Creep Measurements Using Dynamic Mechanical Analysis

Materials under constant load will move or deform slowly over periods of time. This property is known as creep. A function of applied load, time, temperature, and intrinsic properties, creep can occur at stress loads that are below a materials' yield strength. Creep analysis is very prominent in applications that involve a constant load at high temperatures such as boilers, jet engines, and gas turbines. Even at lower temperatures, materials under extreme load or under load for long periods of time such as beams on bridges, cement pillars, or other structural materials, creep analysis is very important.

Creep occurs in three stages: primary, secondary, and tertiary. Primary creep occurs at the beginning of the tests and does not occur at a steady rate. Creep of the material is resisted until the second stage. The creep becomes constant during the secondary creep stage and is referred to as steady state creep. In tertiary creep, the creep rate starts to increase as the cross sectional area of the specimen decreases due to necking of the specimen. The material may remain in the elastic region and fully recover or creep all the way until failure. The creep of a material is affected by temperature and is typically much more severe near the glass transition and melting temperatures.

To illustrate creep properties of a material, Ebatco's NAT Lab tested a coupon of polycarbonate (PC) as a function of temperature as seen in Figure 1. The glass transition temperature (T_g) of PC is about 147 ˚C. As the temperature neared the T_g, the creep of the material increased significantly showing how temperature is a major factor in creep. Increasing the applied load and loading time will also increase the total amount of creep. The first stage of creep occurs when the load is initially applied and is seen as a sharp increase in the creep compliance. After the initial deflection the creep increases steadily until the load is removed and the next temperature is approached. The PC never reaches the third stage of creep as the testing was not long enough to achieve mechanical failure.

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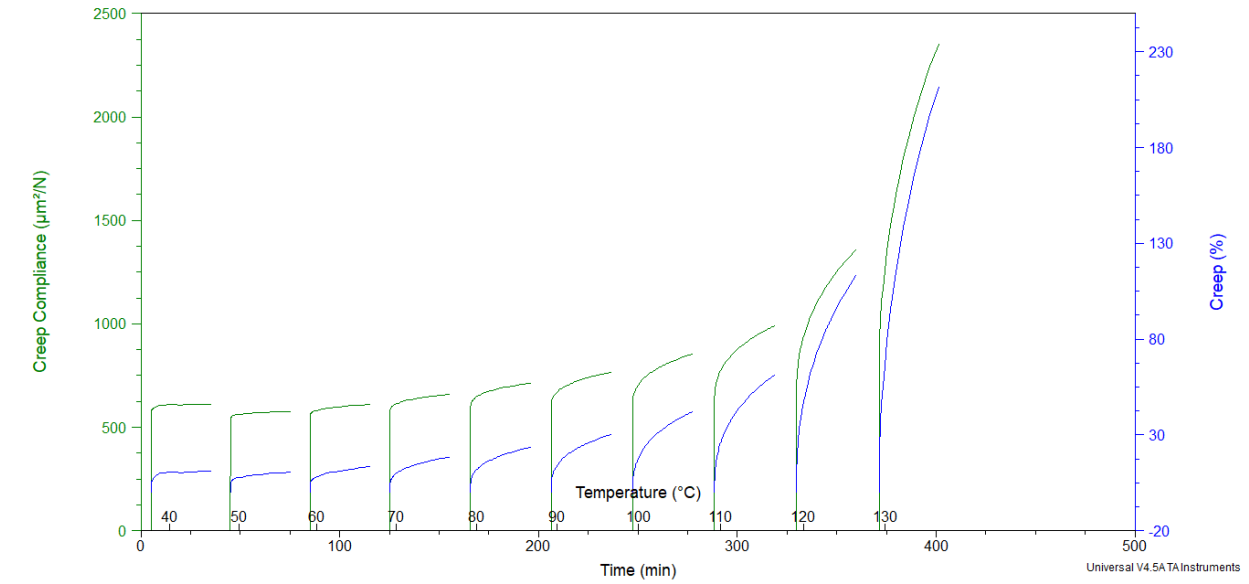

Figure 1. Dynamic mechanical analysis of the creep of a polycarbonate coupon as a function of temperature.

To summarize, creep is a very important mechanical property of materials that are under a constant load, especially when elevated temperatures are involved. Over long periods of time materials can fail if the creep becomes too large. Polymers and metals will generally have much higher creep than ceramics as ceramics are brittle and thermally resistant. Analyzing materials for their creep properties can help prevent long term and elevated temperature failures.