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Comparative Study of LM6 – Graphite Particulate Metal Matrix Composites. -A Good Substitute of Automobile Brake Drum.

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***Abstract:*-- LM6/Graphite Particulate Metal Matrix Composites (PMMC) have enhanced material properties for a variety of general and special applications in aerospace and automotive industries owing to their superior strength to weight ratio and high temperature resistance. Aluminium alloys with Graphite in different compositions shows extraordinary qualities because Graphite particles provide high resistance to wear in the composite. The widespread adoption of particulate metal matrix composites for engineering applications has been hindered by the high cost of producing components. Although several technical challenges exist with casting technology yet it can be used to overcome this problem. Achieving a uniform distribution of reinforcement within the matrix is one such challenge, which affects directly on the properties and quality of composite material. In the present study a modest attempt has been made to develop aluminium based graphite Particulate Metal Matrix Composites with an objective to develop a conventional low cost method by Stir casting Process.**

Aluminium alloys has been chosen as matrix and Graphite (different grain size) as the reinforcement material. Experiments are conducted by varying weight fractions of Graphite (2%, 4%and 6%) and grain size of Graphite if necessary. i.e. aluminium matrix composites are not a single material but a family of materials whose stiffness, strength, density, thermal and electrical properties can be tailored. The PMMC is to be casted and conduct various tests and compare this with Stainless steel whether it is suitable for Automobile Brake drum.

Index Terms:- LM6, Graphite, stir casting, Metal Matrix Composites, Brake drum.

1. INTRODUCTION

The need for engineering materials with the technological importance for the areas of air and land vehicles has led to a rapid development of composite materials. Composite materials have an edge over monolithic materials because of their superior properties such as high specific strength and stiffness, increased wear resistance, and enhanced temperature performance together with better thermal and mechanical fatigue and creep resistance. Metal matrix composites (MMCs) are one of the important innovations in the development of advanced materials. Among the various matrix materials available, aluminum and its alloys are widely used in the fabrication of MMCs and have reached the industrial production stage. The emphasis has been given on developing affordable Al-based MMCs with various hard and soft reinforcements (SiC, Al2O3, zircon, graphite, and mica) because of the likely possibilities of these combinations in forming highly desirable composites. Graphite, in the form of fibres or particulates, has long been recognized as a high-strength, low-density material. Aluminum graphite particulate MMCs produced by solidification techniques represent a class of inexpensive tailor-made materials for a variety of engineering applications. Their uses are being explored in view of their superior technological properties such as the low coefficient of friction, low wear rate , superior gall resistance , high seizure resistance , high damping capacity (and good machinability). Several processes involving incorporating graphite particles in aluminum-base alloy to produce particulate composites have been developed. The most economical production of such composites is by stir casting;

. In order to explore the possibilities of using Al/graphite composites as structural materials, mechanical properties need to be enhanced by controlling the nature of the distribution of the graphite particles and the interface that exists between the graphite and the matrix. The use of the brake is to slow down or completely stop the motion of a moving system. The simplest way to stop a vehicle is to convert the kinetic energy into heat energy[3]. Excessive temperature can prematurely or permanently damage the lining. Realizing the potential as well as availability of Aluminum considerable efforts are being made to explore the possibilities of improving the mechanical strength and wear resistance so as to meet the requirements of various applications.

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2. OBJECTIVE AND PROPOSED OUT COMES

The following are the main objectives of this work:
Making a thorough knowledge and cast LM6 (aluminum alloy) / Graphite Particulate Metal Matrix Composites in different ratios of graphite ie; 2%, 4%, 6% by using stir casting method.
To check the effect of graphite in the properties especially mechanical by conducting the processed materials by the following tests.
1. Tensile test for determining the ultimate tensile strength.
2. Compression Test for determining the compressive strength.
3 To conduct wear analysis for the different combinations prepared and evaluates the results.

STIR CASTING
This involves incorporation of ceramic particulate into liquid aluminium melt and allowing the mixture to solidify. Here, the crucial thing is to create good wetting between the particulate reinforcement and the liquid aluminium alloy melt. The simplest and most commercially used technique is known as vortex technique or stir-casting technique. Micro structural in-homogeneities can cause notably particle agglomeration and sedimentation in the melt and subsequently during solidification. In homogeneity in reinforcement distribution in these cast composites could also be a problem as a result of interaction between suspended ceramic particles and moving solid-liquid interface during solidification. Generally it is possible to incorporate up to 30% ceramic particles in the size

3 METHODOLOGIES

For achieving the desired surface quality and optimum cutting rate on the LM6 -Gr composite work piece, the present investigation has been planned in the following steps:
(i) Literature survey
(ii) Weighing of LM6 and Graphite in appropriate proportions.
(iii) Melting of LM6 in stir casting unit.
(iv) Preheat Graphite each time of casting in pure aluminium foil.
(v) Set correct die for casting.
(vi) Casting the composite and allow to cool.
(vii) Conduct following tests:
(a) Hardness Test for determining Hardness.
(b) Tensile Strength for determining the ultimate tensile strength.
(c) Conduct wear analysis in different proportional castings
(viii) Optimize the analysis and select the best combination suitable for brake drum
Casting and machining of composite rods

Casting:
The first objective is to manufacture Al alloy LM6/SiC and LM6/Gr particulate metal matrix composites using stir casting method. In this case aluminium alloy, LM6 is considered as the matrix phase and Gr particles is considered as the reinforcing phase of the composite material to be manufactured.
First of all 2% by weight of Graphite of grain size 20 µm is weighed and kept in polythene covers. Die casting method was selected for the easy preparation of the specimen. A metal mould die of cylindrical shape of dimensions ϕ40mm x 250mm is prepared from cast iron. The process was repeated for various percentage of graphite. The various steps involved in stir casting process are given below:

Fig.1. Molten LM6 in the furnace at 7500C

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FIG2. Preheating of Graphite at 9000C

Fig .3. Adding preheated Graphite into molten LM6

Fig.4 Finished casting after rough turning

Brake Rotors & Brake Drum

AMMCs offer a very useful combination of properties for brake system applications in replacement of cast iron. Specifically, the wear resistance and high thermal conductivity of AMMCs enable substitution in disk brake rotors and brake drums, with an attendant weight savings on the order of 50 to 60%. Because the weight reduction is unsprung, it also reduces inertial forces, providing an additional benefit in fuel economy. In addition, lightweight AMMC rotors provide increased acceleration and reduced braking distance. It is reported that, based on brake dynamometer testing, AMMC rotors reduce brake noise and wear, and have more uniform friction over the entire testing sequence compared to cast iron rotors. Metal-matrix composite brake rotors and drums are typically produced by casting processes such as semi-permanent gravity casting. Aluminium-magnesium and aluminium-silicon matrix alloys and both SiC And

Al_2O_3 particle reinforcements have also been used.

Fig 5.Prototype brake disc

Testing:

(a) ACID DISSOLUTION: The actual percentage of reinforcement in the cast Al-graphite MMC specimens was determined by checking the graphite weight percentage in each specimen using the acid dissolution and gravimetric analysis method

$2Al + 6\ HCl = 2AlCl_3 + 3H_2$

GRAVIMETRIC ANALYSIS: The gravimetric analysis involves the burning of the dried filter paper in a porcelain crucible under a gas burner. Before burning the crucible without any content was weighed to get the initial mass of the crucible. During the burning process, the filter paper gets burned completely leaving only graphite particle in the crucible.

(c) HARDNESS: The steel ball indenter is selected, inserted & fastened with a screw into the machine.. The specimen is

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subjected to a preliminary load of 10kgf. The reading corresponding to the position of the big pointer gives the hardness number directly (red scale HRB).

(d) WEAR TESTING: The wear testing was conducted in Winducom 2010 machine, The specimen prepared were mounted on the holder one after the another for doing the test after adjusting the track diameter, the speed of the disc and loads number of tests were conducted.

RESULTS AND DISCUSSIONS

The objective of the thesis is to cast the composite in different ratios of Graphite and to conduct various tests to determine the presence of Graphite and its proportion, the hardness value, the ultimate tensile strength and to study the wear characteristic and also find out whether this material is suitable for brake drum material.

1. Material Preparation and Time for Casting

Sample (LM6 Composite Scrape)	weighting m	Melting Started		Melting Ends		Sample (Graphite20micron)	Wt. ing m	Pre heating temperature			
								Starting		Ending	
		Time	Temp.	Time	Temp			Time	Temp	Time	Temp.
N-1	245	11.35	400	12.00	800	N-1	5	11.40	450	12.00	520
N-2	240	12.10	450	12.35	800	N-2	10	12.15	450	12.35	520
N-3	235	1.00	450	1.35	800	N-3	15	1.05	450	1.35	520

2 .HARDNESS TEST

Sl.No	Material	Indentor	Load (kgf)	Mean BHN
1	LM6+GR 2%	Steel Ball	1500	78
2	LM6+GR 4%	Steel Ball	1500	87
3	LM6+GR 6%	Steel Ball	1500	30

3. TENSILE TEST

Sl.No	Material	Ultimate Tensile Strength (MPa)
1	LM6+GR 2%	124
2	LM6+GR 4%	162
3	LM6+GR 6%	160

WEAR ANALYSIS

The wear test was conducted on pin on disc tribometer. The wear rate for different combinations of the parameter such as composition weight and speed are found out. By analyzing the results the wear resistance of the given composite is maximum at 4% of Graphite.

Material	Weight (gm)	Speed (rpm)	Wear(micrometer)
LM6+GR 2%	2.5	250	50
LM6+GR 2%	5	500	234
LM6+GR 2%	7.5	750	28
LM6+GR 4%	2.5	250	36
LM6+GR 4%	5	500	28
LM6+GR 4%	7.5	750	40
LM6+GR 6%	2.5	250	1200
LM6+GR 6%	5	500	1800
LM6+GR 6%	7.5	750	840

Comparison of lm6/gr material with cast iron

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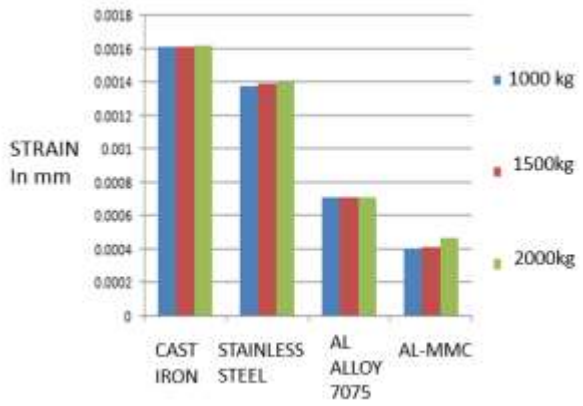

CONCLUSIONS

From all these results LM6 / GR 4% is a good composite and can be suggest as a good composite for the material of brake rotor.

SCOPE FOR FUTURE WORK

The project is clear that the wear resistance of the Aluminium Graphite particulate composite is prepared by stir casting method is very high and from the results of the experiments Aluminium alloy with 4% Graphite composites exhibits good wear resistance. The aim of this project was to check the properties of this material and suggest whether this material is suitable for brake rotor and that was achieved. I suggest this material may be a good substitute for cast iron and other MMC's. The manufacturing and testing of brake rotor using this composite can be done as the future development.

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