ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization *Volume 4, Special Issue 2, February 2015*

5th International Conference in Magna on Emerging Engineering Trends 2015 [ICMEET 2015]

On 27th & 28th February, 2015

Organized by

Department of Mechanical Engineering, Magna College of Engineering, Chennai-600055, India.

Influence of Metal (Aluminium) Layer Thickness in Glare

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ABSTRACT: The ductile resistance of the fibre-metal laminates has been analysed experimentally on three various different FML laminates that is made up of aluminium sheets of three different thickness namely 0.2mm, 0.3mm & 0.4mm. Tensile and flexural tests on the specimens were carried out to analyse the ductile behaviour of the FML laminates. Stress vs strain curve for tensile and load vs displacement curve for flexural test. The respective parameters like ultimate stress, young's modulus, longitudinal strength, flexural failure, flexural modulus, etc., are calculated from the plots. The results were compared with each other to evaluate what is the impact of metal layer thickness in the FML plates. There is good variation between the experimental results is obtained. Finally the best fiber to metal ratio is found out and the result is justified.

I. INTRODUCTION

The aircraft industry is very conservative in the adoption of new designs and technologies. Significant safety issues and low profit margins provide little incentive to change. Even when new aircraft are introduced, they tend to build heavily upon past designs, introducing only incremental updates in technology. Large changes can occur, but the process is very slow.

In "Glare: History of the Development of a New Aircraft Material," Ad Vlot documents the introduction of an entirely new class of materials to the industry. The transition from wood to aluminum began in the 1930s and was spurred to completion by World War II. Carbon and glass composites were gradually introduced in the 1970s and 1980s and continues even today. Glare, a specific type of fiber-metal laminate (FML) made from aluminum and fiberglass composite, is now poised to be only the third new material to be used in aircraft primary structures. The new A380 jumbo jet from Airbus will make extensive use of Glare in the fuselage.

The history of Glare can be traced back to early bonded wood and bonded metal aircraft structures. True fiber-metal laminates, comprised of alternating thin layers of aluminum and fiber-reinforced plastic composites, were first developed in the 1970s. The first commercial FML was Arall, an aramid-aluminum FML developed at the Delft University of Technology (Delft). Arall was used in a few select aircraft components, but it had structural limitations that prevented wider use. Glare, a glass-aluminum FML, was developed in part to overcome these limitations. 14

Vlot was introduced to Arall in 1985, as an undergraduate at Delft. He remained active in the development of Glare and its application to the A380 until his untimely death in April of 2002. Arall was introduced in 1981, and Glare was selected for the A380 in 2001, so Vlot's career spanned almost the entire lifetime of the material.

As an engineer, Vlot tends to emphasize the technical challenges faced with developing and qualifying a new material for the aircraft industry. Although a strong technical background is not needed to follow the book, engineers will appreciate the level of detail.

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The history of FMLs involved many different academic, industrial and governmental organizations, located on both sides of the Atlantic. Each had its own internal agendas, which were often at odds with the other organizations. The Arall and Glare programs were almost killed several times, for reasons sometimes totally unrelated to technical merits. In some cases, just the different work habits at two groups caused friction. Early on, the informal environment at Delft allowed rapid development of the Arall and then Glare. To qualify the material for commercial use, however, a more rigorous approach had to be followed. Neither approach was right or wrong, but each had its place at different stages in the program.

The book ends in 2001, after Glare had been selected for portions of the A380 fuselage. The story doesn't end there, however: even in mid-2002, the design is not yet finalized, and it is likely Glare will be used over a larger area to further reduce the aircraft weight. Glare had gone from a controversial idea to a critical design choice.

II. LITERATURE REVIEW

In open literature survey, a huge collection of studies about the mechanical behavior of composites as well as fiber metal laminates can be found. Among them a few of them which are considered to be very vital to our topic have been discussed and summarized in appendix. For a clearer survey we have described each and every paper as follows. Different approaches of fiber metal lamination have been tried out and metal layer influence in various laminates inducting some new aspects resulting in the drastic changes over the properties of the fiber metal laminates. The studies are mainly focused on the influence of thickness in various type of strengths for a fiber metal laminate which includes the impact resistance, in-plane tensile strength, high velocity impact, elastic-plastic nature and so on. The changes in properties due various thickness have been analyzed keenly and some interesting results been acquired. Those results are verified both numerically or computationally in some reports.

III. FABRICATION OF GLARE LAMINATE

3.2.1 Preparation of glass fiber mat:
Glass Fibers of dimensions 330x330mm are cut from the big roll.
Glass fiber layers are required for preparing a GLARE Laminate.
The weight of all the glass fiber is measured using an electronic weighing machine.
3.2.2 Preparation of epoxy resin:
Epoxy Resin equal in weight to that of the fiber is weighed and taken separately.
Then hardener is added to the resin in the ratio of 1:10.
The epoxy resin mixture is then mixed thoroughly.
3.2.3 Preparation of the aluminium:
Both the upper and lower aluminium surface should be cleaned using acetone initially to remove the dirt present if any.
Using sand paper to roughen the aluminium sheets.
3.2.4 Procedure for preparation of GLARE cross-ply laminate:
Place the polythene on the table.
Apply wax on the surface of the lower polythene.
Next place the first layer of glass fiber and apply the matrix by using dustless brush.
Then use rollers to squeeze the excess resin.
Place the aluminium sheet over the glass fiber matrix and apply the matrix over the surface of the sheet.
And again use the rollers to squeeze the excess resin.
Repeat the procedure with alternating layers of Resin, Glass fiber and aluminium until the laminate are finished.
Finally place the glass fiber mat and apply the matrix.
And applying the wax on the another polythene paper.
Then place the polythene on the top of the laminate.
Next the laminate is placed in the compression moulding machine under a pressure of about 100bar.
Then the laminate is allowed to cure under this condition for 24 hours.

After 24 hours the laminate is removed from the compression molding machine.
Then remove the polythene cover carefully after that the laminate is placed in the sunlight for more then half hour
The laminate after removal from the mould will look like fig 10

3.2.5 Surface preparation and curing:

Considering bonded joints the surface preparation takes an important role in perfect bonding, we used hand abrasion technique to introduce roughness in the surface. The entire mould with glass fabric lay-ups has been kept in 24 hours for curing. The curing has been done at a room temperature. If the specimen is not cured properly the strength of the bond drastically reduces. The major defects found in bonding of two materials are disbonding, porosity, voids is mostly due to improper curing. There is also a possibility of voids generation due to vaporizing of water molecule present in the adhesive. To prevent dislocation of specimen in bond region proper load should be applied.

IV. PROCEDURE

Before the test
1. Put gauge marks on the specimen
2. Measure the initial gage length and diameter
3. Select a load scale to deform and fracture the specimen. Note that tensile strength of the material type used has to be known approximately.

During the test:
1. Record the maximum load
2. Conduct the test until fracture.

After the test:
1. Measure the final gauge length.
2. Measure the breaking load.
3. Measure the ultimate stress

V. CONCLUSION

Since the invention of composites the fiber metal laminates have gained much more attention for researchers who are witnessing excellent replacement for metals as well as pure composites. The metal layer in the fiber metal laminates dominates the change in entire strength of the whole laminate. From our experimental analysis it is found that even though the metal layer thickness in the GLARE 1-1&2-1 is minimal compared to the rest of the laminates but it tends to bear high load capacity and also have higher value for various parameters which estimates the strength of the laminate. GLARE 1-1 & 1-2 is found to be able to bear 10%-11% higher loads than GLARE 1-2 & 2-2 and 14%-15% higher loads than GLARE 1-3 & 2-3.

This clearly states that the physical strength of the FML is not increasing when the metal thickness is increased, rather it purely depends upon the no of layers of interaction between the metal and glass fiber also the bonding strength. 65

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