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PREPARATION OF COMPOSITE POLYMER GFRP STRUCTURES FOR SPACE APPLICATIONS

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ABSTRACT

The unrelenting passion of the aerospace industry to enhance the performance of commercial and military aircraft is constantly driving the development of improved high-performance structural materials. Composite materials are one such class of materials that play a significant role in current and future aerospace components. At present composites material are becoming important in Aerospace engineering due to its increased strength at lower weight, stiffness and corrosion resistance. This paper investigates the composite materials used in Aircraft structure and also reviews the advanced composites as structural materials. Results of Fourier-transform infrared spectroscopy revealed that physical toughening mechanisms enhanced the strength of the nanoparticle-reinforced composite. Failure analysis of the damaged area through scanning electron microscopy (SEM) evidenced the presence of key toughening mechanisms like damage containment through micro-cracks, enhanced fiber-matrix bonding, and load transfer

1.0 INTRODUCTION

The rapid development and use of composite materials beginning in the 1940s had three main driving forces. Military vehicles, such as airplanes, helicopters, and rockets, placed a premium on high-strength, light-weight materials. While the metallic components that had been used up to that point certainly did the job in terms of mechanical properties, the heavy weight of such components was prohibitive. The higher the weight of the plane or helicopter itself, the less cargo its engines could carry. Polymer industries were quickly growing and tried to expand the market of plastics to a variety of applications. The emergence of new, light-weight polymers from development laboratories offered a possible solution for a variety of uses, provided something could be done to increase the mechanical properties of plastics. The extremely high theoretical strength of certain materials, such as glass fibers, was being discovered.

Application in Aircraft and Space

Aircraft are required reduction in weight to find the greater speed. Fiber reinforced composite has been found to be ideal for this purpose. Carbon fiber with a hybrid condition is used for making large numbers of aircraft components. Carbon and Kevlar materials are used for making wings, fuselage, empennage components, elevator face sheets, horizontal stabilizers and upper rudder etc. of commercial

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aircraft. Epoxy resin with FRP is used for making of helicopter blades. A missile structure, when made of FRP is light in weight and increased its range of action Graphite composites are used for its high stiffness, strength and minimum weight. Graphite and Kevlar fibers are well suited for space allocations because of their high specific strength and modulus and low coefficient of thermal expansion. Strength and stiffness of composite material are the major consideration for the aircraft and low coefficient of thermal expansions and high stiffness are the major consideration for space applications. Antennas, booms, support trusses and struts of spacecraft, all are made by FRPs

2.0 LITERATURE REVIEW

Boominathan, R.; Arumugam [1]Even though Glass fiber reinforce polymer (GFRP) pipe made by filament wind technique require further machining to facilitate dimensional control for easy assembly and control of surface quality for functional aspects.

Mercy, J.L.; Prakash, S.; Krishnamoorthy [2]the surface roughness on machining of GFRPcomposites, according to them,higher cutting-speed produce more damage on the machined surface. This is attributedtohigher cutting temperature, which results in local softening of work material. They also studied the machinability of FRP composites using the ultra-sonicmachining technique.

Mokhireva, K.A.; Svistkov, A.L [3]Glass Fiber Reinforced Plastics (GFRP) have been widely used in construction of structures, replacing the usual steel elements, particularly in truss structures such as electrical transmission lattice towers. These materials are essentially composed of glass-fibers embedded in a resin matrix polymer. GFRP prismatic components can be manufactured with different cross sections via the process of pultrusion, in which the fibers are wetted in a viscoelastic matrix (resin) and subsequently pulled through a die for compacting and curing.

Al-Maharma, A.Y.; Sendur [4]Initially, composite materials were used only in secondary structure, but as knowledge and development of the materials has improved, their use in primary structure such as wings and fuselages has increased. The following table lists some aircraft in which significant amounts of composite materials are used in the airframe

3.0 COMPOSITE MATERIALS IN AEROSPACE INDUSTRY:

Composite materials can provide a much better strength-to-weight ratio than metals: sometimes by as much as 20% better. The lower weight results in lower fuel consumption and emissions and, because plastic structures need fewer riveted joints, enhanced aerodynamic efficiencies and lower manufacturing costs. The aviation industry was, naturally, attracted by such benefits when composites first made an appearance, but it was the manufacturers of military aircraft who initially seized the opportunity to exploit their use to improve the speed and manoeuvrability of their products. Weight is everything when it comes to heavier-than-air machines, and designers have striven continuously to improve lift to weight ratios since man first took to the air. Composites materials played a major part in weight reduction, and today there are 3 main types in use: carbon fiber, glass and aramid – reinforced epoxy. There are others, such as boron-reinforced (itself a composite formed on a tungsten core). Composites are versatile, used for both structural applications and components, in all aircraft and spacecraft, from hot air gondolas and gliders, to passenger airliners or fighter planes. The types have different mechanical properties and are used in different areas of aircraft construction.

Table: GFRP Properties

Properties	Unit	Fiber parallel direction	Fiber transverse direction
Tension Strength	MPa	200 - 400	50 - 60
Compression Strength	MPa	200 - 400	70 - 140
Sheer Strength	MPa	25 - 30	
Elastic modulus	GPa	20 - 40	5 - 9
Distortional moulus	GPa	3 - 4	

GFRP profiles are compared with typical construction materials, such as wood, aluminium, PVC and steel, in terms of stress – strain tensile constitutive relationship, young's modulus and tensile strength.

4.0 results and discussions:

Individual fibers of pristine composites are pulled out from the matrix without any fracture. This indicates poor adhesion between the matrix and fiber filaments in neat composites resulting in a weak interfacial bonding. Also, smooth fracture surfaces are evidenced in pristine composites along failed matrix edges. Figure 8 represents the fracture analysis of toughened composites with 0.75 wt% nanosilica as secondary reinforcements highlighting the fracture of fibers witnessing a better load transfer and also highlighting the multiple cracks propagating along the matrix edges. Similar observations are made in which is an effect of utilizing secondary reinforcements

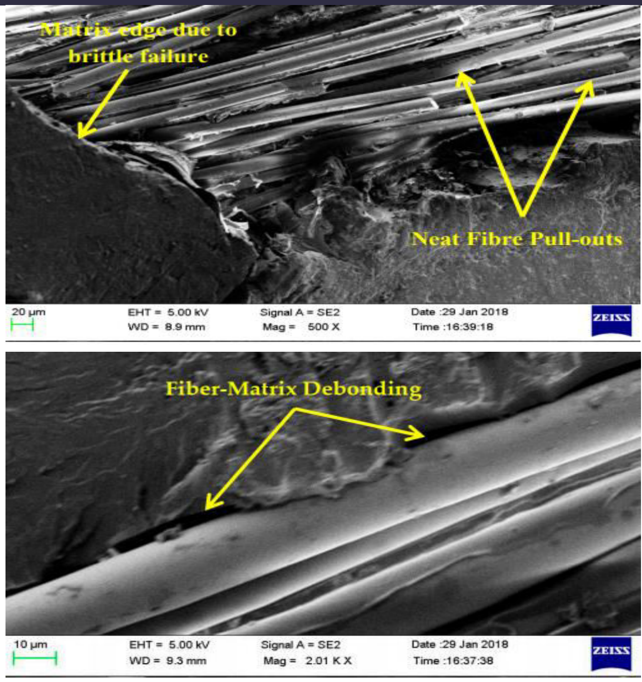

Figure: Failure analysis of pristine composites (a) Fibre pulled out neatly without fracture anddamage (b) Poor interfacial bonding between matrix and fibre

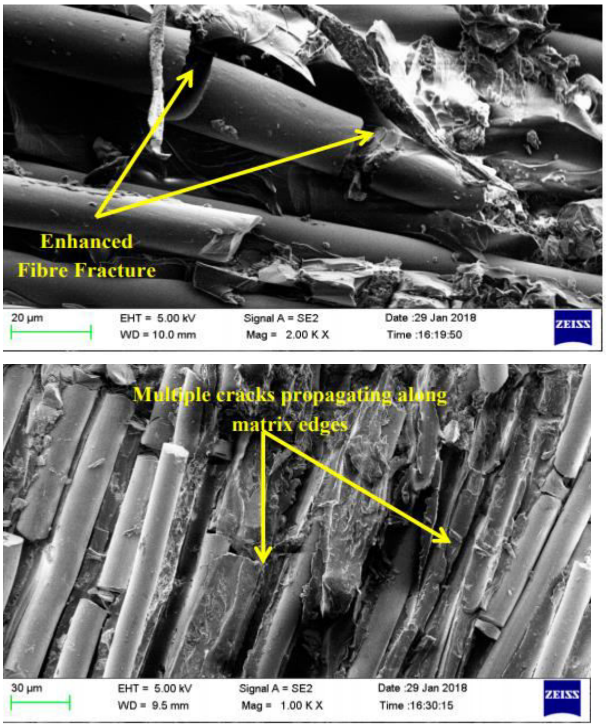

Figure: a) Enhanced fibre damage; (b) Crack initiation and propagation in matrix

The enhancement in the mechanical behavior of nanosilica-reinforced composites could be attributed to the higher strength and toughness of the matrix system loaded with nanosilica. Plastic deformation of the matrix system instigated by micro-cracking, crack propagation, debonding of nanoparticles, fiber pull-out, and fiber fracture are significant toughening mechanisms encountered due to the presence of nanoparticles in the matrix. These toughening mechanisms must consume significant amounts of energy, thus leading to increased stress transfer.

Conclusion:

Fiber reinforced polymer composites have low density, high strength, low price and solidified easily as compared to synthetic composite materials. So FRP utilizes in construction and building materials, automotive industries, aircraft, space, marine field and other commercial applications. FRP composite improves the mechanical behavior of polymers. This article evaluates the properties and characteristics of FRP composites like energy absorption, thermal and mechanical properties, tribology properties, relaxation and viscoelastic behavior etc. Different fabrication methods of FRP are compared by the easiest way of fabrication with various applications.

FUTURE SCOPE:

With the increasing fuel costs and environmental lobbying, commercial flying is under sustained pressure to improve performance, and weight reduction is a key factor in the equation. Beyond the day-to-day operating costs, the aircraft maintenance programs can be simplified by component count reduction and corrosion reduction. The competitive nature of the aircraft construction business ensures that any opportunity to reduce operating costs is explored and exploited wherever possible

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