METALLURGY

Effect of Temperature on the Discontinuity in the S/N Fatigue Curve of a Stainless Steel

RECENT investigations of the fatigue characteristics of a wide range of alloys have revealed a discontinuity in the S/N fatigue curves at high-stress levels. Finney[1] reports that the discontinuities in extruded high-strength aluminium alloys of Australian manufacture to specifications *DTD* 683/3 and 2024–*T*4 involve a shift to shorter fatigue lives at stresses above the discontinuities. These tests were carried out in rotating cantilever machines with notched test pieces ($K_t = 1\cdot5$), and Finney also showed that the size of the discontinuity increases with increasing rate of cyclic loading in tests within the range 100–1,200 c/min. A similar tendency was observed by Williams and Mitchell[2] in rotating cantilever tests of smooth test pieces prepared from weldable aluminium alloy—'Alcan 3032*WP*'. The discontinuities reported for tests on steels[3] show an opposite tendency to increased fatigue lives immediately above the discontinuities, and the trend is similar for both a ferritic steel to *BS*970*EN*3*B* and an austenitic stainless steel *S*130, when smooth test pieces are fatigued in a Rolls-Royce fatigue machine.

The strain ageing phenomenon in steels induces special characteristics in their fatigue behaviour, for example, the appearance of a 'knee' in their S/N curves[4]. It has been suggested that the discontinuity is associated with 'cyclic creep'[5] involving a general yielding of the metal due to exhaustion of strain hardening. The plastic deformation involved would induce hysteretic heating in steels and thus cause an increase in both dislocation density and diffusion rates to enhance strain ageing effects. To assess the role of strain ageing during the fatigue cycling of an 18/8 stainless steel, comparative fatigue tests were undertaken at room temperature and at −80° C. Calculations showed that the diffusion rate would be very slow at −80° C and strain ageing thus suppressed.

The tests were performed in a pull–pull fatigue machine utilizing flat specimens 0·061 in. thick and containing a drilled hole ($K_t = 2\cdot5$). Figs. 1 and 2 show the results obtained. Testing at −80° C has raised the stress-level of the discontinuity by about 15·9 tons per in.² and the shift of the curve above the discontinuity is to shorter fatigue lives. Metallographic examination of the fatigued stainless steel revealed extensive martensitic transformation at the slip bands (Fig. 3). It appears, therefore, that suppression of the strain ageing phenomenon is associated with a reduced resistance of the stainless steel to fatigue damage at stresses above the discontinuity.

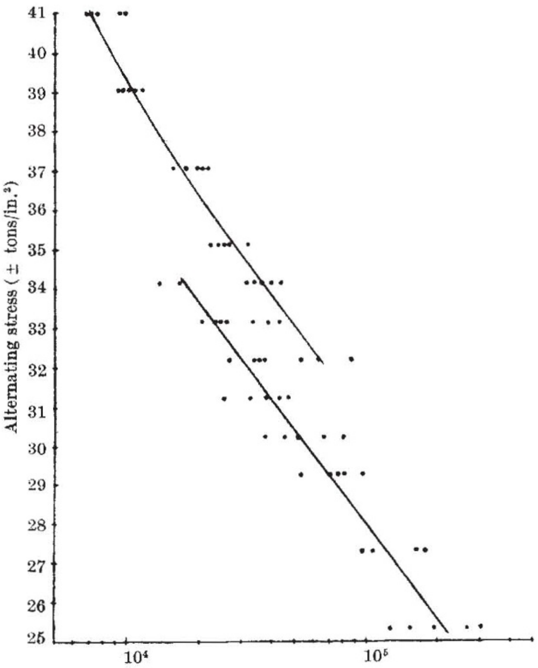

Fig. 1. Conditions: temperature, +20° C; loading, sinusoidal; frequency, 120 c/s.; stress concentration factor, 2·5

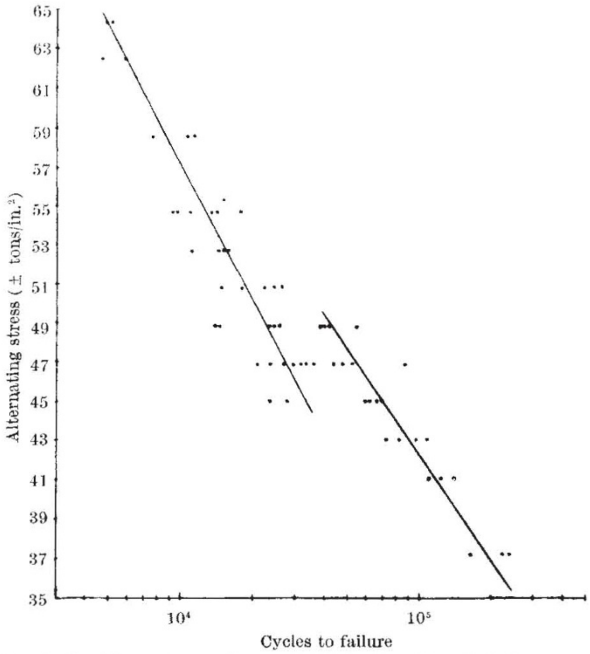

Fig. 2. Conditions: temperature, −80° C; loading, sinusoidal; frequency, 120 c/s; stress concentration factor 2·5

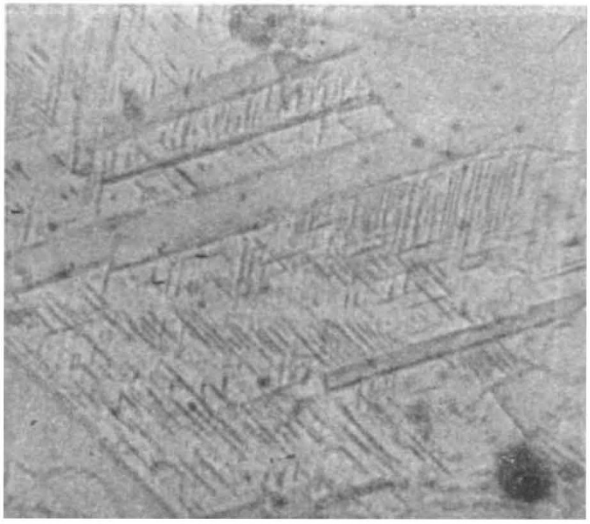

Fig. 3. (×c. 666)

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