THE INFLUENCE OF ENVIRONMENT AND METALLURGICAL FACTORS ON FATIGUE CRACK GROWTH OF HIGH STRENGTH STEEL

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INTRODUCTION

The kinetics of fatigue crack growth of high strength martensitic steels is significantly influenced by load cycle parameters, surrounding environment as well as metallurgical factors [1] , [2] . The purpose of the presented work is to show the influence of environment air, distilled water , tempering temperature and load frequency on the fatigue crack growth rate in cyclic loaded plate specimens machined from high strength CrNiMo steel.

EXPERIMENTAL TECHNIQUE AND RESULTS

Test material was cut off from thermomechanically treated sheets and tempered at 200 °C, 350 °C, 450 °C, 550 °C and 650 °C for 4 hours. After tempering centre cracked plate specimens were machined. The fatigue tests were performed on a MTS servohydraulic test equipment in air and in distilled water at a constant load amplitude, with an R factor of $R = 0$ and a sinusoidal loading waveform. To investigate the effect of the load frequency on the fatigue crack growth rate in a corrosive medium, the tests in distilled water were performed at frequencies of 0.1 and 1 Hz while the tests in air were all run at 10 Hz because it was prooved that frequency effects are absent from air environment in this material.

Reactions running during tempering induced significant changes of mechanical properties that are illustrated in Fig.1.

Fig.2 summarizes the found dependences of the fatigue crack growth rate $d2a/dN$ on ΔK in air for all tempering temperatures. As can be seen from this figure tempering temperature has only little influence on the fatigue crack growth rate in the range of ΔK investigated.

The results of fatigue tests in distilled water prooved, that no matter at which tempering tempera-

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ture the specimens had been tempered, fatigue cracks always propagated more rapidly in water than in air, see Fig.3,Fig.4. This crack growth rate enhancement is due to hydrogen embrittlement of microvolumes ahead of the propagating crack front [3] ,[4] . Unlike the tests in air the crack growth rate in corrosive environment is influenced by load frequency as well as tempering temperature. The decrease of the load frequency induced here considerable increase in fatigue crack growth rate. The fractographic analysis of the fracture surfaces revealed a change in failure mechanism. The specimens that had been tested in water exhibited both intergranular and transgranular fracture areas. Quantitative evaluation prooved that the proportion of intergranular fracture varies with the value of ΔK, load frequency and tempering temperature. The significant influence of tempering temperature (especially at load frequency of 0.1 Hz) shows the important role of metallurgical parameters and mechanical properties on susceptibility of the material to hydrogen embrittlement during fatigue crack growth in corrosive environment. As can be seen from Fig.1, 3,4 the enhancement of crack growth rate is not dependent only on yield strength of the material but also on brittle fracture resistance and for this type of material it can be expressed by means of the ratio of $KCU2/R_p0,2$. As this ratio decreases, the susceptibility to corrosive environment increases.

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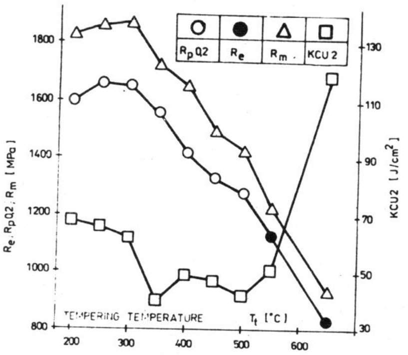

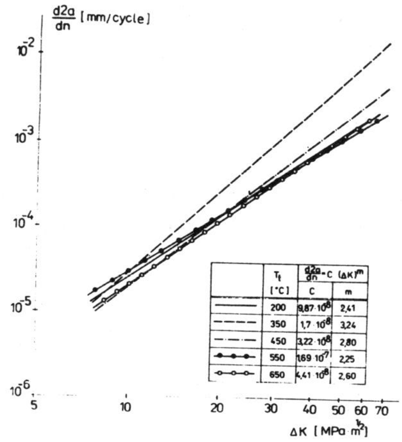

Fig.1 $R_p0,2$, R_m, KCU2 vs tempering temperature

Fig.2 d2a/dN vs ΔK in air environment

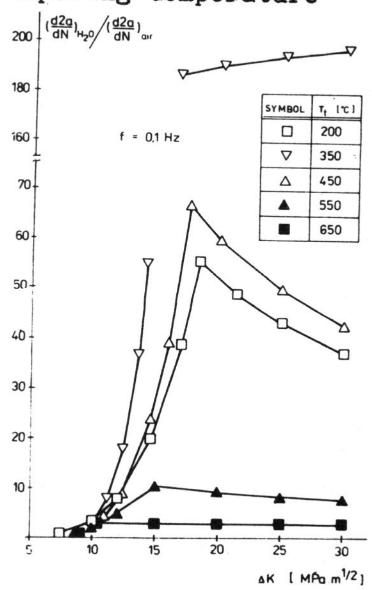

Fig.3 $(d2a/dN)_{H_2O}/(d2a/dN)_{air}$ at frequency of 0.1 Hz

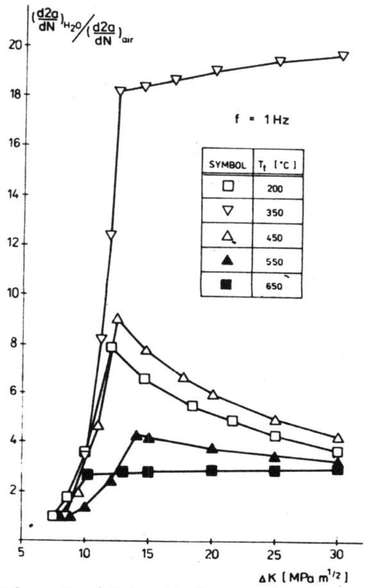

Fig.4 $(d2a/dN)_{H_2O}$ / $(d2a/dN)_{air}$ at frequency of 1 Hz