Microstructure analysis and mechanical behaviors of Al6063 reinforced with B_4C and red soil metal matrix composite

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ABSTRACT

High-quality mechanical properties and good microstructure of metal matrix composites create a challenge in different fields like automobile, structural, aeronautical applications. The basic reason of metals reinforced with ceramic particles is to improve properties than its original mechanical properties like hardness, strength, stiffness etc. Stir casting process is principally used for developing a hybrid particulate reinforced metal matrix composite in uniform distribution. The composites are prepared using aluminum alloy based casting by stir casting machine. It is one of the most economical method of processing MMC. In this paper by means of stir casting machine, preparation of AMC material by using aluminum 6063 as reinforcement of boron carbide and red soil to get better hardness of the material .It would be improved by using stir casting machine. To prepare the work materials, the percentage of weight fraction in boron carbide (2%, 4%) is varied and all the parameters are maintained constant. The result shows the increase in hardness due to the weight percentage of boron carbide. The microstructure of Al6063 reinforced with B_4C and red soil metal matrix composite is uniformly distributed throughout the material.

KEY WORDS: Aluminum, Composite Materials, Stir Casting Process, Hardness Test.

1. INTRODUTION

The composite materials have wide applications in the range of advance materials used in the field of aeronautics, automotives, boats, sports parts and medical devices. Composites have excellent structural properties and have electrical, thermal and environmental applications. Optimization is implemented in modern composite material for balancing the properties in various fields of applications. A composites are combined constituents to form a structural material which are not soluble each other in a macroscopic level. One element is represented as reinforced phase and other implant known as matrix.

The literature data available on the effect of various reinforcement types, their size and volume fraction with Al based MMC's. Metal matrix composites are a group of two phases, matrix and the reinforcement. Composites are selected, based on the application where matrices are combined with selected aluminum alloys e.g. Al 2000, 6000, 7000, 6061,6063 , reinforcement materials like Al_2O_3, SiC, B_4C, etc. and with red soil are taken in different sizes by using sieves equipment . Combine the reinforcement materials together with the matrix materials to create a large composite structure. There are different processing methods such as powder metallurgy; squeeze casting, hot extrusion, stir casting etc are done to create a uniform mixing of composite materials. The alumina and aluminum alloy 6063 is scattered uniformly through stir casting machine to form composite material, microstructure analysis and test is done in tensile strength and Hardness for mechanical Properties Al 6061 matrix is fabricated by combining silicon carbide and titanium di boride reinforce to create hybrid metal matrix composite by using stir casting method for analyzing the microstructure and mechanical properties. The various reinforcements material compositions are 10% SiC, 2.5%, 5% and 10% TiB_2 are studied using micro hardness and wear to have increased hardness value as a result. The matrix Al6061 increase in hardness value due to the addition of SiC and TiB_2 reinforcement. The current studies were done on Al 6061, Al 7075 with the particles of Al_2O_3 and SiC are mixed in the size 20 μm base matrix and the reinforcing phase. The densities of composites are greater than the base matrix and it is observed that further increases in the percentage of filler content in the composites will have a increase in density. In the microstructure view, the distribution of reinforcements in the matrix are common which can be observed in it. MMC materials have unreinforced matrix with advanced properties such as increased strength, hardness, greater electrical, increased wear resistance, low coefficient of thermal expansion and thermal conductivity. The mechanical properties are good to attain, by choosing approximate percentage of matrix and reinforcement material. The different metal matrix composites produced from Al6061, Al 6063 and Al 7072 matrix alloys reinforced with silicon carbide particulates are been analyzed and mechanical properties are tested. Improvement in the wettability in between the Al and SiC particles.

2. SELECTION IN COMPOSITE MATERIALS

Physical Properties For Aluminum Alloy6063: Aluminum are economical and attractive to form an aluminum alloy, by choosing variety of uses such as exterior, chemical properties, light weight, physical properties, mechanical properties, and corrosion resistance. Al 6063 is the combination of base metal aluminum alloy, with magnesium and silicon as the alloying elements. The standard formation of composite composition is followed from the aluminum association are tabulated below.

Table.1. Physical properties for aluminum alloy6063

S. No	Property	Value
1	Density	2700 kg/m^3
2	Melting Point	600°C
3	Modulus of Elasticity	69.5 GPa
4	Electrical Resistivity	0.035x10^{-6} Ω.m
5	Thermal Conductivity	200 W/m.K
6	Thermal Expansion	23.5 x 10^{-6} /K

Chemical Composition of Aluminum Alloy 6063: The matrix material of aluminum alloy 6063 used in the experimental investigation in a chemical composition (in weight %) is listed in Table.2. aluminum alloy, Magnesium, iron and Si as its major alloying elements for the aluminum alloy 6063. The most common aluminum alloy element has good mechanical properties and its general purpose use in all engineering application. During composition the molten metals have high fluidity and solidify at constant temperature with uniform mixing. Aluminum alloy 6063 is usually used in Engineering applications, Extrusions, Irrigation tubing and Architectural.

Table.2. Chemical Composition of aluminum alloy 6063

S. No	Element	Content (%)
1	Silicon	0.2%-0.6%
2	Iron	0.35%
3	Copper	0.10%
4	Manganese	0.10%
5	Magnesium	0.9%
6	Chromium	0.10%
7	Zinc	0.10%
8	Titanium	0.10%
9	Aluminum	Balance

The increase in mechanical properties of matrix composite material is the aim of the reinforcement in a metal with a work piece. The different sized particulates used in composites have different properties and the properties of the composite are affected in different ways. Boron carbide with Chemical formula is extremely having a hard boron–carbon ceramic and ionic material used in various industrial applications like tank armor, bulletproof vests, engine sabotage powders. Hardness value greater than 30 MPa is the hardest for composite material which will be equivalent to the hardness of diamond and cubic boron nitride. Magnesium can be used only in a graphite furnace and the byproduct are cleared by acid treatment. The red soil is ground finely and sieve to known size which is then used as particle reinforcement in the composite.

3. EXPERIMENTAL PROCEDURE

The stir casting machine is to fabricate the metal matrix composites by combining the base material aluminum alloy 6063 and reinforcement material is with mass fraction of 3%, 6%. There are two compositions of composite materials prepared by using stir casting machine. Aluminium alloy6063 casted with reinforcement material in the mass fraction of 4% boron carbide and 6% of red soil (150micron).

Figure.1. Stir Casting Machine

It consists of two furnaces, one is a melting furnace with stirrer setup and another one is a reinforcement preheating furnace.

Step1: Aluminum alloy 6063 is made to melt in furnace at 780°C for couple of hours.

Step2: Boron carbide and red soil mixture is preheated (200°C) in the furnace for two hours

Step 3: Melted aluminum alloy6063 and preheated boron carbide and red soil mixture are combined in a graphite crucible. Along with the melt coverall, nucleant & degasser of 5gm are added.

Coverall: It is a complex of KCl+HNO_3, avoids oxidation.

Nucleant: salt tablets. It enhances good grain structure.

Degasser: Hexa-chloroethane tablets, it removes the gases present in molten metal.

Step4: After adding the above items the molten metal are stirred at speed of 400rpm for 15minutes.
Step5: Simultaneously, the dies are placed in a different furnace and heated for 2 hours at 300°C.
Step6: Conclusively the molten metal discharged into the die which is preheated already and solidification of molten metal is done.

Figure.2. Aluminum alloy6063+(B4C 4%wt+Red soil 6%wt)

3. RESULT AND DISCUSSION

Mechanical Properties: The hardness number is calculated by sample test carried out at room temperature using Rockwell hardness tester machine and the average values were determined. Load of 100 Kg is applied on Rockwell's hardness tester at dwell time intervals of 20 sec. for each sample.

Figure.3. Hardness test sample

The hardness is increased with increase in the volume fraction of particulate in the aluminum alloy matrix. The hardness value is increased by addition of B_4C & red soil particles .Enhanced hardness of composite are harder than Al alloy. The average hardness of aluminum alloy 6063 is 62.66 HRB for sample.1, which is aluminum alloy 6063+ (B_4C 2%wt+Red soil 6%wt). The average hardness of composite material is to 72.66 HRB which is aluminum alloy6063+(B_4C 4%wt+Red soil 6%wt).

Table.3. Comparison of Rockwell hardness in composite

Sample No	Trail-1	Trail-2	Mean hardness (HB)
Sample -1	26.5	27.2	26.85
Sample -2	28.6	28.8	28.7
Sample -2	29.8	29.5	29.65

The Rockwell hardness test shows the hardness value of the aluminum alloy6063 reinforcement with boron carbide and red soil gives comparatively high value then the aluminum alloy6063 material. So the composite material has ability to resist the external load when in the working field.

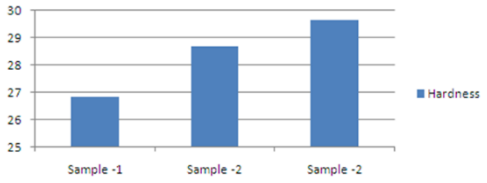

Figure.4. Hardness test result comparison

Microstructure Analysis: The microstructure results shows the reinforcement particles homogeneously dispersed in the metal matrix composite. Figure.5, shows the uniform distribution of the Al6063 alloy with B_4C 2%wt and red soil 6%wt has been micro photographed using electron microscope. Similarly the uniform distributions of the Al6063 alloy with B_4C 4%wt and red soil 6%wt is shown in Figure.6.

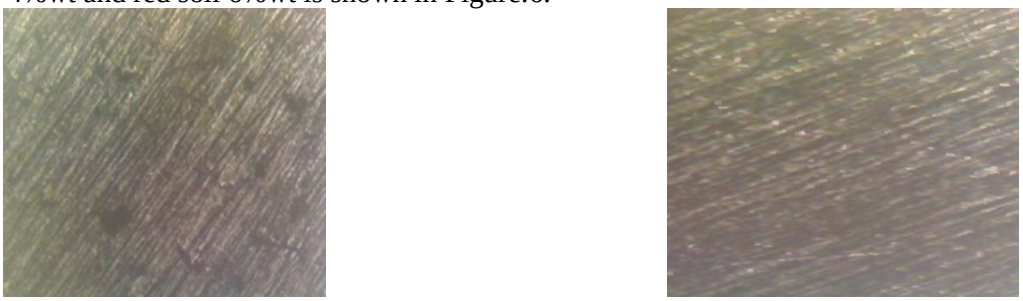

Figure.5. Microphotograph of Al 6063 alloy with B_4C 2%wt+red soil 6%wt

Figure.6. Microphotograph of Al 6063 alloy with B_4C 4%wt+red soil 6%wt

4. CONCLUSION

The aluminum alloy composites were prepared by stir casting with B_4C and red soil as reinforcement and the microstructure, mechanical properties are evaluated. From the results we can bring into the following conclusions: Regarding the microstructure, uniform distribution of B_4C and red soil particles is shown in optical micrographs which have a better improvement from the previous works and indicates a growing trend in the preparation of composites by Stir casting method. The hardness increases with increase in reinforcement particulate of boron carbide powder and red soil in the matrix material. Developed aluminum Metal Matrix composite shows improvement in mechanical and physical properties compared to aluminum alloy6063 which also offer for improvement for the specific design needs.

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