INVESTIGATION OF MECHANICAL BEHAVIOUR OF HYBRID POLYMER NANOCOMPOSITES

by

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Polymer; Nanocomposites; Nanomaterials

DEDICATED

TO

MY PARENTS

CERTIFICATE

This is to certify that the thesis entitled "**Investigation of Mechanical Behaviour of Hybrid Polymer Nanocomposites**" being submitted by Mr. Sanjeev Kumar Shrivastava, to Indian Institute of Technology Delhi for the award of the degree of Doctor of Philosophy is a record of the bonafide research work carried out by him. Mr. S. K. Shrivastava has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge has reached the requisite standard.

The Thesis, or any part thereof, has not been submitted to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Glass fibres in the form of chopped strand mat and woven roving with epoxy resin as polymer matrix are used in the fabrication of composite laminates employed for structural applications. A vacuum assisted resin transfer mould (VARTM) is designed and developed for fabrication of composite laminates. Performance of the developed VARTM technique is compared with the hand layup technique. The mechanical properties of composites fabricated using VARTM technique are investigated.

Further, a nanofiller is added to this glass fibre composite to develop glass fibre epoxy nanocomposite materials. These nanofillers enhance the mechanical properties of the composites. The dispersion of filler into polymer at the nano-level is a challenging task. Therefore, on the basis of Young's modulus, the process parameters for dispersion, namely, the loading of clay, stirring time and sonication time are optimized. Dispersion of filler at the nano-level is confirmed using X-ray diffraction and transmission electron microscopy techniques. Effects of seawater on mechanical properties of these hybrid epoxy nanocomposites are also investigated. A study of the delamination modes, namely, mode I, mode II and mixed mode bending for glass fibre epoxy nanocomposites is done to observe the effects of addition of nanofiller on strain energy release rate.

A vacuum assisted resin transfer mold (VARTM) process gives better results as compared to hand layup technique. Better interfacial bonding is observed for lower weight-percentages of nanofiller into epoxy. Enhancements in mechanical properties due to intercalation morphology are observed (more than 143% in tensile modulus and more than 133% in flexural modulus as compared to conventional composites), but the

specimens having exfoliated structures give a better flexural modulus for nanocomposites. The mechanical properties of hybrid epoxy nanocomposites show an inconsistent behavior when exposed to seawater.

Addition of clay into epoxy improves the delamination resistance in mode I and mixed mode, however it is reduced in mode II.

The theoretical calculations of the elastic constants for single laminas and mixed composites, as well as, epoxy nanocomposites show that they are in agreement with the experimental results.

A study on natural fibre composites using the VARTM technique shows the potential of the VARTM setup, for fabricating laminates.

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