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Modelling of Cu-Al_2O_3 Metal Matrix Composite Prepared By Powder Metallurgy Route

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Abstract— ***In recent development of Copper-Alumina metal matrix composites, the applications which need the materials with high thermal and electrical conductivity are attracting researchers interest. Copper matrix was reinforced with Al_2O_3 particles with varying amounts of Al_2O_3 by weight were prepared by powder metallurgy (PM) route having size less than 10µm. Copper powder which is electrolytic and atomized of size 45µm are used to fabricate the MMC's. The powder is blended and compacted at optimized load of 350, 400 & 450MPa to produce green compacts of h\/d ratio in the range 1.1 to 1.5 and sintered in hydrogen reducing atmosphere at temperature of 800^{0}C for 1 hour. and then furnace cooled to room temperature. Wear behaviour of the composite will investigated on a pin-on-disc machine to find out effects of hardness on the composites which prepared by varying the amount of alumina in copper matrix and compare it with the previous work on the composites.***

Keywords- Al_2O_3 MMC's, 350, 400 & 450MPa

I INTRODUCTION

Metal matrix composites (MMCs) have received substantial attention due to their reputation as stronger, stiffer and lighter materials over the base-alloy. MMCs are composites of recent origin and manufacturing methods are much more complex than that of PMC. As a result, MMC has registered slow progress. Composite materials, or simply composites, are combinations of materials. They are made up of by combining two or more materials in such a way that the resulting materials have certain desired properties or improved properties. The application of MMC and composites is mostly in aerospace structures, cutting tools and automobile engine parts. Currently, the major reinforcements added to improve combination properties is ceramic particles with high mechanical properties ,i.e. SiC, Al_2O_3, TiC and TiB_2, etc.

Previous works have revealed that the incorporation of particulate reinforcements improves both the room- and high-temperature mechanical properties as well as wear resistance of the composites by acting as load-bearing components, while keeps considerably high conductivity. The aim of the present study was, therefore, to investigate the abrasive wear behaviour of copper alumina metal matrix composites produced by PM technique, using a pin on-disc-type of wear machine. Furthermore, ANOVA will employed to investigate the influence of wear parameters and hardness of the different particle sizes of composites, and was compared with previous composites.

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II LITERATURE SURVEY

The proposed work is related to Copper-Alumina metal matrix composites, its synthesis by powder metallurgical route; hence the literature survey in this is particularly focused on Copper-Alumina metal matrix composites with emphasis on these parameters. The brief discussion on the conclusions of the research papers and associated other literature is summarized below.

A. Bakkar and V. Neubert [1] have studied Corrosion characteristics of alumina–magnesium MMC. Alumina magnesium metal matrix composites are a precious alternative for aerospace and automotive applications because of their high stiffness-to-weight ratio.

Subrata Ray [2] has highlighted following features of MMC. Superior high temperature strength and creep resistance of metal matrix composites containing ceramic particles or fibres is very significant aspect in enhancing its potential for variety of applications. Table 1 shows the comparison of these fabrication process parameters employed by various researchers.

Name of Author	Sintering temp. employed ^{0}C	Compact-ion pressure MPa.	Sinteri-ng time Hrs	Sintering Atmosphere
A.A. Yousif	900	150-600	1	Hydrogen
Zuhail wati	850	400	1.5	Argon
Viselvaet	800	350	1	Hydrogen
J.R.Groza	850	480	2	Argon
R.Thiravia m	850	350	1.5	Hydrogen

Table 1 comparison of fabrication process parameters

III METHODOLOGY

A. Deciding Fabrication process parameters

Based on this survey following levels of these fabrication process parameters are chosen for designing the experiment in this work as shown in Table 2.

STE-1 Deciding fabrication parameters based on literature survey.

STEP-2 Fabrication of composite by powder metallurgy route.

STEP-3 Measurement of Mechanical &Physical properties.

STEP-4 Wear test on PIN-ON-DISK machine.

STEP-5 Wear correlation by regression analysis.

Name of operating parameter	Level of operating parameters		
	Low	Medium	High
Amount of alumina reinforcement in %.	5	10	15
Compaction pressure in MPa.	350	400	450
Sintering time in Hrs.	1.00	1.00	1.00
Sintering temperature in ^{0}C.	800	800	800

Table 2 chosen fabrication process parameters.

B. Fabrication process

Copper matrix composites reinforced with 5%, 10% and 15% of alumina particles. The material was manufactured using a powder metallurgy method. The average size of the copper powder and the alumina powder were 45 and l0 µm respectively.

Fig.1 Powder Blender

Pure electrolytic copper powder was firstly mixed with calculated amount of reinforcement powder, and then cold compacted. The green compact was then sintered in hydrogen gas at 800^{0}C for 1 hour.

C. Powder Blending

Copper powder was dry mixed with Al_2O_3 powder for 30 min. in a small setup called powder blender shown in fig. at a speed of 60RPM to make blend with 5%,10%,15% weight of Al_2O_3 in the matrix of Cu.

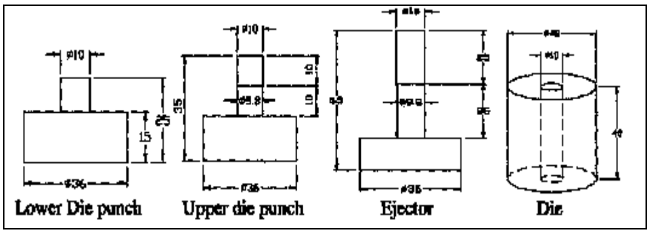

Fig.2 Punch with Die

D. Cold Compaction

The Pressure 350, 400 and 450MPa was found suitable for getting dimension of 10mm diameter and 10-15 mm height for the cold compaction of Cu- Al_2O_3 with 5,10 and 15% of alumina. Before the compaction the die, wall, upper punch, ejector and lower punch was applied with a thin layer of zinc stearate.

The interior of the die is rinsed with zinc stearate whose solution is made in acetone, to provide lubrication `while compaction and easy withdrawal of the green compact after compaction. The blended powder is then cold compacted at the optimized pressure of 350,400 and 450MPa to form cylindrical compacts, on Universal Testing Machine.

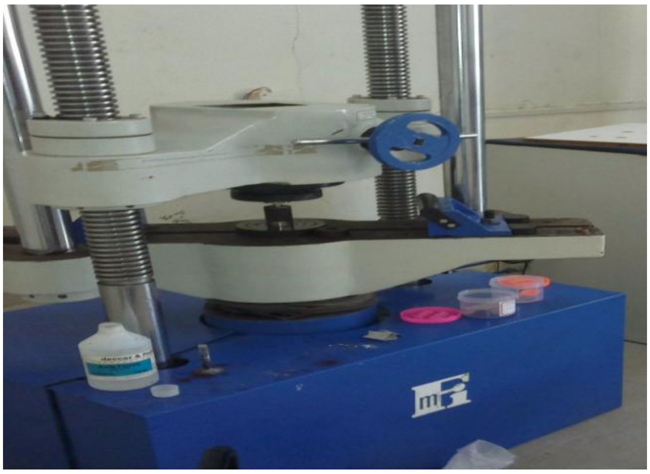

Fig.3 Universal Testing Machine

Fig.4 Sintering Furnace

Once the complete load of 350 MPa is reached it is held there for a period of 30 sec before the load is released. The green compact which is weak in strength therefore is handled very carefully. Zinc stearate and acetone is used to minimize the friction between compact and die wall during cold compaction. Zinc stearate is in the powder form. Die used in making cold compaction of Cu and Al_2O_3 powder mixture is of EN 24 material.

E. Sintering

Sintering of the green compacts was carried out in a sintering furnace in the atmosphere of Hydrogen as shown in fig. The samples were put in small boat. The boat was then slowly slide in the tubular furnace pipe with the help of a strong steel wire, till it goes in the heating zone. The compact were soaked in the Hydrogen atmosphere at a temperature of 800^{0}C for 1 hour followed by furnace cooling. The optimum temperature and timing for sintering is selected based on literature review.

F. Wear Test on pin-on disc machine

The physical and mechanical properties will estimated by optical microscope and wear behavior of the composite will investigated on a pin-on-disc machine to find out effects of hardness on the composites.

Fig.5 Pin-on disc machine

IV. CONCLUSION

Cu/alumina composites were fabricated successfully by PM route. Powder dispersion, and mechanical properties including the micro hardness of these composites were improved by sintering and cold compaction. Wear behaviour of the composite will investigated on a pin-on-disc machine to find out effects of hardness on the composites which prepared by varying the amount of alumina in copper matrix and compare it with the previous work on the composites.

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