

## Investigation on Mechanical properties of Al-6061 Alloy based MMC

Ajit Kumar Senapati<sup>a</sup>, Abhishek-Kumar<sup>b</sup>, Anurag-Kumar<sup>b</sup>,

<sup>a</sup> *Asso.Professor, Mechanical EnggDeptt, GIET, Gunupur,*

<sup>b</sup> *Final Year student's of Mechanical EnggDeptt, GIET, Gunupur*

*senapati.ajit@gmail.com, anuragtiwary11@gmail.com*

**Abstract**— In the present study aluminum alloy (6061) composites containing 10 and 15 wt.% of fly ash particles have been fabricated. Some mechanical behavior of unreinforced alloy and metal matrix composites are studied. Charpy impact test and compression test are considered for mechanical properties study. Results show that the Metal matrix composite prepared with 15 wt.% of fly ash exhibit better mechanical property compared to unreinforced alloy as well as metal matrix composite (MMC) prepared with 10 Wt.% of fly ash.

### 1.INTRODUCTION

Metal matrix composites (MMCs) represent a new generation of engineering materials in which a strong ceramic reinforcement is incorporated into a metal matrix to improve its properties including specific strength, specific stiffness, wear resistance, excellent corrosion resistance and high elastic modulus[1,2]. Over the past two decades metal matrix composites (MMCs) have been transformed from a topic of scientific and intellectual interest to a material of broad technological and commercial significance[3,4]. MMCs combine metallic properties of matrix alloys (ductility and toughness) with ceramic properties of reinforcements (high strength and high modulus), leading to greater strength in shear and compression and higher service-temperature capabilities. Thus, they have significant scientific, technological and commercial importance [5,6]. 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 [7,8]. MMCs offer a unique balance of physical and mechanical properties. Aluminium based MMCs have received increased attention in recent decades as engineering materials with most of them possess the advantages of high strength, hardness and wear resistance [9,10].

Fly ash particles are potential discontinuous dispersoids used in metal matrix composites, since they are low-cost and lowdensity reinforcement available in large quantities as a waste by-product in thermal power plants[10,11]. The fly ash contains the most important chemical constituents like SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub> and CaO. It constitutes quartz, mullite, magnetite, hematite, spinel, ferrite and alumina[12]. Addition of fly ash particles in to Al matrix improves the hardness, wears resistance, damping properties, stiffness and reduces the density [13]. The ductility of the composite decreases with increase in the weight fraction of reinforced fly ash and decreases with increase in particle size of the fly ash. However, for composites with more than 15% weight fraction of fly ash particles, the compressive strength is reported to be decreasing [14,15].

Most of the previous studies carried out on processing of aluminium–fly ash composites have utilized different size of reinforcement, different amount of reinforcement. But very little work has been reported on different amount of reinforcement in analysis of physical test. To overcome that situation, in this present investigation, we have casted two types of metal matrix composites by varying the wt. % of fly ash. As fly ash is cheap, abundant and it is a waste material from thermal power plant. The objective of the investigation was to compared the mechanical and tribological properties of the metal matrix composites with the base alloy.



## 2. EXPERIMENTAL PROCEDURE

### 2.1 MATERIAL

Al-6061 alloy was used as a matrix. The composition of the alloy is given in Table 1. Cenospheres of fly ash were used as a reinforcement material in this investigation. They were formed in the temperature range of 920–1200 °C (32). In this experiment we have used fly ash whose composition is as shown in the table-2.

**Table-1: Composition of Al-6061 alloy [wt. %] designated as a base alloy**

AL	Mg	Fe	Si	Cu
96.63	1.0	0.7	0.6	0.27
Zn	Cr	Ti	Mn	Others
0.25	0.2	0.15	0.15	0.05

**Table-2: Chemical Composition of Fly Ash**

Compound	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	Na <sub>2</sub> O	K <sub>2</sub> O
(Wt. %)	63.34	24.60	4.97	1.23	0.56	0.11	0.64

### 2.2 PREPARATION OF ALUMINIUM 6061 ALLOY

#### BASED METAL MATRIX COMPOSITE BY STIR CASTING

After cleaning Al 6061 ingot, it is cut to proper sizes, weighed in requisite quantities and were charged into a vertically aligned pit type bottom pored melting furnace (Fig.1).



Fig.1: Bottom Pouring Furnace

Fly ashes were preheated to 650°C±5°C before pouring into the melt of Aluminium-6061 Alloy. This was done to facilitate removal of any residual moisture as well as to improve wettability. The molten metal was stirred with a BN coated stainless steel rotor at speed of 400-450 rpm. A vortex was created in the melt because of stirring where preheated fly ash was poured centrally in to the vortex. The rotor was moved down slowly, from top to bottom by

maintaining a clearance of 12mm from the bottom. The rotor was then pushed back slowly to its initial position. The pouring temperature of the liquid was kept around 700°C. Casting was made in rectangular metal mould (250x20x45 mm<sup>3</sup>). For comparison purpose two composites were prepared with 10 and 15 wt.% of fly ash.

## 2.3 Mechanical Properties

### 2.3.1 IMPACT STRENGTH TEST

Impact Strength tests were performed by Charpy V Notchpendulum impact testing machine as shown in Fig 2. The square bar test specimens were placed as simply supported beams. Specimens were prepared by square cross section 10 mm x 10mm and 55 mm in length with 45-degree v notch at the centre as shown in Fig. 3. Single blow of hammer was given at mid span of specimen. The sufficient blow was applied to bend or break the specimen at centre. The striking energy was measured as 310 ±10 joules.



Fig.2 Impact testing machine



Fig.3 Specimen before impact test

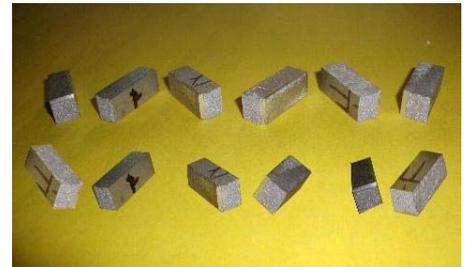


Fig.4 Specimen after impact test

### 2.3.2 COMPRESSION STRENGTH TEST

Compression test was done in the Universal Testing Machine (UTM) shown in Fig5. The cylindrical test specimen was mounted on the base plate of the UTM. The specimen here used had same diameter as that of height of the specimen shown in Fig6. The load was applied on the specimen gradually until the sample was compressed until its height reduced by 50%. As the application of load increased the displacement also increased, then the displacement reduced drastically as it cannot be compressed more. The photograph of used UTM and test specimens is shown in Fig below.



Fig.5 UTM machine



Fig.6 Specimen before compressive test



Fig.7 Specimen after compressive test

## 3. RESULT AND DISCUSSION

### 3.1 MECHANICAL PROPERTIES

Charpy Impact data for the three materials i.e. Al-6061 alloy, MMC with 10% fly ash and MMC with 15% fly ash were depicted in Table3. It was observed that the amount of energy absorbed by MMC prepared with 15% fly ash is higher in comparison to the other two materials i.e. Al-6061 alloy and MMC prepared with 10% fly ash. The

compressive test result was listed in Table 4. Data from compression test had also shown the highest strength value for MMC prepared with 15% fly than the other two materials. From the table-4, it can be observed that the compressive strength increased with an increase in the weight percentage of fly ash particles. This is due to the hardening of the base alloy by fly ash particles

**Table-3: Impact Strength of Al-6061, MMC with 10% fly ash and MMC with 15% fly ash.**

Sample no.	Sample name	Trial no.1	Trial no.2	Trial no.3	mean
01.	Al-6061	0.71	0.72	0.70	0.71
02.	MMC with 10% fly ash.	1.63	1.63	1.62	1.62
03.	MMC with 15% fly ash.	1.81	1.82	1.81	1.81

**Table-4: Compressive Strength of Al-6061, AMC with 10% fly ash and AMC with 15% fly ash.**

Sample No.	Sample Name	Trial no.1	Trial no.2	Trial no.3	Mean Compressive Strength In N/mm <sup>2</sup>
01.	Base alloy	460	462	459	460
02.	MMC with 10% fly ash.	478	479	479	479
03.	MMC with 15% fly ash	483	482	484	483

#### 4.CONCLUSION

- Stir casting method was used to prepare the composite which result in uniform distribution of flyash particles.
- Al-6061 alloy matrix composite was successfully fabricated with uniform distribution of flyash particales.
- Impact strength of the material was found to be increased with the increase in flyash concentration.
- It was observed that due to addition of flyash particles Compressive strength of the composite was increased.
- Physical properties of the Al-6061 alloy matrix was inanced due to the addition of flyash which ultimately inanced due to addition of flyash which ultimately inanced mechanical properties of the metal matrix composite.

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