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Study of Al-Cu-Ag Np Metal matrix composite for EDM Application

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Abstract – ***Electron discharge machining is a non – conventional manufacturing process, material removal takes place by spark erosion method. This technique is suitable for conducting metals only. In this study metal matrix composite Al-Cu-Ag Np is used as electrode tool in EDM process. Powder metallurgy process is used to prepare the composite, sintered at 100^{0}c for 1hour 30 minutes. Silver Nano particles are synthesized by chemical reduction process that is Turkevich method. By varying Silver Nano particles by 3, 5 and 7% in composite the external particle morphology is done by SEM and Electrical Properties, hardness, thermal Properties, erosion properties are studied. The hardness, electrical conductivity, thermal conductivity increases as percentage of silver NP increases whereas erosion rate decreases.***

Key Words: *EDM, Aluminium, copper, silver nano particles, SEM.*

1. INTRODUCTION

Metal matrix composite is one of the oldest engineering materials being used for various applications in the industries due to their outstanding properties like weight to strength ratio, good electrical and thermal conductivity, low density, high wear resistance and corrosive resistance. [1]

It is a composite material with two or more constituents, one being a metal acts as a base matrix and other may be metal, ceramic or organic compound act as reinforcement. Major concern is choosing suitable reinforcement which adds desirable properties. The aluminium, copper, magnesium or titanium reinforced with particles, whiskers and fibers were used in aerospace, automotive and thermal management industries. [2]

There have been many experimental and theoretical studies indicates that the decreases of the size of the reinforcing particles can lead to substantial improvements in properties of the composite. Thus Morteza et el.[3] finds that nano structured Al-Cu-Mn metallic multilayer composite prepared by accumulative roll bonding process, with its progressive ARB process tensile strength and micro hardness increased by decreasing the strain.

L.Zhang et el. [4] finds that in Cu- Ag micro composite, there is an increased hardness, electrical conductivity and strength.

2. EXPERIMENTAL DATA

2.1 Materials

The composite is prepared by using atomized aluminium (160 and 200 grit size mixed by 50:50 ratio total weight of aluminium), electrolytic copper 350 grit size and silver nano particles.

2.2 Synthesis of silver Nano particles

The synthesis of silver nano particles is done by chemical reduction process. The Turkevich method of synthesis is used. The silver Nano particles were extracted by reducing silver nitrate, and was prepared by using a 10 gm of pure silver bar and dissolving it in a 12 milliliter of AR grade concentrated nitric acid. Silver nitrate thus obtained was white in color and a crystalline powder. A dilute solution of 20 mM of silver nitrate heated to boiling point and is titrated against 200mM solution of tri-sodium citrate with 10ml of a stannous chloride for reduction. Sodium lauryl sulphate was added 2% by weight of the silver nitrite to stabilize the forming particles. The titration was carried at a rapid stirring speed of 850rpm on magnetic stirrer. The color of the Ag Np solution gives the size of particles. The UV spectrum is used to ensure the particle size. The colloidal solution is observed in spectrometer and size is confirmed in the range of 80-100nm. The colloidal particles are dried and stored in air tight container.

Fig-1: Silver Nano particle synthesis by Turkevich method

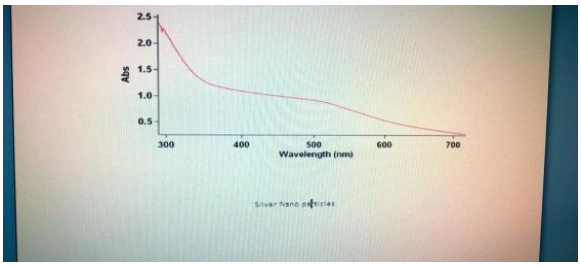

Fig-2: UV spectra of nano particles

2.3 Mixing of powder

The homogeneity of the composite was obtained by mixing the powders thoroughly. The powders were weighted in the right proportion and were mixed in a tumbler in the lathe machine. The powders were put in a steel tumbler along with six steel balls and the tumbler was rotated at 350,500 and 710 rpm in the chuck of the lathe about 10 min .

2.4 Powder compaction

Mixed powder is compacted in the split steel die by using UTM. The inside surface of the die is coated with grease for easy removal of compacted powder. The powder is compressed with a load of 15Mpa. The powder is compressed without any binder because Ag nano particles tend to react with binders. Due to cold welding of powder grains shape of the die is obtained to the compact. Compact must have sufficient green strength in order to handle and withstand the ejection from the die without any damage. Compaction uniformity and density determines the shape, which reflects on the mechanical properties of the composite.

2.5 Sintering

It is consolidating process of green compact. The sintering temperature must be 70-90% melting temperature of the constituent. Initially decided sintering temperature by considering base matrix Aluminium at 500^0c for an hour by increasing the temperature by 100^0c. But after sintering due to agglomeration of silver nano particles at high temperature specimen failed. Further from survey it was found that dried silver nano particles melt and agglomerate at 150^0c so lower sintering temperature was considered. Thus 100^0c was decided as the sintering temperature . Sintered for 1 hour 30 min in the muffle furnace.

Fig-3: Final specimen sintered at 100^0c

3. SEM ANALYSIS OF THE COMPOSITE

The External particle morphology is studied by Scanning Electron Microscopy for varying composition of silver nano particles that is 3, 5 and 7 % shown in fig 4, 5 and 6 respectively. The result shows that there is agglomeration of the silver nano particles because of this porosity is observed. It is clear from the result that due to low sintering temperature there is less bondage between the constituents.

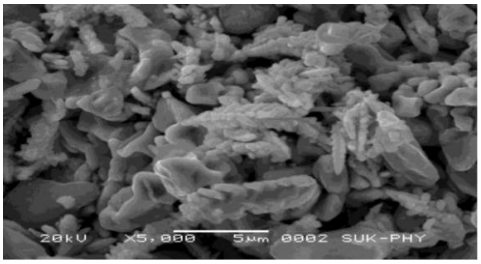

Fig-4: SEM Analysis for 3% composition of Ag

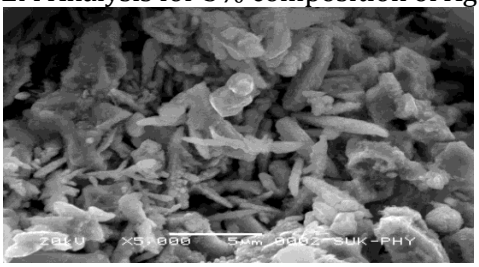

Fig-5: SEM Analysis for 5% composition of Ag

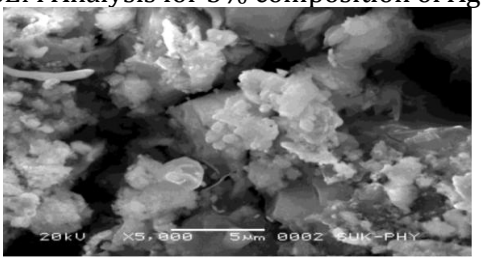

Fig-6: SEM Analysis for 7% composition of Ag

4. RESULTS AND DISCUSSION

4.1 Hardness test

The specimens are subjected to the Rockwell and Brinell hardness test. Specification for RHN: Load P=100kg, indentor D=2.5mm. Specification for BHN: Load P=187.5kg, Indentor D=2.5mm.

Table-1: Hardness values

S.NO	Composition	Rockwell hardness	Brinell hardness
1	3% Ag Np	49	55
2	5%Ag Np	49	56
3	7%Ag Np	51	57

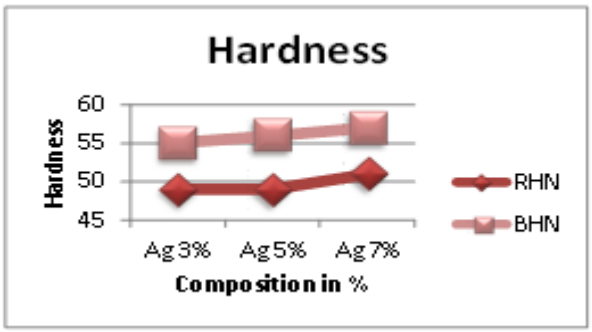

Chart-1: Hardness values

Char -1 shows the hardness values for 3, 5 and 7% composition of Ag. The hardness goes on increasing as the percentage of silver nano particles increases.

4.2 Electrical conductivity test

The electrical conductivity is measured by using Wheastone Bridge. The specimen was made one of the resistances. The resistance (R) values at the center and at the outer surface of the specimen are measured.

Table-2: Resistance and Resistivity values

S.NO	Composition	Resistance (Ohms)		Resistivity (Ohm meter)	
		Center	Diametric end	center	Diametric end
1	3% Ag Np	3	16	0.01963	0.1047
2	5% Ag Np	2	14	0.01427	0.0999
3	7% Ag Np	1	12	0.00523	0.0924

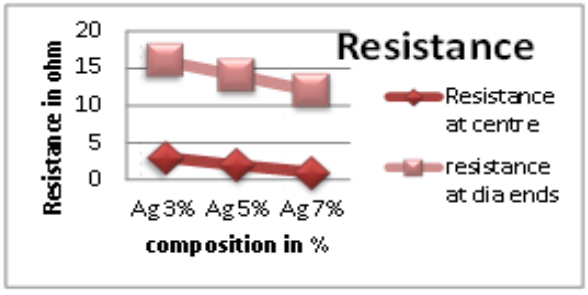

Chart-2: Resistance values

From the chart-2 and Chart-3 the resistance goes on decreasing as the silver nano particles in the composite increased, which ensures that electrical conductivity goes on increasing as the silver nano particles are increased in the composition.

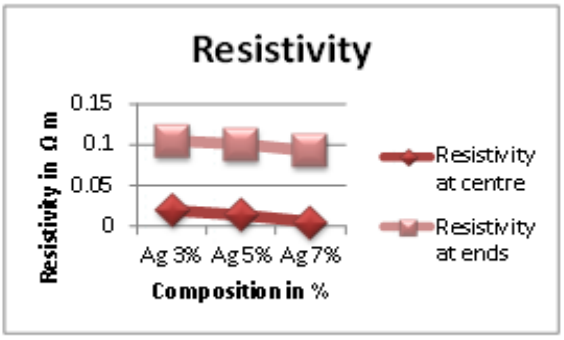

Chart-3: Resistivity Values

4.3 Thermal conductivity test

The thermal conductivity was measured by using Emissivity apparatus. The specimen were placed on the plate of the apparatus and heated to attain uniform temperature, the top and bottom temperature of the specimen was measured. The heat input was measured by taking a tap of water and immersing the specimen in the water.

Table-3: Values of thermal conductivity

S NO	Composition	Thermal conductivity W/ mK
1	3% Ag Np	123.56
2	5% Ag Np	133.69
3	7% Ag Np	256.68

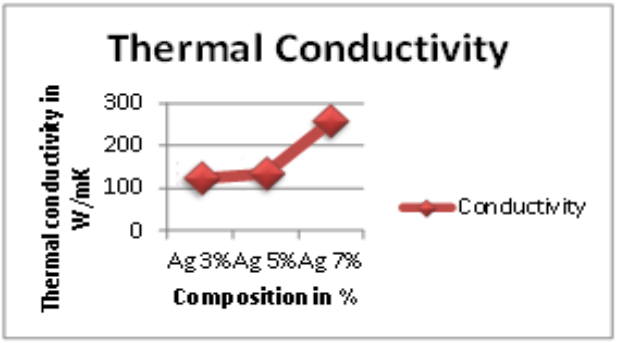

Chart-4: Thermal conductivity

From the Chart-4, the thermal conductivity of the composite increases as the percentage of the silver nano particles in the composition increased.

4.4 Spark erosion test

The Electric Discharge Machine is used to measure the erosion of the specimen. The specimen is used as the EDM

tool. Mild steel was used as the work piece. Weight of the initial tool and weight of the tool after the erosion was measured.

Table-4: Erosion Rate

S.NO	Composition	Wear rate gams/sec
1	3% Ag Np	0.00012277
2	5% Ag Np	0.000068888
3	7% Ag Np	0.000015

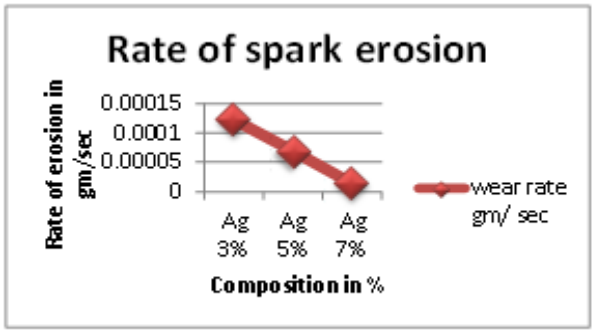

Chart-5: Spark wear rate

From Chart-5 the erosion decreased as the percentage of the silver nano particles in the composition increased.

5. CONCLUSIONS

In this paper Al-Cu-Ag NP composite was prepared by powder metallurgy process. Mechanical, electrical, thermal properties and microstructure was studied. The following are the conclusion.

1. Since the silver Nano particle melt and agglomerate at 150^0c the sintering temperature was kept at 100^0c , so the aluminium and copper particles do not bond completely. As a result of this the specimen hardness values are relatively less.

2. By SEM results it is found that silver nano particles are agglomerated and there is porosity.

3. As the percentage of the silver nano particles increased the electrical conductivity of the composite increased.

4. As the percentage of the silver Nano particles increased the thermal conductivity of the composite increased.

5. As the percentage of the silver nano particles increased the erosion of the composite decreased.

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