EXPERIMENTS AND MODELING OF NATURAL AGING IN ZAMAK ALLOYS

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Zinc die casting alloys are widely used in the production of components of cars and machines. Because of their low melting point and their ability to produce very accurate components, these alloys are considered to be the best castable of all commonly used alloys. This advantage is accompanied by a pronounced rate dependence, temperature dependence and aging [4].

Aging denotes the development of the material properties and the mechanical response due to microstructural changes over the course of time. These changes are associated with precipitation of alloying elements or phases with low solubility, phase decomposition, and changes in the crytallographic structure [5]. These microstructural changes influence the mechanical response of the material [3].

1. Experimental investigation

In order to characterize the temperature-dependent aging behavior, the experiments of [4] were extended to three additional aging times. In this previous work, tension, compression and torsion experiments with thin-walled tubes were carried out at different temperatures and strain rates. As exposed in [1] and [2], torsion tests in thin-walled cylinders offer the advantage of isolating the deviatoric behavior of the material, which simplifies the identification process.

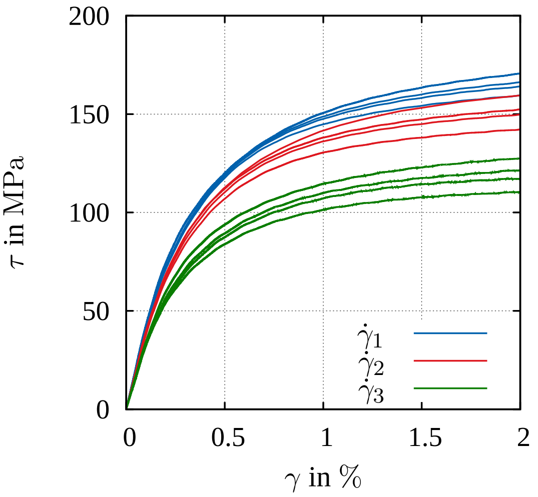

Figure 1: Torsion tests at a constant temperature of 20 °C for three different strain rates (different colors) and for every strain rate, four aging times. Higher aging times show a decreasing stress-strain curve at the same strain rate.

Moreover, other aging-dependent thermal properties such as the thermal conductivity and the shrinkage, were also experimentally characterized.

2 . Modeling and identification

The modeling and identification steps are closely connected to each other, since the temperature and aging-dependent parameters are developed after some previous pre-identification steps. The constitutive model has a partitioned structure, in which the total stress is decomposed into an equilibrium and an overstress part

$$\mathbf{T} = \mathbf{T}_{\text{eq}} + \mathbf{T}_{\text{ov}}. \tag{1}$$

This decomposition of the total stress has also advantages in the identification step, since the parameters of the equilibrium stress can be identified independently of the other parameters with the help of the equilibrium hysteresis.

The aging is modeled with the help of an internal variable g

$$\dot{g} = f(\Theta, g). \tag{2}$$

This variable has a positive, growing value between 0 and 1. The value 0 corresponds to the initial, unaged stage and 1 to the completely aged stage. The aging rate is defined temperature-dependent in a way that higher temperatures result in a faster aging process. The influence of the aging in the model is introduced with the selection of aging-dependent parameters. Finally, the thermodynamical consistency of the model is ensured with the selection of the free energy.

3 . Implementation of the model

The model is implemented in the in-house FE-code TASAFEM. In the case of small deformations, the internal variables of the model can be computed directly from the input variables of the stress algorithm, which means that in this model a local Newton-iteration is not necessary. This leads to shorter computation times.

4 . Simulation example

The behavior of the model is shown with a simulation example using the finite element code TASAFEM.

Acknowledgments We would like to thank the German Research Foundation DFG for funding this research project with the project no. DFG HA2024-18/1.

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