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CFD Analysis and Fabrication of Aluminium Cenosphere Composites

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Abstract: *Metal matrix composites are engineered materials with a combination of two or more dissimilar materials, to obtain enhanced properties. Aluminium alloys reinforced with ceramic particles exhibit superior mechanical properties when compared to unreinforced aluminium alloys and hence are candidate for engineering applications. In the present investigation aluminium alloy is used as the matrix and cenosphere as the reinforcing material. The hybrid metal matrix composite is produced using conventional foundry techniques by casting route. The cenosphere is to be added in 2%, 4% and 6% by volume and also with the influence of the particle size of cenosphere, to the molten metal with Magnesium, which is the main parameter for the wet ability of cenosphere and aluminium alloy. The hybrid composite is to be tested for hardness, density, mechanical properties and impact strength. The density decreases with increase in cenosphere content. The impact strength increases with increase in cenosphere content. The resistances to dry wear and slurry erosive wear increases with increase in cenosphere content and hence this material can be used as bearing material. This composite material being less dense than aluminium can therefore be used in place of conventional aluminium alloys in aircraft components*

Keywords: *Metal matrix composites, Aluminium alloy, Cenosphere.*

I. Introduction

Conventional monolithic materials have limitations with respect to achievable combinations of strength, stiffness and density. In order to overcome these shortcomings and to meet the ever increasing engineering demands of modern technology, metal matrix composite are gaining importance, In recent years discontinuously reinforced aluminium based metal matrix composites have attracted worldwide attention as a result of their potential to replace their monolithic counterparts primarily in aerospace, automobile and energy sector.The present investigation has been focused on utilization of waste fly ash particle in a useful manner by dispersing it in aluminium matrix to produce a composite. In the present work, fly ash particle which mainly consists of refractory oxides like silica, alumina and iron oxides will be used as the reinforcing phase and to increase the wettablity, magnesium or silicon were added. Further these composites will be characterized with help of optical microscopy. Fly ash particle used in current work is called as cenosphere or micro balloon. It is a hollow sphere made up of ceramic outer surface. cenospheres as a filler in Al casting reduces cost, decreases density and increases hardness, stiffness, wear and abrasion resistance. It also improves the maintability, damping capacity, coefficient of friction etc, which are needed in various industries like aerospace, automobile.etc

II. Parameter Selection

Only three specimens are casted and the experiments are conducted for these specimens alone. The particle size is taken constant because theoretically valid result will be encountered at this size interval only and it is expected that the tensile strength of the composite decreases with increase in the particle size. The Mg proportion is also taken constant at 2% by weight during experimentation.

The spcimen A is casted with cenosphere proportion% of 2% by volume aluminium, The specimen B is casted with cenosphere proportion% of 4% by volume aluminium and the Specimen C is casted with 6% by volume of aluminium and all the three specimen has and mg proportion of 2% by weight of aluminium and particles size of 0-200 µm.

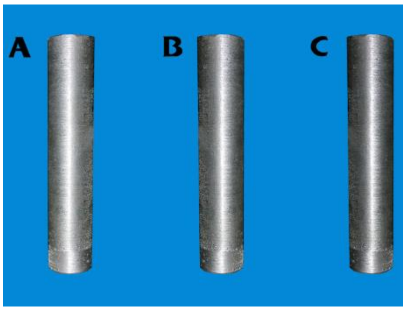

Figure 1. Specifications of various specimens

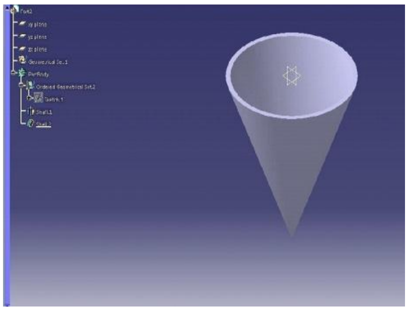

Figure 2. CATIA Cone Model

SPECIFICATION OF THE SPECIMENS

Table.1 Three specimens volume percentage, Mg proportion and particle size of the cenosphere.

Specimens	cenosphere proportion(%)by volume of aluminium	mg proportion(%)by weight of aluminium	cenosphere particle size in μm
Specimen A	2	2	0-200
Specimen B	4	2	0-200
Specimen C	6	2	0-200

TEST EXPERIMENTS

Following tests are carried out with the selected parameters

- SEM Analysis to check the dispersion of particles.
- Tensile Test in UTM Machine.
- Hardness test in Brinell & Vickers Hardness Machine.
- Impact test in Izod Machine.

Specimens are created based on ASTM standard and number of specimens was decided based on number of parameters and levels.

SEM ANALYSIS REPORT

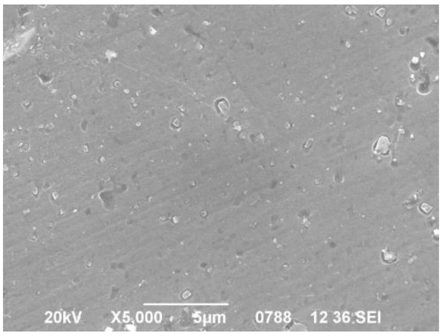

Figure 3. Image at a Magnification of 5000.

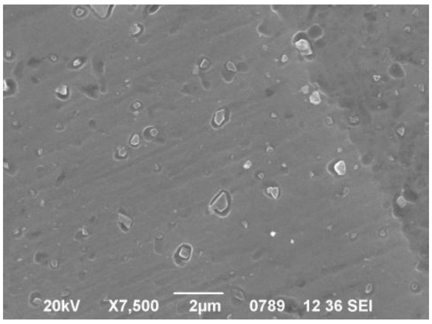

Figure 4. Image at a Magnification of 7500.

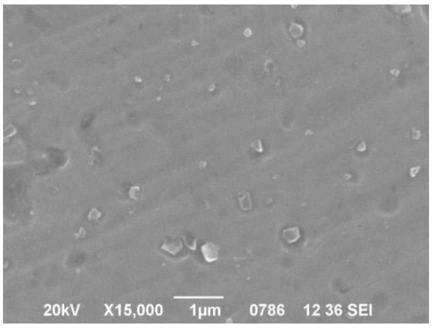

Figure 5. Image at a Magnification of 15000.

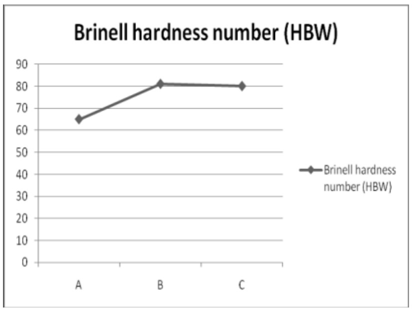

Figure 6. Comparison of Brinell hardness number of the specimens.

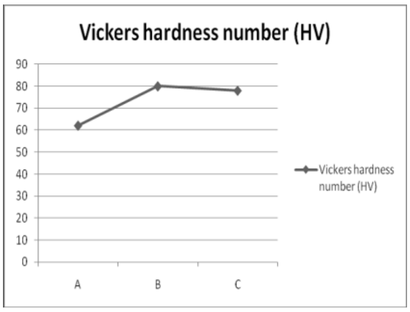

Figure 7. Comparison of Vicker hardness number of the specimens.

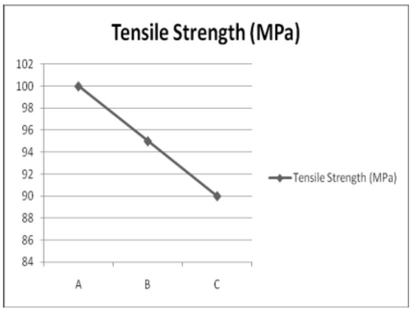

Figure 8. Comparison of Tensile Strength of the specimens.

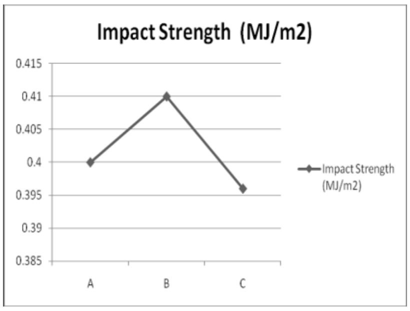

Figure 9. Comparison of Impact strength of the specimens.

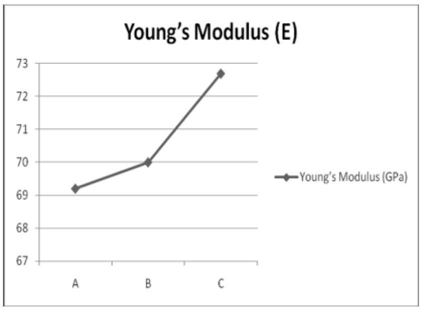

Figure 10. Comparison of Young's Modulus of the specimens.

SEM test was carried out under an accelerating voltage of 20kV Figure 3 gives the Image at a Magnification of 5000, Figure 4 gives Image at a Magnification of 7500 and Figure 5 gives Image at a Magnification of 15000. Figure 6 gives the image of graph of Comparison of Brinell hardness of specimens, The result gives that the Specimen A, B and C has the Brinell hardness number of 67, 82, and 81 respectively. Figure 7 gives the image of graph of comparison of Vickers hardness, The result gives that The Specimen A, B and C has the Vickers hardness number of 61, 81, and 79 respectively. Figure 8 gives the image of graph of comparison of Tensile strength number of the specimens, the result shows that the specimen A, B and C has the Tensile strength of 101Mpa, 96Mpa, and 89Mpa respectively. Figure 9gives the image of graph of comparison of impact strength of the specimens, the result shows that the specimen A, B, and C has the impact strength 0.401 MJ/m2, 0.411 MJ/m2, 0.397 MJ/m2 respectively. Figure 10gives the image of graph of Comparison of Young's Modulus of the specimens, the result shows that The Specimen A, B, and C has the Young's Modulus of 69.1Gpa, 70Gpa, 72.6Gpa respectively.

III. Results of the Analyzed Inlet Cone

An inlet cone for the turbojet engine is made with material of the new specimen casted and it is analyzed in ANSYS for stress and strain analysis, and in FLUENT for its flow analysis, and the results are given below

Design of The Inlet Cone

The cone is designed using CATIA V5R17 software as shown in figure 2.
The specifications of the inlet cone are,

- Diameter, D = 160 mm,
- Length, L = 250 mm,
- Thickness, t = 5 mm.

Inlet Cone with the Properties of Specimen A

When the load acting at the point P2 = 36 mm from the base of the cone.

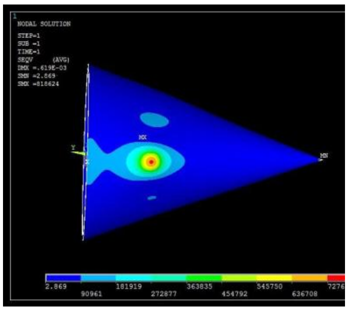

Figure 11.Von Mises Stress acting on the Cone

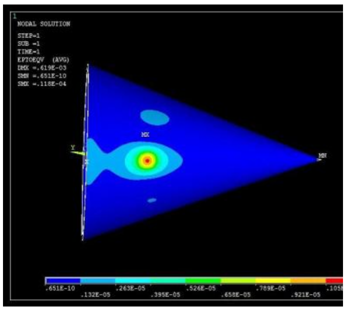

Figure 12. Von Mises Strain acting on the Cone

Inlet Cone with the Properties of Specimen B

When the load acting at the point P1 = 138.5mm from the base of the cone.

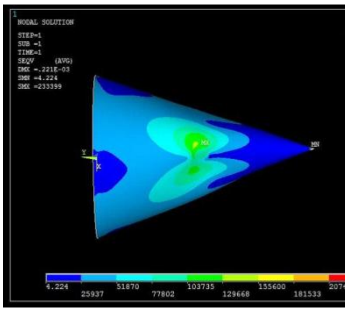

Figure 13.Von Mises Stress acting on the Cone

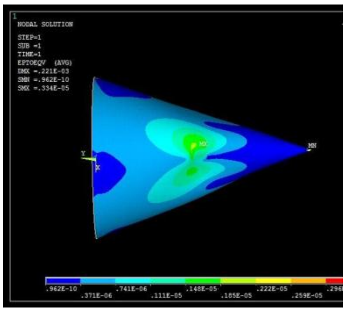

Figure 14.Von Mises Strain acting on the Cone

Inlet Cone with the Properties of Specimen C

When the load acting at the point P3 = 25 mm from the base of the cone.

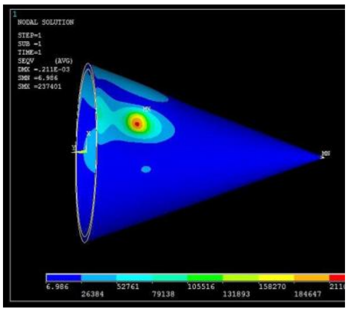

Figure 15. Von Mises Stress acting on the Cone

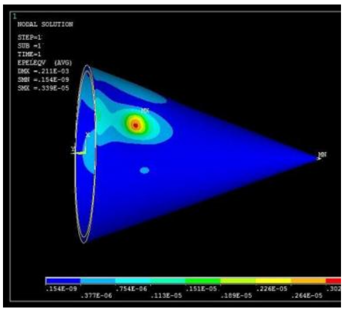

Figure 16.Von Mises Strain acting on the Cone

Flow Analysis

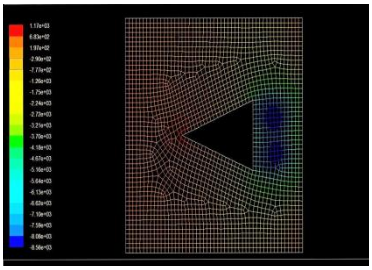

Figure 17.Pressure Distribution over the Cone

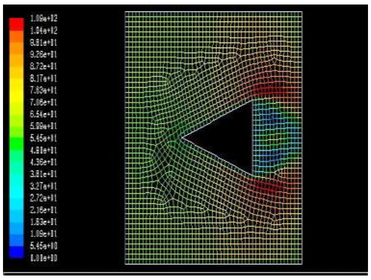

Figure 18. Velocity Distribution over the Cone

IV. Conclusion

Thus, the aluminium cenosphere composites were fabricated and tested for studying their mechanical properties. The tested results reveal that the Impact strength, Hardness and Young's modulus increases due to the presence of the cenosphere and the variation in these properties are shown. The density of the material decreases and it is less compared to the aluminium alloy which makes the composite lighter. The aluminium cenosphere composites show good mechanical properties when compared with its monolithic counterpart and are well suited for the aeronautical structural applications.

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