INTRODUCTION

COMPOSITE MATERIALS

The expression composite material has several meanings based on various literatures; one of them is the combination of dissimilar multifunctional material systems that provide excellent properties which are not possible in singular systems.

Initial studies were made with process improvement using fiber reinforcement, Anisotropy, costly fabrication and restricted secondary treating has guided to the use of short fiber / particulate / whisker reinforced composites. The mixture of good transverse properties, low cost, high workability and large increase in performing over unreinforced alloys are the commercially good-looking features of these discontinuous reinforced composites.

Compared to dispersion toughened systems, particulate reinforced composites have coarse size reinforcement (1-100 µm) in comparatively high weight elements (1-30%). In particulate composites, both matrix and reinforcement bear substantial weight. In addition, matrix strengthens as affected by precipitation and dislocation strengthening plays an important role in the load bearing ability of these composites. Metallic matrix composites strengthened with ceramic particles are generally used due to their high particular modulus, strength and wear resistance.

LITERATURE REVIEW

Metal matrix composites (MMCs) are inventions during early 60’s, composed of basically a metallic matrix reinforced with generally ceramics. MMCs exhibit a combination of metallic (toughness and formability) and ceramic (high strength and hardness with load bearing capacity) properties.

These are tailor made materials to suit to particular requirements like reduction in density or improvement in stiffness, yield strength, ultimate tensile strength, which can be translated to improved specific properties. In MMCs one of the constituents is aluminium / aluminium alloy, which forms a continuous phase and is termed as matrix.

The other constituent is embedded in this aluminium / aluminium alloy matrix and serves as reinforcement, which is usually non-metallic material (common ceramics such as SiC, Flyash, graphite powders and Al2O3). On account of the excellent physical, mechanical properties...
of MMCs, they are applied widely in aircraft technology, electronic engineering and automotive industries.

**FABRICATION OF METAL MATRIX COMPOSITES**

The major problem of hybrid composites is related with their fabrication processes. In addition, the mechanical properties of MMCs are perceptive to the processing technique used to fabricate the materials. Various authors have used different techniques for the preparation of composites.

**METHODS FOR FABRICATION OF ALUMINUM SILICON CARBIDE FLYASH COMPOSITE**

Over recent years there has been a quickly increase in the utilisation of aluminium hybrid metal matrix composites. The hybrid metal matrix Composite is a structural material which is composed of two or more particulates. However aluminium hybrid metal matrix composites are the most communal MMC’s and commercially available ones due to their economical production. Conventional materials like steel, cast iron, brass etc. will fail due to cracks initiation and propagation will takes location within a short span. To overwhelm this problem conventional materials are replaced by aluminium alloy materials due to their outstanding mechanical properties.

**FABRICATION FACILITIES**

In the present study, preparation of alloys and fabrication of composites were implemented in pot furnace, furnace details were given below.

### Furnace Details

The following are the furnace details for preparation of alloys and fabrication of composites and process details were discussed thoroughly.

- **Furnace** : Pot furnace
- **Make** : KRISHMET-T Heating element
- **KANTHAL-A1**
- **Melt capacity** : 1.5 kg

### MANUFACTURING OF PISTON WITH COMPOSITE MATERIAL ALUMINUM ALLOY 6061 AND FLYASH

**Aluminum alloy 6061 Pieces**

- Aluminum alloy 6061 Pieces
- Silicon Carbide
- Fly ash
- Manufacturing process
- Specimen

- Pot Furnace
- same with a stirrer
TESTING FACILITIES

Physical Testing
Optical Microscopy
Regular polishing techniques were used to investigation the microstructures. Dilute Keller’s reagent was used for etching. Study of microstructures and record was done using Olympus, C – 5060- G x 4, Japan, Composition of Keller’s reagent: HF= 1.0 cc, HCL =1.5 cc, HNO3 =2.5 cc H2O= 95cc

EDS & SEM

Energy Dispersive X-ray Spectroscopy (EDS) and Scanning electron microscopy (SEM) were executed using SEM-Hitachi S-3400N – Japan and SEM – ZEISS SUPRA 55VP worked at 20 kV, in order to evaluate the morphological and chemical constituents observed in the present investigation.

XRD

All the investigated alloy powders was characterized with an X-Ray Diffractometer figure 2.4 (Model: 2036E201; Rigaku, Ultima IV, Japan). JADE software was used to investigate the phases present in them. Sample preparation of XRD was done as per the standard practice.

Compression testing machine details

<table>
<thead>
<tr>
<th>S. No</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Make</td>
<td>Dak system Inc</td>
</tr>
<tr>
<td>2</td>
<td>Model</td>
<td>9102</td>
</tr>
<tr>
<td>3</td>
<td>Capacity</td>
<td>100 kN</td>
</tr>
<tr>
<td>4</td>
<td>Platens</td>
<td>Die Steel</td>
</tr>
<tr>
<td>5</td>
<td>Diameter of the platens</td>
<td>100mm</td>
</tr>
</tbody>
</table>

Uniaxial compression test conditions

<table>
<thead>
<tr>
<th>S.No</th>
<th>Control parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre Load</td>
<td>0.02 KN</td>
</tr>
<tr>
<td>2</td>
<td>Safe Load</td>
<td>300 KN</td>
</tr>
<tr>
<td>3</td>
<td>Hold Time</td>
<td>60 sec</td>
</tr>
<tr>
<td>4</td>
<td>Load Rate</td>
<td>40 kN/Min</td>
</tr>
<tr>
<td>5</td>
<td>Stress Rate</td>
<td>10 kN/Min</td>
</tr>
<tr>
<td>6</td>
<td>Strain Rate</td>
<td>0.001</td>
</tr>
<tr>
<td>7</td>
<td>Initial valve open</td>
<td>20%</td>
</tr>
</tbody>
</table>

Ring Compression Test

Ring compression tests were operated to know the friction factor for a given set of flat platens and work piece while upsetting. Ordinary ring compression samples of OD: ID: H=6:3:2 (48:24:16mm) were prepared. The deformation was Considering slowly with a ram speed of (0.25 mm/sec) on compression examination machine (DAK Test Bench, 100kN Capacity).

Wear Test

Dry sliding wear tests have been executed on a pin- on-disc apparatus (Model: Ducom TR- 20 LE, (Figure 3.16) by sliding a cylindrical pin against the surface of tough steel disc (with a hardness value of HRC 62) under Surrounding condition. The disc was ground to a smooth surface appearance and renewed for each test.

The wear test samples were prepared from the alloy and composite moldings in the dimensions of 4 mm and 30 mm length. Prior to testing, test Specimens were smooth with emery papers and cleaned in acetone, dried and then weighed using an electronic balance (Model: lyco balance) having a resolution of 0.1 mg.
INTRODUCTION

Metal Matrix composites (MMCs) are becoming attractive materials for advanced aerospace and automobile structures because of their properties can be tailored through the addition of selected reinforcements [1,2]. In specific particle reinforced MMCs have got special attention because of their high particular strength and specific stiffness at room or high temperature. Generally micron sized ceramic particles are used as reinforcement to develop the properties of the MMCs. Ceramic particles have minimum coefficient of thermal expansion (CTE) than metallic alloys, and therefore combination of the these ceramic particles may Presence interfacial disparity between matrix and reinforcement. This Phenomenon of may be higher for high ceramic particle concentration.

Density and hardness studies

The average theoretical and measured density values of the AA 6061 alloy and its respective composites were given in table 4.2. It was observed that the addition of fly ash and SiC particles into the AA 6061 alloy matrix significantly decreases the density of the resultant composites in compare to the base alloy.

Deformation Studies

Compression Test of Composites

Specimens preparation: Standard cylindrical samples of 12 mm X 12 mm Φ (H/D=1.0) and 12 mm X 18 mm Φ (H/D=1.5), were machined from the extruded material. Sample edges were chamfered to minimize folding. Concentric grooves of 0.5 mm depth were made on both the end surfaces of the sample.

Testing: A computer controlled servo hydraulic 100T (FIE-UITE Model) universal testing machine was used to upset the samples. Standard samples were upset by placing between the platenes at a constant cross head speed in dry conditions. The compression tests were carried out until either 50% reduction in height or beginning of the fracture on the specimen surface whichever is earlier. A PC based data logging system was used to record and store the loads and displacements continuously.

The specimens subjected to upset forging, from 10% height reduction, with sequential increments of 10%, to 50% height decrease or till the appearance of an appreciable crack whichever is earlier. A closer view of sample deformation was shown in figure 5.4. The image of specimens at various after deformation levels for Ho/Do = 1.0 and 1.5.
RESULTS AND DISCUSSION

Hollomon Power Law Parameters
True stress vs true strains were calculated using Load – displacement data; during the cold upsetting of alloy and composites. The calculated true stress vs true strains were fit into well-established Hollomon power law given by:

\[ \sigma = K \varepsilon^n \]

Where: \( \sigma \) = true stress  
\( \varepsilon \) = true plastic strain  
\( K \) = strength coefficient, and  
\( n \) = strain hardening exponent

STRUCTURAL ANALYSIS ON PISTON
**RESULTS and CONCLUSIONS**

**Structural analysis**

<table>
<thead>
<tr>
<th></th>
<th>Deformation(mm)</th>
<th>Stress(Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum alloy 6061/ FLY-ASH/ SiC</td>
<td>0.0011</td>
<td>2.693</td>
</tr>
<tr>
<td>Aluminum alloy 7075/ FLY-ASH/ SiC</td>
<td>0.0031</td>
<td>2.754</td>
</tr>
</tbody>
</table>

**CONCLUSION**

From Microstructure and mechanical properties of FLY-ASH/SiC particles reinforced AA 6061 hybrid composites

1. The bulk density of the fly ash particles was found to be 2.42 g/cm³.

2. A6061/FA/SiC Hybrid composites were produced by stir casting route successfully.

3. There was a uniform distribution of FA/SiC particles in the matrix phase.

4. From the SEM figures, it clearly shows that there were no voids and discontinuities in the composites; there was a good interfacial bonding between the FA/SiC particles and matrix phase.

5. The density of the composites decreases with increasing the percentages of FA/SiC particulates compared to the density of the alloy 2.680 g/cm³.

6. The measured densities were lower than that obtained from theoretical calculations. The extent of deviation increases with increasing FA/SiC content.

7. From the EDX analysis of composites shows that no oxygen peaks were observed in the matrix area, confirming that the fabricated composite did not contain any additional contamination from the atmosphere. This might be due to a shield of argon gas was maintained during the mechanical stirring while reinforcement addition.

8. The hardness of the composites increased with increasing the amount of FA/SiC than the base alloy.

**From the deformations studies, the following conclusions can be made:**

1. Strength coefficient increases with increase in reinforcement content compared to the alloy.

2. At high aspect ratio both alloy and the composites exhibits lower compression strength values.

3. Strain hardening exponent increases with increase in reinforcement content compared the alloy.

4. At high aspect ratio, strength coefficient decreases while strain hardening exponent increases.

5. For both alloy and composites effective strain increases and the circumferential stress component becomes tensile with continued deformation.

6. The increase in circumferential stress component value was found to be more in case of specimens deformed for lower aspect ratio compared to the higher aspect ratio conditions.

7. The axial stresses, for alloy as well as the composites increased in the very initial stages of deformation but started becoming less compressive immediately as barreling developed.

8. At the beginning of deformation axial compressive stress increased in magnitude but as the deformation progress the magnitude reduced.

**From the analysis results, the following conclusions can be made:**

By observing the structural analysis results, the deformation and frequency values are more for aluminium alloys than Carbon Steel but by modal analysis the deformation and frequency values are less for aluminium alloys than Carbon Steel. The weight of the connecting rod is reduced when Aluminum alloys are used than carbon Steel since their densities are less.

**FUTURE RECOMMENDATIONS**

In the present work the deformation studies are conducted to the specimen. Further this can be extended by measuring the mechanical properties like young's modulus, Poisson's ratio, density and strength of the composite Aluminum 6061, Flyash and Silicon Carbide.
REFERENCES


AUTHOR

Haitham Mohammed Ibrahim,
Research Scholar,
Department of Mechanical Engineering,
University College of Engineering & Technology,
Acharya Nagarjuna University, Guntur, India.

Dr. M. Gopi Krishna Mallarapu,
Assistant professor,
Department of Mechanical Engineering,
University College of Engineering & Technology,
Acharya Nagarjuna University, Guntur, India.