International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 04 | Apr 2024 www.irjet.net p-ISSN: 2395-0072

# Experimental Analysis of Machining Parameters of Metal Matrix Composite

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**Abstract -** Metal matrix composites (MMCs) represent a crucial category of style and square measure mass-economical structural materials that square measure encouraging each field of manufacturing tenders. It takes Associate in Nursing collective curiosity in mixtures having solidity and short price backups. Amid varied intermittently spread artifacts castoff, aluminum oxide is an amongst the foremost cheap then compactness strengthening out there massive amounts for instance solid excess through-invention throughout burning of coal in thermal power plants. Hereafter, mixtures by aluminum oxide as strengthening square measure possible beat value fence aimed at varied unfold solicitations in motorized and little engine solicitations to supply Al matrix forged element mixtures, wet ability the ceramic atoms by liquid Al is crucial to boost wet ability, parts such as aluminum oxide square measure adscititious into Al soften to include the ceramic particles. the current work has been targeted on the employment of pr out there industrial waste. Aluminum oxide in helpful manner by dispersing it into aluminum oxide matrix to made composites by mechanical stir casting. Wide size varies (0.1- 100μm) aluminum oxide elements were used. The properties like tensile strength, hardness, toughness which are related to mechanical is investigated during my work . The experimental investigation of hybrid metal matrix composites with Aluminium and Alumina reinforced aluminum alloy (Al 6064) composites samples 5%, 10%,15%, 20%,25% and 30% volume fraction applied for the purpose of production and testing of the materials. Also the machining parameters of Lathe Machine in turning namely the speed, feed, depth of cut and nose radius are optimize by using response surface methodology.

**Keyword-MMCs, $Al_2$ $O_3$ , Turning operation in Lathe, RSM, Mechanical Properties of metal etc.**

## 1. INTRODUCTION

### 1.1. Metal Matrix Composite

Metal matrix composites normally, carries with it a minimum of 2 elements, first is that metal matrix, other element is strengthening. Matrix is outlined as a metallic completely told belongings, however a pure metal isn't typically castoff because the medium it's typically Al alloy within the efficiency of the compound the matrix and also strengthening square measure varied along. Before few years, expansion of metal matrix composite (MMCs) received international courtesy on account of their higher strength and toughness additionally great attire resistance and creep resistance contrast to their conforming alloys.

Aluminums metal matrix composites (Al MMCs) square measure being thought of as a bunch of latest advanced materials for its light-weight mass, high strength, high specific modulus, low co-efficient of thermal growth and smart wear resistance properties. Combination of those properties isn't obtainable during a conservative material.

### 1.2. Advantages of MMC:

Cover patterns and ply buildup during a half are often wont to offer the desired mechanical properties in varied tips.

- Excellent strength-to mass and stiffness-to-mass ratios are often achieved by compound Material.
- Higher electrical and thermal conductivities.
- No wetness absorption.
- Higher cross stiffness and strength.
- Fire confrontation
- Higher temperature capability.

### 1.3. Disadvantages of MMC:

- Compound production strategies for fiber-reinforced systems (except for casting).
- Relatively undeveloped technology.
- Higher value of some measurable systems.

### 1.4. Production Techniques of Metal Matrix Composite.

**Spray co-deposition method**

It is an economical method of producing a Particulate composite. In this method alloy to be sprayed is melted in a flask by induction heating. The flask is pressurized and the metal is ejected through a nozzle into an atomizer where, at the same time, particles are injected into the atomized metal and dropped on a preheated substrate placed in the line of flight. On collector a solid credit is built up. The shape of the final formation depends on the atomizing condition and the shape and the motion of the amasser.

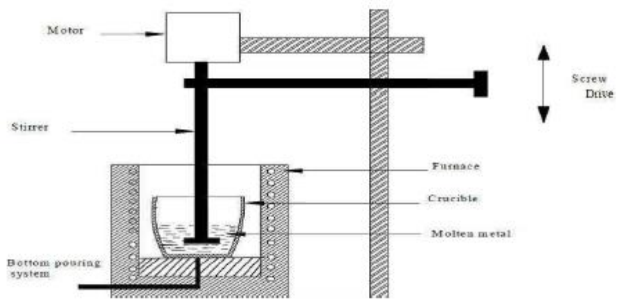


**Figure 1.1 Mechanical stir casting**

The crucial thing is to create good moistening between the particulate strengthening and the molten metal, in this process. Micro structural in equalities can cause particularly particle collection and sedimentation in the melt and then during solidification. In similarity in strengthening spreading in these cast composites could also be a problem as a result of contact between suspended ceramic particles and moving solid-liquid interface during Solidification. The manufacture costs of MMCs are very low by use of this process it is the main advantage of this process

### 1.6. MACHINING PARAMETERS OF LATHE MACHINE

**Cutting speed (V):** Cutting speed is relative velocities among cutting tool and work piece. In turning on Lathe machine it is the speed of the work piece while in drilling on drilling machine, it is the speed of the cutting tool. In turning, it is given by the surface speed of the work piece,

$$V = \pi DN/1000$$

Where D is the diameter of the work piece.

**Depth of cut (d):** It is the distance the cutting tool cuts into the work piece. In turning on lathe machine, for example, it is given by:

$$d = (D1-D2)/2.$$

**Feed (f):** It is movement of the tool per revolution. In turning, it is the distance the tool travels in one revolution of the work piece and is given the units of mm/rev or in/rev.

**Tool rake angle:** The rake angle specifies the ease with which a metal is cut. Higher the rake angle, better is the cutting and less are the cutting forces .There is the maximum limit to the rake angle and this is normally of the order of $15^0$ for high speed steel tools .It is possible to have rake angle as zero or negative. These are generally used in case of highly brittle tool materials such as carbides or lozenges for giving extra strength to tool tip. It is of two types (a) Back rake angle (b) Side rake angle

**Back rake angle**: It is the angle between the face of the tool and a line parallel to the base of the tool and measured in a plane erect through the side cutting authority. This angle is positive if the side cutting edge slope downstairs from the point towards the Shank and is negative if the slope of the side cutting edge is reverse.

**Side rake angle:** It is the angle between the tool face and a line parallel to the base of the tool and measured in a plane perpendicular to the base and the side cutting edge. The side rake angle is negative if the slope is towards the cutting edge and constructive if the slope is away from the cutting edge.

**Tool nose radius**: Nose radius is provided to remove the fragile junction of the tool. It increases the tool life and improves surface finish. Small nose radius is used for small cutting depth, reduce shaking and large nose radius is used for substantial feed rate, large depth of cut.

## 2. LITERATURE REVIEW

Y. Iwai et al in 2000 studied the dry sliding wear behavior of die-cast ADC12 aluminum alloy composites bulletproof with short alumina fibers were studied by using a pin-on-disk wear tester. From the analysis of wear data and detailed examination of (a) worn surfaces, (b) their cross-sections and (c) wear debris, two modes of wear mechanisms have been identified to be functioning, in these materials and these are: (i) glue wear in the case of unreinforced milieu material and in MMCs with low $V_f$ and (ii) scratchy wear in the case of MMC with high $V_r$. [1]

C.G. Kang et al in 2000 deliberate the Metal matrix fusions (MMCs) fabricated by the compocasting process show a homogeneous scattering of the reinforcing fiber in the matrix. Microstructure surveillance of hot extruded MMCs reveals that as the extrusion ratio intensifications, the fiber alignment becomes improved, but fiber fracture occurs more severely. The mechanical properties of hot extruded MMCs are better than those of the milieu metal, with the omission of the elongation at failure, and are not influenced suggestively by the extrusion temperature. The tensile strength and resistance of MMCs are improved to a greater degree by hot extrusion using a constant-strain-rate die. Also, there exists a critical extrusion ratio that gives maximum strength, [2]

B. Venkataraman et al in 2000 investigated the slithering friction and wear behavior of aluminium (Al), aluminium alloy 7075 (Al-7075) and SiC particulate reinforced aluminium matrix composites (Al-SiC) under gasping sliding wear positions. The wear tests were approved out at a sliding speed of 1m/s and at normal load ranging up to 220 N. The overall objective of the study is to improve our current indulgent with regard to the influence of mechanically mixed layers (MML), which form on the surface of the wearisome material during the course of the wear test, on the friction and wear comportment. The aluminium alloy 7075 was used in both solution treated and aged conditions. The aluminium based metal matrix complexes studied limited 10 and 40 vol% of SiC particles as the underlining phase [3].

O. Yılmaza et al in 2001 studied the effects of volume fraction, $Al_2O_3$ particle size and possessions of porosity in the composites on the abrasive wear resistance of compo-casting Al alloy MMCs different abrasive conditions..

## 3. GAP AND OBJECTIVES

Following objectives are decided.

- Manufacture of Al6082/$Al_2O_3$ metal matrix mixtures with different % of bolstering by Stir casting method.
- Microstructure surveillance of all invented samples to observe dispersal of reinforcement.
- Investigation of mechanical belongings of all samples.
- Properties of turning parameters on dimensional deviation of metal matrixcomposite

## 4. MATERIAL SELECTION AND METHDOLOGY

By aluminum alloy Most of the automobile parts, aerospace structures and its allied substructure are made by considering Al 6082 which was used for making pressure vessel cylinders is now testing for aircraft structures in this context. Al 6082 has more corrosion resistance and it can be seen in forms of extruded rod bar and wire and extruded shapes. It can be easily machine-able and can have an extensive variation of surface finishes. It also has good electrical and thermal conductivities and is highly reflective to heat and light. Al 6082 offers extremely low maintenance due to the superior corrosion resistance. Al 6082 is only one-third the mass of cast iron, with about 75% of equivalent tensile strength. The tensile strength on circular rod specimen of Al 6082 is verdict out by applying the loads on universal testing machine with various dimensions in this analysis. The analytical results were found acceptable to offer the another alloy for aircraft structures.

The physical and mechanical properties of aluminum alloy (6082) have been reviewed from literature data for the resolution of illustrating the mechanical for manufacturing method in engineering submission.

### 4.1. COMPOSITION OF MATRIX MATERIAL (Al6082)

| Aluminum | Copper | Magnesium | Silicon | Iron | Manganese | Others |
|---|---|---|---|---|---|---|
| 95.2- 98.5 | 0.1% | 0.4-1.2% | 0.6-1.3% | 0.6% | 0.4-1.0% | 0.3% |

## 5. EXPERIMENTAL PROCEDURE

The work materials used in the present work are aluminium alloy 6082 and aluminium oxide ($Al_2O_3$ as reinforcement). These materials are chosen due to their easily mixable property and gives good mechanical properties. First of all the aluminium alloy (Al6082) is heated up to its melting temperature in a electric furnace and then aluminium oxide is heated and mixed gradually in molten aluminium alloy with the help of stirrer. The mixer is left for cool down in the crucible in which it was melted and mixed. There are six samples in different ratios which are prepared for testing mechanical properties and choosing the best. The ratios are shown below in the Table.

**Table 5.1 Composition selection**

| Material | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 |
|---|---|---|---|---|---|---|
| Aluminium alloy (AA6082) | 97.5% | 95.0% | 92.5% | 90.% | 87.5% | 85% |
| Aluminium oxide ($Al_2O_3$) | 2.5% | 5% | 7.5% | 10% | 12.5% | 15% |

**Figure 5.1 Sample of aluminium + $Al_2O_3$ 2.5 and 5% Alumina in Aluminium**

**Figure 5.2 Sample of aluminium + $Al_2O_3$ 7.5 and 10% Alumina in Aluminium**

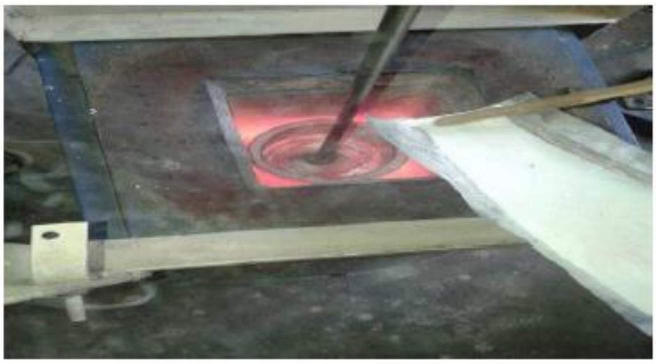

**Figure 5.3 Preparation of sample by mechanical stir casting**

**Figure 5.4 Cutting of samples on Power Hacksaw**

### 5.1. OPTIMIZATION TECHNIQUE

Optimization is a process of arranging different input variables to get the best output. In this project optimizing the four parameters like feed rate, Depth of cut, speed and tool nose radius, and study the behavior of these parameters on dimensional deviation.

### 5.2. RESPONSE SURFACE METHODOLOGY

Response surface methodology (RSM) is a collection of mathematical and statistical techniques for empirical model construction. By careful design of experiments the objective is to optimize a response (output variable) which is influenced by several independent variables (input variables). An experimentation is a series of tests, called runs, in which changes are made in the input variables in order to identify the reasons for changes in the output response. Originally, RSM was developed to model experiments responses (Box and Draper in 1987) and then migrated into the modeling of experiments. In physical experiments, inaccuracy can be due ,for example, to measurement errors while, in computer experiments, numerical noise is a result of incomplete convergence of iterative processes, round -off errors or the distinct representation of continuous physical phenomena. In RSM the errors are assumed to be random. The most extensive applications of RSM are in the particular situations where several input variables potentially influence some performance measures or quality characteristics are called the response. The input variables are sometime called independent variables, and they are subjected to the control of the engineer or scientists.

## 6. RESULT AND DISCUSSION

### 6.1. ANALYSIS OF MICROSTRUCTURE

Microstructures of the MMC models are seen using metallurgical microscope. When describing the structure of a material, we make a clear difference between its crystal structure and its microstructure. The tenure 'crystal structure' is used to label the average positions of atoms within the unit cell, and is completely itemized by the lattice type and the fractional arranges of the atoms. The term 'microstructure' in metal matrix composites is used to define the appearance of the strengthening material. A realistic working definition of microstructure is "The arrangement of phases and defects within a material.

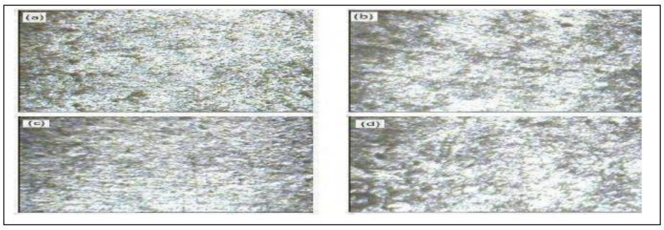

**Figure 6.1 Microstructure of different samples (a) 2.5% Reinforcement, (b) 5% Reinforcement, (c) 7.5% Reinforcement, (d) 10% Reinforcement**

### 6.2. ANALYSIS OF TENSILE STRENGTH

Tensile testing of MMC is conceded out on Tensometer machine. Tensometer is a device used to calculate the tensile properties of materials such as their Young's Modulus and tensile strength. It's a common testing machine loaded with a sample between two grips that are either adjusted manually or automatically to apply force to the model. The machine works either by driving a screw or by hydraulic ram. Testing is done by holding the specimen in the jaws of the Tensometer. The load is applied slowly and the material starts elongating. After the maximum load reached the specimen breaks.

**Figure 6.2. Tensile Testing on Tensometer**

**Table 5.1 Tensile Test Result**

| Samples (of $Al_2o_3$) | Ultimate strength(N) | Elongation (mm) | Break load (N) | Break Elongation (mm) | True UTS (N/ sq mm) | Area(A) (sq. mm) |
|---|---|---|---|---|---|---|
| 2.5% | 699.8 | 0.53 | 148.3 | 0.63 | 26 | 28.386 |
| 5.0% | 637.5 | 0.5 | 205.9 | 0.67 | 22.9 | 28.186 |
| 7.5% | 1398.1 | 2.16 | 1008.3 | 2.50 | 62.2 | 26.123 |
| 10% | 441.3 | 0.38 | 304 | 0.54 | 15.8 | 28.286 |
| 12.5% | 342 | 0.32 | 298 | 0.48 | 14.9 | 26.282 |
| 15 % | 308 | 0.30 | 282.2 | 0.39 | 14.5 | 25.832 |

### 6.3. STUDY OF TOUGHNESS TEST

In the MMC, specimen's toughness is verified by breaking it with impacting force of a hammer assessing 21 kg. The Hammer is leaved from 140 degree of angle with the initial energy of 300 J. We can see the table for results while testing as follows.

Fig 6.3 Toughness sample of 2.5 % of Alumina in aluminum

Fig 6.4Toughness sample of 5% of Alumina in aluminum

Fig. 6.5 Toughness sample of 7.5 % of Alumina in aluminum

Fig 6.6 Toughness sample of 10% of Alumina in aluminum

**Table 6.2 Toughness Sample Test Results**

| $Al_2O_3$ % in Al | A | B | AVEREGE Toughness (Joule) |
|---|---|---|---|
| 2.5% | 28 | 36 | 32 |
| 5% | 96 | 102 | 98 |
| 7.5% | 70 | 64 | 67 |
| 10% | 38 | 36 | 37 |
| 12.5% | 40 | 48 | 44 |
| 15 % | 66 | 70 | 68 |

### 6.4. STUDY OF HARDNESS TEST

Hardness Test is conceded out on the Brinell hardness testing machine .In this test a standard steel ball is pressed into the surface of the specimen by a slowly applied load, which is maintain on the specimen for definite time the diameter of the impress so obtained is measured by a microscope and the Brinell Hardness Number (BHN) is found out by the following formula:

BHN = Load / Area of impression/indentation = $2P / \pi D (D - \sqrt{D^2 - d^2})$

Where, P = Load (kg), D = Diameter of ball in mm. (2.5 mm) d = Diameter of indentation circle found from microscope

**Figure 6.7 Brinell hardness testing machine**

**Figure 6.8 MMC sample after pockmark on Hardness Testing Machine**

**Table 6.3 Hardness Test Result**

| $Al_2O_3$ % in Al | A | B | Average BHN |
|---|---|---|---|
| 2.5% | 51 | 59 | 55 |
| 5% | 59 | 59 | 59 |
| 7.5% | 60 | 70 | 65 |
| 110% | 34 | 44 | 39 |
| 12.5% | 51 | 51 | 51 |
| 15 % | 52 | 44 | 48 |

## 7. CONCLUSIONS

The following conclusions can be drawn from analysis:

- Within the investigated range of process parameters, lower speed (100 m/ min), lower feed (0.15 mm/rev.) and lower depth of cut (0.20 mm) and rake angle (-9 .00) are preferred for low dimensional deviation of machined A6064/7.5% Al2O3 metal matrixcomposite.

- Within the process parameters range; dimensional deviation of machined A6064/7.5%Al2O3 metal matrix composite decreases, by increasing the speed, feed rate and depth of cut and increases by increasing rake angle.
- Mechanical properties are better by adding the reinforcement material Alumina at 7.5% in Al6064
- The value of dimensional deviation is 2.5933

## 8. FUTURE SCOPE

The present work has been completed but permits way for further work in future:

- The work can be carried out by making use of other design technologies like fractional factorial design, design expert tools, Box bancken design etc.
- Composite can be prepared by other matrix material and other reinforcing materials like SiC, B4C etc.
- The work can be carried out by taking more machining parameter like feed, Speed, Depth of cut, Rake angle, Nose radius, Coolant use etc..

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