INVESTIGATION OF MACRO PROPERTIES ON Al 6082 HYBRID METAL MATRIX COMPOSITES

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ABSTRACT

The present study deals with the investigation of effect of reinforcement (B_4C+ZrO_2) particles on mechanical properties of aluminum alloy (Al6082) composites, fabricated by Stir casting method. The MMC specimens were prepared by varying volume based fraction ofthe reinforced particles 1% B_4C & 2% ZrO_2, 2% B_4C & 4% ZrO_2, 3% B_4C & 6% ZrO_2, 0% B_4C & 0% ZrO_2 and 1% graphite respectively and keeping all other parameters constant. The various mechanical propertieshas to be analyzed the MMC's. Generally cast iron is used as drum brakematerial but nowadays it replaced by aluminium to improve heat dissipation and reduce fade. This project works to enhance the propertiesof aluminium and mainly focused to increase wear resistance to replace cast iron in brake rotor.

INTRODUCTION

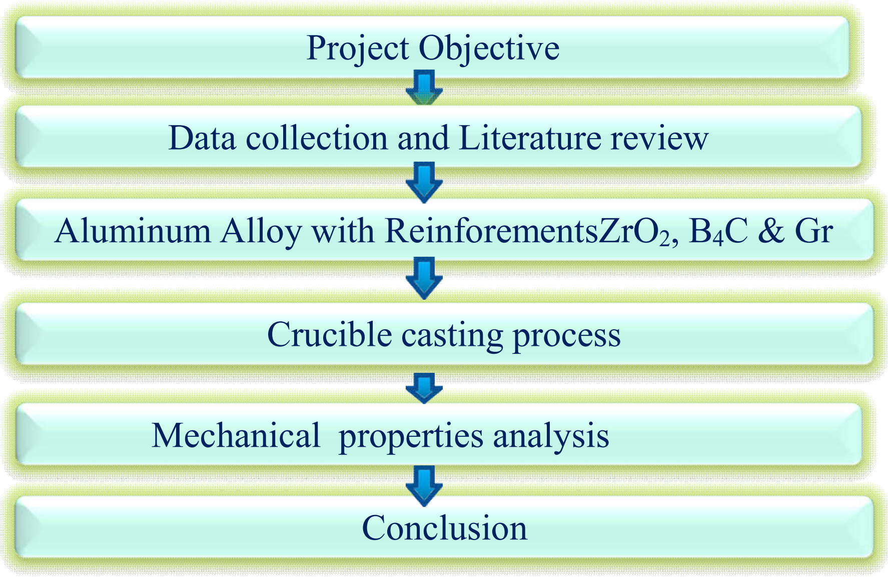
A review of the literature data available on the effect of various reinforcement types, their size and volume fraction, ageing behavior with Al based MMC's. Metal matrix composites are a combination of two phases, matrix and the reinforcement. Matrices can be selected from a number of Aluminum alloys e.g. 6082 and many reinforcement types and various mass of Boron Carbide and Zirconium oxide with constant weight of graphite.

OBJECTIVES

OBJECTIVES OF PRESENT WORK

The requirement of composite material has gained popularity in these days due to their various properties like low density, good wear resistance, good tensile strength and good surface finish. The present study deals with the investigation of effect of reinforcement (B_4C+ZrO_2) particles on mechanical properties of aluminumalloy (Al6082) composites, fabricated by Stir casting method. The Hardness strengthwill also be taken into consideration. For the achievement of the above, an experimental set up is prepared where all the necessary inputs will be made. The composite has to be prepared by crucible casting technique and has to be analyzed various mechanical properties.

EXPERIMENTAL PLAN



Experimental plan

Al 6082has a good surface finish, high corrosion resistance, is readily suited to welding and can be easily anodized. Most commonly available as T6 temper, inthe T4 condition it has good formability.

CHEMICAL COMPOSITION OF ALUMINUM 6082

Table 4.1- Typical chemical composition for aluminum alloy 6082

ELEMENT	PERCENTAGE
Si	0.2 to 0.6
Fe	0.0 to 0.35
Cu	0.0 to 0.1
Mn	0.0 to 0.1
Mg	0.45 to 0.9
Zn	0.0 to 0.1
Ti	0.0 to 0.1
Cr	0.1
Al	Balance

AL 6082 ALUMINUM MECHANICAL PROPERTIES

Table 4.2- Aluminum alloy 6082 properties

Density	2700 Kg/m^3
Melting Point	600^{0}C
Modulus of Elasticity	69.5Gpa
Thermal conductivity	200 W/m.K
Thermal expansion	23.5 x 10^{-6} /K
Electrical resistivity	0.035x10^{-6} Ω.m

FABRICATION OF 6082 ALUMINUM

1. Process Rating
2. Workability - Cold Average
3. Machinability Average
4. Weldability – Gas Excellent
5. Weldability – Arc Excellent
6. Weldability – Resistance Excellent
7. Brazability Excellent
8. Solderability Good

APPLICATIONS OF 6082 ALUMINUM

Aluminum alloy 6082 is used in the same applications as 6082 aluminum. Itis also used in: Road transport, Rail transport, Extreme sports equipment Source.

MACHINABILITY

The heat-treated alloy has fairly good machining properties, but tools shouldpreferably be of high speed steel and must be kept sharp. A moderately high rate oftool wear may be expected. Liberal cutting lubricant should be employed.

CASTING CHARACTERISTICS

FLUIDITY -Good, suitable for fairly thin castings.

PRESSURE TIGHTNESS -Excellent, suitable for castings required to beleak tight

HOT-TEARING -Excellent, problems due to hot tearing are rarely seen.TYPICAL POURING TEMPERATURE -710°C

BORON CARBIDE

Boron Carbide is one of the hardest materials known, ranking third behind diamond and cubic boron nitride. It is the hardest material produced in tonnage quantities.

Typical properties of boron carbide.

Property	Value
Density (g.cm^{-3})	2.52
Melting Point (°C)	2445
Hardness (Knoop 100g) (kg.mm^{-2})	2900-3580
Fracture Toughness (MPa.m$^{-½}$)	2.9 - 3.7
Young's Modulus (GPa)	450 - 470
Electrical Conductivity (at 25°C) (S)	140
Thermal Conductivity (at 25°C) (W/m.K)	30 - 42
Thermal Expansion Co-eff. x10^{-6} (°C)	5
Thermal neutron capture cross section (barn)	600

EXPERIMENTAL PROCEDURE

The aluminum metal matrix composite materials is the combination of two or more constituents in which one is matrix and other is filler materials (reinforcements). Aluminum metal matrix may be laminated, fibers or particulates composites. These materials are usually processed through powder metallurgy route,liquid cast metal technology or by using special manufacturing process. The processing of discontinuous particulate metal matrix material involves two major processes (1) powder metallurgy route (2) liquid cast metal technology. The powdermetallurgy process has its own limitation such as processing cost and size of the components. Therefore only the casting method is to be considered as the most optimum and economical route for processing of aluminum composite materials. Foralloy development aluminum 6082 rod and silicon nitride average particles size 200µm were purchased from local market. The aluminum rod was melted in a graphite crucible and alloyed with required quantity of reinforcements.

CRUCIBLE CASTING

In this project we have used sand mold casting for produce the requirement size. Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. It is relatively cheap and sufficiently refractory even for steel foundry use. A suitable bonding agent (usuallyclay) is mixed or occurs with the sand. The mixture is moistened with water to develop strength and plasticity of the clay and to make the aggregate suitable for molding. The term "sand casting" can also refer to a casting produced via the sand casting process. Sand castings are produced in specialized factories called foundries.Over 70% of all metal castings are produced via a sand casting process.

Fig: 5.1 crucible casting setup

CALCULATION FOR ALL RATIOS:

Volume = $\pi/4\ d^2 * L$

= $\pi/4 * 2.5^2 * 30$---vol 147.26

Plate: L*B*H (cm)

=10* 1.5*1.5=22.5 147.26 +22.5=169.76

Al=169.76 *2.7=458g+20% Extra-91.6 (Density-2.7 g/cm^3)Total Al 6082-600 gram

Table . Sample Composition of Percentage

	AL 6082 (%)	Zr O2 (%)	BORON CARBIDE (%)	Graphite (%)
0	100	0	0	0
I	96	2	1	1
I I	93	4	2	1
I I I	90	6	3	1

Table Sample Composition of Mass Fraction

s	AL 6082 (gm)	ZrO2 (gm)	bic (gm)	gr (gm)
A	600	0	0	0
B	576	12	6	6
C	558	24	12	6
D	540	36	18	6

HEAT TREATMENT

Heat Treatment is one method used to improve the mechanical and physical properties of an aluminum casting. Heat Treatment consists of the heating and cooling of a casting in a controlled and specified manner, which does not change or affect the shape of a casting. Heat Treatment not only improves the strength, hardness and electrical conductivity of an aluminum casting but it also helps to improve other manufacturing processes such as machining. Heat Treatment must be conducted in properly designed furnaces that provide the internal thermal conditions and temperature controls to meet strictly specified guidelines and controls.

THE STAGES OF HEAT TREATMENT

Solution Heat Treatment - consists of heating an aluminum alloy casting to a high temperature for a desired amount of time. After the casting is heated to a high temperature it is rapidly quenched, by immersing the entire casting in a water or water glycol solution. This process is usually done to increase the strength of a casting.

In this project solution heat treatment process were followed.

Fig 5.2 Muffler furnace

Artificial Aging – consists of heating an alloy for an extended amount of time. During the Artificial Aging process the castings are heated for a specified period oftime but to a much lower temperature ten the Solution Heat Treatment process.

By maintaining the heating process for an extended amount of time the grain structure is refined, producing much greater strength properties of the castings. Artificial Aging is used to create a harder casting.

The Artificial Aging speeds up the process of aging of a casting that would normally occur naturally over several years.

MECHANICAL TEST

INTRODUCTION OF HARDNESS

There are three types of tests used with accuracy by the metals industry; they are the Brinell hardness test, the Rockwell hardness test, and the Vickers hardness test. Since the definitions of metallurgic ultimate strength and hardness are rather similar, it can generally be assumed that a strong metal is also a hard metal. The waythe three of these hardness tests measure a metal's hardness is to determine the metal's resistance to the penetration of a non-deformable ball or cone. The tests determine the depth which such a ball or cone will sink into the metal, under a givenload, within a specific period of time. The followings are the most common hardnesstest methods used in today`s technology

ROCKWELL HARDNESS TEST

Rockwell Hardness

1. Rockwell Hardness systems use a direct readout machine determining the hardness number based upon the depth of penetration of either a diamond point or asteel ball. Deep penetration indicated a material having a low Rockwell Hardness number.

2. However, a low penetration indicates a material having a high Rockwell Hardness number. The Rockwell Hardness number is based upon the difference in the depth to which a penetrator is driven by a definite light or “minor” load and a definite heavy or “Major” load.

3. The ball penetrators are chucks that are made to hold 1/16” or 1/8” diameter hardened steel balls. Also available are ¼” and ½” ball penetrators for the testing ofsofter materials.

4. There are two types of anvils that are used on the Rockwell hardness testers. Theflat faceplate models are used for flat specimens. The “V” type anvils hold round specimens firmly.

5. Test blocks or calibration blocks are flat steel or brass blocks, which have been tested and marked with the scale and Rockwell number. They should be used to check the accuracy and calibration of the tester frequently.

Fig 6.2 Hardness specimen

Using the “B” Scale;

a. Use a Diamond indenter

b. Major load: 100 Kgf, Minor load: 10 Kg

c. Use for alloy metal.

d. Do not use on hardened steel

RESULT

HARDNESS VALUE

Table: Hardness value

S	Material	HRB
A	Al6082-100%	62
B	2%-ZrO_2 + 1% B_4C +1%Gr Remaining Al-6082	65
C	4%-ZrO_2 + 2% B_4C +1%Gr Remaining Al-6082	68
D	6%-ZrO_2 + 3% B_4C +1%Gr Remaining Al-6082	71

HARDNESS TEST GRAPH

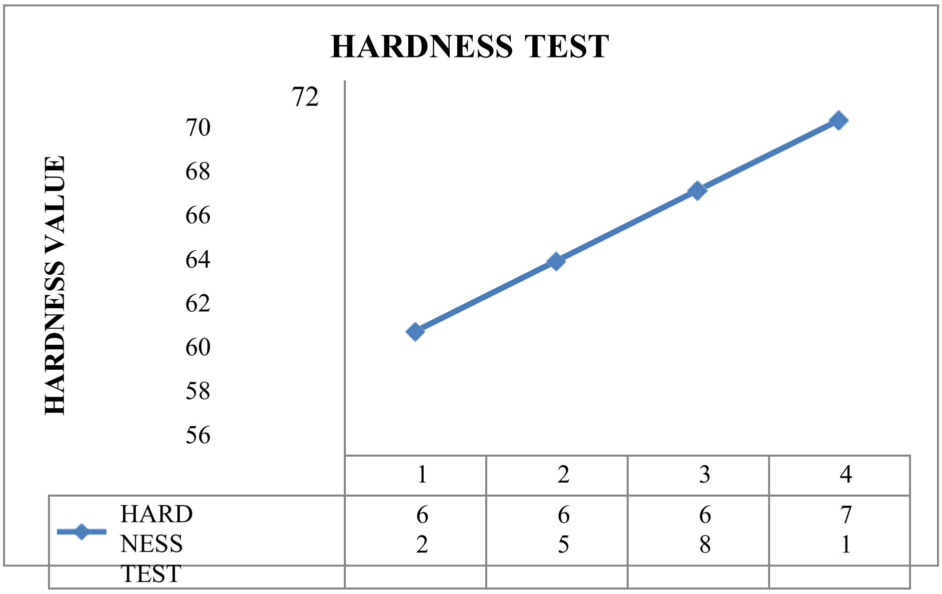


Fig Sample Vs Hardness Strength

CONCLUSION & FUTURE WORKS

Composite materials especially Aluminum 6082 and Zirconium oxide, Boron carbide & Graphite composites having good mechanical properties compared with the conventional materials. It is used in various industrial applications these materials having light weight along with high hardness. The material and the casting ratio were selected, based on the literature survey and getting some idea from the experts. Materials were purchased, according to the standards, and material casted as per the dimension. Sample 4 shows highest hardness value 71HRB.Highly reinforced composites show higher variations due to the agglomeration of particles

In **Phase-II** the following test are going to do to check the mechanical characteristics of the material. The tests are

1. Impact test
2. Density test.
3. Publish paper in a reputed Journal.

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