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Analysis and Characterization of Al1050-Zro_2-Graphite Based Composite Material

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Abstract: Composite materials are increasingly replacing traditional engineering materials because of their advantages over other materials. The development of metal matrix composite has been one of the major innovations in the materials in the recent times. The Metal Matrix Composite is a material which consists of metal alloy reinforced with continuous fibers, whiskers or particulates of ceramics [1]. These MMCs are widely being used in the transport, aerospace, marine, automobile and mineral processing industries, owing to their improved strength, stiffness and wear resistance properties [1]. Aluminium alloy is the most commonly used matrix for the metal matrix composites.

In this project, composites based on aluminium alloy (Al 1050) reinforced with 2.5%,5%,10% weight fraction of zirconium oxide and 2.5% weight fraction of Graphite particles is produced by stir casting method. The stir casting method is one of the better known approaches used to create and maintain a good distribution of the reinforcement material in the matrix alloy. The cast composites were carefully machined to prepare the test specimens for hardness, tensile tests, and force dynamic test as well as for micro structural studies as per ASTM standards. Micro structural analysis of cast specimens has been carried out to investigate the influence of processing parameters.

Keywords: aluminium alloy, MMC, mechanical properties, zirconium oxide.

I. INTRODUCTION

This Aluminum metal matrix composites are gaining widespread acceptance for automobiles, aerospace, agriculture farm machinery and many other industrial applications because of their essential properties such as high strength, good wear resistance to any other metal [2]. The main advantage of a composite material over conventional material is the combination of different properties which are not often found in the conventional materials. The extraordinary combination properties include high strength to weight ratio, higher stiffness to weight ratio, improved wear resistance, improved corrosion resistance, higher wear resistance and fracture toughness etc. There are a number of situations in service that demand an unusual combination of properties. Further, the present day trend is to go in for light weight constructions for easy handling and reduced space and aesthetic appearance [2].These factors have propelled the modern designers to develop newer composite materials up to the stage of large-scale production with exacting requirements.

Aluminium is the most popular matrix for the metal matrix composites. The aluminium alloys are quite attractive due to their low density, their capability to be strengthened by precipitation, their good corrosion resistance, high thermal and electrical conductivity, and their high vibration damping capacity[2]. They offer a large variety of mechanical properties depending on the chemical composition of the aluminium matrix. They are usually reinforced by aluminium oxide, silicon carbide, silicon dioxide, graphite, boron nitride, boron carbide etc[4]., Aluminium based composites, reinforced with ceramic particles, offer improvements over the matrix alloy: an elastic modulus higher than that of aluminium, a coefficient of thermal expansion which is closer to that of steel or of cast iron, a greater resistance to wear and an improvement in rupture stress especially at higher temperatures and possibly improved resistance to thermal fatigue[3].

Composites as a class of engineering materials provide almost unlimited potential for higher strength, stiffness and corrosion resistance over pure material systems of metals, ceramics and polymers. Composite materials are formed by combining two or more materials that have quite different properties. The different materials work together to give the composite unique properties, but within the composite the materials can be differentiated since they do not dissolve or blend into each other. Composites are made up of two materials namely **matrix** and **reinforcement.** The objective of developing the Al-Zro2-C metal matrix composite in the present study is to derive their potential application in the engineering fields. They are prepared by making use of stir casting technique and then attempt has been made to study the mechanical properties viz. Hardness, Tensile strength and wear rate of the cast composite specimen

II. EXPERIMENTAL DETAILS

2.1 Material Preparation

2.1.1 Processing of materials

Three different categories namely Aluminium alloy (Al 1050), zirconium oxide (ZrO_2), Graphite (C) MMCs were prepared by stir casting technique in which the particle were added into the molten alloy in solid state with mechanical stirring at rotating speed of 700rpm. Zirconium oxide particles size ranged from 30-50 μm and Graphite 700 mesh were used as a reinforced material.

Fig 2.0 STIR CASTING SETUP

2.1.2 Sampling

Large number of cylindrical specimens with dimensions 35 × 350mm was prepared with stir casting technique from cast ingots to investigate the mechanical characterizations.

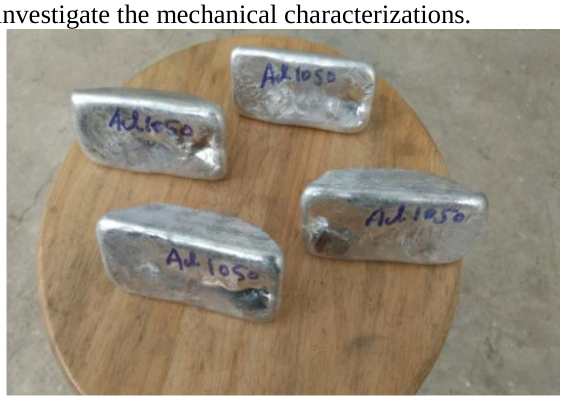

Fig 2.1 Aluminium 1050 Ingots

Fig 2.2 Casted Specimen

2.2 Mechanical characterization

2.2.1 Tension Test

The specimens were prepared and tensile testing was carried out as per ASTM E8 standard in computerized UTM

Fig 2.3 tensile test specimen

2.2.2 Dynamic Force Measurement

Cutting force were measured by using the lathe tool dynamometer which suit to a wide range of lathes and easily fixed to lathe cross-slide.by the application of cutting tool theory, the effect of various parameters such as cutting speeds, feed and cutting forces on the action of cutting tool by varying the depth of cut has been observed. The values of forces exerted on the machine components which affect the geometrical accuracy of work pieces.

2.2.3 Hardness Test (RHN)

The Rockwell Hardness number is obtained by applying load of 100 Kg and 150kg for 30-60sec with ball indenter on flat composite specimens.

Fig 2.4 Hardness specimen

2.2.4 Wear Rate

Wear test are conducted on composites to determine the wear rate

Fig 2.5 wear test specimen

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III. RESULT AND DISCUSSION

Results

Al-ZrO2-C composite of different composition were prepared by stir casting process. The cast specimens were subjected to mechanical characterization and turning characterization. The result of the characterization tests are discussed in

3.1 Tensile Test

Specimen (E8 standard)
Diameter:12.5mm
Gauge Length:75mm

Table 3.1 Tensile Test Results

Serial No	Zirconium Content	Graphite Content	Peak Load (KN)	Tensile Strength (N/Mm²)	% Elongation
1	2.5	2.5	18.1	146.67	13.28
2	5	2.5	22.02	179.26	12.26
3	10	2.5	16.3	132.57	11.46

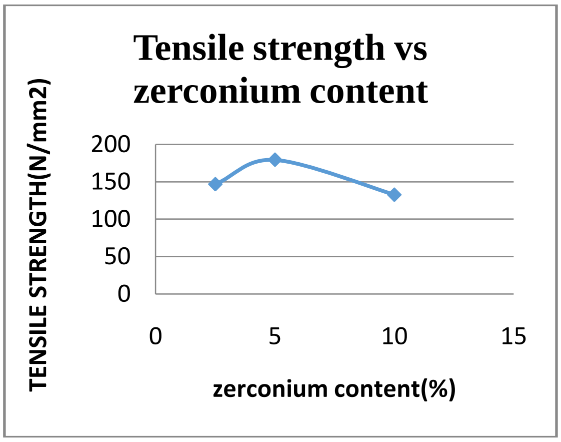

Fig 3.2 Tensile strength (N/mm2) vs. zirconium content(%)

3.2 Wear Rate Calculations

Length: 30mm
Diameter: 8mm
Disc diameter: 104.8mm

3.2.1 Wear Rate Vs Load

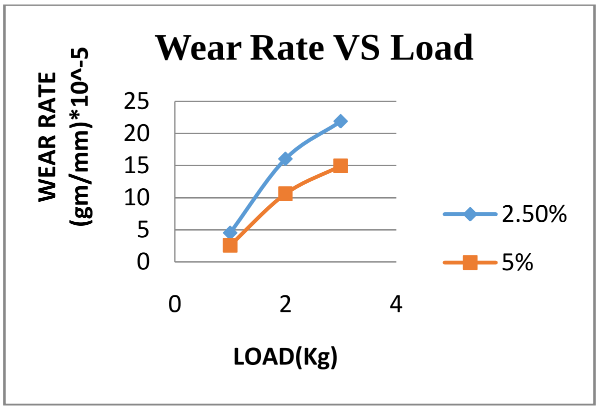

Fig 3.3 Wear rate vs. Load

The wear rate of Al-based composite with addition of ZrO2 & graphite. The wear rate of pure aluminium is greater than other composite. The wear rate increases as the load increases. the The wear rate is more for 2.5% composite and decreases with addition of zirconium oxide. The graph a shows wear rate vs load of composite.

3.2.2 Wear Rate Vs Time

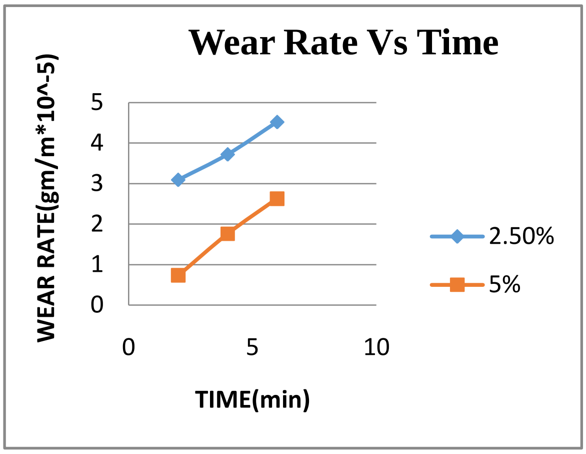

Fig 3.4 wear rate vs time

The wear rate of Al-based composite with addition of ZrO2 & graphite. The reniforcement particles is increased so wear rate is decreased. The wear rate increases with Respect to Time. The adding zirconium oxide reduces wear rate The graph a shows wear rate vs time of composite.

3.2.3 Wear Rate Vs Speed

The wear rate of Al-based composite with addition of ZrO2 & graphite. The reniforcement particles is increased so wear rate is decreased. The wear rate decreases when speed increses. The adding zirconium oxide reduces wear rate compared to the aluminium. The graph a shows wear rate vs. speed of composite.

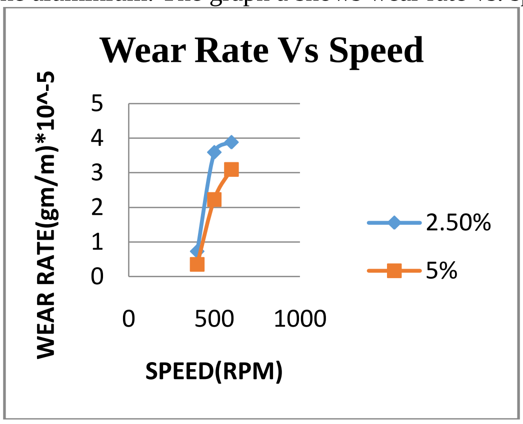

Fig 3.5 Wear rate vs. Speed

3.3 Rockwell Hardness Test

The Rockwell Hardness number is obtained by applying load of 100 Kg and 150kg for 30-60sec with ball indenter on flat composite specimens.

Table 3.2 Hardness test

Zirconium %	Load (kgf)	Trial 1	Trial 2	Trial 3	RHN
2.5	150	22.5	25	23	24
5	150	28	29	30	29
10	150	26	28	24	26

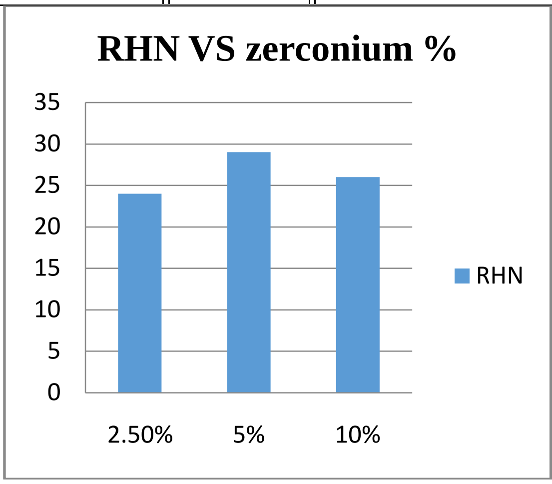

Fig 3.6 RHN VS Zirconium oxide

Above graph shows the influence of zirconium oxide and graphite in the aluminium metal matrix composite. The hardness of composite with 5% (ZrO_2) is more compared to 2.5% & 10%.

3.4 Dynamic Force Analysis

3.4.1 Force Vs Speed

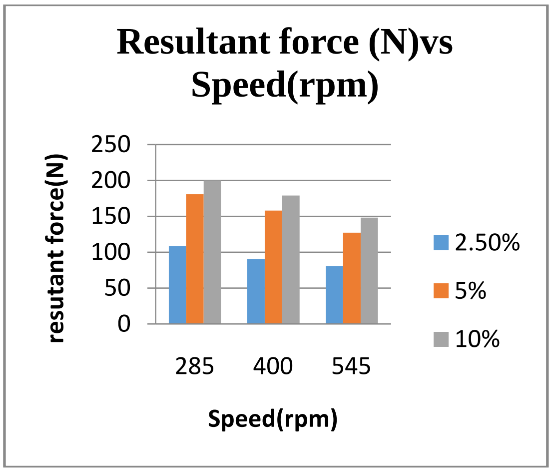

Fig 3.7 Resultant force vs. Speed

The above graph show force analysis carried out by varying speed on tool lathe dynamometer. The resultant force decreases when speed increases & resultant force is more for 10% compared to the 5% & 2.5%.

3.4.2 Force vs. Depth of cut

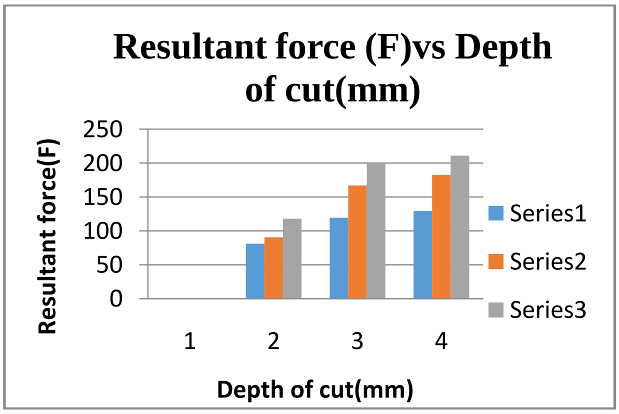

Fig 3.8 Resultant force(F) vs. Depth of cut(mm)

The above graph show force analysis carried out by varying depth of cut on tool lathe dynamometer. The resultant force is more for 10% compared to the 5% & 2.5%.

3.4.3 Resultant Force VS Feed rate

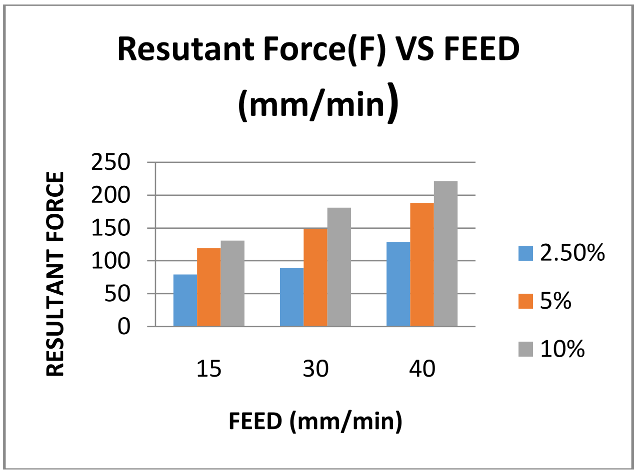

Fig 3.9 Resultant force (F) vs. Feed(mm/min)

The above graph show force analysis carried out by varying feed on tool lathe dynamometer. The resultant force increases with feed rate. The resultant force is more for 10% compared to the 5% & 2.5%.

IV. CONCLUSION

Experimental investigations conducted in the present work to study the influence of percentage composition of zirconium oxide particles and graphite particulates in Al1050 Aluminium matrix alloy on the micro structural mechanical and turning characteristics have provided the following conclusions.

- From tensile test results it has been observed that addition of reinforcement to base metal increases tensile strength of the composite.
- It has been concluded from the hardness measurement that, addition of zirconium oxide has effect on hardness value, but addition of ZrO_2 up to 10% leads to porosity which effects hardness value.
- It has been proved from wear analysis that zirconium particles increase the wear resistance behaviour of aluminium metal matrix composites.
- Mechanical properties of composite increased compared to aluminium alloy(1050)
- The wear rate of 5% zirconium oxide is lower than 2.5 %
- Hardness of the material increased with increase in zirconium oxide content in aluminium.

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