

Comparison of Torsional Fracture strength of Cast Iron and Boron (SAE-1042)/ Epoxy/ Aluminum (6061 t6) (B/Ep/Al) Laminated Metal Composite (LMC) Specimens

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ABSTRACT: To understand the mechanical property of a component is imperative before it is used as a motive to keep away from any breakdown. Composite structures put into practice can be subjected to different types of loads. One of the loads among such is torsional load. This paper shows the experimental study and results of comparison of torsional fracture strength of Cast Iron (CI) and Boron (SAE-1042)/Epoxy/Aluminum (6061 t6) Laminated Metal Composite (LMC) Specimens. LMCs are a single form of composite material in which alternating metal or metal containing layers are bonded mutually with separate interfaces. Boron metal is amongst the hardest materials from the earth's crust joined with the aluminum metal, it is known that one side of boron and aluminum plates are appropriately knurled and afterward adhesively bonded with an epoxy which perform as binder and compressed by using heavy upsetting press. Processes of torsion tests are conducted in a 750 kg-cm capacity AVERY Birmingham, testing machine, where both specimens with the same geometry of Cast Iron and Boron (SAE-1042)/Epoxy/Aluminum (6061 t6) were tested.

KEYWORDS: FML, GLARE, LMC, Boron (SAE-1042), Epoxy, Aluminum (6061-t6), B/Ep/Al, torsion, lattice truss.

I. INTRODUCTION

Sandwich structures with lattice truss cores have drawn attentions recently due to their excellent specific strength and stiffness and potential multi-functionality [1–4]. The early lattice truss core sandwich structures were made of metals or alloys [5–9]. As we all know, composite materials of continuous carbon fiber reinforced resin, possessing low density and high stiffness and strength, could be a good alternative material to fabricate lattice truss core sandwich structures. Fan et al. [10] adopted an interlocking method to fabricate planar Kagome lattice grid sandwich with carbon fiber composite, and investigated the out-of-plane compression, inplane shear and bending behaviors of the manufactured sandwich structures. Finnegan et al. [11] manufactured carbon fiber composite pyramidal core sandwich using a snap-fitting method, and found that the measured out-of-plane compressive strength increased with increasing the relative densities of core. Wang et al. [12] adopted a hot compression molding method to fabricate carbon fiber composite pyramidal core sandwich structures, and then studied the out-of-plane compression and in-plane shear properties. From the above discussions, it is found that a large research effort about the mechanical behaviors of lattice truss core sandwich focuses on the out-of-plane compression, in-plane shear and bending responses [13]

Apart from these type of composites, Laminated Metal Composites (LMCs) consist of alternating metal or metal containing layers that are bonded with 'sharp' interfaces. These materials represent a unique laminated or layered

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composite form that should be distinguished from graded materials, which have diffuse interfaces, or layered materials, in general, which can consist of alternating layers of a wide range of materials including metal/metal, metal/ceramic, ceramic/ceramic, or intermetallic/ceramic combinations. Laminated metal composites can dramatically improve many properties including fracture toughness, fatigue behavior, impact behavior, wear, corrosion, and damping capacity or provide enhanced formability or ductility for otherwise brittle materials. In many cases through the choice of laminate architecture (such as volume percent of the component materials and layer thickness), component materials, and processing history, LMCs can be engineered to produce a material with prescribed properties. [14]

The review paper of D. R. Lesuer *et al.*, [14] This review deals with the mechanical behavior of LMCs - including history, processing, and properties. This general subject was reviewed in 1974 in an extensive paper by Wright and Levitt. [15] Since then, significant advancements in this technology have occurred including improved mechanistic understanding of impact behavior and stress-strain response as well as detailed studies of fracture toughness, fatigue behavior, and super plasticity. In addition, considerable work and commercial application of LMCs in the former Soviet Union is becoming known in the western world. Some of this work has been documented in a book by Potapov *et al.*, [16] which emphasizes the processing and application of LMCs including bimetals. In the West, commercial applications of layered materials have occurred including macro laminates of aluminium alloy and aramid fibre reinforced epoxy (ARALL) as well as aluminium alloy and glass fibre reinforced epoxy (GLARE). In addition, a wide range of laminates and bimetals for non-structural applications are commercially available.

However, the torsional response of laminated metal composite, which is an important elastic response and often arises in many engineering fields, to the authors knowledge, has not been explored much.

Accordingly, to study the torsion property experimentally, an effort is made in this work by using Cast Iron and Boron (SAE-1042)-Epoxy/Aluminium (6082 T651) (B/Ep/Al) Laminated Metal Composite (LMC) specimens.

II BORON/EPOXY/ALUMINIUM LAMINATED METAL COMPOSITE

Recently, a new generation matrix metal laminate with enhanced stiffness and improved crack initiation properties is developed as a solution for the shortcomings such as low stiffness, low yield strength, low fatigue and low impact properties at room and moderate temperatures. Laminated metal composite consists of boron and aluminium layers with epoxy in between them. Boron metal plate is used for their high young's modulus (400 GPa) in comparison with glass fibers (86.9 GPa). Due to high modulus of boron plate, the overall modulus of laminated metal composite can be improved and is higher than the conventional GLARE.

Experimentally we investigate the mechanical properties of the tensile specimens of all the three specimens in this paper.

III EXPERIMENTAL DETAILS

Two different metal plates viz. Boron Steel plate (SAE-1042) and Aluminum plate (6082 T651) (of dimensions 450x350x12 mm each) were chosen for this research work. One side of both plates are knurled to a depth of 2 mm and are sandwiched with the help of epoxy (thermostat) as shown in figure 1.

Epoxy, which is a composition of standard mixture of **Resin X** (M-544) of 100 parts by weight (pbw) with clear uniform paste of colour yellow and **Hardener y** (H-209) of 40 pbw with clear uniform paste of colour beige. The ratio of this cold setting is 60:40 with resin X and hardener Y respectively were kept with room temperature for 20 to 25 minutes.

To prepare the finished composite metal laminate, the sandwiched plate is pressed under the capacity of 400 tonnes upsetting press with a temperature of 90⁰ C and the duration of press was 155 Seconds. The composite laminate was

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removed from the upsetting press and allowed to cool under room temperature. Figure 1 shows the finished composite metal laminate.

IV EXPERIMENTAL RESULTS



Fig. 1

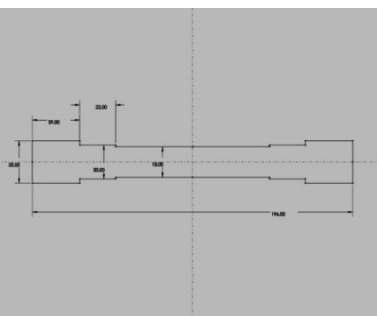


Fig. 2



Fig. 3

Fig. 1 Laminated Metal Composite (LMC) of Boron (SAE-1042) / Epoxy / Aluminum (6061 t6) of dimensions 450 mm x 380 mm x 24 mm (each metal plate has a thickness of 12 mm), manufactured at M/s Permali Wallace Pvt. Ltd. Bhopal. MP (India) and Fig. 2 Line diagram showing the dimensions of torsion specimen and Fig 3 shows Cast Iron Specimen of required dimension.

As per the standard dimension as shown in figure 2, specimens are developed from cast iron metal and newly developed Boron (SAE-1042) / Epoxy / Aluminum (6061 t6) Laminated Metal Composite (LMC) as shown in figure 3 and 4 respectively.



Fig. 4



Fig. 5



Fig. 6

Fig. 4 Laminated Metal Composite (LMC) of Boron (SAE-1042) / Epoxy / Aluminum (6061 t6). Fig. 5 Torsion testing machine at Maulana Azad National Institute of Technology (MANIT) Bhopal. MP (India) and Fig 6 Specimen of Laminated Metal Composite (LMC) of Boron (SAE1042) / Epoxy / Aluminum (6061 t6) under torsion loading.

Processes of torsion tests were conducted in a 750 kg-cm capacity AVERY Birmingham, testing machine, as shown in figure 5 and figure 6 shows the Specimen of Laminated Metal Composite (LMC) of Boron (SAE1042) / Epoxy

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/Aluminum (6061 t6) under torsion loading. Both specimens with the same geometry of Cast Iron and Boron (SAE-1042)/Epoxy/Aluminum (6061 t6) were tested and the results were recorded as shown in the following figures.



Fig. 7



Fig. 8



Fig. 9

Fig 7 Tested torsion specimen of Laminated Metal Composite (LMC) of Boron (SAE1042) / Epoxy /Aluminum (6061 t6) and Fig 8 Tested torsion specimen of Laminated Metal Composite (LMC) of Boron (SAE1042) / Epoxy /Aluminum (6061 t6) and Fig 9 Tested torsion specimens of both Cast Iron and Laminated Metal Composite (LMC) of Boron (SAE1042) / Epoxy /Aluminum (6061 t6).

Figure 7 and 8, shows tested torsion specimen of Laminated Metal Composite (LMC) of Boron (SAE1042) / Epoxy /Aluminum (6061 t6) and Fig 9 Tested torsion specimens of both Cast Iron and Laminated Metal Composite (LMC) of Boron (SAE1042) / Epoxy /Aluminum (6061 t6).

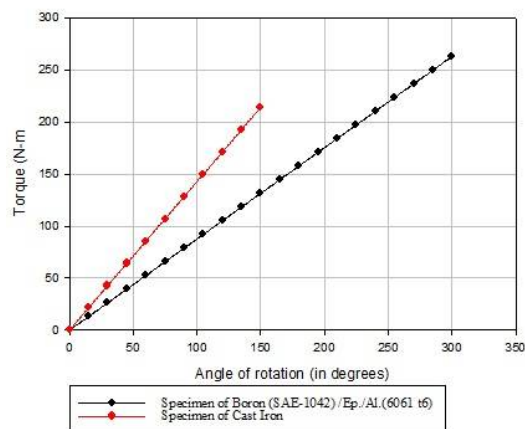


Fig 10 Torque Vs angle of rotation curves of tested torsion specimens of Laminated Metal Composite (LMC) of Boron (SAE1042) / Epoxy /Aluminum (6061 t6) and Cast Iron.

Figure 10, shows the comparison of the tested results for Cast iron and Laminated Metal Composite specimens. This comparison concludes far better values of torque and angle of rotation in case of LMC when compared to CI.

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V. CONCLUSIONS

In this study, the results of experimental values of torsional fracture strength of Cast Iron and Boron (SAE-1042)/Epoxy/Aluminum (6061 t6) Laminated Composite (LMC) Specimens were compared. The cast iron tends to be brittle in its nature, it gets fracture at a torque of 214 N-m , angle of twist as 29.185 degree and the fracture occurs in a time period 31.77 seconds. It does not show any considerable sign of twisting nature on the specimen. Now, when compared with the LMC specimen of Boron (SAE1042) / Epoxy /Aluminum (6061 t6), Boron metal is amongst the hardest materials from the earth's crust joined with the aluminium metal, which is ductile in nature. It is known that one side of boron and aluminium plates are appropriately knurled and afterward adhesively bonded with an epoxy which perform as binder and compressed by using heavy upsetting press. Processes of torsion tests are conducted in a 750 kg-cm capacity AVERY Birmingham, testing machine. The tested results of Laminated Metal Composite specimen show a value of torque as 263 N-m , angle of twist as 271.34 degree and the fracture occurs in a time period 332 seconds. This comparison concludes far better values of torque and angle of rotation in case of LMC when compared to CI.

Table 1 Shows Comparison data of torsion testing for CI and B/Ep/Al.

S.No	No. of Specimen	Specimen material	Torque (Nm)	Angle of rotation (deg)	Time taken to fracture (sec)
1	1	CI	214	21.185	31.77
2	1	B/Ep/Al	263	271.34	332

From fig 10, the graph clearly shows the commanding values of torque in Nm, angle of rotation in degree and time taken to fracture in case of B/Ep/Al laminated metal composite over Cast iron.

These result of torsion test for Laminated Metal Composite (LMC) of Boron (SAE1042) / Epoxy /Aluminum (6061 t6) clearly indicated the nature of ductility, whereas cast iron as brittle.

The above results may be improved, if the depth of knurling would increase from 2 mm to 3 mm.

It is assumed that the data presented here will be useful to others for development of constitutive theories.

VI. ACKNOWLEDGEMENT

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