STABLE CRACK GROWTH FAILURE OF Al-Si BRONZE

J. Byrne, M.A. Phoplonker* and R.L. Jones**

INTRODUCTION

The sea water corrosion resistance and moderate strength of copper-aluminium alloys are of great value in a number of marine applications, e.g. propellers, flanges and fasteners. However, fracture failures have been experienced in fasteners under both sustained static and cyclic loading in air. The findings of this paper, a continuation of earlier work(1,2), are a contribution to understanding the failure mechanisms involved.

The alloy studied is an aluminium-silicon bronze (ASB), the primary elements being 6.5% Al, 2.3% Si and 0.5% Fe with a 0.2% Proof Stress of 394 MPa. Full details of the composition, mechanical properties and microstructure are given in references (1) and (2).

RESULTS AND CONCLUSIONS

Stable crack growth under sustained constant load has been studied at different initial stress intensity factor levels using pre-cracked bend specimens in different environments. Cracks were found to bifurcate and advance macroscopically in the directions of maximum shear stress in the plastic zone of the fatigue pre-crack (Fig. 1). On the microscale this cracking was intergranular (Fig. 2) whilst the final overload fracture was by transgranular micro-void coalescence. The incubation period for the onset of stable crack growth and time to complete failure were found to be strongly dependent on the initial value of stress intensity, K_i, as shown in Fig. 3. The reduction of moisture in the test atmospheres used (nitrogen and oxygen) was found to increase both crack growth incubation time and total life. A threshold value of K_i for the sustained load cracking in air was found at 10 $MPa\sqrt{m}$ (1000 hr exposure), which corrected for crack branching and crack tip blunting gave a value of 6 $MPa\sqrt{m}$, as shown in Fig. 4.

Near-threshold fatigue crack growth in this alloy has also been found to occur in an intergranular mode(2), though macroscopically perpendicular to the applied stress. The value of K_{max} at thres-

*Department of Mechanical Engineering, Portsmouth Polytechnic, UK
**A.R.E. Holton Heath, Poole, Dorset, U.K.

hold was found to be 5 MPa$\sqrt{m}$ for stress ratios, R, of both 0.1 and 0.5. This is only slightly lower than the corrected K_i threshold of 6 MPa$\sqrt{m}$ found for the sustained load cracking (Fig. 4) and indicates that there is an environmental time dependent contribution to stable crack growth under both static and cyclic loading of this alloy.

REFERENCES

(1) Scheffel, R.D., Phoplonker, M.A., Byrne, J., Jones, R.L. and Barnes, P., Proc. 6th European Conference on Fracture (ECF6), Vol. 3, 1986, pp. 1851-1860.

(2) Phoplonker, M.A., Byrne, J., Scheffel, R.D., Duggan, T.V. and Barnes, P., Proc. IMechE, Int. Conf. on Fatigue of Engineering Materials and Structures, Vol. 1, 1986, pp. 137-144.

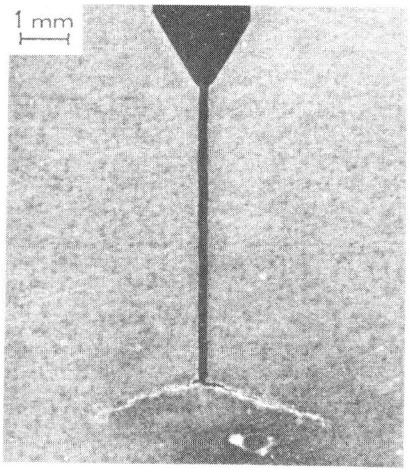

Fig.1 Sustained load crack branching shown at mid-thickness of a specimen.

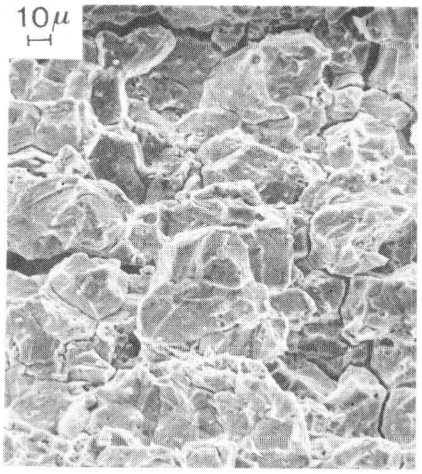

Fig.2 SEM fractograph showing the inter-granular mode of the sustained load cracking.

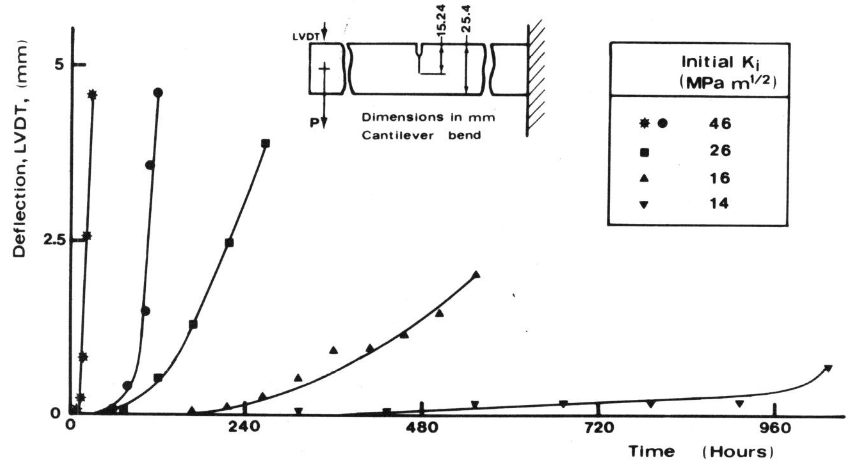

Fig.3 Sustained load cracking (as indicated by LVDT signal) with time in room temperature air.

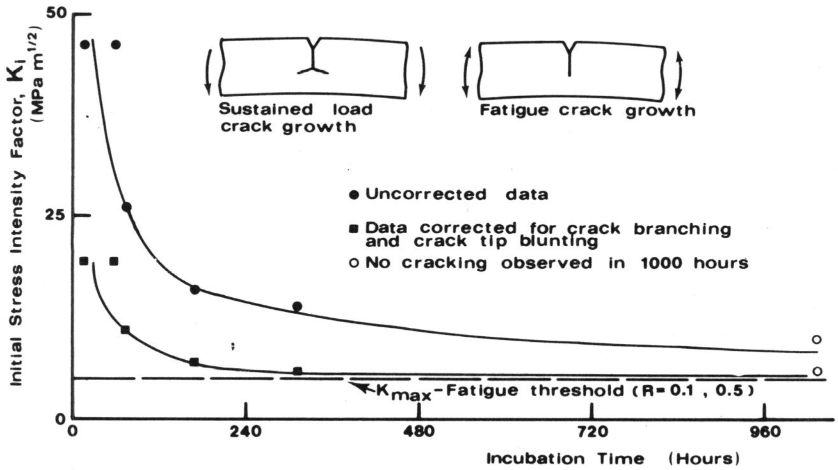

Fig.4 Initial stress intensity, K_i, as a function of incubation time for the onset of stable crack growth in room temperature air.