THE BEHAVIOUR OF MILD STEEL UNDER CYCLIC LOADING IN THE PLASTIC RANGE

Timothy Hamilton Topper

Abstract

An examination of the behaviour of a material at low endurances provides insight into both the static and fatigue problems as well as the low endurance problem. The most fundamental and applicable method of testing at low endurances is cyclic strain testing but in this method of testing considerable difficulties arise in imposing strains and in measuring the stresses and strains.

In this dissertation a description is given of a frequency modulated system utilizing capacity gauges which enable complete stress-strain behaviour to be obtained for the material at strain ranges varying between the elastic limit and the monotonic fracture strain. Testing equipment which imposed the above strain ranges is also described.

Results of tests on mild steel using this apparatus are presented and discussed. Testing programme includes cyclic strain tests in which; the mean strain is zero; a prestrain is applied to give a positive or a negative value of mean strain; more than one strain range is applied; the specimen is notched prior to testing at zero or a tensile mean strain.

The strain history was found to have little permanent effect on the hardness eventually reached by the material, with initially hardened material softening, and initially soft material hardening, to reach a level of hardness dependent, primarily, on the cyclic strain range.

Cyclic frequency had no detectable effect on the deformation behaviour of the material but the introduction of a notch resulted in increased hardening at all levels of strain. A slow change in the form of the stress train loops was noted with increasing strain range. The stress strain behaviour of the material, it was found, could be divided into three regions in each of which the logarithm of the strain range.

The critical variable in determining failure was found to be either the plastic strain range or the energy per cycle. The logarithm of each of these variables was linear with the logarithm of the endurance. A simple damage criterion based on plastic strain was evolved and gave excellent predictions for sequential tests. The damage due to the tensile prestrain

was found to be linear with prestrain. A considerable increase in cyclic frequency (30 times) resulted in only a small increase in endurance but the introduction of a notch into the test specimen resulted in a considerable decrease in endurance.