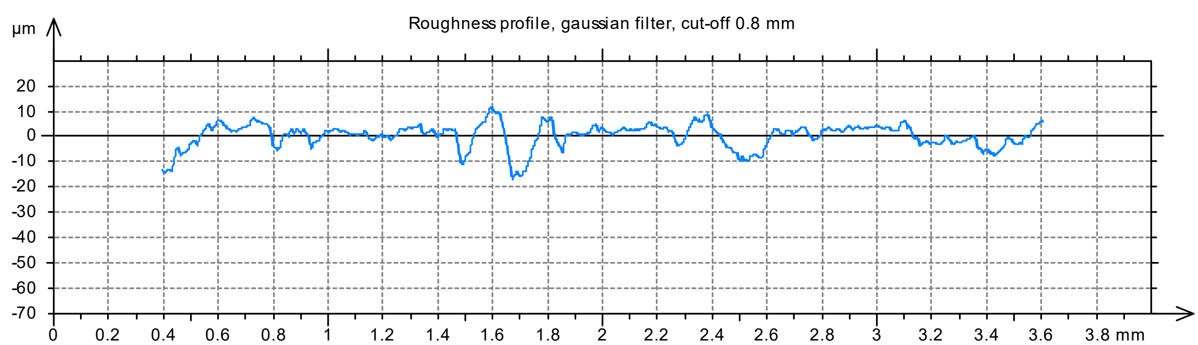

Figure 5-44 Roughness Graph for point 3

Ra=3.75 µm

Point 4

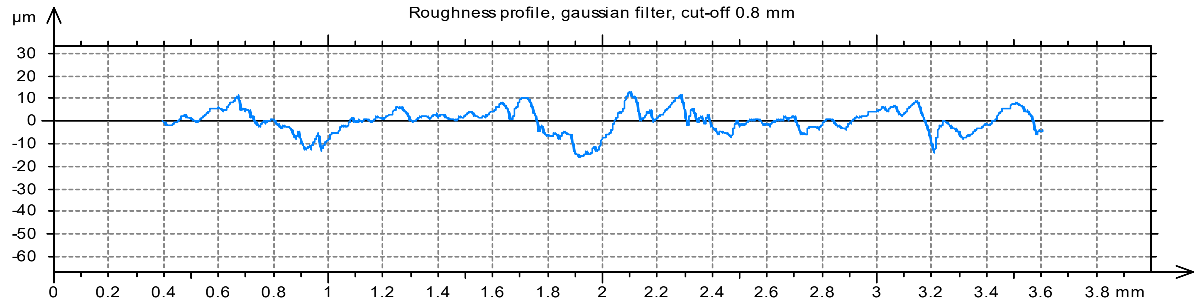

Figure 5-45 Roughness Graph for point 4

Ra=4.14 µm

Average value of Ra=**4.1925 µm**

d) Hybrid AMC

Point 1

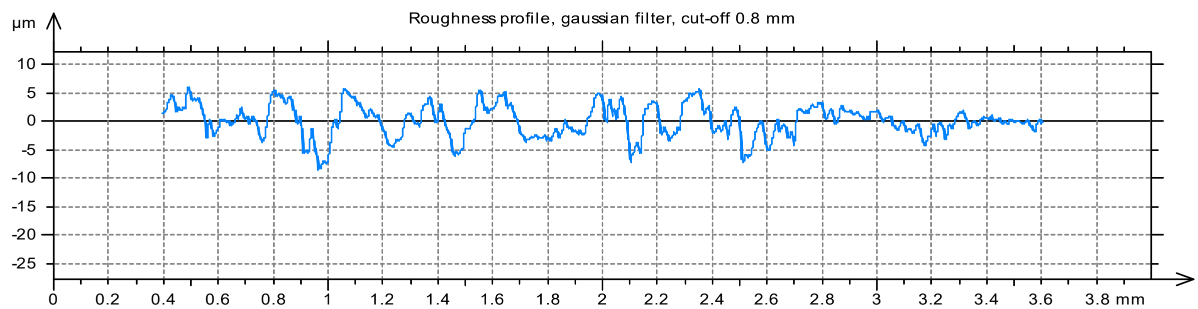

Figure 5-46 Roughness Graph for point 1

Ra=2.59 µm

Point 2

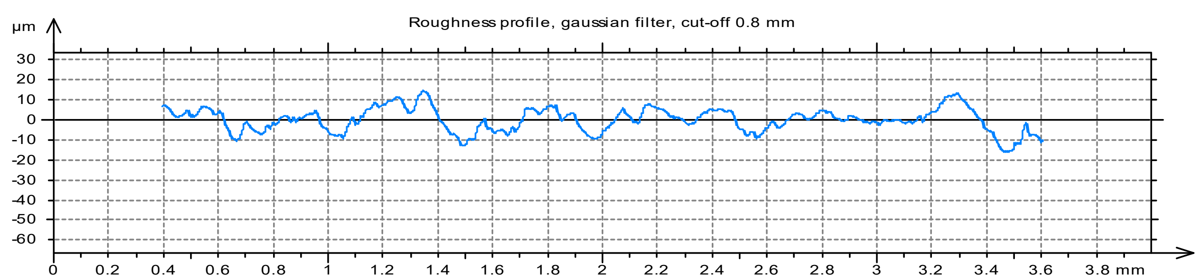

Figure 5-47 Roughness Graph for point 2

Ra=4.57 µm

Point 3

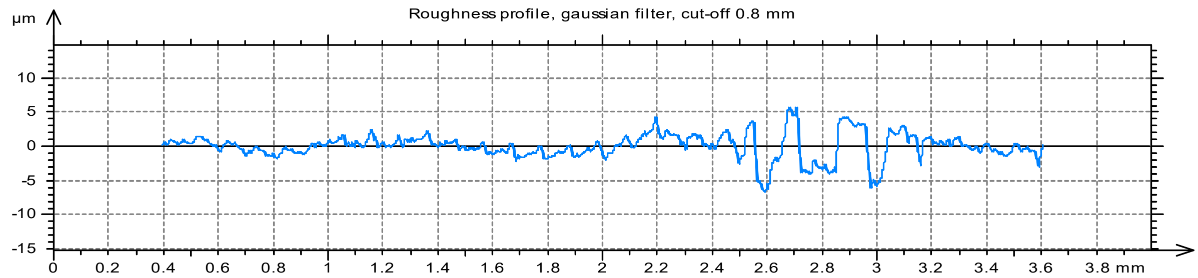

Figure 5-48 Roughness Graph for point 3

Ra=1.16 µm

Point 4

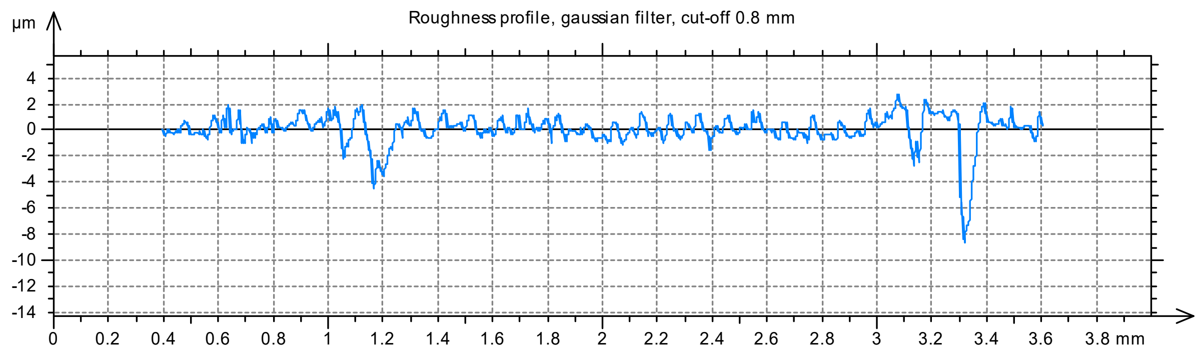

Figure 5-49 Roughness Graph for point 4

Ra=0.581 µm

Average value of Ra=**2.2252 µm**

Examining the above results, it is observed that Base alloy Al-6063 has highest surface roughness with Ra equal to 4.7925 µm whereas Hybrid AMC has lowest Ra value equal to 2.2252 µm.

(4) Evaluation of Temperature between tool-work piece interface

The experiment of measuring cutting temperature during CNC turning was completed successfully using infrared thermal imaging camera having emissivity of 0.95.

Process parameters like cutting speed, feed rate and depth of cut were kept constant during the turning operation and temperature were measured in three stages-Initial cut ,Intermediate cut and Final cut over the length of 50mm of the specimen.

(a) Base Alloy

(1)Initial cut

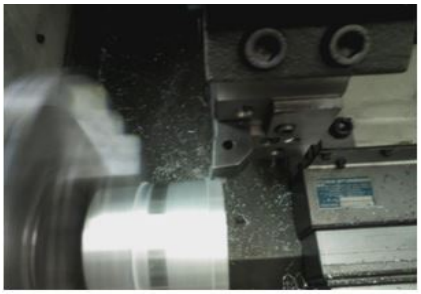

Figure 5-50 Infrared Image

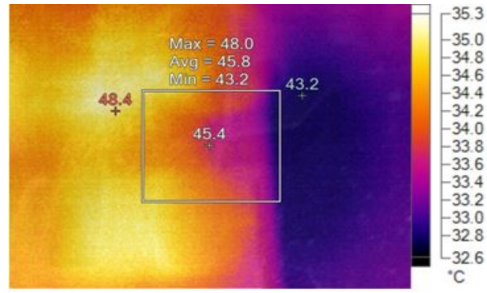

Figure 5-51 Visual image

Table 5-1Image information

Background temperature	22.0°C
Emissivity	0.95
Transmission	0.50
Average Temperature	45.8°C
Image Range	43.2°C to 48.4°C
Camera Model	Ti400
IR Sensor Size	320 x 240
Camera serial number	Ti400-13120004
Camera Manufacturer	Fluke Thermography
Image Time	5/3/2019 10:52:45 AM
Calibration Range	-20.0°C to 80.0°C

Average temperature=45.8 °C

(2)Intermediate cut

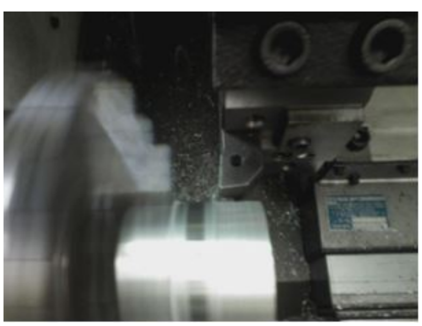

Figure 5-52 Visual image

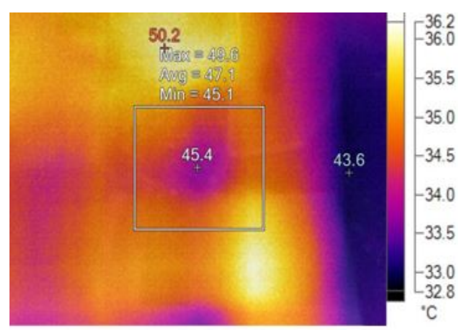

Figure 5-53 Infrared image

Table 5-2Image information

Background temperature	22.0°C
Emissivity	0.95
Transmission	0.50
Average Temperature	47.0°C
Image Range	43.6°C to 50.2°C
Camera Model	Ti400
IR Sensor Size	320 x 240
Camera serial number	Ti400-13120004
Camera Manufacturer	Fluke Thermography
Image Time	5/3/2019 10:53:10 AM
Calibration Range	-20.0°C to 80.0°C

Average temperature=47.0 ℃

(3)Final cut

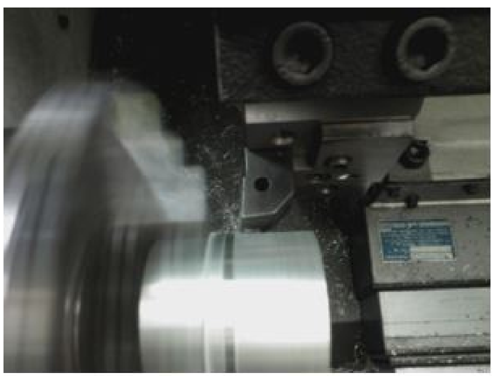

Figure 5-54Visual image

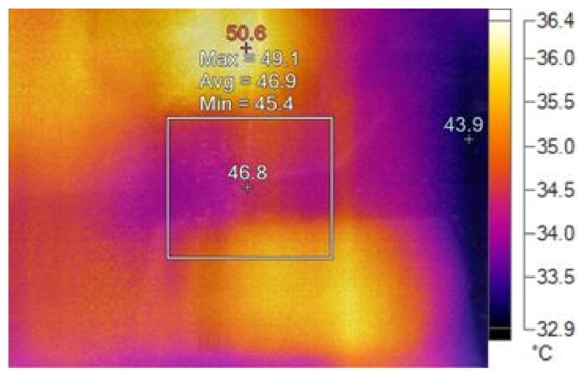

Figure 5-55Infrared Image

Table 5-3Image information

Background temperature	22.0°C
Emissivity	0.95
Transmission	0.50
Average Temperature	47.1°C
Image Range	43.9°C to 50.6°C
Camera Model	Ti400
IR Sensor Size	320 x 240
Camera serial number	Ti400-13120004
Camera Manufacturer	Fluke Thermography
Image Time	5/3/2019 10:53:24 AM
Calibration Range	-20.0°C to 80.0°C

Average temperature=47.1 ℃

Overall average temperature of above three reading=46.6 ℃

(b) AMC with eggshell

(1)Initial cut

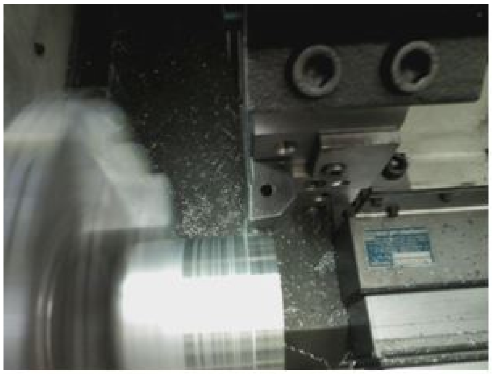

Figure 5-56 Visual image

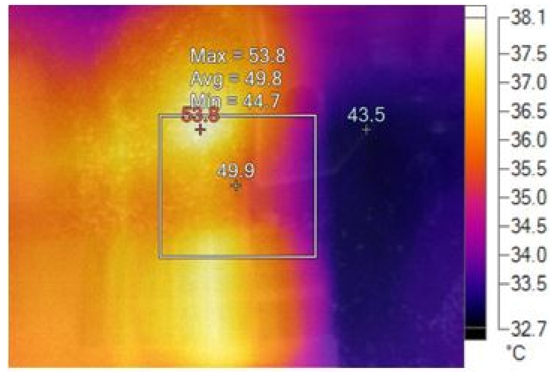

Figure 5-57 Infrared image

Table 5-4Image information

Background temperature	22.0°C
Emissivity	0.95
Transmission	0.50
Average Temperature	48.3°C
Image Range	43.5°C to 53.8°C
Camera Model	Ti400
IR Sensor Size	320 x 240
Camera serial number	Ti400-13120004
Camera Manufacturer	Fluke Thermography
Image Time	5/3/2019 11:17:47 AM
Calibration Range	-20.0°C to 80.0°C

Average temperature=48.3 ℃

(2)Intermediate cut

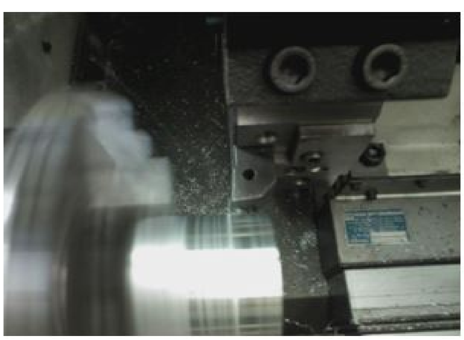

Figure 5-58 Visual image

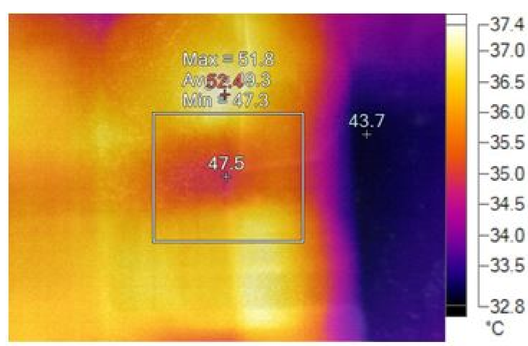

Figure 5-59 Infrared image

Table 5-5Image information

Background temperature	22.0°C
Emissivity	0.95
Transmission	0.50
Average Temperature	48.5°C
Image Range	43.7°C to 52.4°C
Camera Model	Ti400
IR Sensor Size	320 x 240
Camera serial number	Ti400-13120004
Camera Manufacturer	Fluke Thermography
Image Time	5/3/2019 11:17:58 AM
Calibration Range	-20.0°C to 80.0°C

Average temperature=48.5 °C

(3)Final cut

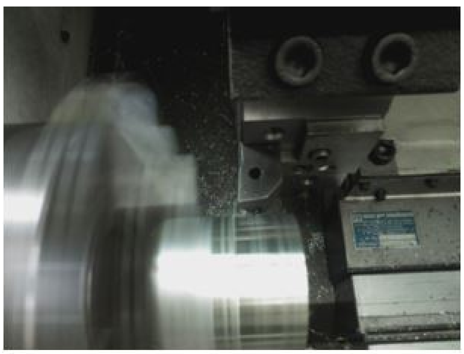

Figure 5-60 Visual image

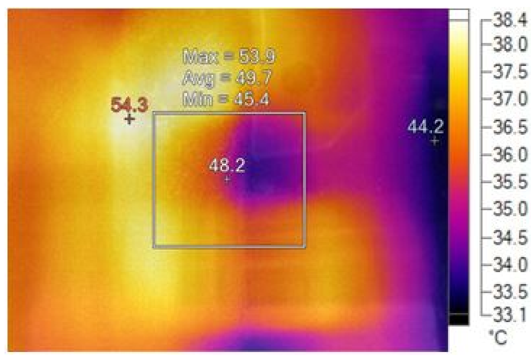

Figure 5-61 Infrared image

Table 5-6Image information

Background temperature	22.0°C
Emissivity	0.95
Transmission	0.50
Average Temperature	50.0°C
Image Range	44.2°C to 54.3°C
Camera Model	Ti400
IR Sensor Size	320 x 240
Camera serial number	Ti400-13120004
Camera Manufacturer	Fluke Thermography
Image Time	5/3/2019 11:18:13 AM
Calibration Range	-20.0°C to 80.0°C

Average temperature=50.0 °C

Overall average temperature of above three reading=49.6 °C (c)**AMC with B_4C**

(1)Initial cut

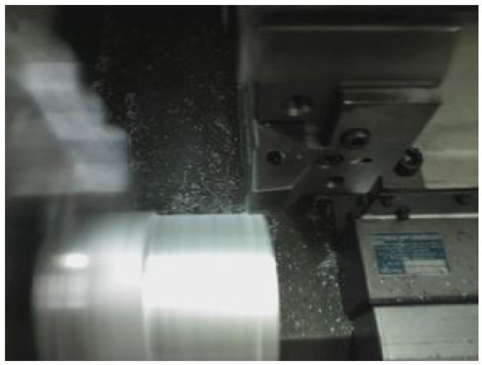

Figure 5-62 Visual image

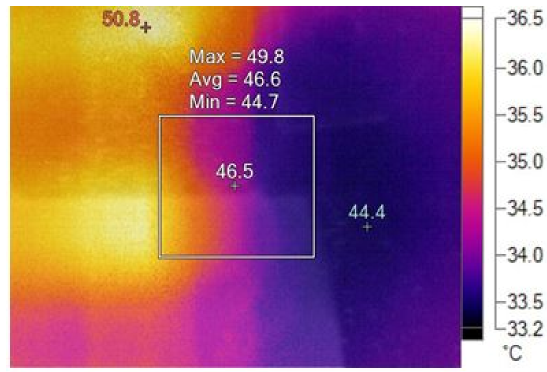

Figure 5-63 Infrared image

Table 5-7Image information

Background temperature	22.0°C
Emissivity	0.95
Transmission	0.50
Average Temperature	46.9°C
Image Range	44.4°C to 50.8°C
Camera Model	Ti400
IR Sensor Size	320 x 240
Camera serial number	Ti400-13120004
Camera Manufacturer	Fluke Thermography
Image Time	5/3/2019 12:23:17 PM
Calibration Range	-20.0°C to 80.0°C

Average temperature=46.9 ℃

(2)Intermediate cut

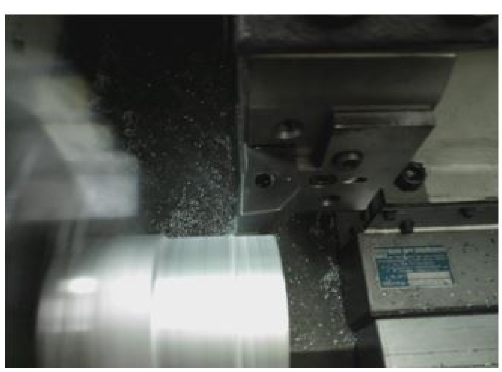

Figure 5-64 Visual image

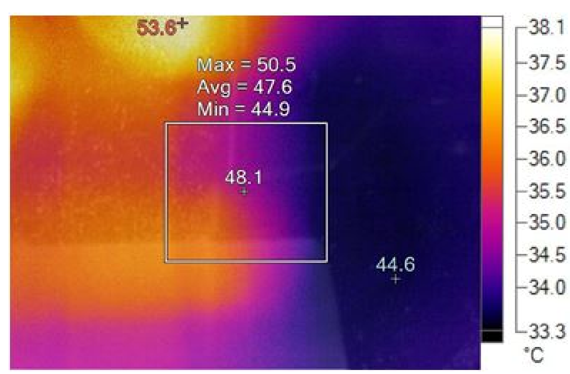

Figure 5-65 Infrared image

Table 5-8Image information

Background temperature	22.0°C
Emissivity	0.95
Transmission	0.50
Average Temperature	47.6°C
Image Range	44.6°C to 53.6°C
Camera Model	Ti400
IR Sensor Size	320 x 240
Camera serial number	Ti400-13120004
Camera Manufacturer	Fluke Thermography
Image Time	5/3/2019 12:23:30 PM
Calibration Range	-20.0°C to 80.0°C

Average temperature=47.6 °C

(3)Final cut

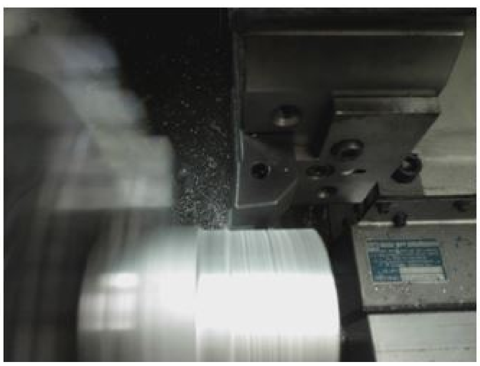

Figure 5-66 Visual image

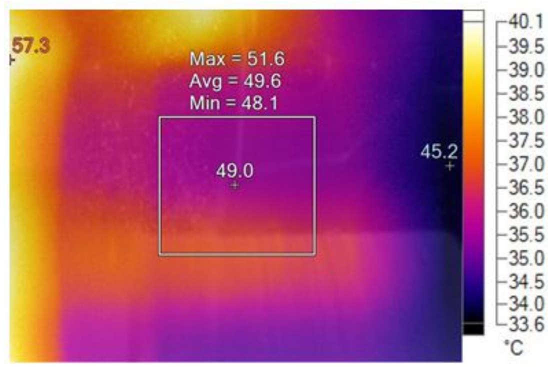

Figure 5-67 Infrared image

Table 5-9Image information

Background temperature	22.0°C
Emissivity	0.95
Transmission	0.50
Average Temperature	49.9°C
Image Range	45.2°C to 57.3°C
Camera Model	Ti400
IR Sensor Size	320 x 240
Camera serial number	Ti400-13120004
Camera Manufacturer	Fluke Thermography
Image Time	5/3/2019 12:23:53 PM
Calibration Range	-20.0°C to 80.0°C

Average temperature=49.9 °C

Overall average temperature of above three reading=47.93°C

(d) Hybrid AMC

(1)Initial cut

Figure 5-68 Visual image

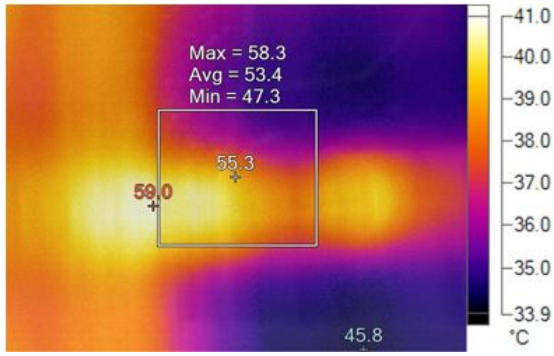

Figure 5-69 Infrared image

Table 5-10Image information

Background temperature	22.0°C
Emissivity	0.95
Transmission	0.50
Average Temperature	51.6°C
Image Range	45.8°C to 59.0°C
Camera Model	Ti400
IR Sensor Size	320 x 240
Camera serial number	Ti400-13120004
Camera Manufacturer	Fluke Thermography
Image Time	5/3/2019 11:20:40 AM
Calibration Range	-20.0°C to 80.0°C

Average temperature=51.6 °C

(2)Intermediate cut

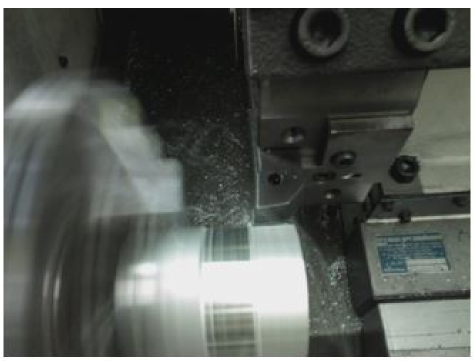

Figure 5-70 Visual image

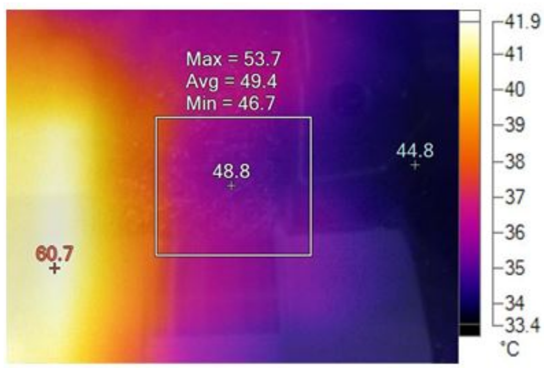

Figure 5-71 Infrared image

Table 5-11Image information

Background temperature	22.0°C
Emissivity	0.95
Transmission	0.50
Average Temperature	50.8°C
Image Range	44.8°C to 60.7°C
Camera Model	Ti400
IR Sensor Size	320 x 240
Camera serial number	Ti400-13120004
Camera Manufacturer	Fluke Thermography
Image Time	5/3/2019 12:20:53 PM
Calibration Range	-20.0°C to 80.0°C

Average temperature=50.8 ℃

(3)Final cut

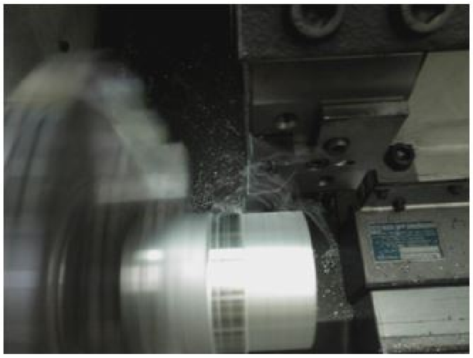

Figure 5-72 Visual image

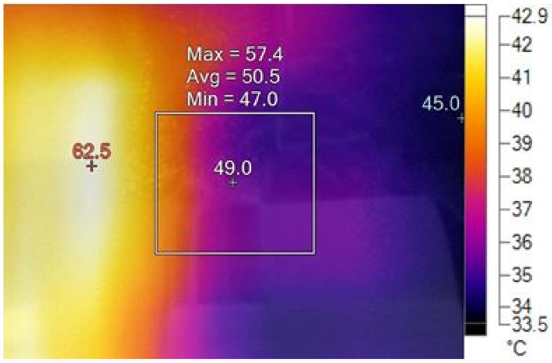

Figure 5-73 Infrared image

Table 5-12Image information

Background temperature	22.0°C
Emissivity	0.95
Transmission	0.50
Average Temperature	52.3°C
Image Range	45.0°C to 62.5°C
Camera Model	Ti400
IR Sensor Size	320 x 240
Camera serial number	Ti400-13120004
Camera Manufacturer	Fluke Thermography
Image Time	5/3/2019 12:21:04 PM
Calibration Range	-20.0°C to 80.0°C

Average temperature=52.3 ℃

Overall average temperature of above three reading=51.1 ℃

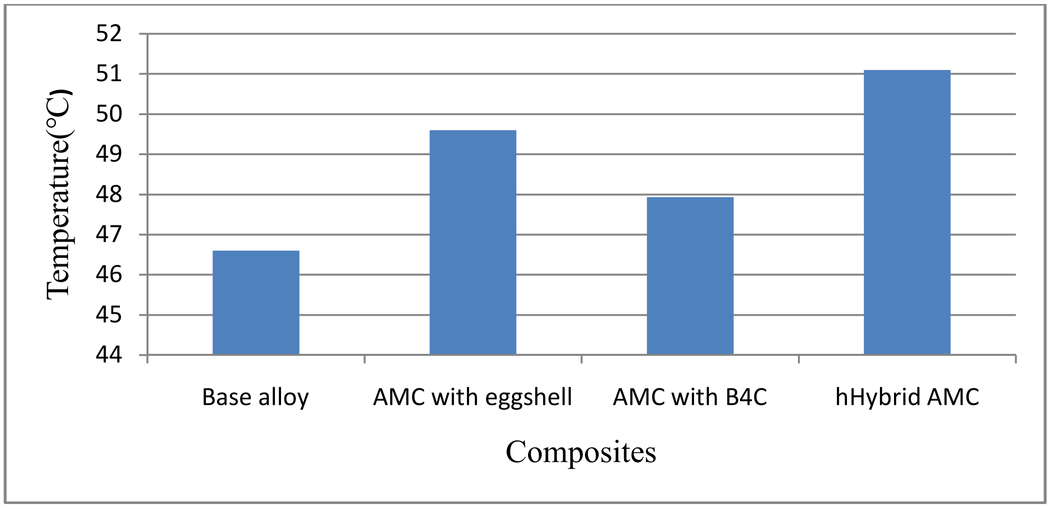

Figure 5-74 Bar graph between Composites and temperature

Based on above average temperature values and plotting tha bar graph,it is concluded that Hybrid AMC has maximum cutting temperature of 51.1℃ during turning,follwed by AMC with egg shell particle and B4C particle respectively.Base alloy stand at the bottom with least temperature of 46.6 ℃.The reason for this being that while calculating it was found that MRR of hybrid AMC comes maximum as cutting tool was in contact of the workpiece for the maximum time.

CONCLUSION

From the above study, following significant conclusions has been derived-

1. Fabrication of Aluminum Metal Matrix composite using Al 6063 T6 as base matrix with different reinforcement –Boron carbide(B_4C) and Egg shell adding separately and in combine form both, with mesh size of 150 (104µm) by stir casting technique was successful.
2. CNC turning of the base alloy and developed AMC's were performed by keeping the process parameters like cutting speed, feed rate and depth of cut constant.
3. Calculation of MRR showed that Hybrid AMC has maximum MRR of 32.7160 mm^3/sec whereas base alloy has the minimum with value 22.8395 mm^3/sec.
4. Minimum surface roughness value(Ra) was obtained in Hybrid AMC with Ra=2.2252µm
5. Experimental investigation revealed that base alloy has highest value of residual stress having normal stress of compressive nature equals to 48.5 MPa and shear stress of tensile nature equals to 20.5 MPa.
6. Evaluation of cutting temperature between tool-work piece interface during CNC turning concluded that Hybrid AMC records the maximum temperature value of 51.1°C as it has the highest value of MRR compared to other prepared AMC's and base alloy.

FUTURE SCOPE

A lot of research has been already done and is continued in this area, but still there are some gaps that are yet required to be filled.

1) Other fabrication technique for the preparation can be used to develop the desired composite.

(2) During preparation of composite, influence of variation in process parameters like speed, depth of cut, feed rate can be studied.

(3) Effect of using of wet or dry turning during CNC turning can be seen on the various properties of the prepared composites.

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