EXPERIMENTAL INVESTIGATION ON TENSILE STRENGTH OF CROSS STITCHED AND UN-STITCHED FIBRE GLASS - EPOXY LAMINATES

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ABSTRACT

The current trend in aerospace, automobile and structural components is to replace metallic components with composites due to their inherent like light weight and immune to corrosion. Generally the fibre reinforced epoxy laminated plates are fabricated with several layers of fibre with opposite orientation in an epoxy matrix. In this investigation an effort is made to increase the tensile strength by subjecting the fibers to stitching with a cotton thread before the application of the hardener and the epoxy material. The experiments were conducted on stitched and un-stitched fibre glass epoxy laminates. The results of the tensile tests revealed an appreciable increase in the tensile strength of the stitched laminates when compared with the un-stitched laminates.

Key Words: Stitched, Un-Stitched, Tensile strength, fibre glass, epoxy, laminates.

I. LITERATURE REVIEW

The literature on the influence of the stitching of the glass fibers is very less. The tensile behaviour of stitched graphite/epoxy laminates was examined with the aim of evaluating the efficiency of stitching as a reinforcing mechanism able to improve the delamination resistance of laminates. The investigation, which focused on two classes of cross-ply stacking sequences ([03/903]s and [0/90]3s), showed that the role of stitches in controlling damage progression of laminates and their capability to reduce the impact sensitivity of specimens are greatly dependent on the impact behaviour of base (unstitched) laminates. In [03/903]s laminates, in particular, stitching is able to reduce damage area, on condition that the impact energy is higher than a threshold level and delaminations are sufficiently developed. In [0/90]3s laminates, on the other hand, stress concentration regions generated by the stitching process appear to promote the initiation and propagation of fibre fractures, thereby inducing a decrease in the penetration resistance of the laminate [1-3].

In another study it was observed that whereas stitching does not appear capable of preventing the initiation and spread of delaminations, it induces a clear reduction of damage area when stitches bridge delaminations sufficiently developed in length [4]. When comparing studies it is apparent that many contradictions exist: some studies reveal that stitching does not affect or may improve slightly the in-plane properties while others find that the properties are degraded.

In reviewing these studies it is demonstrated that predicting the influence of stitching on the in-plane properties is difficult because it is governed by a variety of factors, including the type of composite (eg. type of fibre, resin, lay-up configuration), the stitching conditions (eg. type of thread, stitch pattern, stitch density, stitch tension, thread diameter), and the loading condition. The implications of these findings for the use of stitching in lightweight engineering structures are discussed [5-6].

The presence of stitches did not affect substantially the material behavior in terms of force–displacement curve and failure load. The data generated suggest that the use of stitches could be unnecessary to hinder delamination in thin 2D laminates [7-8]. The literature survey reveals that very few investigators have worked on the effect of stitching on the tensile strength of fibre glass-epoxy composites.

II. EXPERIMENTAL WORKS

This paper discusses the fabrication of the composite plate and the effect of the stitching of fibre on the tensile strength of glass epoxy composites. The composite plate specimens with different orientations were fabricated by manual method.

The composite was fabricated by hand lay technique and subjected to tensile test. The tensile specimens were subjected to tensile test and fractography studies were carried out. The specimens after fracture were investigated for failure mode using scanning electron microscope.

III. MANUFACTURING METHOD

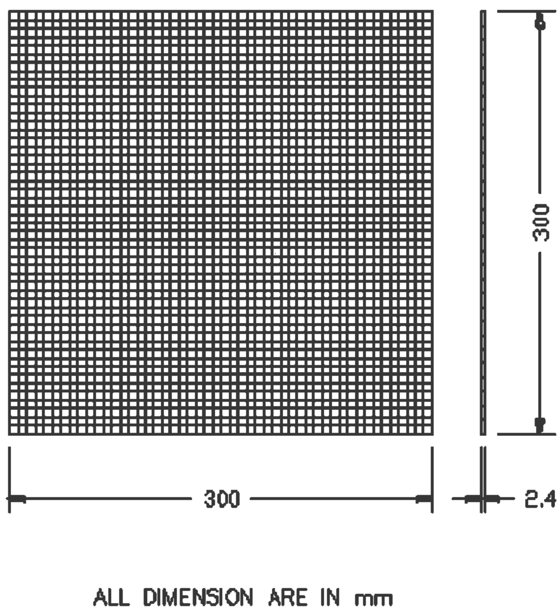

Fig. 1. Un-Stitched pattern

The manufacturing process involves laying a stack of plies consisting of nominally in-plane fibers is penetrated and bounded together by needle and bobbin threads. The stitching was done by using cotton yarn. The laminates were manufactured at room temperature. The laminate fabricated were of size 300 mm × 300 mm of thickness 2.4 mm as shown in figure 1 and 2.

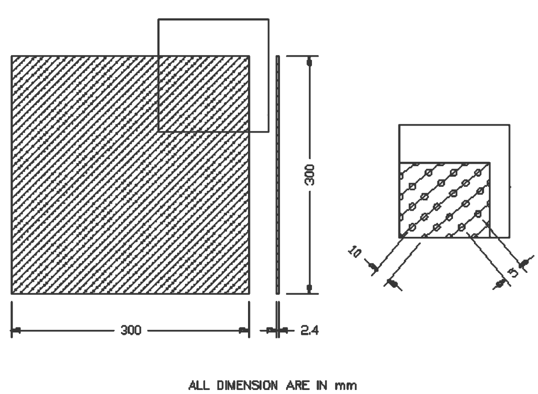

Fig. 2. Stitched pattern

The symmetry in the composite is maintained by using four layers of fibre ply. The stitching is made inclined at an angle 45° of to the fiber direction having 0° surface layers of the laminates and the volume fraction of stitch threads material was about 0.3%. In order to reduce fibred distortion in the interior of the laminate a modified lock stitch was adopted for stitching and thus easing the tension of the needle thread. The mould was cleaned and dried and a release agent was applied. The resin was applied to transfer stress between the reinforcement fibers and act as a glue to hold the fiber together. Generally epoxy, polyester and vinyl ester are used in the industry, in this study the epoxy LY556 was used. The HY951 binder was used, since the fabrication was done at room temperature. Ratio of mixing epoxy and hardener is 10:1. The epoxy mixture is uniformly applied. First mat was laid into the mould, then the resin was applied on the mat by brush followed by a second mat and it was repeated till four layers were achieved. Finally the mould was closed.

Two rectangular Chromium plated mild steel plates having dimensions of 300 mm × 300 mm × 2.44 mm were used to give a smooth finished during the curing period. Four beading covers were used to compress the fiber after the epoxy was applied and fastened using bolt and nuts.

IV. TENSILE TESTING

Tensile testing is a testing procedure done to determine a material's ability to resist tensile forces, deformation and failure. The tensile test was done on a Universal testing machine.

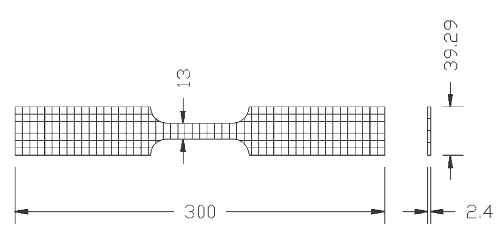

Fig. 3. Un-Stitched Laminate

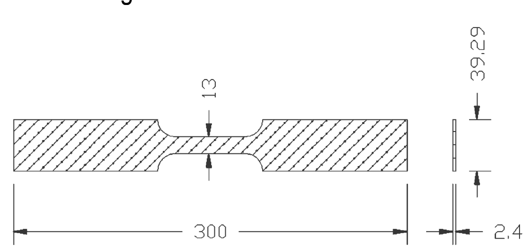

Fig. 4. Stitched Laminate

Fig. 5. Tensile Testing Setup

The tensile test specimens were machined as per the standard size as shown in figure 3 and figure 4. The tensile specimens were subjected to uniaxial loading in a universal testing machine as shown in the figure 5.

V. RESULTS and DISCUSSIONS

The tensile tests revealed a higher tensile strength in the stitched specimens were greater than the un-stitched specimen as shown in table.1. This indicates the stitching process pins the slip planes and increases the tensile strength of the composite laminates.

Table 1. Tensile strength of specimens

S. No	Ultimate Tensile Strength	Stitched Specimen (N)	Un-Stitched Specimen (N)
1	Ultimate Breaking Load (N)	7140	5000

The fractograph images obtained from the scanning electron microscope (SEM) shows lack of bonding and failure due to fibre pull and breakage, in the case of the unstitched specimens as shown in figure 6. In the case of the stitched specimens there is a good bonding between the resin and the fibre and the fibre resist the pulling (delamination) and breakage. Thus the fractography also indicates the benefits of the stitching of the fibres in the glass fibre-epoxy laminates.

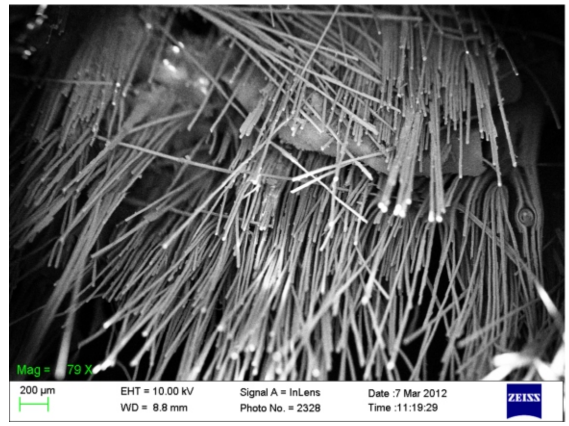

Fig. 6. SEM fractograph image of Un-Stitched tensile test specimen.

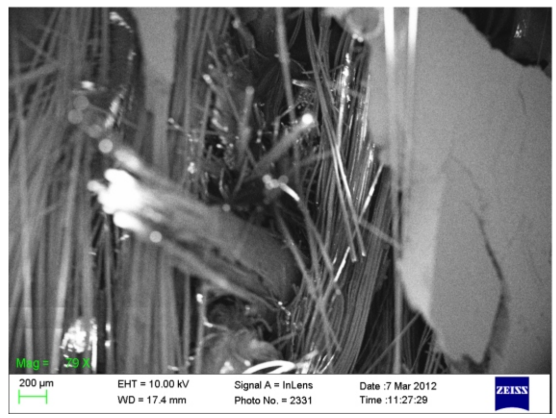

Fig. 7. SEM fractograph image of Stitched tensilet test specimen.

VI. CONCLUSION

The tensile tests were carried out in unstitched and stitched Glass Fiber-Epoxy laminates. A cotton thread was used to stitch prepare layers in fiber direction with stitch density of 6 stitches/cm^2. The tensile tests revealed that the stitching of the laminate improves the tensile strength and the delamination. Further the fractography studies vindicate the influence of stitching in the increase of tensile strength in the stitched test specimens.

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