Ductile-brittle fatigue fracture of Aluminium/PMMA bi-material components

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Abstract

Results are shown from a numerical and experimental ongoing project to investigate the fatigue cracking of bonded bi-material which consists of ductile (aluminium alloy 2024) and brittle (PMMA) components. Precracked bi-material specimens were fatigue tested to failure under 3 point bending constant amplitude cyclic tension load. A cracking path at normal to the interface plane was used and includes a transitional phase where cracks 'jump' the bonded interface between the two materials (insert Figure 1). Cracking behaviour was simulated numerically by using a versatile programme based on the Body Force Method (BFM) theory. The simulated monotonic and cyclic stress intensity factors (SIFS) are shown in Figure 2. These SIFS were used for the experimental fatigue crack growth rate vs. Δk diagram and also to compare the bi-material results with the generic homogeneous materials fracture.

Fatigue results in Figure 1 indicate that in the case of the initial crack in the al 2024 material, the fatigue crack growth rate is higher than that for the generic al 2024 material and lower than that for the PMMA. These experimental results are in agreement with the analytical BFM simulation in Figure 2 where lower SIFS values for particular cracks were obtained in the case of cracking from the aluminium side.

The simulation also shows that for monotonic loading, in the case of the PMMA(upper)/Al(lower) specimen the SIF is much larger than for the homogeneous PMMA specimen while, cracks remain inside the Al 2024. For Al 2024 (upper)/PMMA(lower) specimen, the opposite relation can be seen in Figure 2. The SIF is not a continuous function at the bi-material interface for PMMA/Al specimen while it seemed to be a continuous function of a/2W for the Al/PMMA specimen.

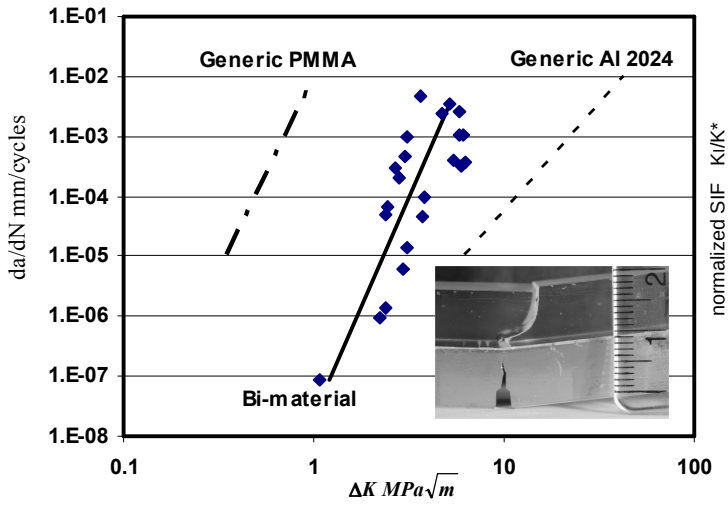

Figure 1 – Bi-material FCG results

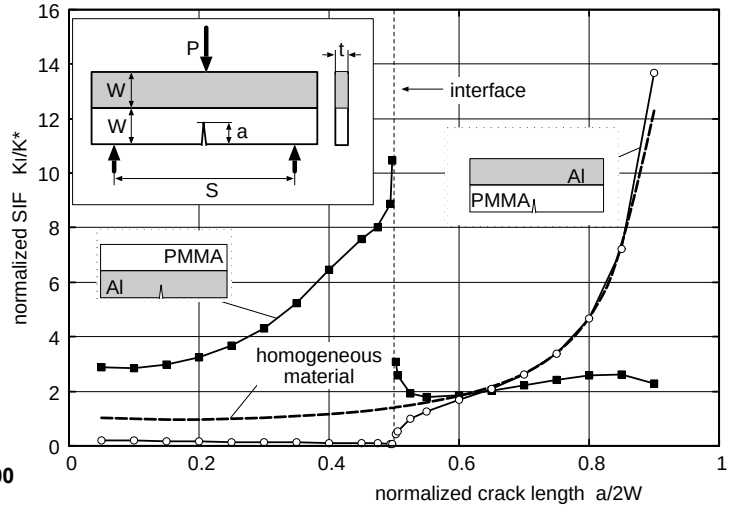

Figure 2 – BFM SIFS solutions