CRACK GROWTH INITIATION IN DUPLEX ELASTIC-PLASTIC PLATES

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INTRODUCTION

The problem of crack growth in a duplex plate with a crack perpendicular to the interface of its two section has been studied by Dally and Kobayachi (1) and Gdoutos (2). In a series of recent publications (3,4) the strain energy density criterion was used to study the problem of crack growth in ductile materials.

In the present work the problem of initiation of crack growth in a duplex specimen consisting of a sheet of thickness t_1 made of aluminum alloy, and containing of crack of length 2a, joined along a straight line to another sheet of thickness t_2 made of steel has been studied. The geometry of the plate and the true stress-strain diagrams of the two materials are shown in Figures 1 and 2 respectively. The composite plate is loaded by a uniform uniaxial tensile stress perpendicular to the crack line. For the study of dependence of crack initiation on the stiffness of the uncracked sheet a series of alluminum sheets of various thicknesses were considered.

CRACK GROWTH INITIATION

The stress and the deformation fields of the cracked duplex plate are analyzed by a finite-element computer program using isoparametric and singular crack-tip elements. The program is based on the J_2 flow theory of plasticity and the Von Mises yield criterion. For the study of the crack growth the strain energy density failure criterion (3,4) is used. According to this criterion the crack starts to grow when material elements at a distance r_0 ahead of the crack absorb a critical amount of stored strain energy density equal to the area under the true stress-strain diagram of the material in tension ($(dW/dV)_c$ = 11.40 MJ/m³ for aluminum). r_0 represents the ratius of the core region in which the continuum model ceases to be able to represent the state of stress and strain (r_0 = 0.01 cm for aluminum).

Based on strain energy density theory a computer program was constructed for the determination of the critical stress σ_i at crack initiation. For the determina-

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tion of the critical tip from which the crack grows first the critical stresses for both tips A and B were determined and compared. Using the computer program the critical stress at crack initiation for the following cases were determined:

i. various values of the distance b of the crack tip from the interface with 2a = 3 cm and $t_2/t_1 = 2$ (Fig. 4).

ii. various values of the crack length 2a with b= 1.5 cm and $t_2/t_1 = 2$ (Fig. 5).

iii. various values of the ratio t_2/t_1 $(1<t_2/t_1<4)$ the same material (aluminum) in two sheets and the same geometric properties (Fig. 6).

Figure 3 presents the contours of the effective stress around the crack for 2a = 3 cm, b = 1.5 cm and $t_2/t_1 = 2$ at the moment of the onset of crack growth. The dark region represents the plastically deformed zone. It is observed that the size of the plastic zone at tip A is greater than at tip B.

CONCLUDING REMARKS

For all the above cases (the uncracked sheet is stiffer than the cracked) the crack starts first to grow from its far remote tip with respect to the interface (Fig.3). The critical stress increases as the stiffness of the uncracked sheet increases (Fig. 6) and as the crack approaches the interface (Fig. 4). The critical stress is higher than the corresponding stress for the same crack length in aluminum plate with constant thickness. For constant b = 1.5 cm the critical stress increases as the crack length increases (Fig. 5).

REFERENCES

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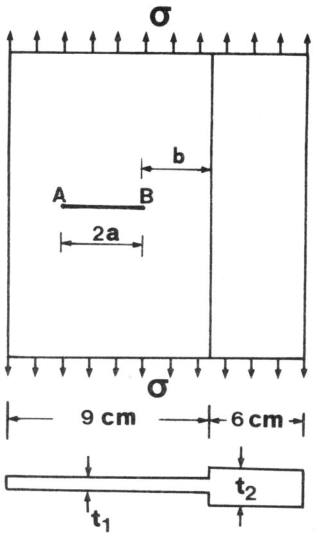


Figure 1 Geometry of the duplex specimen.

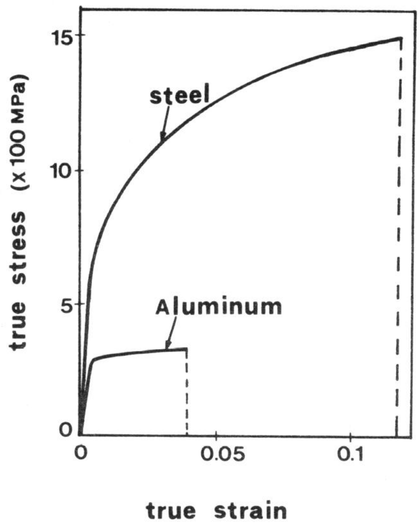
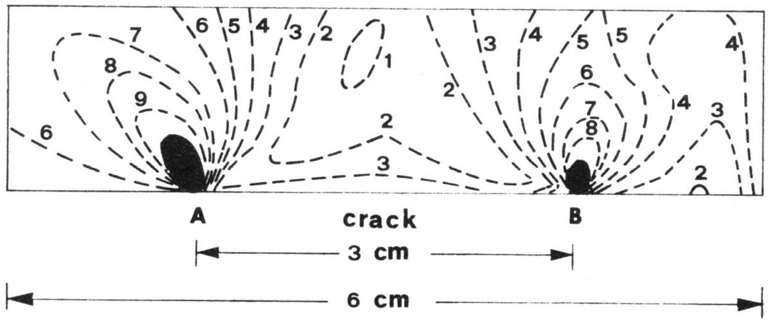


Figure 2 True stress-strain diagram in tension.



CONTOUR VALUES (MPa)

1- 52	2- 75	3- 98	4-121	5-144
6-167	7-190	8-214	9-236	10-260

Figure 3 Contours of the effective stress for 2a = 3 cm, b = 1.5 cm at the moment of the onset of crack growth.

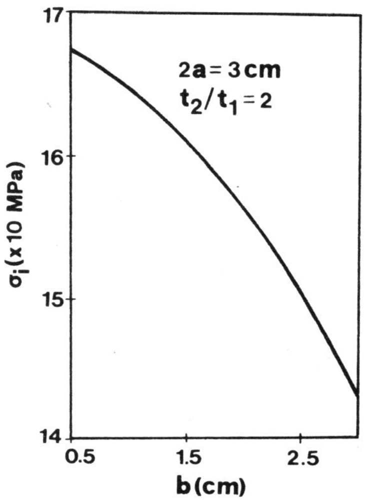


Figure 4 Critical stress variation with b.

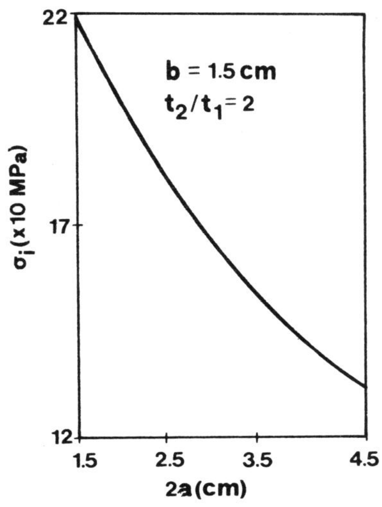


Figure 5 Critical stress variation with crack length 2a.

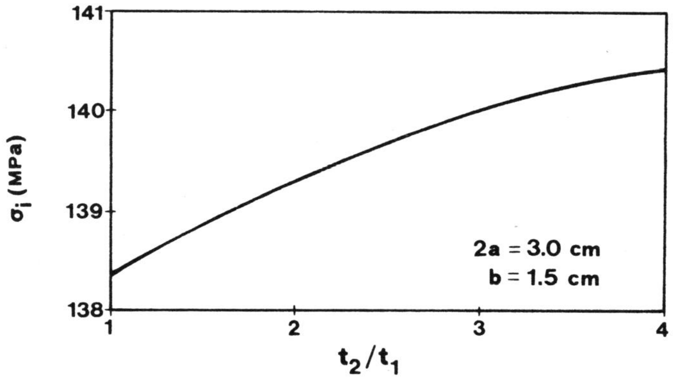


Figure 6 Critical stress variation for an aluminum plate with ratio t_2/t_1.