An Extended Study for Analyzing the Composite Material (SiC)

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ABSTRACT
The material selection criteria involve the requirement of high strength and good corrosion resistance Al alloys for the matrix materials. Metal Matrix Composites (MMCs) have evoked a keen interest in recent times for potential applications in aerospace and automotive industries owing to their superior strength to weight ratio and high temperature resistance. Although several technical challenges exist with casting technology yet it can be used to overcome this problem. Achieving a uniform distribution of reinforcement within the matrix is one such challenge, which affects directly on the properties and quality of composite material. In the present study a modest attempt has been made to develop Al based silicon carbide particulate MMCs with an objective to develop a conventional low cost method of producing MMCs and to obtain homogenous dispersion of ceramic material. To achieve these objectives two step-mixing method of stir casting technique has been adopted and subsequent property analysis has been made. Al 6063, Al 6061, Al 6101 and SiC has been chosen as matrix and reinforcement material respectively. Experiments have been conducted by varying weight fraction of SiC (5%, 7% & 9%), while keeping all other parameters constant. The results indicated that the ‘developed method’ is quite successful to obtain uniform dispersion of reinforcement in the matrix. An increasing trend of hardness and impact strength with increase in weight percentage of SiC has been observed. The best results (maximum hardness 54 BHN) have been obtained at 25% weight fraction of SiC. The results were further justified by comparing with other % of metal matrix. After doing the procedure we perform the microstructure test, tensile test & brinnel hardness.

Key-Words: SiC, Composite, reinforced, monolithic
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1. INTRODUCTION
Israelites using bricks made of clay and reinforced with straw are an early example of application of composites. The individual constituents, clay and straw, could not serve the function by themselves but did when put together. Some believe that the straw was used to keep the clay from cracking, but others suggest that it blunted the sharp cracks in the dry clay. Significant examples include the use of reinforcing mud walls in houses with bamboo shoots, glued laminated wood by Egyptians (1500B.C.), and laminated metals in forging swords (AD. 1800). In the 20th century, modern composites were used in the 1930s when glass fibers reinforced resins. Boats and aircraft were built out of these glass composites, commonly called fiberglass. Since the 1970s, application of composites has widely increased due to development of new fibers such as carbon, boron and aramid and new composite systems with matrices made of metals and ceramics. This chapter gives an overview of composite materials.

Composite
A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. Metal matrix composites (MMCs), as the name implies, have a metal matrix. Examples of matrices in such composites include aluminum, magnesium, and titanium. Typical fibers include carbon and silicon carbide. Metals are mainly reinforced to increase or decrease their properties to suit the needs of design. For example, the elastic stiffness and strength of metals can be increased and large coefficients of thermal expansion and thermal and electric conductivities of metals can be reduced, by the addition of fibers such as silicon carbide.

Advantages of metal matrix composites
Metal matrix composites are mainly used to provide advantages over monolithic metals such as steel and aluminum. These advantages include higher specific strength and modulus by reinforcing low-density metals, such as aluminum and titanium; lower coefficients of thermal expansion by reinforcing with fibers with low coefficients of thermal expansion, such as graphite; and maintaining properties such as strength at high temperatures. MMCs have several advantages over polymer matrix Composites. These include higher elastic properties; higher service temperature; insensitivity to moisture; higher electric and thermal conductivities; and better wear, fatigue, and flaw resistances.
2. LITERATURE SURVEY
The earliest known composite armour for armoured vehicles was developed as part of the US Army's T95 experimental series from the mid-1950s. The T95 featured "siliceous-cored armor" which contained a plate of fused silica glass between rolled steel plates. In 1937 when salesmen from the Owens Corning Fiberglass Company began to sell fiberglass to interested parties around the United States. Fiberglass had been made, almost by accident in 1930, when an engineer became intrigued by a fiber that was formed during the process of applying lettering to a glass milk bottle. The Owens Corning Fiberglass Company was formed in 1935 by Owens-Illinois and Corning Glass. A Japanese company (Nitto Boseki) had also made fiberglass and was attempting to market the fibers in Japan and the United States. The initial products for this finely drawn molten glass were as insulation (glass wool) but structural products soon followed.

The fiberglass salesmen realized that the aircraft industry was, in particular, a likely customer for this new material because the many small and vigorous aircraft companies seemed to be creating new aircraft designs and innovative concepts in manufacturing almost daily with many of these innovations requiring new materials. One company, Douglas Aircraft, bought the first roll of fiberglass shipped to the west coast because they believed that the fiberglass would help them solve a production problem. They had a bottleneck in the making of metal molds for their sheet metal forming process. Each changed aircraft design needed new molds and metal molds were expensive and had long lead times. Douglas engineers tried using cast plastic molds, but they could not withstand the forces of the forging process. Maybe if the plastic molds were reinforced with fiberglass they would be strong enough to allow at least a few parts to be made so that the new designs could be quickly verified. If the parts proved to be acceptable, then metal dies could be made for full production runs. In collaboration with Owens Corning Fiberglass, dies were made using the new fiberglass material and phenolic resin Peroxide curing systems were already available with benzoyl peroxides being patented in 1927, lauroyl peroxide in 1937, and many other peroxides following not too long afterward. Higher performance resin systems also became available about this time with the invention of epoxies in 1938. The materials and the applications seemed to be converging at the same time. Several innovative manufacturing methods were also developed in the late 1940's and early 1950's including pultrusion (by Goldsworthy), vacuum bag molding, and large-scale filament winding.

3. OBJECTIVE
These are the following objective of the project
1. To develop the Al metal matrix composite with silicon carbide at different percentage.
2. Microstructure of the specimen.
3. Brinell hardness test of the specimen.
4. Tensile test of the specimen.
5. Load-Displacement diagram of the specimen.

4. METHODOLOGY
1. Materials:
   - Different grade of Al
     - Al 6063
     - Al 6101
     - Al 6061
   - Silicon Carbide (powder form)
   - Coal
2. Apparatus:
   - Furnace
   - Safety Device
   - Moulding Device
   - Electronic Weight Machine
3. Procedure:
   - Preparation of the moulding sand.
   - Making of the mould cavity.
   - Charge preparation by the stir casting process.
   - Pouring the melt metal (Al & SiC) in the mould cavity.
   - Final rod of composite material.
OBSERVATION TABLE

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Material</th>
<th>Specimen Wt. (gm)</th>
<th>Slag &amp; Wastage (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Al 6063+5% Sic</td>
<td>693</td>
<td>223</td>
</tr>
<tr>
<td>2</td>
<td>Al 6063+7% Sic</td>
<td>717</td>
<td>217</td>
</tr>
<tr>
<td>3</td>
<td>Al 6063+9% Sic</td>
<td>733</td>
<td>343</td>
</tr>
<tr>
<td>4</td>
<td>Al 6101+5% Sic</td>
<td>567</td>
<td>137</td>
</tr>
<tr>
<td>5</td>
<td>Al 6101+7% Sic</td>
<td>578</td>
<td>128</td>
</tr>
<tr>
<td>6</td>
<td>Al 6101+7% Sic</td>
<td>601</td>
<td>120</td>
</tr>
<tr>
<td>7</td>
<td>Al 6061+5% Sic</td>
<td>819</td>
<td>419</td>
</tr>
<tr>
<td>8</td>
<td>Al 6061+7% Sic</td>
<td>843</td>
<td>193</td>
</tr>
<tr>
<td>9</td>
<td>Al 6061+7% Sic</td>
<td>862</td>
<td>402</td>
</tr>
</tbody>
</table>

**5. CALCULATION AND ANALYSIS**

**Brinell Hardness**

The Brinell hardness test is commonly used to determine the hardness of materials like metals and alloys. The test is achieved by applying a known load to the surface of the tested material through a hardened steel ball of known diameter. The diameter of the resulting permanent impression in the tested metal is measured and the Brinell Hardness Number is calculated as:

\[ \text{BHN} = \frac{2P}{\pi D (D - (D^2 - d^2)^{1/2})} \]

Where

- \( \text{BHN} = \) Brinell Hardness Number
- \( P = \) load on the indenting tool (kg)
- \( D = \) diameter of steel ball (mm)
- \( d = \) measure diameter at the rim of the impression (mm)
- \( \text{Load of the indenting tool (250kg)} \)
- \( \text{Diameter of the steel ball (5mm)} \)

**Observation table of BHN test**

<table>
<thead>
<tr>
<th>Material</th>
<th>5% Sic</th>
<th>7% Sic</th>
<th>9% Sic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al 6063</td>
<td>47</td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>Al 6061</td>
<td>52</td>
<td>44</td>
<td>47</td>
</tr>
<tr>
<td>Al 6101</td>
<td>40</td>
<td>56</td>
<td>44</td>
</tr>
</tbody>
</table>

**Tensile Test**

Tensile strength measures the force required to pull something such as rope, wire, or a structural beam to the point where it breaks. The tensile strength of a material is the maximum amount of tensile stress that it can be subjected to before failure. Fig shows the 50 tonne UTM on which hardness test is performed.

**Observation table of Tensile Test**

<table>
<thead>
<tr>
<th>Material</th>
<th>Ultimate Tensile Strength (MPa)</th>
<th>Yield Stress (MPa)</th>
<th>Elongation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al 6063+5% Sic</td>
<td>104.1</td>
<td>79.6</td>
<td>5.6</td>
</tr>
<tr>
<td>Al 6063+7% Sic</td>
<td>114.6</td>
<td>85.1</td>
<td>5.6</td>
</tr>
<tr>
<td>Al 6063+9% Sic</td>
<td>120</td>
<td>91.2</td>
<td>6.8</td>
</tr>
<tr>
<td>Al 6101+5% Sic</td>
<td>81.9</td>
<td>59.9</td>
<td>5</td>
</tr>
<tr>
<td>Al 6101+7% Sic</td>
<td>93.5</td>
<td>69.2</td>
<td>6.8</td>
</tr>
<tr>
<td>Al 6101+9% Sic</td>
<td>104.1</td>
<td>79.6</td>
<td>5.6</td>
</tr>
</tbody>
</table>

**CALCULATION**

Let us take the example of Al 6063+5% Sic

Given Data: \( \text{Dia.} = 10.30 \text{m} \)

Area \( A = \frac{\pi d^2}{4} = \frac{\pi}{4} (10.30)^2 = 83.28 \text{ mm}^2 \)

Gauge Length \( = (5.65) \times \sqrt{1/2} \)

\( = (5.65) \times 83.28^{1/2} = 51.3 \text{ mm} \)

Elongation\( (%) = \frac{\text{Elongated Length} - \text{Gauge Length}}{\text{Gauge Length}} \times 100 \)

\( = \frac{51.3 - 50.0}{50.0} \times 100 = 2.6\% \)
6. TESTING OF MICROSTRUCTURE SPECIMENS:

Procedure for testing the Microstructure of specimen
1. Polishing the specimen with the use of immery paper of grain size (60-800).
2. Use the diamond paste with following grades in order 15 micron, 10 micron, 8 micron, 5 micron, 3 micron, 2 micron, 1 micron.
3. Use the etching agent of 0.5% HF (hydrofluoric acid) + 99.5% Distilled water.
4. Then find the microstructure of 100X magnification.

MICROSTRUCTURE OF SPECIMEN

1. Al6063+5% SiC

2. Al6063+7% SiC

3. Al6063+9% SiC

4. Al6101+5% SiC

5. Al6101+7% SiC

6. Al6101+9% SiC

7. Al6061+5% SiC

8. Al6061+7% SiC

9. Al6061+9% SiC

7. RESULT AND CONCLUSION

a) In the hardness test that when the concentration of the SiC increase the hardness of our specimens also increasing.

b) In microstructure photograph that the density of SiC in specimens is increasing as increase the % of SiC.
c) As the concentration of SiC is increases the voids and crack hole are also decreases and hence increase the strength of material.

Composite materials are used where high strength to weight ratio is required. These materials are used in:

1. Automobiles
2. Aerospace
3. Marines

Al and SiC metal matrix composite is an engineering Material yet such in the modern demand and important of this seemingly simple engineering material is continuing to develop new to meet the exacting and ever increasing requirement of present day technology.

REFERENCES

2. Book of Material Science by O P Khanna
3. Book of Composite materials and Structure by P.K Sinha
5. SPECTRO Analytical Labs Limited