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Applicability of J-integral approach in determination of mixed-mode fracture energy in a ductile adhesive

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Abstract:

In this work, a J-integral-based data reduction approach was used for fracture characterisation of a ductile two-component epoxy adhesive with steel adherends under mixed-mode loading. The applied method is a closed-form relation which requires only rotation angle of the load introduction points and the applied load as input. Double Cantilever Beam (DCB) tests as well as Mixed Mode Bending (MMB) tests (with different mixed-mode ratios) were carried out to achieve a wide range of mode-mixity. Based on the measured values of fracture toughness G_c, the full fracture envelope of the adhesive was developed by using the Benzeggagh-Kenane (B-K) fracture criterion. Good agreement between the FE and experimental load-displacement curves proved that the applied method is accurately capable of determining the fracture toughness of the adhesive. The proposed approach shows high potential to account the dissipated energy in the fracture process zone in the ductile adhesives.

Keywords: Fracture toughness; Fracture mechanics; Joint design; Finite element stress analysis; J-integral; Mixed-mode

1. Introduction

The use of adhesives in lightweight structures (aerospace and automotive industry) has been remarkably increased in the recent years. Adhesively bonded joints can offer many advantages in comparison with other joining techniques. Apart from that, introducing new lightweight design concepts such as hybrid structures has also increased the attention to adhesively bonded joints. Having an accurate material model for predicting the failure of such joints eases not only the process of design concept but also improves the design quality. Within the last decades, there have been many efforts in modelling failure of adhesively bonded joints by using different methods which are well documented [1]. These studies include different variety of approaches, i.e., Continuum Mechanics [2-4], Fracture Mechanics which is based on two fracture criteria namely

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