A LATIN-PGD model reduction approach for the simulation of fatigue damage

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ABSTRACT

The simulation of mechanical response of structures subjected to cyclic loadings for a large number of cycles remains a challenge. The goal herein is to develop an innovative computational scheme for fatigue computations involving non-linear mechanical behaviour of materials, described by internal variables. The failure in such cases is quantified by the decrease in the load carrying capacity of structures which is indicated by the loss of stiffness and described by the growth of damage. Direct time incremental techniques may lead to high CPU cost and there is need for alternative approaches. In this work, the focus is on the Large Time Increment (LATIN) method, a non-incremental iterative scheme that allows to build approximations of the solution over the whole time-space domain [1]. This method permits to introduce a Proper Generalized Decomposition (PGD) model reduction technique which leads to a drastic reduction of the computational cost, very suitable for the simulation of large numbers of cycles.

The proposed framework is exemplified for a structure subjected to cyclic loading, where damage is considered to be isotropic and micro-defect closure effects are taken into account. A difficulty herein for the use of the LATIN method comes from the state laws which cannot be transformed into linear relations through an internal variable transformation [2]. A specific treatment of this issue is then introduced in this work.

Concerning the PGD model reduction, a multi-time scale approach is thereby proposed for the simulation of fatigue involving large number of cycles. This approach takes into account the slow evolutions of the quantities of interest along the cycles and their fast evolution within each cycle. The quantities of interest are calculated only at particular pre-defined cycles called the “nodal cycles” and a suitable interpolation is used to estimate their evolution at the intermediate cycles [3].

The combination of these techniques reduces the numerical cost drastically and seems promising in tackling cyclic loadings for a large number of cycles. An illustration of the proposed method and its critical analysis will be demonstrated.

REFERENCES

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