WEAR BEHAVIOUR OF CARBON NANOFIBER-EPOXY COMPOSITES

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Carbon nanofibers (CNFs) have been used in recent times to increase the mechanical properties of polymer matrices [1-3], the use of CNFs provide several advantages compared with the use of micro-sized fillers; they allow the production of micromechanical components and thin coatings and they do not cause embrittlement and deterioration of strength as microscopic fillers often do. These nanofillers also exhibit excellent thermal and electrical properties which make them excellent candidates for the production of conductive polymer composites, capable of dissipating electrostatic charges or even act as shielding devices from electromagnetic radiation. To benefit from the good reinforcing properties of the CNFs a good dispersion of the fibers in the polymer matrix is crucial since a well dispersed filler network results in a more uniform stress distribution within the composite. A good dispersion also minimizes the presence of agglomerates that can act as centres for stress-concentration which decrease the general strength and modulus of the composite.

This work deals with the effect of carbon nanofiber reinforcement on the performance of epoxy resin against sliding wear. Samples containing different volume concentrations of carbon nanofibers were systematically manufactured and tested under uniform sliding against a martensitic steel ring (100Cr6) in a block-on-ring configuration. Tested composite surfaces were analyzed by means of electronic microscopy in order to study the observed effects on the wear behaviour of the polymer matrix.

In our research nanofibers were dispersed in the polymer matrix with the aid of a three roll calender (**Fig. 1**). The use of this device for the dispersion of carbon nanotubes in an epoxy matrix was first reported by F.H. Gojny et al. [4] .This technology achieved excellent dispersion results without reducing the aspect ratio of the fillers which is important to enable a good load transfer from the polymer matrix to the nanofillers. One further advantage of the calendering method is the possibility of up-scaling the manufacturing process to meet technical demands. The manufactured composites, containing different volume concentrations of carbon nanofibers, were characterized by tribological analysis in order to study the effects that the nanofibers had on the wear resistance of the epoxy resin.

(**Fig.2** left) depicts the results of the wear experiments conducted on a block on ring machine. The rotation speed was chosen two be 1 m/s and two different forces 15 N and 20 N were applied on the samples during testing. The specific wear resistance is documented as a function of the filler content. Low wear rates represent a high material resistance against wear. As Fig 2 shows the addition of CNF to the epoxy resin does not significantly affect the tribological performance of the matrix. (**Fig. 2** right) shows the evolution of the friction coefficient of the nanocomposites with increasing filler contents. A small decrease in the friction was observed with the addition of 0.05 vol % of carbon nanofibers. Furter increase of fillers resulted in a minimal increase in the friction coefficient of the composites.
Scanning electron microscopy examinations was used to study the morphology of the tested surfaces (**Fig.3**). The aim was to study the role of the added carbon nanofibers in the measured tribological properties of the samples. The main features of the worn surface of the epoxy resin (Fig.3 left) are smooth areas showing triangular scratches opening in the wear direction. The

morphology of the worn surface of the sample containing 1.5 vol. % CNF (**Fig.3 right**) does looks quite similar to the one observed for the neat epoxy verifying the test data. Only a slight reduction in the size of the wear cracks might be appreciated.

References:

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[3] P. Richard, T. Prasse, J-Y. Cavaille, L. Chazeau, C. Gauthier, J. Duchet, Materials Science and Engineering. A **352(1–2)** (2003), 344–348.
[4] F.H. Gojny, M.H.G. Wichmann, U. Köpke, B. Fiedler, K. Schulte, Composites Science and Technology **64** (2004) 2363–2371.

Figures:

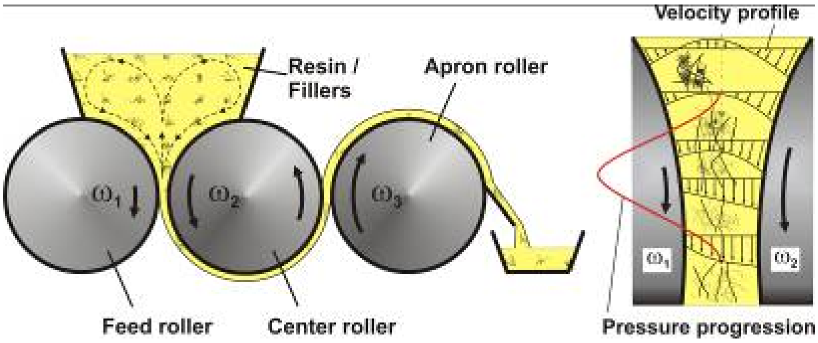
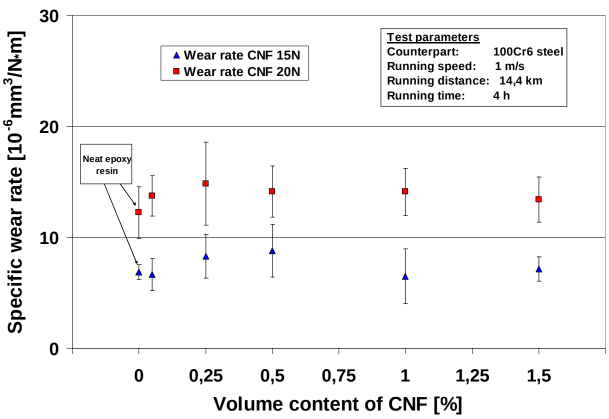


Fig. 1. Schematic view of the three roll calender and its working principle.



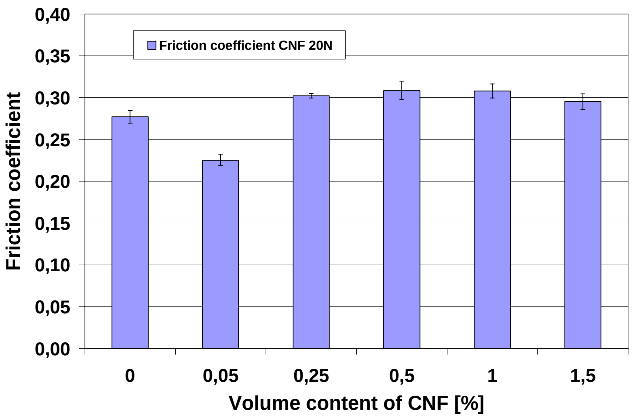
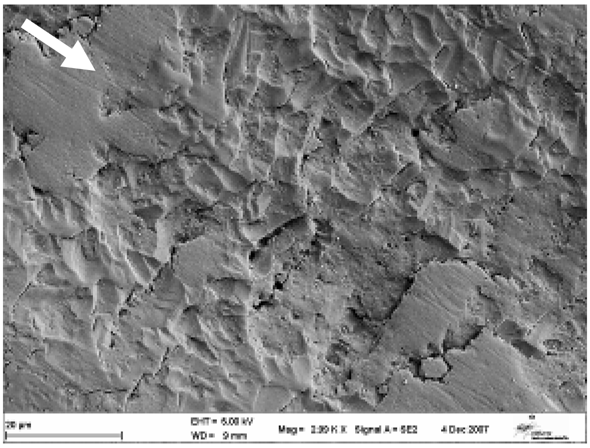


Fig.2 Specific wear rate (left) and friction coefficient (right) of the epoxy/CNF nanocomposites as a function of nanofiber volume content



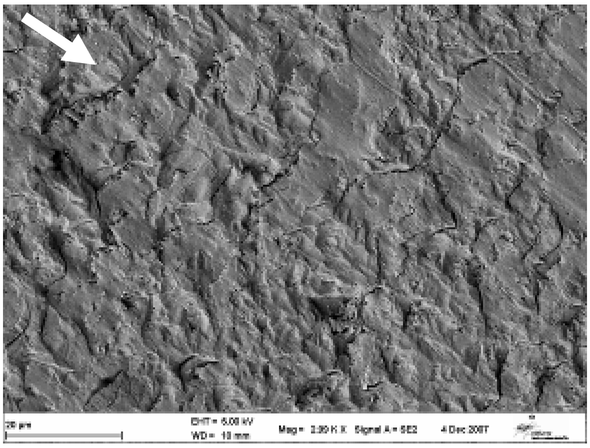


Fig.3 (Left) Neat epoxy surface from tribological testing.. (Right) Nanocomposite (1.5 % vol. of CNF) test surface surface. White arrows indicate the sliding wear direction.