**VISCOELASTIC BEHAVIOUR OF POLYMERS**

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 **ABSTRACT**

In Polymeric materials mechanical properties exhibit two ideal cases hence they are known as viscoelastic. The stress is a function of strain and time for viscoelastic material. The most common characteristic features of viscoelastic 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 removed from the materials, they have the ability to recover slowly with a period of time. These effects can also be observed in metals at very high temperatures whereas in plastics they occur at room temperature.

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

1. **Introduction**

The photo-plastic effect is a very reliable method to simulate the transparent polymers and elasto-plastic behaviour of prototype materials [1].The behaviour of optical and mechanical in polymer depends basically on their viscous character. Photo-plasticity is the phenomena to determine stress and strain distribution in plastically deformed materials, 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.

1. **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 play an 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.

1. **Viscoelastic Behaviour of Polymers**

In a perfectly elastic material, the stress σ is directly proportional to the strain ε. For uniaxial stress and strain the relationship may be represented as

 σ = constant$×$ε (1)

Where the constant is the modulus of the material.

In a perfectly viscous fluid the shear stress τ is directly proportional to the rate of strain $\dot{γ}$.This relationship may be represented as

 τ = constant $×\dot{γ}$ (2)

Where the constant is referred to as the viscosity of the fluid.

Polymeric materials exhibit mechanical properties which exhibit between these two ideal cases and hence they are termed as viscoelastic. A viscoelastic material in which the stress is a function of strain and time described by an equation [2]

 σ = f (ε, t) (3)

This type of response is referred to as non-linear viscoelastic and may be reduced to the form.

 σ = ε f (t) (4)

This equation is the basis of linear viscoelasticity and indicates the stress will be directly proportional to the strain.

Polymers are molecular materials and are generally non crystalline solids at ordinary temperature. When shaping is carried out it pass through a viscous stage in course of their formation. Polymers exhibit viscoelastic behaviour that they respond to an applied stress by both recoverable and time dependent permanent de formations. Using combinations of macroscopic models, the entire spectrum from the purely elastic to fully viscous behaviour of polymers can be described. Polymers being viscoelastic exhibit deformation which are very sensitive to such as rate of extension, stress level, temperature.

1. **Results**

Temperature influences the mechanical behaviour of thermoplastic through its effect on the strength of the Vander waals bonding between the chains. At high temperature, the bonds are so weak and viscous flow occurs easily at less or no applied stress. As the temperature decreases, viscoelastic behaviour becomes pronounced as the strong bonds form chain sliding more difficult and complex materials. 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 polymer is usefulness and the polymer can be formed into a useful shape at the upper temperature.

1. **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.

**6. References**

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