A progressive damage fatigue model for unidirectional laminated composites based on Finite Element Analysis: Theory and Practice

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ABSTRACT.
The fatigue damage of laminated composites under multi-axial and variable amplitude loadings has to deal with several new challenges and damage modelling compared to the well-known models for metal fatigue. In this paper we present how to account for variable amplitude and multi-axial loading by using the damage hysteresis operator approach for fatigue. That approach was developed to be used in industrial context by Siemens together with the University of Ljubljana for efficiently handle thermal fatigue influences in metal fatigue.
It is now applied to a fatigue model for intra-laminar damage based on stiffness degradation laws combined with the 'damage' cycle jump approach from Van Paepegem and has been extended to deal with unidirectional carbon fibres.
The parameter identification method is presented here and parameter sensitivities are discussed. The initial static damage of the material is accounted for by using the Ladevèze damage model and the permanent shear strain accumulation based on Van Paepegem's formulation.
This approach is implemented into commercial software (Siemens PLM). This intra-laminar fatigue damage model combined efficient methods with a low number of tests to identify the parameters of the stiffness degradation law, this overall procedure for fatigue life prediction is demonstrated to be cost efficient at industrial level.
This work concludes with the outlook on how to apply this model also to fatigue effects in the inter-laminar behaviour, which can lead to delamination.