Synthesis and Evaluation of Mechanical Properties of Aluminium Metal Matrix Hybrid Composite

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Abstract *- Composite materials are becoming a substitute for traditional engineering materials because of their advantages over monolithic materials. Metal matrix composites (MMC) possess properties like high wear resistance, hardness and corrosion resistance compared to unreinforced alloys. They are widely used in the marine, transport, aerospace, automobile and mineral processing industries to increase their endurance life. Aluminium 6061 alloy have been used as matrix material for its excellent corrosion resistance and tribological properties coupled with good formability. In this project, composite was fabricated by aluminum alloy (Al6061) as base metal reinforced with 4% volume fraction of Zirconium oxide Particulates (ZrO_2) , 4 % volume fraction of Fly ash and 0.2% volume fraction of Cerium oxide (CeO_2) particles. Then the composite was heat treated and quenched in various quenching methods. Hardness measurement was done in Vickers hardness tester, wear test conducted in pin-on-disc apparatus and corrosion test carried out with 3.5% of NaCl solution for Al6061 alloy composite. The composite was manufactured using stir casting equipment for uniform distribution of reinforcement particulates in metal matrix. Inverted microscope was used to ascertain the uniform distribution of reinforcement particulates. The experimental results revealed that the composite with heat treatment at 500 °C and oil quenching found to be is good hardness and wear resistance.*

Keywords - Al6061, Zirconium oxide, Fly ash, Cerium oxide, stir casting, quenching

I. INTRODUCTION

Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form. A composite is combination of two materials in which one of the materials, called the reinforcing phase, is in the form of fibers, sheets, or particles, and is embedded in the other materials called the matrix phase. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Composites typically have a fiber or particle phase that is stiffer and stronger than the continuous matrix phase and serve as the principal load carrying members. The matrix acts as a load transfer medium between fibers, and in less ideal cases where the loads are complex, the matrix may even have to bear loads transverse to the fiber axis. The matrix is more ductile than the fibers and thus acts as a source of composite toughness. The matrix also serves to protect the fibers from environmental damage before, during and after composite processing. When designed properly, the new combined material exhibits better strength than would each individual material. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications. Metal Matrix Composite (MMC) is material consisting of a metallic matrix combined with a ceramic (oxides, carbides) or metallic (lead, tungsten, molybdenum) dispersed phase. Most commonly used matrixes are aluminium, magnesium, copper, titanium and zinc. The most commonly used reinforcements are silicon carbide, alumina, boron, graphite and fly ash. Development of these materials is a subject of great interest as they offer attractive combination of physical and mechanical properties, which cannot be obtained in monolithic alloys.

II. OBJECTIVE

The objectives of this project are

- To fabricate Metal matrix composites with the base metal as Aluminum reinforced with a Zirconium oxide particulates , Fly ash particulates and Cerium oxide particulates by Stir casting method.
- To evaluate the mechanical properties of metal matrix composite.

Selection of Materials and Composition

- The matrix metal is chosen as Aluminium 6061.
- The reinforcement is chosen as Zirconium oxide particulates and Fly ash particulates.
- With the base metal as Aluminium 6061, the composite is to be fabricated with 4% of Zirconium

oxide particulates , 4 % of Fly ash particulates and 0.2% of Cerium oxide particulates.

III. FABRICATION PROCESS

The 4% of Zirconium Oxide particles, 4% of Fly ash particles and 0.2% of Cerium Oxide particle were preheated at 400 °C by muffle furnace. The stir casting technique was used to fabricate the composite specimen as it ensures a more uniform distribution of the reinforcing particles. This method is most economical to fabricate composites with discontinuous fibers or particulates. In this process, matrix alloy (Al 6061) was first superheated above its melting temperature and then temperature is lowered gradually below the liquidus temperature to keep the matrix alloy in the semisolid state. The composite slurry temperature was increased to fully liquid state and automatic stirring was continued to about two minutes at an average stirring speed of 500 rpm under protected organ gas. The Zirconium Oxide particles, Fly ash particles and Cerium Oxide particle uniformly mixed throughout the matrix alloy. The melt was then superheated above liquidus temperature and finally poured into the cast iron permanent mould. The specification of the fabricated billet composite is 300 mm length and 35 mm diameter. Then composite metal ejected from the mold. Six set of specimens were machined from the billet materials for various mechanical testing purpose shown in Figure 1.

Figure 1 Casted sample

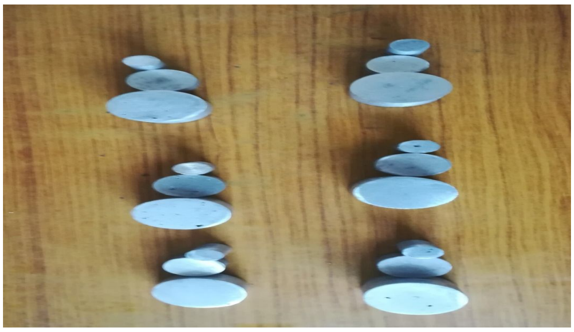

Figure 2 Specimens

IV. EXPERIMENTAL WORK

Heat Treatment

Heat treatment is defined as an operation involving heating and cooling of a metal/alloy in solid state to obtain desirable mechanical properties. The heat treatment is done in the muffle furnace

Types of Quenching Methods Used

- Air quenching
- Water quenching
- Oil quenching

Table 1. Heat treatment and quenching methods

SI. No	Heating temperature(°C)	Heating time (Minutes)	Quenching method
1	-	-	-
2	300	30	Air quenching
3	300	30	Water Quenching
4	300	30	Oil Quenching
5	400	30	Oil Quenching
6	500	30	Oil Quenching

The table 1 shows heat treating temperature and various quenching methods used in composite hardening process.

V. RESULTS AND DISCUSSION

Vickers Hardness

Vickers hardness test method consists of indenting the test material with a diamond indenter, in the form of a right pyramid with a square base and an angle of 136 degrees between opposite faces subjected to a load of 200 grams. The following table shows the micro hardness for different types of quenching specimens. The micro hardness of the composite is increased with in the order of air quenching, water quenching and oil quenching processes. Further the micro hardness is increased with increasing heat treating temperature. The table 2 shows the micro hardness values of different composite specimens. The experimental results revealed that the composite with heat treatment at 500 °C and oil quenching found to be is good hardness. The maximum micro hardness value is 155.9 HV.

Wear

The wear of the composite was studied as a function of the applied load and time. In the wear test the pin was pressed against the counterpart rotate against EN 31 steel disc with hardness 65 HRC by applying the load. An approximately strain gauged friction detecting arm holds and loads the pin specimen vertically into a rotating hardened steel disc.

Table 2. Micro hardness

SI. No	Specimen Type	Heat Treating Temperature(°C)	Micro Hardness HV
1	Without Heat Treatment	-	117.6
2	Heat Treatment With Air Quenching	300	121.7
3	Heat Treatment With Water Quenching	300	128.7
4	Heat Treatment With Oil Quenching	300	133.7
5	Heat Treatment With Oil Quenching	400	147.8
6	Heat Treatment With Oil Quenching	500	155.9

The figures 3, 4, 5, 6,7 and 8 shows wear behavior of various set of specimens. From the graphs experimental results revealed that the composite with heat treatment at 500 °C and oil quenching found to be is good wear resistance.

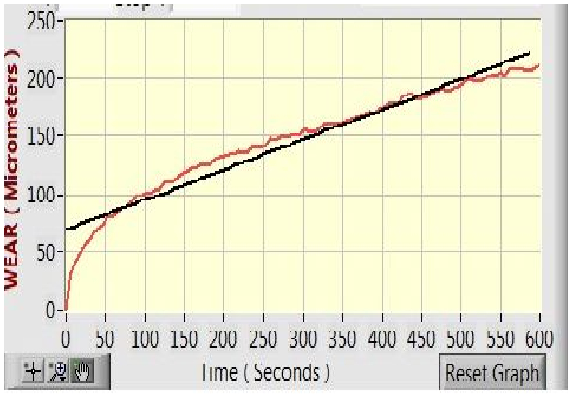

Figure 3 Wear behavior of without heat treatment sample

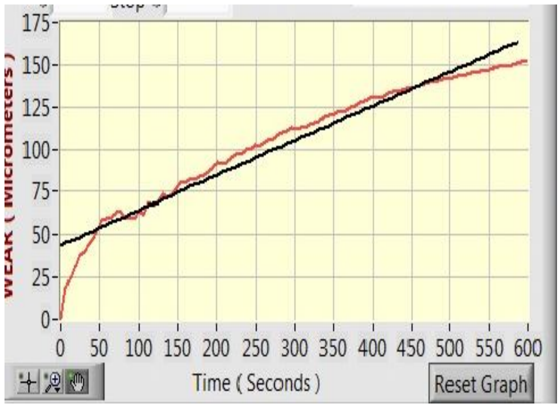

Figure 4 Wear behavior of heat treatment (300°C) and air quenching sample

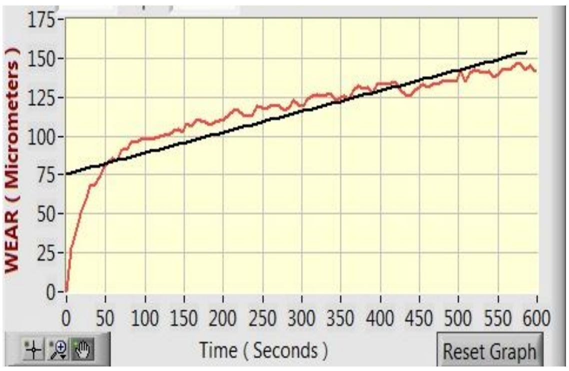

Figure 5 Wear behavior of heat treatment (300°C) and water quenching sample

Figure 6 Wear behavior of heat treatment (300°C) and oil quenching sample

Figure 7 Wear behavior of heat treatment (400°C) and oil quenching sample

Figure 8 Wear behavior of heat treatment (500°C) and oil quenching sample

VI. CONCLUSION

Experimental investigations conducted in the present work to evaluate the influence of 4% of zirconium oxide , 4% of fly ash and 0.2% of cerium oxide particulates in Aluminium 6061 matrix alloy. The following conclusion were drawn from the experimental work. The composite was manufactured using stir casting equipment for uniform distribution of reinforcement particulates in metal matrix. Inverted microscope was used to ascertain the uniform distribution of reinforcement particulates. The experimental results revealed that the composite(Al6061 +4% of zirconium oxide + 4% of fly ash and +0.2% of cerium oxide particulates) with heat treatment at 500 °C and oil quenching found to be is good hardness and wear resistance.

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