VISCO ELASTIC BEHAVIOUR OF POLYMERS

Abstract

In Polymeric materials mechanical properties exhibit two ideal special cases hence these are known as visco elastic materials. The property of stress is a function of strain and function of time for visco elastic material. The very common characteristic features of visco elastic materials are a time dependent strain response to a constant stress and a constant strain response to a time dependent stress. When the applied stress is less or zero to the materials, the material recovers slowly with a time. This type of effects also observed in metals at very high temperatures whereas in plastics they show this type of behaviour at room temperature.

Keyword: Photo-plastic effect, Deformation, Photo-mechanical effect

Author

Shalini Patil
Department of Physics
Government Autonomous Post Graduate College
Chhindwara, Madhya Pradesh, India
dr.shalinipatil19@gmail.com

I. INTRODUCTION

The photo-plastic effect is a very effective method to simulate the transparent polymers and also for elastic-plastic behaviour of rubber, plastic, ceramics, metals(prototype materials) [1].The optical and mechanical behaviour in polymer basically depends on their viscous performance. Photo-plasticity is a phenomenon to determine the plastic flow stress and strain distribution in plastically deformed materials altered by the absorption of light, where a similar stress-strain behaviour exhibit in transparent polymers. The theory of viscosity is based upon the molecular theory of liquids. According to which the potential energy of two adjoining molecules of the liquid and their molecular configurations are related. The theory of the movement of liquids considers the resulting displacement of the molecules relative to their structure, which impedes movement and thus influences the extent of that displacement.

II. THEORY OF VISCOELASTIC DEFORMATION

Viscoelastic deformation can be assumed wherever the resistance to stress in the medium depends upon the velocity of the process mostly in creep and relaxation or generally wherever large deformation occurs, but viscoelastic deformation can also be presumed when the deformation process is influenced by residual or thermal stresses. The theory is based upon Boltzmann’s principle of superposition which states that the resultant strain is a function of loading. This means that each contribution towards the resultant strain which is then simply the sum of all the contributions. The linear theory requires strain for every arbitrary time interval to be reasonably proportional to stress. With non-linear relationships the mathematical description becomes complicated therefore the non-linear theory of viscoelasticity is more complex. The knowledge of deformation behaviour of macromolecular substances playas subsequently role in the determination of their chemical and physical nature. The structure of an amorphous, linear polymer is formed by a skeleton of molecular nuclei loosely interlocked by rather long chains of the same length. The molecular nuclei are affected, on the one hand by the Vander Waals mass forces, the dipole interactions, the hydrogen bonds and stable covalent bonds etc. and on the other hand, by force that arise from the tendency of the chains to return after deformation to a state of maximum entropy by means of Brownian or thermal motion. The presence of bonds of different strength serves as a pointer to the viscoelastic properties of polymers.

III. VISCOELASTIC BEHAVIOUR FOR POLYMERS

On close examination of polymer systems, for viscous the activation energy, flow is found to be constant only for small ranges of temperature. In viscous flow the dissipated mechanical energy depends upon the strain rate.

In a pure elastic material, the stress and strain are directly proportional to each other. For example, stress σ and strain ε for any uniaxial cay be represented as $\sigma \alpha \varepsilon$

$$\sigma = \eta\times\varepsilon \tag{1}$$

Where η is the modulus constant of the material.

Viscosity based on the concept of free volume. In a pure viscous fluid, the shear stress τ and rate of strain $\dot{\gamma}$is related with each other as follows $\tau \alpha \dot{\gamma}$

$$\tau = \upsilon \times \dot{\gamma} \tag{2}$$

Where the υ is the viscosity constant of the fluid.

Polymer materials have mechanical properties involving large deformation depend on the long-chain nature of polymers and hence they are known as viscoelastic. The flexibility of material in which strain and time is the function of stress and expressed by an equation as [2]

$$\sigma = f(\varepsilon, t) \tag{3}$$

At elevated temperature polymer chains exhibit rapid micro-Brownian motion so that equation (3) may be written as.

$$\sigma = \varepsilon f(t) \tag{4}$$

Equation (4) is the basis of linear viscoelasticity and indicates the Hook’s law.

The flow of matter in polymer involves several different phenomena, which can be related to some extent to different molecular mechanisms. These phenomena and their associated mechanism like viscous flow, elasticity in rubber, Hooke an elasticity and viscoelasticity together forms the basis of the mechanical properties of amorphous polymers. When shaping is carried out it gets a viscous stage in course of their formation. Polymers exhibit viscoelastic behaviour that they act to an applied force by recoverable and time dependent permanent deformations. Using combinations of macroscopic models, the basis of nonlinear elastic or viscoelastic material behaviour could be explained and described. Polymers being viscoelastic exhibit deformation which occurs only when a certain value of the strain or stress has been optimum.

IV. RESULTS

Temperature influences the mechanical behaviour of thermoplastic through its effect on the strength of the Vander waals bonding between the chains. At very high temperature, the bonds become so weak and viscosity occurs easily at less or without applied stress. In intermediate temperature the polymer is neither glass nor rubber like. It is viscoelastic and may dissipate a considerable amount of energy on being strained. As the temperature decreases, viscoelastic behaviour present marked as the strong bonds. At very low temperatures, the polymers may be so viscous that no chain sliding occurs and the polymers behave as rigid [3,4,5].The covalent bonds between the atoms in the linear chain may be destroyed at very high temperatures and the polymer burns or chars. The limits of degradation temperature for the polymeris usefulness like fiber industry.

An important feature of viscoelastic materials is the similarity between the strain increments at a given strain rate and the levels of temperature,the behaviour of viscoelastic materials at high temperature and high strain rates is similar to that at low temperature and low strain rates.

V. CONCLUSIONS

The theory of the movement of liquids considers the displacement of the molecules relative to their structure, which impedes movement and thus influences the extent of that displacement. Long chain molecules, especially the double bonded ones play an important role in the restriction of movement. It transpires the greatest significance rests with the possibility of movement of the free end or of several free ends of the macromolecule and in polymers with the degree of polymerization.

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