

AN INVESTIGATION OF SOME
VISCOELASTIC PROPERTIES OF
POLYPROPYLENE AND SHORT GLASS
FIBRE-REINFORCED POLYPROPYLENE

by

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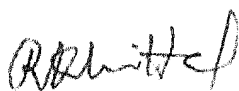
Indian Institute of Technology, Delhi


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CERTIFICATE

This is to certify that the thesis entitled, "AN INVESTIGATION OF SOME VISCOELASTIC PROPERTIES OF POLYPROPYLENE AND SHORT GLASS FIBRE-REINFORCED POLYPROPYLENE" being submitted by Ms. Jhumur Lahiri to the 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 her. She has worked under our guidance and supervision and has fulfilled the requirements for the submission of this thesis which, to our 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

The creep characteristics of unreinforced and short glass fibre-reinforced samples prepared by compression moulding, injection moulding and extrusion were measured at temperatures from 20°C to 55°C over a range of stress from $13.6 \times 10^5 \text{ N/m}^2$ to $11.0 \times 10^6 \text{ N/m}^2$ for 6 hours in a horizontal creep unit specially designed and fabricated for the purpose. A limited investigation was also made on drawn polymer sheet. The torsional modulus and logarithmic decrement were measured on same samples from -40°C to +40°C on a free vibration pendulum which had been earlier fabricated for another research project on similar material and modified to suit our requirements. The data obtained have been prepared and analysed in terms of existing models. The work has been presented in seven chapters and two appendices as follows.

In the first chapter a few comments are first made about the background against which the present investigation was planned. It then gives a brief literature survey of the relevant work done in this area, and also some idea about the present state of art in this field, viz. the creep of polymers.

The second chapter deals with experimental details of the methods used, the samples fabricated and the equipment and techniques used.

The third chapter analyses the tensile creep data on polypropylene and glass fibre-reinforced polypropylene samples made by compression moulding and injection moulding. It is shown that the creep deformation, following the work of Findley and co-workers, can be expressed as being made up of two types of deformation, (i) elastic deformation which is approximately a linear function of stress and it exhibits temperature-dependence within the limited temperature range investigated and, (ii) viscoelastic deformation which is a non-linear function of stress and in comparison to the elastic deformation, it shows a more pronounced temperature-dependence. The incorporation of glass fibres to the extent of 20 to 30% by weight results in suppression of both the elastic and the viscoelastic components of deformation.

In the fourth chapter it is shown that though the creep deformation is non-linearly viscoelastic, linear superposition of data, in the range of strains produced in tests, is possible following the approach suggested by Neville for concrete. This leads to the conversion of creep data to stress relaxation curves. The results are confirmed by limited stress-relaxation studies.

In the fifth chapter, the time-temperature superposition principle was applied to the data. It is shown that the William-Landel-Ferry approach is applicable

particularly to glass fibre-reinforced polypropylene reasonably well, it is also suggested that in the creep of polypropylene physical ageing effects should play an important role. The approximate forms of the retardation spectra for the two materials show important differences. It appears that the incorporation of glass fibres is relatively more effective in suppressing the long retardation times,

The sixth chapter presents the dynamic mechanical data alongwith the creep data on stretched polypropylene and extruded glass fibre-reinforced polypropylene composite. While the incorporation of glass fibres is shown to result in a stiffening effect in shear (e.g., by a factor of about 1.5 at 20°C) the drawn polymer sheet shows a marginal change in torsional modulus (e.g., by a factor of 0.95 at 20°C) over a wide temperature range. On the other hand, glass fibres are not able to suppress the creep deformation as effectively as reinforcement by molecular alignment at low temperatures; at higher temperatures the situation reverses. Effect of angular orientation on creep and dynamic mechanical behaviour of drawn and reinforced materials have also been studied. It is shown that whereas anisotropy is much more pronounced in the fibre-reinforced material in torsion, the opposite is the case in tension. Reinforcement by molecular orientation causes very high degree of anisotropy in the

latter case. The mechanisms of reinforcement have been explained in terms of the anisotropy of molecular forces and their temperature dependence.

The seventh chapter presents the major conclusions from the present studies and suggests further work in this area.

The appendix presents the computer programme used for linear superposition as well as some analytical results for torsion pendulum studies on anisotropic materials.

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