Mechanical residences of aluminium foam sandwiched with glass fibre epoxy composites in comparison with GFRP

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Abstract:
Glass fiber reinforced plastic (GFRP) skins bonded onto low density cores, offer potential mechanical properties which can be used various industries such as automobile, aerospace, marine and defence because of their high specific stiffness's and strengths, excellent thermal insulation. In this research, aluminium foam core with the thickness of (0.5 & 1 mm) sandwiched with glass fibre epoxy laminate are fabricated using hand layup process. Mechanical properties such as tensile, impact and flexural strength was investigated on the fabricated samples. It this work it was observed that, maximum of 115.52 N/mm^2 tensile strength was obtained in the aluminium foam core with 1 mm thickness sandwiched with glass fibre composites. Also 84.28 J/m impact strength was obtained. 276 Mpa flexural strength was obtained for 1 mm thickness aluminium foam core sand witched with glass fibre.

Key words: Glass, Fibre, Aluminium foam, Mechanical Properties, Tensile, Impact, Flexural, Hardness

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1. Introduction

Now a days sandwich structures are mostly used in various industries such as transportation, defence and automotive due to its excellent mechanical properties. Most current sandwich structures are based on polymeric foams such as poly vinyl chloride and poly urethane. Recently a greater number of metal foams have been developed to replace the polymer foams. These metal foams used in structural applications, fire retardant, damper in automotive and heat exchanger [1]. Due to 95 % of porosity, aluminium foams are multiple times lighter than dense metal. This aluminium foam has widely been used in automotive industries such as body panel, bumbers etc. Also, in aerospace industries aluminium foam composites used such as engine mount brackets, floor panel and protection devices [2].

Fibre reinforced polymer (FRP) composites made of fibres with polymer matrix reinforcement, in which the fibres can be glass, carbon, kevlar and aramid, depending upon the purpose of the final applications. Even though the mechanical strength of GFRP is relatively lower than that of carbon fibre reinforced plastic (CFRP), GFRP has fewer brittle properties and lower cost [3]. For satisfactory mechanical properties, effective bonding between foam core and glass fibre skins is essential for the integrity of the structure. The bonding capability of the fabricated composites depend on the adhesion surfaces and curing conditions [4]. In the manufacturing of aluminium foam core epoxy has been often used as an adhesive in the manufacturing of aluminium foam core sandwich panels with metal face sheets [5].

Many researchers fabricated aluminium foam core sandwiched with various fibrous materials such as glass and carbon fibre composites. Mechanical properties such as tensile, impact, compression in order to improve their properties. The aim of this current research is aluminium foam core with different thickness (0.5 & 1 mm) sandwiched with glass fibre epoxy laminate are fabricated using hand layup process. Tensile and impact strength was investigated on the fabricated samples.

2. Materials and Methods

Aluminium foam core with different thickness (0.5 and 1 mm) were procured from M/S. Bhaseer Traders, Ambathur, Chennai, Tamil Nādu, India. E-Glass woven fibre, epoxy resin and Hardner were procured from Hayel Aerospace Ltd, Poonamalee, Chennai, Tamil Nādu, India. Hand layup process was used for fabricating the aluminium foam core sandwiched with glass fibre. Samples were fabricated with the size of (300 X 300 X 6) mm [8]. Table 1 shows the various composite designation of aluminium foam core with different thickness (0.5 & 1 mm) sandwiched with glass fibre epoxy laminate. Figure 1 shows the fabricated composite samples used for tensile testing. Universal testing machine with the specifications of Capacity: 10 KN, Maximum cross head travel: 1100 mm, testing speed range: 0.001 to 1000 mm/min, weight: 115 kg was used for evaluating the tensile strength. Izod impact test was used for evaluating impact strength [6]. Figure 3 shows the impact testing machine used for evaluate the impact strength. As per the ASTM standard tensile and impact test specimens were prepared. Three samples were tested in each case and the average value is reported.

Table 1 Composite designation used for this investigation

Composite designation	Glass Fibre (%)	Aluminium foam (%)	Total Resin Volume (%)	Aluminium foam thickness (mm)
GF0.5Al foam GF	30	10	60	0.5
GF0.5Al foam GF	20	20	60	1
GFRP	40	-	60	-

Figure 1 Aluminium foam core with different thickness (0.5 & 1 mm) sandwiched with glass fibre epoxy laminate

Figure 2 UTM machine used for evaluating the tensile strength. Capacity: 10 KN, Maximum cross head travel: 1100 mm, Testing speed range: 0.001 to 1000 mm/min, weight: 115 kg

Figure 3 Izod impact testing machine used for evaluating the impact strength. Capacity: 300 J, Overall size: 1.4 x 0.5 x 1.9, Net weight: 450 Kgs

3. Result and discussion

Tensile and impact strength were evaluated on the fabricated Aluminium foam core with different thickness (0.5 & 1 mm) sandwiched with glass fibre epoxy laminate. Table 2 shows the tensile and impact strength obtained for the fabricated composites.

Table 2 Experimental results obtained for fabricated composites

Composite designation	Tensile strength (N/mm^2)	Impact Strength (J/m)	Flexural Strength (MPa)
GF0.5Al foam GF	97.94	74.58	162
GF1Al foam GF	115.52	84.28	276
GFRP	80.54	46.34	143

3.1 Effect of aluminium foam on tensile strength of the glass fibre sandwiched samples

Tensile strength was evaluated for the fabricated composites. In this research tensile strength obtained for 0.5 mm thickness aluminium foam sandwiched with glass fibre was 97.94 N/mm^2 and for 1 mm thickness tensile strength was 115.52 N/mm^2. In this work tensile strength obtained for glass fibre composite without aluminium foam was 80.54 N/mm^2. Figure 4 shows the comparison of tensile strength of aluminium foam with different thickness sandwiched with glass fibre composites.

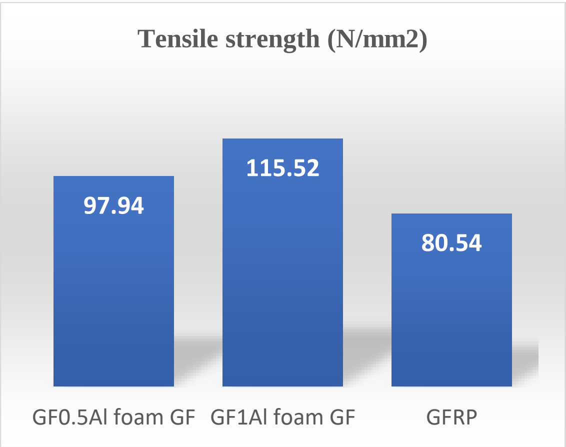

Figure 4 Tensile strength obtained for aluminium foam with different thickness (0.5 and 1 mm) sandwiched with glass fibre compared with GFRP composites

From the Figure 4 it was noted that increasing thickness of aluminium foam in the glass fibre composite increased the tensile strength. The tensile strength of aluminium foam with 1 mm thickness in glass fibre sample is proportional to the bond strength between matrix and reinforcement [7,8]. The bond strength between foam and GFRP increased, which in turn increase the tensile strength. As bond strength increases, the tensile strength also increases [9,10].

3.2 Effect of aluminium foam on impact strength of the glass fibre sandwiched samples

Impact strength was evaluated using izod impact testing machine for the fabricated composites. In this work impact strength obtained for 0.5 mm thickness aluminium foam sandwiched with glass fibre was 74.58 J/m and for 1 mm thickness impact strength was 84.28 J/m. In this work impact strength obtained for glass fibre composite without aluminium foam was 46.34 J/m. Figure 5 shows the comparison of impact strength of aluminium foam with different thickness sandwiched with glass fibre composites [11, 12].

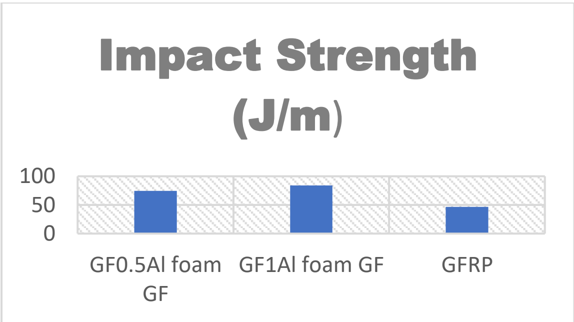

Figure 5 Impact strength obtained for aluminium foam with different thickness (0.5 and 1 mm) sandwiched with glass fibre compared with GFRP composites

From the Figure 5 it was observed that aluminium foam with 1 mm thickness sandwiched with glass fibre composites offer high impact strength as compared with other composites [9]. From this work it was seen that when the thickness of the aluminium foam increased, it observes more energy before get fractured [13, 14].

In this work during impact strength analysis, since all the samples were fabricated using hand layup process, delamination, peeling of matrix and fibre takes place during experimentation. In future same composite designation is fabricated using resin transfer moulding method

3.3 Effect of aluminium foam on flexural strength of the glass fibre sandwiched samples

Flexural modulus is an intensive property which is computed as a ratio of stress to strain in flexural deformation. Figure 6 shows the provides the load vs displacement relationship curves for the fabricated glass fibre reinforced aluminium foam composites. Among this glass fibre reinforced aluminium foam with 1 mm thickness offered better flexural strength as compared with other composites. It shows 20 % higher flexural modulus than other two configuration. It clearly indicates that moderate thickness aluminium foam reinforcement improves the flexural property significantly [15,16].

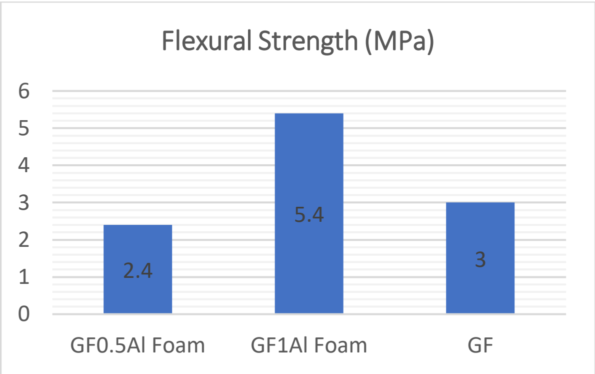

Figure 6 Flexural strength obtained for aluminium foam with different thickness (0.5 and 1 mm) sandwiched with glass fibre compared with GFRP composites

3.4 Hardness Analysis

Hardness is resistance to indentation or penetration. Shore A and Shore C durometers are used as portable hardness testers to find the hardness of three specimens. Higher numbers on the scale indicate a greater resistance to indentation and, thus, harder materials. The hardness test is carried out as per the ASTM D2240 standard. Table 1 shows the hardness values obtained for the current research [17,18]. Table 2 shows the hardness obtained for the fabricated composites. Figure 6 shows the comparison of hardness value for the fabricated glass fibre reinforced aluminium foam (0.5 and 1mm) and glass fibre composites

Table 2 Hardness values for the glass fibre reinforced aluminium foam composites

Composite designation	Hardness Number
GF0.5Al foam GF	253.0
GF1Al foam GF	238.0
GFRP	268.0

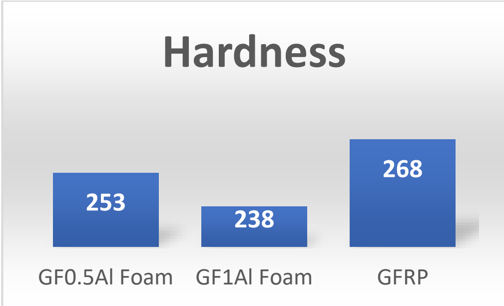

Figure 7 Hardness values obtained for aluminium foam with different thickness (0.5 and 1 mm) sandwiched with glass fibre compared with GFRP composites

4. Conclusions

Aluminium foam with 0.5 and 1mm thickness sandwiched with glass fibre composites were fabricated. Mechanical properties such as tensile and impact strength were evaluated. From this work the it was concluded that when the aluminium foam thickness increased, both the tensile and impact strength increased. Incorporation of aluminium foam in the glass fibre composites increased the mechanical properties

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