

Determination and Study of Mechanical Properties for the Metal-Metal Matrix as Functional Graded Material (Al-SiC)

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ABSTRACT: Materials science FGM may be characterized by the variation in composition and structure gradually over volume, resulting in corresponding changes in the properties of the material. Various approaches based on the bulk (particulate processing), perform processing, layer processing and melt processing are used to fabricate the functionally graded materials. FGM are very important in engineering and other applications but cost of producing these materials makes it prohibitive in some applications.

I. INTRODUCTION

Functionally Graded Material (FGM) belongs to a class of advanced material characterized by variation in properties as the dimension varies. The overall properties of FMG are unique and different from any of the individual material that forms it. There is a wide range of applications for FGM and it is expected to increase as the cost of material processing and fabrication processes are reduced by improving these processes. In this study, an overview of fabrication processes, area of application, some recent research studies and the need to focus more research effort on improving the most promising FGM fabrication method (solid freeform SFF) is presented. Improving the performance of SFF processes and extensive studies on material characterization on components produced will go a long way in bringing down the manufacturing cost of FGM and increase productivity in this regard.

There is limit to which a material can be dissolved in a solution of another material because of thermodynamic equilibrium limit [2]. When more quantity of the alloying material is desired, then the traditional alloying cannot be used. Another limitation of conventional alloying is when alloying two dissimilar materials with wide apart melting temperatures; it becomes prohibitive to combine these materials through this process. Powdered Metallurgy (PM) is another method of producing part that cannot be produced through the conventional alloying, as alloys are produced in powdered form and some of the problems associated with the conventional alloying are overcome. Despite the excellent characteristics of powdered Metallurgy, there exist some limitations, which include intricate shapes and features that cannot be produced using PM; the parts are porous and have poor strength. Although these limitations are of advantage to some applications (e.g. filter and non structural applications) but are detrimental to others. Another method of producing materials with combination of properties is by combining materials in solid state, which is referred to as composite material.

II. RAW MATERIALS

A. Aluminium

Aluminum is chosen as the functionally graded material since, it is low cost and has better properties like good thermal conductivity, high shear strength, abrasion resistance, high temperature operation, non flammability, minimal

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attack by fuels and solvents, and the ability to be formed and treated on conventional equipment. It possesses excellent casting properties and reasonable strength. Aluminium is a chemical element in the boron group with symbol AL and atomic number 13 and it is silvery-white, soft, non magnetic, ductile material by mass aluminium makes up about 8% of earth crust. Aluminium is remarkable for metals low density and it's ability to resist corrosion through the phenomenon of passivation. aluminium and it's alloy are vital to the aerospace industry and important in transportation and structures , such as building facades and window frame. The oxides and sulfates are the most usefull compound of aluminium.This alloy is best suited for mass production of lightweight metal castings. Fig. 1 shows Aluminium.



Fig 1 Aluminium

B. Silicon Carbide



Fig 2 Silicon Carbide

Silicon carbide is also know as carborundum is a compound of silicon and carbon with chemical formula SiC. It occurs in nature as the extremely rare mineral moissanite. Synthetic silicon carbide powder as been mass produced for use as an abrasives grains of silicon carbide can be bonded together by sintering to form very hard ceramics that are widely used in applications requiring high endurance such as car brakes, car clutches and ceramic plates in bullet proofs vests. Electronic application of silicon carbide such as light emitting diodes and detectors in early radios where demonstrated .SiC is used in semiconductor electronic device that operate at high temperature large single crystals of silicon carbide can be grown with lely method they can be cut into gems know as synthetic moissaite. Silicon carbide with high surface area can be produced from SiO₂ contained in plant material.Silicon carbide possesses interesting electrical properties due to its semiconductive characteristics, the resistance of different compositions varying by as much as seven orders of magnitude. In addition high hardness, corrosion resistance and stiffness lead to wide range of applications where wear and corrosion resistance are primary performance requirements. It displays good thermal shock resistance and refractory material (high melting point). It has excellent thermal conductivity and low thermal expansion consequently. Fig. 2 shows.

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III. SPECIMEN PREPARATION

Two specimens were prepared by using stir casting. Table I shows composition of different reinforcements which were added in functional graded material Aluminium.

Sample no.	Aluminum (Al)in Wt%	Silicon Carbide(SiC) in Wt%
1	90	10

TABLE I COMPOSITION OF RAW MATERIALS USED

A. Stir Casting Procedure

Among the variety of manufacturing processes available for functional graded material (FGM), stir casting process is generally accepted as a particularly promising route, currently practiced commercially. Its advantage lies in its simplicity, flexibility and applicability to large quantity production. First of all stirring system has been developed by coupling motor with gear box and a mild steel stirrer. All the melting was carried out in graphite crucible in a oil-fired furnace. Bars of aluminium were preheated at 1000°C for 3 to 4 hours before melting and mixing the SiC particles were preheated at 800c for 1 to 3 hours to make surface oxidized.

The furnace temperature was first raised above the liquids to melt the scraps completely and was then cool down just below the liquids to keep the slurry in semi solid state. At this stage the preheated SiC particles were added and mixed by means of stir casting setup. After sufficient manual mixing was done, the composites slurry was reheated to fully liquid state and then automatic mechanical mixing was carried out for above 10 minutes at a normal stirring rate of 600rpm. In the final mixing process, the furnace temperature was controlled with in 760°C. pouring of composites slurry has been carried out in the die mould prepared according to pin dimensions. Fig. 3 shows the Stir Casting Machine.

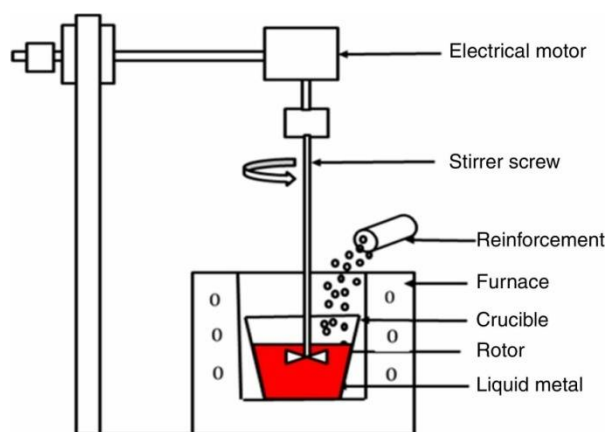


Fig 3 Stir Casting Machine

IV. RESULTS AND DISCUSSION

A. Hardness Test

Hardness is the resistance of a material to localized deformation. A hard material surface resists indentation or scratching and has the ability to indent or cut other materials. Hardness of the four stir casted samples was tested on Brinell Hardness Tester. In the Brinell hardness test, a hardened steel ball is pressed into the flat surface of a test piece

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using a specified force. The ball is then removed and the diameter of the resulting indentation is measured using a microscope. The Specimen used is of IS 1500 standard. Readings on 3 locations were taken and average reading of each sample was considered. Fig. 4 shows the specimens of hardness test.

Table I shows the hardness of the composites. Among the different specimen, Al6063 reinforced with 10% Boron and 5% Graphite has the highest hardness of 38 BHN. But for Al6063 5% Boron carbide, 5% Graphite Hardness value decreases to 34 BHN.



Fig 4 specimens of hardness test

TABLE I HARDNESS OF THE COMPOSITES

	Aluminum Silicon Carbide
HARDNESS (BHN)	34

B. Impact Test

In an impact test a notched bar of material, arranged either as a cantilever or as a simply supported beam, is broken by a single blow in such a way that the total energy required to fracture it may be determined. The energy required to fracture a material is of importance in cases of -shock loading when a component or structure may be required to absorb the K.E of a moving object. Energy absorbed is the energy which is absorbed by the material. The energy is calculated in joules. The energy absorbed is calculated the energy available at the end. The energy absorbed can be found with the help of Charpy impact tests. The standard specimen size for Charpy impact testing is 10mm×10mm×55mm. Fig.5 shows the specimens of Impact testing.



Fig 5 Specimens of Impact Testing

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Table II shows the energy absorbed by the composites. For Al7075, Al7075 + 3% Zircon, Al7075 + 6% Fly Ash and Al7075 + 3% Zircon + 6% Fly Ash energy absorbed are 2J. It is clear that energy absorbed is same for all compositions. Fig. 10 shows energy absorbed by the Composites.

TABLE II ENERGY ABSORBED BY THE COMPOSITES

	Aluminum Silicon Carbide
IMPACT (JOULS)	2.1

C. Wear Test

The dry sliding wear tests were performed on pin-on-disc apparatus. Wear test samples were made of size $\phi 7 \times 50$ mm. The rotating disc material is made of EN-31 steel with the hardness of 63 HRC. Sliding wear tests were conducted on track diameter 15mm with load 10N, sliding speed 0.314 m/s and sliding distance 113.097 m. The dry sliding wear was observed by measuring weight loss. Weight loss of pins was converted into volume loss using density of specimens. Fig.6 shows the specimens used for wear tests. Table III shows Wear rate, Specific Wear rate and Coefficient of Friction.



Fig 6 Specimens of Wear Test

TABLE III WEAR RATE AND FRICTION FORCE

S N O	SP EE D	L O A D	W E A R	T I M E	BEFO RE WEIG HT	AFTE R WEIG HT	AFTE R WEIG HT	FRICTIO N FORCE
1	750	20	14 7	2 0	12.883	12.871	12.871	11.1
2	100	20	35 2	2 0	12.088	12.049	12.049	7.2
3	125 0	20	40 7	2 0	12.427	12.344	12.344	14.8

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V.CONCLUSION

Thus by this project we concluding by saying that the increase in percentage of silicon carbide will results in better hardness as compared to those aluminium pieces which are tested in hardness testing machine.

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