Evaluation of Mechanical Properties and Surface Morphology on Stir Casted Al A356 Reinforced With Fly Ash and E-Glass Fiber

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Abstract- *In recent years, there has been an increasing demand from automotive and aeronautical industries for materials possessing high specific strength, better wear resistance and stability in high temperatures. This paper outlines the stir casting technique and mechanical properties of Al A356 hybrid MMC. Further, it shows that fly ash and E-glassfiber based aluminum composites exhibit tremendous improvement in mechanical properties as compared to the unreinforced base alloy.To investigate the properties of Al A356 reinforced with fly ash and E-glass fiber particulate in the ratio of 91:3:6 respectively at 750°C melting temperature with the pre-heat temperature of 250°C was fabricated by stir casting. To identify the characterization of this composite material, surface texture was examined using inverted microscope. Tensile strength test was conducted using Universal testing machine and hardness test was conducted using Vickers hardness test method. The evaluation of mechanical properties reveals the increase in tensile strength values, ultimate tensile strength and hardness values of the various compositions of the composite material.*

Keywords- Stircasting, Micro-hardness, UTM, Surface Morphology, Inverted Microscope, Metascope software.

I. INTRODUCTION

A356 aluminium alloy is a casting alloy consisting of aluminium, silicon, and magnesium. It has good strength and ductility as well as excellent casting characteristics, high corrosion resistance, and good fluidity. The alloy has been widely applied in the machinery, aircraft and defense industries, and particularly in the automotive industry to replace steel components. A356 aluminium alloy has also been used as the basis for obtaining composites with ceramic reinforced particles and fibers. They also find applications in aircraft pump parts, aircraft structure and control parts, automotive transmission, aircraft fittings, water cooled cylinder blocks and nuclear energy installations. Both hypoeutectic and hyper-eutectic alloys can be used as useful engine block materials on account of their adequate resistance and high strength to weight ratio. There are quite large numbers of studies made on the mechanical behaviour of Al-Si alloys. Attempts are made to increase the strength of Al-Si-Mg by various manufacturing processes, heat treatment, reinforcement of hard and soft reinforcements etc.

II. MATERIAL SELECTION AND EXPERIMENTAL WORK

2.1. MATERIAL SELECTION

A356 has very good casting and machining characteristics. Corrosion resistance is excellent and it has very good weldability characteristics. Mechanical properties are rated excellent. Typically, this alloy is used in castings for aircraft parts, pump housings, impellers, high velocity blowers and structural castings where high strength is required. The fact that A356 has good castability makes it a logical choice for intricate and complex castings where lightweight, pressure tightness and excellent mechanical properties are needed. The properties and chemical compositions of Al A356 are tabulated below in Table 1 and Table 2.

Table 1 Properties of A356

Sl.NO	PROPERTIES	VALUES
1	Young`s modulus	71 GPa
2	Tensile strength	230 MPa
3	Yield strength	56 MPa
4	Elongation	2-5%
5	Density	2.685 g/cm^3
6	Shear strength	120 MPa
7	hardness	75 (BHN)

Table 2 Chemical Composition of A356

Sl. No	Elements	Percentage
1	Si	6.5-7.5
2	Fe	0.13-0.25
3	Cu	0.10
4	Mn	0.05
5	Mg	0.30-0.45
6	Zn	0.05
7	Ti	0.20
8	Al	remainder

2.1.1. ADVANTAGES OF E-GLASS FIBER

- Low cost and high production rates
- Relatively low density
- Able to maintain strength properties over a wide range of conditions
- Relatively insensitive to moisture
- Chemical-resistant

2.2. EXPERIMENTAL WORK

The known amount of commercial pure aluminium and desired amount of fly ash and E-Glass fiber particles was used to prepare composites. The fly ash and MgO particle was preheated to 600^{0}C for three hours to remove moisture. Commercial pure aluminium was melted in a resistance furnace. The furnace temperature was raised up to 750^{0}C and it was degassed by purging hexa chloroethane tablets. The reinforcement was added with molten Al. Then the melt was stirred with the help of a mild steel turbine stirrer. The stirring was maintained between 5 to 7 min at an impeller speed of 200 rpm. The melt temperature was maintained 750^{0}C during addition of fly ash and E-Glass fiber particles. The dispersion of fly ash and E-Glass fiber particles were achieved by the vortex method. The melt with reinforced particulates were poured into the preheated permanent metallic mould. The pouring temperature was maintained at 700^{0}C.The melt was then allowed to solidify the moulds. The composites were made with a different amount of fly-ash (i.e.6, 9 wt. %) with 3 wt. % of E-Glass fiber.

Figure 1 shows the stir casting setup used to manufacture hybrid Al/Fly ash-E-Glass fiber Composites.

Figure 1 Stir Casting Setup

The molten metal was poured in mould cavity for each specimen to get the required shape as shown in Figure 2.

Figure 2 Moulding

It was permitted to obtain room temperature and finally specimens were taken away from the mould cavity.All the specimens were machined to get the standard shape and all the samples were stored carefully. The fabricated specimens are show in Figure 3.

Figure 3 Sample Specimens

III. RESULTS AND DISCUSSION

3.1. TENSILE TEST

The tensile test samples after the test is shown in Figure 4, 5 and6.

Figure 4 Tensile Test Specimen Sample-A (A356-100%)

Figure 5 Tensile Test Specimen Sample-B (A356-91%, E-Glass fiber-3% and Fly Ash-6%)

Figure 6 Tensile Test Specimen Sample-C (A356-88%, E-Glass fiber-3% and Fly Ash-9%)

The tensile strength values of the composite materials sample results are shown in the Table 3

Table 3 Tensile strength values

Sl. No	Sample	Tensile Strength in MPa
1	A	70.66
2	B	71.34
3	C	105.67

Table 4 Elongation in percentage

Sl. No	Sample	Elongation in percentage
1	A	2.72
2	B	2.76
3	C	2.88

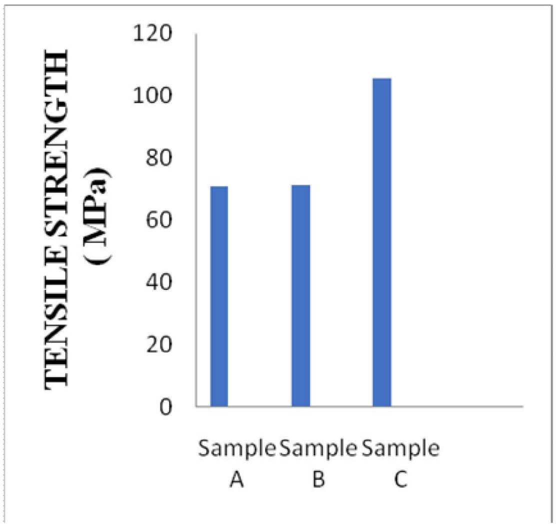


Figure 7 Tensile strength

From the above graph, the tensile strength was increased gradually for sample B compared to the sample A.In the sample B the addition of reinforcement as 3% of E-Glass fiber and 6% of fly ash to the aluminium A356 increases the tensile strength as 70.66MPa to 71.34MPa.In the sample C by increasing the reinforcements of 3% of E-Glass fiber and 9% of fly ash to the aluminium A356 leads to increase the tensile strength as 71.34% to 105.67%.

3.1.1. ELONGATION

The % elongation of the all three samples results are shown in the table 4.

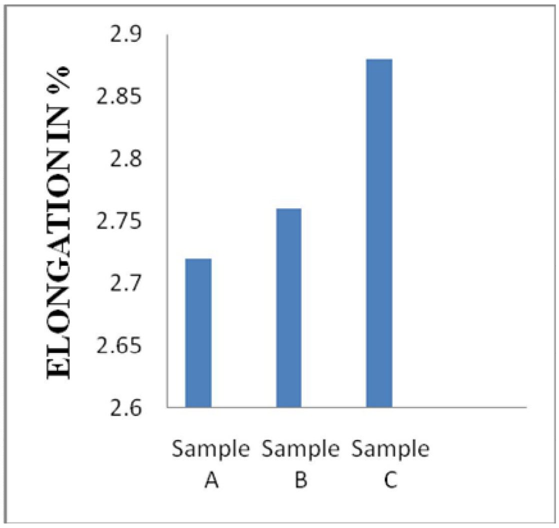


Figure 8 Elongation% for Composite Materials Samples

From the above figure shows that the % of elongation also increases from sample A to sample B at 2.72 to 2.76. Then the addition of reinforcements leads to increases the elongation % of sample C as 2.76 to 2.88. This shows that the addition of reinforcement as 3% of E-Glass fiber and 6% of fly ash increases the elongation. From above results proves that the addition ofreinforcements increases the elongation percentage of the composite material.

3.1.2YIELD STRESS FOR COMPOSITE MATERIAL SAMPLES

The yield strength is an ability of the materials,it is tested during the tensile test the yield load was applied on the specimen the yield point or before breaking point is a yield load is used tocalculate the yield strength of the composite materials. The yield strength of the all three samples results are noted in the table 5.

Table 5 Yield Stress

Sl. No	Sample	Yield Stress in MPa
1	A	65.46
2	B	67.57
3	C	99.43

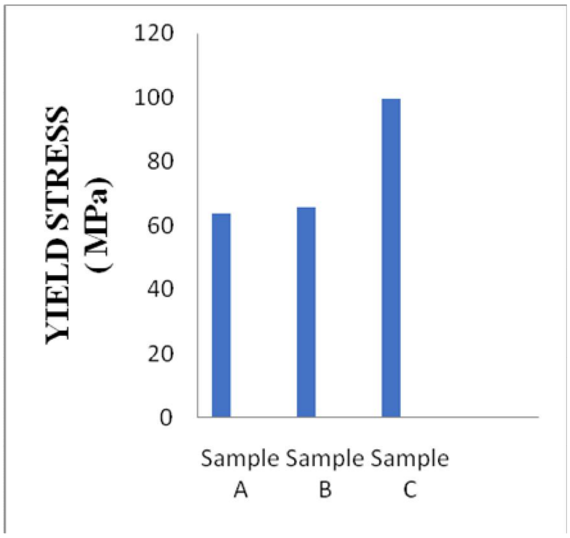


Figure 9 Yield stress

From the above results, it is shown that the yield stress was increased by adding reinforcements of fly ash wt. % and E-Glass fiber wt. % into the aluminium A356. The addition of reinforcement as 3% of E-Glass fiber and 6% of fly ash in the sample B increases the yield stress from 65.46MPa to 67.57MPa. By increasing the reinforcement of 3% of E-Glass fiber and 9% of fly ash to the sample C leads to increase the yield stress as 67.57MPa to 99.43MPa. From above results proves that the addition of reinforcements increases the yield strength of the composite material.

3.2. MICRO HARDNESS

The micro hardness composite material samples are shown in Figure 10.

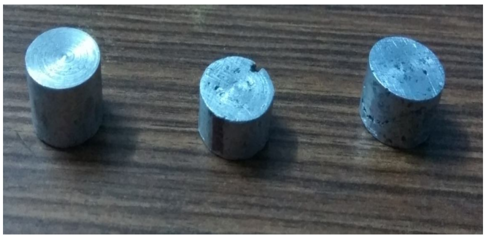


Figure 10 Micro Hardness Samples

TABLE 6 Vickers hardness

Sl.NO	SAMPLE	HARDNESS (VH)
1	A	82
2	B	79
3	C	93

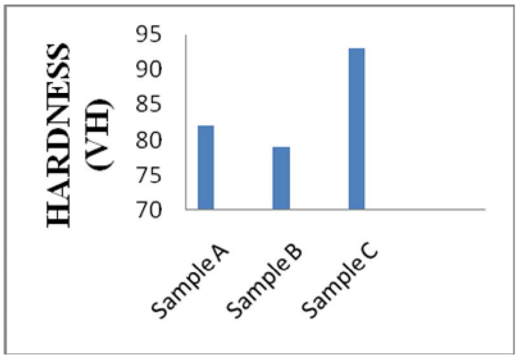
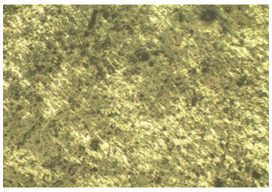


Figure 11 Micro hardness

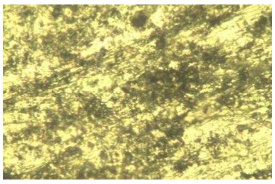
Figure 11 shows the hardness of aluminium A356 and the composites. It is observed that the hardness increased in the composite as compared to aluminium A356. The highest hardness is achieved by sample C for E-Glass fiber 3% and 9% Fly Ash reinforced in aluminium A356 composite.

3.3. SURFACE MORPHOLOGY

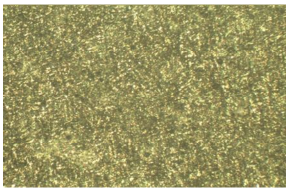
The distribution of reinforcements and the surface texture was analysed using Inverted microscope and metascope software.



Sample A



Sample B



Sample C

Figure 12 Samples under Microscopic view at 100xmagnification

From the above results, it is shown that the sample A is our base alloy and there is some porosity can be noticed. Sample B shows the uneven distribution of reinforcements.Sample C shows that the fine distribution of reinforcements with the base alloy.

IV. CONCLUSION

The Fly ash and E-Glass fiber particulate reinforced aluminium A356 composites were fabricated through stir casting method. The characterization of the samples was taken by using inverted microscope.

The following conclusions are observed from this investigation.

1. The Stir casting technique produces good quality of composite specimen with the better distribution of reinforcements in the matrix.
2. From the tensile test it is found that the ultimate tensile strength of the composite material increases from 70.66MPa to 105.67MPa by increasing the wt. % of the reinforcements.
3. The % of elongation of the composite samples was increased at sample C compared to the sample A and B. The yield strength also increases from 65.46MPa to 99.43MPa.
4. From the Microscopic images, it is clear that the reinforcement particulates are fairly distributed in Al metal matrix composites.

Finally, the effect of E-Glass fiber and Fly ash addition in aluminium A356 matrix was observed to have good mechanical properties. The composition of 3% E-Glass fiber and 9% Fly Ash can be used for various automobile and aircraft applications.

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