MECHANICAL PERFORMANCE OF NANO – COPPER REINFORCED WITH SIC, AL_2O_3 USING POWDER METALLURGY PROCESS

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***Abstract*— Copper metal matrix composites with SiC, Al_2O_3 reinforcements give superior mechanical & physical properties. Their applications in many demand areas, such as automobile, aerospace, defense, sports, electronics, biomedical and other industrial purposes, are essential for the last several decades. . Copper matrix composites (CMC) have a component copper that creates a complex that is characterized as matrix phase and additional components act as elements that are usually ceramic or non-hard material. Metal-matrix composite developed by means of powder metallurgy process in addition by producing different proportion samples with different percentage reinforcement (2.5wt%, 5wt%, 7.5wt %) copper of silicon carbide (SiC) and alumina (Al_2O_3) Are done. These samples were tested under Porosity, Optical Microscopy, Wear Test, XRD conducted. Increasing in the reinforcements of SiC & Al_2O_3 Porosity & Wear Decreases in the Nano-Copper metal matrix.**

***Key Words*— Copper; alumina & SiC Nano-composite powders; Powder metallurgy; Sintering; Porosity; Wear**

1. Introduction

A composite material is prepared by collaborating two or more dissimilar constituents. The reasonable performances of composite in the aspects like cost, strength and ease of fabrication in producing a component and reliability has improved their usage. Composite materials offer better and good quantity of applications in the field of aerospace, automotive and shipbuilding industry, as it has different advantages over other traditional metals. In the metal P / M process, the combination of elemental or pre-alloy powder is compressed interested in the die and further sintered in an oven to create perfect bonding between particles. Ceramic materials with dissimilar characters and varieties are widely used as reinforcement in copper alloy matrix. This is done because of their behaviors and characteristics like refractoriness, high hardness, wear resistance, etc. Powder metallurgy is a technique that extensively spreaded because of their precise sizes and intricate shapes effectively and low-cost. Physical and chemical properties are improved by combining composites Materials combined in solid states with concrete. The overall material provides a wonderful combination with superior properties that is completely different from the individual base material and is light in weight.

2. Literature review

Composite material consists of discrete reinforcement distribution in the continuous phase of the matrix. A part of the copper matrix combination (CMC) is a network that forms the matrix phase and other components are usually reinforced by ceramic or metallic tissue materials. Composite substances play a key role in modern industrial sectors. Our research Centre produces metal-matrix compounds using the stir casting fabrication technique and sets up several present of reinforcement models (5%, 10% and 15% mass) with copper of silicon carbide and alumina.[1] The purpose of this work is to prepare co-precipitation-alumina Nano compounds using co-sedimentation process and hot-tapping method and investigate their mechanical properties. Soluble parameters like soluble temperature, heat pressure and packing time are optimized to strengthen alumina nanoparticles of copper matrix alloys (CMCs). 1wt%, 2wt%, 3wt%, 4wt% and 5wt% alumina nanoparticles have strengthened density, microscopic and biolistic assets.[2] Copper (Cu) - alumina (AL_2O_3) Metal Matrix alloys (MMCs) have attracted the interest of the investigator in recent years because it offers many beneficial properties. Cu-Al2O3 compound materials are widely used materials for products that require high thermal and electrical conductors. In our experimental study, copper alumina metal matrix with 5 wt%, 10 wt% and 15 wt.% alumina particulates were made by mixed reinforced powder metallurgy. Microscope, XRD analysis, microstructure, hardness, wear resistance, electrical conductivity and burning resistance are analyzed and discussed. [3] Composite substances play a key role in modern industrial sectors. Our research Centre produces metal-matrix compounds using the stir casting fabrication technique and sets up several current of reinforcement models (5%, 10% and 15% mass) with copper of silicon carbide and alumina. The major absences of copper-based compounds have reduced conductivity and poor mechanism. [4]

3.1 Powder metallurgy:

Blending or combining of fine powder of materials is defined as Powder metallurgy, desired shapes or form can be prepared or make by using method of pressing and heating process is carried out in a controlled environment and material will get bonded. Powder metallurgy generally done in subsequent steps of processes that occur in powder metallurgy. Primarily work is to Manufacturing the Powder fallowed by blending that powder, and continues with compacting it finally ended up with sintering process. Compacting process is usually done at a temperature 850 ^{0}c. And at atmospheric pressure and at high-temperature process of sintering is done. To achieve special qualities and increased precision. Alternative secondary processing is often conducted.

Sintering and Metal injection molding are considered as two main techniques used in making and consolidate powders. Now-a-days Developments have made use of powder metallurgy processing techniques in manufacturing industries for producing new innovative products Better mechanical strength can be accomplished with this process because the technique is sintered, not melted. Any fusible material can be animated. A number of techniques have developed that has allowed large production rates of powder particles. Often there is substantial control over the size and limits the population of the last grain. Powder can be arranged

by combination, grinding, chemical reactions or electrolyte statement.

3.2 Nano Particles:

The pretentious arrangements of structures by sizes that are ranges in nanometers (nm) are defined as a Nano particle. The principle of Nano- particle is demarcated as the pool of atoms that are joined composed with a radial construction of < 100 nm. Nano-particles are having great scientific attentiveness as they excellently act like a bridge among bulk materials and molecular structures. A bulk material should possess persistent physical properties apart of its size basically size dependent properties are often considered at Nano-scale levels. Accordingly the change in properties of material can be seen when size approaches to Nano-scale and as the atoms percentage at the surface of a material is noted worthy. The proportions of molecules on the surface are considered as irrelevant in relative to quantity of atoms if the material is bulk. i.e., more than 1 micrometer (or 1 micron). Interesting and occasionally unexpected properties of Nano- particles are present largely due to material sizes are larger, which are dominated by the contributions prepared by the small materials for making material bulk.

3.3 Nano Composites:

A multi segment solid material where a single is having one, two or three proportions that are lesser than 100 nanometers (nm), or the structures that having repeated distances between the different phases which made in preparing the material is called Nano composite. porous media, colloids, gels and copolymers, are some phases that can encompassed to define Nano-composite in widest manner. But it is more typically engaged to mean the hard blend of the bulk matrix and Nano-dimensional segments are conflicting in properties due to the chemical and physical divergences. The major differences in Nano-composites are witnessed in the few characteristics that are evidently seen in the component materials in terms of properties like mechanical, electrical, thermal, optical, electrochemical and also in catalytic properties .some standards are determined for making materials i.e., <20 nm, <50 nm <100 nm for catalytic activity, and making a hard magnetic material and soft magnetic materials respectively. And for refractive index changes, and achieving super Para magnetism <50nm and <100 nm correspondingly, and strengthening properties mechanically or for regulatory matrix interruption undertakings.

5. Alumina Powder:

Al_2O_3 is one of the chemical compound. It is the combination of Aluminum and oxygen. Aluminum and oxide combination is seen in their chemical combination so, they are termed as alumina oxide in short form as alumina. And with another name as epoxide. Typically Al_2O_3 availability is in crystalline polymorphic phase symbolical representation is α-Al2O3, which encompasses mineral called corundum, By the using this alumina mineral valuable gems like ruby and sapphire are made. In manufacturing of aluminum the compound alumina plays a crucial role as a metal, alumina is an abrasive material and it possess high rigidity and alumina is having very high melting point so it is used as refractory material

Fig.2

EXPERIMENTAL WORK AND INVESTIGATION

6. Powdered material used for sintering process:

(A) Pure Copper powder (Cu)

(B) Alumina(Al2O3)

(C) Silicon carbide (SiC)

4. Copper powder:

For the reason of having high thermal conductivity and outstanding electrical properties copper powder is extremely used in electrical and electronical manufacturing companies. Alloys that are using by mixing with zinc, nickel and additional elements are used in copper structural parts also friction materials in the form of powder. Copper is used as the component element and iron powder as an alloy element. During sintering process the mechanical properties are legalized. The Dimensional changes that occurred are controlled separately from being made by mixing or infiltration

Fig.1

6.1 Specimen Size and Specifications:

For this purpose of study four sample sizes were considered each of size ø9mm and thickness of 14mm. For each sample four specimens are fabricated at 17KN compaction pressure. Therefore all together eighteen specimens are fabricated. Specimen size is 14×9mm Four Samples have to be fabricated for each composition and totally 18 composites are to be prepared for experiments.

	Composition (Al_2O_3,SiC)
1	Al_2O_3-2.5% combined with Cu (97.5%)
2	Al_2O_3-5% combined with Cu (95%)
3	$Al_2O_3$7.5% combined with Cu (92.5%)
4	Al_2O_3-2.5% + SiC (5%) combined with Cu (92.5%)
5	Al_2O_3-5% + SiC (5%) combined with Cu (90%)
6	Al_2O_3-7·5% +SiC (5%) combined with Cu (86.5%)

6.2Experimental procedure:

In this work, we have created metal matrix briquettes with alumina (Al_2O_3) & silicon carbide (SiC) by powder metallurgy based on freezing compaction technique. Mixed powder content is kept in the mixing chamber. The mixing chamber is rotated with the center of a lathe machine at the lowest speed through a mixture of powder in half an hour clockwise and anticlockwise direction. Composite powder mixture was compacted in a cylindrical-diameter compaction dye. Based on the relationship between green density and compaction pressure of the Copper alloys, the compaction pressure of the samples was chosen to be 17KN and compacted in compression testing machine (CTM, 100KN) for 60 sec under a uniaxial pressure of 17 KN. After the making of total specimens completed, taken them to finding out the length, diameter and on the digital micrometer. Compacted samples were sintered for 30 minutes at 850ºC.using tubular furnace.

Fig.3

Fig.4

Fig.5
Compaction under CTM

Fig.6
Sintering in Tubular furnace

6.3 Specimens of Six different compositions

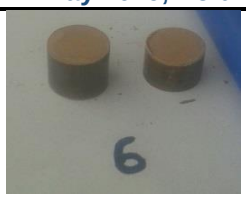
1. Cu (97.5%) + Al_2O_3 (2.5%)

2. Cu (95%) +Al_2O_3 (5%)

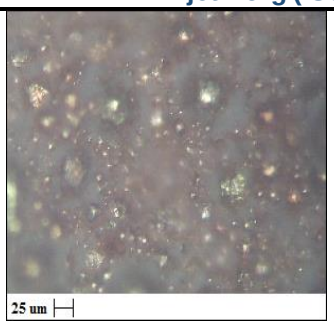
3. Cu (92.5%) + Al_2O_3 (7.5%)

4. Cu (92.5%) +Al_2O_3 (2.5%) + SiC (5%)

5. Cu (90%) +Al_2O_3 (5%) + SiC (5%)



6. Cu (86.5%) + Al_2O_3 (7·5%) +SiC (5%)

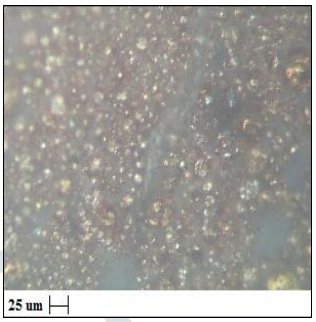


1. Cu-2.5%Al_2O_3

RESULTS & DISCUSSIONS

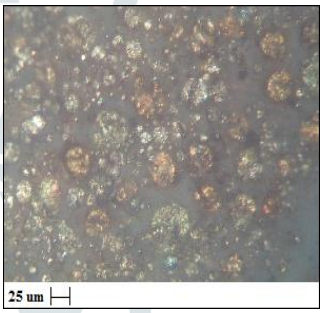
7. Porosity:

Increasing the reinforcement with decreases porosity in the copper metal matrix Nano-composites.

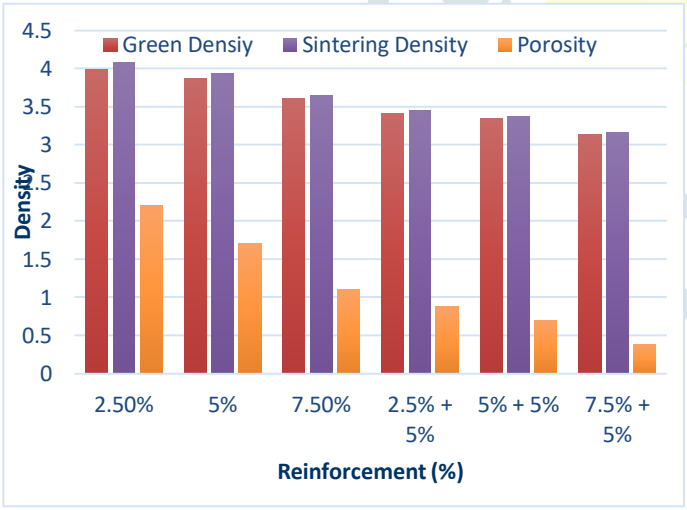


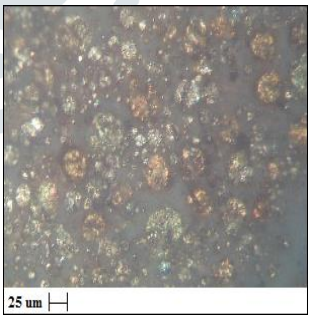
2.Cu-5%Al_2O_3

Reinforced	Green density	Sintering Density	porosity
2.5% (Al_2O_3)	3.985	4.075	2
5% (Al_2O_3)	3.8609	3.927	1.70
7.5% (Al_2O_3)	3.605	3.645	1.097
2.5%+5 (Al+SiC)	3.4016	3.441	1.017
5%+5% (Al+SiC)	3.341	3.365	0.713
7.5%+5% (Al+SiC)	3.142	3.154	0.38



3. Cu-7.5%Al_2O_3

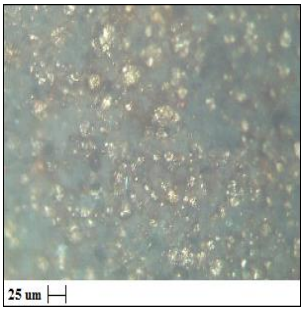




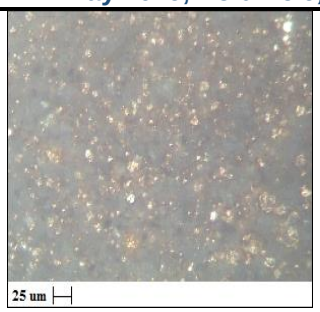
4. **Cu-2.5%Al_2O_3+5%SiC**

8. Microstructure of the composites:

In different percentages optical microscopy is done to see the overall grain structure. It was performed because it shows the kind of relationship between different components of composites and how they are distributed. This is prepared by optical microscope at 100X intensification.



5.Cu-5%Al_2O_3+5Sic

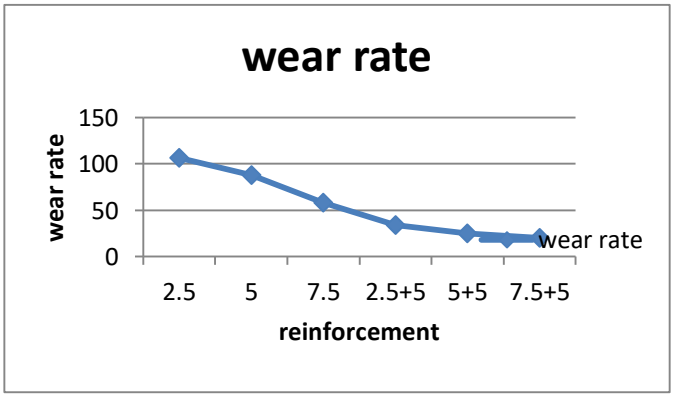


6. Cu-7.5%Al_2O_3 - 5%SiC

9. Wear rate of Nano-composites:

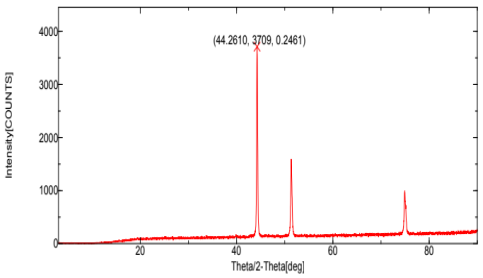
Wear test are conducted using pin-on-disc method at a temperature of 27^0C under dry sliding condition. Cylindrical test specimen with diameter of 9mm. and height 14mm.All tests were conducted applying a fixed load of 5N at 200rpm of revolving counter disc, and time period 2mints. Increasing the reinforcement with decreases wear in the copper metal matrix Nano-composites.

S no	Composition	Reinforcement	Wear rate	Speed
1	2.5% (Al_2O_3)	2.5%	106	200rpm
2	5% (Al_2O_3)	5%	87.86	200rpm
3	7.5% (Al_2O_3)	7.5%	58	200rpm
4	2.5%+5 (Al_2O_3+SiC)	2.5+5%	34	200rpm
5	5%+5% (Al_2O_3+SiC)	5+5%	25	200rpm
6	7.5%+5% (Al_2O_3+SiC)	7.5+5%	20	200rpm



XRD:

X-ray diffraction (XRD) is an increasingly analytical procedure that is predominantly used in detecting the crystalline material. On cell dimensions the data will deliver. The simple element in this method is a X-ray hose with an X-ray sensor and sample pocket. XRD graphs can be observed with the help of X-ray diffraction-meter. As well as representation of Results will be in the form of graphs. The intensity of peak value decreases with the increases of the reinforcements Al_2O_3 and SiC to the pure Copper.



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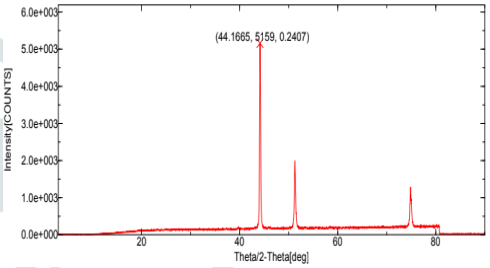

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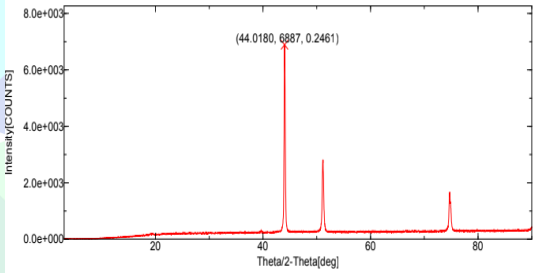

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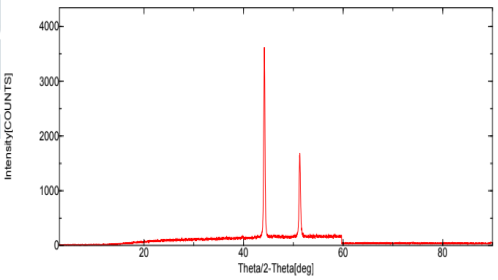

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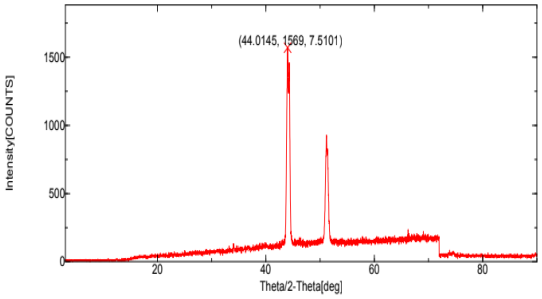

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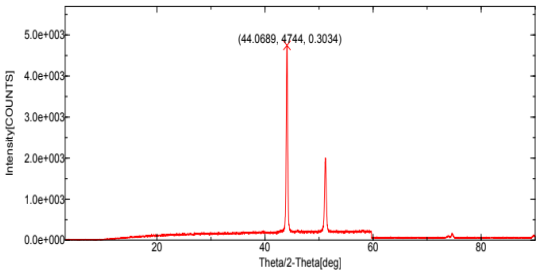

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CONCLUSION

- When the amount of Nano-alumina increased in Nano-composites the results shows that the major decreases in porosity. The material's behavior ensured change with the addition of reinforcements of alumina and Silicon Carbide
- XRD graphs can be observed through an X-ray diffraction-meter the representation is in graphical format. Intensity of peak value decreases with the increases of the Al_2O_3 and SiC to the pure Copper.
- The upsurge in the volumes of Nano aluminum oxide in Nano-composites confirmed the substantial decreases that appeared on Wear rate.

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