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## Carbon Weaving: *Impediments Experienced.*

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**ABSTRACT:** Carbon fibre has cemented its place in applications like aerospace, military, industrial, constructional and transportation with ascribed to its properties regarding superior stiffness, high strength, and light weight and many more as compared to other fibres. These characteristics along with ease of fabrication of complicated structure, reduced inventory carbon fiber has become an important part of advanced composites. Different methods are employed for carbon fabric manufacturing. Weaving being one of the most widely used methods is considered here. The main objective of this paper is to understand the different types of stress the carbon yarn experiences during weaving due to its inherent properties. An attempt has also been made to suggest measures to be taken during this weaving.

**KEYWORDS:** Carbon, Weaving, Stiffness, Abrasion, tension variations.

### I. INTRODUCTION

Textile reinforced structural composite consist of reinforcement in terms of fibre, yarn and fabrics. Fabrics can be categorised as woven, knitted, braided and non-woven. The most widely used textile manufacturing technique, weaving which accounts for nearly 70% of the two-dimensional fabric produced, is being considered here.

The weaving process is suited to produce panels and woven fabric textiles have been used for several years in two-dimensional laminated composites. [1] The economy of textile composites can be increased by deploying the already available weaving looms for natural and synthetic yarns for high performance yarn like carbon, glass and Kevlar etc. This can lead to easier and quicker manufacture of a finished product and product development.

Due to their high stiffness and strength at low density, high specific energy absorption behaviour and excellent fatigue these high-performance yarns have emerged in areas like aeronautics, space, sporting goods, marine, automotive, ground transportation and off-shore. [1,6-8] Carbon yarn is one of the most fast emerging high-performance yarn. But carbon fibre weaving is difficult task as carbon fibre being stiffer break on slight deformation.

### II. CARBON FIBRE IN ADVANCED COMPOSITES

Carbon fibre is stiffer, stronger, and lighter than other fibres. It is selected for its high strength, lightweight, superior stiffness, electrical conductivity, low thermal expansion, high thermal conductivity and corrosion resistance. [2] especially for military aircraft - for better and lightweight materials became of paramount importance. In recent decades, carbon fibers have found wide application in commercial and civilian aircraft, recreational, industrial, and transportation markets. Carbon fibers are used in composites with a lightweight matrix. Carbon fiber composites are ideally suited to applications where requirements are of superior strength, stiffness, lower weight, corrosion resistance, high modulus and outstanding fatigue characteristics are critical requirements. They also can be used in the occasion where high temperature, chemical inertness and high damping are important. [4] These characteristics along with ease

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## III. WEAVING

Weaving is the most prominently used fabric manufacturing technique. Woven fabrics are produced by interlacing warp (along the length of the fabric) and filling yarn (lies across the width) [1,3,9]. It is primarily done by interlacing two orthogonal sets (warp and weft) of yarns in a regular and recurring pattern. Actual weaving process is preceded by yarn preparation processes namely winding, warping, sizing, drawing and denting. [5] Weaving process involves yarn abrasion due to lot of stresses and strain which undergo during the basic process. The yarn used undergoes damage on its surface due to this continuous tension variations. Weaving of carbon yarn involves these stresses and the problem aggravates with the inherent characteristics of the yarn.

## IV. CARBON WEAVING

Carbon fibres are a new breed of high-strength materials. Carbon fibre has been described as a fibre containing at least 90% carbon obtained by the controlled pyrolysis of appropriate fibres. Carbon fibres are very brittle. The layers in the fibres are formed by strong covalent bonds. The sheet-like aggregations allow easy crack propagation. On bending, the fibre fails at very low strain. [4]

Warp yarn undergo greater amount of stress as compared to filling yarn. The process of weaving involves the abrasion of one warp end against its neighbours and against the adjacent machine parts [3,9]. The use of adhesives and lubricants through sizing limits the damage. But in case of carbon tow on use of adhesives the tow becomes stiffer and is more prone to breakage. In the following segment, the discussion is related to the difficulties.

Carbon tows are available in spools. These spools were converted into weaver's beam using single end direct warping sample loom. This was suitable to use as the number of warp ends on the beam was relatively small. This warping machine had overhead underwinding. With over-end unwinding from a stationary package, there is a change of one turn of twist in the yarn for each coil removed from the package. [3] It also forms balloon which puts stress on the yarn. Such type of tow which suffering from unnecessary twist and tension when enters the guide it is affected by twisting, bending and abrasion. Thus, yarn surface can be damaged and the thin filament in the tow can be broken. So, may be side withdrawal is the solution this problem.

For fabric manufacturing through weaving, three primary motions are required namely shedding, picking and beat up. During weaving carbon warp breakage occur due to may be either by an increase in tension or by a decrease in strength. Tension in warp is controlled by operational parameters like high friction between warp and machine parts. Again, if there are nicks, cuts and roughness on surfaces to which yarn comes in contact then this problem aggravates. There is uneven distribution of load overall the warp threads. During shedding the main tension arises for carbon yarn by the cyclic variations in tension which is caused by periodically changing the shed. Tension compensators can be used but due to dynamic variation going on continuously, it is not possible to eliminate the variation completely. This leads to damage on to the carbon yarn onto the machine parts like heald eye, lease rods and front rest etc as shown in figure (1: a,b).

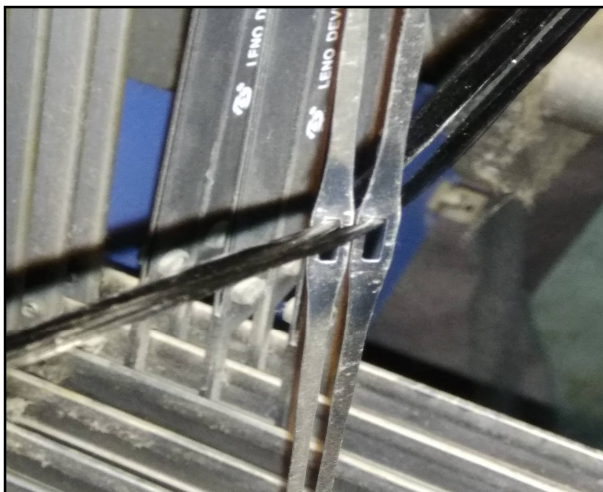
In carbon yarn, another problem also arises when entanglements of broken filaments protrude from the yarn after getting abraded. This lead to ephemeral erratically occurring variation in carbon yarn, leading to cuts on the yarn surface and further weakening it. This also adds to the problem of fly. Due extension of carbon is less, high peaks in tension tend to cause reduction in yarn strength and local stiffness. This overstraining of Carbon yarn must be avoided. Small variations in the extension can cause increase end-breakage rate. The need arises here for specially designing the heald with precise shape of the heald eye to support the working of the carbon yarn smoothly.

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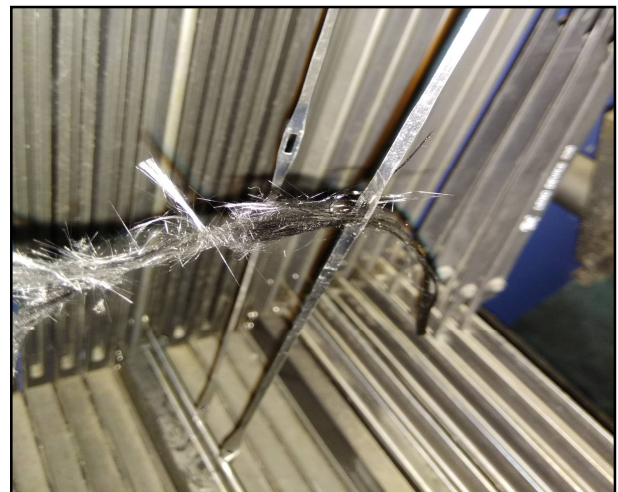
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(a)



(b)

Figure 1 (a) Status of Carbon yarn before shedding operation (b) Status of Carbon yarn after shedding operation

During Beat up operation very high amplitude of tension occurs along with cyclic variations which damages the carbon yarn. The construction of reed must be modified, the surface must be made smooth to prevent aggravation of this problem.

In accordance with the primary motions yarn also undergoes abrasion at various places like lease rods, at the front rest etc. In case of auxiliary motion like let off, if there is improper warp let off the tension variation is very high. In case of carbon yarn this tension variation affects it adversely. The need arises for positive let off mechanism for low carbon yarn damage.

During take up motion the abrasion of fabric with the temple, front rest and nip roller created lot of problem with fabric. The carbon fabric needs some cushioning arrangement to avoid this type of adverse effect. Also, the effect of nip roller must be minimised as the continuous rubbing action not only damages the fabric produced. The carbon yarn when continuously rubs on the surface of the nip roller, the synthetic cot on the roller gets teared off.

## V. CONCLUSION

Carbon fibre is one of the most promising and widely used high performance fibre in the technical field. The excellent properties of this fibre in terms of strength, stiffness and weight make it a ready choice. But the behaviour of carbon during weaving has been studied and it is seen that uniform tension is necessary so that warp behaves the similarly all along. It was found that for weaving carbon on the loom successfully, requires many modifications on regular sample loom also. The surface finish of the metallic parts used where the yarn is in direct contact also require care to avoid damage due to continuous rubbing onto the rough surface. Many appropriate responses have been suggested along this article for the weaving of carbon to be done with least damage to the yarn.

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