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REVIEW ON TRIBO MECHANICAL PROPERTIES OF PMMCS

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ABSTRACT

During the past few years, pmmcs have been used in substantial industrial use. Za alloys are used as an alternate alloy to aluminum, copper and cast iron. In recent years these alloys have found major applications in bearing industries, due to wear resistance, low weight, density, high strength and excellent castability.This paper reviews selection of material, fabrication techniques and behaviour of pmmcs for mechanical properties.

KEYWORDS: PMMCs, Tribo Mechanical properties

INTRODUCTION

Progress in the development of composite materials from many years till today is magnificent. Recognition of potential weight savings materials with reduced cost and greater efficiency is responsible for the growth of new technology of advanced materials. As there is ever increasing demand for newer, stronger, stiffer and light weight materials in the field of aerospace, transportation, automobiles, defense, constructions, mining etc. led to the development of new class of materials [1-3]. As a result of concentrated studies in fundamental characteristics of materials along with better understanding of mechanical and tribological properties a new material can be developed with improved physical and mechanical properties. If a composite is designed and fabricated in the approved manner it combines the strength of the reinforcement with the properties of the matrix to obtain a combination of desirable properties which is not available in single monolithic material [4].

SELECTION OF MATERIAL

In MMC's metals or alloys are used as matrix materials. Matrices act as a bonding material and distribute load to the reinforcement. Load transfer depends on the bonding strength between the matrix and the reinforcement and bonding depends on the type of matrix, reinforcement and fabrication techniques. Zinc aluminum alloys have extensive applications in automobile industries and commonly used as bearing materials due to their fluidity, wear resistant properties, availability and economical in nature. ZA 27 alloys show excellent tribomechanical properties at lower temperature. Latest investigations have done in developing ZA 27 MMCs by reinforcing with ceramic particles [5]

These alloys are alternative bearing materials for brass and bronze [6].Chemical composition and properties is shown in table 2.1 and 2.2 respectively.

Table 2.1: Chemical composition of ZA-27 alloy

Component	% Composition
Aluminium	25-30
Copper	2.06
Iron	0.065
Magnesium	0.012
Silicon	0.02
Zinc	Balance

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Table 2.2: Engineering properties of ZA-27 alloy

Properties	Values
Density	5 gm /cm^3
Ultimate tensile strength	420-490 MPa
Yield strength	378 MPa
Hardness	90-120 BHN
Young's modulus	77.9 GPa
Melting point	376-484^{0}C
Poisson' ratio	0.32
Co-efficient of friction	0.01-0.30
Thermal Conductivity at 20-100° C (x 10^{-6}.)	136 mm/mm/° C

Main role of reinforcement is to carry load, increase strength, stiffness and temperature resistance capacity MMC's. Factors considered to select reinforcing material are:

- Shape: continuous, chopped, spherical, whiskers, irregular.
- Size: diameter to aspect ratio.
- Surface morphology: smooth, rough.
- Chemical compatibility with the matrix.
- Physical and chemical properties.
- Structural defects.

Molybdenum disulfide is a natural inorganic material that occurs as the mineral Molybdenite. It has many unique properties, which makes it most popular solid lubricant. It is considered as a sacrificial lubricant which transfers material between the two mating surfaces involved and is aimed to increase wear resistance. In its appearance it is similar to graphite which is used as a solid lubricant with low co-efficient of friction, greater load carring capacity and tolerates higher loads than graphite [7].properties are exhibited in table 2.3.

Table 2.3: Properties of Molybdenum disulfide

Properties	Values
Density	5 .06 gm /cm^3
Melting point	1185^0 C
Hardness	1-1.5 moh's

FABRICATION METHODS

Stir casting provides better matrix-particle bonding due to stirring action of particles into the melts. The recent research studies reported that the homogeneous mixing and good wetting can be obtained by selecting proper processing parameters like stirring speed, stirring time, and temperature of molten metal, preheating temperature of mould and uniform feed rate of particles. A comparative evaluation of the different

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manufacturing techniques used for the fabrication of discontinuously reinforced metal matrix composite techniques is shown in the table 3.1 [8].

Table 3.1: Comparative evaluation of the different manufacturing technique

Method	Range of size and shapes	Range of vol. fraction	Damage to reinforcement	Cost
Stir casting	Wide range of shapes	Upto 0.3	No damage	Less
Squeeze casting	Limited shapes	Upto .45	Severe damage	Moderate
Powder metallurgy	Restricted size	0.3-0.5	Reinforcement fracture	expensive
Spray casting	Limited shape	0.3-0.7	Reinforcement fracture	expensive

COMPOSITE FABRICATION

Composites are fabricated to shape, machine and join materials. The material will be in the form of ingots obtained by reducing or refining the metal ore. Casting is the best fabrication process to produce the desired shape. It involves:

- Heating the metal till it becomes molten.
- Pouring molten metal into the mould.
- Allowing the molten metal to cool and solidify.

Stir casting route has been used for developing the MMCs by many researchers like Gowri Shankar et al., [8] Kiran et al., [11] etc. because, this method is the most economical method to fabricate MMCs.

EXPERIMENTATION

Microstructure

The micrographs should indicate the evidence of minimum porosity in both alloy and its composites. It should show uniform distribution of the reinforcement particles in the composite material. EDXS analysis and SEM images are observed for microstructure.

Mechanical properties

Hardness is a measure of how resistant the material is to various kinds of permanent indentations when a compressive force is applied. The Brinell scale characterizes the indentation hardness of materials through the scale of penetration of an indenter, loaded on a material test-piece. BHN is calculated using the equation.

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

Where,
P = applied force (N)
D = diameter of indenter (mm)
d = diameter of indentation (mm)

Increase in hardness is expected by using ceramic particulates as they are very hard which possess positiveness to the hardness of composite material which are similar to the results obtained by the papers of Ramesh et al., [9], Bhaskar et al., [10], Kiran et al .,[11] and Basavarajappa et al., [12].

Tensile test

Tensile strength is a measurement of the force required to pull a material or structure to the point where it breaks. Universal testing machine is used to conduct tensile test. The test specimen has two shoulders and a gage in between as shown in figure5.1.The enhancement of tensile strength with incorporation of particulates can be explained as the presence of hard particulates, the load on the matrix gets transferred to the reinforcing elements thereby increasing the load bearing capability of the composites. Moreover, with the

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presence of hard ceramics there is a restriction to the plastic flow as a result of dispersion of these hard particles in the matrix, thereby providing enhanced tensile strength in the composite. The tensile strength of alloy is less compared to that of composite which is similar to the results of researchers like Ramesh et al., [9], Seenappa et al., [13] and Shailesh et al., [14].

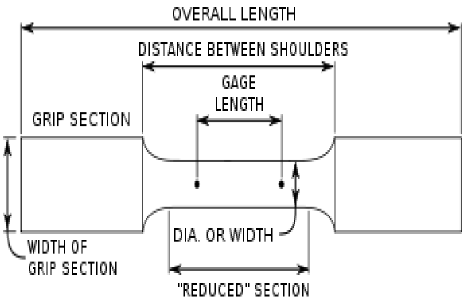

Figure 5.1: Standard tensile test specimen

Sliding wear test

Wear measurement is carried out to determine the amount of materials removed (or worn away) after a wear test. The material worn away can be expressed either as weight (mass) loss, volume loss, or linear dimension change depending on the purpose of the test, the type of wear, the geometry and size of the test specimens, and sometimes on the availability of a measurement facility. Common techniques of wear measurement include using a precision balance to measure the weight (mass) loss, profiling surfaces, or using a microscope to measure the wear depth or cross-sectional area of a wear track so as to determine the wear volume loss or linear dimensional change.

The equations used to calculate the wear rate are:
Co-efficient of friction, μ =frictional force/load
Sliding distance , m $=\pi dNt$

Where
d=track diameter in meter
N= speed in rpm
T= running time in minutes
Wear rate ,m^3/m =(wear x 10^{-6}x πd^2) /(4 x sliding distance)

The addition of ceramic particles to matrix material improves the sliding wear resistance as compared to the unreinforced matrix material as results compared with many researchers like Ramesh et al., [9], Bhaskar et al., [10], Kiran et al .,[11]

CONCLUSIONS

- Successful fabrication of metal matrix composites with ceramic reinforcement is possible using stir casting method.
- With the incorporation of particulate reinforcement the tensile strength improves.
- With the addition of particulate reinforcement the hardness values can be improved.
- Addition of hard ceramic particulates into matrix material improves the sliding wear resistance compared to unreinforced matrix material.

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