**VISCOELASTIC BEHAVIOUR OF POLYMERS**

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 **ABSTRACT**

Polymeric materials exhibit mechanical properties which come somewhere between these two ideal cases and hence they are termed as viscoelastic. In a viscoelastic material the stress is a function of strain and time. The most characteristic features of viscoelastic materials are that they exhibit a time dependent strain response to a constant stress and a time dependent stress response to a constant strain. In addition when the applied stress is removed the materials have the ability to recover slowly over a period of time. These effects can also be observed in metals but the difference is that in plastics they occur at room temperature whereas in metals they only occur at very high temperatures.

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

1. **Introduction**

The photo-plastic method using transparent polymers is a very reliable method to simulate the elasto-plastic behaviour of prototype materials [1].The optical and mechanical behaviour of polymer depends basically on their viscous character. Photo-plasticity is one of the experimental methods to determine stress and strain distribution in plastically deformed materials, where transparent birefringence polymers are used which exhibit a similar stress- strain behaviour to the objective material. 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 the entire history of loading. This means that each step is an independent 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 important 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 (Hookean) material the stress σ is directly proportional to the strain ε and the relationship may be written for uniaxial stress and strain as

 σ = constant$×$ε (1)

Where the constant is referred to as the modulus of the material.

In a perfectly viscous (Newtonian) fluid the shear stress τ is directly proportional to the rate of strain $\dot{γ}$ and the relationship may be written as

 τ = constant $×\dot{γ}$ (2)

Where the constant in this case is referred to as the viscosity of the fluid.

Polymeric materials exhibit mechanical properties which come somewhere between these two ideal cases and hence they are termed as viscoelastic. In a viscoelastic material 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 but as simple analysis it is often reduced to the form.

 σ = ε f (t) (4)

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

The most characteristic features of viscoelastic materials are that they exhibit a time dependent strain response to a constant stress (creep) and a time dependent stress response to a constant strain (relaxation). When the applied stress is removed the materials have the ability to recover slowly over a period of time. These effects can also be observed in metals but the difference is that in plastics they occur at room temperature whereas in metals they only occur at very high temperatures. Polymers being viscoelastic exhibit deformation which are very sensitive to such things 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 very weak and viscous flow occurs easily at little or no applied stress. As the temperature decreases, viscoelastic behaviour becomes pronounced as the stronger bonds make chain sliding more difficult and complex. At very low temperatures, the polymers may be so viscous that no chain sliding occurs and the polymers behave as rigid [3,4,5].

At very high temperatures the covalent bonds between the atoms in the linear chain may be destroyed and the polymer burns or chars. This degradation temperature limits the usefulness of the polymer and represents the upper temperature at which the polymer can be formed into a useful shape.

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.

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