INVESTIGATION OF MECHANICAL PROPERTIES OF DURALUMIN SANDWICH HYBRID COMPOSITE USING E-GLASS FIBER

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ABSTRACT
During the past, few decades metal/polymer composites had rapidly increased their demand in various applications due to their synthesis mechanism of combining two or more diverse materials and bringing together with the intent of enhancing properties and thus their performance. Hence it is desirable to perform a study on these combinations. Aluminium glass fiber reinforced polymers are used in applications such as structural, automobile, aerospace, marine, etc. Dural/Duralumin is a strong alloy of aluminium, in addition to aluminium the main components are copper, silicon, magnesium and manganese. So, replacing aluminium with duralumin will give far more strength than aluminium and can increase the efficiency of the product. This paper focuses on how to cast the duralumin, then fabrication of duralumin with E-glass fiber hybrid composite where epoxy resin was used as a binder, thus a sandwich panel was prepared by hand lay-up process. The specimens were cured and tested as per ASTM standards to determine various mechanical properties such as Tensile, flexural and impact strengths and corresponding results were analyzed.

Key words: Duralumin, E-glass fiber, Epoxy Resin, Hybrid Composite, Sandwich panel

http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=8&IType=5
1. INTRODUCTION
Glass fiber reinforced composites are widely used in industries for the development of high-end applications such as automotive spare parts, aerospace because of their ability to withstand high tensile, flexural and impact loads. This work focuses on finding the mechanical properties of duralumin and duralumin glass fiber composite. Duralumin has excellent strength to weight ratio, having a good strength while being lightweight. Duralumin was casted by taking its standard composition of aluminium, copper, magnesium, manganese and silicon. Casted duralumin panels were bonded to E-glass fiber using epoxy resin (LY 561) [6] and Hardener (HY951) through Hand Lay-up Process. These composites were heat treated using muffle furnace (mufflefurnace is a furnace with an externally heated chamber, the walls of which radiantly heat the contents of the chamber, so that the material is being heated with no contact with the flame) so that we can eliminate excess resin or gaps in the composite material. Tensile, Impact, Flexural Tests were performed to investigate the strength of the composite material.

2. FABRICATION PROCESS

2.1. Casting of Duralumin
A wooden plank was cut into required dimensions, by considering tolerances which was to be used as a pattern. The wooden pattern was used for making mold by marking the runners, ingates, screw and risers in the molding box and the boxes were kept aside until they were solid and stable. Aluminium (94%), copper (4%), silicon (1%), magnesium (0.5%) and manganese (0.5%) [1], melted by considering their respective melting points and composition. Mixing of metals was done to form molten duralumin alloy in the furnace [8]. slag was removed and the molten metal was poured into molding boxes. Molding boxes were placed without being disturbed for an hour and were allowed to cool down. Duralumin pieces were removed from the boxes. Thus, casting of duralumin alloy was complete.

2.2. Machining Process
Duralumin pieces obtained from casting consists of surface roughness and uneven thickness. So, the duralumin pieces were surface finished using surface grinder and to obtain required dimensions’ duralumin specimens were machined using milling machines. Specimen dimensions for tensile test are 160x13x5, specimen dimensions for impact test pattern were 65x13x10 and specimen dimension for flexural test are 100x25x5. (All dimensions in mm).

2.3. Manufacturing of Composite Material
Composite material was manufactured using hand lay-up process in which a wide variety of composite products from very small to very large materials can be manufactured. E-glass fiber of 1mm thickness was taken without any dust particles on it and resin-hardener [6] were mixed thoroughly in the ratio of 10:1, which acts as a binder. Resin was applied by pouring and brushing on either side of glass fiber and duralumin was placed on both the sides of glass fiber [3]. These specimens were left untouched for 28 hours with weights placed on them, so that the air gaps and voids can be eliminated. The unnecessary glass fibre around the composite material was cut and Thus, composite specimens were ready to be used for tensile, flexural and impact tests. Composite Specimen before cutting the extra glass fibre is shown below in the fig 1.
2.4. Curing Process
In general, uncured epoxy has low bonding strength, poor mechanical, chemical and heat resistant properties. Curing may be achieved by heating the composite material at a certain temperate in an oven or furnace for 2 hours, which varies from material to material.

Composite materials after cutting the extra glass fiber pieces were subjected to heat treatment for 2 hours at 60° degree centigrade in a furnace to remove unnecessary gaps and increase its bonding strength [9]. Muffle Furnace is shown in the fig 2 below.

3. EXPERIMENTATION
To assess the mechanical properties of fabricated duralumin e-glass fiber composite tensile, flexural and impact tests [2] [4] were conducted on the specimen taken according to ASTM standards. Through these tests important material properties can be found, so that their structural and automobile applications can be determined.
3.1. Tensile Test
The tensile test was carried out with standard specimens on universal testing machine of 100 tons’ load capacity at a strain rate of 1mm. The test was carried out with four different samples, namely duralumin bar, glass fiber laminates, duralumin and glass fiber sandwich hybrid composite [7]. The specimen dimensions of the hybrid composite panel are 160x12.7x5 mm. The specimen was mounted to the grip of the testing machine and gradually loaded in tension. Thus, the tensile properties of the specimen were determined. Standard values of duralumin according to online resource MATWEB are yield strength = 460 MPa, ultimate tensile strength = 730 MPa, break strength = 310 MPa. The tensile test sample before testing is shown below in fig 3.

![Figure 2 Tensile Test Specimen](image)

3.2. Flexural Test
The flexural bending test was carried out with a digital tensometer of 2-ton capacity according to ASTM standards for determining flexural strength. This technique requires specialized fixtures and precision displacement measurement system. The composite test specimen with dimension 110x25x5 mm was mounted on rollers and load was applied on specimen. The flexural strength of the specimen can be calculated by the formula,

\[ S = \frac{3pl}{2bt^2} \]

Where \( p \) – Maximum load, \( l \) – Distance between two rollers, \( b \) – width of the specimen, \( t \) – thickness of specimen. Thus, flexural behavior of the composite specimen was determined. The specimens before flexural testing is shown below in fig 4.

![Figure 4 Flexural test Specimen](image)
3.3. Impact Test
The impact strength was assessed by the Charpy impact testing machine which determines the energy absorbed by the material during fracture. The dimensions of the composite specimen were 63.5x12.7x11mm and a 4mm notch was made at the center portion of specimen to perform charpy impact test [5]. The specimen was mounted on the test apparatus and the test was performed. The impact strength can be calculated by the formula

\[ I = \frac{EI}{T} \]

Where \( EI \) = Impact energy, \( T \) = Thickness of the sample. Thus, impact energy of the composite specimen is determined. The specimens of impact testing are shown below in fig 3.3

![Impact Test Specimen](image)

**Figure 5** Impact test Specimen

4. RESULTS AND DISCUSSIONS

4.1. Tensile Test Results
Duralumin Manufactured for the purpose of testing are as follows

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<td><strong>Table 1</strong></td>
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<tr>
<td>Yield Strength</td>
<td>450 MPa</td>
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<td>Ultimate Tensile Strength</td>
<td>720 MPa</td>
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<tr>
<td>Break</td>
<td>300 MPa</td>
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when compared with standard values of duralumin from online resource MATWEB and casted duralumin as mentioned above are within the same range. Hence, casted duralumin has similar properties and can be used in standard structural applications.

**Duralumin with Glass Fiber Composite**

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<td><strong>Table 2</strong></td>
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<tr>
<td>Yield Strength</td>
<td>430 MPa</td>
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<tr>
<td>Ultimate Tensile Strength</td>
<td>620 MPa</td>
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<tr>
<td>Break</td>
<td>475 MPa</td>
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By comparing the properties of duralumin specimen and duralumin composite material we can clearly understand that the break and yield strength of duralumin composite are higher.
4.2. Flexural Test Results
At a load of 810N the elongation of the duralumin composite is 2.9mm, which means duralumin specimen can withstand flexural load till 810N. The results of the flexural test method are sensitive to specimen, loading geometry and strain rate. Duralumin E-glass fiber composite may not be suitable for applications in which high bending stress is required.

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<th>Load (N)</th>
<th>Elongation (mm)</th>
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<td>810</td>
<td>2.9</td>
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4.3. Charpy Impact Test Results
Impact tests were determined to find out the material toughness or impact strength in presence of notch size 4mm and impact load. According to online resource MATWEB [1] Duralumin impact energy is 22 joules. Impact energy observed in the testing of duralumin glass fibre Composite was 26 joules.

When compared Duralumin-glass fibre composite with standard duralumin it was observed that duralumin composite can sustain heavy loads. So, duralumin composites can be used where impact strengths are crucial like aerospace, automotive applications.

5. CONCLUSION
The hybrid composite specimens were tested for the tensile, flexural and impact properties and their respective strengths were calculated. Duralumin and hybrid composite were compared for mechanical properties and it is observed that duralumin composite has far greater strength, so we can conclude that most of the duralumin applications can be shifted to duralumin E-glass fiber hybrid composite.

REFERENCES
[1] Goodfellow Dural Aluminum/Copper/Magnesium Alloy, Online resource Matweb


