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MECHANICAL AND TRIBOLOGICAL BEHAVIOR OF AL6061-GLASS PARTICULATE MMCs

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Abstract
Particulate reinforced aluminum matrix composites are attractive materials due to their strength, ductility, toughness. This study presents the result of an experimental investigation on the mechanical and wear properties of aluminum alloys 6061 MMC reinforced with glass particulate of 40 microns where dispersed in aluminum matrices at 2, 4, 6 and 8 wt%. Therefore judicious selection of the variables is important to optimize the properties of composites. The shape, size, volume fraction and orientation of reinforcement particles and matrix compositions have to be carefully chosen. The composite prepared by stir casting method the stir casted specimen wear tested for the mechanical and wear properties. The aluminum matrix is strengthening when it is reinforced with hard ceramic phases. In this work the effect of Glass particulate in aluminum matrix on the mechanical and wear properties of the composites is investigated the mechanical properties of composite materials are strongly dependent on micro structural parameters of the system the investigation relives that the significant improvement in the mechanical and wear properties of the composites.

Keywords: Glass particulates, wear, aluminum matrix composites

INTRODUCTION

Metal Matrix Composites (MMCs) provide as a material for advanced application such as diversified applications such as structural, aerospace, automotive, electronic, thermal management and wear applications. The MMCs have numerous advantages over monolithic metals including a greater specific modulus, greater specific strength, better properties at elevated temperatures, reduced thermal expansion and better wear property. The term composite widely refers to a material system which is composed of a discontinuous phase disbursed in a continuous phase and which derives its distinguishing characteristics like properties, geometry, architecture and boundaries of its constituents, between different constituents .The second phase is embedded in the matrix in a discontinuous form. This secondary phase is called dispersed phase. Dispersed phase is usually stronger than the matrix, therefore it is sometimes called reinforcing phase. Many of common material (metal alloys, doped ceramics and polymers mixed with additives) also have

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a small amount of dispersed phases in their structures, however they are not considered as composite materials since their properties are similar to those of their base constituents.

Glass particle is an attractive reinforcement for aluminum and its alloys. It shows many of the mechanical and physical properties required of an effective reinforcement, in particular high stiffness, 72GPa, and it is known as a robust material having hardness of 6 mohs scale matching and even surpassing those of conventional reinforcements such as Al_2O_3 and Sic These factors, combined with a density, 2.53g/cm^3, less than that of solid aluminum, 2.7 g/cm^3, indicates that large specific property improvements are possible and specific properties will improve with increasing particle addition. The proposed work aims at synthesizing Metal Matrix composites (MMCs) of aluminum alloy of grade 6061 with addition of varying percentage composition of glass particulates of size 40µm by stir casting technique. It was also proposed to evaluate the mechanical and wear properties of prepared composites. The prepared samples were subjected to tensile, hardness and wear tests.

EXPERIMENTAL WORK

Aluminum 6061

Aluminum alloy 6061 is used as matrix in the synthesis of composite. Aluminum alloy was cut from its ingot size into smaller pieces by an electric power saw in order to feed the crucible properly. Chemical composition of the matrix alloy is given in the table 1.

Table 1: Chemical composition of aluminum alloy 6061 by wt%

Cu	Mg	Si	Fe	Mn	Cr	Zn	Aluminum
0.40	1.2	0.80	0.70	0.15	0.35	0.25	balance

Glass Particulates

In the present work, glass particulates have been used as the reinforcing material. Glass particulate is the most common reinforcing material used in metal matrix composites. Glass particulate of 40µm size is used in this work. Chemical composition of the glass particle is given in the table 2.

Table 2: Chemical composition of glass particulate by wt%

Sio_2	Na_2o	Cao	Mgo	Al_2o_3	K_2o	Tio_2	Fe_2o_3
73	14	9	4	0.15	0.03	0.02	0.1

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FABRICATION AND TESTING OF COMPOSITES

The cleaned Aluminum alloy was melted to the desired temperature of 740°C in graphite crucible. Cover flux was added in to the molten metal in order to minimize the oxidation. Electrical resistance furnace with temperature controlling device was used for melting. For each melting 0.250 kg of alloy was used 3g of C_2Cl_6 – solid hexachloro ethane was added as degassing tablet in to the super heated molten metal at a temperature of 700°C. Glass particulates preheated to around 300°C for 30 mins.Were then added to the molten metal and stirred continuously for 5 min. During stirring, magnesium was added in small quantities to increase the wettability of glass particulates. The dispersion of the preheated glass particulates was achieved in accordance with the stir casting route. The melt with reinforced particulates were poured into the dried cylindrical permanent metallic moulds of size 12.5mm diameter and 160mm height. The pouring temperature was maintained at 680°C. The melt was allowed to solidify in the moulds.
The casting procedure was examined under the optical microscope to determine the reinforcement pattern and cast structure. The microstructures of etched specimens were observed using optical microscope the tensile tests were conducted on servo hydraulic UTM at room temperature. The samples are prepared according to ASTM E8M. The tensile properties of the alloys were determined by performing the tension test on standard cylindrical tensile specimens. Micro hardness was calculated by using Zwick/Roell Micro Vickers's hardness testing machine. A precision diamond indenter is impressed on material at a load of 50 grams for 10 secs. Dry sliding wear tests for different number of specimens was conducted by using a pin disc machine The wear test for all specimens was conducted under the normal loads of 5kg and a fixed sliding velocity of 0.628 m/s. The pin samples were 22 mm in length and 8 mm in diameter.

RESULTS AND DISCUSSION

The optical microscope views of the fabricated MMCs are shown in figure 1. It is observed from the figure that glass particles of 40 µm are dispersed uniformly in the aluminum matrix up to 6%and in 8% the particles are agglomerated. The size of the glass particle appears to be uniform throughout the aluminum matrix. This can be attributed to the effective stirring action and the use of appropriate process parameters.

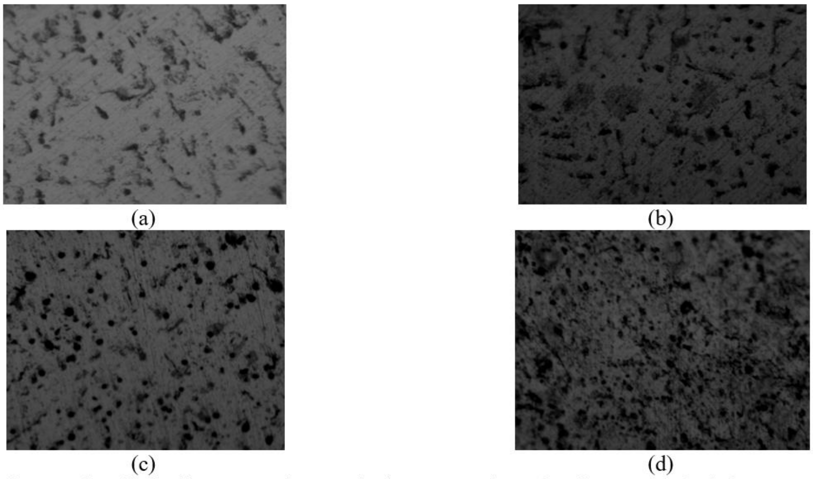

Figure 1: micrographs of Al -alloy 6061-Glass particulate composites of various wt% of reinforcement of 40µm at 100X (a) 2%, (b) 4%, (c) 6%, (d)8%.

1. Tensile results:

1.1 Tensile result of varying microns level of varying wt%

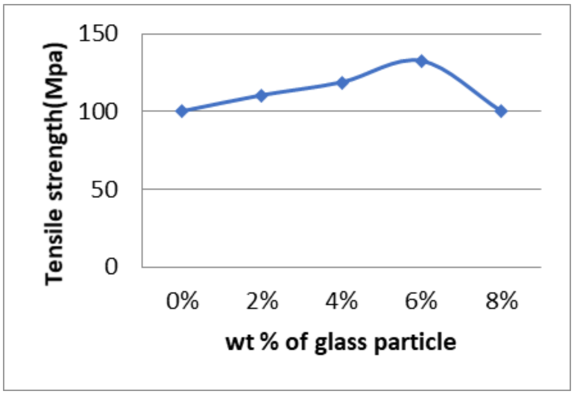

Figure 2: variation of tensile strength of the composites with the different wt% of glass particulate

Figure-2 shows that the tensile strength of different composites cast using reinforcement of different microns. It can be noted that the tensile strength of different microns increases with increasing in the weight percentage of reinforcement up to 6%. Tensile result of as-cast aluminum alloy with out reinforcement is 100 MPa. By adding reinforcement of different microns by varying wt% the tensile strength increases than as-cast unreinforced composite.

Table3: Tensile strength results for different particulate sizes and wt%

Sl.no	Composites	Tensile strength Mpa
1.	Al-Alloy	100.1
2.	Al-2%Gp	110.43
3.	Al-4%Gp	118.73
4.	Al-6%Gp	132.5
5.	Al-8%Gp	100.2

It may be further noted that tensile strength indicated in table3 and in figure-1 increases due to incorporation of hard particles in the matrix alloy. In most cases, ceramic reinforced MMCs have superior mechanical properties to the unreinforced matrix alloy because these MMCs have high dislocation densities due to dislocation generation as a result of differences in coefficient of thermal expansion. Increase in tensile strength (reinforcement up to 6 wt %) is also attributed to increase in grain boundary area due to grain refinement, at the interface and effective transfer of applied tensile load to the uniformly distributed well bonded reinforcement (strength of ceramic materials lies much higher than metallic materials)as the tensile strength of the composite developed is higher than that of the matrix alloy.

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2 Hardness results

2.1 Hardness result of varying microns of varying wt%.

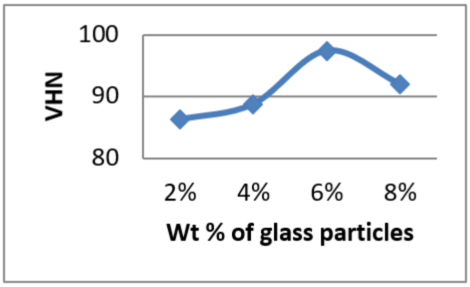

Figure3: variation of hardness of the composites with the different wt% of glass particulate

Figure-3 shows the hardness (VHN) for different composites cast using reinforcement of different microns. In ceramic-reinforced MMCs, there is generally big difference between the mechanical properties of the dispersoidand those of the matrix. This results in incoherence or high-density of dislocations near the interface between the dispersoid and the matrix. Precipitation reactions are accelerated because incoherence and the high density of dislocations act as heterogeneous nucleation sites for precipitation. As dispersoid content is increased, there is a tendency for the hardness to increase because dispersoid provides more nucleation sites for precipitation. As expected, increasing the glass particle content (up to 6wt %) causes the hardness of the MMC to increase since the glass of particulates is so much harder than the matrix alloy. Therefore, results of hardness measurements revealed that an increase in the reinforcement content leads to a significant increase in the hardness and can be attributed primarily to presence of harder glass ceramic particulates in the matrix, a higher constraint to the localized deformation during indentation due to their presence and reduced grain size. Table -4shows the hardness results for particulates size of 40µm.

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Table 4: Vickers hardness results for different particulate sizes and wt%

Sl.no	Material	40µm VHN
1	2%	86.27
2	4%	88.77
3	6%	97.4
4	8%	92

3 Wear results

Sliding Wear Rate Performance of Different Specimens with and without Reinforcement of different microns into the Matrix

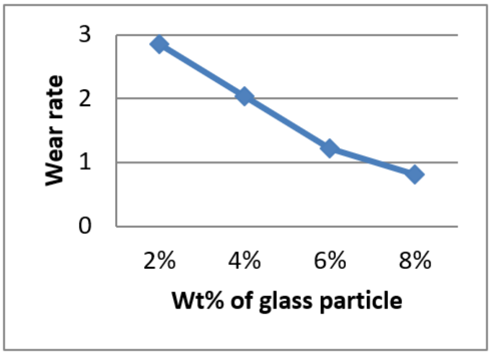

Figure 4: Wear Rate Performance of Different Specimens

From figure -4 it is observed that the wear rate of composite decreases after addition of glass particles than unreinforced Aluminum alloy 6061. It can be attributed to the increase in hardness of the material due to the presence of hard ceramic particles. Material removal in a ductile material such as aluminum alloy matrix is due to the indentation and ploughing action of the sliding disc which is made from hard steel material (EN32 steel disc). Incorporation of hard glass particulate in the Aluminum alloy 6061 restricts such ploughing action of hard steel counterpart and improves the wear resistance. Comparing the wear properties of composites reinforced with glass particle, it is observed that despite their higher hardness, composites reinforced with glass particles shows lower wear rate as compared to unreinforced composites. Table5 shows the wear rate results for different particulate size 40µm.

Table 5: Wear rate results for different particulate sizes and wt%

Sl.No	Material	40µm Wear rate
1	2%	2.854
2	4%	2.038
3	6%	1.223
4	8%	0.815

CONCLUSIONS

The Aluminum alloy 6061-glass particulate composites were produced by stir cast route with different particle sizes and wt% of reinforcement and the microstructure, mechanical and wear properties were evaluated.

From this study, the following conclusions are derived.

1. Aluminum alloy 6061 matrix composites reinforced with particles successfully synthesized by the stir casting method.
2. The reinforcement of particle has enhanced the tensile strength of aluminum matrix composites with the increase in particle size of the reinforcement up to 6 wt% and decreases in 8 wt%.
3. The micro hardness of the composites increases with the increase in particle size of the reinforcement up to 6% and decreases in 8 wt%.
4. Microstructure observation shows that the glass particles are uniformly distributed in the Aluminum Alloy 6061 matrix upto6wt%. In 8 wt% the glass particulates are agglomerated.

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