Rubber-like material's behavior law for fatigue analysis by self-heating approach

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1 Presentation of the context

The present work is dedicated to one of the sector market of Trelleborg Boot : the constant velocity joint (CVJ see figure 1) boots. During their life, this type of joints is subjected to severe constraints such as wide temperature range, self-contact, friction between coils, grease. In order to increase their lifespan, Trelleborg Boot is investigating a new material and particularly a thermoplastic copolyester (TPE-E).

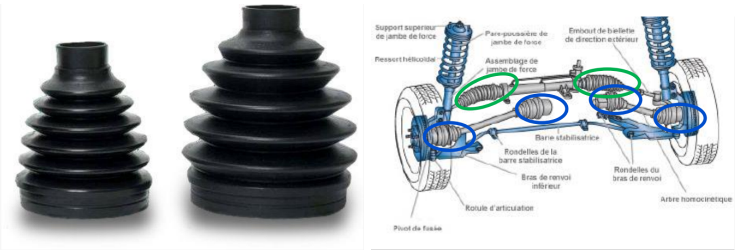

FIGURE 1 – constant velocity joint (CVJ) boots

The goal of our research is to find a fatigue criterion as well for the constitutive material as for the structure under different loading paths. The research works are split into 2 main steps : the first one corresponds to the writing of a behavior law adapted for this new material, and the second one consists to mix the previous behavior law with fatigue testing. The identification of fatigue criterion will be done using both Wöhler curves and self-heating tests. Indeed, for metallic materials, some previous research works demonstrate an equivalence between the fatigue limit coming from the self-heating tests and the Wöhler curves ([1]). Same conclusions have been noticed by other authors working on thermoplastic composite materials [2]. Whatever the case of study, the main advantage of this methodology is its low time cost. That are some reasons why we are convinced of the benefits brought by the self-heating tests for our material and problem.
In this paper, we focus only on the first step : the behavior law formulation for thermoplastic copolyester. We also suggest some results including the influence of the grease on the mechanical behavior as well as some thermomechanic studies.

2 Thermomecanical behavior law

The thermoplastic copolyester exhibits some mechanical properties similar to the rubbers which includes large deformations, viscoelasticity, incompressibility... (figure 2). However, the experimental campaign that we carried out on the material also shows that viscoplasticity must be taken into account. Based on a multiplicative decomposition of the deformation gradient tensor F, the behavior law is inspired by the Bergström-Boyce Model [4]. In order to find an equilibrium between research and industry expectation, the thermodynamical formalism will be the same as in S. Méo and S. Lejeunes works' [5][6]. We upgrade the previous model by introducing an approach for crystalline polymer. This implementation leads to the visco-hyperelastic part of the behavior law. Concerning the hyperelastic and damage parts, the model is inspired by the GDM model [7]. Finally, the viscoplastic part is based on the work done by A.V. Shutov [8]. The whole model is formulated in lagrangian formulation. All the implementation of this model has been done at the integration point in Matlab.

FIGURE 2 – tensile curve with loading/unloading

3 Conclusion and future prospects

The developed model is now used to identify the influence of the grease on the mechanical behavior of thermoplastic copolyester. Some experiments are in progress relative to initial and aged material (in the grease at 100 °C. for one week) The first main conclusions are that the grease does not change the whole behavior of the material but more affects its mechanical properties. The thermomechanical experiments are in progress and will complete the work. Once the behavior law validated, our next work will be to study as well Wölher curve and self heating methods for our material in order to identify the fatigue criterion.

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