"OPTIMIZATION OF MATERIAL REMOVAL RATE AND SURFACE ROUGHNESS USING TAGUCHI AND ANOVA TECHNIQUES"

A project report submitted in partial fulfillment of the requirement for

the award of the degree of

BACHLOR OF TECHNOLOGY

IN

MECHANICAL ENGINEERING

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ABSTRACT

Now a day's demand of light materials is increasing continuously and MMC of aluminum playing a vital role to fulfill these demands due to their light weight, high strength and appreciable hardness etc. This study deals with the manufacturing of Aluminum based MMC of Alumina and followed by dry turning of it by using coated tungsten carbide tools. Turning tests were performed at various speed, feed rate, depth of cut. Furthermore the responses of surface roughness and metal removal rate were optimized using taguchi and ANOVA methods. From the results it is found that the optimal combinations of process parameters for MRR is obtained at 0.4mm of nose radius, 1250 RPM of speed 0.2 mm/rev of feed & 0.9 mm of Depth of cut. Similarly for surface roughness the optimal combination is obtained at 0.8 mm of nose radius, 1250 RPM of speed, 0.1 mm/rev of feed & 0.3 mm of Depth of cut respectively. The ANOVA results revealed that DOC & feed are most predominant factors for MRR & surface roughness respectively.

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1. INTRODUCTION TO COMPOSITES AND LATHE:

1.1 INTRODUCTION

The challenge of modern machining industries is mainly focused on the achievement of high quality, in term of work dimensional accuracy, surface finish. Surface texture is concerned with the geometric irregularities. The quality of a surface is significantly important factor in estimating the productivity of machine tool and machined parts. The surface roughness of machined parts is a significant effect on some functional attributes of parts, such as, contact causing surface friction, wearing, light reflection, ability of distributing and also holding a lubricant, load bearing capacity, coating and resisting fatigue.The need for selecting and implementing optimal machining conditions and most suitable cutting tools has been felt very important over few decades. Surface roughness has become the most significant technical requirement and it is an index of product quality.

A good surface finish is desired in order to improve the properties, fatigue strength, corrosion resistance and aesthetic appeal of the product. The manufacturing industries specially are focusing their attention on dimensional accuracy and surface finish. In order to obtain optimal cutting parameters to achieve the best possible surface finish, manufacturing industries have resorted to the use of handbook-based information and operators experience. This traditional practice leads to improper surface finish and decreases in the productivity due to sub-optimal use of machining capability and also leads to high manufacturing cost and low product quality. Surface roughness is mainly a result of process parameters such as tool geometry (i.e. nose radius, edge geometry, rake angle) and cutting conditions (feed rate, cutting speed, depth of cut). Surface roughness is harder to attain and track than physical dimensions are, because relatively many factors affect surface roughness.

Some of these factors can be controlled and some cannot. Controllable process parameters include feed, cutting speed, tool geometry, and tool setup. Other factors, such as tool, work piece and machine vibration, tool wear and degradation, and work piece and tool material variability cannot be controlled as easily. The important cutting parameters considered for discussion here are cutting speed, feed and depth of cut. It is found in most of the cases surface roughness decreases with increase in cutting speed and decrease in feed and depth of cut. Surface roughness most commonly refers to the variations in the height of the surface relative to a reference plane. It is measured either along a single line profile or along a set of parallel line profiles (surface maps).

Input parameters

Cutting speed

Feed rate

Depth of cut

Output parameters

Material removal rate

Surface roughness

1.2 COMPOSITE

A composite is a material made from two or more constituent materials with significantly different Physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials.

Composites were developed because no single, homogeneous structural material could be found that had all of the desired characteristics for a given application. Fibre-reinforced composites were first developed to replace aluminium alloys, which provide high strength and fairly high stiffness at low weight but are subject to corrosion and fatigue.

1.3 HISTORY OF COMPOSITE MATERIALS

The first uses of composites date back to the 1500s B.C. when early Egyptians and Mesopotamian settlers used a mixture of mud and straw to create strong and durable buildings.. Straw continued to provide reinforcement to ancient composite products including pottery and boats. Later, in 1200 AD, the Mongols invented the first composite bow. Using a combination of wood, bone, and "animal glue," bows were pressed and wrapped with birch bark. These bows, were extremely powerful and extremely accurate, Composite Mongolian bows provided Genghis Khan with military dominance, and because of the composite technology, this weapon was the most powerful weapon on earth until the invention of gunpowder. The modern era of composites did not begin until scientists developed plastics. Until then, natural resins derived from plants and animals were the only source of glues and binders.

In the early 1900's, plastics such as vinyl. Polystyrene, phenolic and polyester were developed. These new synthetic materials outperformed resins that were derived from nature. However, plastics alone could not provide enough strength for structural applications. Reinforcement was needed to provide the strength and rigidity. In 1935, Owens Corning introduced the first glass fibre, fibre glass. Fibre glass, when combined with a plastic polymer creates an incredibly strong structure that is also lightweight. This is the beginning of the Fibre Reinforced Polymers (FRP) industry as we know it today.

1.4 PROPERTIES OF COMPOSITE MATERIALS

High Strength to Weight Ratio: Fibre composites are extremely strong for their weight. By refining the laminate many characteristics can be enhanced.

Lightweight: A standard Fibreglass laminate has a specific gravity in the region of 1.5, compared to Alloy of 2.7 or steel of 7.8. When you then start looking at Carbon laminates, strengths can be many times that of steel, but only a fraction of the weight.

Fire Resistance: The ability for composites to withstand fire has been steadily improving over the years. There is two types of systems to be considered:

Fire Retardant: Are self-extinguishing laminates,

Fire Resistant: More difficult and made with the likes of Phenolic Resins.

Electrical Properties: Fibreglass Developments Ltd produced the Insulator Support straps for the Trans Rail main trunk electrification. The straps, although only 4mm thick, meet the required loads of 22 kN, as well as easily meeting insulation requirements.

Chemical & Weathering Resistance: Composite products have good weathering properties and resist the attack of a wide range of chemicals. This depends almost entirely on the resin used in manufacture, but by careful selection resistance to all but the most extreme conditions can be achieved.

Colour: Almost any shade of any colour can be incorporated into the product during manufacture by pigmenting the gel coat used. Costs are therefore reduced by no further finishing or painting. Soluble dyes can be used if a translucent product is desired.

Translucency: Polyester resins are widely used to manufacture translucent mouldings and sheets. Light transmission of up to 85% can be achieved.

Design Flexibility: Because of the versatility of composites, product design is only limited by your imagination.

Low Thermal Conductivity: Fibreglass developments has been involved in the development and production of specialized meat containers which maintain prime cuts of chilled meat at the correct temperature for Export markets. They are manufactured using the RTM process, with special reinforcing and foam inserts.

Manufacturing Economy: Fibre glass developments produce several models of fuel pump covers for Fuel quip. Fibreglass is an ideal material for producing items of this type for many reasons, including being very economical.

1.4.1 ADVANTAGES OF COMPOSITES

- Lower density (20 to 40%)
- Higher directional mechanical properties (specific tensile strength (ratio of material strength to density) 4 times greater than that of steel and aluminium.
- Higher Fatigue endurance .

- Higher toughness than ceramics and glasses.
- Versatility and tailoring by design.
- Easy to machine.
- Can combine other properties (damping, corrosion).
- Cost.

1.4.2 DISADVANTAGES OF COMPOSITES

- •The resin used in composite material weakens at temperatures as low as 150 degrees, making it essential for these aircraft to avoid fires.
- •Fires involved with composite materials can release toxic fumes and micro particles into the air. Temperatures above 300 degrees can cause structural failure.
- •Finally, composite materials can be expensive, but long-term cost savings typically offset the high initial costs
- •Composite materials don't break easily, but that makes it hard to tell if the interior structure has been damaged at all. In contrast, aluminium bends and dents quickly, making it easy to detect structural damage; the same damage is harder to detect with composite structures. Repairs can also be more difficult when a composite surface is damaged.

1.4.3 APPLICATIONS OF COMPOSITE MATERIALS

Composites are used in a wide variety of markets, including aerospace, architecture, automotive, energy, infrastructure, marine, military, and sports and recreation. Each year, fibre-reinforced polymer composites (FRP) find their way into hundreds of new applications, from golf clubs and tennis rackets to jet skis, aircraft, missiles and spacecraft. FRPs offer designers an increasing array of potential uses as a material and system solution.

Aerospace: Major OEMs such as Airbus and Boeing have shown the potential for large-scale composite applications in aviation, and NASA is continually looking to composites manufacturers for innovative space solutions for rockets and other spacecraft.

Architecture: The architecture community is experiencing substantial growth in the understanding and use of composites. Composites offer architects and designer performance and value in large-scale projects and their use is increasing in commercial and residential buildings.

Energy: New advancements in composites, particularly those from the U.S. Department of Energy, are redefining the energy industry. Composites help enable the use of wind and solar power and improve the efficiency of traditional energy suppliers.

Automotive: As the largest composites market, the automotive industry is no stranger to composites. Composites help make vehicles lighter and more fuel efficient.

Infrastructure: Composites are used all over the world to help construct and repair a wide variety of infrastructure applications, from buildings and bridges to roads and railways.

Marine: The marine industry uses composites to help make hulls lighter and more damage resistant. Composites can be found in many more areas of a maritime vessel, including interior moldings and furniture on super yachts.

Pipe & Tank: Fibre-reinforced polymer composite pipes are used for everything from sewer upgrades and wastewater projects to desalination, oil and gas applications. When corrosion becomes a problem with pipes made with traditional materials, FRP is a solution.

Sports & Recreation: From football helmets and hockey sticks to kayaks and bobsleds, carbon fibre and fibreglass composite materials help athletes reach their highest performance capabilities and provide durable, lightweight equipment.

Transportation: While FRP in cars gets most of the attention, composites can also play a big role in increasing fuel efficiency in trucks. A number of U.S. state Departments of Transportation are also using composite to reinforce the bridges those trucks travel on.

1.5 CLASSIFICATIONS OF COMPOSITE MATERIAL

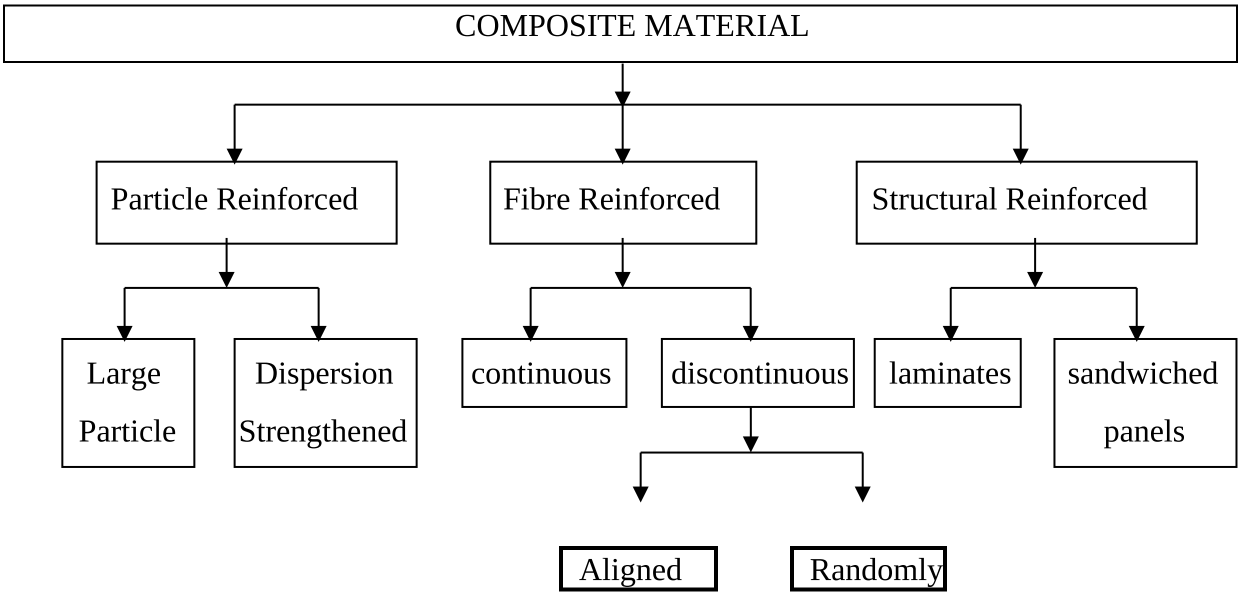

Fig 1.1 Classification of Composites

1.5.1 PARTICLE-REINFORCED COMPOSITES

A particle has no long dimension. Particle composites consist of particles of one material dispersed in a matrix of a second material. Particles may have any shape or size, but are generally spherical, ellipsoidal, polyhedral, or irregular in shape. They may be added to a liquid matrix that later solidifies; grown in place by a reaction such as age hardening; or they may be pressed together and then inter-diffused via a powder process. The particles may be treated to be made compatible with the matrix, or they may be incorporated without such treatment. Particles are most often used to extend the strength or other properties of inexpensive materials by the addition of other materials.

1.5.2 FIBRE-REINFORCED COMPOSITES

A fibre-reinforced composite (FRCs) is a composite building material that consists of three components:

1. The fibres as the discontinuous or dispersed phase,
2. The matrix as the continuous phase, and

3. The fine interphase region, also known as the interface.

This is a type of advanced composite group, which makes use of rice husk, rice hull, rice shell, and plastic as ingredients. This technology involves a method of refining, blending, and compounding natural fibres from cellulosic waste streams to form a high-strength fibre composite material in a polymer matrix. The designated waste or base raw materials used in this instance are those of waste thermoplastics and various categories of cellulosic waste including rice husk and saw dust.

1.5.3 STRUCTURAL COMPOSITES

Structural composites are engineered products made from plastic, wood, glass, or carbon fibre materials. The formed or extruded products have applications as outdoor deck floors, railings, fences, landscape timbers, cladding, siding, moulding, trim, and window or door frames. These low maintenance products are resistant to cracking and can be smooth or have a simulated wood grain. Available in a variety of colours and sizes, structural composites are shaped using typical woodworking tools.

1.6 CLASSIFICATION BASED ON THE TYPE OF MATRIX

1. Organic Matrix Composites (OMCs) –
   - Polymer Matrix Composites (PMCs)
   - Carbon matrix composites (carbon-carbon composites)
2. Metal Matrix Composites (MMCs)
3. Ceramic Matrix Composites (CMCs)

1.6.1 ORGANIC MATRIX COMPOSITE

In this the matrix material is an organic compound. For example, organic composites are Asphalt concrete, dental concrete, syntactic foam. The matrix is made up of either a polymer or carbon or both. Thus it is sub divided into 2 categories:

(i) polymer matrix composites

(ii) carbon matrix composites

1.6.1.1 Polymer Matrix Composites

Polymer matrix composites are materials made up of fibres that are embedded in an organic polymer matrix. These fibres are introduced to enhance selected properties of the material. Polymer matrix composites are classified based on their level of strength and stiffness into two distinct types:

a) Reinforced plastics - confers additional strength by adding embedded fibrous matter into plastics
b) Advanced Composites - consists of fibre and matrix combinations that facilitate strength and superior stiffness. They mostly contain high-performance continuous fibres such as high-stiffness glass (S-glass), graphite, aramid, or other organic fibres

On the basis of type of polymer resin used, composite materials can be classified into Thermoplastic Composites and Thermo-set Composites.

<u>Thermoplastic Composites</u>: This is type of composite with thermoplastic resin like polyester, HDPE etc. They are lesser used as high-tech materials due to their higher viscosity which cause problem during their penetration into the reinforcement.

<u>Thermo-set Composites</u>: In these composites thermo-set polymers like epoxy, unsaturated polyester and vinyl-ester are used as resin. They are most used type of composites materials in automotive, naval, aeronautical and aerospace applications.

Polymer matrix composites (PMCs) are present in almost all aspects of modern life - from gadget components to a vast selection of automotive accessories.
Polymers that are often used as composites are thermoplastic polymers, thermosetting polymers or elastomers. They are a source of a wide variety of low-priced, raw materials which offer many advantages like:

1. Low specific weight
2. High material stability against corrosion

3. Good electrical and thermal insulation
4. Ease of shaping and economic mass production
5. Attractive optical properties

APPLICATIONS FOR PMC

- Automotive industry - Body panels, leaf springs, driveshaft, bumpers, doors, racing car bodies, and so on.
- Aircraft and aerospace industry - Used in the construction of structural parts for military aircraft, space shuttles, and satellite systems. The main purposes of using PMCs are to reduce aircraft weight, which can improve its performance, and to reduce its costs.
- Marine - Fibreglass boat bodies, as well as canoes and kayaks.
- Sports goods - Used in performance footwear, sports equipment and other sporting goods because of their lightweight and high-strength properties.
- Biomedical applications - Medical implants, orthopaedic devices, MRI scanners, Xray tables, and prosthetics.
- Electrical - Panels, housing, switchgear, insulators, and connectors. It also covers electronic devices like capacitors, Li-ion and flexible batteries and covers for digital portable equipment like headphones, etc.
- Protective equipment - Since polymer matrix composites can withstand extreme hot or cold and other hazardous conditions, they are often made as raw materials for bulletproof vests and other armour.
- Industrial - Chemical storage tanks, pressure vessels, pump housing, and valves.

PMCs are also used in impellers, blades, blower and pump housings, and motor covers.

- Structural - Polymer matrix composites are used to repair bridges and other construction materials and equipment like booms and cranes.

1.6.1.2 Carbon Matrix Composites

Carbon composites are special kind of composite that consists of carbon fibres embedded in a carbonaceous matrix. Carbon is an excellent high temperature material when used in an inert or non-oxidizing atmosphere. Potential high temperature applications call for 10 *h* to a few 1000 *h* at greater than 1000 °*C* and at times approaching 2200 °*C*. The major drawback of carbon is that it reacts with oxygen, forming gaseous oxides of carbon. In this chapter, we describe the processing, structure, properties of carbon fibre reinforced carbon composites.

1.6.2 METAL-MATRIX COMPOSITES(MMCs)

The matrix in these composites is a ductile metal. These materials may be utilized at higher service temperatures than their base metal counterparts; furthermore, the reinforcement may improve specific stiffness, specific strength, abrasion resistance, creep resistance, thermal conductivity, and dimensional stability. Some of the advantages of these materials over the polymer-matrix composites include higher operating temperatures, nonflammability, and greater resistance to degradation by organic fluids. Metal-matrix composites are much more expensive than PMCs, and, therefore, their (MMC) use is somewhat restricted.

These composites can be used at higher service temperatures than their base metal counterparts. These reinforcements in these materials may improve specific strength, abrasion resistance, creep resistance and dimensional stability. The MMCs are light in weight and resist wear and thermal distortion, mainly used in the automobile industry. Metal matrix composites are much more expensive than PMCs. Though generating a wide interest in research, they are not as widely in use as plastic. High strength, fracture toughness and stiffness are offered by metal matrices when compared to their polymer counterparts. They withstand elevated temperature in corrosive environment than polymer composites.

Most metals and alloys are used as matrices. Hence, require reinforcement materials that are stable over a range of temperatures and non-reactive too. Guiding aspect for the choice depends on matrix material.

• Light metals (low strength) form the matrix while the reinforcements have high modulig.

• If metal matrix has high strength, they require even higher modulus reinforcements.

Hence, light metals (Al, Ti, and Mg) are the popular matrix metals with their low density. e.g. carbide in a metal matrix.

The melting point, physical and mechanical properties of the composite at various temperatures determine the service temperature of composites.

Most metals, ceramics and compounds can be used with matrices of low melting point alloys. As the melting points of matrix materials become high, the choice of reinforcements becomes small.

1.6.3 CERAMIC MATRIX COMPOSITES (CMC)

One of the main objectives in producing CMCs is to increase the toughness. Ceramics materials are inherently resistant to oxidation and deterioration at elevated temperatures were it not for their disposition to brittle fracture. Some of these materials would be ideal candidates for use in higher temperature and serve stress applications, specifically for components in automobiles and aircraft gas turbine engines. The developments of CMCs has lagged mostly for remain reason, and most processing routes involves higher temperature reinforcements.

Most ceramic possess high modulus of elasticity and low tensile strain and hence addition of reinforcements to improve their strength have proved futile. This is because at the stress levels at which ceramics rupture, there is insufficient elongation of the matrix which keeps composite from transferring an effective quantum of load to the reinforcement and the composite may fail unless the percentage of fibre volume is high enough. However, addition of any high-strength fibre (as reinforcing material) to a weaker ceramic has not always been successful and often the resultant composite has proved to be weaker.

They differ from conventional ceramics in the following properties:

•Elongation to rupture up to 1%

•Strongly increased fracture toughness

•Extreme thermal shock resistance

•Improved dynamical load capability

•Anisotropic properties following the orientation of fibres

1.7 CLASSIFICATIONS BASED ON REINFORCEMENTS

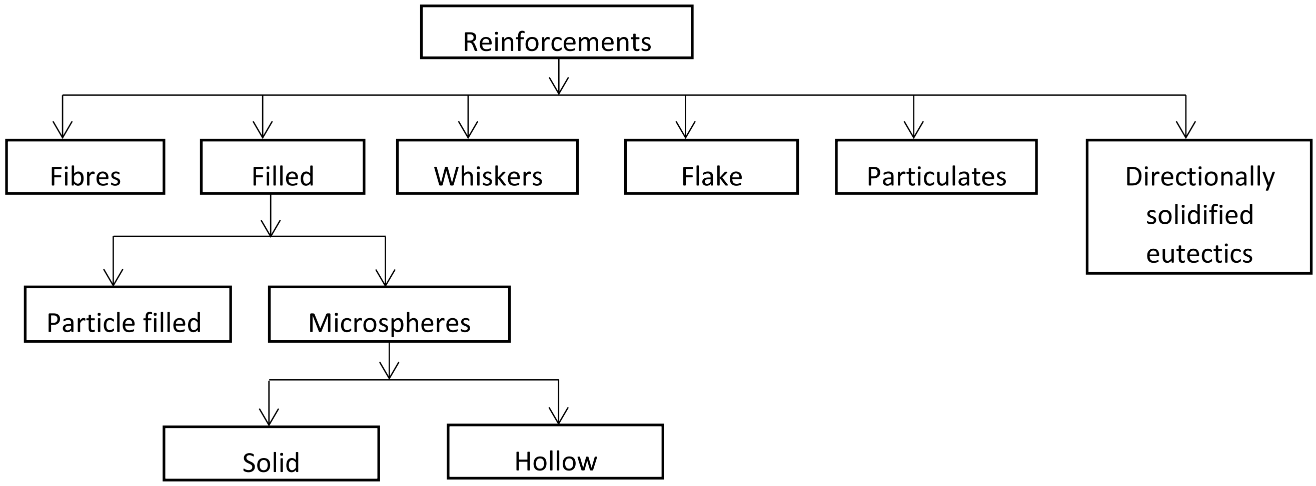

Fig 1.2 Classification Based on Reinforcement

Reinforcement is a strong, inert, woven and non-woven fibrous material incorporated into the matrix to improve its mechanical and physical properties e.g. asbestos, boron, carbon, metal or glass or ceramic fibres, graphite, jute, sisal, whiskers, macerated fabrics, and synthetic fibres.

Reinforcement is the material, which is added to improve the various properties of the matrix material. The reinforcement material is embedded into a matrix. The reinforcement does not always serve a purely structural task (reinforcing the compound), but is also used to change physical properties such as wear resistance, friction coefficient, or thermal conductivity.

The reinforcement can be either continuous or discontinuous. Discontinuous MMCs can be isotropic and can be worked with standard metalworking techniques, such as extrusion, forging, or rolling. In addition, they may be machined using conventional methods but commonly would need the use of polycrystalline diamond tooling (PCD).

Continuous reinforcement uses monofilament wires or fibres such as carbon fibre or silicon carbide. The fibres are get embedded into the matrix in a specific direction. The result is an anisotropic structure in which the alignment of the material affects its strength. One of the first MMCs used boron filament as reinforcement. Discontinuous reinforcement uses "whiskers", short fibres, or particles. The most common reinforcing materials in this category are alumina and silicon carbide.

1.7.1 FIBRE REINFORCED POLYMER (FRP) COMPOSITES

Fibres - important class of reinforcements, as they effectively transfer strength to the matrix influencing and enhancing composite properties as desired. Glass fibres (earliest known reinforcing fibres)- Ceramic and metal fibres used subsequently to make composites stiffer and more heat resistant.

The performance of a fibre composite is judged by

- Length, shape, orientation, and composition of the fibres and the mechanical properties of the matrix.
- Orientation of the fibre in the matrix (strength greatest along the longitudinal directional & slightest shift in the angle of loading drastically reduce the strength).
- Since unidirectional loading is found in very few structures, a mix of fibre orientations is given to withstand load from different angles (particularly more fibres in the direction where load is expected to be the heaviest).

Organic and inorganic fibres are used to reinforce composites. Almost all organic fibres have low density, flexibility, and elasticity. Inorganic fibres (glass fibres, silicon carbide fibres, high silica and quartz fibres, aluminium fibres, metal fibres and wires, graphite fibres, boron fibres, aramid fibres and multiphase fibres) are of high modulus, high thermal stability and possess greater rigidity than organic fibres.

1.7.2 WHISKER REINFORCED COMPOSITES

Whiskers - Single crystals grown with nearly zero defects (usually discontinuous and short fibres of different cross sections made from materials like graphite, silicon carbide, copper, iron etc.). Typical lengths are range from 3 - 55 nm.

Whiskers differ from particles in that, whiskers have a definite length to width ratio (> 1) with extraordinary strengths up to 7000 MPa. Whiskers (laboratory produced) Metal-whisker combination, strengthening the system at high temperatures, has been demonstrated at the laboratory level. Since whiskers are fine, small sized materials and not easy to handle, it becomes a hindrance in composite fabrication.

1.7.3 FLAKES REINFORCED COMPOSITES

Flakes are often used in place of fibres as they can be densely packed. Metal flakes that are in close contact with each other in polymer matrices can conduct electricity or heat, while mica flakes and glass can resist both. Flakes are not expensive to produce and usually cost less than fibres. But limitations are - control of size, shape of flakes and defects in the end product. Glass flakes tend to have notches or cracks around the edges, which weaken the final product. (Also resistant to be lined up parallel to each other in a matrix, causing uneven strength). They are usually set in matrices, or held together by a matrix with a glue-type binder.

Advantages of flakes over fibres –

- Parallel flakes filled composites provide uniform mechanical properties in the same plane as the flakes.
- While angle-plying is difficult in continuous fibres which need to approach isotropic properties, it is not so in flakes.
- Flake composites have a higher theoretical modulus of elasticity than fibre reinforced composites.
- They are relatively cheaper to produce and be handled in small quantities.

1.7.4 FILLED COMPOSITES

Addition of filer materials to plastic matrices to replace a portion of the matrix which would enhance or change the properties of the composites. The fillers also enhance strength and reduce weight in some cases. Fillers may be the main ingredient or an additional one in a composite. The filler particles may be irregular structures, or have precise geometrical shapes like polyhedrons, short fibres or spheres. They also occasionally impart colour or opacity to the composite which they fill.

As inert additives, fillers can change almost any basic resin characteristic in all directions required, to surpass many limitations of basic resins. The final composite properties can be affected by the shape, surface treatment, blend of particle types, size of the particle in the filler material and the size distribution. Filled plastics tend to behave like two different constituents. They do not alloy and accept the bonding (they desist from interacting chemically with each other).

Although the matrix forms the bulk of the composite, the filler material is also used in such great quantities relatively that it becomes the rudimentary constituent. The benefits of fillers - increase stiffness, thermal resistance, stability, strength and abrasion resistance, porosity and a favourable coefficient of thermal expansion.

1.7.5 MICROSPHERE COMPOSITES

Microspheres are useful fillers due to specific gravity, stable particle size, strength and controlled density - modify products without compromising profits or physical properties. Solid glass microspheres are most suitable for plastics. Microspheres coated with a binding agent - bonds between sphere's surface and resin. This increases the bonding strength and basically removes absorption of Contaminants or moisture (reduce attraction between particles). Solid Microspheres have relatively low density, and therefore, influence the commercial value and weight of the finished product.

Hollow microspheres are essentially silicate based, made at controlled specific gravity, larger than solid glass spheres, used in polymers and have wider range of particle sizes. Commercially, silicate-based hollow microspheres with different compositions using Organic compounds are also available. Due to this modification, they are less sensitive to moisture (reduce attraction between particles) - vital in highly filled polymer composites as viscosity increase constraints limit filler loading.

Hollow microspheres have a lower specific gravity than the pure resin. They find wide applications in aerospace and automotive industries where weight reduction for energy conservation is one of the main considerations. Microspheres, whether solid or hollow, due to their spherical shape behave like minute ball bearing, and hence, they give better flow properties. They also distribute stress uniformly throughout resin matrices. In spherical particles, the ratio of surface area to volume is minimal (smallest). In resin-rich surfaces of reinforced systems, the microspheres which are free of orientation and sharp edges are capable of producing smooth surfaces.

1.7.6 PARTICULATE REINFORCED COMPOSITES

Microstructures of metal and ceramics composites, which show particles of one phase scattered in the matrix, are known as particle reinforced composites. Square, triangular, irregular and round shapes of reinforcement are known, but the particle dimensions are observed to be more or less equal. The size and volume concentration of the dispersant distinguishes particle reinforced composites from dispersion strengthened composites. The dispersed size in particulate composites is of the order of a few microns and volume concentration is greater than 28%.

Particle matrix interactions that lead to strengthening occur on atomic level. The matrix bears the major portion of load. While dispersed particles hinder motion of dislocations. Thus plastic deformation is restricted such that yield and tensile strength as well as hardness improve. e.g.. thoria dispersed nickel. The composite's strength depends on - diameter of the particles, the inter-particle spacing, and the volume fraction of the reinforcement.

1.7.7 CERMETS/CERAMAL

Cermet – 'ceramic' and 'metal' composite are designed to have the optimal properties of both ceramic (high temperature resistance and hardness) and metal (the ability to undergo plastic deformation). The metal (Ni, Mo, Co etc.) used as a binder for an oxide, boride, carbide, or alumina.

Cermets are usually less than 20% metal by volume – used in manufacture of resistors (potentiometers), capacitors etc - experience high temperatures. Also used in spacecraft shielding (as they resist the high velocity impacts of micrometeoroids and orbital debris better than Al and other metals, vacuum tube coatings of solar hot water systems, material for fillings and prostheses, machining of cutting tools. Titanium nitride (TiN), titanium carbon nitride (TiCN), titanium carbide (TiC)

Cermet are usually produced by - using power metallurgy techniques (ceramic and metal powder mixed and sintered). Impregnation of a porous ceramic structure with a metallic matrix binder and coating in powder form which is sprayed through a gas flame and fused to a base material.

1.8 TURNING OPERATION

Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned so that adjacent sections have different diameters.

Turning is the machining operation that produces cylindrical parts. In its basic form, it can be defined as the machining of an external surface:

1. With the work piece rotating.
2. With a single-point cutting tool, and
3. With the cutting tool feeding parallel to the axis of the work piece and at a distance that will remove the outer surface of the work.

1.8.1 Material Removal Rate (MRR)

The Material Removal Rate (MRR) in turning operations is the volume of material/metal that is removed per unit time in cm3/min. For each revolution of the work piece, a ring-shaped layer of material is removed.

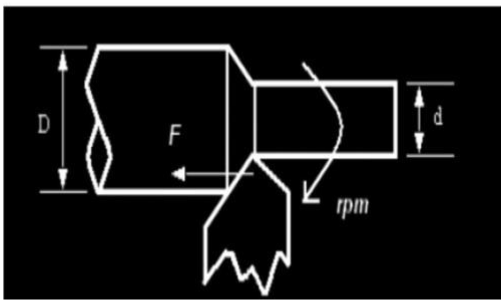

Fig 1.3 Material Removal Rate in turning

Material Removal Rate (MRR) = (v. f. d) in cm3/min.

- Where, v is cutting speed in m/min
- f is feed in mm/rev
- d is depth of cut in mm

1.8.2 Surface roughness

Surface roughness, often shortened to roughness, is a component of surface texture. It is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth. In surface metrology, roughness is typically considered to be the high-frequency, short-wavelength component of a measured surface. However, in practice it is often necessary to know both the amplitude and frequency to ensure that a surface is fit for a purpose. Roughness plays an important role in determining how a real object will interact with its environment.

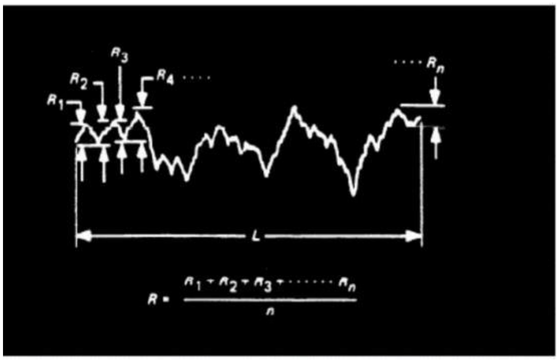

Fig 1.4 Arithmetic Surface Roughness Average (Ra)

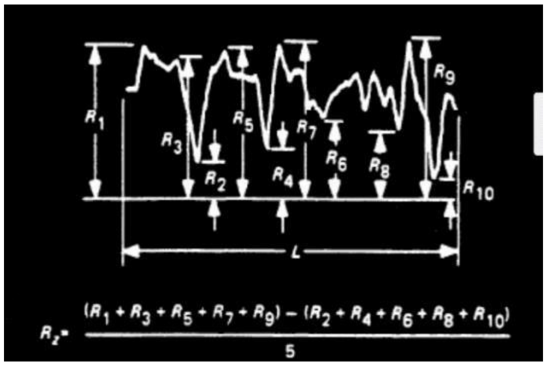

Fig 1.5 Average Peak to Valley Height Profile (R_z)

1.9 LATHE AND ITS OPERATIONS

A lathe is a machine that rotates the work piece against a tool whose position it controls: the spindle is the part of the lathe that rotates. Various work holding attachments such as jaw chucks, collets, and centres can be held in the spindle. The spindle is driven by an electric motor through a system of belt drives and gear trains. Spindle rotational speed is controlled by varying the drive train.

The tailstock can be used to the support the end of the centre, or to hold tools for drilling, reaming, threading or cutting tapers. It can be adjusted in position along the ways to accommodate different length work pieces. The tailstock barrel can be fed along the axis of rotation with the tail stock hand wheel.

The carriage controls and supports the cutting tool. It consists of

- A saddle that slides along the ways;
- An apron that controls the feed mechanisms,
- A cross slide that controls the feed mechanisms;
- A tool compound that adjusts to permit angular tool movement

Engine Lathes

Engine lathe is the basic, simplest and most versatile lathe. This machine tool is manually operated that is why it requires skilled operators. This is suitable for low and medium production, and for repair work On an engine lathe the tool is clamped onto a cross slide that is power driven on straight paths parallel or perpendicular to the work axis.

1.10 TURNING SPEED AND FEEDS

The RPM depends on the cutting speed and the diameter of the part. The RPM setting will change with the diameter of the part. As the diameter of the part gets smaller, the RPM must increase to maintain the recommend surface footage, Again, take the case of the wheel. Think of the part as a wheel and the cutting speed as a distance. A larger wheel (part) will need to turn fewer revolutions per minutes to cover the same distance in the same amount of time than a smaller wheel (part). Therefore, to maintain the recommended cutting speed, larger diameters parts must be run at slower speeds than a smaller diameter part. The lathe must be set so that the part will be operating at the proper surface speed.

Spindle speed settings on the lathe are done in RPMs. To calculate the proper RPM for the tool and the workpiece we must use the following formula.

RPM= (Cutting Speed) / (π x Diameter of workpiece)

If two pieces of different sizes are turning at the same revolutions per minute the larger piece has a greater surface speed. Surface speed is measured in surface feet per minute (SFPM). All cutting speeds work on surface footage principle. Again, cutting speeds depend upon the primarily on the kind of material you are cutting and the kind of cutting tool you are using. The hardness of the work material has a great deal to do with the recommended cutting speed. Harder the work material. slower the cutting speeds. Softer the work material, faster the recommended cutting speeds.

Summary of Turning parameters and formulae:

Cutting feed: The distance that the cutting tool or workpiece advances during one revolution of the spindle, measured in inches per revolution. In some operations the tool feeds into the workpiece and in others the workpiece feeds into the tool. For a multi point tool, the cutting feed is also equal to the feed per tooth, measured in inches per tooth, multiplied by the number of teeth on the cutting tool.

Cutting speed: The speed of the workpiece surface relative to the edge of the edge of the cutting tool during a cut, measured in surface feet per minute.

Spindle speed: The rotational speed of the spindle and the work piece in revolutions per minute (RPM). The spindle speed is equal to the cutting speed divided by the circumference of the workpiece where the cut is being made. In order to maintain a constant cutting speed, the spindle speed must vary based on the diameter of the cut. If the spindle speed is held constant, then the cutting speed will vary.

Feed rate: The speed of the cutting tool's movement relative to the workpiece as the tool makes a cut. The feed rate is measured in inches per minute and is the product of the cutting feed (IPR) and the spindle speed (RPM).

Axial depth of cut: The depth of the tool along the axis of the workpiece as it makes a cut, as in a facing operation. A large axial depth of cut will require a low feed rate, or else it will result in a high load on the tool and reduce the tool life. Therefore, a feature is typically machined in several passes as the tool moves to the specifies axial depth of cut for each pass.

1.11 USAGE OF LATHE

Basically Lathe machine is a tool use to shape elements. In lathe machine, the material is rotated in the cylindrical motion and then touches a cutting tool to it which cuts the material. The metal sheet is fixed on the chuck of the lathe machine and then the chuck rotates in the vertical direction as well as right and left direction and touching byte's tip to the material to cut the metal. The original lathe machine when invented used to complete tasks like cutting cylindrical metal sheets and then it was further developed to produce screw threads, tapered works. drilled holes. knurled surfaces and crank shafts. Modern lathe machines available now days. offer the rotating speeds as well as adjusting manually and automatically the cutting tool in the lathe machine. There are different types of lathe machines available like light duty lathe machines, medium duty lathe machines, heavy duty lathe machines, extra heavy duty lathe machines, all geared lathe machine, imported lathe machine, CNC lathe machine, roll turning lathe machines and many more, No matter what type of lathe machine it is, you need to follow the below. given basic instructions while using it.

- You need to ensure that the lathe machine about not be started cold. First of all warm up the lathe machine for 10 minutes, setting up its speed up to 1000 rpm. The lathe machine should also be well lubricated and you need to check all tools and ensure that they are tight.
- Now tool holder should be located and tool block should be inserted in it. The spot is supposed to be located in the tool block where you can insert a cutter. Also for safety reason, you need to tight the tool black as tighter as you can. The cutters allow the users to cut from left to right, which is also known as cutting on a Z axis.
- The tail stock is to be located where drill chuck can be inserted. The tail stock is very useful as it helps in drilling holes in the metal. The crank at the end of the measuring devices helps in performing precision depths to the cuts.
- The next step would be set your zero and stop the turning spindle. You need to get a tool holder and put in the tool at least 0.5 inch block between the tip of your tool and the metal sheet. Slide the tool holder in and out on an X axis to tighten it. The micrometer wheel should be set to zero.
- Also you need to set your X zero point by pulling the Z axis tool towards the spindle and slide 0.5 inch block between the tool and the work piece. You also need to set the X axis micrometer to zero and turn the wheel 0.58 inch away.

- So, now if you want to cut 0.5 inches from the metal sheet keep X axis and Z axis both 0.25 inches away from the metal sheet and then start the spindle.

1.12 SAFETY PRECAUTIONS

In machining operations always keep safety in mind, no matter how important the job is or how well the machine you know the machine you are operating.

Listed here are some safety precautions that you must follow.

I. Before starting any lathe operation, always prepare yourself by rolling up your shirt sleeves and removing your watch, finger rings and any other jewelry that might become caught while you operate the machine.

II. Wear shades or an approved face shield at all times whenever you operate a lathe or when you are near a lathe that is being operated.

III. Be sure the work area is clear of obstruction that you might fall or trip over.

IV. Keep the deck area around your machine clear of oil or grease to prevent the possibility of slipping or falling into the machine.

V. Always use assistance when handling large work pieces or large chucks

CHAPTER 2

LITERATURE REVIEW

2. LITERATURE REVIEW

Anil Kumar B N, Dr. Abrar Ahamad, Dr. Sumod Daniel, Dr.Tilak:ALUMINIUM -B4C METAL MATRIX COMPOSITES out of the varieties of metal matrices used in composites viz., Aluminum , Iron ,Magnesium, Titanium, Copper etc, Aluminum as a matrix is widely used for various applications due to its light weight, reliable mechanical properties, high thermal and electrical conductivity, ductility, malleability, low coefficient of thermal expansion, better corrosion resistance and may more desirable properties. Addition of various particulate reinforcements like SiC, Al2O3, Boron, B4C, TiC etc. into Aluminum improves their stiffness, specific strength, fatigue, conductivity, creep and fatigue properties, and also improves resistance to wear and corrosion. Of all the particulate's B4C is emerging as a promising reinforcement due to its high hardness, good chemical resistance, good nuclear properties and low density.

Upinder Kumar Yadav et.al. [1] Conducted experiments to optimize surface roughness in CNC Turning by Taguchi method. Medium Carbon Steel (AISI 1045) of Ø: 28 mm, length: 17 mm are used for the turning experiments. An L27 orthogonal array, analysis of variance (ANOVA) and the signal-to-noise(S/N) ratio are used in this study. Three levels of machining parameters are used and experiments are done onSTALLION-100 HS CNC lathe. They concluded that feed rate is the most significant factor affecting surface roughness followed by depth of cut. Cutting speed is the least significant factor affecting surface roughness.

Suleiman Abdulkareem et.al. [2] investigated the influence of the three most important machining parameters of depth of cut, feed rate and spindle speed on surface roughness during turning of AISI 1045. Box Behnken experimental design method as well as analysis of variance (ANOVA) was used to analyze the influence of machining parameters on surface roughness height R_a. From the experiments they concluded that the feed rate is found to be the most important parameter effecting Ra, followed by cutting speed while spindle speed has the least effect. They also found that machining with high cutting speed and spindle speed has positive effect on Raas against feed rate.

SmairKhrais et. Al [3] focused on evaluating surface roughness and developed a multiple regression model for surface roughness as a function of cutting parameters during the machining of flame hardened medium carbon steel with TIN-ALO-TICN coated inserts. Taguchi methodology was adapted for experimental plan of work and signal-to-noise ratio (S/N) were used to relate influence of turning parameters to the workpiece surface finish and the effects of turning parameters were studied by using the ANOVA.

M. Kaladhar et. al. [4] done an experimental investigation for finding the effect of speed, feed, depth of cut, and nose radius on multiple performance characteristics, namely, surface roughness (R_a) and material removal rate (MRR)during turning of AISI 202 austenitic stainless steel using a CVD coated cemented carbide tool. Taguchi's L8 orthogonal array (OA) is selected for experimental planning. They found that the most significant parameter for surface roughness is feed and followed by nose radius. They also analyzed that the most significant parameter for MRR is DOC and followed by cutting speed.

W.H. Yang and Y.S. Tarng [5] studied the Taguchi method, as a powerful tool to design optimization for quality and used to find the optimal cutting parameters forturning operations based on orthogonal array, signal-to-noise (S/N) ratio, and the analysis of variance (ANOVA) to investigate the cutting characteristics of S54C steel bars using tungsten carbide cutting tools. Through this study, they found not only the optimal cutting parameters for cutting operations can be obtained, but also the main cutting parameters that affect the cutting performance in turning operations. Experimental results are provided to confirm the effectiveness of this approach.

Shreemoy Kumar Nayak, et al. [6] conducted experiments by using multi objective Grey relational analysis for optimization of cutting process parameters in dry turning of AISI 304 austenitic stainless steel, and machinability characteristics of material removal rate, cutting force and surface roughness were studied. Experiments were conducted as per Taguchi L27 orthogonal array. From the mean of the overall Grey relational grade it is concluded that feed has high significance on Material Removal Rate (MRR), cutting forces and Surface roughness together followed by speed and depth of cut has least significance.

J. Hashim . Al [7], analysed that combining high specific strength with good corrosion resistance, metal matrix composites (MMCs) are materials that are attractive for a large range of engineering applications. Given the factors of reinforcement type, form, and quantity, which can be varied, in addition to matrix characteristics, the composites have a huge potential for being tailored for particular applications. One factor that, to date, has restricted the widespread use of MMCs has been their relatively high cost. This is mostly related to the expensive processing techniques used currently to produce high quality composites. In this paper, the relatively low cost stir casting technique is evaluated for use in the production of silicon carbide/aluminium alloy MMCs. The technical difficulties associated with attaining a uniform distribution of reinforcement, good wettability between substances, and a low porosity material are presented and discussed.

DiptiKanta Das, et al. [8] have done investigations for finding the optimal combination of cutting process parameters during hard machining of EN 24 steel with coated carbide insert by using Grey based Taguchi(L9 orthogonal array) and Regression methodology for minimum Surface quality characteristics R_a and R_z. The results concluded that the feed is considered to be the most dominant parameter for both Surface Roughness parameters R_a and R_z. The prediction models have been developed using regression analysis for surface Roughness and they are adequate and significant.

M.P.Gang [9]. Conducted an investigation on machining characteristic of C34000 (medium brass alloy) material in CNC turning process using GC1035 Coated carbide tool. In this research paper focused on the analysis of optimum cutting conditions to get the maximum material removal rate in CNC turning of different grades of medium brass alloy material by Taguchi method. It has been found that ANOVA shown that the depth of cut has significant role to play in producing higher MRR.

Somashekara and Lakshmana [10] have studied the machining control factors considering cutting speed, feed rate and depth of cut in order to optimize surface roughness while machining aluminum alloy Al 6351-T6 using uncoated carbide tool. The optimization was carried out using Taguchi techniques and they concluded that speed has a major influence on the surface roughness of aluminum alloy.

C.J.Rao, et al. [11] investigated the influence of speed, feed, and depth of cut on Surface Roughness and Cutting forces during machining of AISI 1050 steels (hardness of 484HV) on CNC lathe with ceramic (Al2O3+TiC matrix) tool. The experiments were conducted by using Taguchi method (L27 design with 3 levels and 3 factors). The results indicated that feed rate has most influence on both Cutting forces as well as Surface Roughness. Depth of cut has a significant influence on Cutting force, but has an insignificant influence on Surface roughness. The interaction of feed and depth of cut and the interaction of all the three cutting parameters have significant influence on cutting forces, whereas none of the interaction effects are having significant influence on the Surface Roughness produced.

Sunil J Raykar, et al. [12] investigated on the effect of process parameters on R_a, R_z, R_q parameters of surface topology in dry machining of EN8 steel by using Taguchi L27 orthogonal array and Regression analysis. Results concluded that feed has greatest influence on surface finish of all three surface topology parameters R_a, $R_q$and R_z next is to cutting speed and depth of cut has least significance. Regression models were prepared and a good correlation is found between Surface Roughness and cutting parameters and hence the models were used for predict the Surface Roughness within the range of cutting parameters under investigation.

M. Kaladhar et al. [13] optimized multi-characteristics response for turning of AISI 202 austenitic stainless steel using a CVD coated cemented carbide tool on CNC TC based on Taguchi and Utility concept. They have used this concept for optimize process parameters such as speed, feed, depth of cut, and nose radius and selected multiple performance characteristics, namely, surface roughness and material removal rate. Taguchi's L8 orthogonal array was selected for experimental planning. The experimental result analysis showed that the combination of higher levels of cutting speed, depth of cut, and nose radius and lower level of feed is essential to achieve simultaneous maximization of MRR and minimization of Ra. They have performed ANOVA for individual quality parameters as well as for multi response case. Based on the ANOVA, the most statistical significant and percent contribution of the process parameters for multiple performances were depth of cut, cutting speed whereas feed and nose radius were less effective.

B.Singarvel et al. [14] have done experimental analysis the optimum machining parameters were evaluated using Taguchi based utility concept coupled with Principal Component Analysis (PCA) on turning of EN25 steel with CVD and PVD coated carbide tools. This strategy has been utilized for simultaneous minimization of surface harshness, cutting power and maximization of material removal rate. They found that the results of ANOM shown that a combination of machining parameters for this investigation were cutting speed of 244 m/ min, feed rate of 0.10 mm/rev and depth of cut of 1.0 mm with CVD coated tool. The result of ANOVA showed that the coated tool was the most significant parameter followed by cutting speed. The prediction error (i.e) the difference between the predicted SN ratio and multi objective SN ratio was within the confidence level.

Hari Vasudevan et al. [15] studied a hybrid multi objective optimization algorithm involving utility and fuzzy coupled with Taguchi methodology. Four process parameters, at three levels were selected for the study viz. tool nose radius, cutting speed, feed and depth of cut and surface roughness, cutting force and material removal rate were chosen as quality performance measures. They used Taguchi L27 orthogonal array to perform experiments. Woven fabric based GFRP/Epoxy tubes produced using hand layup process were finish turned using Poly Crystalline Diamond (PCD) tool. Utility values of the three performance measures were transformed into a single Multi Performance Characteristics Index (MPCI) using Mamdani type fuzzy inference system. Then, MPCI is then optimized using Taguchi analysis. The for multi characteristics the optimal sequence found: tool nose radius of 0.8 mm, cutting speed of 200 m/min, feed rate of 0.05 mm/rev and depth of cut of 1mm. The confirmatory experiment at these settings gives maximum value of MPCI validating the results.

KishanChoudhuri et al. [16] used Taguchi and Utility concept to optimize the process parameters, such as speed, feed, and depth of cut on multiple performance characteristics, namely surface roughness and material removal rate during turning of

Aluminium 6061 using a Carbide cutting tool on CNC TC. Taguchi's L9 orthogonal array was selected for experimental planning. The experimental result showed that combination of higher levels of feed, depth of cut, and lower level of spindle speed was essential to achieve simultaneous maximization of MRR and minimization of surface roughness. They have performed ANOVA analysis for individual response characteristic. From ANOVA analysis they found that the depth of cut (65.57%) was most significantly influences the Ra followed by spindle speed (6.344%) and in case of material removal rate, feed (76.109%) was the most significant parameter followed by spindle speed (9.597%).

Nithyanandhan T. et al. [17] have investigated the effects of process parameters on surface finish and material removal rate (MRR) to obtain the optimal setting of process parameters. And the analysis of Variance (ANOVA) is also used to analyze the influence of cutting parameters during machining. AISI 304 stainless steel work pieces are turned on conventional lathe by using tungsten carbide tool. The results revealed that the feed and nose radius is the most significant process parameters on work piece surface roughness. However, the depth of cut and feed are the significant factors on MRR.

Ali MotorcuRiza [18] studied the surface roughness in the turning of AISI 8660 hardened alloy steels by ceramic based cutting tools with cutting parameters such as cutting speed, depth of cut, feed rate in addition tool's nose radius, using a statistical approach An orthogonal design, signal-to-noise ratio and analysis of variance were employed to find out the effective cutting parameters and nose radius on the surface roughness.

KompanChomsamutr et al. [19] objective of research is to compare the cutting parameters of turning operation the work pieces of medium carbon steel (AISI 1045) by finding the longest tool life by Taguchi methods and Response Surface Methodology: RSM. This research is to test the collecting data by Taguchi method. The analyses of the impact among the factors are the depth of cut, cutting speed and feed rate. This research found that the most suitable response value; and tool life methods give the same suitable values, i.e. feed rate at 0.10 mm/rev, cutting speed at 150 m/min, and depth of cut at 0.5 mm, which is the value of longest tool life at 670.170 min, while the average error is by RSM at the percentage of 0.07 as relative to the testing value.

Sunil Kumar Sharma et al. [20] have analyzed that Taguchi optimization technique pair with grey relational analysis has been adopted for evaluating parametric complex to carry out acceptable surface roughness lower is better, material removal rate higher is better of the AISI 8620 steel during turning on a CNC Lathe Trainer. After identify the optimal process parameters setting for turning operation, ANOVA is also applied for finding the most significant factor during turning operation. In this study it is concluded that the feed rate is the most significant factor for the surface roughness and material removal rate together, as the Pvalue is less than 0.05. Cutting speed and depth of cut is found to be insignificant from the ANOVA study.

Dilbag Singh et. Al [21] investigated the effects of cutting conditions and tool geometry on surface roughness in the finish hard turning of the bearing steel (AISI 52100) with mixed ceramic inserts made up of aluminum oxide and titanium carbon nitride. This study showed that feed is dominant factor determining the surface finish followed by cutting velocity and the tool rake angle and at mathematical model for the surface roughness were developed by using the response surface methodology

Tian-Syung Lan et al.[22] investigated the effect of cutting speed, feed, cutting depth, tool nose runoff with three levels (low, medium, high) on MRR in finish turning based on L9(34) orthogonal array. It have been found that the material removal rates from the fuzzy Taguchi deduction optimization parameters are all significantly advanced comparing to those from the benchmark. Also it has been declare that contributed the satisfactory fuzzy linguistic approach for the MRR in CNC turning with profound insight.

IshwerShivakotiet al.[23] presents a genetic algorithm optimization approach for finding the optimal parameter setting during turning operation in conventional Lathe machine. It was found that material removal rate in-creases with the increase of feed rate. However, at low spindle speed of rotation, the material removal rate is high compared to high spindle speed of rotation. The regression equation for material removal rate (MRR) has been developed using statistical Minitab software. The regression equation was validated through comparative results of MRR achieved during experimentation. Genetic Algorithm (GA) has been used to achieve the optimum machining parametric combination in order to obtain the value of optimal result of material removal rate. The results obtained in this paper can be effectively utilized for machining, particularly turning operation of mild steel material in shop floor manufacturing.

JafarZare and Afsari Ahmad [24] studied the performance characteristics in turning operations of D2 (1.2510) steel bars using TiN coated tools. Three cutting parameters namely, cutting speed, feed rate, and depth of cut, will be optimized with considerations of surface roughness. The study shows that the Taguchi method is suitable to solve the stated within minimum number of trials as compared with a full factorial design. The main objective of this study was to demonstrate a systematic procedure of using Taguchi design method in process control of turning process and to find a combination of turning parameters to achieve low material removal rate.

T. Tamizharasanet. Al [25]analysed the process of hard turning and its potential benefits compared to the conventional grinding operation. Additionally, tool wear, tool life, quality of surface turned and amount of material removed are also predicted.

CHAPTER 3

EXPERIMENTAL DETAILS

3. EXPERIMENTAL DETAILS

3.1 SELECTION OF MATERIAL

The matrix material utilized in the current study is Al2024. The distinctive alloying parts are magnesium, copper, manganese, element, and atomic number 30. It belongs to a gaggle of hypo mixture Al-Si-B alloys and includes a wide field of application within the automotive and aeronautics industries. Besides this, the Al 2024 alloy is employed as a matrix for getting composites that have Associate in Nursing increased wear resistance, favourable mechanical properties at temperature, and increased mechanical properties at elevated temperatures. Al 2024 alloys naturally have Associate in nursing modulus of elasticity of regarding 73.1 GPa. In general, stiffer and lighter styles are achieved with Al 2024 alloys than is feasible with steels.

2024 is commonly extruded, and also available in alclad sheet and plate forms. It is not commonly forged .

T3 is an alloy of the same composition that has been furnace solution heat treated, quenched to room temperature, and cold worked.

Applications of Al2024: 2024 aluminium has excellent machinability, good workability, high strength, and can be made to resist corrosion with cladding, making it an optimal choice for aircraft and vehicle applications. 2024 aluminium is used throughout many industries, but some common applications for this excellent alloy are as follows:

- Rail coaches
- Military and commercial bridges
- Ship building operations
- Towers and pylons
- Rivets
- Aerospace applications (i.e., helicopter rotor skins)
- Transport operations.

Table 3.1 Al 2024 Mechanical Properties

Base Material	Al 2024
Density value	2.78 g/cm^3
Young's modulus value	73.1Gpa
Tensile strength value	140-210Mpa
Elongation at break value	19-27%
Poisson's ratio value	0.33
Melting temperature value	500°c
Thermal conductivity value	151-202 W/(m-k)
Linear thermal expansion coefficient value	$2.34X10^{-5}$
Specific heat capacity value	897 J/(kg-k)

Table 3.2 Al2024 Chemical Composition

Elements	Cu	Mg	Si	Fe	Mn	Cr	Zn
Wt %	4.67	1.5	0.05	0.211		0.003	0.073

Fig. 3.1 Al2024 composite

3.2 REINFORCEMENTS

3.2.1 ALUMINIUM OXIDE REINFORCEMENT:

1. Investigated the effect of Al2O3:-
2. In Aluminium for volume fractions varying from 5-30% and found that the increase in volume fraction of Al2O3 decreased the fracture toughness of the MMC. This is due to decrease in inter-particle spacing between nucleated micro voids. Park et al. investigated the high cycle fatigue behaviour of 6061 Al-Mg-Si alloy reinforced Al2O3 microspheres with the varying volume fraction ranging between 5% and 30%. They found that the fatigue strength of the powder metallurgy processed composite was higher than that of the unreinforced alloy and liquid metallurgy processed composite. Tjong et al compared the properties of two aluminium metal matrix
3. Al-B2-O3-TiO2 system. It was found that the reactive hot pressing the composites resulted in the formation of ceramic Al2O3 and TiB2 particulates as well as coarse intermetallicAl3A.

3.2.2 Boron Carbide (B_4C)

Boron carbide (chemical formula B_4C) is a boron–carbon ceramic and covalent substance that is used in tank armour, bulletproof vests, engine sabotage powders, and a variety of other industrial applications. It is one of the hardest known materials, second only to cubic boron nitride and diamond, with a Vickers hardness >30 GPa. Boron carbide is known as a robust material having extremely high hardness (about 9.5 up to 9.75 on Mohs hardness scale), high cross section for absorption of neutrons (i.e. good shielding properties against neutrons), stability to ionizing radiation and most chemicals. Its Vickers hardness (38 GPa), Elastic Modulus (460 GPa) and fracture toughness (3.5 $MPa \cdot m^{1/2}$) approach the corresponding values for diamond (1150 GPa and 5.3 $MPa \cdot m^{1/2}$).

Table: 3.4 Chemical Composition of B_4C

Element	B	C	Ca	Fe	Si	F	Cl
%	80	18.1	0.3	1.0	0.5	0.025	0.075

Applications of B_4C:

- Abrasives
- Nozzles
- Nuclear applications
- Ballistic Armour
- Other applications include ceramic tooling dies, precision tool parts, evaporating boats for materials testing and mortars and pestles.

Fig. 3.3 B_4C Powder

3.3 MUFFLE-FURNACE

A furnace is one of the most elements of your HVAC system. Once you set your thermostat, you activate the chamber to start heating air. a disciple switches on and circulates this heated air through your home. However, the warmth is transferred to the air depends on the kind of furnace.

A muffle furnace or muffle oven (sometimes retort furnace in historical usage could be a chamber inside which the theme material is segregated from the fuel and all of the product of burning, just as gases and flying debris. at the point when the occasion of high-temperature warming parts and boundless charge in created nations, new mute heaters immediately delighted to electrical styles.

Fig: 3.4 Muffle Furnace

One will set the desired temperature by pressing red colour push by finger, hold a similar in pressing position and temporary worker by rotating coarse, fine knobs and unharnessed the finer from the push. When emotional push, junction rectifier show of controller indicates an actual temperature of **furnace.** There are four main styles of furnaces: gas, oil, electric, and fuel. Electrical furnaces will heat the air by exposing heated parts, whereas alternative styles of furnaces generally need a device or chamber that warms the encompassing air.

3.4 ELECTRIC ARC FURNACE

An Electric arc furna**ce** (EAF) is a furnace that heat charged material by means that of an electrical arc. Mechanical circular segment heaters place size from small units of around one-ton ability (utilized in foundries for assembling fashioned iron items) as much as 400 ton units utilized for optional steelmaking. Circular segment heaters used in investigation research centres and by dental specialists may have a capacity of exclusively around dozen grams. Modern flash chamber temperatures will reach one,800 °C (3,272 °F), while research centre units will surpass three,000 °C (5,432 °F). Circular segment heaters differ from enlistment heaters, in this, the charged material is straightforwardly presented to an electrical bend, and furthermore the flow inside the chamber terminals goes through the charged material.

Fig: 3.5 Electric Arc Furnace

3.5 FABRICATION

3.5.1. PRE-HEATING

Preheating of Reinforcement ought to be exhausted to get rid of agglomeration, wetness, and gases conferred in it. Assault and Al_2O_3 are preheated in a Muffle chamber at a temperature of 3500c for one day. A six-finger die is preheated for one hour at 400^{o}c in Arc chamber such, the liquefied metal doesn't get solid quick.

Fig: 3.6 Muffle Furnace **Fig.3.7 Electric Arc Furnace**

3.5.2. STIR CASTING

Stir casting could be a liquid state technique for the manufacture of composite materials, within which a dispersed particle is combined with a liquefied metal matrix by means that of mechanical stirring. Stir Casting is that the simple technique of liquid state fabrication

It is one of all the foremost appropriate techniques for manufacturing metal matrix composites for various combinations of ceramic and metals.

It could be a sort of easy operation, lower price of production and production capabilities created this system versatile.

In recent past composites as well as steel and titanium-based alloys have additionally been rumoured. The hybrid composites are a brand new age of metal framework composites to achieve desired properties at a nearer approximation of real desires. These might have the potential of satisfying the recent demands of advanced engineering applications.

The Aluminium 2024 is placed within the vessel nearly 800gm-1000gm as per our demand of dying as shown in fig. shut the lid on the vessel and wait until the bottom material turns into liquid and add the reinforcements I Chronicles,2% consistent with the load of the Al-2024 within the chamber.

Fig: 3.8 Stir Casting Furnace

3.5.3 CRUCIBLE

Crucible is that the instrumentality within which the metal is molten then poured into a mould to perform casting. The fabric of mould ought to have a more freezing point, more strength {and ought to |and will| and may} be a sensible conductor of warmth so that heat loss should be low. They are many materials on the market for this purpose like SiC, solid steel, and atomic number 6. For our necessities, the SiC vessel is good for suited, but the price is incredibly high therefore can't be afforded. We have got taken here an atomic number 6 vessel that serves our functions as its melting temperature is 2700°C that is way on top of operating temperature. The vessel is formed in an exceedingly form of a cylinder with decrease diameter so that the high portion remains a cylinder but the lowest half takes the form of a hemisphere. A handle is connected to the aspect of the vessel to carry it whereas putting it within the chamber and whereas gushing hot metal into the mould cavity. It will face up to terribly high temperatures and is employed for metal, glass, and for pigment production additionally as a variety of newly laboratory processes.

3.5.4 STIRRER

The strategy used in the manufacture of MMC needs the scattered particles that are the ceramic particles (SiC) to be blended in a strong state inside the fluid metal. Consequently for the uniform blend of the ceramic particles inside the fluid metal, it's necessary that the combination be mixed well. Thus, a stirrer is required which might withstand the warm temperature and doesn't affect the virtue of the composite. The stirrer is made of a chrome steel pole whose face is associated with a nuclear number 6 fan. It's driven by a ½ H.P. AC engine and pivots at a disturbing 400 rates. The stirrer is embedded upward into the vessel concerning 33% of its tallness once adding the fired particles. Here we've given approaches to mixing through outside mediums that might be associated with the chamber at any reason through the most elevated.

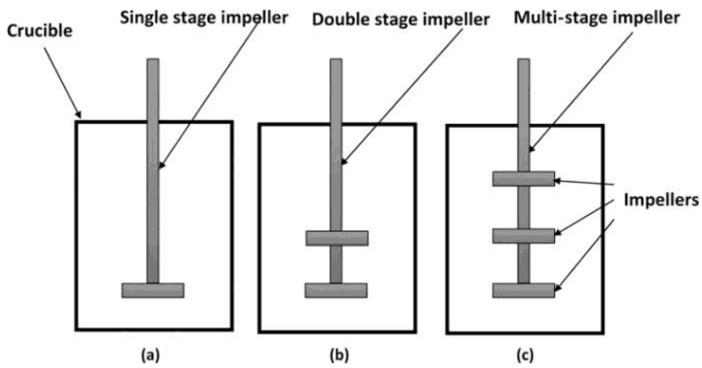

Fig.3.9 Single stage impeller stirrer, double stage impeller stirrer,multistage impeller stirrer

3.5.5 CASTING ON MOLTEN ALUMINIUM

Subsequent to preparing the form, the liquefied metallic component was filled the shape pass on from the vessel and was left to set. When the projecting is finished, it had been isolated from the shape.

Fig 3.10 Casted aluminium bars

The work material selected for the present study was AA2024 and it is a high performance known for its high level of strength, corrosion resistance. It has applications in marine, aerospace, nuclear industries and mainly used in production of vessels, heat exchangers, valves, and fluid distribution systems etc. The process parameters for the machining on work piece using taguchi's standard L18 orthogonal array design given in table 3.5.

Table: 3.5 Process Parameters and Their Levels

Parameters	level		
	1	2	3
Nose radius, mm	0.4	0.8	-
Speed, RPM	750	1000	1250
Feed, mm/rev	0.1	0.15	0.2
Depth of cut, mm	0.3	0.6	0.9

Table: 3.6 L18 OA Design

s.no	Tool nose radius	Speed	feed	Depth of cut
1	0.4	750	0.1	0.3
2	0.4	750	0.15	0.6
3	0.4	750	0.2	0.9
4	0.4	1000	0.1	0.3
5	0.4	1000	0.15	0.6
6	0.4	1000	0.2	0.9
7	0.4	1250	0.1	0.6
8	0.4	1250	0.15	0.9
9	0.4	1250	0.2	0.3
10	0.8	750	0.1	0.9
11	0.8	750	0.15	0.3
12	0.8	750	0.2	0.6
13	0.8	1000	0.1	0.6
14	0.8	1000	0.15	0.9
15	0.8	1000	0.2	0.3
16	0.8	1250	0.1	0.9
17	0.8	1250	0.15	0.3
18	0.8	1250	0.2	0.6

CHAPTER 4

METHODOLOGY

4. METHODOLOGY

Basically, traditional experimental design procedures are too complex and not easy to use. A large number of experimental works have to be carried out when the number of the process parameters increases with their levels. To solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with only a small number of experiments. The greatest advantage of this method is to save the effort in performing experiments, to save the experimental time ,to reduce the cost, and to find out significant factors which effecting the responses. Taguchi robust design method is a most powerful tool for the design of a high-quality system. He considered three steps in a process's and product's development: system design, parameter design, and tolerance design. In system design, the engineer uses scientific and engineering principles to determine the fundamental configuration. In the parameter design step, the specific values for system parameters are determined and tolerance design is used to determine the best tolerances for the parameters.

4.1 TAGUCHI

The taguchi method is a one of the efficient robust technique, proposed by Denichi Taguchi in 1980's. It is a set of methodologies like orthogonal array, Signal-to-Noise ratios, by which the inherent variability of materials and manufacturing processes can be considered at the design stage. It generally takes nominal design points that are responsible to variations in production and user environments to improve the productivity as well as quality of the product. In taguchi method one can conduct limited experimental combinations for getting entire data. It includes three stages; 1. System design, this determines the suitable working levels of design factors. 2. Parameter design, in this stage the selection of proper orthogonal array, run the experiments, analyse the data, identifying optimal condition and confirmation runs can be done. 3. Tolerance design, this determines the results of parameter design by tightening the tolerance of the significant factors. The procedure followed for Taguchi method is as follows

- Find the main functions, side effects
- Noise factors, testing conditions and quality characteristics has to be identified
- Identify the objective function to be optimized
- Fix the control factors and their corresponding levels

- Select the orthogonal array matrix experiment
- Conduct the matrix experiment
- Predict the optimum levels and performance from the analysis
- Carryout the verification experiment and plan the future action

Taguchi's Orthogonal Array (OA) provides a set of well balanced experiments (with less number of experimental run), and Taguchi's signal-to-noise ratios (S/N), which are logarithimic functions of desired output; serve as objective function in the optimization process. Taguchi method uses a statistical measure of performance called signal-to-noise ratio. The S/N ratio take moth variability and the mean into the account. The S/N ratio is the ratio of the mean (signal) to the standard deviation (noise). The ratio depends upon the quality characteristics of product process to be optimized. The standard S/N ratios generally used are as follows:

I. Nominal-is-Best (NB)
II. Lower-the-Better (LB)
III. Higher-the-Better (HB)

The optimal setting is the parameter combination, which has the highest S/N ratio. Because, of the irrespective quality criteria may be (NB, LB, HB) S/N ratio should always be maximized. Once experimental data is normalized using NB/LB/HB criteria; normalized value lies in between 0 & 1. Zero represents worst quality to be rejected and one represents most satisfactory quality. Since S/N ratio is expressed as mean to the noise; maximizing S/N ratio ensures minimum deviation and hence it its (S/N ratio) to be maximized.

4.2 ANOVA (Analysis of Variance)

Analysis of Variance (ANOVA) is a collection of statistical models used to analyze the differences between group means and their associated procedures (such as "variation" among and between groups), in which the observed variance in a particular variable is partitioned into components and attributable to different sources of variation. In its simplest for, ANOVA provides statistical test of whether or not the means of several groups are all equal, and therefore generalizes t-test to more than two groups. Doing multiple two sample ttests would result in an increased chance of committing a type I error. For this reason ANOVA's are useful in comparing (testing) three or more means (groups or variables) for statistical significances.

ANOVA is to study the significance of process parameters on the output characteristics. In this method, first the total sum of the squared deviations SS_T from the total mean of the S/N ratio η can be calculated as

$$SS_T = \sum_{i=1}^{m}\left(\eta_i - \bar{\eta}\right)^2 = \sum_{i=1}^{m}\eta_i^2 - \sum_{i=1}^{m}2\eta_i\bar{\eta} + \sum_{i=1}^{m}\bar{\eta}^2$$

$$= \sum_{i=1}^{m}\eta_i^2 - 2m\bar{\eta}^2 + m\bar{\eta}^2 = \sum_{i=1}^{m}\eta_i^2 - m\bar{\eta}^2$$

$$= \sum_{i=1}^{m}\eta_i^2 - \frac{1}{m}\left[\sum_{i=1}^{m}\eta_i\right]^2$$

Where 'm' is number of experiments in orthogonal array and η_i is the mean S/N ratio for the i^{th} experiment. The total sum of squared deviations SS_T is decomposed into two sources: the sum of the squared deviations SS_p due to each process parameter and the sum of the squared error SS_e.

$$SS_P = \sum_{j=1}^{t}\frac{(S\eta_i)^2}{t} - \frac{1}{m}\left[\sum_{i=1}^{m}\eta_i\right]^2$$

Where p represents one of the experiment parameters, j the level number of this parameter p, t the repetition of each level of the parameter p, the S/N ratio of parameter p at level j is $s\eta_j$.

The sum of squares SS_e is given as

$$SS_e = SS_T - SS_A - SS_B - SS_C$$

The total degree of freedom is D_T = m-1, where the degrees of freedom of the tested parameter D_P = t-1.

The variance, $V_P = SS_P/D_P$.

Then the F-Value for each design parameter is simply the ratio of the mean square's deviation to the mean of the squared error ($F_P = V_P/V_e$).

$S_P = SS_P - D_P.V_e$

The percentage contribution p can be calculated as:

$$P = \frac{S_P}{SS_T}$$

The P value gives the percentage that each process parameter is contributed for the response characteristic.

4.3 MINITAB

Minitab is a statistics package. It was developed at the Pennsylvania State University by researchers Barbara F. Ryan, Thomas A. Ryan, Jr., and Brian L. Joiner in 1972. Minitab is relatively easy to use once you know a few fundamentals.

Minitab has two main types of files, projects and worksheets. Worksheets are files that are made up of data; think of a spreadsheet containing variables of data. Projects are made up of commands, graphs, and worksheets. Every time you save a Minitab project, you will be saving graphs, worksheets, and commands. However, each one of the elements can be saved individually for use in other documents or Minitab projects. Likewise, you can print projects and their elements.

4.3.1 Minitab Project and Worksheets

Minitab has two main types of files, projects, and worksheets. Worksheets are made up of data; think of a spread sheet containing data variables. Projects are made up of commands, graphs, and worksheets. Every time you save a Minitab project, you will be saving graphs, worksheets, and commands. However, each element can be saved individually for use in other documents or Minitab projects. Likewise, you can print projects and their elements.

The Menu bar: You can open menus and choose commands. Here you can find the built-in routines.

The Toolbar: Shortcuts to some Minitab commands.

Windows in MINITAB

1. Session Window: The area that displays the statistical results of your data analysis and can also be used to enter commands.

2. Worksheet Window: A grid of rows and columns used to enter and manipulate the data. Note: This area looks like a spreadsheet but will not automatically update the columns when entries are changed.

Other windows include:

• Graph Window: When you generate graphs, each graph is opened in its own window.

- Report Window: Version 13 has a report manager that helps you organize your results in a report.
- Other Windows: History and Project Manager are other windows. See Minitab help for more information on these if needed.

CHAPTER 5

RESULTS AND DISCUSSION

5. RESULTS AND DISCUSSION

5.1 Taguchi Analysis

The experimental results of material removal rate and surface roughness measured were depicted in the table 5.1. The analysis was carried out using MINITAB-17 software. The effect of process parameters on responses were calculated and plotted. Taguchi results for the responses are given in the tables, where the ranks indicate the relative importance of each factor. The main effect plots were drawn to study the variation effects of parameters on the responses with their changes in levels.

Table: 5.1 Experimental Results

S.no	MRR(cm^3/min)	Ra(μm)
1	0.023	2.626
2	0.068	5.795
3	0.135	6.219
4	0.030	2.509
5	0.090	4.876
6	0.180	5.327
7	0.075	3.049
8	0.169	4.115
9	0.750	4.687
10	0.068	1.005
11	0.034	0.771

12	**0.090**	**6.035**
13	**0.060**	**1.053**
14	**0.0135**	**3.534**
15	**0.060**	**4.965**
16	**0.113**	**1.784**
17	**0.056**	**2.132**
18	**0.150**	**4.158**

Table: 5.2 Taguchi Results for MRR

level	Nose radius	Speed	Feed	Depth of cut
1	**0.09389**	**0.06967**	**0.06150**	**0.04633**
2	**0.08511**	**0.09250**	**0.09200**	**0.08883**
3		**0.10633**	**0.11500**	**0.13333**
Delta	**0.00878**	**0.03667**	**0.05350**	**0.08700**
Rank	**4**	**3**	**2**	**1**

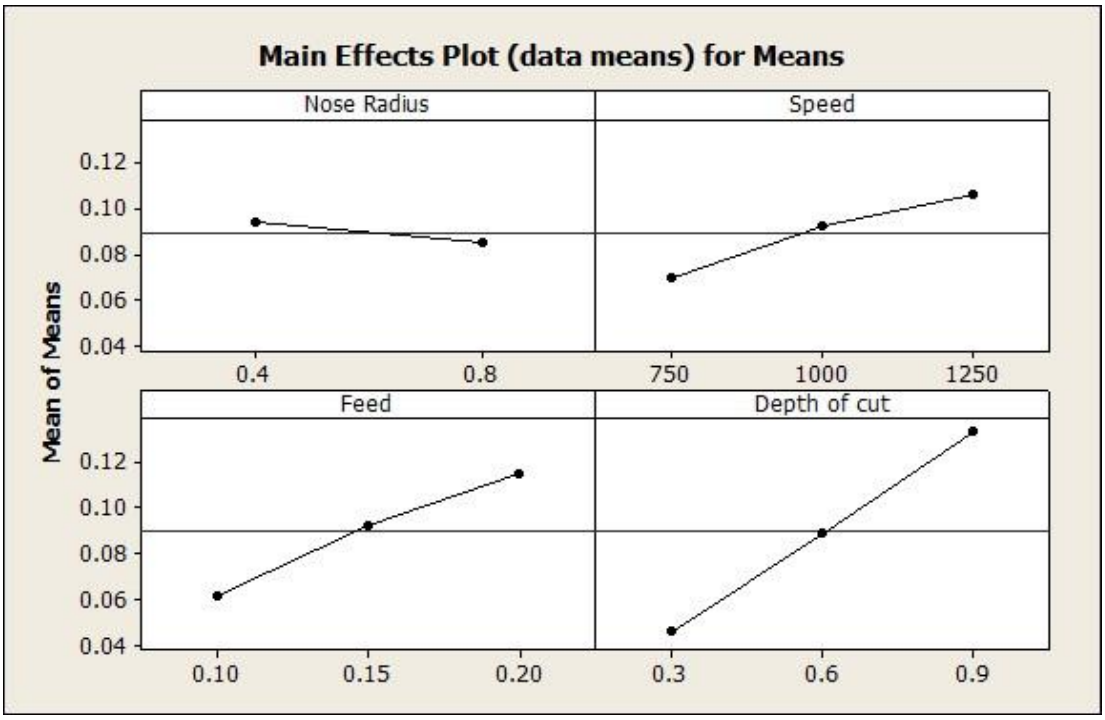

Fig 5.1 Main Effect Plots for Means of MRR

Table: 5.3 Taguchi results for Ra

level	Nose radius	Speed	Feed	Depth of cut
1	4.356	3.742	2.004	2.948
2	2.826	3.710	3.537	4.162
3		3.321	5.232	3.664
Delta	1.529	0.421	3.228	1.213
Rank	2	4	1	3

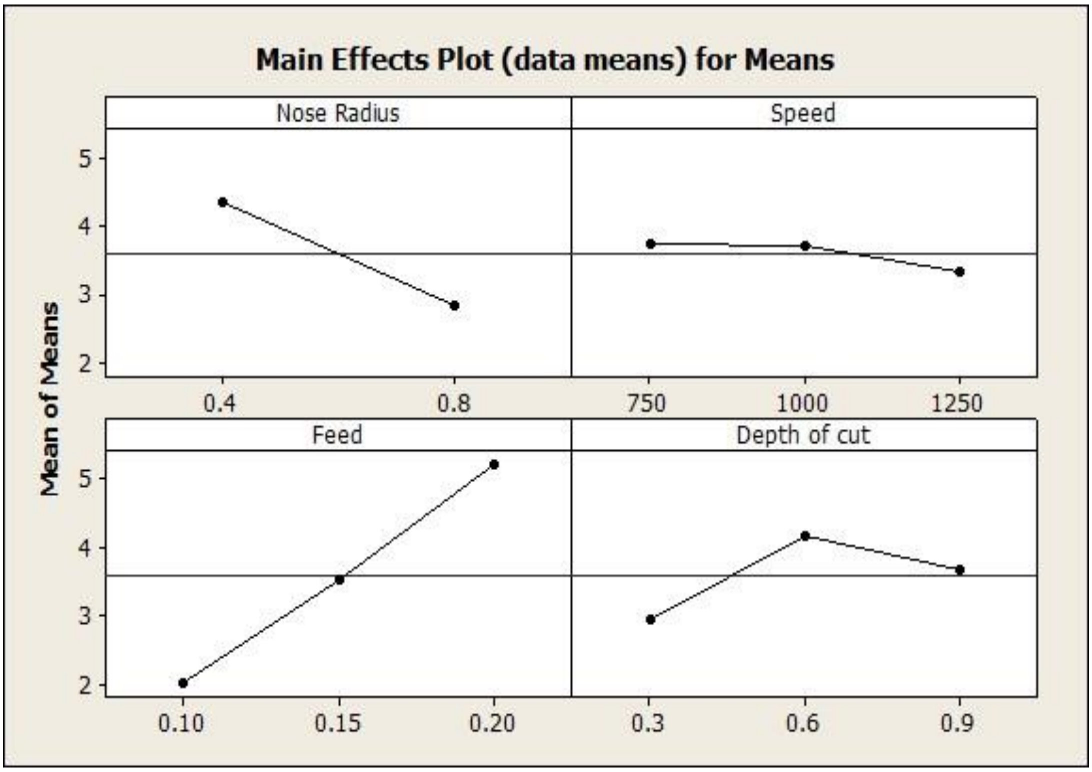

Fig 5.2 Main Effect Plots for Means of Ra

5.2 ANOVA results

ANOVA results of the responses were given in tables 5.6 and 5.7. The residual plots were drawn and shown in figures 5.3 and 5.4. A very good agreement has been found between the predicted and experimental values hence the models prepared were best fit and accurate.

Table 5.4 ANOVA Results of MRR

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Nose radius	1	0.0003467	0.0003467	0.0003467	1.51	0.248
Speed	2	0.0041143	0.0041143	0.0041143	8.95	0.006
Feed	2	0.0086430	0.0086430	0.0043215	18.79	0.000
Depth of cut	2	0.0227110	0.0227110	0.0113555	49.38	0.000
Error	10	0.0022994	0.0022994	0.0002299		

Total	**17**	**0.0381145**				

S =0.0151639, R2 = 93.97%, R2(adj) = 89.74%

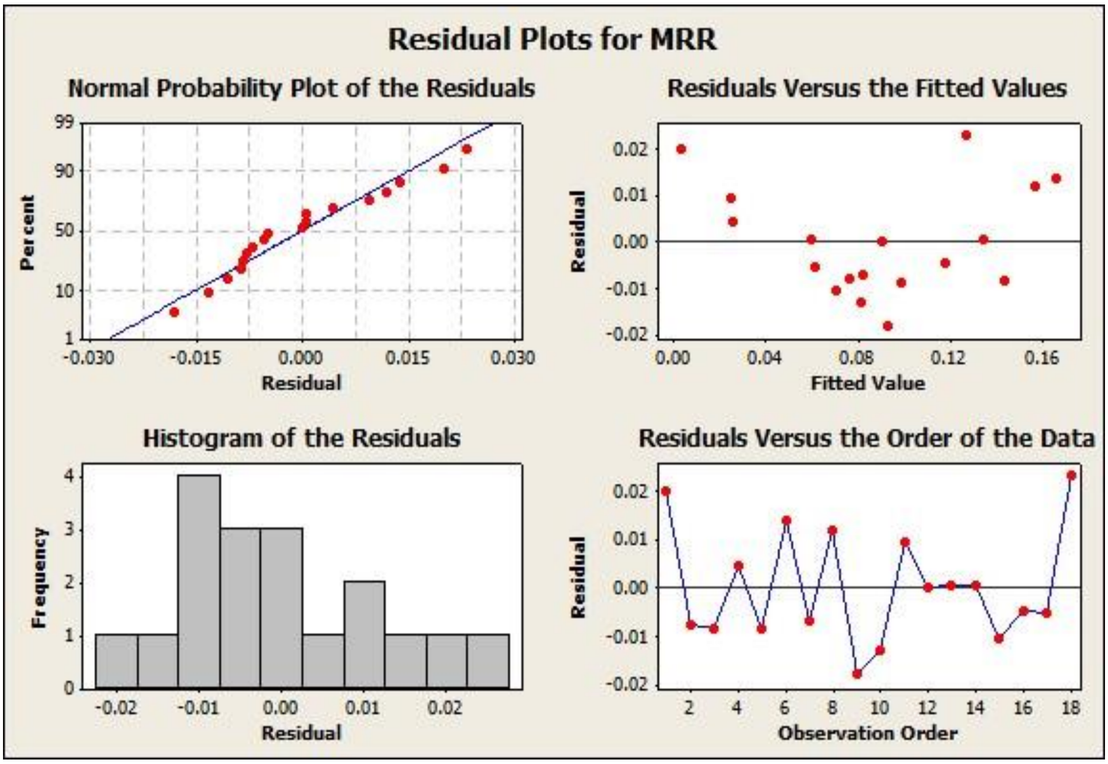

Fig 5.3 Residual Plots for MRR

Table 5.5 ANOVA Results of Ra

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Nose radius	1	10.5233	10.5233	10.5233	13.10	0.005
Speed	2	0.6596	0.6596	0.3298	0.41	0.674
Feed	2	31.2860	31.2860	15.6430	19.47	0.000
Depth of cut	2	4.4634	4.4634	2.2317	2.78	0.110
Error	10	8.0355	8.0355	0.8036		

Total	**17**	**54.9678**				

S = 0.896411, R2 = 85.38%, R2(adj) = 75.15%

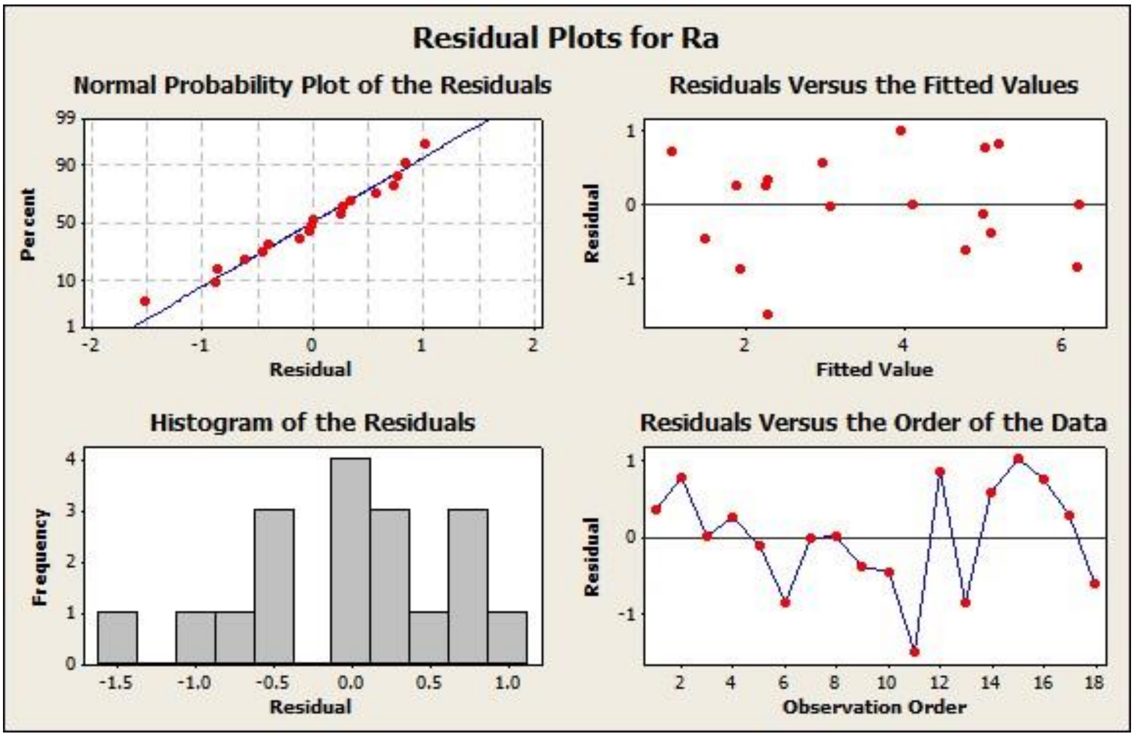

Fig 5.4 Residual Plots for Ra

CHAPTER 6

CONCLUSION

6. CONCLUSIONS

In the present work an attempt to optimize roughness and material removal rate analysis has been made.

The process parameters considered are depth of cut, feed rate and cutting speed From the experimental results table, it is observed that,

- The optimum combination of process parameters for material removal rate is obtained at
  - Nose radius: 0.4 mm,
  - Speed: 1250 RPM,
  - Feed: 0.2 mm/rev
  - Depth of cut:0.9 mm respectively.
- The optimum combination of process parameters for surface roughness is obtained at
  - Nose radius: 0.8 mm,
  - Speed: 1250 RPM,
  - Feed: 0.1 mm/rev
  - Depth of cut:0.3 mm respectively.
- ANOVA results revealed that depth of cut and feed are the most predominant factors for material removal rate and surface roughness respectively

CHAPTER 7

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7. REFERENCES

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