Temperature effects on the fatigue lifetime reinforcement under non-relaxing torsion and comparison with non-relaxing tension loading

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Abstract. Carbon Black filled Natural Rubber (CB-NR) is the most commonly used crystallizable elastomer for antivibratory applications thanks to its outstanding fatigue resistance. Strain-induced crystallization (SIC) is generally considered as responsible for this fatigue resistance, typically the lifetime reinforcement observed under non-relaxing uniaxial tension as soon as 1940 in [1]. SIC is a thermosensitive phenomenon, it is less active when the temperature increases [2]. Therefore, the lifetime reinforcement at high temperature was recently addressed by [3] under non-relaxing uniaxial tension. At 90°C, the fatigue lifetime reinforcement is still present, and lower than at 23°C. This reinforcement and its intensity at high temperature and under other conditions of loading has been rarely investigated [4]. More particularly, this reinforcement at high temperature under non-relaxing torsion, *i.e.* the minimum loadings are due to pure torsion, has not been explored yet in the literature. The present work aims to fully address the effect of temperature on the long-term mechanical behaviour, and the lifetime reinforcement under non-relaxing torsion at 90°C. For that purpose, pure torsion fatigue tests with different loading ratios have been carried out with axisymmetric-shaped specimens at 90°C. Finite element analysis is used to predict the mechanical state at any point of the specimen by taking into account the heterogenous accommodation. Increasing the temperature induces an effect on the stabilized behaviour commonly observed at ambient temperature: the mechanical behaviour is no longer stabilized, and neither the loading ratio. The Haigh diagram at high temperature under torsion is built by calculating equivalent loading ratios considered as representative of the loading ratio during the entire fatigue life. These equivalent loading ratios are used to estimate the minimum loading in terms of Cauchy stress as the normal to the crack plane for the minimum angle applied. Similarly to [3] under non-relaxing tension, a lifetime reinforcement is still observed under non-relaxing torsion loading at 90°C, but lower than at 23°C. It is found that the lifetime reinforcement under non-relaxing torsion is of the same intensity to the one obtained under uniaxial tension at the same temperature. Post-mortem analysis carried out at both the macroscopic and the microscopic scales enabled to investigate damage mechanisms.

References

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