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Comparison Of Mechanical Properties For Aluminium Metal Laminates (GLARE) Of Three Different Orientations Such As CSM, Woven Roving And 45^0 Stitched Mat

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Abstract *: Fiber Metal Laminates (FMLs) are hybrid materials consisting of alternating layers of thin metal sheets and composite layers. GLARE is the best known example of these laminates and is applied in the Aircraft application. Aiming this objective, new lightweight FML has been developed. The moisture absorption in FML composites is slower when compared with polymer composites. In this article three type of orientation were taken such as 4/3 layer of Chopped Strand Mat (CSM), 4/3 layer of woven roving, and 4/3 layer of 45^0 stitched mat and corresponding Tensile and Flexural test had been taken and experimentation was performed. This laminates were obtained by hand layup technique. Specimens are cut off from wire cutting as per ASTM standards. Experimental work was conducted on computer controlled UTM such as AUTOGRAPH-50KN capacity for tensile and INSTRON-100KN capacity for flexural. From the experimental work, load vs. displacement and stress vs. strain graphs were plotted. It was revealed that the mechanical properties of 4/3 layer of 45^0 stitched mat had superior tensile and flexural strength than that of the other orientation*.

Keywords - *Chopped Strand Mat (CSM), Fiber Metal Laminates (FML), Glass Fiber reinforced aluminium (GLARE), Tensile and flexural, woven roving, 45^0 stitched mat.*

I. INTRODUCTION

FMLs are advanced aerospace material. They consist of multiple thin layer of metal alternately bonded to thin layers of Fibre-reinforcement as shown in fig. 1. FMLs combine the best properties of the metal and the Fiber. FMLs are known to be light weight, have good fatigue properties and impact resistance, high flame and corrosion resistance [1]. So FMLs like GLARE, a very attractive material for aerospace application, where matrix is made up of aluminium alloy and Fiber is made up of glass.

GLARE is currently used as coating material for the Airbus A380 fuselage to the wing leading edge. Fiber metal laminates were developed at Delft University of Technology in the Netherlands by L.B. Vogelesang[2]. The basic idea for the development of Fiber metal laminates was to develop a material with high crack growth resistance for fatigue prone areas of modern civil aircraft. Aluminium alloys are most commonly used in FMLs as metal, and Fiber can be Kevlar or glass[3]. Hingeless and bearingless helicopter rotor hubs that are designed using laminated composite materials experience centrifugal loads as well as bending in the flapping flexure region[4]. The main reason for switching to glass fibers is that aramid fibers failed at some loading conditions. But, fiber failure is unacceptable for the excellent fatigue resistance of FML. The glass fiber ply in GLARE does not have the disadvantage of failing fibers, and therefore GLARE became the most important variant for FML. In spite of mentioned advantages of FMLs, their impact properties still need more understanding and attention[5]. Although many articles have been published regarding to impact resistance of FMLs, the research on this part of FMLs' performance is still in the early stages.

This work examines the use of aluminium in FML construction, as it is significantly cheaper than other alloy and may be suitable for applications where weight is one of the critical issues. There are numerous grade available in aluminium such as 7075-T6, 2024-T3, 7475-T761, T-1050, like that in fiber, S-glass, E-glass were used[8]. In this research aluminium T-1050 and E-glass fiber were choosen. An important milestone in the development of GLARE was the solving of the scaling problem by so-called "splicing" of the metal layers [9] as shown in fig. 2. This was corrected by designing the moulding box with the similar dimension of specimen.

The main aim of the present investigation was to study the influence of Fiber orientations on tensile and structural properties and also the influence of thickness of the specimen. Researchers revealed that there was a significant change in tensile and flexural properties due to their different orientations. Suggested fiber orientation such as CSM, Woven roving, and some angular orientation.

II. EXPERIMENTAL WORK

Three types of orientation were fabricated, (i) 4/3 layer of CSM, (ii) 4/3 layer of woven roving, (iii) 4/3 layer of 45^0 stitched mat. Glare 4/3 laminates consisting of four 0.3 mm thick aluminum sheets supplied by JSK Industries and three E-glass fibers supplied by Goa Glass Fiber Ltd. /. Density of corresponding CSM, Woven roving and 45^0 stitched mat were 300 gms/m^2, 700 gms/m^2 and 1600gms/m^2 respectively. Epoxy resin plies were fabricated using a hand-layup technique [10]. Hand-layup technique was chosen as it was ideally suited to manufacture low volume with minimum tooling cost [12]. The nominal weight fraction of fibers in GFRP was kept constant at 60%. The plies were laminated in such a way that the warp and weft directions were parallel to the edges of the laminates. The plates were then post-cured in an oven at 100°C for 4 hours after they had been cured under 15 kPa pressures for one day at room temperature [13]. These laminates were then cut up to 250x25 mm for tensile specimens and 127x12.7mm for flexural specimens as per standard ASTM D3039 and D790 [16,17] respectively.

The processing of glare laminate was i) hand abrasion by 200 grit Aluminium oxide papers, to create a roughness, ii) Etching in acetone, iii) Washing by dilute alkaline solution up to 5mins at 60˚c to 70˚c, iv) rinsing in hot water and Etching aluminium sheets in sulfochromic solution (FPL-Etch) based on ASTM D2674 [18] and D2651 [19] standards.

2.1 Tensile test

Tensile specimens are 250 mm long and 25 mm width of 4/3 CSM – 3.48mm, 4/3 Woven roving – 3.10mm and 4/3 45^0 stitched mat -4.50 mm thick with a gauge length of 200 mm were prepared [16]. The tensile properties of the glass Fiber reinforced aluminium laminate composites were determined according to ASTM 3039 test standard specifications. The average tensile properties were determined from 4 specimen tests on each type of orientation. Tensile tests were performed on an Autograph-AGIS-Shimadzu-50KN capacity universal testing machine at a crosshead rate of 5 mm/min which corresponds to a strain rate of 0.2% per second. Tensile properties were determined from these specimens [8]. Fig. 6 show the specimen before and after tensile testing. Fig. 5 shows the specimen during tensile and flexural testing.

Specimens are mounted on the grips of a universal testing machine and gradually loaded in tension while recording load. The ultimate strength of the material can be determined from the maximum load carried before failure and also various failure modes were analysed. After that, the stroke was monitored with displacement transducers then the stress-strain response of the material can be determined, from which the tensile strain, modulus of elasticity were derived [16].

2.2 Flexural test

Flexural specimens are 127 mm long and 12.7 mm width of 4/3 CSM – 3.10mm, 4/3 Woven roving – 3.48mm and 4/3 45^0 stitched mat -4.50 mm thick with a gauge length of 16:1 mm were prepared [16]. Flexural tests were performed on an Instron-100KN capacity universal testing machine. Fig. 7 shows the tested flexural specimen. The flexural properties of the glass fiber aluminium laminate composites were determined according to ASTM D790 test standard specifications. The average flexural properties determined from 3 specimen test on each type of orientation.

III. Result And Discussion

3.1 For Tensile test

Graph shows load vs. displacement plot for different orientation such as CSM, Woven roving and 45^0stitched mat and there corresponding thickness were 3.10, 3.48, 4.50mm .Fig. 7 shows 45^0 stitched mat of 4.50mm thickness glare laminates withstand the maximum load of 32.495KN but the CSM and woven roving laminates withstand only 8.150KN and 11.63KN respectively. It also shows that 45^0 stitched mat can withstand more than 74.91% of CSM and more than 64.20% of woven roving. Ultimate tensile strength 45^0 stitched mat was 307.28N/mm^2. This output value was also greater than the above two. Table reveals that the strength of the FML also depends upon the density, because 45^0 stitched mats had greater thickness than other orientation.

3.2 For Flexural

Graph shows load vs. displacement plot for different orientation such as CSM, Woven roving and 45^0stitched mat and there corresponding thickness were 3.10, 3.48, 4.50mm .Fig.9 shows 45^0 stitched mat of 4.50mm thickness glare laminates withstand only the maximum load of 223.33N but the woven roving laminates withstand 310.60N. It was higher than both CSM and angled orientation.

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1. FIGURES AND TABLES

Fig. 1 Fiber metal laminates

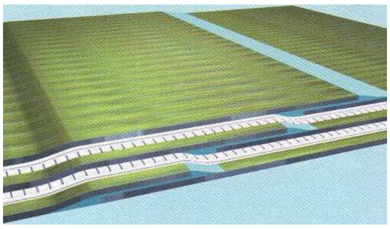

Fig. 2 Splicing of GLARE

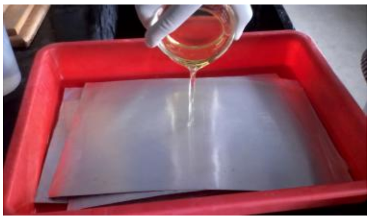

Fig. 3 Surface treatment

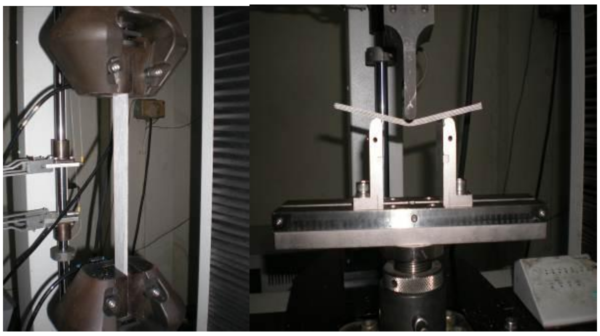

Fig. 5 Specimens during tensile and flexural test

Fig. 6 Tensile specimen

Fig. 7 Flexural specimen

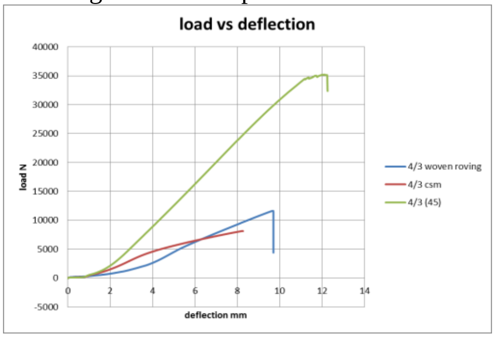

Fig. 7 Load vs deflection for tensile properties

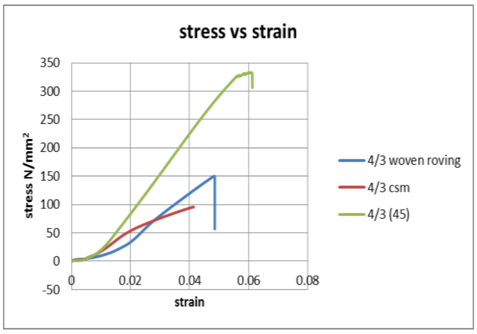

Fig. 8 Stress-strain curve for tensile loading

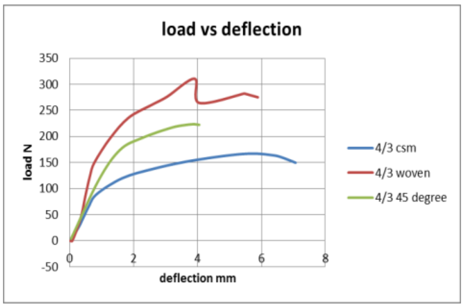

Fig. 9 Load vs deflection for flexural properties

Table.1 Tensile properties three different orientation

Orientation	**Maximum breaking load (N)**	**Ultimate tensile strength (N/mm^2)**	**Displacement (mm)**	**Thickness (mm)**
CSM	8150	95.68	8.24	3.10
Woven roving	11631	150.08	9.69	3.48
45^0 stitched mat	32495	307.28	11.15	4.50

Table. 2 Flexural properties of three different orientation

Orientation	Maximum breaking load (N)	Ultimate bending strength (N/mm^2)	Displacement (mm)	Thickness (mm)
CSM	167.13	320.719	5.75	3.10
Woven roving	310.60	308.62	3.90	3.48
45^0 stitched mat	223.33	208	3.86	4.50

IV. Conclusion

In this article, presents the experimental investigations of tensile and flexural behaviour of glass Fiber reinforced aluminium laminates (Glare) with different orintation was compared.

The following conclusions are drawn:

i. The tensile and flexural behaviour of Glare laminates are mainly dependent on volume percentage of Fiber and orientation.
ii. 45^0angled orientation had superior tensile properties compared with that of other orientation such as chopped and woven roving. So this angled orientation may withstand tensile loading.
iii. In flexural strength, the woven roving had greater flexural properties than the other two. So woven roving may withstand flexural loading.

REFERENCES

[1] Vogelesang, L.B.; Vlot, A. *Journal of Materials Processing Technology*, v. 103, p. 1-5, 2000.
[2] E.M. Castrodezaa, J.M. Rodrigues Touçaa, J.E. Perez Ipiñab, F.L. Bastiana Determination of *CTODC* in Fiber Metal Laminates by ASTM and Schwalbe Methods, Material Research vol 5, No. 2, 119 – 124, 2002.
[3] Abrate S. *Impact on laminated composite materials*. Appl Mech Rev 1991;44(4):155–89.
[4] Botelho EC, Silva RA, Pardini LC, Rezende MC. A review on the development and properties of continuous fiber/epoxy/aluminum hybrid composites for aircraft structures. Mater Res 2006; 9(3):247–56.
[5] Tamer Sinmazçelik et al. A review: Fiber metal laminates, background, bonding types and applied test methods. Materials and Design 32 (2011) 3671–3685
[6] B.M.Liaw, Y.X.liu and E.A.Vilars Impact damage mechanism in Fiber metal laminates Proceedings of the SEM annual conference on Experimental and applied mechanincs June 4-6, 2001, Portland, Oregon 536-539
[7] Y.X.Liu and B.M.Liaw, Drop weight impact on Fiber metal laminates using various indenters.Proceedings of SEM X International congress and Exposition on Experimental and Applied mechanics, Costa Meas, CA, June 7-10, 2004, Paper no 386.
[8] Prashanth Banakar,H.K.Shivananda and H.B.Niranjan, Influence of Fiber Orientation and Thickness on Tensile Properties of Laminated Polymer Composites Int.J.Pure Appl.sci. Technol., 9(1)(2012), pp. 61-68
[9] Krishnakumar, S., Fiber Metal laminates-the Synthesis of Metals and Composites, Material and Manufacturing Processes, Vol. 9, 1994, pp. 295-354.
[10] Wu, H. F., Wu, L. L., Use of Rule of Mixtures and Metal Volume Fraction for Mechanical Property Predictions of Fiber-Reinforced Aluminum Laminates, Journal of Materials Science, Vol. 29, No. 17, 1994, pp. 4583- 4591.
[11] Alderliesten RC. Fatigure. In: Vlot A, Gunnick JW, editors. Fiber– metal laminates: an introduction. Dordrecht: Kluwer Academic Publishers; 2001 [chapter 11].
[12] N.Rajesh Mathivanan, J.Jerald. Experimental investigation of low-velocity impact characteristics of woven glass epoxy composite laminates of EP3 grade. Journal of Minerals & Materials charcterisation & Engg, 2012;11(3)pp. 321-333
[13] A. Pourkamali Anaraki G. H. Payganeh, F. Ashena ghasemi, A. Fallah. An Experimental Study on the Tensile Behavior of the Cracked Aluminum Plates Repaired with FML Composite Patches. World Academy of Science, Engineering and Technology, 2012pp.61
[14] H. Esfandiar, S. Daneshmand and M. Mondali. Analysis of Elastic-Plastic Behavior of Fiber Metal Laminates Subjected to In-Plane Tensile Loading, Int J Advanced Design and Manufacturing Technology, Vol. 5/ No. 1/ December- 2011
[15] Mohammad Alemi Ardakani, Akbar Afaghi Khatibi and Hady Parsaiyan. An Experimental Study on the Impact Resistance of Glass-Fiber-Reinforced Aluminum (Glare) Laminates (2008).
[16] ASTM, Standard test method for tensile properties of polymer matrix composite materials, ASTM D3039, Annual Book of ASTM Standards, American Society for Testing and Materials, PA, 15(03) (2006).