ABSTRACT

Composite materials offer numerous advantages over conventional engineering metals. Over the years, the use of composite materials has increased drastically. Today, composite materials play significant roles in many scientific and engineering realms, primarily due to their unique physical and mechanical response characteristics, such as light weight, specific strength, fracture toughness, corrosion and wear resistance.

It is extremely great importance that nanocomposite materials possess a high toughness, stiffness and impact resistance. On the other hand, the braided composite materials have a broad range of industrial applications. The most common commercial applications of braided composites are, but not limited to, over-braided fuel lines, braided air ducts, rocket launch tubes, and aircraft structural parts. Experimental evidence shows that some nanocomposite with special matrices and filler materials may achieve significant and simultaneous improvements in stiffness, fracture toughness, impact energy absorption and vibration damping, and these characteristics could be of particular importance in automobile or airplane structures.

In this research, biaxial carbon braided fiber composites samples were fabricated using biaxial braided carbon fiber sleeves and epoxy resin mixed with Neat Epoxy (NE), Titanium (IV) Oxide (1, 3 and 5 wt %), Nanoclay (1, 3 and 5 wt %) and Carbon nanofiber (0.2, 0.5 and 1 wt %) nanoparticles separately. Magnetic hot plate stirring method was used to mix nanoparticles with epoxy resin. The biaxial carbon braided composites were manufactured through hand-layup technique. The developed composites were cut according to ASTM standards in water jet cutting machine and were tested for their mechanical properties like tensile, flexural, shear and impact strength. A small amount of CNF (0.5wt%) added into the epoxy of braided nanocomposites can enhance the tensile strength by 62%, flexural strength by 79%, double shear strength by 60% and impact strength by

17% than NE biaxial carbon braided fiber composites. Morphologies of the biaxial carbon braided fiber composites were analyzed by Scanning Electron Microscopy (SEM Image). SEM study revealed better dispersion of 3wt% of TiO_2, 3wt% of NC and 0.5wt% of CNF in biaxial carbon braided fiber composites.

A theoretical method was developed for calculation of tensile stiffness and shear stiffness of biaxial carbon braided fiber composites. A unit cell has been introduced as a representative cell of biaxial carbon braided fiber composite. Each unit cell consists of two groups of braided tows which are aligned in $\pm 45^o$ and a matrix with different percentage of nanoparticles. The developed model, which is based on discrete three layer model and thickness average method for predicting the tensile stiffness and shear stiffness of biaxial carbon braided fiber composites. Using rule of mixtures, mechanical properties of each layer are calculated. Then, using a thickness average method, the total stiffness of the biaxial braided nanocomposite is calculated. The results obtained from the theoretical model compared with the experimental results. It was found that all the values were closer to each other in comparison.

Considering overall performance of TiO_2, NC and CNF biaxial carbon braided fiber composites, one best composite was selected from each nanoparticles composite materials. A bicycle frame was designed in NX.9.0 (Unigraphics) and analyzed using FEmap (Preprocessing and Post processing) and NX Nastran 9.0 (solver). 3wt%TiO_2, 3wt%NC and 0.5wt%CNF biaxial carbon braided fiber composites bicycle frame were compared with Aluminium and bamboo bicycle frames. 0.5wt%CNF biaxial carbon braided fiber composite bicycle frame was shown better performance and saves weight compared to other bicycle frames.

Based on the studies it was concluded that, by proper selection of nanoparticles, fibers, mixing methods and proportions, composite materials would serve as an effective alternate for conventional metals.