FATIGUE AND FRETTING-FATIGUE FRACTURE OF HOT ROLLED CARBURISING STEEL

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In practical applications, several failures occur under the synergic effect of both fatigue and fretting. In general, it is very difficult or even impossible to separate the single contributions to the damage: thus, further experimental and theoretical work appears to be needed in order to better understand the underlying mechanisms. A comprehensive discussion can be found in the treatise by Waterhouse (1).

The present communication reports some original experimental results obtained by using test-bars of hot-rolled carburising steel. The composition (% weight) of the latter was: 0.38 C, 0.39 Si, 1.62 Mn, 0.014 P, 0.059 S, 1.77 Cr, 0.19 Ni, 0.15 Mo, 0.13 Cu. The laboratory equipment for the test was based on an MTS 100 kN hydraulic testing machine working under computer control. An auxiliary device, originally developed by Klaffke (2) at BAM in Berlin, was mounted onto the test-bar to obtain fretting-fatigue tests. In each case, suitable software was developed to allow fully computerized data acquisition. A schematic drawing of the experimental apparatus is reported in Fig. 1 which also shows the shape of the selected test-bar. Further details about these experimental conditions can be found in a report by Bacci et al.(3).

The carburising steel used showed a very pronounced texture due to previous rolling; a fact which was taken into account when extracting the test-bars from the plate. However, even though the specimens were oriented in the best possible way, some residual effects of texture could not be avoided. Moreover, it was found that the amount of inclusions in that steel was far from negligible. As a consequence, the scattering in the experimental results of the fatigue tests, was more evident than that which usually results due to the statistical character of the phenomena. For this reason some strongly scattered experimental points are not taken into account; the total experimental

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results were used to obtain Woehler curves were obtained for the same group of test-bars - with and without fretting, see Fig. 2. It may be deduced from the two curves that the fretting-fatigue fracture stress, for a given number of cycles, is about 70% of the pure fatigue one.

Successive fractographic investigations carried out on the test-bars confirmed the presence of a considerable amount of anisotropy both in the bulk material and in the intergranular inclusions. In particular, sample areas have been examined from regions on or near to the fracture surface. The fracture surface showed a pronounced fibrous character. The fractographic examination allows, as expected, a straightforward distinction between the specimens broken under pure fatigue and those broken under fatigue-fretting conditions. In particular, both fatigue fractures and fretting-fatigue were compared using specimens broken at the same load and/or at about the same number of cycles. Differences were observed in the fracture zones, but they were even more pronounced in the bar surface near to the fracture. As expected, the fretting-fatigue fractures showed a peculiar behavior in the friction area; these can be verified in Fig. 3. Mainly two phenomena occur: 1) several scales, more or less parallel to the surface, were found due to the fretting action, 2) perpendicular to them, deep cracks developed in the main section of the bar. One of them is actually responsible for the fracture.

The investigation of fretting-fatigue interactions is still in progress; its aim is to interpret the experimental results on the basis of continuous damage mechanics.

REFERENCES

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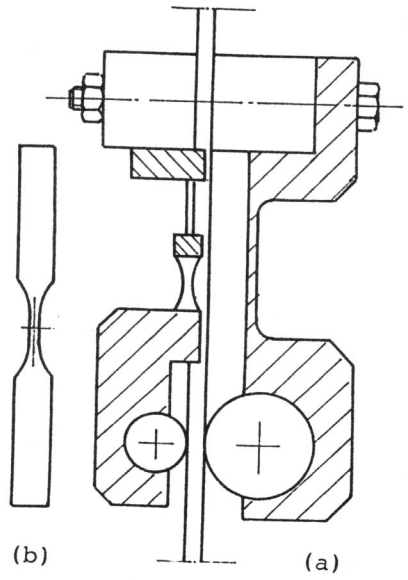

Fig.1 Schetch of (a) testing apparatus and (b) test-bar

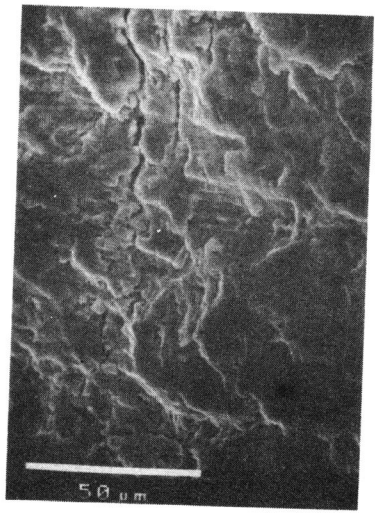

Fig. 3 SEM view of the fretting surface

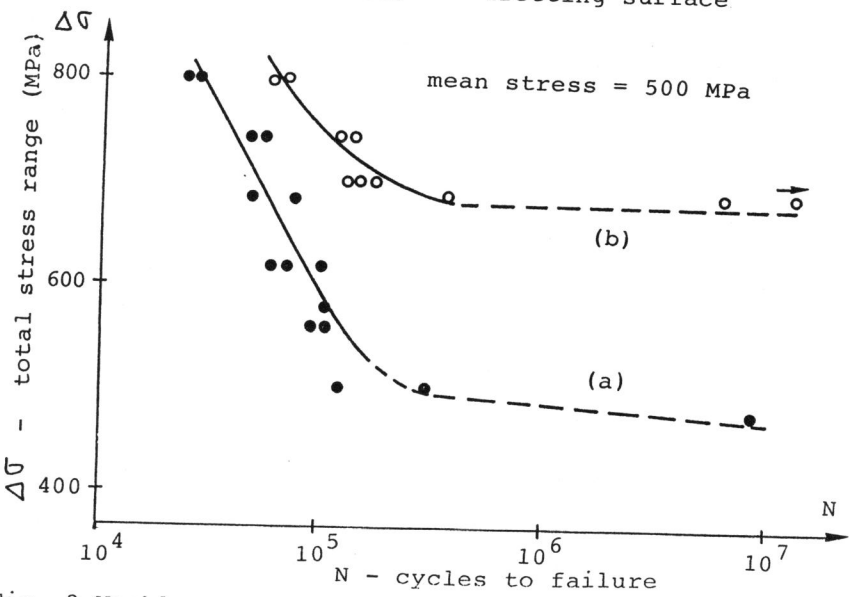

Fig. 2 Woehler curves for fretting-fatigue (a), and fatigue (b).