Study of Hardness Test on Copper Alloy Reinforced with Ceramics for Marine Applications

Sachin S Raj[1], Elavarasan E[2], Uday Kumar[3], Sumit Kumar[4], Shravan Kumar[5], Sarvesh Kumar[6]
Assistant Professor[1, 2]
UG Students[3, 4, 5, 6],
Department of Mechanical Engineering,
[1, 3 ,4, 5, 6]Gnanamani College of Technology, Namakkal, India.
[2]Kongunadu college of engineering and technology, Namakkal, India.

***Abstract*:- This paper defines a study of reinforcement of the most commonly used and economically available ceramics into copper nickel alloy matrix in specific measured weight percentage ratios, three different samples are fabricated and tested to prove the enhancement in mechanical properties of the new composite, especially the increase in hardness since the copper tubes which are ductile in nature undergo malleability in deep sea applications due to the strong ocean currents which leads to corrosion and fracture in due course, without much reduction the basic mechanical properties of copper, this comparison attempt is made to identify the best suitable ceramic which can help reduce the ductility and improve hardness of the copper nickel alloy.**

Keywords-* *Reinforced Composite, Ceramics, Stir-Casting, Brinell hardness, Cutting Force.

I. INTRODUCTION

A composite material is made by combining two or more dissimilar materials. They are combined in such a way that the resulting composite material or composite possesses superior properties which are not possessed by individual material. So, in technical terms, we can define a composite as a multiphase Material from a combination of materials, differing in Composition or form, which remain bonded together, But retain their identities and properties, without going into any chemical reactions1.The advantages of the composite materials are only realized when there is a reasonable cost – performance relationship in the Component production. The use of a composite material is obligatory if a special property profile can only be achieved by application of these materials. Copper Matrix Composite can be used in electrical switches and connecting pins due to its enhanced strength and electrical conductivity. Also it can be used in electrical applications for the brushes of DC Motor which get worn out regularly and in electrical switches where copper parts are used these composites can be used to increase the life of the Switches. The reinforcement of metals can have many different objectives. The reinforcement of ceramic materials opens up the possibility of application in areas where strength, hardness and thermal stability have first priority. The pre-condition here is the improvement of the component properties. The development objectives for metal composite materials are:

- Increase in yield strength and tensile strength
- At room temperature and above whilemaintaining the minimum ductility or rathertoughness,
- Increase in creep resistance at higher
- Temperatures compared to that of conventional
- Alloys.
- Increase in fatigue strength, especially at
- Higher temperatures,
- Improvement of thermal shock resistance,
- Improvement of corrosion resistance,
- Increase in Young’s modulus,
- Reduction of thermal elongation.

The basic reason of metals reinforced with hard ceramic particles is improved properties than its original material in terms of strength, stiffness, hardness, electrical conductivity etc.

II. METHODOLOGY

2.1. Materials and Procedures

The materials used in preparing copper matrix hybrid Composite are Copper which serves the purpose of Metal matrix along with reinforcements such as Nickel as the first reinforcement and other ceramics which are widely used in composite materials which have high mechanical properties, like Al_2O_3, SiC, BC to obtain the Desired properties of hybrid composite. Copper-nickel combination generally being a high corrosive resistance element towards salt water is the most widely used material for marine applications, Ceramics reinforced in copper matrix composites correspond to a fair degree of increase in strength, thermal stability and increase in hardness. Desirable properties of composite materials are high Stiffness and strength, low density, high electrical and thermal resistacane, low thermal expansion, corrosion resistance and enhanced wear resistance.

ELEMENT	MASS (gm)
COPPER	80
NICKEL	10
Al_2O_3	10

Table 1: Weight fraction for reinforcement of Alumina.

ELEMENT	MASS (gm.)
COPPER	80
NICKEL	10
SiC	10

Table 2: Weight fraction for reinforcement of Silicon Carbide.

ELEMENT	MASS (gm.)
COPPER	80
NICKEL	10
BC	10

Table 3: Weight fraction for reinforcement of Boron Carbide.

2.2 Stir Casting Fabrication

Stir casting was recognized for fabrication of MMC (Metal Matrix Composite),and currently Practiced commercially. Its advantages lies in its Ease, suppleness and its application in large scale production and, in principle it permits conventional metal processing route to be used, and its low cost. The cost of preparing composites materials using a Casting method is about one-third to one-half that of other methods. Normally stir casting of MMC Involves producing a melt of the chosen matrix Material, followed by the addition of a reinforcing material into the melt, and achieving a suitable dispersion through stirring. The subsequent step is the solidification of the melt containing suspended particles to obtain the desired distribution of the dispersed phase in the cast matrix. In the composites formed through this method, particle distribution will vary significantly depending on process parameters during both the melt and solidification stages of the process .The addition of particles to the melt drastically changes the viscosity of the melt, and this has outcomes for casting processes. It is vital that solidification occur before considerable settling has been allowed to take place. The process is generally attained out at two dissimilar rranges of temperature of the melt, beyond the liquids temperature or at the melt temperature controlled within the partially solid range of the alloy the technique concerning the latter range of temperature is called the compo-casting process and it is very efficient in making cast composites with elevated particle content.

The most important condition when using a stir casting technique is continuous stirring of the melt with a motor driven agitator to prevent settling of particles. The stirrer was set to a constant speed of 300rpm and the heat was maintained at 800°C, since 650°C being the melting point of 99.9% pure copper and 720°C being the Melting point of 90-10 Cuppro-Nickel alloy. The carbide powders were heated to 300°C before reinforcing into the molten metal to avoid thermal mismatch and clogging up of ceramic particles. The stirring operation was performed for 10 minutes for each sample to provide even reinforcement of the ceramic powders and to avoid distortion and defects due to air bubbles. Bottom pouring was performed into the die of size (50mmx50mmx20mm), Length, Breadth and Thickness respectively.

2.3 Brinell Hardness Test

The fabricated composite material was tested under brinell hardness test using a ball indend of 10mm dia with a constant load of 1000Kg and 2000Kg were maintained for all the three samples. The depth created by the indend of the ball was measured and the hardness was calculated mathematically using the formula.

$$BHN = 2P/\pi D(D-\sqrt{D^2-d^2})$$

Where,
BHN - Brinell Hardness Number.
P - Load.
D - Steel ball diameter.
D - depression diameter.

The indend of the ball was fixed at 10mm and the depth of the indention was measured in mm according to the depth created by the radius of indend. All the samples were tested at two different locations on the surface.

2.4 Cutting Force Measurement

The three samples that were fabricated using the different ceramics alumina, silicon carbide and tungsten carbide were cut into dimensions of (50mmx50mmx30mm) respectively and placed in the vertical milling machine inorder to measure the cutting foce required to machine the workpieces using an endmill cutter of HSS material.
Based on the hardness of the materials, the cutting forces varied for the different depth and feed given to the vertical milling machine. Three sample x,y,z values were noted from the digital force measurement dynamometer for every individual workpiece of different ceramic composition and graphs were plotted against the feed rate and cutting force required and the mean cutting force was determined for every sample of the workpiece. Each sample was experimented 4 times with varying depth of cut increasing them with a constant of 0.25 mm.

The formula used to calculate the cutting force is

$$\text{Cutting Force} = \sqrt{x^2+y^2+z^2}.\ \text{KN}$$

III. RESULTS AND DISCUSSION

3.1 Brinell Hardness Test

Sl:No	**Material**	**P/D² value Kg/m m²**	**Major Load (P) Kg**	**Dia of Ball Indention (D) mm**	**Dia of Indention (d) mm**	**BHN Kg/m m²**
1	Cu	5	2000	10	7.8	38.02
2	Ni	5	1000	10	5.8	38.34
1	Cu	5	2000	10	6	48.54
2	Ni Al_2O_3	5	1000	10	5.1	49.53
1	Cu	5	2000	10	5.5	108.5
2	Ni SiC	5	1000	10	4.2	86.26
1	Cu	5	2000	10	6.8	77.24
2	Ni BC	5	1000	10	5.7	68.84

TABLE 4.1.1

The hardness for the SiC reinforced Cu Ni alloy is the maximum compared with the other specimens. The Brinell Hardness Number is 108 Kg/MM² at its highest.

3.2 Cutting force Measurement

The cutting force for the sample containing Alumina as reinforcement.

Sl:No	Depth of cut(mm)	X axis	Yaxis	Z axis
1	0.25	15.5	15.8	14
2	0.50	16.1	16	15.5
3	0.75	18	18.5	16
4	1.0	19.4	18.8	17
MEAN		17.5	17.7	15.8

TABLE 4.2.1

The cutting force for the sample containing Silicon Carbide as reinforcement.

Sl:No	Depth of cut(mm)	X axis	Yaxis	Z axis
1	0.25	18.5	18.8	17
2	0.50	19.1	19	17.5
3	0.75	21	20.5	18
4	1.0	22.4	22	19.8
MEAN				

TABLE 4.2.2

The cutting force for the sample containing Boron Carbide as reinforcement.

Sl:No	Depth of cut(mm)	X axis	Yaxis	Z axis
1	0.25	19	18.4	17.9
2	0.50	19.7	19.6	19
3	0.75	20.8	20.8	19.7
4	1.0	22.1	21.9	20.2
MEAN				

TABLE 4.2.3

CONCLUSIONS

1. There is tremendous improvement in hardness of all the three components, compared to plain cupro nickel alloy
2. Cutting force results show that the reinforcement with Boron Carbide has the highest level of hardness and corrosion resistance.
3. Both Silicon carbide and Boron carbide have similar cutting force, but considering the factor that Silicon carbide is cheaper and more Economically available, SiC is the most suitable reinforcement.
4. The reinforcement with BC also shows brittleness in structure and appearance as compared to that of Alumina and SiC reinforcements.
5. In microstructure the aluminum oxide, siliconcarbide and Boron carbon phases are clearly visible but the mixing is not homogenous, so thecomposite obtained is of discontinuous type.

Hence from above observations it can be inferred that,

- High stiffness and strength is achieved in the
- Increased mechanical strength.
- Reduced electrical and thermal conductivity
- Increased wear resistance.
- Reduced machinability and surface finish

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