NOTES

Inverse Creep

Polymer substances exhibit phenomena like creep and stress relaxation. These are time dependent and result from the molecular movement or flow in the polymeric substances. It is now generally accepted that polymeric substances are made up of long chain molecules arranged in crystalline, semicrystalline, and amorphous phases. A single molecule may pass through a large number of such zones. A long polymer molecule can be considered as made up of small segments joined together. Each segment may be a few monomer units long and may be called an element. These elements continue to change positions at normal temperature relative to their surroundings due to thermal motion. These changes are normally small and few, and are unnoticeable, but when the substance is subjected to external stress, the flow of such small elements increases considerably, leading to the occurrence of large strains. This flow is associated with deformation. Therefore, the resulting strain or stress is time dependent and is fast in the beginning and slows down over a period of time. The entire process at the molecular level is highly complex and depends on the polymeric material, the type of stress applied, the constraints imposed, the surrounding temperature, etc.

Under a constant stress, deformation in a polymeric substance increases with time, the phenomenon being known as creep. When stress is completely removed, there is immediate partial recovery of the deformation. This is followed by a delayed recovery, known as creep recovery. Similarly, when a stressed polymer is constrained at a constant strain, the stress in it decreases with time, the phenomenon known as stress relaxation. Creep, creep recovery, and stress relaxation have been studied in a large number of substances by earlier research workers. Some studies have been carried out on inverse relaxation, a recently observed phenomenon, at our Institute and elsewhere.[1-8] But no work seems to have been carried out on inverse creep.

Inverse creep is a phenomenon found to occur in a polymer when the applied stress is partially reduced. In this condition, the strain in the substance goes on reducing continuously with time, in spite of the fact that the substance is still under stress. This phenomenon is a corollary of inverse relaxation and appears to depend on the stress history of the substance.

A nylon filament (156 denier) was used in the experiment. The cross section of the filament was circular and of radius 70 μm. By using a simple loading arrangement comprised of a pan hung from the free end of the filament, a stress of 7.14×10^3 N/cm^2 was applied on the filament. The immediate extension was noted and creep over a period of 100 s was measured. The stress on the specimen was then reduced abruptly to 3.95×10^3 N/cm^2 by removing a weight from the pan. Change in extension immediately after the stress was reduced and then over a period of 200 s was noted. The stress was further reduced to 0.76×10^3 N/cm^2 and immediate change in extension followed by time dependent extension measurement over a period of 200 s was carried out. Change in extension for the entire experiment with respect to time is shown in the Figure 1.

As can be seen from Figure 1, there is immediate extension OA in the filament followed by creep along the curve AB when a stress of 7.14×10^3 N/cm^2 is applied to it. There is immediate contraction in the filament from point B to point C as the stress is reduced to 3.95×10^3 N/cm^2, followed by further reduction in strain (curve CD) over the time period the phenomenon was studied. Similarly, at 0.76×10^3 N/cm^2 stress, the length of the filament reduced from D to E, followed by further reduction in strain with time (curve EF). This shows that the specimen had contracted even when it was under stress. The curves CD and EF represent inverse creep. In fact, it has been observed that when the reduction of the stress is very small, the substance continues to creep. With a little more reduction in stress, there is almost no creep or inverse creep. As more and more stress reduction takes place, the inverse creep sets in and it goes on increasing. Creep recovery can be considered as a special case of inverse creep when the stress has been completely removed.

This phenomenon of inverse creep has been observed in the Institute for a number of other textile materials, which are also polymeric in nature, like polyester, viscose, cotton, wool, etc. A detailed study of the phenomenon is under way and the results will be published in due course.

Journal of Applied Polymer Science, Vol. 53, 1123–1124 (1994)
 CCC 0021-8995/94/081123-02

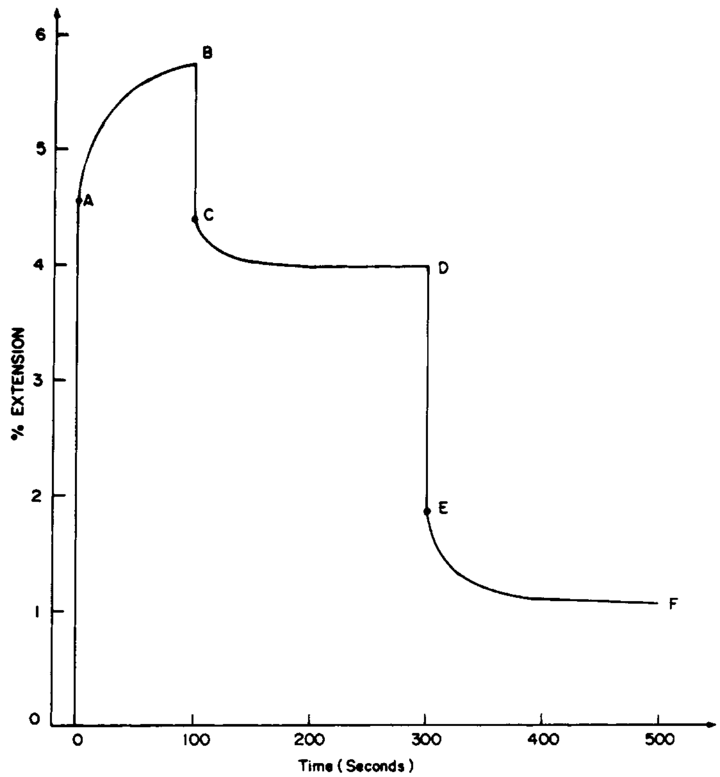

Figure 1 Extension vs. time curve for nylon monofilament in an inverse creep experiment. OAB corresponds to extension-time curve when a stress of 7.14×10^3 N/cm^2 was applied at point 0. BCD and DEF represent extension-time curves when the stress was reduced to 3.95×10^3 N/cm^2 at point B and to 0.76×10^3 N/cm^2 at point D, respectively.

The author wishes to thank Dr. K. R. K. Iyer, Head, Physics Division, for encouragement and Dr. N. B. Patil, Director, CIRCOT, for permission to publish this article.

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Received January 19, 1994
Accepted January 27, 1994