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Computational Model for Predicting Polymer Degradation and Accelerated Aging

Strategic, infrastructural and engineering installations are often in environments that are exposed to extreme weather conditions and are designed to function with little or no maintenance. With the advent of engineered materials, polymers are increasingly used in all such installations, including as replacement for metals. However, polymers exposed to varying and extreme temperatures can degrade chemically over time. To study the degradation simulated tests are carried out in labs but is very difficult to imitate and maintain the exact environmental conditions for a longer duration, which in turn makes it challenging to collect good, reliable, and quality data. In this research the noise reduction technique on sample data to enhance the time-temperature superposition technique is used. The principle of time-temperature superposition (TTS) states that the viscoelastic behavior of a material at a given temperature can be predicted by measuring its behavior at a different temperature and scaling the time axis by a factor known as a shift factor. The aging behavior of polymers can be predicted using time-temperature superposition master-curves, which account for the effect of temperature on the viscoelastic properties of the polymer. The specific polymer used within this project is Ethylene Propylene Diene Monomer, which is better known as EPDM. Three key prevalent techniques in this research are the Isothermal, Isostress, and stepped methods. The initial approach is to use the Isothermal method which predicts long-term creep behavior, by loading a single specimen under a constant load, while increasing temperature in a stepwise manner until failure. To construct these master-curves, horizontal and vertical shift factors are calculated to superimpose viscoelastic data taken at different temperatures onto a reference temperature curve. A well-known geometric algorithm, based on minimizing the arclength between two data points, is utilized to determine the shift factors, though it struggles with noisy data. The shift factors used are decided based on the testing methods/law used i.e. Arrhenius, Eyring, or William-Landel-Ferry would serve as shift factors. The developed computational model for accelerated aging procedure, using machine learning techniques, will greatly improve material degradation predictions. This research aims to enhance this geometric algorithm by implementing noise reduction techniques.

*Keywords: accelerated aging, time temperature superposition, shift factor, viscoelastic, EPDM

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