INVESTIGATION OF FRACTURE FEATURES IN Cr-Mo STEEL AFTER DIFFERENT THERMOMECHANICAL TREATMENT

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INTRODUCTION

The surface cracking of cylindrical part of the crank after forging and quenching was investigated. Determination of failure causes on the basis of fracture features of crank after different stages of thermomechanical treatment is the aim of this paper.

EXPERIMENT

The crank was produced from middle alloyed steel with 0.42 wt% C, 1.42 wt% Cr and 0.176 wt% Mo. After forging in a closed-die a series of 237 pieces was solution treated at 860^{o}C during 95 min, quenched in oil and finally tempered at 650^{o}C during 120 minutes. Using ferro-flux method surface cracking after forging (1.27%), i.e. quenching (46.4%) was detected. The crack, usually only one, appears at the surface of cylindrical part of the crank always in the shear plane. The equal thermomechanical treatment, except for the annealing (at 620^{o}C/ 90 min) between forging and quenching in order to relax the internal stresses, was applied on the second series of 210 pieces. Surprisingly enough, the same amount of surface cracking was observed in the second series of cranks (1,2).

In order to explain this, we point out the complexity of forging technology (1), emphasizing the large plastic deformation per forging cycle, as well as the last operation, i.e. cutting into shape at the temperature higher than 850^{o}C with subsequent cooling in the air.

Samples with crack are taken from the cranks sfter certain stage of treatment and afterwards broken along the crank in order to get fracture s rface. Technique of two-stage palladium-carbon replica, as well as the transmission electron microscopy, were applied for investigation of fracture characteristics.

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RESULTS AND DISCUSSION

Characteristic fracture features are shown in Fig. 1-4. Generally, it can be seen that fracture features are different after different stages of treatment, showing brittle, brittle-ductile or ductile fracture.

After forging fracture feature is as one can expect, except for the porosity appearing as small shiny flake--like regions, Fig. 1a. At high magnification some areas of porosity show the step-like geometric patterns, as shown in Fig. 1b, indicating poor quality of either forging or material (3). Fig. 2 shows characteristic brittle fracture after quenching, although some other areas contain inclusions (MnS and carbides) of different sizes, distributions and shapes, as well as a small amount of porosity (2).

Fracture surface of the tempered sample is typically ductile, but with different features regarding existance of dimples of different sizes, Fig. 3a, or with large flat facet, Fig. 3b. The facet contains fine shallow conical-like dimples, but perhaps two of many possible systems of slip (3).

Based on a detailed analysis of mechanical properties and fractographies analysed here, we conclude that there are two main causes of the crank surface cracking:

- usage of low quality (high porosity) material, which could not be improved neither by forging, nor by annealing, and
- usage of cutting tool with incorrect geometry, causing higher shear stresses in the cutting plane.

The existance of these two caused an initiation and further growth of microcracks. Their mutual influence have reduced ductility of the forging, specially at the position of plane cutting.

LITERATURE

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a.

b.

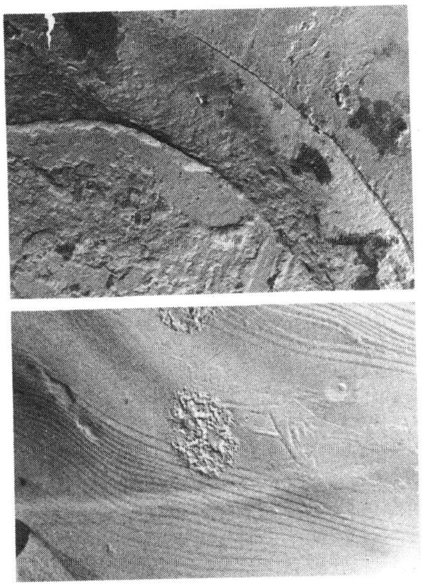

Fig.1 Fracture feature after forging a.3400x b.9000x

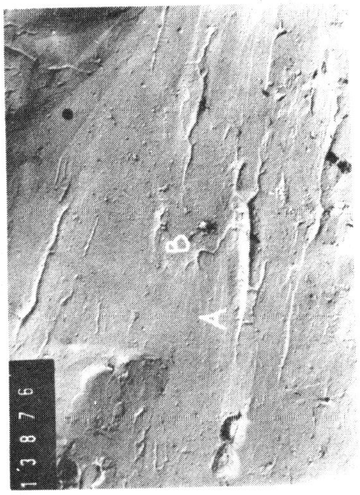

Fig.2 Fracture feature after quenching, 6000x

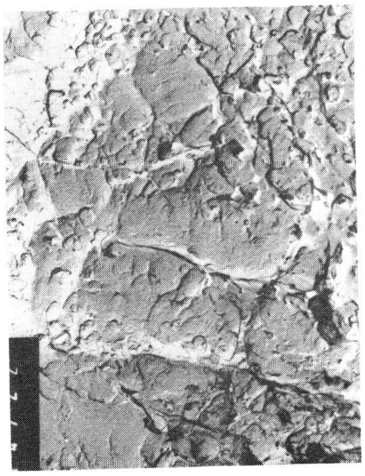

Fig.3a Fracture feature after tempering, 6000x

Fig.3b Fracture feature after tempering, 6000x