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Dry Sliding Wear Behaviour of aluminium Matrix Composite Materials

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Abstract:
Recently all engineering sectors aluminium metal matrix composite (AMMCs) are widely used because of their improved tensile strength, hardness, stiffness and tribological behaviour of the materials. In the present investigation, to fabricate the composite materials by using stir casting method and find the dry sliding wear behaviour of aluminium AA6061, zirconium Di- oxide (ZrO_2) and graphite (C) composite materials. They have using constant input parameters 1000m sliding distance and 2KN axial load are using find the wear rate of AMMCs. 5.3e-9 g/mm Maximum wear rate obtained by 2 Wt% of ZrO_2 inclusion of matrix material and 4.63e-9 g/mm minimum wear rate obtained by 2 Wt% ZrO_2 and 4 Wt% C of inclusion of matrix material.

Keywords*: Metal matrix composite, stir casting, wear behaviour*

I. INTRODUCTION:

The Metal Matrix Composites (MMC) are considered as alternatives for conventional metals and alloys. These composite materials provide specific-mechanical properties. Such composite materials have certain advantages related to their performance, which include compact and desired mechanical, physical and thermal properties. The properties are viewed with regard to their less density, increased mechanical, thermal and wear properties [1].

MMC have specific and typical applications in almost every filed such as satellite fabrication, missile and physical structures of helicopter. Heavy industrial applications include temperaturestructural support, piston and piston ring, engine block liners,connecting rod. In addition, MMC are applied in several needs in aerospace and automotive fields. The MMC are known for their superior mechanical properties in the form of drive they employ. The salient characteristic of MMC is, however, their sharing of the properties found in other composites. This is enabled by the way of selecting appropriate matrix materials, reinforcements, and reinforcement orientations. It is also made possible that the properties of a component are compatible to the design specific needs[2].

Further, the performance characteristics of composite materials are highlighted by their peculiar physical and mechanical properties.The reinforcement particulates are only decide the properties on the composite materials. Naturally the AMMC are having many advantages like light weight materials, Superior mechanical, thermal, wear and corrosion behaviour of materials. In addition, the AMMC utilize reinforcement properties, which are usually ceramic, such as dense stiffness, wear resistance of high value, thermal expansion at low-efficiency[3]. The characterization of a material and the composition is derived by making a comparative analysis of the reinforcement properties of a metal component. Varied MMC possess equally varied and distinguishable properties, due to certain factors, which are,

- The properties of reinforcement particulates, basic form of geometric arrangements
- Weight or volume fraction of reinforcement particulates
- The interfacial bonding properties due to mixing of matrix and reinforcement particulate
- In the form of degradation in reinforcement particulates due to high temperature and mechanical damage from impact, processing, [4] etc.

These factors can be categorized under material reinforcement, material matrix and mechanical properties. Exclusive properties related to reinforcement are, form, geometric arrangement, fraction of weight or volume, reinforcement interface and degradation of the reinforcement. Specifically, the degradation is the result of chemical reactions occurring at high temperatures. Matrix properties include effects arising out of porosity [5]. Mechanical properties are illustrated by way of residual stresses caused due to mechanical and thermal origin of the compositematerials. The reinforcement Degradation was produce the under mechanical properties comes in the wake of damage in processing, and operational impacts[6] etc.

1. Materials and method

For the proposed research study AA6061 alloy is selected as matrix based on its better thermal conductivity, low density, easy processing, better cast-ability and weldability. AA6061 alloy has better mutability than other high thermal conductivity matrix-metal like copper. AA6061 alloy is a precipitation-hardening aluminum alloy containing magnesium and silicon. two different kinds of reinforcement are employed namely ZrO_2 and C. Of these two, ZrO_2 is applied for materials related to the primary reinforcement while C is meant for materials related to the secondary reinforcement. ZrO_2 has received much response in case of multi-industrial and technological applications in recent material studies. This is due to its immense mechanical properties, low co-efficient thermal expansion, less cost and high thermal conductivity. For example, ZrO_2 has 175 W/m K thermal conductivity which is lesser than 250 W/m K of SiC. As regards, the materialistic stability ZrO_2 more heat resistant than SiC. Graphite (C) which is the secondary reinforcement is noted for its flexibility (though not elastic), valuable electric as well as thermal conductivity and high wear resistance. The fabrication of MMCs is done by way of applying various types. These include in-situ method, squeeze casting technique, powder injection moulding process, pressure infiltration process and, powder metallurgy. However, stir casting process is unique in a way that it enables MMCs fabrication in many ways. This process is economical, mass production, less porosity, formation of less cracks, and continuous matrix than the sintered MMCs.

The various levels of weight percentages of ZrO_2 and C are taken for experiment. The process involved, firstly, with the chopping of the AA6061 matrix material into small pieces. Then the pieces are laid in a crucible to melt in an induction furnace at 1000^oC. Yet, the primary and the secondary reinforcements undergo the preheating process at 350^oC so as the moisture is removed and enabled to readily mix with molten Aluminium. Once the material becomes to the semi-liquid state, it was stirred for nearly 10 minutes at the consistent speed of 450rpm. This resulted with the homogeneously distributed particulates.

The wear resistance behaviour of fabricated MMC was analyzed using pin-on-disc test as per the ASTM G0099 standard. The pin samples were cut from the MMC cast billets (with dimension of 8 mm diameter and 32 mm length). The rotating disc was fabricated using a hardened steel of 62 HRC. The constant sliding distance of 1000 m was obtained by maintaining the distance of the pin from the centre of the rotating disc and the sliding velocity. A load of

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9.81 N was applied on the pin, and the frictional forces were measured. The coefficient of friction for each MMC was calculated based on the frictional force and applied normal force.

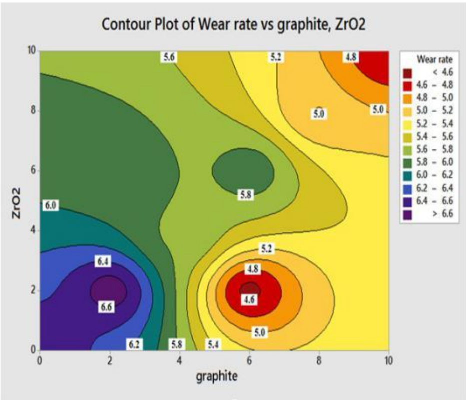
3. **Result and discussion**

Table 1 gives the details of hybrid composites. The variation interpretation in the wear rate in proportion to that of particulate reinforcements is illustrated in the surface plot displayed in Figure 1 (a) and (b). From the graphical illustration, it can be observed that there is a direct proportion of the wear rate. However, there is an increase of the wear rate when there is an addition of the reinforcements at the equal rate of 6%. In case of the specified range of ZrO_2, and with the addition of C more than 4.5%, there has been a significant increase in the wear rate. The intensity of the wear rate is maximum when there is an increase in C but decrease in ZrO_2. The intensity of the wear rate is moderate when there is a decrease in C and increase in ZrO_2. The graphical plot trend proves that the addition of ZrO_2 proves to be a resistant agent thereby reducing the wear rate. It is also proved that the ceramic reinforcement makes a significant impact in reducing the wear rate of the selected and fabricated MMCs.

Table 1 weight percentage and wear rate of AMMC

Sl.No	**AA6061**	**ZrO2**	**C**	**Wear rate**
1	100	0	0	6.56
2	96	2	2	6.69
3	92	4	4	5.779
4	92	2	6	5.97
5	92	6	2	4.56
6	88	6	6	5.91
7	84	8	8	4.998
8	80	10	10	4.608

a



b

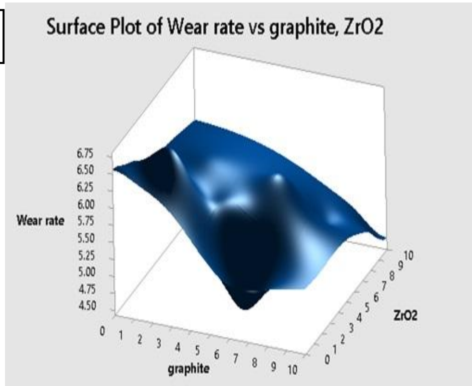


Fig.1(a)contour plot hardness vs graphite,ZrO_2 wear rate

Fig. 1(b) surface plot hardness vs graphite wear rate

CONCLUSION

Successfully fabricated the aluminium matrix composite materials with different weight percentage of matrix and reinforcement particulates by using stir casting method. The constant input parameters are used in Pin-on-machine like 1000m sliding distance and 2KN axial load and also find the wear rate of AMMCs. Compare to the base alloy AA6061 the AMMC are improved the wear behaviour up to 27%.

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