CHARACTERISATION AND MODELLING OF THE MEAN STRESS EFFECT ON TEXTILE-REINFORCED COMPOSITES UNDER TENSION-COMPRESSION FATIGUE LOADING

M. Gude, W. Hufenbach, I. Koch and R. Protz
Institut für Leichtbau und Kunststofftechnik - ILK
Technische Universität Dresden
Holbeinstr. 3, 01307 Dresden, Germany
e-mail: maik.gude@ilk.mw.tu-dresden.de, web page : http://www.ilk.mw.tu-dresden.de

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Summary. The fatigue behaviour of 3D textile-reinforced composites has been characterised focussing on the effect of different stress ratios for tension-compression loadings. With the help of textile reinforced tube specimens and accompanying damage characterisation techniques, such as strain measurement and video observation with high speed cameras, the damage mechanisms have been monitored. Furthermore, a failure mode related model for the constant life diagram has been developed.

1 INTRODUCTION

3D textile-reinforced epoxy with multi-layered weft knit fabric reinforcement (GF-MLG/EP) characterised by a non-crimp arrangement of weft and warp fibres, which are fixed by a glass knit thread – show a high specific stiffness and strength. For the development of durability models there is, however, a lack of well-founded knowledge of the fatigue degradation behaviour.

Many investigators have already studied the influence of mean stress on the fatigue life of general composites (see, e.g. [1-4]). The influence of mean stress can be quantified in constant life diagrams (CLD). Usually, composites show a significant difference between tensile and compressive strengths, so that the CLD diagram is unbalanced about the alternating stress axis. Furthermore, the peaks of the constant life lines are shifted to the direction of the critical stress ratio. Several modelling approaches take these basic findings into account and may therefore be used for the description of the mean stress effect of 3D textile-reinforced composites.

2 EXPERIMENTAL PROCEDURE AND MODELLING APPROACH

The experimental and theoretical investigations of this study aim at the characterisation of the mean stress effect at tension-compression loading of GF-MLG/EP. The fatigue strength tests under uniaxial loading conditions are carried out on textile-reinforced tube specimens on a servo-hydraulic tension-compression test machine. The determined fatigue strength values under four different stress ratios are used to evaluate an extended Goodman approach [5], the anisomorphic concept by Kawai [1] and the bell shaped constant life curves proposed by Harris et al [2]. Furthermore, the dynamic stiffness values and the damage evolution and
propagation are used to quantify the unbalance of tension and compression stiffness of the damaged textile-reinforced composites.

3 RESULTS

Firstly the Goodman approach and the anisomorphic concept have been used to predict the constant life curves based on the static strength data and the fatigue strength on the critical stress ratio. According to Figure 1 (left) the fatigue life is insufficiently described by these approaches especially in the area of tension dominated stress ratios.

Using the bell shaped constant life diagram proposed by Harris et al, which is determined using the additional fatigue strength data of the stress rations $R = 10$ and $R = 0.1$, a better prediction is achieved, although the fatigue life at $R = -1$ is still over estimated. To overcome these difficulties the different failure modes under tension dominated and compression dominated fatigue loading have to be considered by a model with an intrinsic unbalance to the critical stress ratio. Therefore a new approach is proposed using the same experimental input information and by stressing an additional transition condition between two separated Harris like approaches at the critical stress ratio. A significantly better fatigue strength prediction has been achieved with this failure mode related CLD (Figure 1 (right)).

REFERENCES