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Experimental Investigation of Mechanical properties of Al-8011 Hybrid Composite Reinforced with Fly ash & E-glass

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Abstract- The intension of the present analysis is to determine the effect of varying reinforcements such as E-glass and Fly ash on the mechanical properties of Al 8011 hybrid composite. The hybrid composite test specimens are produced by the process called stir casting making use of graphite die with varying concentrations of E-glass and fly-ash particulates. A total of 64 numbers of specimens were prepared by varying E-glass and fly ash. The test specimens were made as per requirement of ASTM standard for conducting tensile and compression tests. The Metal matrix composites (MMCs) results in improvised properties like increased specific strength, specific modulus, damping capacity and good wear resistance in comparisons to regular alloys. Among the available MMC's aluminium composites are main in use due to their high strength to weight ratio. The MMC's have important characteristics like high specific strength and stiffness; good wear resistance, high electrical and thermal conductivity.

Index Terms-E-glass, Al8011, Fly-ash, Metal matrix composites.

1. INTRODUCTION

In the modern era of technology the usage of composite materials have found large application in the field of aerospace because of the limitations in achieving good mixture of properties like strength, stiffness, density & toughness by the conventionally used materials. Metal matrix composites gives very good mechanical properties such as good specific strength, greater damping capacity and good wear resistance, etc. in comparison with regular alloys. The composites are highly finding its application due to its low density and low cost of reinforcement available such as fly ash, it is hugely available as the bi-product of power plants usually using coal. E-glass fibre is an inorganic reinforcement which has very good mechanical properties and low density, therefore the use of both the fly ash and the E-glass fibre reinforcements with the Al-8011 as hybrid composite will not increase its density rather the mechanical properties are greatly enhanced.

Particulate aluminium reinforced composite materials are widely used due to its properties like low density, isotropic nature and the cost of production is low and the secondary processing such as fabrication and use of these material is easier than any conventionally used. While finding the mechanical properties of e-glass short fibres and fly-Ash reinforced Al-7075 by Prabhakar Kammar, Dr H K Shivanand & Santosh Kumar have found that there is an improvement in the UTS with the presence of fly ash and e-glass when compared to base metal alloy. The present research is to study the effect of reinforcement's like the fly ash and e-glass on mechanical properties of Al-8011. Different compositions of Al-8011 hybrid composites were made by stir-casting method by varying the weight percentage of fly ash, e-glass and Al-8011 alloy, then it is followed by machining of casts to standard test specimen size was done. Later tensile and compressive test were performed on the test specimens. For detailed analysis Scanning through electron microscope is done to know the reasons for fracture of the test specimens.

1.1 *Hybrid composites*

These are the composite material in which there will be two reinforcing constituents one organic and another inorganic reinforcement. In this research work fly ash is organic reinforcement whereas e-glass is inorganic reinforcement. Reinforcing materials usually withstand maximum load which is a desirable property. Further, even though composite types are being different from each other, no clear determination can be actually made. To ease definition, the accent is frequently shifted to the higher levels at which differentiation are made such as microscopic or macroscopic levels. In matrix-built structural composites, the matrix has two important roles to be performed, one is to binding the reinforcement phases in place and second one is deforming to dispense the stresses among the constituents of reinforcement material under an applied load condition. The demands on matrices are many. The matrices need to be temperature variations, be whether good conductors or resistors should have moisture sensitivity etc. These materials retain its elasticity till final facture occurs and show decreased failure strain, when loaded in tension and compression. Choice of production method depends on matrix properties and its effect on reinforcements. One of the prime considerations in the selection and construction of composites is that their constituents should be chemically inactive and non-reactive. Figure 1. helps to classify matrices.

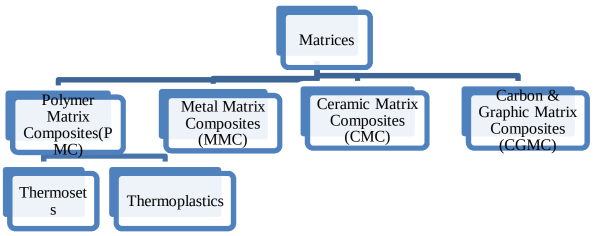

Fig. 1: Classification of matrix materials

1.2 Metal matrix composites

MMC's, at presently creating a huge interest in research field but are not commonly used as compared to the usage of plastic. Properties such as high strength, good fracture toughness and stiffness are the significant characteristics of metal matrices in comparisons with the properties of polymer matrices. And also MMC's can withstand higher temperature in corrosive environment. Many of the metals and alloys available can be used as matrices but they need important reinforcement materials having stability over a range of temperature and also it should be non-reactive. However the deciding factor for their selection depends essentially on the matrix material. Light metals are preferred as the matrix for the application where the operating temperatures are high and the reinforcements in addition to those reasons which are mentioned above and are recognized by high moduli.

The strength-to-weight ratios of the formed composites are greater than most alloys. The physio mechanical properties of the composite at different temperatures decide the working temperature of composites. In matrices of alloys with low melting points most of the available metals, ceramics are used. The selection of reinforcements becomes narrower with increase in the melting point of matrix materials.

1.3 *Particulate reinforced composites*

Microstructures of metal and ceramics composites, showing particles with one phase scattered in the other, are termed as particle reinforced composites. Different shapes of reinforcement such as triangle round and square are known, but in each of the cases dimensions of all their sides are observed to be near about equal. The size and its volume of the dispersion differentiate it from dispersion hardened materials. The size of dispersed in this composites is in the range of a few microns and its volume concentration is near about greater than 28%. The difference among these composite and dispersion is the strengthened ones thus it is oblivious and they are different in mechanism used to strengthen them. The dispersed in the dispersion-strengthen materials matrix alloy is reinforced by arresting movement of dislocations and thus needs greater forces to fracture the restriction created by dispersion. In particulate composites, system is strength is added by the particles by means of their hydrostatic coercion of fillers in the matrices and also by their hardness comparative to the matrix. The 3-dimensional reinforcement in composites gives isotropic properties, because of the presence of three systematically orthogonal planes. As it is heterogeneous, properties of the material are sensitive to the constituent properties and also sensitive to the factors like geometric shapes of the array and interfacial properties. The composite's strength usually depends on the factors like the radius of the particles, its inter- particle spacing, and also the fraction volume of the reinforcement. The matrix properties influence the behavior of particulate composite too.

2. METHODOLOGY

The matrix material for this experiment investigation is commercially aluminium alloy Al 8011 ingot, fly ash and e-glass. The hybrid composite is prepared by stir cast method. Firstly specimens were prepared with different compositions of hybrid composite by weight percentage of Al 8011, fly ash and e-glass. Commercial aluminium ingot Al 8011 is heated in electric furnace at 750°C for up to two hours in graphite crucible. Then the melt is stirred for two minutes with the addition of fly ash, e-glass which are weighed, hexa chlorine ethane tablets to prevent de-gasification. Then the melt is added to die and allowed for cooling. Upon cooling the cast is taken out and machined to standard test specimen sizes.

2.1 *Step by step procedure of experimentation*

- Ingot of Al-8011, fly-ash and e-glass were weighed for preparing different compositions.
- The weighed ingot of Al-8011 was heated in electric furnace up to 750C and degassed by hexachloro ethane tablets. The weighed fly-ash and e-glass were poured and stirred for a minute then the hybrid composite was poured into die.
- Hybrid composites of different compositions were prepared by keeping fly-ash constant and varying e-glass. For instance the first four hybrid composites were prepared by keeping 2% fly-ash and varying e-glass 1%, 3%, 5%, 7% into Al-8011 melt.
- Hybrid composites of different compositions were machined to ASTM standard test specimen size.
- Tests were performed in UTM.

3. CASTING PROCESS

3.1. *Stir casting*

Fig.2.0 Stir Casting Process

Steps involved in casting process

- First of all, approximately 1250gm weighing Aluminium 8011 ingot placed in a clay graphite crucible was melted in a resistance furnace. The melting point is 750°C.
- After melting, the crucible was removed from the resistance furnace and degassed by purging hexachloro ethane tablets into the clay graphite crucible. Degasification is the process of removal of dissolved gases in liquids, especially water or aqueous solutions.
- Flyash& E-glass fibres in required proportion are added to the melted red hot liquid. With the help of mechanical stirrer, all the added composites are well stirred such that all the constituent material get mixed properly with the base metal i.e., Al 8011.
- Later the red hot liquid mixture is poured into the dies made as per ASTM standard and allowed for solidification for a minimum time of 30 minutes.
- Then the casting dies are separated out to get the cast products which are sent for machining.

3.2. *Castings of different compositions of hybrid composites*

Hybrid composites of different compositions were prepared by keeping fly-ash constant and varying e-glass. For instance the first four hybrid composites were prepared by keeping 2% fly-ash and varying e-glass 1%, 3%, 5%, 7% into Al-8011 melt. The above step was repeated for by keeping fly-ash constant for 4%, 6% and 8%.
Different compositions of hybrid composites are provided in the table below

4. RESULTS & DISCUSSIONS

The following table shows the tensile and compressive strength of various composition of test specimens after testing.

Table No.1: Tensile and compression strength test results

Sl No	Composition			Average UCS (MPa)	Average UTS (MPa)
	Al8011 (%)	E-glass (%)	Fly-ash (%)		
1	97	1	2	626.25	137.01
	97	1	2		
2	95	3	2	649.92	94.15
	95	3	2		
3	93	5	2	657.32	132.89
	93	5	2		
4	91	7	2	665.96	112.25
	91	7	2		
5	95	1	4	713.70	120.94
	95	1	4		
6	93	3	4	734.70	101.95
	93	3	4		
7	91	5	4	682.69	116.12

	91	5	4		
8	89	7	4	710.61	113.57
	89	7	4		
9	93	1	6	655.01	129.87
	93	1	6		
10	91	3	6	674.29	122.60
	91	3	6		
11	89	5	6	701.92	97.03
	89	5	6		
12	87	7	6	526.09	130.11
	87	7	6		
13	91	1	8	627.28	133.65
	91	1	8		
14	89	3	8	626.91	118.16
	89	3	8		
15	87	5	8	684.99	103.00
	87	5	8		
16	85	7	8	682.59	94.30
	85	7	8		

4.1. *Tensile test*

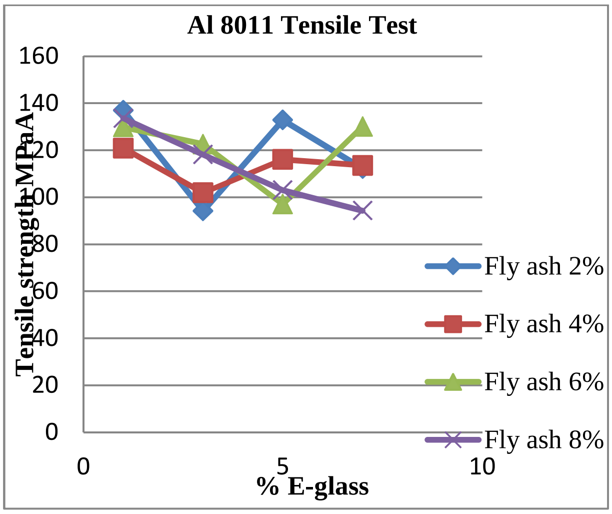

Fig. No.3 Comparison of Tensile strength of Hybrid Composites

From the above comparative graph with varying percentages of fly ash and e-glass in Al 8011 it is observed that as percentage of fly ash increase tensile strength increases. The optimum combination of fly ash and e-glass to get increased tensile strength is found to be 2% fly ash 1% e-glass and 8% fly ash 1% e-glass.

4.2. *Compression test*

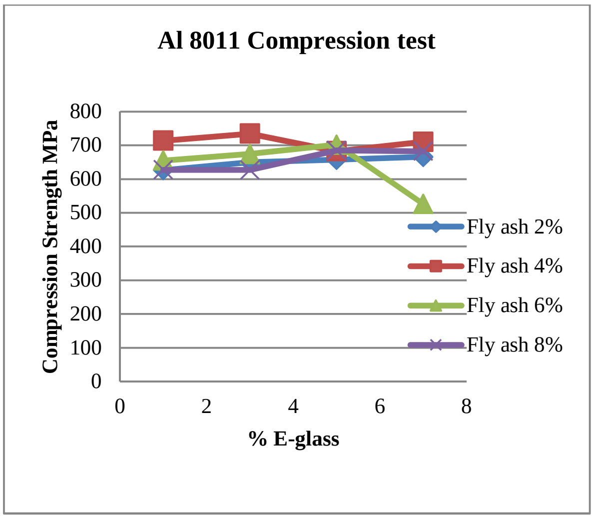

Fig No.4 Comparison of compression strength of Hybrid Composites

From the above comparative graph it is observed that with increase in percentage of fly ash and e-glass there is increase in compression strength. The optimum composition to get maximum compression strength is found to be 4% fly ash 3% e-glass.

5. CONCLUSION

5.1. *Tensile strength test:*

For Fly-ash 2%: From the test results of the first four samples it is observed that with increase in the percentage of e-glass i.e. 1%, 3%, 5%, 7% tensile strength decreases and tensile is maximum for fly-ash 2% E-glass 1%.
For fly-ash 4%: Again the samples from five to eight are follows the same trend, tensile strength is maximum for fly-ash 4% and e-glass 3%
For fly-ash 6%: The test results of samples nine to twelve depict that with increase in percentage of fly-ash and e-glass tensile strength decreases
For fly-ash 8%: The test results of samples thirteen to sixteen depict that with increase in percentage of fly-ash and e-glass tensile strength decreases.

5.2. *Compression Test:*

For fly-ash 2%: From the compression test results it is observed that for sample one to four with the increase in the percentage of e-glass compression strength is increasing.

For fly-ash 4%: Again the samples from five to eight are following the same trend, compression strength is maximum for fly-ash 4% and e-glass 3%.
For fly-ash 6%: The results of samples nine to twelve depict that with the rise in percentage of fly-ash and e-glass compression strength decreases.
For fly-ash 8%: From the test results obtained for the samples thirteen it is see that with increase in the percentage of e-glass compression strength is decreasing.

From the above discussion it can be conclude that the tensile and compression strength of the specimens is decreasing with the increase in the percentage of fly-ash and e-glass. The optimum percentage for moderately increase of strength in tension of Al-8011 is Fly-ash 2% and e-glass 1% whereas the optimum percentage for moderately increased compression strength is fly-ash 4% and e-glass 3%.

Present work was done keeping fly-ash constant and varying e-glass, now there is a scope to carry out the work by keeping e-glass constant and varying fly-ash. And also the Analysis of fracture of hybrid composites can be done by using ansys.

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