Time-multi-scale parameter identification of models describing material fatigue

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When dealing with the numerical prediction of material fatigue, classical life estimation methods, such as those described in [1], can give poor results as far as one is interested with complex loading histories (such as a loading with a slow-evolving average) or inertia effects (for high frequency loadings). It seems indeed more relevant for such cases to use time-transient models describing how internal variables, such as plastic strain, or isotropic damage, change with respect to time. However, the computational cost associated with such simulations can become prohibitive if each individual cycle has to be computed.

Therefore a specific method is proposed here to drop the calculation cost by factors up to several thousands: it relies on periodic time homogenization, which is similar to what is usually developed in space homogenization. Moreover, the method is based on a sound mathematical framework, which can guarantee the accuracy of the derived equations and solutions. A first formulation of this method has been proposed in [2]: it is based on the assumption that two different time scales (a fast one, associated with the fast cycles, and a slow one) can be defined and decoupled. Using asymptotic expansions of the scale ratio, it then allows to solve the different equations at the slow time scale only, by taking into account the averaged effect of the fast cycles in the homogenized solution. Since this reference, several extensions have been studied, such as the dynamic framework [3] or how to describe an isotropic damage evolution [4,5].

Moreover, in order to get accurate predictions of fatigue life, it is possible to address the parameter identification process for such time-homogenized problems. This latter is solved by minimizing a misfit function defined as a norm quantifying the discrepancy between the available measurements and the associated quantities derived from the model, as in [6]. Work is in progress to address the main questions arising when one tries to use in the identification process the time-homogenized model rather than the reference problem.

Eventually, this should lead to a suitable strategy for addressing accurate fatigue predictions and associated parameter identification for arbitrary cases of study, whereas the computational cost remains affordable.

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