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EVALUATION OF MECHANICAL PROPERTIES OF COPPER POWDER REINFORCEMENT EPOXY MATRIX

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ABSTRACT: Currently,engineering research is being conducted to replace metallic components with distinct materials that may improve the mechanical properties of metals. Here in this paper, two separate materials, i.e., metal and non-metal, are combined to evaluate distinct properties possessed by both metal and non-metal. In this paper we use copper powder and epoxy resign is used for the fabrication of the material by hand layout technique.

The main purpose of this thesis is to evaluate the mechanical properties like low density, enhanced hardness, tensile strength, stiffness, and materials capable of performing at elevated temperatures without losing properties, like high toughness, stiffness, good wear resistance, and variations in thermal and electrical conductivity, fatigue, and corrosive resistance.

The properties of the material completely depend upon the matrix and reinforcing materials and the nature of the interface between them. The characteristics of the resin matrix are affected by the interfacial adhesion and particle size. In this paper, polymeric material is prepared by using copper powder as reinforcement of particle size 7.2 µm with various weight percentages (0%, 15%, 25%, 35%, and 45%) and epoxy resign as matrix. Mechanical properties such as tensile strength, compression strength, bending and hardness were investigated. The results show that tensile, compression, bending, and hardness increase with the percentage of copper and ductility malleability decreases with increasing copper percentage in the material. Stiffness and fractural strength also decrease with increasing copper percentage in the material.

Key words: copper powder, epoxy resign, tensile strength, compression strength, bending and hardness.

1. INTRODUCTION:

The substance that consists of two or more materials which are insoluble with one another combined to form a useful engineering product is called a "composite material" [1]. Polymer composites, polymer matrix, and inorganic micro particles will all have a significant impact on a material's properties. That's why researchers are concentrating on composite matters, which differ in properties like thermal, mechanical, optical, and electrical ones. The properties of the material can be controlled by the reinforcing material's shape and size. So the material so prepared will result in low density, high toughness, stiffness, good wear resistance, and variations in thermal, electrical conductivity, fatigue, and corrosive resistance.

Epoxy resins are thermosetting polymers that play a vital role in protecting surfaces from corrosion. They are used for surface emulsions, paints, or protective layers over the surfaces to avoid corrosion. It has high mechanical strength and chemical resistance, with some being rigid and

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brittle in nature and poor in crack resistance.

The aim of this thesis is to study the effect of powder metal and its percentage on the mechanical properties of the material.

2. Experimental work:

2.1. Matrix material:

Epoxy resigns: Epoxy resin refers to a type of reactive prepolymer and polymer containing epoxide groups**.** It possesses higher mechanical properties and more thermal and chemical resistance than other types of resin. Therefore, it has exclusive use in making aircraft components. Epoxy resin is also called polyepoxide.

Fig-1: Epoxy resigns

Properties of epoxy resign.

Properties	Value
Density at 21^{o} C (gm/cm^{3})	1.06
Viscosity at 21^{o}C	300
Flexural strength (MPa)	62
Modulus of elasticity(MPa)	2790
Fracture Toughness (MPa)	0.6
Colour	Colorless
Glass temperature (^{o}C)	56
Bending property (N/mm^{2})	45

Table 1: Show the properties of epoxy material.

2.2. Reinforcement material

Copper powder is a shiny orange-red metallic powder used mainly in cold casting techniques. By mixing finely-ground copper powder with a liquid bonding agent (such as polyester or polyurethane resin), it is possible to create a paste that can be moulded and hardened to create composite castings that mimic pure metal ones without the need for a hot foundry. Copper is a very ductile and malleable metal and it is widely used because of its thermal and electrical conductivity. Copper is used in electrical wires and also in combination with other metals to form different alloys (ie. in combination with tin to give bronze). When exposed to air, the outer copper layer slowly oxidises to a black copper oxide. Depending on the conditions, it can also form copper carbonate, which is the green colour associated with a patinated copper roof or copper cladding.

Fig-2: Copper powder

Properties of copper powder

Properties	Value
Density at 21^{o} C (gm/cm^{3})	8.96
Flexural strength (MPa)	210
Modulus of elasticity(GPa)	**110**
Fracture Toughness (MPa)	10.2
Color	Reddish
Vickers hardness (MPa)	369

Table 1: Properties of copper powder

2.3. Composite Fabrication:

Fabrication of composite material is the crucial step in the thesis. The composite is made up o hand layout process. The materials are made in 5 different proportional mixing of metal powder and epoxy. The resign and hardener are mixed to make matrix solution in 3: 1 proportion. Copper powder is added to the resign at different weight percentages i.e., 0%, 15%, 25%, 35% and 45%.

To solution is stirred the solution for 10 min with homogenizer with 500 rpm to make the solution homogeneous throughout the solid. The solution is left undisturbed for 15 min to make solution bubble free

Fig-3: During sedimentation of solution

Mould preparation:

Mould preparation is made according required dimension for test specimen. The mould is prepared with a nonstick PVC plastic material and blend was poured slowly to avoid bobble formed. The mould material should be easily breakable without damaging the specimen. Later moulds are undisturbed for 24hrs allowing them to solidify at room temperature. As shown in the **Fig**ure-4 the mould is prepared according to the ASTM standard dimension for both tensile and bending test. Size 100X10X10 mm (length*breath*height).

Fig-4: Mould for tensile and bending test

As shown in the Figure-4 the mould is prepared according to the ASTM standard dimension for compression, hardness and micro structure. For compression test- internal diameter 20mm and height 20mm. for hardness test internal diameter 20mm and height 20mm, and for micro structure internal diameter 20mm and height 10mm.

Fig-5: mould for compression hardness and microstructure.

Then the mould is allowed to solidify for 24hrs without disturbing.

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Fig-6: solidified specimens in mould specimens.

3. Mechanical properties:

3.1 Hardness test and Compression test:

Hardness and compression test specimens are prepared according to the ASTM standards for all the four different composition composites and one pure substance of epoxy and shore hardness is tested on the specimen at three different location on the surface average of three values are considered. For compression test the specimen is placed on the UTM load per unit area is calculated and graphs are drawn.

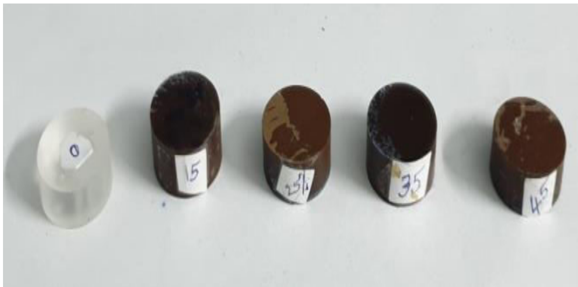

Fig-7: Similar specimens are prepared according ASTM standards with variation of heights for compression and hardness test.

3.2 Three Point Bending and Tensile Test:

Three point bending test was carried on the specimens by Instro 1120, with capacity of load 5kN. The specimen is placed on the two sup[ports and weight is applied on the middle of the specimen. The test load of 1mm/min and speed sheet drawing 10mm/min.

Fig-8: Similar specimens are prepared according ASTM standards for bending and tensile test.

Tensile test is performed on UTM machine. The specimen made as per the ASTM standards and axial load is applied on it. The **Fig**ure-8 shows the prepared specimen for tensile testing.

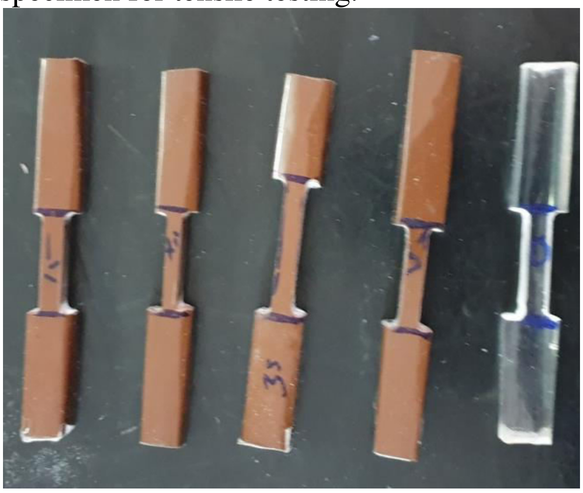

Fig-9: specimens for tensile test after finishing

4. Result and Discussion

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4.1. Results:

Materials	Shore hardness				Tensile strength	Compression strength	Bending load
	1	2	3	avg	(N/mm^2)	(N/mm^2)	(N)
Epoxy+0% copper powder	75	76	75	75.33	12.07	91.50	900
Epoxy+15% copper powder	87	87	88	87.33	27.12	90.90	1260
Epoxy+25% copper powder	84	84	85	84.33	27.73	95.30	1320
Epoxy+35% copper powder	85	85	86	85.33	34.01	95.10	1040
Epoxy+45% copper powder	80	80	81	80.33	40.72	90.41	800

Table-2: Values of shore hardness, ultimate tensile strength, compression strength and bending load of pure epoxy and percentage of copper mixed composites.

Fig-10: Specimens after testing

4.2. Discussions:

Shore hardness:

Shore hardness of the material increases when the percentage of copper powder is 15 and later on decrease with increasing in copper powder percentage in the composite. The detailed comparison is shown in the graph-1. If the hardness of the material place the major role for the application 15% copper powder composite is preferable.

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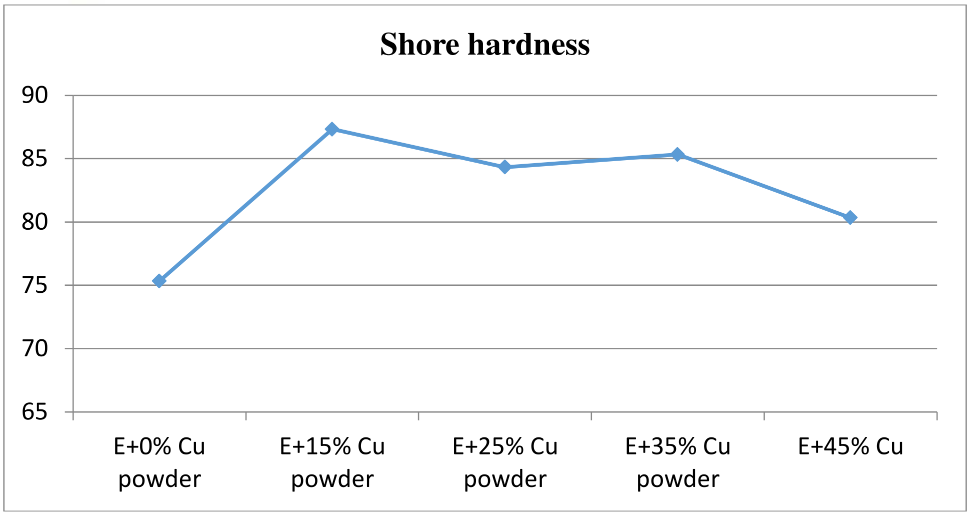
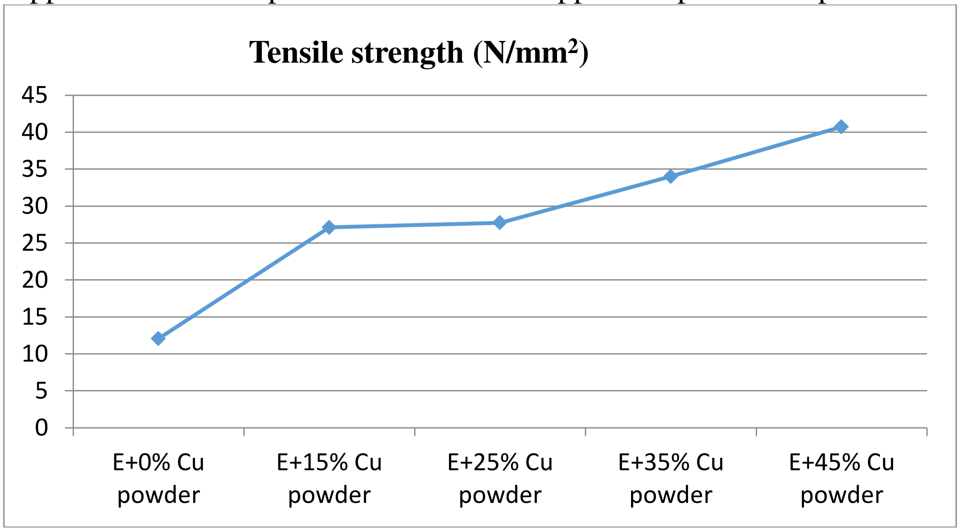


Graph-1: Shore hardness of the composites with different copper powder percentages.

Tensile strength:
Tensile strength of the specimens increases with the copper percentage. Detailed comparison of the specimens shown in the graph-2. If the tensile strength of the specimen plays a vital role in the application the composite with the max copper composition is preferable.



Graph-2: Tensile strength of the composites with different copper powder percentages.

Compression strength:
Compression strength of the specimen fluctuates with the copper powder percentage. In the graph-3 shown detailed variations of the compression strength with the copper powder percentage. Compression strength is maximum when the percentage of copper powder is 25 and minimum at 45 percentages. According to the necessary the suitable composite is applicable.

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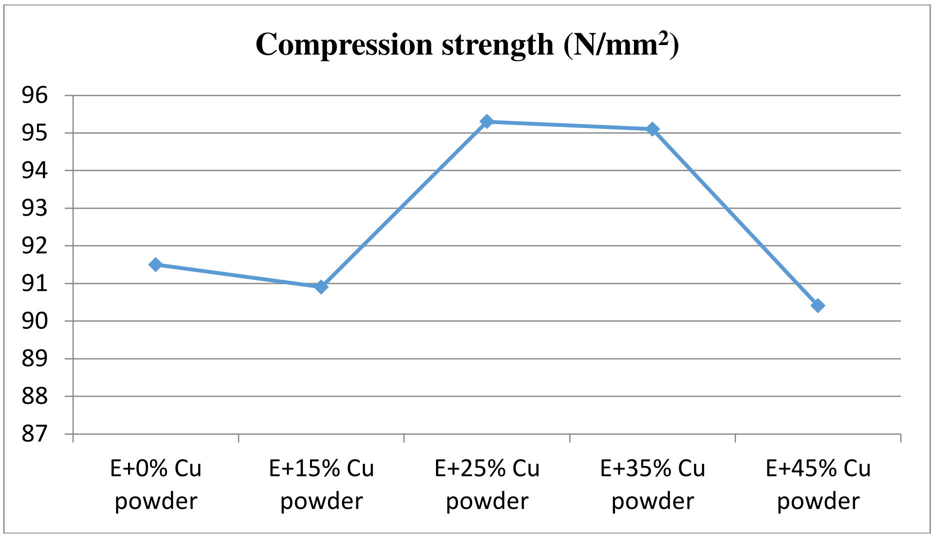
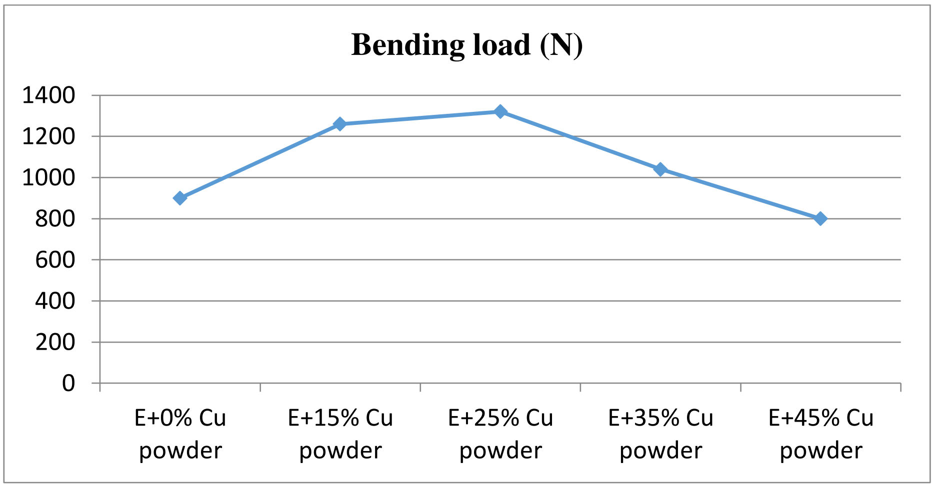


Graph-3: Compression strength of the composites with different copper powder percentages.

Bending load (N): Bending load is varying rapidly with the copper powder percentage. In the graph-4 states that the bending load is maximum at 25% copper powder. Bending load of the specimen increases from 0 to 25% copper composition and decreases from 25 to 45%. This shows that maximum bending can be seen at 25% and minimum at 45% copper composition.



Graph-4: Bending load of the composites with different copper powder percentages.

Conclusion:

The Conclusions obtained from following experimental study are:

1. Shore hardness maximum when the percentage of copper powder is 15 i.e. 87.33
2. Tensile strength increases with increasing with copper percentage absorbed maximum at 45% of copper power in the composite.
3. Compression strength of the specimen is maximum at 25% of copper powder in the composite
4. Bending strength of the specimen with 25% copper powder in the composite.

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