Tensile and Flexural Characterization of Nomex and E-Glass Fibre Reinforced Epoxy Composites

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Abstract— Over the last three decades’ composite materials have been used in the engineering field. Automotive and aerospace industries require materials which have high strength to weight proportion. Composite materials are being used as lightweight materials for vehicle bodies to meet targets for reducing fuel consumption and emissions and as structural composites in aerospace. There is a need for heat resistant composites in fields of automotive and aerospace. Resistance to long term exposure of heat is possible by reinforcing the Glass fibres with Nomex sheet which has high temperature resistance characteristics. These unique composites can be used in high temperature thermal protection systems and as flame deflectors for aerospace applications. In this present investigation a composite using Epoxy/Nomex sheet /Glass fibre is prepared by Hand-layup technique. Chopped strand mat of E-glass fibre, Nomex sheet of 0.08 mm thickness and Epoxy resin is used in the present investigation. Four different types of composites are fabricated using 0%wt, 10%wt, 15%wt, and 20%wt of Nomex paper with Chopped Strand Mat-E glass fibre and epoxy resin. After all the samples were prepared and mechanical tests were carried out on the samples to discover the changes observed due to the composition of Nomex sheet. The obtained results were compared and graphically charted to characterize the new composite material.

Key words: Nomex, E-Glass fibre, Epoxy composites, Hand layup Techniques

I. INTRODUCTION

Fibre reinforced composite materials are being used because of its breakthrough in the construction of lightweight structures. One major benefit has been realized in the aerospace industry is that it meets the performance requirements with the strict demands of reliability. Almost all aerospace structural components-airframes of fighter aircraft, helicopters, control surface and fins of civil aircraft, various planes in satellites, antennas, rocket motor casings and some complete airframes of small aircraft are witnessing an increasing use of the advanced composites. Heat resistance composites are required in applications where parts of the component are exposed to high temperatures up to 400oc while reducing the weight of the component for the optimum design [1-5]. There is a growing need in aerospace, defence, space, automotive and motor sports to replace metals with heat resistant composite materials where the metals are exposed to heat or fire [6-8]. Despite advances in the fields of organic matrix composites and ceramic-matrix composites, a practical solution is still being sought for lightweight materials which can replace titanium, steel or Inconel in the 300-1000°C temperature range. E-Glass (V-9)/Di-amine modified phenolic composites and Rayon carbon/ether modified Phenolic composites were being used as heat resistant composites which serve the work to some extent [9-12]. The Geo polymer matrix resin is being evaluated for fire proof aircraft interior panels. In order to fight the problem in this present study Nomex sheet is reinforced with E glass fibre and Epoxy. Epoxy base matrix composite has great potential to replace the traditional metallic material. Nomex sheet which has the heat resistant property is used in present study. Combining the two components into a single laminate can produce a composite that exhibits high tensile strength, low weight, high wear resistance and increased temperature resistance [13-15].

II. MATERIALS AND METHODS

A. Selection of Materials:

Chopped strand mat of E glass fibre with thickness of 0.2mm is used as reinforcing material, it is a structural fibre used in aerospace applications and cost of the material is less so this material is selected. The chemical composition of E-glass materials by weight % is shown in Table 1.

<table>
<thead>
<tr>
<th>SiO2</th>
<th>Na2O</th>
<th>CaO</th>
<th>MgO</th>
<th>Al2O3</th>
<th>K2O</th>
<th>TiO2</th>
<th>Fe2O3</th>
<th>B2O3</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>0.1</td>
<td>20</td>
<td>12</td>
<td>1</td>
<td>0.8</td>
<td>0.4</td>
<td>0.6</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Chemical composition of E-Glass by weight%

Nomex T410 sheet with 0.08mm thickness is selected. It is an insulating material with good heat resistant property. Nomex sheet structures have good mechanical properties at high temperatures. Nomex meta-aramid, poly (meta-phenylenisophthalamide) is depicted in Fig. 1. It is prepared from meta-phenylenediamine and isophthaloyl chloride in an amide solvent. It is a long chain polyamide in which at least 85% of the amide linkages are attached directly to two aromatic rings. The aromatic rings and the conjugated amide bonds that link them together are particularly strong and resistant to chemical attack. They also provide a high degree of heat resistance to the polymer backbone. As a result, the material does not melt and drip, and merely chars when exposed to high temperatures for prolonged periods. A Nomex sheet structure also retains good mechanical properties at low temperatures. This allows the material to work in cryogenic temperatures. The properties of nomex sheet are illustrated in Table 2.

![Fig. 1: NOMEX Meta-aramid Synthesis](image)

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Table 2: Mechanical Properties of Nomex sheet

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>0.08 mm</td>
</tr>
<tr>
<td>Density</td>
<td>0.80 g/cc</td>
</tr>
<tr>
<td>Base weight</td>
<td>63 g/m²</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>65 N/cm</td>
</tr>
<tr>
<td>Thermal conductivity</td>
<td>114mWatt/meterK</td>
</tr>
</tbody>
</table>

Epoxy resin is a thermosetting polymer resin. It is being used as matrix material for laminated composites. Epoxy resins have high strength low creep characteristics; it has low viscosity and good adhesion property, low shrinkage during curing. LY556 is used as epoxy and HY951 is used as hardener in the present study.

B. Experimental details

In this study the matrix material Epoxy resin of density 1.18 g/cm³ and hardener of density 0.98 g/cm³ is mixed in the ratio of 9:1. The laminates are prepared using hand lay-up technique the samples are prepared in sizes of 3 mm thick, 160 mm square laminate with subsuming stacked layers of 0.08 mm thick Nomex sheet and 0.2 mm thick E-glass fibre. Thickness of the layers has been developed by stacking the layers of Nomex sheet and E-glass fibre in the mould. Chopped strand mat of E-glass fibres and Nomex sheet is cut in required weight proportions and as per dimensions of the mould. Epoxy resin (LY 556) is mixed with hardener (HY951) in the weight ratio 9:1 in a beaker. The mould is cleaned with acetone and then wax is applied to the moulds for easy removal of the cured laminate. The mould is coated with mixed resin before placing the Nomex sheet, the sheet is cut in the form of strips as per mould dimensions is placed in the mould and then mixed epoxy resin is poured and spread with the help of roller and then chopped E-Glass strand is paces as another layer and rolling is done with roller to remove air bubbles and again epoxy resin is poured and Nomex sheet is placed on to it and the process continues until desired thickness of laminate is achieved. Mold is closed with the plastic sheet and load is applied on composite material for 24 hours for curing. Four laminated composites were prepared with different compositions of nomax sheet and E-Glass fibre the compositions are 0%Nomex+10% E-Glass fibre, 10%Nomex +10% E-Glass fibre, 15%Nomex +10% E-Glass fibre and 20%Nomex +10% E-Glass fibre. The composites were obtained as shown in the figure 2. The samples were prepared based on the ASTM standards tensile and flexural testing.

Fig. 2: Laminate Composite

III. RESULTS AND DISCUSSION

A. Mechanical Properties

The mechanical properties of a composite are affected by many factors like types of reinforcement, amount of reinforcement, processing parameters, dispersal of reinforcing material in the matrix and the bonding that takes place between the matrix and the reinforcement. To evaluate the mechanical properties, tensile tests and flexural tests were executed on the prepared composites and the following results were observed.

B. Tensile Test

The tensile test determines the ability of a material to withstand loads before elongation. For this, the specimens were cut as per ASTM: D638-10 and the tests were conducted on the UTM. The results are displayed in Fig. 3 with the help of bar graphs. From figure 3, it is clear that the tensile strength increases from 1732 MPa of 0% Nomex+10% E-Glass fibres to 2256, 2489, 2798 in 10% Nomex+10% E-Glass fibres, 15% Nomex+10% E-Glass fibres, 20% Nomex+10% E-Glass fibres respectively. An increase in tensile strength is observed due to addition of nomex sheets to the laminate.

C. Flexural Test

The flexural test determines the performance of materials under simple beam loading. It plays a significant role in structural application purposes. To find out the flexural strength of composites, a three-point bending test was carried out. For this, the specimens were cut as per ASTM D2344-84 and the tests were conducted on the UTM. The results are displayed in Fig. 4 with the help of bar graphs. From figure 4, it is clear that the flexural strength increases from 7092 MPa of 0% Nomex+10% E-Glass fibres to 7889, 8088, 8298 in 10% Nomex+10% E-Glass fibres, 15% Nomex+10% E-Glass fibres, 20% Nomex+10% E-Glass fibres respectively. An increase in tensile strength is observed due to better interaction between the epoxy and reinforcement.

Fig. 3: Tensile strength of Composite specimens

Fig. 4: Flexural strength of Composite specimens
IV. CONCLUSION

The present work deals with the preparation of nomex and e-glass fibre reinforced epoxy composite. A study has been done to find out the mechanical properties of the prepared composites and the following conclusions are drawn:

1) An epoxy based composites reinforced with nomex and e-glass fibre is successfully produced using hand lay-up technique.
2) A good bonding is observed between the reinforcements and the epoxy LY556 which imparts superior mechanical properties.
3) The tensile strength of the composite increases with increase in weight % of nomex sheet with e-glass and it is highest for 20% Nomex+10% E-Glass fibres.
4) The flexural strength of the composite increases with increase in weight % of nomex sheet with e-glass and it is highest for 20% Nomex+10% E-Glass fibres.
5) The present work has a future scope which includes chemical analysis, thermal analysis, wear analysis, and SEM analysis.

REFERENCES


