FATIGUE CRACK GROWTH IN A LOW-ALLOY STEEL

by

Jeremiah Kitheka Musuva, B.Sc.(Eng.), M.Sc., D.I.C.

A thesis submitted for the award of the degree of Doctor of Philosophy in the University of London

Ph. D.

October 1980

Department of Mechanical Engineering
Imperial College of Science and Technology
University of London
London S.W.7.

ABSTRACT

A fracture mechanics approach was applied in the investigation of fatigue crack growth characteristics in BS4360-50D low-alloy structural steel currently used for construction of North Sea oil platforms.

Fatigue crack growth tests were performed on standard compact specimens in both air and salt water environments. The tests covered the full subcritical range of growth rates, from threshold to ductile tearing at very high values of ΔK.

The effects of stress ratio, thickness, salt-water environment, loading frequency, as well as transient effects under two-level block loading, were investigated. In general, the crack growth rates increased with increasing stress ratio and plate thickness. These effects were most significant at low growth rates in the thinnest plate and at low stress ratios. The crack closure concept was found to be satisfactory in explaining the observed effects of stress ratio and thickness. A model based on the effective stress intensity factor range was developed to characterise low crack growth rates and thresholds.

Cyclic frequency had little influence on the growth rates at low stress ratios. However, at high stress ratios, lower frequencies caused higher growth rates. In salt water the decrease in frequency caused an increase in the crack growth rates at both low and high stress ratios.

Elastic-plastic crack growth behaviour under both monotonic and cyclic loading was also investigated using the J-integral approach. The onset of slow stable crack growth was found to be thickness dependent. A double-mechanism model was developed to describe the crack growth under elastic-plastic conditions.

Two-level block loading fatigue tests were performed to investigate the transient effects. The crack growth acceleration was recorded in Lo-Hi block loading, while the crack growth retarded in Hi-Lo block loading. Crack closure effects, strain hardening of crack tip material, as well as crack front changes were used to explain the observed transient interactions.

The use of an A.C. crack microgauge for crack length measurement was also investigated. It was found that the microgauge was suitable for crack length measurements under both constant amplitude and variable amplitude loading.