THE EFFECT OF THE ADHESIVE THICKNESS ON THE STRENGTH OF A BONDED JOINT.

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INTRODUCTION

Adhesives have been used in structural applications for many years now. With most modern high peel strength adhesives, joint failure in metal to metal bonds will invariably occur through a cohesive failure of the adhesive. Thus it is a reasonable premise that analysis based on the material properties of the adhesive and adherend should provide a good tool for joint design.

Potentially such analysis offers a means of establishing stress levels within the adhesive, of assessing the suitability of a proposed configuration and of investigating the mechanisms governing failure of the joint. However, there are a number of restrictions and difficulties which prevent this potential being fully exploited. These difficulties are largely concerned with the complexity inherent in the analysis of a non-linear bi-material system with geometric discontinuities. There are essentially two main categories of analyses used; the closed form analysis and finite element (FE) analysis.

The problem with the closed form approach is that the assumptions that are made in order to model the joint invariably considerably restrict the range of its usefulness. This is nowhere more apparent.
than in the way that the predicted strength of a joint varies with the adhesive (layer) thickness and this will be considered in the next section.

The FE method does not suffer this restriction but does require an extensive amount of both effort and understanding to implement. There are however software packages available now that considerably reduce the effort and this technique has been the principal tool in this work. Currently one of the major difficulties with the FE approach is to apply the results to give predictions of joint strengths. This has been done through the use of appropriate adhesive failure criteria. However most of this work has been carried out with the joints having a single adhesive thickness. There is good reason to believe, as will be shown later, that if applied to other adhesive thicknesses, these failure criteria would not be so successful.

The purpose of this work was to investigate how the adhesive thickness effects the strength of a lap joint. This was achieved through programmes of test and non-linear analyses of lap joints. The results from the analyses have illustrated how failure occurs in the joint and how this failure is effected by the adhesive thickness. This in turn has led to the development of a new failure criteria for bonded joints.

BACKGROUND

In the previous section it was stated that the closed form approach of analysis was not capable of assessing the effect of adhesive thickness on the strength of a joint. Fig 1 based on a closed form analysis of a single lap joint [1] at a load of 400 Nmm\(^{-1}\) shows that the stress levels increase with decreasing adhesive thickness and, in the absence of any further information, this clearly implies that the joint strength should decrease with decreasing adhesive thickness. In practice this seldom occurs as will be evident from the experimental work reported later. This thickness dependency is not peculiar to the particular analysis cited. Other analyses of this and other joint configurations exhibit similar characteristics.