THE CLOSED FORM TIME-TEMPERATURE-PRESSURE SHIFTING ALGORITHM

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Time-dependent material functions of engineering plastics within the exploitation range of temperatures extend over several decades of time. For this reason material characterization is carried out at different temperatures and/or pressures within a certain time interval, commonly called as "experimental window", which for practical reasons extends typically over four decades of time [1]. For example, when relaxation experiments in shear, are performed at different constant temperatures, and/or different constant pressures, a set of $G(t,T,P)$ segments is obtained. Using the time-temperature ($t-T$) and/or time-pressure ($t-P$) superposition principle (if applicable), these segments can be shifted along the logarithmic time-scale to obtain a master curve at a selected reference conditions, T_0 and P_0 [2].

This shifting is commonly performed manually ("by hand"), and requires some experience. Unfortunately, manual shifting is not based on a commonly agreed mathematical procedure which would, for a given set of experimental data, yield always exactly the same master curve, independently of a person who executes the shifting process. Along with "hand shifting" there are different numerical procedures for calculation of shift factors. Practically, all of these methods include, as a preliminary step, fitting of the experimentally obtained segments. However, the approximating procedure by itself is not universal. The authors suggest variety of the interpolation functions starting from a simple linear fitting and finishing with multi parameter complex expressions.

Thus, starting from the same set of experimental data two different researchers could, and very likely will, construct two different master curves. The shifting procedure is therefore one of the weakest points in the utilization of the time-temperature, or equivalently time-pressure superposition principle.

Based on these considerations we have derived a closed form mathematical methodology (CFS) for calculation of time-temperature, or equivalently, time-pressure shift factors [3]. The CFS algorithm determines unique master curve and completely removes ambiguity related to different shifting procedures.

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2. Ferry, J.D., "Viscoelastic Properties of Polymers", 3rd edition, John Wiley & Sons, New York (1980).
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