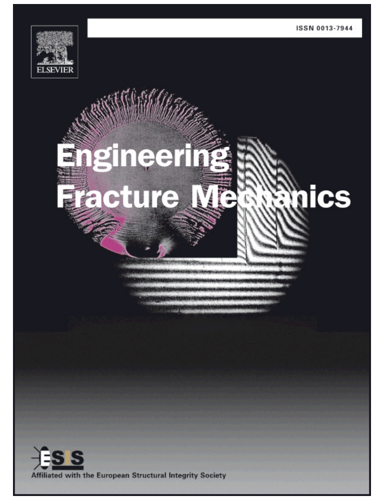

Fatigue performance and life estimation of automotive adhesive joints using a fracture mechanics approach

Qiuren Chen, Haiding Guo, Katherine Avery, Xuming Su, Hongtae Kang

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Fatigue performance and life estimation of automotive adhesive joints using a fracture mechanics approach

Qiuren Chen[a], Haiding Guo[a], Katherine Avery[b], Xuming Su[b], Hongtae Kang[c]

[a] Jiangsu Key Laboratory of Aerospace Power System, Nanjing University of Aeronautics and Astronautics, 29 Yudao St, Nanjing, Jiangsu, China

[b] Research and Innovation Center, Ford Motor Company, 2101 Village Rd, Dearborn, Michigan, USA

[c] College of Engineering and Computer Science, University of Michigan Dearborn, 4901 Evergreen Road, Dearborn, Michigan, USA

Abstract:

Practical fatigue life prediction methods using computer aided engineering (CAE) for adhesively bonded joints are needed to reduce the risk of potential fatigue failures and unnecessary over-designs for automotive body structures. This paper presents an investigation on the tensile and fatigue behaviors of adhesively bonded lap shear and coach peel joints for A5754-O. From suspended tensile tests, macroscopic cracks were found in the adhesive layer of the lap shear joints before the joints reached the peak quasi-static strengths. A fatigue life estimation approach for automotive adhesive joints was developed based on coarsely meshed finite element models and the analytical J-integral solution. This approach also includes the influence of the macroscopic cracks in the adhesive layer on the fatigue life of lap shear joints. Finally, the fatigue life estimation approach was validated with fatigue test results of U-shape specimens, and it was found that the J-integral based parameter can effectively predict the fatigue life of adhesive joints with different substrate thicknesses and various joint types.

Key words: Adhesive joint; Fatigue life prediction; J-integral;

1. Introduction

Adhesive bonding is being considered as a promising means of joining to replace traditional joining techniques such as welding and riveting. Adhesive bonding has advantages for joining lightweight materials due to its lower weight, its joining capability for different materials, and its good fatigue resistance [1, 2]. In the automotive industry, adhesive bonding is often combined with welded [3] or riveted joints [4] to reach an even higher level of performance. Adhesive joining frequently represents the most convenient and cost-effective joining technique, since the bonding process can often be easily automated [5].

Fatigue failure is one of the major considerations for automotive structure designs. Under repeated cyclic loads, a joint may fail at a small percentage of its static strength. Thus, a reliable fatigue life estimation approach for adhesively bonded joints is needed in order to reduce the risk of potential fatigue failures as well as unnecessary over-designs of the structures.

Predicting the fatigue lives of adhesive joints is challenging due to the various joint types and geometries [6]. Generally, it is preferred to design an adhesive joint geometry with minimum peel loads for the sake of strength [7]. Consequently, most research focuses on joints that mainly bear shear loads (e.g., single lap shear or double lap shear). However, in real applications of