SSRG International Journal of Mechanical Engineering
ISSN: 2348 – 8360 /doi:10.14445/23488360/IJME-V7I4P104

Volume 7 Issue 4, 29-33, April 2020

# Critical Analysis of The Strut Made of Fiber Reinforced Polymer Tested Under One End Hinged And The Other End Free

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## ABSTRACT

*The present research work focuses on developing manufacturing processes and establishing critical test procedures for the polymer reinforced composite struts to be used in certain engineering applications. The following sections would deal with the materials used in Polymer matrix composites and manufacturing processes in general. The following sections also provide the information related to the development of the experimental setup and testing procedure adopted. The struts are manufactured and tested with one end hinged and the other end free condition .the struts are tested under compression analysis.*

## INTRODUCTION

Polymer composite materials have been a part of the automotive industry for several decades. These materials have been used for low production volumes because of their shortened lead times and lower investment costs relative to conventional steel fabrication. Important drivers of polymer composites' growth have been the reduced weight and parts consolidation opportunities the material offers and design flexibility, corrosion resistance, material anisotropy, and mechanical properties. Although the industry well recognizes these benefits, polymer composite use has been dampened by high material costs, slow production rates, and to a lesser extent, concerns about recyclability. Also impeding large-scale automotive applications is a curious mixture of concerns about material issues such as crash energy absorption, recycling challenges, competitive and cost pressures, the industry's general lack of experience and comfort with the material, and industry concerns about its capabilities.

## RELATED WORK

Composite pipes are not only analyzed by tension, but some scientists are tested under compression also. The design of lightweight structures requires a material with high strength and stiffness and low density. For many practical structural applications, the stiffness requirements impose greater limitations than the strength requirements. B.Walter rosent[1]proved that improvements in material properties solve failure criteria and reliability assessment, non-destructive evaluation, damage tolerance fatigue ,creep, joints, and attachment problems. The energy is absorbed in both progressive folding and progressive crushing. The specific energy absorption is directly related to the micromechanics of the fracture.D.Hull[2] explained that changing the fibers' distribution, changing the micromechanisms of crush and matrix properties can have a small effect on crush behavior. The laminates exhibit many phenomena such as viscoelasticity, damage, and moisture absorption, which can affect the pipes' proper function, D. Perreux et al. [3] explained clearly that frequency effect is mainly due to a creep/fatigue interaction and damage development is strongly dependent on the stress ratio.

The non-linear quasi-static behavior of a laminate has two main causes; D.Perreux [4] explained in his research that the first one is the laminate behavior is due to the layers which are assumed to be plastic and the second effect is induced by the damage and the laminating and the plastic strain is due to the connection of the laminating and the damage. Fiber reinforced epoxy composites have relatively low impact resistance; A.B.Doyum [5]observed that delamination was the most significant damage and also concluded that in E-glass specimens, parallel running circumferential cracks developed at the lateral sides concerning the impact point at high energy levels, and this is due to large elastic deformation of the thin walls. The helical filament winding is used to sus stain more hoop stresses[6]. Also, filament wound strips exhibit high failure strains under static tensile loading because of fibers' alignment in the load direction. Fiber-reinforced thermoplastic composite fabrics consist of thermoplastic filaments that prove that the layer design strongly influences fatigue strength. The main cause of the initial stiffness drop is caused by stress release[7]. Fatigue behavior of filament wound behavior under cyclic thermal and pressure loads at cryogenic temperatures was investigated by cevdet [8] and observed that during fatigue loading, the first damage mechanism is usually matrix cracking for all stress levels, and the failure stage increases by increasing the loading frequency mainly due to the decrease in the time under load. In most of the few experimental investigations on frp pipes under fatigue loading, F.Ellyin[9]made investigations and found the imperfections included the misalignment of fibers from the layup's intended angle and the existence of partial layers. Sandwich pipes have been used for many years because of their high performance in high stiffness with lightweight; M.Xia [10] found that stresses and strains depend strongly on winding angle and also observed that the axial stresses and strains at the inner surface could be larger than those at the outer shell for a pipe within a certain range of winding angle. The use of hollow fibers has been proposed to improve fiber reinforced composite materials' mechanical performance under compressive loading[11]. Advanced structures and materials are at the core of vehicle research activity. The thin-walled shells are efficient absorbers of impact energy, offering a constant retarding force through the impact and continuous deceleration through the entire stroke. E.Mahdi[12] explained the same in his research work.

To repair or reinforce a degraded civil infrastructure with the aid of polymer composites have many commercial benefits. Hsienet .al[13]proved effectively that the stress concentration caused by the stress is significantly reduced by the circumferentially reinforced composites leading to its higher strength. Filament has matured to become one of the major manufacturing processes in the fabrication of high-performance fiber-reinforced composites. Sung et al. [14] discussed the effects of filament winding angles on through-thickness material properties. The residual strains of a thick composite rings and stresses are decreased in the radial direction. During composites, it is noticed that composites do not sustain operating pressures that correspond to the dimension values. It can be proved by M.Tarfaoui et al. [15] and explained that there is a strong coupling between the structure and material. It is important to control the influence of development conditions on the limiting values of the material. A comprehensive study of failure developing in composite structures under complex stress fields to understand the performance and establishing damage tolerant design that compressive strength in fiber direction was degraded along with shear modulus reduction this was proved by A.E.Antoniou[16].winding angle could influence the stress distribution of the reinforced laminate and plays quite an important role in mechanical properties Qian Zhang et al. [17] discussed the effect of layer thickness, winding angle and reinforced volume fractions and effective elastic constants and indicates that the pipes with small winding angle have good stiffness in a circular direction and low stiffness in the axial direction.

## EXPERIMENTATION

In one end hinged and another end free condition, the maximum load which the strut can bare is 65 KN. The minimum load is 21KN, The maximum longitudinal stress is 255.53 N/mm$^{2,}$ which is at [±20°]$_{6,}$ and minimum longitudinal strain is 82.556 N/mm$^2$ at [±40°]$_{6,}$ and the maximum hoop stress is 38.89N/mm$^2$at [±20°]$_6$ and minimum hoop stress is 1.33 N/mm$^2$ at [±40°]$_6$, The maximum longitudinal strain is 0.00926 at [±20°]$_6$ and minimum longitudinal strain is 0.00305 which is at [±40°]$_6$, the top hoop strain is 0.00983 which is at [±20°]$_6$ and minimum hoop strain is 0.00175 which is at [±40°]$_6$.

## RESULTS AND DISCUSSIONS

The stresses and strain values which are obtained from the experimentation are tabulated below

| S.No | Orientation angle (Deg) | Load (Kn) | Longitudinal stress (N/mm$^2$) | Hoop stress (N/mm$^2$) | Longitudinal strain | Hoop strain |
|---|---|---|---|---|---|---|
| 1 | [±20°]$_6$ | 65 | 255.53 | 38.89 | 0.0926 | 0.00983 |
| 2 | [±25°]$_6$ | 38 | 149.388 | 12.69 | 0.0019 | 0.00261 |
| 3 | [±30°]$_6$ | 30 | 117.93 | 9.64 | 0.0035 | 0.00158 |
| 4 | [±35°]$_6$ | 22 | 86.488 | 1.68 | 0.0035 | 0.00566 |
| 5 | [±40°]$_6$ | 21 | 82.556 | 1.33 | 0.00305 | 0.00175 |

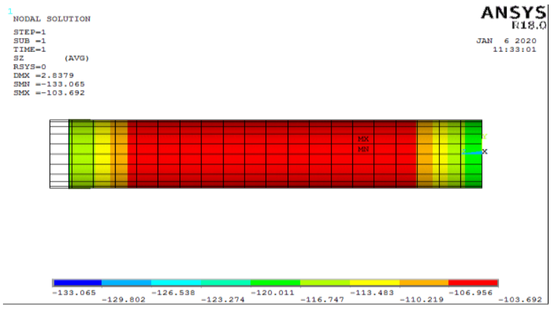


fig 1

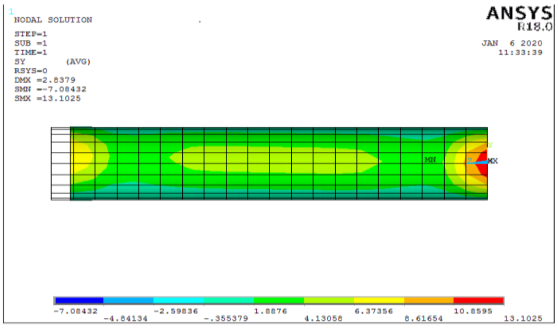
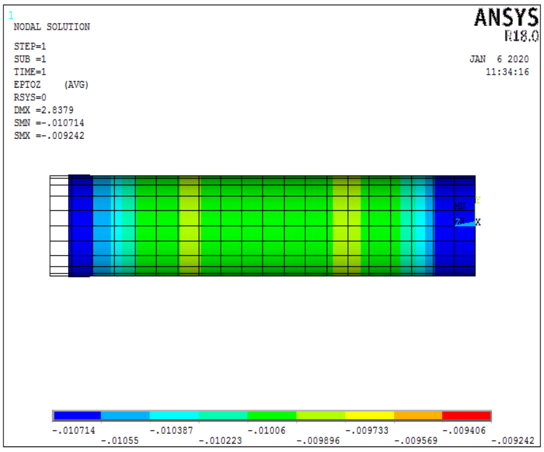


fig 2



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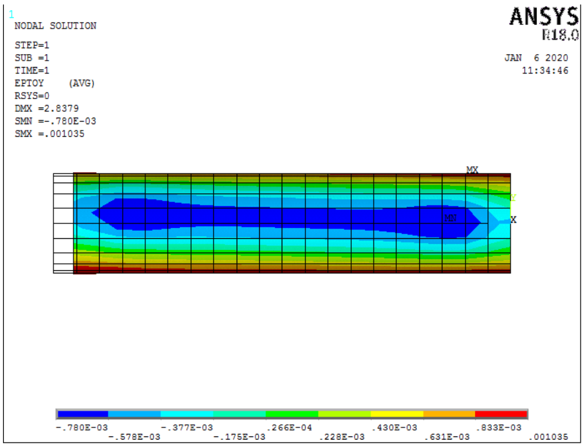

fig 4

fig 5

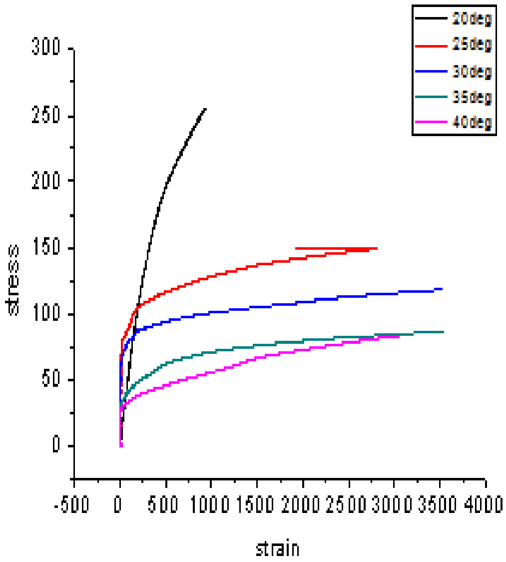

fig 6

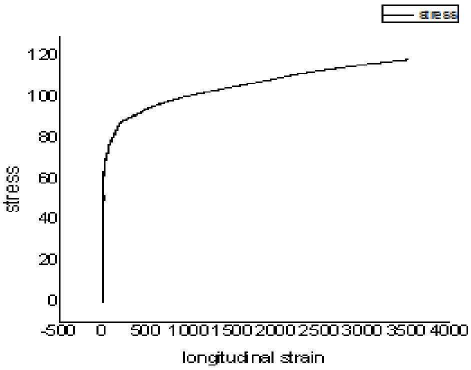

fig 7

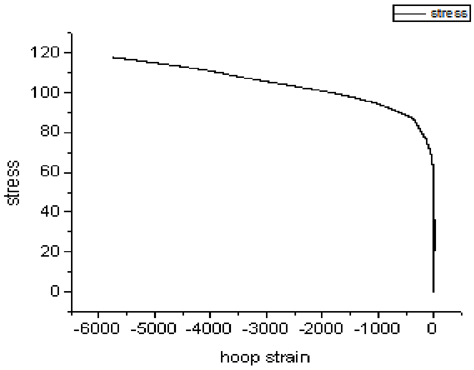

fig 8

Figures 1 and 2 give the details of the strut's stress condition in longitudinal and hoop direction. From figures3 and 4, we can know the strut's strain condition in longitudinal and hoop direction. Figure 5 gives the strut's details with [±30°]$_6$ orientation angle tested under one end hinged and the other end free condition. The edges are strengthened to obtain good results. Figure 6 explains the strut condition with different orientation angles. From figures 7 and 8, we can explain the stress and strain conditions of the strut. And At this angle, the strut can resist 30Kn, and the longitudinal stress is 117.93N/mm$^{2,}$ and hoop stress is 9.64N/mm$^{2,}$ and also the longitudinal strain is 0.0035, and hoop strain is 0.00566. Still, we got the stresses and strains from ANSYS as the longitudinal stress is 133.065N/mm$^{2,}$ and hoop stress is 7.084N/mm$^{2,}$ and longitudinal strain is 0.0107 hoop strain is 0.0078.

## CONCLUSIONS

From the above discussions, we analyze the strut as fibers are strong in longitudinal direction weak in hoop direction, but the struts able to bare longitudinal as well as hoop directional stresses, so we require moderate values like not too strong in the longitudinal direction and too weak in hoop direction, so the strut st fiber angle [±30°]$_6$orientation angle is exhibiting better results and the strain is also 0.004.

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