Development of a time basis from Fast Fourier Transform and PGD modes to predict the behavior of polymer under cyclic loading

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ABSTRACT

To determine fatigue criteria for viscous polymers, a large number of cycles has to be simulated to reach the accommodated cycle. In fact, the thermoviscoelastic behavior of such material has to be taken into account to accurately predict this stabilized cycle. This subject has already been studied within the Finite Element framework [1]. A very large computation time or a non convergence due to the different time scales have been noticed. To circumvent this difficulty, we here propose to combine the use of the Fast Fourier Transform and the Proper Generalized Decomposition (PGD) method [2] to determine an a priori reduced time basis.
In this paper, the approach is implemented in a more simple case where we only consider a 3D thermal problem under cyclic temperature. Nevertheless, this equation allows to deal with two different times: one linked to the characteristic time of the thermal problem called physical time and one linked to the cycle time called loading time. The PGD method is used to compute the solution of such a problem. The time modes are then studied within the Fast Fourier Transform. The variable parameters of the simulations are : the characteristic time, the time cycle and the amplitude of the cyclic loading. Based on this study, we are able to get a relationship between the time modes, the cycle time, the amplitude and the relaxation time.The PGD simulation is then computed by considering an a priori time basis. The efficiency of such an approach has to be tested within the Finite Element framework before investigating the strongly coupled behavior.

Key words: Proper generalized decomposition; Fast fourier transform; Thermoviscoelasticity; Model reduction

REFERENCES

[1] Song Thanh Thao Nguyen and Sylvie Castagnet and Jean-Claude Grandidier *Nonlinear viscoelastic contribution to the cyclic accommodation of high density polyethylene in tension: Experiments and modeling* . International Journal of Fatigue 55:166-177, 2013.

[2] Chinesta F, Keunings R, Leygue A *The Proper Generalized Decomposition for Advanced Numerical Simulations.* A primer, Springer, 2014.