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# MECHANICAL PROPERTIES OF AL 6061 T6 ALLOY MIXED WITH FLY ASH

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***Abstract:*** Aluminium metal matrix composites are used in various engineering practices. Properties of aluminium metal matrix composites are boosted by stir casting which is known as low cost manufacturing. Composite materials with extraordinary isotropic nature are factory-made using this technique. Today Industries look forward for the composite material being in good excellence as well low cost for various applications. It is perceived that fly ash is used as strengthening material due to its mechanical possessions. Density of fly ash adds as the major benefit for being the strengthening material. In current project work, various mechanical properties like tensile stress, impact strength, compressive stress, hardness, elongation are studied for aluminium 6061 T6. Further reconnoitered the properties of composite material wit fly ash at 3%, 6% and 9% with Al6061 at 97%, 94% & 91% respectively and compare the results with alloy 6061.

***Index Terms* - Aluminium 6061T6, Aluminium alloy, Metal Matrix Composites, Fly ash.**

## I. INTRODUCTION

Metal matrix composites are able to fulfill all the anticipated conceptions of the component inventers in order to cater the unambiguous demands of different engineering applications. For improvement MMC, various metals used are titanium, magnesium, copper, nickel and aluminium. However, the most widely used base metal is aluminium due to its lightweight, strength, excellent thermal and electrical properties, good reflective properties, impermeability and cost effectiveness. Applications of AMMC's result into robust enhancement in product strategy and improvement with reduced weight, thus offering economically viable replacements. Main aim of developing metal matrix composites is to attain desired properties by wavering matrix phase, reinforcement shape and size, synthesis route, volume fraction and processing parameters. In metal matrix composites, the tough reinforcements are infused into the soft metal matrix to achieve a blend of improved physical, mechanical and electrical properties. Various research literature on the Aluminium composite material has been studied and most of the material when added to aluminium at the certain quantity shows good results with improved mechanical properties. Since the automobile, aerospace and sports industries require various aluminium based composites components, to be used in diverse conditions, hence rigorous research has been done in past recent years with different aluminium alloys combined with various reinforcements. The available literature shows that adequate investigations have been done to interpret the development mechanism and characteristics analysis depending upon reinforcement content, reinforcement size and process parameters. By using suitable quite reinforcement with aluminium matrix, the properties of aluminium metal matrix composite are often altered. MMCs chain metallic properties of matrix alloys with ceramic properties of reinforcements, resulting in greater strength in shear and compression and higher service-temperature capabilities [1, 2]. Metal matrix composites (MMCs) represent a replacement generation of engineering materials during which a robust ceramic reinforcement is merged into a metal matrix to enhance its possessions including specific strength, specific stiffness, wear resistance, excellent corrosion resistance and high coefficient of elasticity [3, 4]. Thus, they need significant scientific, technological and commercial importance. During the last decade, because of their improved properties, MMCs are being used extensively for high performance applications such as in aircraft engines and more recently in the automotive industry [2, 4]. MMCs offer a singular balance of physical and mechanical properties. Aluminium based MMCs have received growing attention in recent eras as engineering materials with most of them possessing the aids of high strength, hardness and wear resistance. The stir casting method is widely used among the various processing techniques available. Stir casting usually involves prolonged liquid reinforcement contact, which may cause substantial interface reaction [5]. Over the past years metal matrix composites (MMCs) are changed from a subject of scientific and intellectual interest to a cloth of broad technological and commercial significance [6]. Basavarajappa et al. examined the mechanical possessions of aluminum alloy (Al2024) reinforced with SiC and graphite elements. Their results revealed that the mechanical properties such as ultimate lastingness , yield strength, hardness and compressive strength of the composite increased predominantly with the increase in volume fraction of reinforcement [7]. Mahendra et al. [8] studied the properties of Al-4.5% Cu alloy composite through fly ash as reinforcement. They reported the rise in hardness, tensile strength, compression strength and impact strength with increase within the ash content. Sudarshan et al. determined that composites with thin size range fly ash particle exhibit superior mechanical properties compared to composites with wide size range fly ash particles [9]. Mahagundappa et al. have studied the influence of reinforcement and thermal aging on the mechanical properties of Al 6061 based hybrid composites, and concluded that the ultimate tensile strength, compression strength, young's modulus and hardness increases with increasing the reinforcement content but the ductility decreases substantially

## II. METHODOLOGY AND TECHNIQUES

Composite material means that two dissimilar materials are combined together intimately bonded to form integrated structure. Two main segments of composites are matrix and reinforcement, which is continuous and discontinuous. Processing techniques are classified as solid and liquid state processing. The factors considered for processing techniques are application, reinforcement materials and state of matrix. For the current work, In manufacturing of desired composite material is liquid state processing. Methods like infiltration, spray detection, stir casting, etc,. are available in which stir casting method is selected

### 2.1. MATERIALS USED

Alloy 6061 is one among the foremost widely used alloys within the 6000 Series. This typical structural alloy, one among the foremost useful of the heat-treatable alloys, is mutual for medium to high strength requirements and has good toughness characteristics. Applications range from transportation components to machinery and equipment applications to recreation products and durables . Al6061 is used for standard and custom shapes, rod and bar products, and seamless and structural pipe and tube. Alloy 6061 has brilliant weathering resistance to atmospheric conditions and good corrosion resistance to sea water. T6- Solution heat-treated and artificially aged. Aluminium 6061 T6 alloy containing 95.8 - 98.6 % of Al is used as matrix. The Chemical composition of alloy are given below in Table I. Chemical composition of Fly ash which is used as strengthening material is shown in Table II. They are formed in range of 920-1200$^0$C

TABLE I
Chemical Composition of Al6061T6 designated as base alloy

| S.No | Compound | Wt[%] |
|---|---|---|
| 1 | Al | 95.8 - 98.6 |
| 2 | Cr | 0.04-0.35 |
| 3 | Cu | 0.15-0.4 |
| 4 | Fe | 0.7 |
| 5 | Mg | 0.8-1.2 |
| 6 | Mn | 0.15 |
| 7 | Si | 0.4-0.8 |
| 8 | Ti | 0.15 |
| 9 | Zn | 0.25 |

TABLE II
Chemical Composition of Fly ash designated as strengthening material

| S. No | Compound | Wt[%] |
|---|---|---|
| 1 | $SiO_2$ | 59.95 |
| 2 | $Al_2O_3$ | 19.09 |
| 3 | $Fe_2O_3$ | 2.78 |
| 4 | $TiO_2$ | 1.14 |
| 5 | $K_2O$ | 1.09 |
| 6 | CaO | 0.63 |
| 7 | MgO | 0.38 |
| 8 | $Na_2O$ | 0.34 |
| 9 | CuO | 0.01 |

### 2.2. CASTING METHOD

AMMC processing is split into in-situ and ex-situ synthesis, where stir casting comes under Ex-Situ synthesis. Aluminium metal matrix composite is casted using stir casting technique. This is the simplest and most commercially used technique, and also known as vortex technique. Properties of composites developed by this method can be altered by varying different process parameters such as pouring temperature, preheat temperature, stirring speed, processing temperature, melt temperature, holding time, size and position of the stirrer, etc. Stir casting process is used in mixing of aluminium metal matrix alloy with fly ash. Stir casting is a suitable treating technique to formulate aluminum matrix composites and hybrid aluminum matrix composites as it is an cost-effective process and ideal for mass production. The first step of stir casting encompasses melting of aluminum. During melting, aluminum melt reacts with the atmosphere and moisture and forms a layer of alumina . Stir casting process involves stirring of melt, during which the melt is stirred continuously which exposes the melt surface to the atmosphere which tend to continuous oxidation of aluminum melt. Pouring temperature of casting liquid is maintained around 700$^0$C.

Fig. 1. Stir Casting Mechanism

**2.2.1. MELTING**

Out of varied furnaces, bottom pouring furnace is suitable for fabrication of metal matrix composites in stir casting route, this sort of furnace contains automatic bottom pouring technique which provides instant pouring of matrix and reinforcement. Automatic bottom pouring is especially utilized in investment casting industry. In stir casting process, the matrix material is melted and maintained a particular temperature for two to 3hours during this furnace. Simultaneously, reinforcements are preheated during a different furnace. After melting of the matrix material, the stirring process has been began to form the vortex.

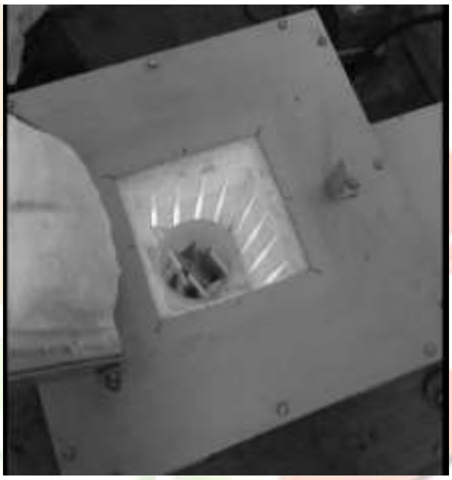

Fig. 2. Melting of Aluminium 6065 T6

**2.2.2. STIRRING**

In stir casting process, the mechanical stirrer is including the varying speed motor to regulate the speed of the stirrer. Double stage and multi stage stirrer are mainly utilized in chemical industries whereas single stage impeller stirrer is usually used for fabrication of AMCs and HAMCs due flexibility and to avoid excessive vortex flow. Stirring plays an important role over the ultimate microstructure and mechanical properties of the casted composites because it controls the distribution of reinforcements within the matrix. Stirring speed may be a significant parameters which affect the distribution of the reinforcement particles within the matrix material. Studies conclude 600 rpm and 10 min is that the best combination of stirring speed and stirring time for uniform hardness value through the composite. This confirms the uniform distribution of particles over the aluminum matrix.

**2.2.3. BLADE ANGLE**

The vortex formed by the stirring on solid-liquid mixing transfers reinforcements particles into the melt from the liquid surface whereas shearing action assist to interrupt the buildup formed by the reinforcement particles and cause uniform distribution. Therefore, selection of an appropriate blade angle is crucial to accumulate good level of axial flow and shearing action. Moreover, stirring time plays a crucial role over the distribution of solid particles and power consumption by the stirring motor.

**2.2.4. STIRRING TIME**

Stirring time may be a significant process parameter in stir casting process. Lower stirring time may cause clustering of particle reinforcements and results non-homogeneous distribution of reinforcement particles. Whereas, higher stirring time may cause the deformation of the chrome steel stirrer impeller blade at very high working temperature. The working temperature of some reinforcement with aluminum matrix are very high. This temperature range is 850–950°C, which may deform the stirrer impeller. optimal value of stirring time is essential. has been investigated and suggested 10 min as optimal value of stirring to realize better distribution of reinforcements and uniform value of hardness throughout the composite.

### 2.2.4. FEED RATE

Feeder should be designed in such a fashion that it allows continuous flow of particles. High feed rate results particles accumulation within the composite and low federate is difficult to realize thanks to the formation of lumps of small solid particles.

Thus, selection of optimal rate of feeding is crucial. Less than 0.8 g/s is extremely difficult to realize and greater than 1.5 g/s results particle accumulation, hence the optimal rate of feeding is within the range of 0.8–1.5 g/s to avoid the buildup of reinforcements within the composite and achieve homogeneous dispersion of reinforcement particles throughout the composite. Accomplishing homogeneous distribution of particles in the melt and oxidation is the key problem frequently faced in stir casting process, which is controlled by stirring parameters. Therefore, choice of stirring parameters plays major role in stir casting method. Stirring speed, stirring time, impeller blade angle, size of impeller and position of impeller are major parameters, affecting the distribution of the reinforcements in the matrix

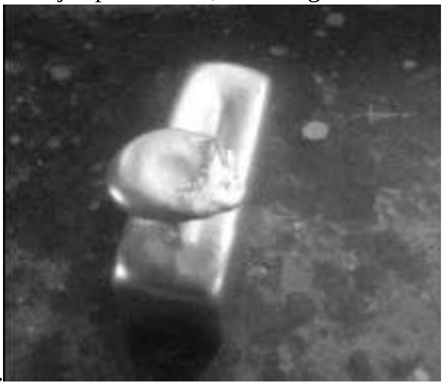

Fig. 3. Moulded Alumium Metal Matrix Composite

### 2.3. IMPACT TEST

Impact resistance of materials are determined by Izod method of impact test. During Izod test pivot arm is raised to a specific height and then released. During the swing arm hits the specimen to break. The dimensions of a typical specimen for ASTM are 63.5 × 12.7 × 3.2 mm. The utmost common specimen thickness is 3.2 mm, but the width can vary between 3.0 and 12.7 mm.

### 2.4. MICRO HARDNESS TEST

Micro hardness tests were performed by alphanumeric display micro hardness tester HVS-1000. The specimens were polished upto the specified standards then held perpendicular to the indenter. The used micro hardness testing machine gives an allowable range of load for testing with a diamond indenter; the resulting indentation was measured and converted to a hardness value. During the test, a continuing load of 0.98 N was maintained.

Fig. 4. Micro Hardness Testing

### 2.5. COMPRESSION TEST

Compression test is completed within the Universal Testing Machine (UTM). The cylindrical test specimen is mounted on the bottom plate of the UTM. The load is applied on the sample gradually until the sample is compressed until its height decreases by 50%. With increase in load displacement increases to a certain limit then reduces drastically when compressed more. The goal of a compression test is to determine the behavior or response of a material while it experiences a compressive load by measuring Ultimate Tensile Strength.

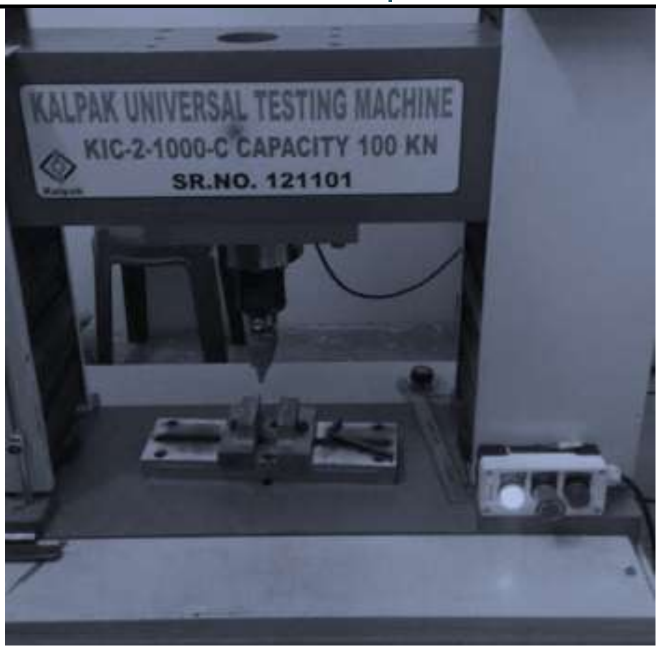


Fig. 5. Universal Testing Machine

### 2.6. BENDING TEST

Bending test deform the test specimen at the midpoint causing a concave surface or a bend to make without the occurrence of fracture and are usually accomplished to work out the resistance to fracture of that material. Unlike during a flexure test the goal isn't to load the fabric until failure but rather to deform the sample into a selected shape. The test sample is loaded during a way that makes a concave surface at the midpoint with a specified radius of curvature consistent with the quality in reference to which the test is performed. Bending assessments are as popular as tensile test, compression test, and fatigue tests.

Fig. 6. Bend Testing Machine

### 2.7. TENSILE TEST

An UTM is used for testing the Aluminium metal matrix specimens. The specimens were prepared using ASMT standards Constantly increasing speed is applied on the specimen where UTS and percentage elongation is recorded

## III. RESULT AND DISCUSSION

Table III gives the Impact resistance of materials Al6061 T6, AMC with 3% fly ash , AMC with 6% Fly ash, AMC wit 9% Fly ash are taken as Base alloy, Sample 1, Sample 2 and Sample 3 Respectively, where Sample 1 exhibits good impact resistance of materials. Table IV gives the material hardness / Resistance to penetration. Sample 1 which is prepared with 3% of fly ash has recorded highest of other samples. The flexural strength of sample 1 in bending test gives better results when compared with other samples. Table VI and VII gives the trend for Compression strength, Elongation and tensile strength where among the samples considered sample 1 exhibits good Mechanical properties

TABLE III
IZOD Test

| S. NO | Sample | Value of J for given Thickness |
|---|---|---|
| 01 | Base Alloy | 3.55 |
| 02 | Sample 1 | 3.75 |
| 03 | Sample 2 | 3.65 |
| 04 | Sample 3 | 3.70 |

Table IV
Micro Hardness Test

| S. NO | Sample | Micro Hardness (Vickers) HV(H) |
|---|---|---|
| 01 | Base Alloy | 74 |
| 02 | Sample 1 | 78.5 |
| 03 | Sample 2 | 75.1 |
| 04 | Sample 3 | 69.7 |

Table V
Bending Test

| S. NO | Sample | Flexural Strength (Mpa) |
|---|---|---|
| 01 | Base Alloy | 272.53 |
| 02 | Sample 1 | 350.21 |
| 03 | Sample 2 | 273.72 |
| 04 | Sample 3 | 271.22 |


Fig. 8. Bending Test (Load Vs Length) for Sample 1


Fig. 9. Bending Test (Load Vs Length) for sample 2


Fig. 10. Bending Test (Load Vs Length) for sample 3

Table VI
Compression Test

| S. NO | Sample | Compression Strength ($N/mm^2$) |
|---|---|---|
| 01 | Base Alloy | 234.56 |
| 02 | Sample 1 | 256.07 |
| 03 | Sample 2 | 214.45 |
| 04 | Sample 3 | 239.09 |

Table VII
Tensile Strength

| S. NO | Sample | % Elongation | UTS [$N/mm^2$] |
|---|---|---|---|
| 01 | Base Alloy | 18.64 | 133.48 |
| 02 | Sample 1 | 21.13 | 144.49 |
| 03 | Sample 2 | 17.47 | 105.46 |
| 04 | Sample 3 | 16.41 | 106.949 |


Fig.11. Tensile Strength (Load Vs Length) for Sample 1


Fig. 12. Tensile Strength(Load Vs Length) for Sample 2

Fig. 13. Tensile Strength for Sample 3

## IV. CONCLUSION

From the study on 6061 T6 aluminium alloy various mechanical properties of AMMC are tested for Base alloy, Fly ash @ 3%, 6% and 9% mixed with Aluminium and the Results are tabulated and compared to check which composition of materials gives good Yield. The experimental data show that selection of material is one of the very important aspects in production of metal matrix composites especially when enhanced mechanical properties are desired. Several iteration of experiments are needed before manufacturing. It is also seen that exceeding 10% of fly ash composite results in formation of blow holes and pores during casting. When the strengthening material added at a lower amount gives good mechanical properties.

## REFERENCES

[1] Y. H. Seo, and C. G. Kang, "The effect of applied pressure on particle dispersion characteristics and mechanical properties in melt-stirring squeeze-cast SiC/Al composites," J. Mater. Process. Technol., vol. 55, pp. 370–379, 1995.

[2] K. Purazrang, K. U. Kainer, and B. L. Mordike, "Fracture toughness behavior of a magnesium alloy metal-matrix composite produced by the infiltration technique," Composites, vol. 22 (6), pp. 456–462, 1991.

[5] G. S. Hanumanth, and G.A. Irons, "Particle incorporation by melt stirring for the production of metal-matrix composites," J. Mater. Sci., vol. 28, pp. 2459–2465, 1993.

[4] Y. Sahin, and S. Murphy, "The effect of fibre orientation of the dry sliding wear of borsic-reinforced 2014 aluminium alloy," J. Mater. Sci., vol. 34, pp. 5399–5407, 1996.

[5] Y. Sahin, "Wear behaviour of aluminium alloy and its composites reinforced by SiC particles using statistical analysis," Materials and Design, vol. 24, pp. 95-103, 2003.

[6] D. B. Miracle, "Metal Matrix composites-From science to technological significance," Composites Science and Technology, vol. 65, pp. 2526-2540, 2005.

[7] S. Basavarajappa, G. Chandramohan, and A. Dinesh, "Mechanical properties of MMC's- An experimental investigation," in Proc. ISRME'04, 2004, paper 01, p. 1-8.

[8] K. V. Mahendra, and K. Radhakrishna, "Fabrication of Al-4.5% Cu alloy with fly ash MMC and its characterization," Material science Poland, vol. 25, pp. 57-68, 2007

[9] Sudarshan, and M. K. Surappa, "Synthesis of fly ash particle reinforced A356 Al composites and their characterization," Material Science and Engineering- A, vol. 480 (1-2), pp. 117-124, 2008.

[10] M. B. Mahagundappa, H. K. Shivanand, and M. Muralidhara, "Influence of Reinforcements and Thermal Ageing on the Mechanical Properties of Al (6061) Based Hybrid Composites," India Foundry Journal, vol. 52, pp. 20-43, 2006.