Experimental Evaluation of Aluminium –Cu composite material to increase the Mechanical properties with different composition for Automotive applications

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Abstract:

Automobiles are using heavy materials which reduce the mechanical efficiency, thermal efficiency and fuel Consumption are increasing. To overcome all these drawbacks composite materials can be used instead of heavy metals in manufacturing. High specific stiffness and near-zero coefficient of thermal expansion is being experienced in Metal Matrix Composites (MMC'S).Alumina (Al_2O_3) possesses favourable physical and chemical properties such as high strength, hardness, elastic modulus and thermal, chemical resistance. So, its applications are t limited because of poor toughness and thermal resistance. Using an intense mixture of Al_2O_3 with different Copper contents (10, 20 or 30 mass %) several Al2O3-Cu composite materials were fabricated and tested. It has been reported that the incorporation of some amounts of Copper particles into an Al2O3 matrix, in the proportion of Al_2O_3, Cu (90%-10%), Al_2O_3, Cu (80%-20%) and Al_2O_3, Cu (70%-30%) composites, can significantly improve the toughness and hardness.

Key words: Metal matrix composite (MMC),Stir Casting,Wear

Introduction:

Copper is easily worked, being both ductile and malleable , which it can be drawn into wire makes it useful for electrical work in addition to its excellent electrical properties. Copper can be machined, although it is usually necessary to use an alloy for parts like threaded components, to get really good machinability. Copper has good corrosion resistance , brazing and soldering properties and can also be welded.

Characteristics of Aluminium are soft, durable, lightweight, ductile, malleable, nonmagnetic and non sparking. The yield strength of pure Aluminium is 7–11 MPa and has about one-third the density and stiffness of steel .Corrosion resistance was excellent due to a thin surface layer of Aluminium oxide that forms when the metal is exposed to air. The Aluminium alloys are less corrosion resistant due to galvanic reactions with alloyed copper.

Composite materials are made from two or more constituent materials with different physical or chemical properties which remain separate and distinct on a macroscopic level within the finished structure.

Metal matrix composite (MMC) is composite material with minimum of two distinct parts, one being a metal and the other material may be a different metal or another material, such as a ceramics. MMCs are more expensive than the more conventional materials they are replacing.

MMCs are having high resistant to fire, do not absorb moisture, have better electrical and thermal conductivity, radiation resistance. MMCs tend to be more expensive than the fiber-reinforced materials which may be difficult to fabricate.

Manufacturing of MMCs are by dispersing a reinforcing material into a metal matrix and the reinforcement surface can be coated to prevent a chemical reaction with the matrix.

Polymer or Metal matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. In many applications, the matrix is usually a lighter metal like aluminium, magnesium, or titanium, and provides a good support for the reinforcement. Cobalt and Cobalt-nickel alloy matrices are common in the high temperature applications.

The reinforcement material is embedded into the matrix. The reinforcement does not always serve a purely structural task but is also used to change physical properties like wear resistance, friction coefficient, or thermal conductivity. The reinforcement can be either continuous, or discontinuous. Discontinuous MMCs can be isotropic, and worked with standard metalworking techniques, such as extrusion, forging or rolling. They may be machined using conventional techniques, but commonly would need the polycrystalline diamond tooling (PCD).

LITERATURE REVIEW:

[1] This paper reveals that that with increasing concentration of aluminium with Cu, the coefficient of friction and wear rate decreased. In the case of low voltage and high current density, it is required to employ materials with a very high specific electrical conductivity, good thermal conductivity and low friction coefficient. such conditions are fulfilled only by Cu-Aluminium composite materials.

[2] This paper reveals that the microstructure and hardness of the surface infiltrated composite (Cu/ Al_2o_3) layers produced on copper substrates. High electrical and heat conductive copper is widely used in optics, electrical contact and heat conducting materials . Their low strength and poor wear resistance are required to improve with the developing industry.

[3] This paper reveals that the use of SiC or diamonds particles as reinforcements in copper based composites is considered very attractive to meet the increasing demands for high performance heat sink materials and packages.

[4] This paper reveals that he lubricant graphite and MoS2 powders were coated with Cu to reinforce their bonding to the Cu particles in the composites during sintering. The friction and wear properties of the materials were improved.

[5] This paper reveals that Tungsten, being a refractory metal, provides some degree of wear and arcing resistance when used with copper as an electrical contact material. Its wear resistance is better than that of wear-resisting tool steels. Tungsten carbide undergoes no phase changes during heating and cooling and retains its stability indefinitely.

[6] This paper reveals that Copper-based composites appear to be a promising material for engineering applications due to their excellent thermo physical properties coupled with better high temperature mechanical properties as compared to pure copper.

[7] This paper reveals that Cu–graphite composites were prepared by hot isostatic pressing from the copper and graphite powders in the range of 0–50vol.% of graphite. The same graphite powder was copper coated and used for the preparation of coated composites with 30 and 50vol.% of graphite. It was confirmed that with increasing concentration of graphite the coefficient of friction and wear rate of coated and uncoated composites at first decreases.

[8] This paper reveals that the effects of the interfacial design on the thermo-physical properties of SiCp/Cu composites were studied in detail. Thermal conductivity and expansion test results showed that silicon carbide particles coated with uniform and compact molybdenum coating have improved the comprehensive thermal properties of the SiCp/Cu composites.

[9] This paper reveals that Copper matrix composites with Al2O3–graphite reinforcement (0.5-0.5, 1.0-1.0, 1.5-1.5 and 2.0-2.0 wt%) were prepared by stir casting process. Phase, microstructure, density, hardness, wear, compressive strength and specific heat of prepared samples have been investigated. X-ray diffraction revealed that there is no intermediate phase formation between matrix and reinforcement phase as a result of interfacial bonding between them. Microstructure study shows the uniform distribution of Al2O3–graphite particles in the Cu-matrix. Density and hardness were found to decrease with increase in reinforcements percentage whereas the compressive strength was found to increase as the amount of reinforcements was increased. Composite containing 2.0 wt% reinforcements showed the maximum resistance to wear.

Methodology:

In this research sand mold casting was used for produce the requirement size. Sand casting, is a metal casting process characterized by using sand as the mold material and bonding agent like clay is mixed with the sand. The mixture is moistened with water to create strength and plasticity of the clay and to make the aggregate suitable for molding.

Material requirement for various ratios

Mixing ratio-90%&10% (Copper and Aluminium):

Volume of copper=180*0.90=162 gm

Volume of Aluminum=180*.10=18 gm

Density of copper=8.9gm/cc

Weight of copper 162*8.9=1441.8 gm =1.441kg

Density of aluminum=2.7gm/cc

Weight of Aluminum =18x2.7= 48.6 gm

30 % for excess (Runner&riser,slag)

Total weight of mixture

Copper=1441.8 gm +410 gm= 1851.8 gm

Aluminum=48.6+15=63.6 gm

Mixing ratio-80%&20%(Copper and Aluminium):

Volume of copper=180*0.80=144 gm

Volume of Aluminum=180*.20=36 gm

Density of copper=8.9 gm/cc

Weight of copper 144*8.9=1281.6 gm/cc=1.281kg

Density of aluminum=2.7gm/cc

Weight of Aluminum =36x2.7=97.2 gm

30 % for excess (Runner&riser, slag)

Total weight of mixture

Copper=1281.6Kg+360 g= 1641.6gm

Aluminum=97.2+30=127.2 gm

Mixing ratio-70%&30%(Copper and Aluminum):

Volume of copper=180*0.70=126 gm

Volume of Aluminum=180*.30=54 gm

Density of copper=8.9gm/cc

Weight of copper 126*8.9=1121.4 gm =1.121kg

Density of aluminum=2.7gm/cc

Weight of Aluminum =54x2.7=145.8 gm

30 % for excess (runner &riser, slag)

Total weight of mixture

Copper=1121.4g+300 g= 1421.4gm=1.421kg

Aluminum=145.8+45=190.8gm

Hardness Details

Type : Rockwell Hardness

Major Load Applied : 100Kgf

Types of Indenter used : 1/16 “

Table - 1 Verification of Raw Materials

S.No	Material	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean
1	Pure Aluminium (LM4)	39	41	48	40	40	39.5
2	Pure Copper	81	79	78	83	83	81

Table -2 Verification of Composite Materials

S.No	Material	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean
1	Cu – 90% Al_2O_3 – 10%	35	39	33	32	39	35.6
2	Cu – 80% Al_2O_3 – 20%	54	58	60	69	68	62
3	Cu – 70% Al_2O_3 – 30%	12	16	14	13	11	13.2

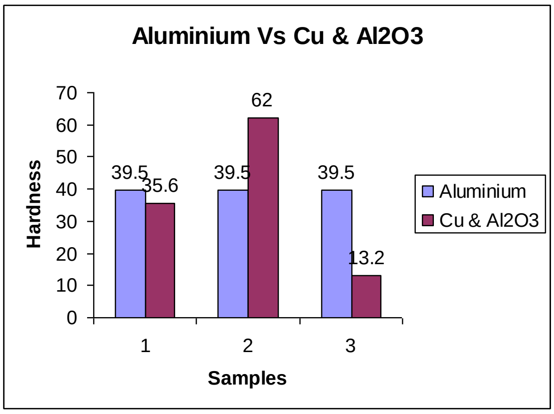

Figure 1 Comparison Graph

Sample 1 : 90% Cu 10% Al_2O_3

Sample 2 : 80% Cu 20% Al_2O_3

Sample 3 : 70% Cu 30% Al_2O_3

IMPACT TEST

Izod impact strength testing is an ASTM standard method of determining impact strength. A notched sample is generally used to determine impact strength. In this research Impact Strength determined through impact testing machine by Izod method.

Specification of the Machine :

Energy Range = 0 – 168 J

Least Count (1 Division) = 2J

SPECIMEN LENGTH	=	75 mm
SIZE	=	10Sqmm
NOTCH	=	V NOTCH (45^{O} Included Angle)
FALL ANGLE	=	90^{O}
SPECIMEN SUPPORTING	=	Cantilever Beam setup
NOTCH DEPTH	=	2mm
AREA	=	64mm^2

COMPOSITION I : (90%-10% Cu and Al_2O_3)

I = K/A J/m^2

I = Impact Strength

K = Energy Observed

A = Area

Energy Observed = 0.9687 J/mm^2

COMPOSITION II : (80%-20% Cu and Al_2O_3)

I = K/A J/m^2

Energy Observed = 1.15 J/mm^2

COMPOSITION III : (70%-30% Cu and Al_2O_3)

I = K/A J/m^2

Energy Observed = 0.156 J/mm^2

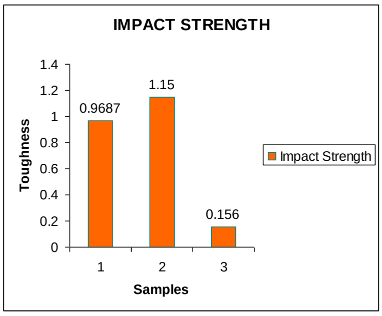

Figure 2 Comparison Graph (Impact Strength)

Sample 1 : 90% Cu 10% Al_2O_3

Sample 2 : 80% Cu 20% Al_2O_3

Sample 3 : 70% Cu 30% Al_2O_3

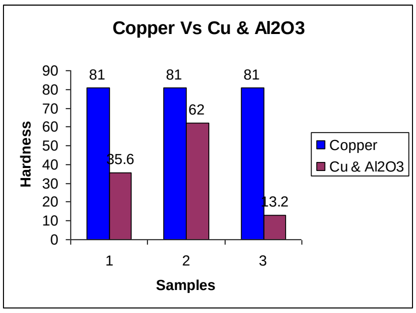

Figure 3 Comparison Graph (Hardness)

Sample 1 : 90% Cu 10% Al_2O_3

Sample 2 : 80% Cu 20% Al_2O_3

Sample 3 : 70% Cu 30% Al_2O_3

RESULTS AND DISCUSSION:

MICROSTRUCTURE ANALYSIS RESULTS

The microstructures of the Cu- Al_2O_3 composites are shown in Figures below. It is observed that on increasing percentage of aluminium may increase the porosity and coring. It is observed that the percentage of the aluminum increases the hardness of the specimen also increases.

Microstructure of Samples:

Sample I : Cu-Al_2O_3 at 90%-10%

Sample II : Cu-Al_2O_3 at 80%-20%

Sample III : Cu-Al_2O_3 at 70%-30%

Figure - 4 SAMPLE – I

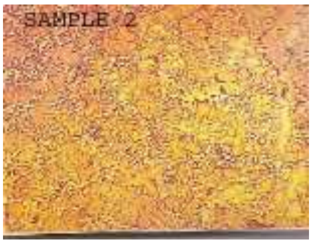

Figure - 5 SAMPLE – II

Figure – 6 SAMPLE – III

Sample I matrix shows completely fine transformed beta as the matrix. Some equi-axed alpha also present in the matrix of beta. Sample II matrix shows large grains of alpha in a matrix of beta solid solution. The matrix also shows the intergranular voids. This may also due to shrinkage defect taken place during casting. Sample III matrix shows cast fine inter-dendritic grains of alpha and beta. The matrix is beta and the presence of alpha solid solution is about 20% in a matrix of beta solid solution. Void shows the material is cast and due to shrinkage defect.

CONCLUSION

Composite materials especially Cu-Al_2O_3 composites having good mechanical properties compared with other conventional materials. It is used in various industrial application because of light weight along with high hardness .It with stand high load compare with the existing materials are most applicable in the engineering products instead of existing materials. The percentage in the proportion of Al_2O_3, Cu (90%-10%), Al_2O_3, Cu (80%-20%) and Al_2O_3, Cu (70%-30%) composites Aluminium increases the hardness and toughness.

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