Fabrication and Characterization of Al 7075-Cenosphere Composite & its comparison with pure Al 7075

Vikrant Chandel \(^1\), Onkar Singh Bhatia \(^2\)
Research Scholar, Dept. of Mechanical Eng, Green Hills Eng. College, Solan, India.
Associate Professor, Dept. of Mechanical Eng, Green Hills Eng. College, Solan, India.

**Abstract**— In this paper, the various methods of fabrication & characterization of Al 7075 cenosphere composite & its comparison with pure Al 7075 alloy are discussed. Composites are most successful & widely used materials used now a days in the various types of industries as these exhibit significantly improved properties including low density, high tensile strength, toughness, good wear resistance & hardness as compared to alloys or any other metal. There has been an increasing interest in composites consisting of reinforcements having low density and low cost. Al 7075 alloy as matrix and cenosphere as reinforcement has been used widely since it has various applications in aircraft and space industries because of wear resistance, lower weight to strength ratio and creep resistance. Among various reinforced materials used, Cenosphere, is one of the cheapest & low density reinforcement which is available as waste product after the coal has been burnt in thermal power plants. Hence Al 7075 metal matrix with cenosphere as reinforcement can easily overcome the cost barrier & can serve as best supplement having different physical and mechanical properties for serving a wide range of applications offering wide use in the today’s world.

**Keywords**— Composite, Fabrication, Cenosphere, Reinforcements.

I. INTRODUCTION

The composite materials are mostly used materials having the advantage of achieving good combination of various properties like density, strength, toughness & stiffness. Conventional materials had certain limited fields of applications. For certain applications, the use of composites instead of metals has resulted in savings of both cost and weight. Composites are now increasingly used for rehabilitation & strengthening of pre-existing structures that have to be retrofitted to make them seismic resistant, or to repair any damages. Increasingly enabled by the introduction of newer resin matrix materials like polymer and reinforcement fibres of glass, carbon and aramid possessing high performance, the penetration of these advanced materials has led to a steady expansion in uses and volume. The increased volume has resulted in an expected reduction in costs. Calculation of high performance FRP can now be done in such diverse applications as composite armoring designed to resist explosive impacts, support beams of highway bridges, fuel cylinders for natural gas vehicles, windmill blades, industrial drive shafts, support beams of highway bridges. Above all composites have already proven their worth as weight-saving materials.

II. COMPONENTS OF A COMPOSITE MATERIAL

In its most basic form a composite material is defined as which is composed of two different elements combined together to produce a new material having properties that are different from the properties of parent elements. In actual, most composites consist of a bulk material (the ‘matrix’), and some kind of reinforcement, added to increase the stiffness and strength of the matrix.

A. METAL MATRIX COMPOSITE

In general, metal matrix composites consist of 2 components, metal matrix and the reinforcement. The matrix is defined as a metal, but a pure metal is rarely used as the matrix. It is generally an alloy. The matrix and the reinforcement are mixed together in the production of the composite.

Now a day’s, research all over the world is concentrating mainly on Aluminium because of its unique combination of low density, good corrosion resistance and improved mechanical properties. The unique thermal properties of Aluminium composites such as metallic conductivity with coefficient of expansion that can be brought to zero, add to their prospects in aerospace and avionics.

B. CENOSPHERE AS A REINFORCEMENT

Among various reinforced materials used, cenosphere, is one of the cheapest & low density reinforcement which is available as waste product after the coal has been burnt in thermal power plants. Hence composites of Al 7075 with cenosphere as reinforcement can easily overcome the cost barrier & can serve as best supplement having different physical and mechanical properties for wide use in the today’s world & serve a wide range of applications.

III. OBJECTIVE OF THE PRESENT WORK

Objective of this work is to fabricate the Al 7075-Cenosphere composite by using stir-casting technique. This approach involves mechanical mixing of the reinforcement particulate into a molten metal bath and transferring the mixture directly into a shaped mould prior to complete solidification. In this technique...
aluminium alloy 7075 ingot pieces are to be heated in the furnace to its molten state. When the temperature is maintained between 800-850°C, a vortex will be created using a mechanical stirrer. Cenosphere particles are to be preheated in the furnace. The temperature of the furnace is maintained between 825-850°C. Preheated cenosphere particles are to be added to the melt when the stirring is in progress. Stirring is continued for about 15 min after addition of cenosphere particles for uniform distribution in the melt. Castings are prepared by pouring the melt into preheated moulds of cylindrical shapes. Then these specimens are to be tested for wear & various other mechanical & electrical properties & to be compared with pure Al 7075.

IV. COMPOSITE PREPARATION

The matrix used in this work is aluminium alloy 7075 (density 2.73gm/cc). The fly ash cenosphere having particle size 60 µm was used as filler material or reinforcement.

Composite is prepared by stir casting technique. Stir-casting technique is currently the simplest and most commercial method of producing MMCs. The basic approach involves mixing of the reinforcement particulate into a molten metal bath mechanically and transferring the mixture directly to a shaped mould so as to allow complete solidification to occur. In this technique aluminium alloy 7075 ingot pieces were heated in the furnace to its molten state. When the temperature is maintained between 800-850°C, a vortex was created using a mechanical stirrer. Cenosphere particles were preheated in the furnace. The temperature of the furnace is maintained between 825-850°C. Preheated cenosphere particles were added to the melt when the stirring was in progress. Stirring is continued for about 15 min after addition of cenosphere particles for uniform distribution in the melt. Castings were fabricated by pouring the molten metal into preheated moulds of cylindrical shapes.

V. CHARACTERIZATION TECHNIQUES

1. MECHANICAL CHARACTERIZATION

• DENSITY AND VOID FRACTION

The density of the composite can be calculated using rule-of-mixture as shown in the following expression Agarwal and Broutman.

\[ \rho_{\text{Composite}} = \frac{\rho_m W_m + \rho_p W_p}{W_m + W_p} \]

Where, W and \( \rho \) represents the weight fraction and density respectively. The suffix m, and p stand for the matrix and particulate filler respectively. The actual or experimental density \( \rho_{\text{exp}} \) of the composite, however, can be determined by simple water immersion technique (Archimedes principle). The volume fraction of voids \( (V_v) \) in the composites is calculated using the following equation:

\[ V_v = \frac{(\rho_{\text{act.}} - \rho_{\text{exp}})}{\rho_{\text{exp}}} \]

Table 1 Composite designations and their experimental and theoretical densities

<table>
<thead>
<tr>
<th>Composite designation</th>
<th>Composite composition</th>
<th>Experimental density (g/cm³)</th>
<th>Theoretical density (g/cm³)</th>
<th>Void Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td>Pure Al7075</td>
<td>2.76</td>
<td>2.80</td>
<td>0.01441</td>
</tr>
<tr>
<td>Sample A</td>
<td>Al7075 + 3wt% Cenosphere</td>
<td>2.73</td>
<td>2.77</td>
<td>0.01465</td>
</tr>
<tr>
<td>Sample B</td>
<td>Al7075 + 6wt% Cenosphere</td>
<td>2.69</td>
<td>2.73</td>
<td>0.01487</td>
</tr>
<tr>
<td>Sample C</td>
<td>Al7075 + 9wt% Cenosphere</td>
<td>2.60</td>
<td>2.70</td>
<td>0.03846</td>
</tr>
</tbody>
</table>

Volume fraction of voids is small in the composite having 3wt% Cenosphere and increases when the percentage of cenosphere increases in the composite.

• TENSILE STRENGTH

The results of tensile tests are used in selecting materials for engineering applications. Tensile properties often are used to predict the behavior of a material under forms of loading.

Figure 1 Stir-Casting method

Figure 2 Tensile Test Specimen before testing

Figure 3 Tensile Test Specimen after testing
Table 2 Tensile Strength of different samples

<table>
<thead>
<tr>
<th>Composite designation</th>
<th>Composite composition</th>
<th>Tensile Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td>Pure Al7075</td>
<td>250</td>
</tr>
<tr>
<td>Sample A</td>
<td>Al7075 + 3wt% Cenosphere</td>
<td>140</td>
</tr>
<tr>
<td>Sample B</td>
<td>Al7075 + 6wt% Cenosphere</td>
<td>118</td>
</tr>
<tr>
<td>Sample C</td>
<td>Al7075 + 9wt% Cenosphere</td>
<td>40</td>
</tr>
</tbody>
</table>

It is clear that the tensile strength of the composite material decreases when the percentage of the filler loading is increased.

![Figure 4 Variation of tensile strength of composite material](image)

Table 3 Strength of different samples

<table>
<thead>
<tr>
<th>Composite designation</th>
<th>Composite composition</th>
<th>Flexural Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td>Pure Al7075</td>
<td>89</td>
</tr>
<tr>
<td>Sample A</td>
<td>Al7075 + 3wt% Cenosphere</td>
<td>95</td>
</tr>
<tr>
<td>Sample B</td>
<td>Al7075 + 6wt% Cenosphere</td>
<td>105</td>
</tr>
<tr>
<td>Sample C</td>
<td>Al7075 + 9wt% Cenosphere</td>
<td>110</td>
</tr>
</tbody>
</table>

Flexural strength increases on increasing the filler loading of composite material.

![Figure 5 Variation of Flexural Loading (wt%)](image)

* FLEXURAL STRENGTH

The flexural strength of a composite is the maximum stress that it can withstand during bending before reaching the breaking point.

Table 4 Hardness for different samples

<table>
<thead>
<tr>
<th>Composite designation</th>
<th>Composite composition</th>
<th>Hardness No. (V.H.N.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td>Pure Al7075</td>
<td>176</td>
</tr>
<tr>
<td>Sample A</td>
<td>Al7075 + 3wt% Cenosphere</td>
<td>180</td>
</tr>
<tr>
<td>Sample B</td>
<td>Al7075 + 6wt% Cenosphere</td>
<td>186</td>
</tr>
<tr>
<td>Sample C</td>
<td>Al7075 + 9wt% Cenosphere</td>
<td>184</td>
</tr>
</tbody>
</table>

Hardness is the measure of how resistant solid matter is to various kinds of permanent shape change when a force is applied.

![Figure 6 Vicker’s Microhardness Tester](image)

![Figure 7 Indentation at 10X optical zoom](image)
Hardness increases on increase in filler % upto certain extent & then starts decreasing as shown in given graph.

2. Wear Characterization

Dry sliding wear tests for different number of specimens was conducted by using a pin-on-disc machine. It is a pin on disc type wear and friction monitor with facilities to monitor wear and friction under dry, lubricated and desired environmental condition.

Table 5 Parameter taken constant during sliding wear test

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Load</td>
<td>2 Kg.</td>
</tr>
<tr>
<td>Speed</td>
<td>1.6 m/s</td>
</tr>
<tr>
<td>Total Time</td>
<td>30 min.</td>
</tr>
</tbody>
</table>

Effect of different % of reinforcements on Weight Loss of M.M.C’s under Dry Sliding Condition:

A pin-on-disc tribometer is used to perform the wear experiment. The wear track, alloy and composite specimens are cleaned thoroughly with acetone prior to test. Each specimen is then weighed using a digital balance having an accuracy of ±0.0001 gm. After that the specimen is mounted on the pin holder of the tribometer ready for wear test.

Table 6 Weight loss of Samples under dry sliding condition

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Composition</th>
<th>Initial Weight (gm)</th>
<th>Final Weight (gm)</th>
<th>Weight Loss (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td>Pure Al7075</td>
<td>6.64630</td>
<td>6.62088</td>
<td>0.02542</td>
</tr>
<tr>
<td>Sample A</td>
<td>Al7075 + 3wt% Cenosphere</td>
<td>6.15920</td>
<td>6.13370</td>
<td>0.0255</td>
</tr>
<tr>
<td>Sample B</td>
<td>Al7075 + 6wt% Cenosphere</td>
<td>5.82509</td>
<td>5.80113</td>
<td>0.02396</td>
</tr>
<tr>
<td>Sample C</td>
<td>Al7075 + 9wt% Cenosphere</td>
<td>6.17206</td>
<td>6.15246</td>
<td>0.0196</td>
</tr>
</tbody>
</table>

As the reinforcement wt% increases, the weight loss of MMCs decreases. This happens may be due to either the proper dispersion of cenosphere into the matrix or due to the formation of strong interfacial bonding in between Al7075 alloy & Cenosphere composite. It is clear from the diagram that the maximum wt. loss is for sample A (Al7075 + 3wt% Cenosphere) & minimum wt. loss is for sample C (Al7075 + 9wt% Cenosphere).
Variation of wear loss of alloys with sliding time:

A pin-on-disc apparatus was used to perform the wear experiment. The wear track, alloy and composite specimens are cleaned thoroughly with acetone prior to each test. After that the specimen is mounted on the pin holder of the tribometer ready for wear test. For all experiments, the sliding speed is adjusted to 1.6 m/s, wear track diameter 60mm, load 2kg.

Table 7 Wear loss of MMCs and alloy Vs Time

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>300</th>
<th>600</th>
<th>900</th>
<th>1200</th>
<th>1500</th>
<th>1800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear loss</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample</td>
<td>68.98</td>
<td>142.66</td>
<td>192.01</td>
<td>232.02</td>
<td>268.04</td>
<td>302.2</td>
</tr>
<tr>
<td>Sample A</td>
<td>64.88</td>
<td>132.98</td>
<td>189.86</td>
<td>235.48</td>
<td>281.78</td>
<td>308.5</td>
</tr>
<tr>
<td>Sample B</td>
<td>138.55</td>
<td>163.41</td>
<td>189.14</td>
<td>215.17</td>
<td>243.84</td>
<td>270.19</td>
</tr>
<tr>
<td>Sample C</td>
<td>44.24</td>
<td>78.88</td>
<td>124.76</td>
<td>174.44</td>
<td>217.43</td>
<td>269.0</td>
</tr>
</tbody>
</table>

Figure 11 Weight losses of the Composites

Figure 12 Wear in Micrometers Vs Time in seconds of Samples

Graph shows the wear loss as a function of time for the Al alloy 7075 and composites reinforced with cenosphere particles at a constant load of 20 N and total time is 30 minute. It is observed that wear loss of Al alloy 7075 decreases after addition of Cenosphere particles. Material removal in a ductile material such as aluminium alloy matrix is due to the indentation and ploughing action of the sliding disc which is made from hard steel material.

Sliding Wear Rate performance of different samples at ambient temperature

Table 8 Wear rate of MMCs and alloy Vs Sliding Distance

<table>
<thead>
<tr>
<th>Sliding distance (m)</th>
<th>500</th>
<th>1000</th>
<th>1500</th>
<th>2000</th>
<th>2500</th>
<th>3000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear Rate X10^-3 (mm^3/m)</td>
<td>Sample</td>
<td>15.2882</td>
<td>8.7967</td>
<td>6.3692</td>
<td>5.0981</td>
<td>4.8193</td>
</tr>
<tr>
<td>Sample A</td>
<td>13.5954</td>
<td>8.0395</td>
<td>6.942</td>
<td>6.0082</td>
<td>5.6002</td>
<td>5.6087</td>
</tr>
<tr>
<td>Sample B</td>
<td>14.0122</td>
<td>8.3382</td>
<td>6.4671</td>
<td>5.5008</td>
<td>5.0136</td>
<td>4.7181</td>
</tr>
<tr>
<td>Sample C</td>
<td>7.8969</td>
<td>7.4129</td>
<td>6.625</td>
<td>6.2136</td>
<td>5.6657</td>
<td>5.4069</td>
</tr>
</tbody>
</table>

Figure 13 Variation of wear rate with sliding distance

S.E.M. analysis of different specimens

Scanning electron micrographs at lower magnification shows that the distribution of Cenosphere particulate throughout the MMCs. Following figure shows the homogeneous distribution of cenosphere particles in alloy matrix. Homogeneous distribution of particles is desired for achieving better wear behaviour and mechanical properties. Homogeneous distribution of particles in a molten
alloy is achieved due to the high shear rate caused by stirring which also minimize the particles settling. However, agglomeration of particles in some regions is clearly visible; this is due to the presence of porosity associated to it. Presence of entrapped air and moisture in the reinforcement particles results in the voids/porosity after casting.

(a) F.L. =3%, S.D. = 2000m

(b) F.L. =3%, S.D. = 3000m

(c) F.L. =6%, S.D. = 2000m

(d) F.L. =6%, S.D. = 3000m

VI. LITERATURE REVIEW

A. K. Dhingra (1986) [1], had derived that the composite structures have shown universally a savings of at least 20% over metal counterparts and a lower operational and maintenance cost. R.L. Trumper (1987) [2], stated that the researchers all over the world are focusing mainly on aluminium because of its unique combination of good corrosion resistance, low density and excellent mechanical properties. Mechmet Acilar, Ferhat Gul (2004) [3], have shown in their work that the choice of Silicon Carbide as the reinforcement in aluminium composite is primarily meant to use the composite in missile guidance system replacing certain beryllium components because structural performance is better without special handling in fabrication demanded by latter’s toxicity. A.Alahelisten (1996) [4], J.Q.Jiang (1996) [5], P.N.Bindhumadhan (2001) [6], stated that though their low density (35% lower than that of Al) makes them competitive in terms of strength/density values. Magnesium alloys do not compare favorably with aluminium alloys in terms of absolute strength. The reason for aluminium being a success over magnesium is said to be mainly due to the design flexibility, good wettability and strong bonding at the interface. S. Tjong (1997) [7], H.Z.Wang (1996) [8] & D.P.Mondal (2003) [9] concluded in their studies that the reinforcement inconsistency will persist because many of the aspect cited above in addition to contamination from processing equipment and feedstock may vary greatly. Since most ceramics are
available as particles, there is a wide range of potential reinforcements for particle reinforced composites. Ferdinand A.A. (1958) [10] & Elmer P. (1962) [11] have shown that the use of graphite reinforcement in a metal matrix has a potential to create a material with a high thermal conductivity, excellent mechanical properties and attractive damping behaviour at elevated temperatures. However, lack of wettability between aluminium and the reinforcement, and oxidation of the graphite lead to manufacturing difficulties and cavitations of the material at high temperatures.

Thakur R.S. (1975) [12], Harvath G (1975) [13] & Muralidhar J. (1977) [14] have shown that the alumina and other oxide particles like TiO2 etc. have been used as the reinforcing particles in Al-matrix. Alumina has received attention as reinforcing phase as it is found to increase the hardness, tensile strength and wear resistance of aluminium metal matrix composites. Aggarwal P.S. (1977) [15], Grigoreva.D. (1977) [16], Kudinov B.Z. (1977) [17], Pustilnik G.L. (1977) [18] & Zamb J. (1979) [19] have concluded that mica, alumina, silicon carbide, clay, zircon, and graphite have been widely used as reinforcements in the production of composites. Numerous oxides, nitrides, borides and carbides were studied by Zedalis as reinforcements for reinforcing high temperature discontinuously reinforced aluminium (HTDRA). It has been inferred from their studies that HTDRA containing TiC TiB2, B4C, Al2O3, SiC and Si3N4 exhibit the highest values of specific stiffness. Nikolaev (1983) [20], Stanescu N. (1990) [21], MinePet.Gaze & R. Mehrabian (1974) [22] proved that the ceramic particles are effective reinforcement materials in aluminium alloy to enhance the mechanical and other properties. The reinforcement in MMCs are usually of ceramic materials, these reinforcements can be divided into two major groups, continuous and discontinuous. The MMCs produced by them are called continuously (fibre) reinforced composites and discontinuously reinforced composites. However, they can be subdivided broadly into five major categories: continuous fibres, short fibres (chopped fibres, not necessarily the same length), whiskers, particulate and wire (only for metal). With the exception of wires, reinforcements are generally ceramics, typically these ceramics being oxides, carbides and nitrides. These are used because of their combinations of high strength and stiffness at both room and elevated temperatures. Common reinforcement elements are SiC, Al2O3, TiB2, boron and graphite.

J. Eliasson and R. Sandstorm (1995) [23], term fibre may be used for any material in an elongated form that has a minimum length to a maximum average transverse dimension of 10:1, a maximum cross sectional area of 5.1X10^-4 cm2 and a maximum transverse dimension of 0.0254 cm. Continuous fibers in composites are usually called filaments, the main continuous fibres includes boron, graphite, alumina and silicon carbide. The fibre is unique for unidirectional load when it is oriented in the same direction as that of loading, but it has low strength in the direction perpendicular to the fibre orientation. As regards cost, continuous fibres are about 200 times higher than discontinuous fibres. Therefore for specific purposes only, that continuous fibre is used. The other advantage of discontinuous fibres is that they can be shaped by any standard metallurgical processes such as forging, rolling, extrusion, etc.

John E. Allison (1993) [24], D. J. Lloyd (1990) [25], M.G. McKimpson (1989) [26], H.J. Rack (1990) [27], A. W. Uvughart (1991) [28], V. V. Bhanuprasad (1991) [29] & M. S. Zedias (1991) [30] showed that the short fibres are long compared to the critical length (lc = d Sf / Sm where d is the fibre diameter, Sf is the reinforcement strength and Sm is the matrix strength) and hence show high strength in composites, considering aligned fibres. Nevertheless, misoriented short fibres have been used with some success as AMC (Aluminium Matrix Composite) reinforcement. Short fibres are still used mainly for refractory insulation purposes due to their low strength compared with others, but they are cheaper than fibre and whisker.

R. A. Higgins (1986) [31] stated that whiskers are characterized by their fibrous, single crystal structures, which have no crystalline defect. Numerous materials, including metals, oxides, carbides, halides and organic compounds have been prepared under controlled conditions in the form of whiskers. Generally, a whisker has a single dislocation, which runs along the central axis. The relative freedom from discontinuous means that the yield strength of a whisker is close to the theoretical strength of the material.

M.S. Zedias, P. S. Gilman and S.K. Das (1990) [32], silicon carbide whiskers seem to offer the best opportunities for MMC reinforcement. Presently, silicon carbide whisker reinforcement is produced from rice husk, which is a low cost material. The physical characteristics of whiskers are responsible for different chemical reactivity with the matrix alloy and also health hazard posed in their handling. Therefore the inherent interest shown by the researchers in whiskers reinforcement has declined.

P. You (1987) [33], T. W. Clyne (1987) [34] & M. Gupta (1991) [35] have stated that the particulates are the most common and cheapest reinforcement materials. These produce the isotropic property of MMCs, which shows a promising application in structural fields. Initially, attempts were made to produce reinforced Aluminium alloys with graphite powder but only low volume fractions of reinforcement had been incorporated (<10%). Presently higher volume fractions of reinforcements have been achieved for various kinds of ceramic particles (oxide, carbide, nitride). The SiC particulate-reinforced aluminium matrix composites have a good potential for use as wear resistant materials. Actually, particulates lead to a favorable effect on properties
such as hardness, wear resistance and compressive strength.


- **Solid-phase fabrication methods**: diffusion bonding, hot rolling, extrusion, drawing, explosive welding, PM route, pneumatic impaction, etc.

- **Liquid-phase fabrication methods**: liquid-metal infiltration, squeeze casting, compocasting, pressure casting, spray codeposition, stir casting etc.

- **Two phase (solid/liquid) processes**: Which include Rheocasting and Spray atomization. Normally the liquid-phase fabrication method is more efficient than the solid-phase fabrication method because solid-phase processing requires a longer time.

Herbert Dietrich (1991) [41], T.S. hester (1991) [42], M.V. Roode (1993) [43], D. Huda (1993) [44], Alok Satapathy (2002) [45] & E. Hunt [46] stated that the attractive physical and mechanical properties that can be obtained with metal matrix composites, such as high specific modulus, strength and thermal stability, have been documented extensively. The various factors controlling the properties of particulate MMCs and the influence of the manufacturing route on the MMC properties has also been reviewed by several investigators. Improvement in modulus, strength, fatigue, creep and wear resistance has already been demonstrated for a variety of reinforcements. Of these properties; the tensile strength is the most convenient and widely quoted measurement and is of central importance in many applications.

D. H. Kim, E.J. Lavernia and J. Earthman (1990) [47] have documented extensively the attractive physical and mechanical properties that can be obtained with metal matrix composites, such as high specific modulus, strength and thermal stability. The various factors controlling the properties of particulate MMCs and the influence of the manufacturing route on the MMC properties has also been reviewed by these investigators. Improvement in modulus, strength, fatigue, creep and wear resistance has already been demonstrated for a variety of reinforcements. Of these properties; the tensile strength is the most convenient and widely quoted measurement and is of central importance in many applications.

P.J. Meachter and J.E. Oneil (1984) [48] stated that the strength of particle-reinforced composites is observed to be most strongly dependent on the volume fraction and particle size of the reinforcement.

- Dislocation strengthening will play a more significant role in the MMC than in the unreinforced alloy due to the increased dislocation density.

- Of greatest concern appears to be the introduction of defects and inhomogeneities in the various processing stages, which has been found to result in considerable scatter in the mechanical properties.

J.E. Hack, R. E. Page and G.R. Leverant (1984) [49] stated that there exists a critical reinforcement volume fraction above which the composite strength can be improved relative to that of the unreinforced material and below which the composite strength decreases, owing to the ineffective load transfer from matrix to reinforcement in MMCs. For low volume fraction of reinforcement, the composite strength was observed to be governed by the residual matrix strength, which decreases with increasing reinforcing volume fraction.

N.Eustathopoulos, D. hatan and L. oudurier (1991) [50] proved that apart from the reinforcement level, the reinforcement distribution also influences the ductility and fracture toughness of the MMC and hence indirectly the strength. A uniform reinforcement distribution is essential for effective utilization of the load carrying capacity of the reinforcement.

M. Taya & R.J.Arsenault (1989) [51] stated that non-uniform distributions of reinforcement in the early stages of processing was observed to persist to the final product in the forms of streaks or clusters of unfinilibrated reinforcement with their attendant porosity, all of which lowered ductility, strength and toughness of the material.

R.J.Arsenault (1984) [52] proved that tensile fracture of conventional alloys is considered in terms of the micro void coalescence model (MVC). Void nucleation in unreinforced alloys occurs at constituent particles, either through particle failure, through interface decohesion. Decohesion is most common, but particle cracking occurs with elongated particles. In composites, there are three possible mechanisms for void nucleation particle cracking, interfaces decohesion, and matrix void nucleation is the same mechanism as occurs in the unreinforced alloys.

Kassim S. Al-Rubaie (1999) [53] shown that SiCp particles reinforcement improved the abrasion resistance against all the abrasives used. This improvement generally was higher against alumina than against silicon carbide. The abrasion resistance increased with an increase in the volume fraction and size of SiCp particles reinforcement. The results also showed that the abrasion resistance decreased with increasing the relative abrasive penetration depth, until a critical value; above this limit, the abrasion resistance was generally independent of the penetration depth.

P.K. Rohatgi (2006) [54] reported that with the increase in volume percentages of fly ash, hardness value increases in Al–fly ash (precipitator type) composites. He also reports that the tensile elastic modulus of the ash alloy increases with increase in volume percent (3–10) of fly ash.

J. Babu Rao (2010) [55] studies that metal matrix composites (MMCs) possess significantly improved properties compared to unreinforced alloys. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various dispersoids used, fly ash is one of the most
inexpensive and low density reinforcement available in large quantities as solid waste by-product. Shahnugasundaram (2011) [56] studied the development of lightweight materials has provided the automotive industry with numerous possibilities for vehicle weight reduction. Progress in this area depends on the development of materials, processing techniques, surface and heat treatments Aluminium matrix ceramic reinforcement composites have attracted increasing attention due to their combined properties such as high specific strength, high stiffness, low thermal expansion coefficient and superior dimensional stability at elevated temperatures as compared to the monolithic materials. V. Constantin, L. Scheed & J. Masounave (1999) [57] studied the sliding wear of an aluminium matrix composite, reinforced with different volume fraction of particles, against a stainless-steel slider. In dry conditions, i.e., unlubricated tests, the pairs (slider and specimen) wear. When rubbing against an aluminium alloy (unreinforced), the slider does not wear but the aluminium alloy wears quickly by adhesion. In dry conditions, both slider and composite wear, but there is a minimum wear rate for this pair at a critical volume fraction of reinforcing particles. Under lubricated conditions, the situation changes dramatically. The composite no longer wears, but the slider wears very quickly. Under water, results are a compromise between the two previous situations, dry and lubricated.

D. L. McDanels and R. A. Signorelli [58] fabricated & evaluated panels of discontinuous SiC composites, with several aluminium matrices. Modulus, yield strength and tensile strength results indicated that the properties of composites containing SiC whisker, nodule or particulate reinforcements were similar. The modulus of the composites was controlled by the volume percentage of the SiC reinforcement content, while the strength and ductility were controlled by both the reinforcement content and the matrix alloy.

VIII. CONCLUSION

Here we successfully fabricated the Al 7075-cenosphere composites by using Stir Casting arrangement with proper distribution of ash particles all over the specimen. We have drawn various conclusions from the various calculations based on the diff. experimental tests:

a) The density of the composites decreased with increasing ash content. Hence these light weight composites can be used where weight of an object matters as like in the aero and space industries.

b) The tensile strength of the composite decreases with increase in filler content and the flexural strength increases as filler content increases.

c) Hardness of the composite increases on increase in filler % up to certain 6% & then starts decreasing.

d) The wear rate increases when the filler increases from 3wt% to 6wt% and wear rate decreases when the filler content increases from 6wt% to 9wt%.

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