

**MECHANICAL AND TRIBOLOGICAL BEHAVIOUR ANALYSIS OF  
METAL POWDER REINFORCED FILLED 7075 ALUMINIUM ALLOY  
COMPOSITES FOR GEAR MATERIAL APPLICATION**

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***“Production and Industrial Engineering”***

**by**

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**AUGUST, 2021**

## **CERTIFICATE**

This is to certify that **Mr. /Mrs. Gaurav Kaushal** (Enroll. No.1800101833) has carried out the dissertation work presented in the thesis titled “**Mechanical and tribological behaviour analysis of metal powder reinforced filled 7075aluminium alloy composite for gear material application**” submitted for partial fulfillment for the award of the **Degree of Master of Technology in Production and Industrial Engineering** from **Integral University, Lucknow** under my supervision.

It is also certified that:

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## **DECLARATION**

I hereby declare that the thesis titled “**Mechanical and tribological behaviour analysis of metal powder reinforced filled 7075aluminium alloy composites for gear material application**” is an authentic record of the dissertation work carried out by me under the supervision of **Dr.P.K.BHARTI** Department of mechanical engineering, for the period from JULY 2018 to SEP 2021 at Integral University, Lucknow. No part of this thesis has been presented elsewhere for any other degree or diploma earlier.

I declare that I have faithfully acknowledged and referred to the works of other dissertation wherever their published works have been cited in the thesis. I further certify that I have not willfully taken other's work, para, text, data, results, tables, figures etc. reported in the journals, books, magazines, reports, dissertations, theses, etc., or available at web-sites without their permission, and have not included those in this M.Tech. thesis citing as my own work.

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## TABLE OF CONTENTS

	<b>Page no.</b>
Certificate	ii.
Declaration	iii.
Acknowledgements	iv
List of Table	vii
List of Figures	viii
List of symbols and nomenclature	x
Abstract	
<b>CHAPTER-1 INTRODUCTION</b>	<b>1-6</b>
1.1 INTRODUCTION	2
1.2 Composition of Al7075	3
1.3 Properties of Al7075	4
1.4 Corrosion of aluminium alloys	4
1.5 Definition of composites materials	5
1.6 Classification of composites on the basis of matrix	5
<b>CHAPTER-2 LITERATURE REVIEW</b>	<b>7-11</b>
2.1 Literature review	8-11
2.2 Objective	12
<b>CHAPTER-3 MATERIAL AND METHOD</b>	<b>13-20</b>
3.1 Material and method	14
3.2 Physicals and mechanical characterizations	15-16
3.3 Sliding wear experiments condition	16-17
3.4 Stir castings route for fabrication of MMC	18
3.5 Stir casting process parameters	19
3.6 Advantage of aluminium based MMCs	20
<b>CHAPTER-4 RESULT AND DISCUSSION</b>	<b>21-39</b>
4.1 Effect of voids contented on cu filled Al7075 alloy composites	22
4.2 Effects of flexural potency on cu metal powder filled Al7075 alloy composite	22-23
4.3 Effects of tensile potency on cu metal powder filled Al7075 alloy composite	24-25
4.4 Effects of impacts strength on cu metal powder filled Al7075 alloy composite	26-27
4.5 Effects of sliding velocity on specific wear rate of cu filled Al7075 alloy composites	28-29
4.6 Effect of load on specific wear rate of cu filled Al7075 alloy composites	30-31
4.7 Effect of sliding distance on specific wear rate of cu filled Al7075 alloy composites	32-33
4.8 Calculations of mean S/N ratio for wear rate	36

4.9	Analysis of experimental results by Taguchi's experimental design	36-37
4.10	Anova and Effect of Factors	38-39
<b>CHAPTER-5</b>	<b>CONCLUSION</b>	40-41
<b>CHAPTER-6</b>	<b>LIMITATIONS &amp; FUTURE SCOPE OF WORK</b>	42-43
<b>CHAPTER-7</b>	<b>REFERENCES</b>	44-48
<b>CHAPTER-8</b>	<b>PUBLICATION</b>	49

## LIST OF TABLE

<b>Table no.</b>		<b>Page no.</b>
1.2	Composition of Al7075	3
1.3	Properties of Al7075	4
3.1	Design of the copper series formulation	15
3.2	Evaluation of experimental density and theoretical density	18
4.1	Effect of flexural potency on copper metal powder filled Al7075 alloy composites	23
4.2	Effect of tensile strength on copper metal powder filled Al7075 alloy composite	25
4.3	Effect of impact strength on copper metal powder filled Al7075 alloy composites	27
4.4	Effect of sliding velocity on specific wear rate of copper filled Al7075 alloy composites	29
4.5	Effect of normal load on specific wear rate of copper filled Al7075 alloy composites	31
4.6	Effect sliding distance on specific wear rate of copper filled Al7075 alloy composites	33
4.7	Experimental layout of L25 orthogonal array	34
4.8	L25 orthogonal array with parameters and their levels	35
4.9	Response table for S/N ratio	36

## LIST OF FIGURES

<b>Figure no.</b>		<b>Page no.</b>
3.1	High vacuum casting machine	14
3.2	Multi specimen tester equipment	17
3.3	Stir casting experimental setup	19
4.1	Effect of flexural potency on copper metal powder filled 7075 al alloy composites	24
4.2	Effects of tensile strength on copper metal powder filled 7075 al alloy composites	26
4.3	Effect of impact potency on copper metal powder filled 7075 al alloy composites	28
4.4	Effect of sliding velocity on specific wear rate of copper filled Al7075 alloy composites	30
4.5	Effect of normal load on specific wear rate of copper filled Al7075 alloy composites	32
4.6	Effect sliding distance on specific wear rate of copper filled Al7075 alloy composites	33
4.7	Effects of control factors on wear rate for copper filled Al7075 alloy composite	37
4.8	Interaction Plot between wears rate and normal load at various levels of filler content	38
4.9	Interaction plot between wear rate and sliding velocity at various levels of sliding distance	39

## SYMBOLS AND NOMENCLATURE

$\mu$	$\equiv$	Coefficient of friction
$\rho$	$\equiv$	Density
AMCs	$\equiv$	Aluminium matrix composites
ASTM	$\equiv$	American society for testing and materials
ANOVA	$\equiv$	Analysis of variance
MMCs	$\equiv$	Metal matrix composites
COF	$\equiv$	Coefficient of friction
PMC	$\equiv$	Polymer matrix composite
CMC	$\equiv$	Ceramic matrix composite
GISS	$\equiv$	Gas induced-semi solid
SS	$\equiv$	Sum of squares
Al	$\equiv$	Aluminium
Cu	$\equiv$	Copper
Sic	$\equiv$	Silicon carbide
Zn	$\equiv$	Zinc
Cr	$\equiv$	Chromium
Fe	$\equiv$	Iron
$F_N$	$\equiv$	Normal force
$F_F$	$\equiv$	Friction force
Gr	$\equiv$	Graphite
Mg	$\equiv$	Magnesium
Mn	$\equiv$	Manganese

## ABSTRACT

The thesis work shows the results obtained from the geometric and mechanical properties of Al7075 alloy compounds reinforced with copper metal powder (0-2% by weight) for gear materials produced by high vacuum casting. The wear test is carried out in a multi-sample tester in a lubricated state. The composite model produced can be used as a newly developed material for the manufacture of gears in the automotive industry. The introduction of the charge of copper particles can cause significant changes in the behaviour of these materials. Bending force improves from 329 - 499 MPa, tensile force improves from 232 – 396 MPa and impact force improves from 20 - 70 kJ / m<sup>2</sup> of grain-reinforced alloy composites. Improved mechanical properties by increasing copper metallic powder from 0% to 2% showed that the composite material consisting has the lowest wear index compared to the base alloy, and the wear resistance of the composite material improved it. It is composed of Al7075 alloy filled with metallic copper powder. A combined approach is used to optimize performance parameters and characteristics based on Taguchi methods. The experimental design is based on the Taguchi L25 orthogonal matrix. The order of the ANOVA analysis was calculated Load and sliding distance were identified as the main contributing parameters. Change in normal load has the highest impact on the specific wear rate.

Sliding distance, sliding velocity and filler content also affect the specific wear rate.

# **Chapter 1**

## **INTRODUCTION**

**1.1 INTRODUCTION**

7075 aluminium alloy matrix composites are used as excellent materials in a variety of automotive, aerospace, aviation, defence and defence applications. It has more specific potency and hardness in various engineering fields and has improved wear resistance compared to alloys. Regardless of the load applied and slide speed. Such alloy compounds continue to replace such as increased wear resistance, light weight, hardness and toughness. Numerous authors from around the world report on their particular archive studies. Pramanik investigated the effect of reinforcements on the wear resistance of aluminium matrices. It was observed that the metal matrix composite had the highest wear resistance and that the size of the debris increased with increasing length. Many authors have reported that the enrichment of granular uniform powders in the unfilled alloy matrix improves the wear resistance and toughness of composites. Sliding friction behaviour of Al<sub>2</sub>O<sub>3</sub> and short carbon fibers filled by such alloy compounds. They figured out the coefficient of friction and wear. By improving the improved content (Al<sub>2</sub>O<sub>3</sub>) of the metal matrix composite material, the potency is improved, which is effective in improving the coefficient of friction and wear resistance. We investigated the dry-slip properties of Al<sub>2</sub>O<sub>3</sub> and MMC fibers made from aluminium reinforced with SiC particles produced by compression moulding technology. As the wear resistance of the compound decreases, the temperature increases, while as the filler content (SiC) increases at room temperature, the wear resistance decreases. Increased hardness, density and volumetric friction content while reducing impact resistance of A384 micro TiO<sub>2</sub> / (Al<sub>2</sub>O<sub>3</sub> alloy loaded with Al<sub>2</sub>O<sub>3</sub> particles shows reduced porosity but this alloy shows reduced porosity. In the study, Naplocha and Granat studied the geometric behaviour of Al / Saffil / c-compounds of metal matrix compounds. They have increased abrasion resistance with increasing particle number of the compound and with increasing filler content. Reported an increase in the durability and brightness of copper. Abrasion properties due to the filler of 7075 aluminium matrix compound. The effect of adding graphite to the Al7075 alloy matrix under wet slip conditions. Reported that hardness, coefficient of friction, and wear rate decreased as filler content of matrix alloy Al7075 increased with increase filler content.

In recent years, many researchers have worked on the production of aluminium compounds with desirable inductive and mechanical properties. Friction and wear rate than

nanocomposite lubricants. Naveed et al. [4] used graphite as a reinforcing agent to keep constant the content of SiC and aluminium as base material. Raghavendra et al. [5] The NiAl<sub>2</sub>O<sub>3</sub> electroplating compound, coated with NiAl<sub>2</sub>O<sub>3</sub> nanoparticles in the electroplating process on aluminium, showed better wear resistance than the Ni coating. This ratio decreased with increasing fly ash content and increased with increasing applied load. Nagara et al [7] used SiC and graphite as reinforcements and Al6061 as base material Crystal lattice. They also concluded that the slip distance and disc speed increased volumetric wear as the applied load increased. Gireesh et al. [8] enriched the metal matrix compound Al6061 with aloe vera and found that the maximum wear resistance, density and tensile potency did not show a significant difference in tensile potency. Increased hardness compared to pure metal matrix composites based on aluminium reinforced with aloe vera. Mittal et al [9] uses SiC, Al<sub>2</sub>O<sub>3</sub>, red mud as reinforcement material and Al7075 as base material. As the mass% of Al<sub>2</sub>O<sub>3</sub> increases the wear rate decreases and the SiC of the red sludge decreases to 7.5 mass%. I found it. By further increasing the wear rate, Baradeswaran et al. [10] found that increasing the content of B<sub>4</sub>C used as the reinforcing agent and AA7075 as the base alloy would increase the wear resistance.

## 1.2 COMPOSITION OF Al 7075,

Material	Weight %
Copper.	1.53%
Chromium.	0.20%
Magnesium	2.50%
Zinc.	5.45%
Iron.	0.20%
Manganese.	0.25%
Silicon.	0.30%
Titanium.	0.16%
Aluminium.	Remaining

**Table-1.1 Composition of Al 7075**

Magnesium, copper and zinc also form compounds with controllable aluminium that govern the curing properties of these alloys. The compounds in the case of Mg and Cu are  $Mg_2Al_3$  and  $CuAl_2$ , respectively. Display of stable phases of the network of Formed during aging of zinc-aluminium alloy. When magnesium and silicon are present together, aluminium can form the stable compound  $Mg_2Si$  in addition to the above compounds. The solubility of these alloying elements decreases with decreasing temperature, but it can be retained in solution during quenching. The solute atoms try to precipitate due to the difference in solubility between room temperature and high temperature.

### 1.3 PROPERTIES OF Al 7075

Mechanical properties	Values
Hardness – Brinells	94.961
Tensile yield potency	199.3MPa
Elongation at beaks	5.42%
Modulus of Elasticity.	71.65GPa
Poisson Ratio.	0.35
Machinability.	71%
Shear modulus.	27 GPa
Shear potency.	331Mpa

Table-1.2 Properties of Al 7075

### 1.4 Corrosion of aluminium's alloys –

If the metal is anodic with aluminium, it will corrode, reducing or preventing corrosion of the aluminium. This type of action is commonly used to minimize corrosion and is known as cathodic protection. However, the characteristics of electrochemical corrosion are generally heterogeneous and are limited to selected areas such as grain boundaries, defects, large amounts of precipitation, and the location of internal stresses. Therefore, the structure of the alloy and the composition of the phases are dominant factors in the control of corrosion. The composition is greater than 99.5%, Al becomes the anode, and the following becomes the cathode. Since  $MnAl_6$  has the same electrode potential as aluminium,  $AlMn$  alloy has very good corrosion resistance. Chromium has little effect on the potential of the Al electrode. Its addition improves resistance to stress corrosion cracking and is therefore added in small amounts to  $AlZnMg$  alloys.  $AlSi$  alloys resist corrosion for the same reason.  $AlMg$  alloy has

a solid solution structure, and the precipitation of  $Mg_2Al_3$  causes an electrochemical reaction, and  $Mg_2Al_3$  is more anodic than the solid solution and therefore corrodes.

### **1.5 Definition of composites materials**

A composite material can be defined as a material system consisting of a combined mixture of two or more trace components that are insoluble with each other and differ in the shape and/or composition of the material. These materials can be prepared by arranging two or more different materials to mechanically act as a single unit. The properties of these materials differ from those of their components. These materials can embed the hard phase into the soft phase and vice versa. In general, in composite materials, the flexible matrix has a hard phase, the hard phase acts as a reinforcing agent to increase the potency and modulus, and the soft phase acts as the matrix material. The necessity for satisfying the over mentioned condition is

- a. The composite material has to be man-prepared
- b. The composite materials must be an amalgamation of at least two chemically dissimilar materials with a boundary separating the components.
- c. The properties of composite should be three dimensionally merged.

### **1.6 Classification of composites on the basis of matrix**

Composite can be classified in the subsequent groups:

#### **(a) Polymer-matrix composites (PMC.)**

The most common substrate material for composites is polymers. Polyester vinyl esters are the most widely used and cheapest polymers. These matrix materials are used primarily for fibreglass reinforced composites for these materials. Epoxy is more expensive and is used in PMC for aerospace applications in addition to a wide range of commercial applications. The main drawbacks of PMC are its low maximum operating temperature and high coefficient of thermal expansion, which makes it dimensionally unstable and sensitive to radiation and humidity. It has lower potency and hardness than metal and ceramics.

#### **(b) Metal-matrix composites (MMC)**

The matrix of these compounds is a ductile metal. These compounds can be used at higher operating temperatures than the corresponding base metals. These reinforcing materials can improve certain resistance to convergence, wear, creep and dimensional stability. Weight and resistance to abrasion and thermal deformation which is why it is mainly used in the

automotive industry. Metal matrix composites are much more expensive than PMCs, so their use is somewhat limited.

(c) Ceramic-matrix composites (CMC.)

One of the main goals of CMC production is to increase durability. Not because of their workability in the event of breakage, some of these materials are ideal candidates for use in high temperature applications and air compressors, especially in automotive parts and gas turbine engines. Most treatments involve high temperatures and are only used with high temperature reinforcement.

On the basis of reinforcement can be classified into three types:

(a) Particle reinforced composite

Particulate potencyening have dimensions that are just about equal in all directions .The figure of the reinforcing particles may be spherical, cubic, platelet or any ordinary or irregular geometry. These composite can classified underneath two sub groups:

- (i) Large particles composites
- (ii) Diffusion potencyened composites

(b) Fiber reinforced composites

Fiber-reinforced plastics are characterized by their length being much longer than their width. However, the relationship between the length and the size of the cross section, known as the aspect ratio can vary widely. In single-layer composites, long fibers with high aspect ratios are manufactured using continuous fiber-reinforced composites, while staple fiber reinforced composites are manufactured with short fibers with a low aspect ratio. The direction of the wires can be random or preferred. The preferred orientations commonly found in the case of continuous fiber composites are called unidirectional and random, respectively. The situation can be addressed by potencyening the two-way fabric.

# **Chapter 2**

## **LITERATURE REVIEW**

## LITERATURE REVIEW

### 2.1 Literature Review

Raman etc. [11] When AMMC was manufactured using SiC as a reinforcing material and treated by stirring casting, it was observed that the wear rate decreased and the wear resistance improved as the SiC content increased. The particle size and pore morphology of the treated material has been reduced. [14] SiC is used as the reinforcing material and Al is used as the base material. The wear rate increases under normal load, but for composites it increases less than for pure aluminium.

Alizadeh et al. [15] Used nanoparticles of B<sub>4</sub>C as a reinforcing material and Al as a reinforcing material. It has been observed that the tensile potency is improved and the wear rate is lower than that of the coarse Al matrix.

Gireesh et al [16] used fly ash and aloe separately to reinforce aluminium and concluded that aluminium reinforced with aloe offers better wear resistance than aluminium reinforced with fly ash.

Butra et al. [17] found that the profile of the FSP tool was the least influential factor and that the rotational speed of the FSP tool had the greatest effect on micro hardness. The rheology of 7075Al alloys produced by a new technology, gas-induced semi-solid technology (GISS), was investigated. This study shows that the optimal conditions for dissolving non-dendritic 7075 aluminium alloys are 4 hours at 450 ° C. It rotates at 120 ° C, 145 ° C, 165 ° C, 185 ° C for various times. The maximum aging condition was 72 h of artificial aging at 120°C, with a tensile potency higher than 486 MPa recorded at 2% elongation. The primary hardening phase was identified as the  $\beta$  phase, but nucleation of the initial phase in samples with higher aging temperatures resulted in lower alloy potency. Survey is 95,827 J/mol. In his article, Mohd Fizam Zainon [2] reported on the effect of aging on the wear properties of aluminium alloy pistons. These studies were conducted to improve the polishing properties of this method. For this purpose, an AlSiCuMg alloy containing 8% Si was used. Melting was performed at 5000 ° C for 5 hours, then quenched and the samples were aged at 1300 ° C, 1700 ° C, and 2100 ° C for 1-6 hours to observe the effect of aging conditions on their properties. A Vickers micro hardness test was performed to measure the hardness of the sample. The analysis of the microstructure of the sample was carried out using an optical microscope equipped with a digital camera and a scanning electron microscope (SEM). The

results show an improved aging time of 2 hours at 170°C. Wear characteristics of aluminium alloy pistons.

Gowri Shankar M. [3] It has been reported that the potency of Al6061 alloy can be improved by precipitation hardening during precipitation of the stable phase formed by the supersaturated solid solution. Experimental studies have focused on the artificial aging process of Al6061 alloy hardened in solution at 100°, 150° and 200°. Maximum hardness can be obtained at different aging temperatures by plotting hardness versus time. It is observed that the maximum aging time varies between 3 and 10 hours. Depending on the aging temperature, as the aging temperature decreases, the precipitation of the solute-rich secondary stage occurs in more intermediate stages. The intermediate phase deforms the lattice during precipitation to improve its mechanical properties, resulting in weaker mechanical properties aging temperature. In this paper, we study the mechanical properties such as micro-hardness, tensile potency and wear resistance to study the effect of artificial aging on Al6061 alloy, but in the same condition. Processing condition, heat precipitation hardening alloy is the better machine.

Clock ascast.22Y.Redalloy [4] is a metal matrix alloy of Al6061 SiC and Al7075 Al<sub>2</sub>O<sub>3</sub> and R. Clark et al. [9] Reports in a study of Al7075 that "pre-treatment at different regression temperatures improved hardness, tensile properties, and resistivity." The slip friction and wear behaviour of aluminium alloy 7075 (Al7075), and grain-reinforced aluminium matrix alloy SiC (AlSiC) were studied under dry slip wear conditions. The wear test was performed with a sliding speed of 1 m / s and a normal load of up to 220 N. The general purpose of this study was to improve the current understanding of the effects of mechanical composite layers (MML). Surface formation, friction and wear behavior of abrasives during wear tests. Aluminium alloy 7075 is used both in the molten state and in the aging state. The studied aluminium-based metal matrix alloy contains SiC particles of 10 and 40% by volume as a reinforcing stage. A detailed description of MML was performed using SEM, EPMA, and micro hardness tests, and the effects of test materials and loads on the composition, hardness, and thickness of the MML produced, as well as the effects of MML on friction and base. I understood. The above description shows that the observed friction and wear behavior of Al, Al7075, AlSiC alloys is better understood in terms of MML formation and fracture rate rather than the volumetric properties of the material.

Kleber S Cruz, Elisangela S. Meza, Frédéric A.Fernandes, Jose'M.Quaresma, Luiz C. Casteletti and Amauri Garcia [6] The objective of this study is to contribute to a better understanding of the relationship between the size of dendritic networks and their

corresponding mechanical properties and their wear behaviour. AlSn (15 and 20 wt% Sn) and AlSi (3 and 5 wt% Si) alloys orient well under unstable heat flow conditions in water-cooled molds, allowing widely spaced dendritic samples. Tensile and wear tests were performed to determine experimental quantitative formulas for primary tensile potency (UTS) of dendritic arm spacing (DAS), tensile potency, elongation, and mass d 'wear. Abrasion resistance has been shown to be significantly affected by the distance scale of major dendritic branches. In the case of the AlSi alloy, the wear resistance was improved by the miniaturization of the dendritic matrix, but in the case of the AlSn alloy, the opposite effect was observed. In other words, the increased arm spacing and primary dendrites improve wear resistance. The effect of cleavage on the wear resistance observed with the AlSn alloy was also analyzed.

Estrada Lewis. [16] 7075 Aluminium alloy Nanostructured alloy and carbon coated silver nanoparticles were synthesized by mechanical grinding using a SPEX 8000M high energy mill. The resulting powder is compressed, sintered and hot extruded to produce a rod with a diameter of 1 cm. material. Silver nanoparticles have been shown to prevent material wear by acting as an obstacle to the movement of deflection during plastic deformation of the contact surface. The same applies to substances and solid lubricants when separated from the contact surface metal matrix.

Rathee et al. [23] manufactured the AA6061/SiC compounds through FSP and optimized the design of the experiments to achieve maximum microscopic stiffness. The maximum microscopic stiffness was obtained in the grain zone and the optimal parameters obtained were 50 mm min<sup>-1</sup> horizontal speed, 2.50 and 1400 rpm tilt angle.

Deepak et al [24] of FSP manufactured Al5083 using nano-SiC as reinforcement, and found that the hardness of the composite was higher than that of the base material, but the wear resistance was low due to the force friction and high coefficient of friction that i have observed.

Salehi et al [25] is an Al6061 compound made from FSP containing SiC nanoparticles, with the weight percent of SiC ranging from 0% to 18%.The micro-hardness of composite materials is higher than that of the base metal. They also suggest that the smaller the inter-particle space, the higher the microscopic stiffness.

Kurt et al [26] from FSP produced commercially pure aluminium containing SiC particles at different rotational and lateral velocities of the instrument. An increase in grain size and hardness was observed. 1000 RPM and 20 mm min<sup>-1</sup> are optimal parameters for the distribution of particles through the substrate.

Paidar et al [27] improved the AA5182 in WC using FSW at different tool travel speeds. They found that the compounds improved micro hardness, wear resistance and grain size by reducing transmission rates number of trips. Glass grain size and wear decrease, but the UTS value increases as the number of passes increases.

Devaraju et al. [29] of FSP used SiC and Gr as reinforcement to form an aluminium compound. Taguchi was used to improve the mechanical and frictional properties in order to optimize the mass percentage of reinforcement and the rotational speed of the tool. Wear and hardness increase under optimal conditions respectively, but tensile properties are lower than base metal under optimal conditions. FSP's Izadi et al [30] found that it formed an AlSiC compound with a volume fraction of 4-16% by volume and had voids and no consolidation during the 16% volumetric SiC treatment. The sample shows an increase in hardness and increases with increasing SiC content.

Adilokht et al [31] improved the AA350 with SiC and MoS<sub>2</sub> using FSP with constant rotational speed and tool displacement. The hardness and wear resistance of the treated compound is higher than that of the base metal due to the presence of reinforcing agents.

Jun and friends. [4] Studied that the slip and friction behaviour of Al<sub>2</sub>O<sub>3</sub> and reinforced short carbon fibers meets these alloy compounds. It is abrasion resistant. Yiqi and Jungil [5] studied the dry-slip wear behaviour of compression-molded Al<sub>2</sub>O<sub>3</sub> fiber-reinforced aluminium-based CMMs and SiC particles. On the other hand, the temperature improves as the wear resistance of the composite decreases.

Gangwar et al. [6] and Kukshal et al. [7] A study aimed to increase the hardness, density and volumetric friction content while reducing the impact resistance of alloy compound A384 loaded with fine particles TiO<sub>2</sub>/ (Al<sub>2</sub>O<sub>3</sub>). However, this alloy is has porosity as well as energy/impact stiffness / Indicates a decrease in density increases with increasing filler content similar results were reported by Baradeswaran and Elaya Perumal [8] for B<sub>4</sub>C and Kumar et al content [ 9] with SiC/Al<sub>2</sub>O<sub>3</sub>.Naplocha and Granat [10] studied the geometrical properties of Al / Saffil / C hybrid metal matrix compounds, increasing wear resistance at higher particle sizes of the compound and durability and luster at higher filler contents. Reported that it would also improve yield at filler content.

Mohan et al. [12] They also reported improved mechanical properties (traction, impact and toughness) and polishing properties of the filler content of 7075 aluminium matrix composites.

Walker et al. [13] investigated the TEM properties of surface deformation due to lubrication, sliding and wear of alloy compounds. They report better wear resistance on lubricated and

abrasive surfaces of composites. Sweat. [14] The effect of adding graphite to the Al7075 alloy matrix under wet sliding condition was investigated. Improved filler content in matrix alloy 7075 has been reported to reduce hardness, coefficient of friction and rate of wear High vacuum casting machine. The aim is to improve the overall mechanical and wear properties to make this alloy more suitable for gear applications.

## **2.2 Objectives,**

Based on the literature review the research gap formed is as follows:

- To change in copper percentage for 0 to 2% can be done by al7075 alloy for in present in mechanical properties.
- The physical and mechanical characterization of copper and silicon carbide (Sic) with 7075 aluminium alloy composites.
- Study of sliding wear properties of copper and silicon carbide (Sic) with 7075 aluminium alloy composites

# **Chapter 3**

## **MATERIAL AND METHOD**

**3.1 MATERIAL AND METHOD,**

The stirring casting process is used to produce Al7075 alloy matrix composites reinforced with different weight percent Cu metal powders. % magnesium is added to improve the wetting of alloy compounds the base material (Al 7075) is melted in a graphite crucible at 750°C in a vacuum furnace and the assembly is assembled by a heating element containing graphite crucible, passing piston. Adopts a thin tip with a diameter of 8 mm and a temperature measuring instrument Therefore, the molten material with the reinforcement added is injected directly into the cast iron mould through the open piston and then solidified. After casting, the alloy compound produced is brought to room temperature and then a compound sample is prepared to determine the mechanical and wear properties of the compound.

Production of 7075 alloys composites samples the designed alloy composites were fabricated using elevated temperature vacuum casting equipment (Fig. 3.1). The unfilled and particulate filled with aluminium alloy composites at diverse



**Fig. 3.1.High vacuum castings machine**

Percentage by mass of Cu particles (0-2% by mass and percentage by mass of other elements unchanged) metal powder content The preparation of Al7075 alloy compounds loaded with Cu particles is carried out in a vacuum foundry consisting of a single heating chamber. It consists of a graphite crucible, a piston passing through a small 8mm diameter nozzle and a built-in internal temperature sensor. The primary alloy is first melted in a furnace in a graphite crucible at about 700°C, then mixed with 2% magnesium by weight to improve wetting Analysis of the construction material (Table 3.1). Then add / mix briefly (5 min) the preheated reinforcement (150 ° C) according to the filler content to cause the material to melt in the mould. Pour the solid (140 x 90 x 10 mm<sup>3</sup>) through an open plunger. After the technical composite was cooled to a temperature of 30 ° C, samples of the technical composite were cut to obtain different test properties.

Design of the copper (Cu) series formulations-

S.NO.	COMPOSITES	Al7075 (wt %)	Ni (wt %)	Cu (wt %)	Cr (wt %)	SiC (wt %)
1	A	94	2	0	2	2
2	B	93.5	2	0.5	2	2
3	C	93	2	1	2	2
4	D	92.5	2	1.5	2	2
5	E	92	2	2	2	2

Table 3.1 Design of the copper (Cu) series formulation

### 3.2. Physicals and mechanical characterizations

The investigational densities of designed alloy composites models was computed via benchmark water fascination method in confirms with archimedes principle as per ASTM D792 benchmark while theoretical densities was determined using the imperative of mixture via eq. (1)

$$\rho_t = \frac{1}{\frac{w_{Al7075}}{\rho_{Al7075}} + \frac{w_{Co}}{\rho_{Co}}} \quad \text{----- (1)}$$

Where w and q point out the weight fraction and density of elements in that order the void portion or porosity in the designed composite samples was calculated by using eq [2]

$$\text{void fraction} = \frac{\text{theoretical}(\rho_t) - \text{experimental}(\rho_e)}{\text{theoretical}(\rho_t)} \quad (2)$$

The hardness properties calculate the resistance to local plastic deformation due to mechanical or index able wear. In this process, the material is placed on the material with a load of 200 g for 10 seconds in a straight pyramidal shape with an angle between the bottom of the square and the opposite surface at 136°C.

$$H = 1.854 \frac{f}{d} \quad (3)$$

Where, 'f' is load in kg and 'd' is the signify diagonal in mm.

The tensile tests of designed composite are carry out using universal testing machine (UTM) Instron 1195 (ASTM D 3039– 76) having flat rectangular model size of 150 10 mm<sup>3</sup> , 75 mm span length, cross head speed of 2 mm/s. For flexural potency sample size 50 x 4 x 4 mm<sup>3</sup> with span length of 40 mm at 2 mm/s cross-head hustle is used on UTM subsequent ASTM E-290 standard. The working out of flexural potency is calculated by using

$$F.S = \frac{3PL}{2bt^2} \quad (4)$$

Where, 'P' is the greatest load, 'b' is the width of specimen's' is the thickness of sample and L is the span length of the sample. The impact potency of designed composite models are measured in-terms of impact energy on impact tester as per ASTM E-23 of sample size of 64 x 12.7 x 3.2 mm<sup>3</sup>, depth under the notch is 10.2 mm. For compression test, sample size of 10 x 30 x 10 mm<sup>3</sup> having span measurements lengthwise of 50 mm are used as per ASTM E9-09 on UTM with 2 mm/s cross-sectional speeds.

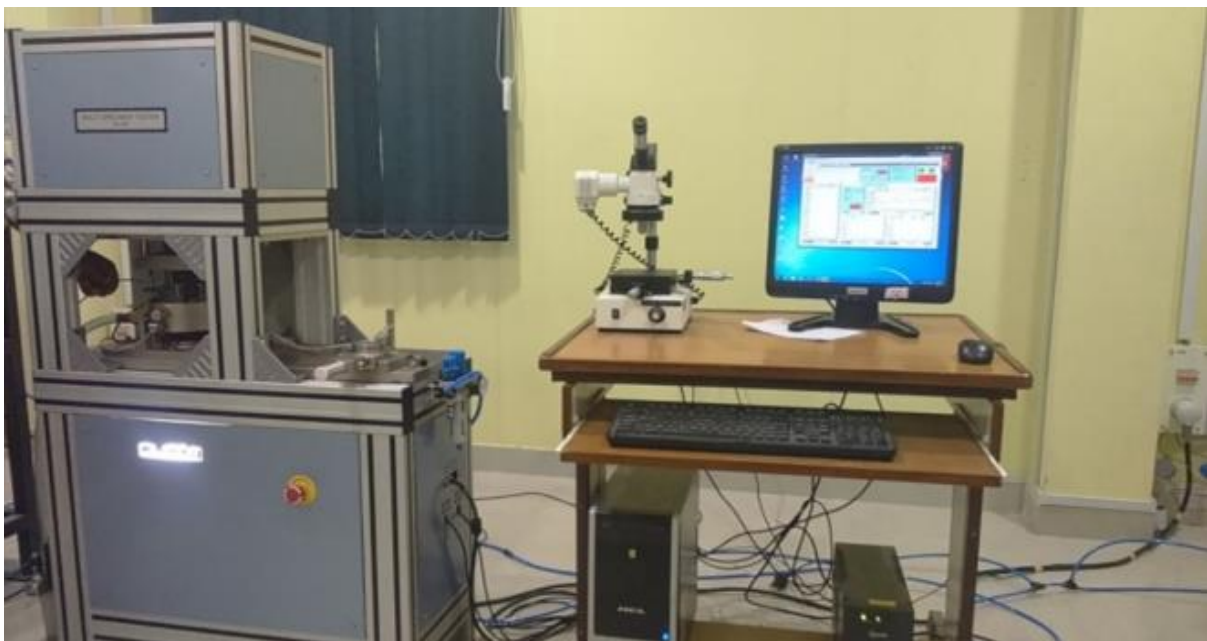
### 3.3. Sliding wear experiments condition,

Abrasion and friction triangulation tests are performed on a multi-sample tester (MST), an A7075 aluminium alloy composite filled with metallic copper powder, using a spindle disk configuration for rotating lakes on the copper surface. I did. 62 ASTM G99 compliant HRC hardened steel valve. Samples (dimensions 10 x 9 x 14 mm<sup>3</sup>) were placed vertically with a load on a fixed sample holder. The test conditions include normal loads (0.25, 0.5, 0 slip speed settings).Sliding speed at constant normal load 20 N at 75.1, 1.25 m/s. For all landslide sites, 5 slides of 250 m length, each with a constant diameter of 40 mm were made. During

each test, strain gauges record the coefficient of friction values at intervals of each second in the global configuration of the cantilever of the device. In addition to the friction data, vibration and noise behaviour were recorded, and with the naked eye, they noticed wear on the surface of the rotating shaft, during and after implementation, respectively. All tests are carried out under ambient conditions, and at the start of each pass the steel contact surfaces are polished with 200, 320, 420 ghat, 600 Grits sandpaper for several minutes, accumulation of wear and material traces . Pass pins. After taking it out, it is washed off with alcohol. Finally, in all tests, the battery samples were washed with alcohol and then equilibrated with an electronic balance to an accuracy of  $\pm 0.001$  mg. The data obtained and analyzed include specific wear rates in the form of weight loss and coefficient of friction values. Therefore, the test details listed in table 3 use hardened EN31 (60-70 HRC) steel discs. Abrasion of mixed alloy samples was measured by both sample height loss (micrometer units for LVDT sensors) and gravimetric analysis (grams (g) using precision electronic balances). Accuracy  $\pm 0.001$  mg), groove diameter is 40 mm. The specific wear ratio ( $W_s$ ;  $\text{mm}^3 / \text{Nm}$ ) of alloy compounds is evaluated using the following formula. The specific wear ratio ( $W_s$ ;  $\text{mm}^3 / \text{Nm}$ ) of alloy compounds is evaluated using the following formula.

$$W_s = \frac{\Delta m}{\rho \times v_s \times t \times f_n} \quad (5)$$

Where,  $\Delta m$  stand for mass loss of models (g),  $\rho$  is the model density (g/cc),  $v_s$  is the sliding velocity (m/s),  $t$  is the test duration (s.) and  $f_n$  is the normal load (N.).



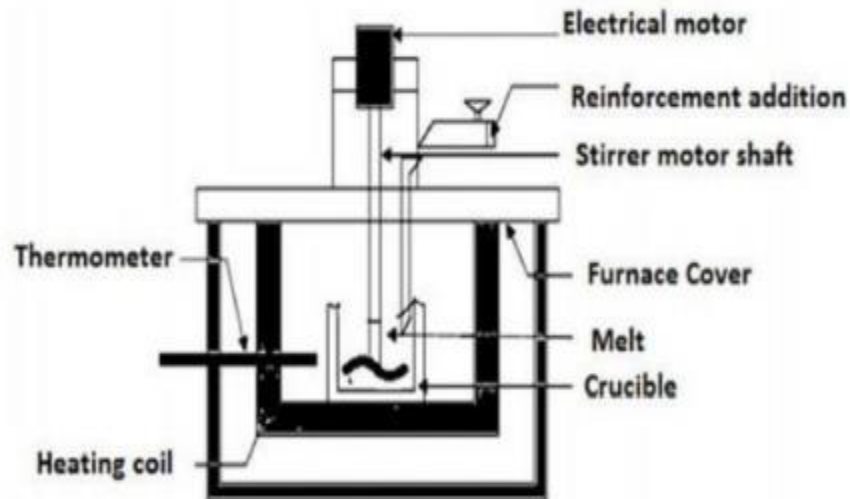
**Fig.3.2. Multi specimen tester equipment**

S.NO.	COMPOSITION	Theoretical density (g/cm <sup>3</sup> )	Experimental density (g/cm <sup>3</sup> .)	Void content. (%)
1	0 wt%cu	3.15	3.10	1.58
2	0.5 wt%cu	3.21	3.02	5.91
3	1 wt%cu	3.26	2.97	8.89
4	1.5wt%cu	3.31	2.95	10.87
5	2 wt%cu	3.35	2.92	12.83

Table 3.2 Evaluation of experimental density and theoretical density

### 3.4 STIR CASTINGS ROUTE FOR FABRICATION OF MMC,

Of all the processing processes, liquid metallurgy is the most sought after because of its many advantages, including mass production, cost effectiveness, and the ability to manufacture fibrous parts. Therefore, the casting method should only be considered as the most optimal and economical method. Processing aluminium composites among the various casting processes, agitation casting is considered to be the most effective. The agitation casting method is relatively simple and in expensive. The composition of the stirring foundry mainly consists of a furnace and a stirrer assembly. The stirrer is used to stir the molten metal matrix. The stirrer is usually made of a material that can withstand melting temperatures higher than the temperature of the mould. Graphite stirrer is commonly used for foundry stirrer. The stirrer is mainly made up of two cylindrical parts. Rod and wheel one end of the connecting rod is connected to the wheel and the other end is connected to the motor shaft. The stirrer is usually kept upright and is rotated by a motor at various speeds. In this process, the metal in the mold is first heated above the liquid temperature and completely melts. It is then cooled to a temperature between liquids. The solid state means that it is in a semi-solid state, in which the preheated reinforced particles are then added to the molten matrix, heated again to a completely liquid state, and well agitated to produce a mixture of matrix alloy and copper. can be done with this method, particles accumulate frequently. The accumulated particles can be dissolved at high temperature with vigorous stirring. The liquid composite is then poured into a sand casting / mold and then solidified. Stirring casting is suitable for the production of composites containing up to 30% by weight of reinforcement. Particles due to different process parameters and material properties lead to a non-uniform metal distribution.



**Figure 3.3: Stir castings experimental setup**

### 3.5 STIR CASTING PROCESS PARAMETERS,

Process parameters participate a vital role on properties of Al based MMC. In case of Stir casting, procedure parameters similar to stirring rate, stirring temperature, pouring temperature etc., are to be maintained for achieving enhanced properties of MMC

- ❖ Speed of rotary motion: For successful construction of casting, the control of speed is very significant. Rotating speed also influences the configuration; increase of speed promotes enhancement and very low speed results in instability of the fluid mass. It is logical to use the highest speed to keep away from tearing.
- ❖ Stirring speeds: Stirring speed is one of the most significant process parameters as wettability is promoted by stirring i.e. bonding sandwiched between matrix & potencing. The flow pattern of the molten metal is in a straight line controlled by the stirring speed. As solidify rate is faster it will enlarge the percentage of wet capability.
- ❖ Stirring temperature: The viscosity of Al matrix is manipulated by the processing temperature. The subdivision distribution in the matrix is based to the change of viscosity. When dispensation temperature is increased all along with increasing holding time of stirring, there is a reduce in the viscosity of liquid. There is also acceleration in the chemical reaction amid matrix along with reinforcement.
- ❖ Stirring time: Identical giving out of the particles in the fluid and perfect boundary bond amid potencing along with matrix is promoted besides stirring. In the dispensation of

composite, the stirring time among matrix and potencing is considered as significant factor.

- ❖ Pouring temperature: A main role is participated by the pouring temperature on the method of solidification along with determines family member partly to the necessitated structure type. Stumpy temperature is associated through maximum grain refinement as well as equated structure while elevated temperature promotes columnar enlargement in numerous alloys. However, the series is limited in practical state of affairs. To certify acceptable metal flow as well as freedom from collapse whilst keep away from coarse structures, the pouring temperature must be adequately high.
- ❖ Mould temperature: Its principal significance lies in the degree of expansion of the die with preheating. The hazard of tearing in casting is diminished beside expansion. The mould warmth should neither be too low nor be too high, in non-ferrous casting. The mould should be at least 25 mm thick through the thickness increasing size along with weight of casting.

### **3.6 ADVANTAGES OF ALUMINIUM BASED MMCS.**

The major advantages of AMCs compared to unreinforced materials are as follows,

- ✓ Greater potencies
- ✓ Improved stiffness
- ✓ Reduced density (weight).
- ✓ Improved elevated temperature properties.
- ✓ Controlled thermal expansions coefficient
- ✓ Thermal/heat management
- ✓ Enhance as well as tailored electrical presentation
- ✓ Improved abrasion along with wear resistance
- ✓ Control of masses

# **Chapter 4**

## **RESULT AND DISCUSSION**

## **4. RESULT AND DISCUSSION**

### **4.1. Effect of voids contented on cu filled Al7075 alloy composites,**

Table 3.2 shows the theoretical / experimental density and void content of Al7075 alloy compounds filled with metallic copper powder. Increasing the metallic copper powder from 0 to 0.5% by weight was reported to increase the void percentage from 1.58% to 5.91%. Correspondent this may be due to a better interfacial bond between the filler and the composite alloy, and the reduced density may be due to the presence of voids.

From 1.58% to 8.89% the main reason for the increase in void content from 1.4 to 10% due to the filler content may be due to improper mixing / wetting of hard filler particles with the mold material during manufacturing. The metal powder in the alloy increases rapidly when the void content reaches 10.87 and 12.83% by weight respectively compared with 1.58% for the uncharged alloy compound. The reason for this could be the retention and release of air in the molten state, but solidification can cause voids acceptable. High void content can lead to inadequate casting and, in fact, poor product performance.

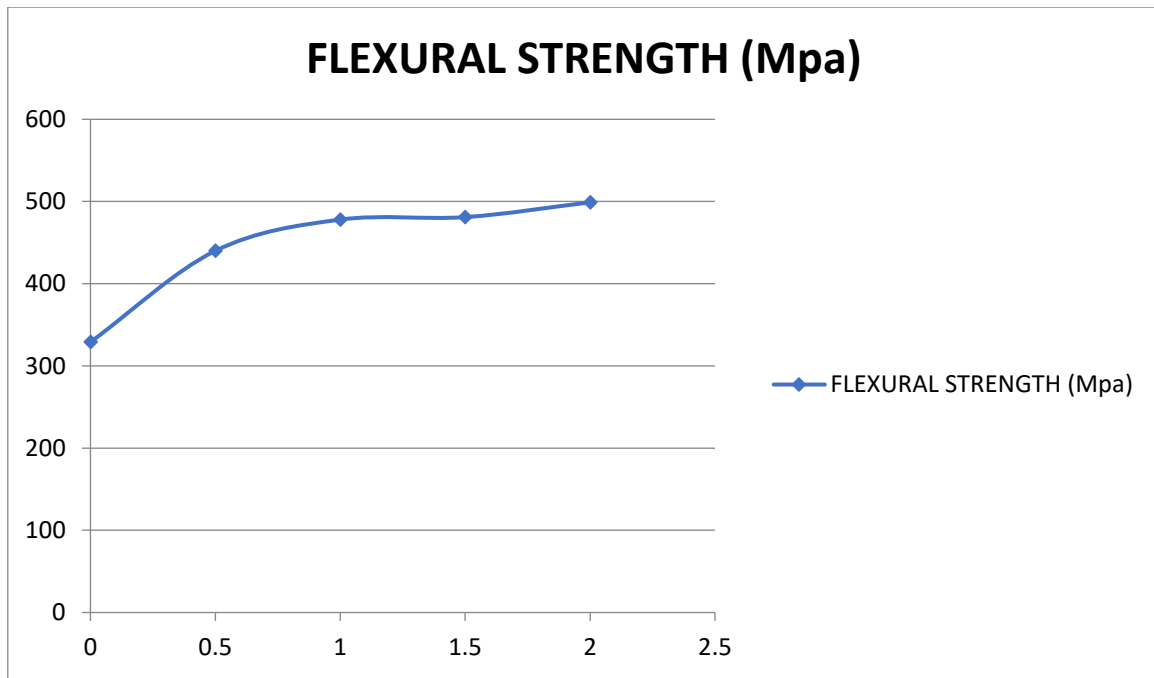
### **4.2 Effects of flexural potency on cu metal powder filled Al7075 alloy composite,**

Figure 4.1 shows the change in flexural potency of an Al7075 alloy composite filled with metallic copper powder. Displays the change in flexural potency of Al7075 alloy compound filled with metallic copper powder. In Figure 4.1 you can see that the flexural potency of the composite increases. 329-440 MPa with 0 and 0.5% by weight of copper metal powder with the addition of 1% by weight of metallic copper powder, the flexural potency increased from 440 to 478 MPa. Likewise, with the addition of 1.5 and 2 wt% filler, the flexural potency of the alloy compound slightly increased from 478 to 481 MPa. In general, flexural potency is based on the combined influence of the size of the deposited silicon particles, the potency of the backing / dies surface bond, and the presence of voids. Flexural potency increases with increasing filler content in the alloy. Matrix it can be seen that the produced compound exhibits higher ductility, achieving a higher potency of 2% by weight of copper metallic powder particles in the compound and increasing the flexural potency to 499 MPa. Therefore, the interface joint cannot be transferred correctly during the bending test amid the matrix and the particles of copper metal powder.

Flexural potency is based on the behaviour of the composite microstructure, which increases with increasing ductility and decreasing plastic deformation. The flexural potency of the specimen increases with the fine grain metal. Second, the powder provides the potency of the compound.

S.NO.	COMPOSITES	TRIALS	FLEXURAL POTENCY.(MPa)	AVERAGE FLEXURAL POTENCY(.MPa)
1	A	TRIAL1 TRIAL2 TRIAL3	328 332 327	329
2	B	TRIAL1 TRIAL2 TRIAL3	437 443 440	440
3	C	TRIAL1 TRIAL2 TRIAL3	478 475 481	478
4	D	TRIAL1 TRIAL2 TRIAL3	478 482 483	481
5	E	TRIAL1 TRIAL2 TRIAL3	502 496 499	499

**Table 4.1 Effect of flexural potency on copper metal powder filled 7075 al alloy composites.**



**Fig.4.1 Effect of flexural potency on copper metal powder filled 7075 al alloy composites.**

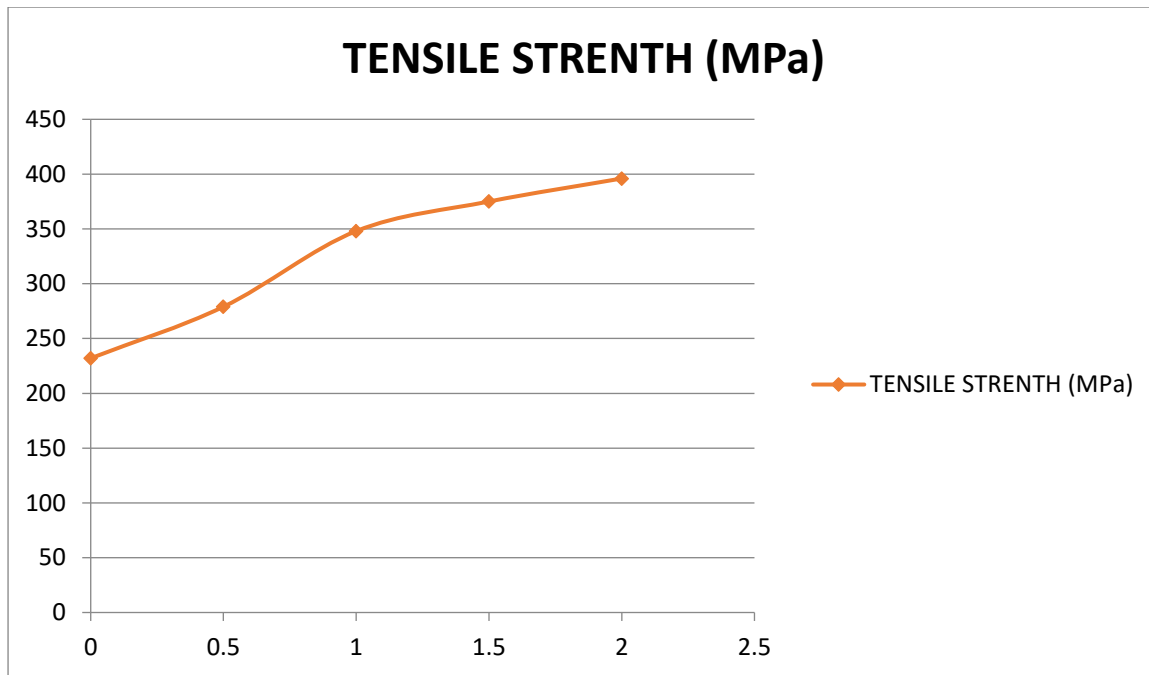
#### **4.3. Effects of tensile potency on Cu metal powder filled Al7075 alloy composite,**

The effect of copper metal powder on tensile potency of Al7075/ Cu alloy composites is illustrating in Fig. 4.2. It is noticed that the tensile potency of produce composite samples amplify with the boost in filler content from 232 MPa at 0 wt% copper metal powders to 279 MPa at 0.5 wt% copper metal powder in alloy composite. Additional on addition of 1 wt% copper metal powder potencyned, tensile potency is enhanced from 279 to 348 MPa. Likewise, once more addition of 1.5 and 2 wt% copper metal powder filled alloy composite of tensile potency was 375 MPa and 396 MPa. It can be observed that tensile potency is maximum 396 MPa at 2 wt% copper metal powder reinforced filled Al7075 alloy composite as compared to unfilled alloy. This is mostly attributed to the detail that the tensile potency is increased with increasing the copper metal powder particle contented along with it is above all higher than the potency of the copper reinforced alloy composite matrix. In common, the tensile potency enhancement through the addition of copper metal powder particles could be owing to the stimulation of more potency to the copper reinforced alloy composite, by offering superior resistance to the tensile stresses. This is due to the move of load from the matrix side to the reinforcement grown-up the tensile potency of composites. The tensile

strength of composite material is enhanced nature and deeds of reinforced particles matrix alloy composite. It may be finish off that the fine interfacial bond among base matrix as well as particulate filler played an imperative role in increasing the tensile potency of composites. Tensile potency improves for the reason that of fine size and shape of the strengthening. The tensile potency of developed composite can be also attributed to the interaction between copper metal powder particles as well as dislocation when composite experience load along with dislocation are increased due to the distinction of filler content in addition to coefficient of thermal expansion between copper reinforcement and alloy composite. This reinforcement act as prevents to enhancement dislocation due to load furthermore the dispersion reinforcement helps the transferring the load on or after the matrix. Hence, all higher wt. % manufactured composite of tensile potency is improved as compared to the unfilled alloy.

S.NO.	COMPOSITES	TRIALS	TENSILE POTENCY(MPa)	AVERAGE TENSILE POTENCY(MPa)
1	A	TRIAL1	232	232
		TRIAL2	234	
		TRIAL3	230	
2	B	TRIAL1	276	279
		TRIAL2	283	
		TRIAL3	278	
3	C	TRIAL1	348	348
		TRIAL2	344	
		TRIAL3	352	
4	D	TRIAL1	373	375
		TRIAL2	374	
		TRIAL3	378	
5	E	TRIAL1	394	396
		TRIAL2	398	
		TRIAL3	396	

Table 4.2 Effect of tensile strength on copper metal powder filled 7075 al alloy composites.



**Fig. 4.2 Effects of tensile strength on copper metal powder filled 7075 al alloy composites.**

#### **4.4. Effects of impacts strength on Cu metal powder filled Al7075 alloy composite,**

The effect of metallic copper powder on the impact strength of various weight% particle fillers (0.05, 1, 1.5, and 2) is shown in the figure. From fig. 3, it can be seen that the impact force obtained in the charpy test increases linearly as the content of metallic copper powder increases by 2% by weight. It can be clearly seen that the impact force of the non-alloy alloy is 20J, and after reinforcing 0.5% by weight of the non-alloy metal copper powder, the impact force gradually increases to 36J. Likewise, the impact force of a 1% weight reinforced aluminium alloy compound is 48 J, and at 1.5% weight of an alloy compound filled with copper metal powder, the impact force is 61 J. As a result, the composite materials produced have a higher tensile strength (69 J) with a filler content of 2% by weight, but at lower impact forces they are found with a filler content of 0% by weight. Kumar et al. [19] originate that the first-order ductile fracture coefficient and the best interfacial bond between the reinforcement and the alloy matrix increased the tensile strength of the composite produced. In general, the impact force is based on the energy consumed by the material under load. The impact resistance of other manufactured composites is high due to the plastic deformation energy stored in the material prior to cracking occurs. This composite alloy exhibits

exceptional strength due to the high impact of copper-filled alloy composites [25]. Li and associates [26] Reported a like trend that increasing the filler particles content increased the impact force of the mixture through increasing particle size, hot extrusion ratio and temperature.

S.NO.	COMPOSITES	TRIALS	IMPACT POTENCY(KJ/m <sup>2</sup> )	AVERAGE IMPACT POTENCY(KJ/m <sup>2</sup> )
1	A	TRIAL1	21	20
		TRIAL2	20	
		TRIAL3	19	
2	B	TRIAL1	37	36
		TRIAL2	36	
		TRIAL3	35	
3	C	TRIAL1	48	48
		TRIAL2	46	
		TRIAL3	50	
4	D	TRIAL1	61	61
		TRIAL2	62	
		TRIAL3	60	
5	E	TRIAL1	69	69
		TRIAL2	70	
		TRIAL3	68	

Table 4.3 Effects of impact strength on copper metal powder filled 7075 al alloy composites.

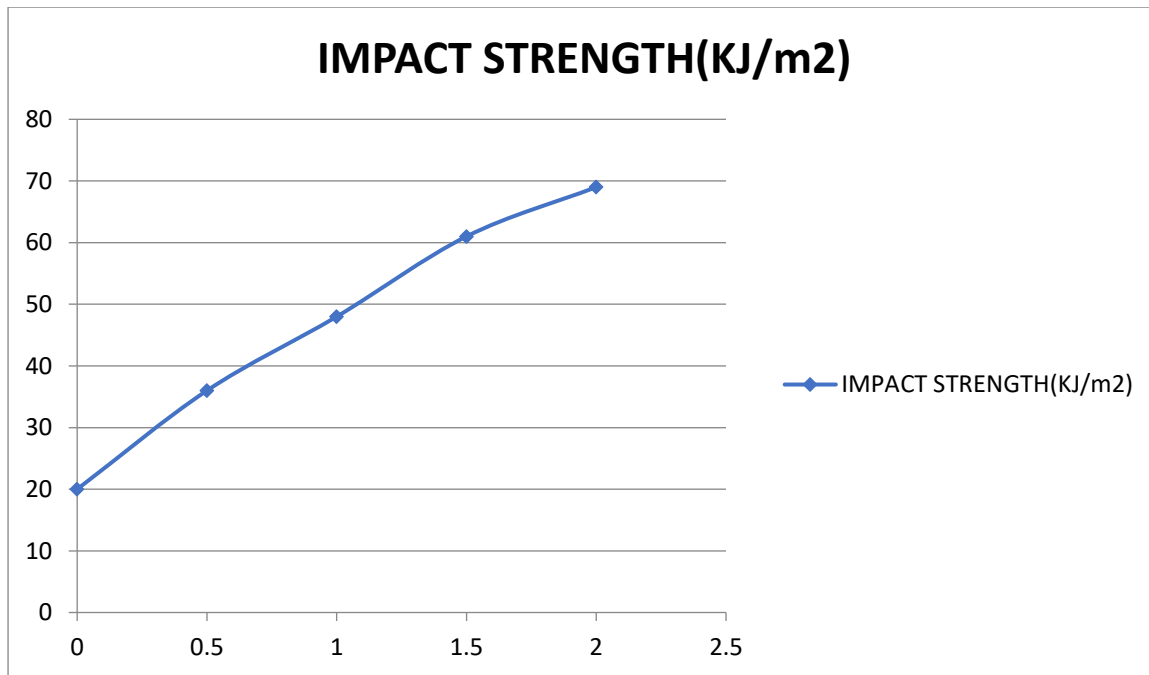


Fig. 4.3 Effect of impact potency on copper metal powder filled 7075 al alloy composites.

#### 4.5 Effects of sliding velocity on specific wear rate of Cu filled Al7075 alloy composites

The figure 4.4 shows the specific wear rate of the Al7075 alloy compound as a function of the sliding speed. Alloy compounds are expressed as a significant change in wear rate as a function of sliding speed and steady state tests are performed under different conditions (I. Sliding speed = (0.25-1.25 m / s); Normal load = 20 N; Sliding distance = 250 meters). Approximately the same pattern of change in a particular wear rate is indicated by an increase in slip rate under different fillings. It dropped significantly to m / s, and finally to a low point of 1. In addition, as the filler content increases, the wear rate decreases significantly, so this larger variation in the wear rate as a function of the slip rate appears to be of great importance technical. It is interesting to study the behaviour of insects as a function of the sliding speed, in particular the wear behaviour and the properties at 0.25, 0.75 and 1.25 m/s. From the graph, he showed that the specific wear rate of the initial alloy compounds decreased as the sliding speed increased from (0.25 to 1.25 m/s), but the unloaded compounds showed a high degree of hardness. Specificity than other compounds I observed from the graph, we see that the order of the specific wear rates is 0% mass Cu > 0.5% mass Cu > 1% mass Cu > 1.5% Cu > 2% mass Cu at all speeds. Alloy compounds have been observed. When the particles have a weight of 2%, the specific wear rate is low, especially at low sliding speeds. Sliding speed (when it goes from 1 to 1.25) m / s All alloy compounds

showed the lowest specific wear rates. This may be due to the strong surface bond between the matrix and the particles using the material that interacts with the abrasive phenomenon. A. Baradeswaran and A. Elaya Perumal reported similar results when studying the behaviour of Al<sub>2</sub>O<sub>3</sub> / graphite alloys in sliding wear. Composite material filled with Al7075. They reported that increasing Al<sub>2</sub>O<sub>3</sub> / graphite particle weight percent reduced the wear rate compared to unfilled alloys.

SLIDING VELOCITY m / s	SPECIFIC WEAR RATE FOR A (mm <sup>3</sup> /Nm)	SPECIFIC WEAR RATE FOR B (mm <sup>3</sup> /Nm)	SPECIFIC WEAR RATE FOR C (mm <sup>3</sup> /Nm)	SPECIFIC WEAR RATE FOR D (mm <sup>3</sup> /Nm)	SPECIFIC WEAR RATE FOR E (mm <sup>3</sup> /Nm)
0.25	6.3x10 <sup>-3</sup>	6.1x10 <sup>-3</sup>	5.9x10 <sup>-3</sup>	5.4x10 <sup>-3</sup>	5.0x10 <sup>-3</sup>
0.50	5.1x10 <sup>-3</sup>	3.9x10 <sup>-3</sup>	3.6x10 <sup>-3</sup>	2.8x10 <sup>-3</sup>	2.3x10 <sup>-3</sup>
0.75	3.4x10 <sup>-3</sup>	2.8x10 <sup>-3</sup>	2.4x10 <sup>-3</sup>	2.2x10 <sup>-3</sup>	1.8x10 <sup>-3</sup>
1	2.5x10 <sup>-3</sup>	2.2x10 <sup>-3</sup>	1.9x10 <sup>-3</sup>	1.6x10 <sup>-3</sup>	1.2x10 <sup>-3</sup>
1.25	2.1x10 <sup>-3</sup>	1.8x10 <sup>-3</sup>	1.6x10 <sup>-3</sup>	1.1x10 <sup>-3</sup>	0.9x10 <sup>-3</sup>

**Table 4.4 Effect of sliding velocity on specific wear rate of cu filled Al7075 alloy composites**

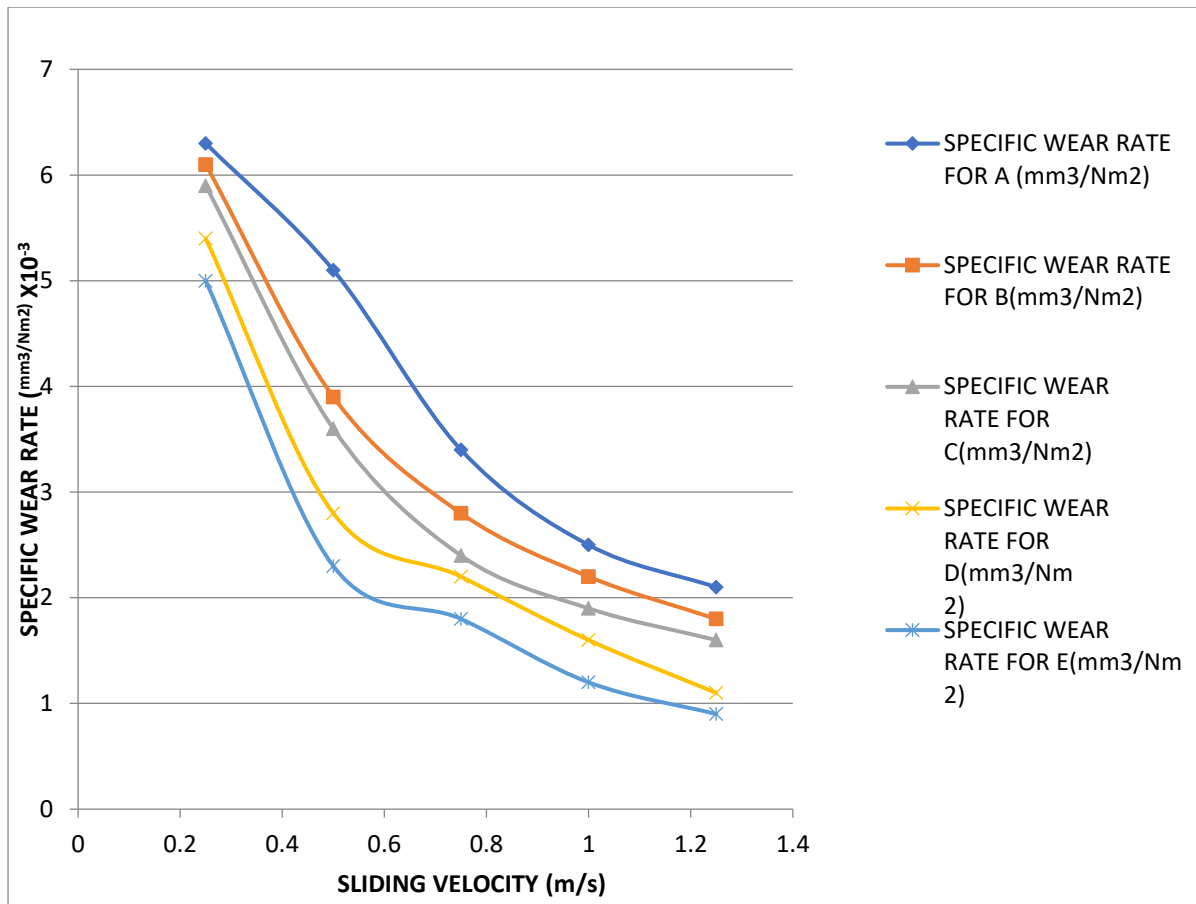


Fig. 4.4. Effects of sliding velocity on specific wear rate of cu filled Al7075 alloy Composite.

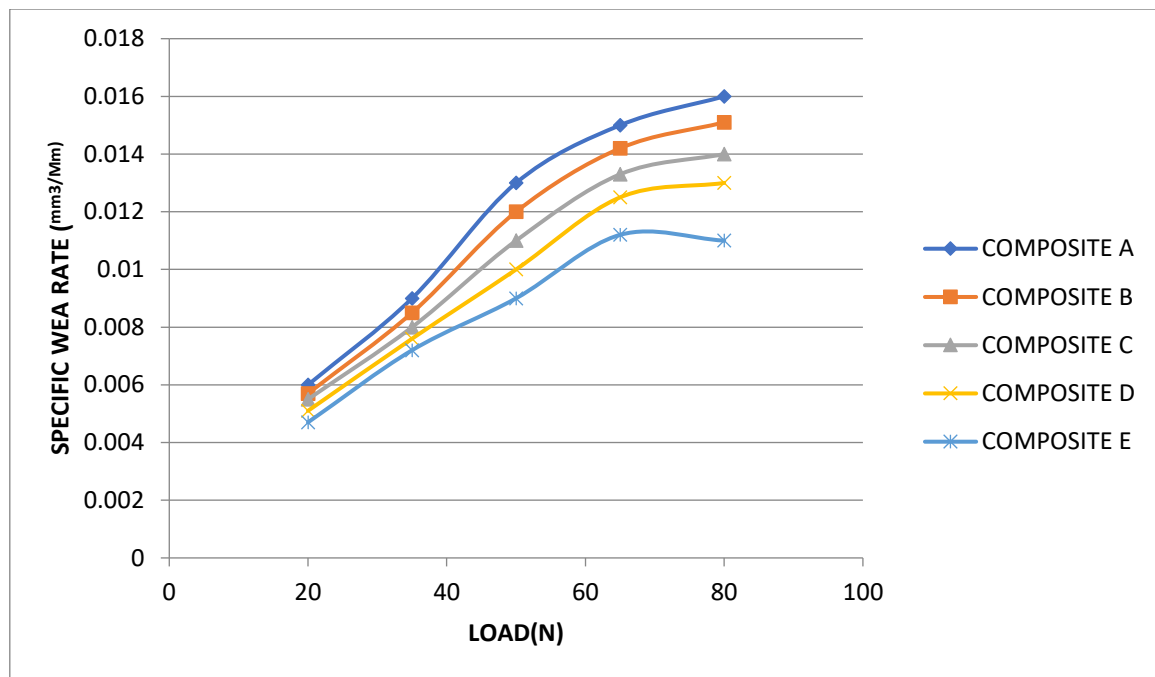
#### 4.6 Effect of load on specific wear rate of Cu filled Al7075 alloy composites

The influence of normal load on the explicit wear rate of the alloyed composites underneath steady state condition (sliding velocity of sliding velocity of 0.25 m/s; sliding distance of 250 m; normal load of 20 N–80 N) are represented in fig. 4.5. There specific wear rate amplify hastily by means of increasing the normal load from the graph it is observed that the definite wear rate of formulated composites is superior at 0 wt% copper metal powder particulate filler while for 2 wt% copper metal powder of the specific wear rate is lower. It can be noticed from the fig. 4.5 that the all wt. % the wear rate of fabricated composite trend is almost comparable along with least wear rate at 20 N normal loads as evaluated to unfilled/neat alloy composite. In common, the specific wear rate enlarges with increase the normal load (20–80 N) while declines through enhance the particulate content. This is mostly attributed to the fact the specific wear rate of 2 wt% copper particulate contented filled alloy composites illustrate the minimum wear rate in association to neat alloy composites. It is obvious apparent that the specific wear rate of fabricated composites order is 0 wt% Cu >0.5

wt% Cu >1.0 wt Cu % >1.5 wt% Cu >2 wt%. cu. This may be because of the wear rate for composite materials increasing through increasing the normal load which illustrates the wear resistance capability of composite material is unfortunate at various loading condition. It is due to the grain refinement get better the wear resistance of alloyed composites while the wear rates of composites explain inversely correlated with material hardness the formulate composite material hardness reduces due to the high porosity which illustrate increase the wear rate of new composites with amplify the normal load.

LOAD (N)	SPECIFIC WEAR RATE FOR A (mm <sup>3</sup> /Nm)	SPECIFIC WEAR RATE FOR B (mm <sup>3</sup> /Nm)	SPECIFIC WEAR RATE FOR C (mm <sup>3</sup> /Nm)	SPECIFIC WEAR RATE FOR D (mm <sup>3</sup> /Nm)	SPECIFIC WEAR RATE FOR E (mm <sup>3</sup> /Nm)
20	0.006	0.0057	0.0055	0.0051	0.0047
35	0.009	0.0085	0.0080	0.0076	0.0072
50	0.013	0.012	0.011	0.010	0.009
65	0.015	0.0142	0.0133	0.0125	0.0112
80	0.016	0.0151	0.014	0.0130	0.011

**Table 4.5 Effects of normal load on specific wear rate of cu filled Al7075 alloy composites.**



**Fig. 4.5 Effects of normal loads on specific wear rate of cu filled Al7075 alloy composites.**

#### **4.7 Effect of sliding distance on specific wear rate of cu Filled Al7075Alloy Composites:-**

The measured specific wear rate of the specimen models are plotted alongside the sliding distance in (Fig. 4.6) for Cu filled Al7075 aluminium alloy amalgamated. It examined that specific wear rate raise among increase sliding distance for alloyed composites. The order of specific wear rate of alloyed composites is 0 wt% Cu >0.5 wt%, Cu >1 wt%, Cu>1.5 wt% Cu >2 wt% Cu. The specific wear rate illustrates lowest assessment at lower sliding distance (250 m) except higher specific wear rate at higher sliding distance (1250 m). It examined that unfilled alloy of specific wear rate shows higher at (0 wt% Cu) alloyed merged while lower wear rate at 2 wt% Cu content. The specific wear rate of 2 wt% cu alloyed composites show minimum over the neat alloyed composite due to move ahead hardness and disintegration of particles possessed through TiO<sub>2</sub> particles supports minimum wear loss of higher wt. % filler content. In sliding wear, Disintegration of particles roles illustrates the development of interface film, which reduces the wear loss of composite sample. The specific wear rate of alloyed composites amplify through increase the sliding distance due to sliding part of fixed particles are fractured as well as worn out derbies particle on or after the counter surface and free non fractured particles scraped the counter surface.

The motive for contact area of sliding surface enhanced among increased in contact time which in turns enhanced wear of the composite.

SLIDING DISTANCE (m)	SPECIFIC WEAR RATE FOR A (mm <sup>3</sup> /Nm.)	SPECIFIC WEAR RATE FOR B (mm <sup>3</sup> /Nm)	SPECIFIC WEAR RATE FOR C (mm <sup>3</sup> /Nm)	SPECIFIC WEAR RATE FOR D (mm <sup>3</sup> /Nm)	SPECIFIC WEAR RATE FOR E (mm <sup>3</sup> /Nm)
250	0.006	0.0100	0.0120	0.0122	0.0135
500	0.0056	0.0095	0.0110	0.0114	0.0124
750	0.0052	0.0085	0.0100	0.0106	0.0119
1000	0.0044	0.0075	0.0092	0.0100	0.0116
1250	0.0041	0.0060	0.0082	0.0091	0.0112

Table 4.6 Effects of sliding distance on specific wear rate of cu filled Al7075 alloy Composites

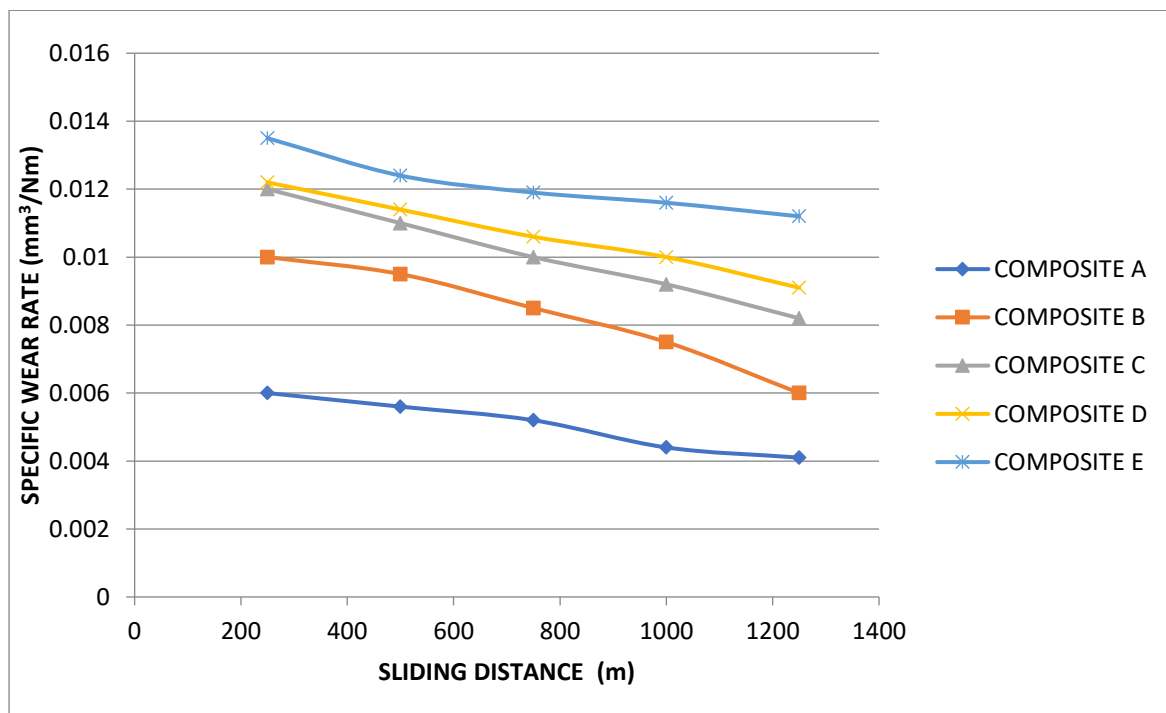


Fig.4.6 Effect of sliding distance on specific wear rate of cu filled Al7075 alloy composites.

Experimental's layout of L25 orthogonal array:-

Experiment no.	Filler Content (wt %)	Normal Load (N)	Sliding Distance(m)	Sliding Velocity(m/s)
1	1	1	1	1
2	2	1	2	2
3	3	1	3	3
4	4	1	4	4
5	5	1	5	5
6	1	2	2	3
7	2	2	3	4
8	3	2	4	5
9	4	2	5	1
10	5	2	1	2
11	1	3	3	5
12	2	3	4	1
13	3	3	5	2
14	4	3	1	3
15	5	3	2	4
16	1	4	4	2
17	2	4	5	3
18	3	4	1	4
19	4	4	2	5
20	5	4	3	1
21	1	5	5	4
22	2	5	1	5
23	3	5	2	1
24	4	5	3	2
25	5	5	4	3

Table 4.7 Experimental layout of L25 orthogonal array

Experiment no.	Filler Content (wt%)	Normal Load (N)	Sliding Distance. (m)	Sliding Velocity (m/s)	Specific wear rate (mm <sup>3</sup> /N-m)	S/N Ratio (db)
1	0	20	250	0.25	0.006	44.43
2	0.5	20	500	0.50	0.0056	45.03
3	1.0	20	750	0.75	0.0052	45.67
4	1.5	20	1000	1.0	0.0044	47.13
5	2.0	20	1250	1.25	0.0041	32.25
6	0	35	500	0.75	0.0095	40.44
7	0.5	35	750	1.0	0.0085	41.41
8	1.0	35	1000	1.25	0.0075	42.49
9	1.5	35	1250	0.25	0.0060	44.43
10	2.0	35	250	0.50	0.0100	40.0
11	0	50	750	1.25	0.0100	40.0
12	0.5	50	1000	0.25	0.0092	40.72
13	1.0	50	1250	0.50	0.0082	41.72
14	1.5	50	250	0.75	0.0120	38.41
15	2.0	50	500	1.0	0.0110	39.17
16	0	65	1000	0.50	0.0100	40.0
17	0.5	65	1250	0.75	0.0091	40.81
18	1.0	65	250	1.0	0.0122	38.27
19	1.5	65	500	1.25	0.0114	38.86
20	2.0	65	750	0.25	0.0106	39.49
21	0	80	1250	1.0	0.0112	39.01
22	0.5	80	250	1.25	0.0135	37.39
23	1.0	80	500	0.25	0.0124	38.13
24	1.5	80	750	0.50	0.0119	38.48
25	2.0	80	1000	0.75	0.0116	38.71

Table 4.8 L25 Orthogonal Array with Parameters and their Levels

The equation for the calculation of S/N ratio for material removal rate is:

$$S/NLB = -10 \log (\Sigma (1/y_i^2))$$

#### 4.8 Calculations of mean S/N ratio for wear rate,

Level	Normal load	Filler content	Sliding velocity	Sliding distance
1	0.00506	0.00934	0.00884	0.01074
2	0.00830	0.00872	0.00914	0.00998
3	0.01008	0.00910	0.00948	0.00924
4	0.01066	0.00914	0.00946	0.00854
5	0.01212	0.00946	0.00093	0.00772
Delta	0.00706	0.00074	0.00853	0.00302
Rank	2	4	1	3

Table 4.9 Response table for S/N ratio

#### 4.9 Analysis of experimental results by Taguchi's experimental design:-

As a project tool for finding robustness, the signal-to noise (S/N) ratio is the most important part of constraint design. In this technique, the word 'signal' expresses the wanted target i.e. sliding wear rate as well as the word 'noise' expresses the undeniable significance. In listed table 4.8 of S/N ratio is in fact the standard of two replications. The on the whole mean for the S/N ratios of copper metal powder particulate filled among aluminium alloy composites is found to be 40.498 db correspondingly. The S/N ratio of composite is analysed by using the trendy software known as MINITAB 16. From the considerable consequence on specific wear rate plot as indicate in fig. 4.7, it is observed that in order to get lower wear rate, in complimentary parameter procedure should be in low stage for normal load (20 N), middle level for filler content (1 wt%), towering level for sliding velocity (1.25 m/s) and middle level for sliding velocity (750 m). additional it is also examined that the order for the significant effect on wear rate like as sliding velocity < Normal Load < sliding distance < filler content table 4.9 indicates the tribological concert of developed alloyed composites under different sets of controlling aspects further more for utilized appropriate gear material applications.

## Regression Equation

$$\begin{aligned} \text{Specific wear rate (mm}^3\text{/N-m)} = & 0.005583 + 0.000110 \text{ Normal Load (N)} \\ & + 0.000040 \text{ Filler Content(wt\%)} - 0.000003 \text{ Sliding Distance(m)} \\ & + 0.000496 \text{ Sliding Velocity(m/s)} \end{aligned}$$

## Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	4	0.000165	92.71%	0.000165	0.000041	63.57	0.000
Normal Load (N)	1	0.000136	76.50%	0.000136	0.000136	209.85	0.000
Filler Content(wt%)	1	0.000000	0.01%	0.000000	0.000000	0.03	0.862
Sliding Distance(m)	1	0.000028	15.76%	0.000028	0.000028	43.23	0.000
Sliding Velocity(m/s)	1	0.000001	0.43%	0.000001	0.000001	1.19	0.289
Error	20	0.000013	7.29%	0.000013	0.000001		
Total	24	0.000178	100.00%				

Table 4.10 Analysis of variance for S/N ratios of wear rate

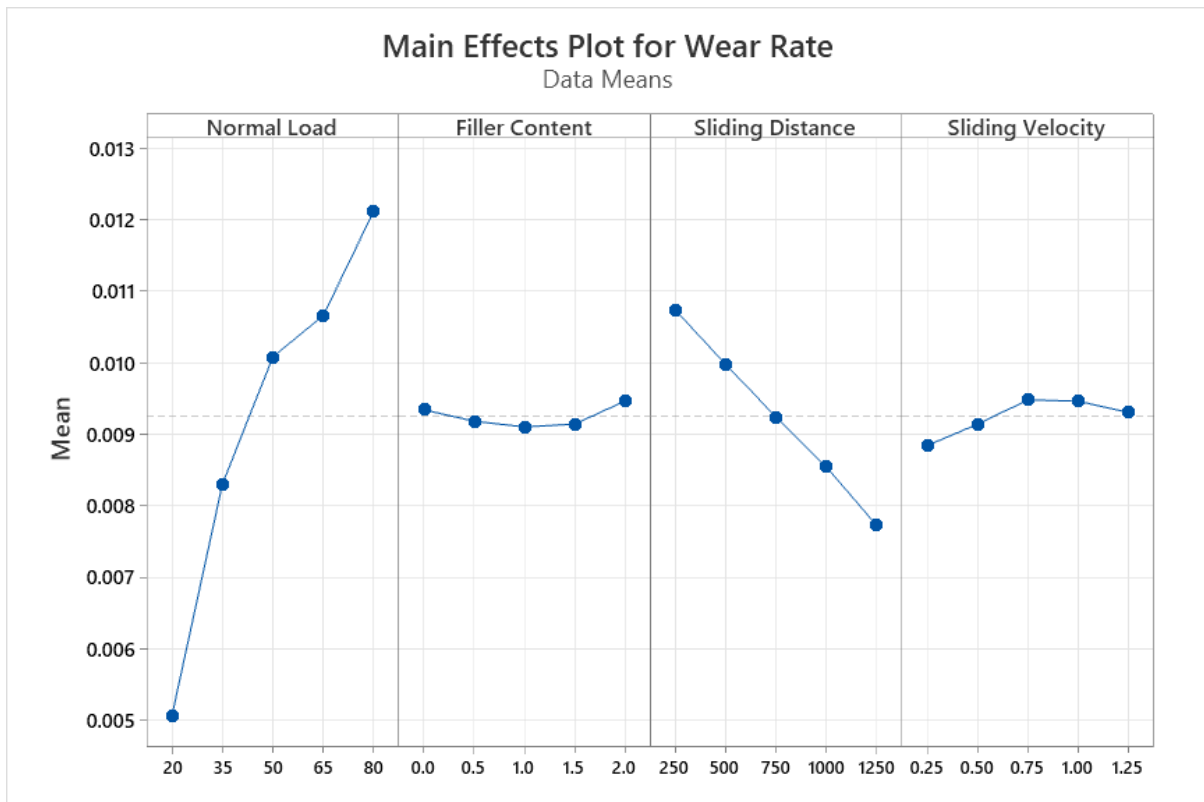


Fig.4.7. Effects of control factors on wear rate for copper filled Al7075 alloy composite.

#### 4.10 ANOVA and effect of factors.

The examination of variance (ANOVA) is a valuation tool used to acquire the importance of the variable on specific wear rate. Beginning the analysis of variance for S/N ratios of the wear rate indicated in table 4.9 with find load as well as sliding distance were recognized the most important parameters with (76.50%) and (15.76%) involvement respectively. The consequence of filler content along with sliding velocity on the specific wear rate was finding to be inconsequential with very less percentage involvements. The following order of outcome on specific wear rate is identified: normal load > sliding distance > sliding velocity > filler content.

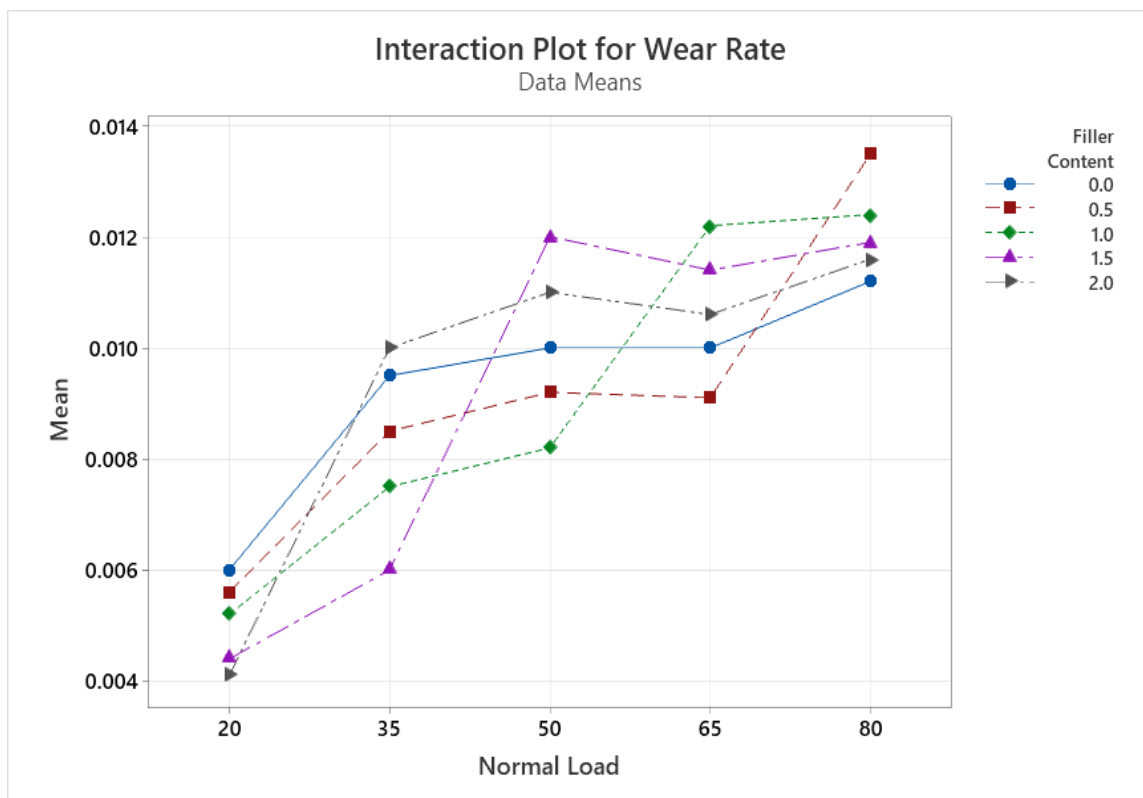
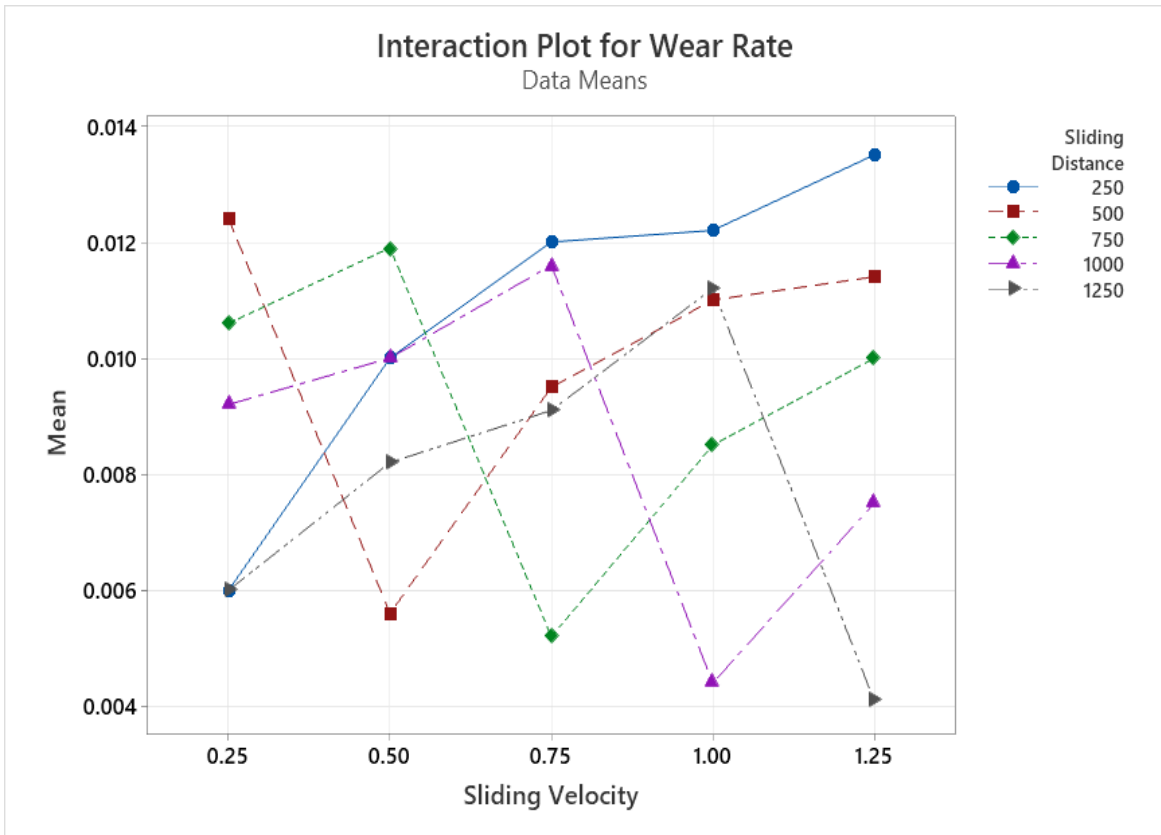


Fig4.8 Interaction plot between wears rate and normal load at various levels of filler content



**Fig4.9 Interaction plot between wear rate and sliding velocity at various levels of sliding distance**

# **Chapter 5**

## **CONCLUSION**

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## CONCLUSION

In this study work, copper (for 0–2 wt %) particulate filled Al7075 alloy composites are made-up via elevated temperature vacuum casting technique. pursue description the very important findings are:

- There were enhancements in thermo mechanical along with wear resistance performance with filler content.
- The designed composite for specific wear rate enhance with sliding velocity via steady state situations. The succession order is: 0 wt% Cu > 0.5 wt% Cu > 1 wt% Cu > 1.5 wt% Cu > 2 wt% Cu.
- The designed composite of specific wear rate reduces with normal load (20–80 N) via steady state test situation. The succession orders is 0 wt% Cu > 0.5 wt% Cu > 1 wt% Cu > 1.5 wt% Cu > 2 wt% cu irrespective of the normal load situation as well as wear rate increase with increasing the load on definite design composite.
- The experimental investigation via taguchi approach highlights it is examined that in order to acquire lower wear rate, in encouraging parameter procedure should be in low intensity for normal load (20 N), middle level for filler content (1 wt%), high level for sliding velocity (1.25 m/s) and middle level for sliding distance (750 m).
- The ANOVA investigation order is analysed load and sliding distance were identified the foremost parameters among (76.50%) along with (15.76%) contribution correspondingly. The consequence of filler content as well as sliding velocity on the specific wear rate was got to be in significant with very smaller amount percentage involvements. The subsequent order of consequence on specific wear rate is identified: normal load > sliding distance > sliding velocity > filler content.
- The alloy composites with 1 wt% Cu particulate filler contented shows minimum specific wear rate therefore, deemed fit for gear applications.

# **Chapter 6**

## **Limitations & Future Scope of Work**

### **Limitations & Future Scope of Work**

- When compared to other aluminium alloys, the 7075 have a lower Resistance to corrosion.
- Despite having good Machinability, its ductility is still the lowest when compared to other 7000-series alloys
- Its cost is relatively high, which limits its use.
- The use of the 7075 aluminium usually parallels with the use of the 2024, but the 7075 will remain the first choice when the job requires higher mechanical properties.
- There is a wide extension for future researchers to investigate and explore the current research area.
- The present work can be additionally reached out to contemplate different parts of alloy like utilization of copper and assessment of their dynamic mechanical, physical, tribological properties and the experimental results can be likewise be broke down.
- The same alloy material used can be subjected to various heat treatments and the wear analysis can be studied.
- Further experiments can be carried using lubricants i.e. wet lubrication method. Hence further may include erosion and severe abrasion properties.

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