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Assessment of Mechanical and Corrosion properties of Aluminium Reinforced with Fly Ash (ALFA) Metal Matrix Composites

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***Abstract* - Aluminium alloy with Fly Ash composites which is now recognized as ALFA metal matrix composites are innovative and are most favorable materials in engineering applications. Several investigations promising in employing fly ash as reinforcement material with different aluminium series alloys other than Al5083 was studied. In the present work development of ALFA composites by using Al5083 alloy reinforced with fly ash through varying weight percentages in order of 5, 10 and 15 was accomplished. Fabrication was through stir casting means, machining and mechanical assessments was accompanied as per the ASTM defined standards. In order to determine the mechanical properties of these components they were exposed to different tests like tensile, hardness along with microstructure examination. Corrosion kinetics which is to study the weight loss in the material was carried out in the research. These samples were kept in sea water basin and weight loss was tested over a period of time. As the end result indicated that there was an improvement in ultimate tensile strength, hardness and bonding along with decline in weight loss was observed up to limiting percentage of fly ash addition.**

***IndexTerms* - ALFA, MMC, Fly Ash, Composites, Al-5083 alloy, Tensile strength, Hardness, Corrosion Kinetics**

I. INTRODUCTION

Composites can be well-defined as per when two or more unlike materials ensuring dissimilar properties/assets substantially combined together, they work towards development of composite materials. These composites materials have unique properties resulting after their combination which stand superior to individual properties. The major key factor in selecting any of the composites is in its strength to weight ratio. Composites are selected since it reduces the total weight of the material and accordingly increases the material strength. Composite materials set up essential standards in design and in weight-efficient structural materials that exist in every sphere of engineering applications. Composites exist in 3 types on the source of matrix material used are,

a. Polymer matrix composites
b. Ceramic matrix composites
c. Metal matrix composites

Metal matrix composites (MMC) comprises of metal as discrete medium with a different metal as reinforcement medium, these MMC preserve their upgraded properties once compared to unreinforced alloys. The benefit in using MMC comprises of higher specific strength, good elastic properties, higher wear and fatigue resistance when related to other composites. Metal Matrix Composites (MMCs) are widely used in several areas like in design of automobile components, aerospace industry, military equipment's, marine industry etc.

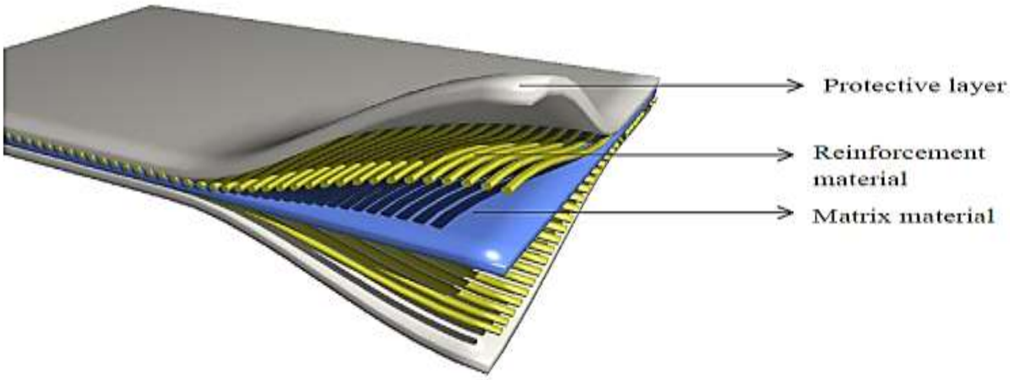

Figure 1: Composite Material

II. EXPERIMENTAL PROCEDURE

The procedure carried out in this present work is as shown below,

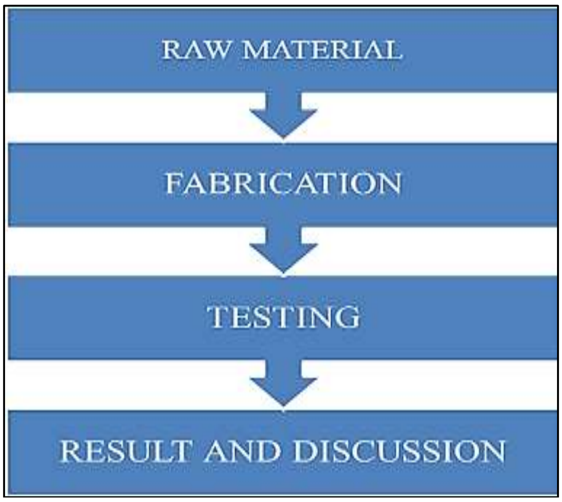

Figure 2: Work Process

2.1 Selection of Raw Material

Selection of material is essential in any research. It depends on the application of the material that is used and also on the type of reinforcement used with it. Here in this study the matrix material used is Aluminium 5083 alloy and the reinforcement matrix used is fly ash.

2.1.1 Al-5083 alloy

In marine industry, increase in usage of aluminium is through capitalizing on its prominent qualities. The two major potentials in selecting aluminium are in its lightness and corrosion resistance. Hence commonly used aluminum alloy which exhibit suitable strength plus excellent corrosion resistance is 5xxx series or Al-Mg alloy. Al-5083 alloy consists of magnesium as principle alloying element with bits of manganese and chromium in it. As a result for the reason of its high resistance to corrosion with high strength, hence it is widely used in ship building and pressure vessels etc. In the present investigation Al-5083 was preferred as the matrix material in improvement of ALFA composites.

Table 1: Chemical composition of Aluminium-5083

Element	% Present
Aluminium (Al)	Balance
Magnesium (Mg)	4.00 - 4.90
Manganese (Mn)	0.40 - 1.00
Iron (Fe)	0.40 Typical
Silicon(Si)	0.0 - 0.40
Titanium(Ti)	0.05 - 0.25
Chromium (Cr)	0.05 - 0.25
Others (Total)	0.0 - 0.15

Table 2: Mechanical Properties of Aluminium-5083

Property	Value
Proof Stress	125 Min MPa
Tensile Strength	275 - 350 MPa
Hardness Brinell	75 HB

2.1.2 *Fly Ash*

In thermal power plants however generation of electricity is over combustion of coal (burning fossil fuel). The discarded unburnt residue after combustion in massive is well-known as fly ash. Fly Ash an unused by-product is nowadays used as reinforcement material in development of composites. The key benefit of using fly ash is for the reason that of low density and inexpensive. The applications of fly ash includes in concrete production, agricultural usages as well in civil engineering constructions for the reason that is it reduces the density of the material and increases the strength. Therefore Fly Ash residue was chosen as reinforcement matrix in invention of ALFA composites.

Figure 3: Fly Ash Sample

III. FABRICATION AND MACHINING TECHNIQUE

3.1 *Fabrication*

Fabrication is a step by step procedure in manufacturing of early raw material to complete material. This step by step manner is essential in improvement of composites. In this research, production of ALFA composites was by means of stir casting technique. Stir casting method is a liquid state process were molten metal is dispersed into the mould cavity and exposed to solidification.

The steps includes

a. Raw material casting
b. Adding reinforcement material
c. Stirring process
d. Discharge into mould cavity as per the dimensions
e. Solidify

Figure 4: Stir casting setup

Figure 5: Mould cavity

Table 3: Composition of ALFA MMC

Samples	Compositions Made	No of Components
S1	ALUMINIUM 5083+0%Fly Ash	3
S2	ALUMINIUM 5083+5%Fly Ash	3
S3	ALUMINIUM 5083+10%Fly Ash	3
S4	ALUMINIUM 5083+15%Fly Ash	3

Figure 6: Samples after casting

3.2 Machining

Machining is a process in which the fabricated constituents are subjected to removal of excess material and meet the geometrical standard dimensions setup for testing. The power driven machine tools used are lathe, milling machine and drilling press.

IV. TESTING

Testing on ALFA composites is conceded to estimate the mechanical properties and their behavior at transformed loading situations and to assess the best compositions. The fabricated components are subjected to tensile and hardness tests to define the mechanical characteristics. Microstructure inspection was to examine the distribution of the particles and evaluate the bonding strength. Corrosion kinetics study is to describe the weight loss within the material. Ultimate tensile strength was determined using universal tester. The standard measurement for tensile test samples used was ASTM A-370. Brinell hardness test machine was used to measure the hardness test on the samples with constant load and time. The standard measurement for hardness test samples used was ASTM E-10. Microstructure observations were made on the samples using scanning electron microscope at 100X magnification.

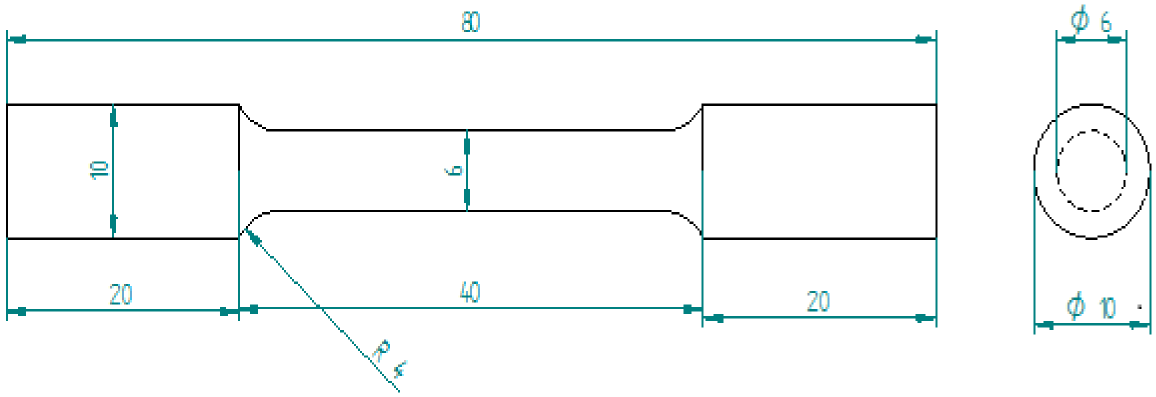

Figure 7: Standard Tensile Test Specimen Drawing (Dimensions are in mm)

V. RESULT AND DISCUSSION

Figure 8a: Before test

8b: After test
Figure 8: Tensile Test Specimens before and after test

Figure 9: Hardness Test Specimens after test

Table 4: Experimental data for Al 5083 + Fly Ash (MMC)

Samples	Ultimate tensile strength (Mpa)	Brinell Hardness No (BHN)
S1	122.43	44.9
S2	149.03	44.6
S3	144.28	56.8
S4	151.46	44.6

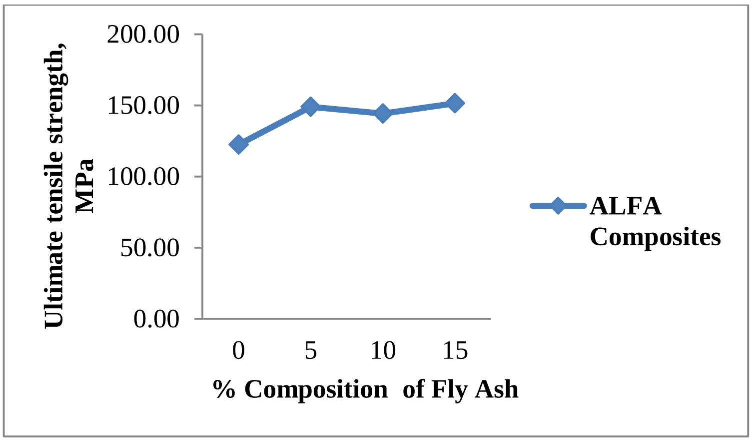

Figure 10: Variation in Ultimate Tensile Strength with Fly Ash Composition

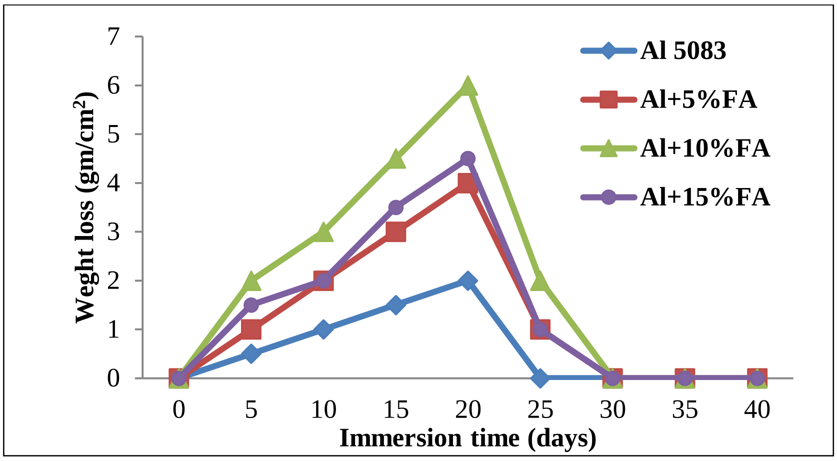

Figure 10: Weight loss in ALFA composites immersed in sea water sample at open air

From the above experimental data table 3, the deviations in ultimate tensile strength as well as in hardness is observed. This indicates the growth and fall in both the properties with changing compositions. From the above figure 9, the weight loss in ALFA composites with variable compositions is shown and it is observed that weight loss in the material with respect to time is non-linear. This displays the weight loss is inconsistent with time, but a rapid drop in weight loss is seen and turns out to be constant with time.

VI. CONCLUSION

From the present research, development of ALFA composites yields preferred mechanical properties comprising of ultimate tensile strength, hardness and bonding strength. The outcomes from corrosion kinetics also revealed lower weight loss in the materials with increase in time. Thus Al 5083 alloy with fly ash in development of ALFA composites can replace the existing Al 5083 alloy in shipbuilding, advanced marine structural applications for better results and performances.

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