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Temperature Variation of Rubber under Uniaxial Cyclic Tension

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Abstract

Thermal response of rubber materials under mechanical loading has special properties that needs to be researched carefully. However, most of existing researches remain as qualitative discussions and its quantitative evaluations are not studied very well. The main objective of this study is to quantitatively clarify the relationship between temperature variation and cyclic deformation behavior of carbon black filled styrene-butadiene rubber (SBR). The specimen is subjected to uniaxial cyclic tension at various loading conditions. Temperature variation on the gauge zone surface of the specimen is captured by infrared camera. In addition to the experiment, the temperature variation of the specimen is predicted theoretically. This prediction is divided into two parts, namely mechanical and thermal parts. The former is to identify the stress-strain model to describe the mechanical behavior. A three-elements model with two rubber elastic elements with considering the Mullins effect and a linear viscous element is employed. The material parameters are determined according to the experimental data at each loading condition. The thermal part predicts the temperature variation by considering three factors: thermoelastic effect, Gough-Joule effect and viscous dissipation effect. The temperature amplitude and the phase difference between temperature and strain are calculated. The predicted results are compared with the experimental results. It is found that the predicted temperature amplitude is in good agreement with ones obtained by the infrared camera. Furthermore, it is shown that the phase difference between temperature and strain is about 180° at the small deformation area while it is about 0° at large deformation area. Moreover, there exists a phase transition area between these two areas.