ABSTRACT

The focus of this research was to investigate the use of Multi-Walled Carbon Nanotubes (MWCNTs) as reinforcements with pure epoxy for creating multifunctional material. The unique mechanical properties such as high strength, ductility, and stiffness as well as their geometrical characteristics of the carbon nanotubes (CNTs) were the vital motivation for this study. The researchers combined the MWCNTs with pure epoxy, which are the bulk structural material used in aerospace, marine, sport goods and textile machinery industry. When compared to other composite materials, a limited amount of research has been conducted on epoxy/MWCNTs nanocomposites.

In the present study, the real potential of MWCNTs as reinforcing in epoxy composites has been exploded, in addition the weight fraction of carbon nanotubes has been investigated, with special attention to the tribology applications. The dry sliding wear and friction behavior of epoxy reinforced with Multi-walled Carbon Nanotubes (MWCNTs) were investigated using pin on disc machine. The MWCNTs with the weight fraction of 0.1wt.%, 0.5wt.%, 1.25wt.%, 2.5wt.% and 5wt.%in the epoxy/MWCNTs were used in this study. A pin of 6mm diameter as epoxy/MWCNTs nanocomposites was slide against steel disc at a speed of 200rpm under the load of 30N, 60N and 90N. Wear performance was observed with the sliding distance of 942m in 30min. The experimental investigation showed that the addition of MWCNTs in
considerable amount can improve the wear performance of epoxy/MWCNTs nanocomposites. The specific wear rate and friction co-efficient of the nanocomposites decrease with the increase of MWCNTs content until the weight fraction of 1.25wt.% is achieved.

However, the weight fraction of 1.25wt.% of MWCNTs nanocomposites shows superior wear resistance than pure epoxy. Furthermore, addition of MWCNTs forms localized bundle and does not exhibit significant improvement of wear performance due to non homogeneous dispersion in the epoxy matrix.

The solid particle erosion of Multiwall Carbon Nanotubes (MWCNTs) reinforced with pure epoxy has been investigated. The erosive wear of these composites have been evaluated at different impingement angles of 30°, 60° and 90° with five different compositions. The erosion experiments have been carried out using irregular silica sand particles (100±20μm) as an erodent with the impact velocity of 70m/s. The erosion losses of pure epoxy and epoxy/MWCNTs nanocomposites were evaluated at various impingement angles with the changes of erosion time. The weight loss was considerably increased for all the samples at 60° impingement angle. However, the 0.1, 0.5 & 1.25wt.% of MWCNTs nanocomposites possess good erosion resistance and exhibit 25%, 30% and 73% better than pure epoxy respectively and also the weight fraction of 1.25wt.% MWCNTs nanocomposites shows superior erosion resistance than pure epoxy. Moreover, the erosion loss rate of all nanocomposites considerably
increases with the increasing of nanotubes content until the content reaches 1.25wt.%.

Similarly, wear in polymer materials is closely attributed to the mechanical properties of the polymer. Therefore, we can assess the polymer nanocomposites wear performance using their mechanical properties data, in order to gain better understanding as to whether the improved wear resistance is due to the mechanical property of the polymer nanocomposites. The mechanical properties of epoxy and epoxy/MWCNTs nanocomposites were collected in experimentally, from that epoxy composites containing 1.25wt.% of MWCNTs exhibited higher tensile strength and Young’s modulus than pure epoxy. Due to high aspect ratio of MWCNTs, well dispersed CNTs in epoxy provided a large surface area available for interaction between the epoxy resin molecules and CNTs, which facilitated better load transferring to the reinforcing phase and thus improved the strength and modulus of the composites. Obviously, MWCNTs was successful reinforcement for epoxy matrix in the present case. However, the elongation at break of epoxy decreased slightly, which indicated that the composites became somewhat brittle compared with epoxy, because MWCNTs restricted the motion of epoxy chains chemically.

Finally, the numerical investigation carried out for prediction of wear on the effect of incorporating MWCNTs in the pure epoxy has been investigated. The potential of using Artificial Neural Networks (ANN) for predicting the dry sliding wear behavior of Multiwall Carbon Nanotubes (MWCNTs) reinforced epoxy material was investigated in this work. A polymer nanocomposite was
investigated using a measured data set of 80 independent dry sliding tests of pure epoxy and epoxy-MWCNTs nanocomposites. Based on measured datasets of epoxy-MWCNTs, specific wear rate was successfully calculated through well trained artificial neural network. Feed forward back propagation neural network (FRBN), radial basis neural network (RBNN), pattern recognition neural network (PRNN) and general regression neural network (GRNN) algorithm models were investigated in order to predict the optimum method that simulates the wear under such parameters. The experimental results were trained in an ANN and the results were compared with experimental values. The GRNN network demonstrated that the average value of relative error is <1% and prediction quality 99% and it is quite suitable tool for prediction of wear in composites.

Clear evidence was obtained from the Field Emission Scanning Electron Microscope (FESEM) image produced from the worn and eroded surface of the specimens: rough and smooth morphology, wave formation of fracture surface, micro plugging, deep grooving, cracking and epoxy pullouts exhibits effects homogeneous distribution of MWCNTs in the pure epoxy. The excessive addition of 2.5wt.% and 5wt.% MWCNTs formed localized bundle in the host matrix. A substantial improvement of tribological properties has been attributed to the considerable addition of MWCNTs as well as the effective interface bonding. In conclusion, considerable amount of MWCNTs as nano reinforcements can effectively improve tribological properties of epoxy/MWNCTs nanocomposites.