

# International Journal of Innovative Research in Science, Engineering and Technology

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## Fabrication of Al 6082, SiC and Boron Glass Powder Composites and Evaluation of Mechanical Properties

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**ABSTRACT:** The project is mainly focused to study the properties of Aluminium (Al) matrix composite material and to improve various properties compared to the existing Al 6082 metals. Fabrication of composite material (Al 6082 alloy with the reinforcement of silicon carbide (SiC) and boron glass powder) in different compositions has been made by using stir casting technique. The mechanical properties value of cast composite material was measured using the computerized universal testing machine, Rockwell hardness test and surface roughness tester SRG-4500 to find its tensile strength, the percentage of elongation, hardness and surface roughness. Finally, select the best reinforcement composite material from tensile test, Rockwell hardness test and surface roughness test values of measured. This composite can be used for making trusses, frames and containers which are used to store chemicals, milk and other corrosive liquids it can replace stainless steel which is used in a salty environment to avoid corrosion.

**KEYWORDS:** Composite, Stir Casting Technique, Universal Testing Machine, Rockwell Hardness Test and Surface Roughness Tester

### I. INTRODUCTION

History is often marked by the materials and technology that reflect human ability and understanding. The recognition of the potential energy savings that can be achieved by spending the advanced composites, which in turn means reduced cost and greater efficiency, was responsible for this advancement in the technology of reinforcements, matrices and fabrication of composites [1]. Composite materials are emerging chiefly in response to unprecedented needs from technology due to rapidly advancing activities in aircrafts, aerospace and automotive industries. These materials have low specific gravity that makes their properties, particularly superior in strength and modulus to many traditional engineering materials such as metals. As a result of intensive studies into the fundamental nature of materials and better understanding of their structure property relationship, it has become possible to develop new composite materials with improved physical and mechanical properties [2]. Metal Matrix Composites (MMCs) are composed of a metallic matrix (aluminium, magnesium, iron, cobalt, copper) and a dispersed ceramic (oxides, carbides) or metallic (lead, tungsten, molybdenum) phase [3]. Metal matrix composites in general, consist of at least two components, one is the metal matrix and the second component is reinforcement. The matrix is defined as a metal in all cases, but a pure metal is rarely used as the matrix. It is generally an alloy. In the productivity of the composite, the matrix and the reinforcement are mixed together [4]. Al alloys are alloys in which Al is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon and zinc. There are two principal classifications, namely casting alloys and wrought alloys. 6000 series are alloyed with magnesium and silicon are easy to machine and can be precipitation hardened. [5] Studied about the properties of Al and SiC: In this Al and SiC composite containing 0.0%, 0.10%, 0.15% and 0.20% SiC with particle size 0.220  $\mu\text{m}$  were fabricated by modifying stir casting technique.

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The addition of SiC in A.384.1, Al Alloy was found to increase mechanical properties such as hardness, proof stress and ultimate tensile strength with respect to unreinforced Al Alloy. [6] Discusses machinability of Al-6082: This paper presents the results of an experimental investigation on the machinability of Al-6082 reinforced with Al<sub>2</sub>O<sub>3</sub> and/or B<sub>4</sub>C (MMC) prepared by stir casting. These composites were characterized by microhardness analysis. [7] Discussed the mechanics of failure of silicon carbide fiber-reinforced glass-matrix composites: Tensile and bending tests have been performed on a high strength silicon carbide fiber reinforced glass matrix composite. The experimental results indicate that the strength of the composite component is strongly dependent on the geometry and loading. [8] Studied about the low velocity impact tests of laminate glass fiber epoxy matrix composite material plates: This work deals with the characterization of composite material suitable for constructing structural parts devoted to dissipate kinetic energy during impacts. In particular glass fiber epoxy matrix laminates are considered, both with unidirectional layers and with woven layers stacking, with three different layers orientations.

From this study inferred that Al alloys are used in modern engineering applications and mechanical properties are improved by adding SiC and Boron class powder as reinforcement to Al 6082. So, this paper presents fabrication of Al 6082, SiC and boron glass powder composites prepared by stir casting and evaluation of mechanical properties.

## II. EXPERIMENTAL DETAILS

The experiment was carried out by preparing of Al 6082 with the addition of varying weight percentage composition of SiC and boron glass powder particles of different percentage composition by stir casting technique. The mechanical properties were tested under laboratory conditions and the change in mechanical properties was taken into consideration. The aim of the experiment was to study the effect of variation of the percentage composition to predict the mechanical properties.

### A. Selection of materials:

Al 6082 is a medium strength alloy with excellent corrosion resistance. It has the highest strength of the 6000 series alloys [9]. As a relatively new alloy, the higher strength of 6082 has seen it replace 6061 in many applications. The addition of a large amount of manganese controls the grain structure which in turn results in a stronger alloy. The extruded surface finish is not as smooth as other like strength alloys in the 6000 series. Al 6082 is the most multiuse of all the medium strength alloys with good mechanical properties, corrosion resistance, weldability and machinability [10].

Table 1. Chemical Composition of Al 6082

| Elements    | Mn        | Fe         | Mg        | Si        | Cu       | Zn       | Ti       | Cr       | Residuals | Al      |
|-------------|-----------|------------|-----------|-----------|----------|----------|----------|----------|-----------|---------|
| Weight in % | 0.40-1.00 | 0.0 – 0.50 | 0.60-1.20 | 0.70-1.30 | 0.0-0.10 | 0.0-0.20 | 0.0-0.10 | 0.0-0.25 | 0.0-0.15  | Balance |

Table 2. Mechanical Properties of Aluminium Alloy 6082

| Property | Proof Stress    | Tensile Strength | Vickers Hardness | Elongation  |
|----------|-----------------|------------------|------------------|-------------|
| Value    | 290 Typical MPa | 340 Typical MPa  | 140 Typical HB   | A50 6 Min % |

Silicon Carbide is also known as carborundum, is a compound of silicon and carbon with chemical formula SiC. It occurs in nature as the extremely rare mineral moissanite. Silicon carbide powder has been mass produced since 1893 for use as an abrasive. Grains of silicon carbide can be bonded together by sintering to form very hard ceramics which are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plates in bulletproof vests [11]. SiC materials exhibit good erosion and abrasive resistance; these properties can be utilized in a variety of applications such as spray Nozzles, shot blast nozzles and cyclone Components.

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The boron glass powder is chemically resistant, has a low thermal expansion coefficient and can be used at relatively high temperatures. It is available in many forms and sizes such as rod, tube, plate and as machined or hot formed components.

### B. Fabrication:

Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) are mixed with a molten matrix metal by means of stirring. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies.

A stir casting setup consists of the preheater, electric furnace with stirrer assembly. Three phase electrical resistance type 10 KW capacity furnace is used. The temperature range of the furnace is 1000° C with a controlled accuracy of ± 10° C fitted with a digital temperature controller. The temperature range of preheater is about 800°C. The melting range of Al in 700°C - 800°C. A known quantity of Al 6082 ingots was pickled in 10% NaOH solution at room temperature for 10 minutes pickling was done to remove the surface impurities. The cleaned ingots after drying in the air were loaded into the crucible of the electric furnace for melting shown in fig 1. The different casting composition for Al 6082 composites is presented in Table 3.

Table 3 the different casting composition for Al 6082 Composites

| S. No | Sic wt% | Boron Glass Powder wt% | Al 6082 wt% |
|-------|---------|------------------------|-------------|
| 1.    | 2       | 1                      | 97          |
| 2.    | 2       | 3                      | 95          |
| 3.    | 4       | 3                      | 93          |
| 4.    | 4       | 5                      | 91          |
| 5.    | 6       | 5                      | 89          |
| 6.    | 6       | 7                      | 87          |



Fig 1. Stir casting equipment

Reason for choosing stir casting method,

1. The simplest and the most cost effective method of liquid state fabrication.
2. This liquid metallurgy technique is the most economical of all the available routes for metal matrix composite production.

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3. Also allows very large sized components to be fabricated.
4. The major merit of stir casting is its applicability to large quantity production.

### C. Tests Performed:

The tests performed on different types of specimens are as follows:

#### a. Tensile Test:

For tensile test first the specimens are machined as per the ASTM standard by using the milling machine. The specimens prepared as per the ASTM standard for the tensile test from the cast. The dimensions of the ASTM standard for the tensile test are shown in the figure 2. Then the machined specimens are taken for tensile test. The ultimate tensile strength (UTS) was estimated using a computerized universal testing machine shown in fig 3.

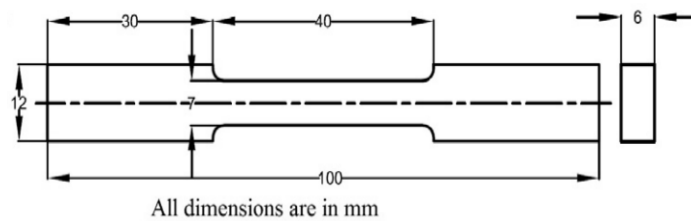


Fig.2 Dimensions of the ASTM standard for the tensile test



Fig.3 Computerized Universal Testing Machine

Table 4 Tensile Machine Specifications

|   |  |
|---|--|
| Machine Name                              | Tensile testing machine                      |
| Testing load range                        | Max 5 Ton                                    |
| Make                                      | Associated Scientific Engg. Works, New Delhi |
| Digital Encoder make                      | Auto Instruments – Kholapur                  |
| Gear rotation speed (for gradual loading) | 1.25, 1.5 & 2.5 mm /min                      |
| Software details                          | FIE make India                               |

By using this computerized universal tensile testing machine the specimens are tested. The tested specimens are shown in fig4.

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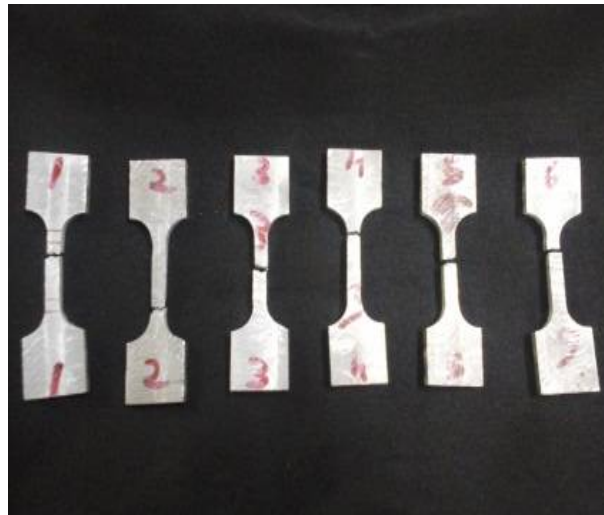


Fig. 4. Specimens after tensile test

### b. Rockwell hardness test

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting. This test method expressing the relationship between hardness and the size of the impression.

Table 5. Rockwell scale used

| Scale | Abbreviation | Load    | Indenter  | Use                              |
|-------|--------------|---------|---|----------------------------------|
| B     | HRB          | 100 kgf | $\frac{1}{16}$ inch diameter<br>(1.588 mm) steel sphere | Aluminium, brass and soft steels |

The scale B indicates the position of indenter during major load. It is important to keep the surface finish clean and decarburization from heat treatment should be removed.

### c. Surface roughness tester

The SRG-4500 is the latest addition to our growing line of precision surface roughness testers and profilometers. This surface roughness tester is extremely sensitive and highly accurate readings from the SRG-4500 Phase II surface roughness tester are offered via 15 popular surface roughness scales including Ra, Rq (Rms), Rt, Rz and Rmax. The most popular parameter is "Ra". Ra is commonly defined as the arithmetic average roughness. While the Ra parameter is easy and efficient, there are other parameters that can be more specific and useful depending on the application requirements.

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## III. RESULTS AND DISCUSSIONS

### A. Tensile test result:

Tensile test result of various combinations of matrix and reinforcement materials in weight percentage is shown in the table 6.

Table 6. Tensile Test Result

| Samples | Ultimate Stress KN/mm <sup>2</sup> | Yield stress KN/mm <sup>2</sup> | Elongation% |
|---------|------------------------------------|---------------------------------|-------------|
| 1.      | 0.159                              | 0.132                           | 1.880       |
| 2.      | 0.170                              | 0.141                           | 2.880       |
| 3.      | 0.175                              | 0.155                           | 3.080       |
| 4.      | 0.198                              | 0.190                           | 3.880       |
| 5.      | 0.204                              | 0.192                           | 4.240       |
| 6.      | 0.207                              | 0.194                           | 4.726       |

The tensile property of Al 6082 is increased by the addition of SiC and Boron Glass Powder. The relation between different weight percentage samples of SiC and boron glass powder reinforcement particulates and tensile of fabricated. SiC and boron glass powder particles are very effectual in improving the tensile strength of the 159 MPa to 207 MPa.

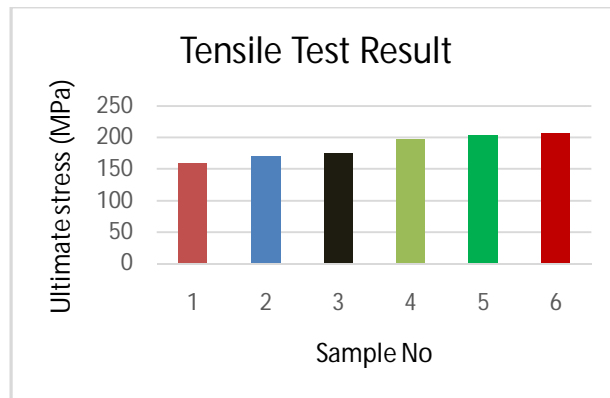


Fig. 5. Tensile Test Result

### B. Rockwell hardness test

The Rockwell hardness test result of various combinations of matrix and reinforcement materials in weight percentage is shown in the table 7.

Table 7 Rockwell Hardness Test Result

| S. No | SiC wt% | Boron Glass Powder wt% | Al 6082wt% | Rockwell hardness number | Average RHN |
|-------|---------|------------------------|------------|--------------------------|-------------|
| 1.    | 2       | 1                      | 97         | 11, 9 & 13               | 11          |
| 2.    | 2       | 3                      | 95         | 10.5, 12 & 11            | 11.67       |
| 3.    | 4       | 3                      | 93         | 14, 15 & 14              | 14.33       |
| 4.    | 4       | 5                      | 91         | 17, 16 & 16              | 16.33       |
| 5.    | 6       | 5                      | 89         | 15, 11 & 12.5            | 12.83       |
| 6.    | 6       | 7                      | 87         | 11.5, 10 & 11            | 10.83       |



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The hardness property of Al 6082 is maximum in specimen 4. The applied load was 100kg, penetrator 1/16” ball point and used scale was ‘B’ (red scale).

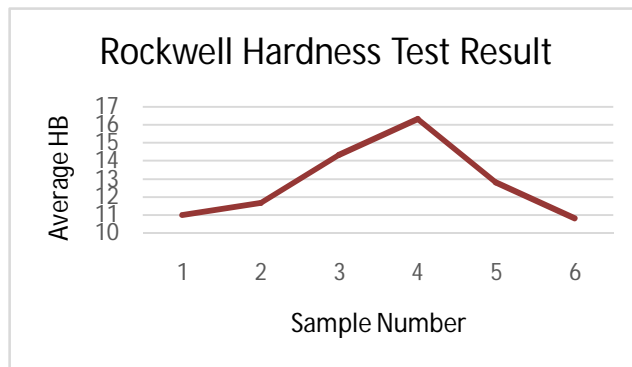


Fig. 6. Rockwell hardness Test Result

### C. Surface Roughness Tester Result:

The surface roughness test result for various combinations of matrix and reinforcement materials in weight percentage is shown in the table 8.

Table 8. Surface roughness Test Result

| Specimen no | Trial 1 | Trial 2 | Trial 3 | Average value $R_a$ ( $\mu\text{m}$ ) |
|-------------|---------|---------|---------|---------------------------------------|
| 1           | 0.34    | 0.57    | 0.19    | 0.36667                               |
| 2           | 0.48    | 0.61    | 0.55    | 0.54667                               |
| 3           | 0.77    | 1.40    | 0.71    | 0.96000                               |
| 4           | 1.56    | 1.07    | 0.96    | 1.19667                               |
| 5           | 1.38    | 0.65    | 1.40    | 1.14333                               |
| 6           | 0.92    | 0.85    | 0.89    | 0.88667                               |

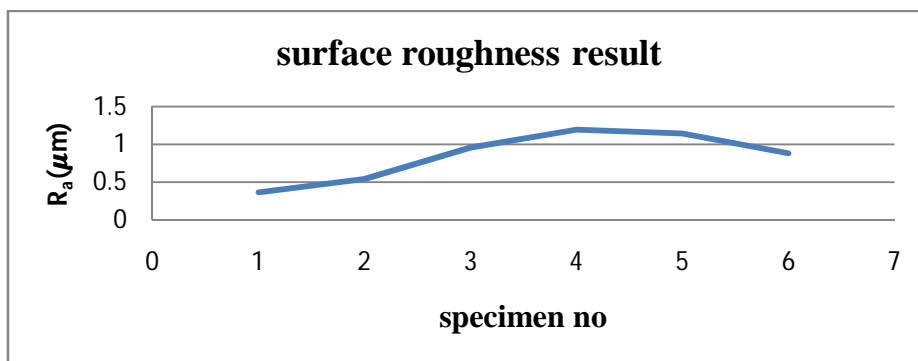


Fig. 7. Surface roughness Test Result

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## IV. CONCLUSION

Al 6082 alloy, SiC-Boron glass powder composites were produced by modified stir cast route with the different weight percentage of reinforcement and the mechanical properties such as tensile, hardness and roughness tests were evaluated. From this study, the following conclusions are derived.

- The reinforcement of particles has enhanced the tensile strength of aluminum matrix and composites from 159 MPa to 207 MPa. Tensile property is very important for any engineering components made of metal.

- The reinforcement of particles has enhanced the hardness of aluminum matrix and composites from 10.83 HB to 16.33 HB.

- The surface roughness test result of various combinations of matrix and reinforcement materials in weight percentage is from 0.03667 to 1.19667.

The aim of this project is to improve various mechanical properties of the Al 6082 alloy which has moderate strength by reinforcing with SiC and boron glass powder and the results justify the objective. SiC is costlier when compared with boron glass powder which is abundantly available in cheap rate, so that both are used in combination to minimize the cost. Al 6082 has been replaced Al 6061 in many applications. Al 6082 is available in grades O, T4 and T6/T651. With the current project have enhanced the properties of ordinary Al 6082 O grade property to Al T6/ T651 property which reduces manufacturing cost very much. This Al 6082 reinforced with SiC and boron glass powder can be used for making trusses, frames and containers which are used to store chemicals, milk and other corrosive liquids it can replace stainless steel which is used in a salty environment to avoid corrosion.

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