FATIGUE AND FRACTURE BEHAVIOUR OF TOOL STEELS

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INTRODUCTION

The making of a tool is a work to which attention is not always given as it should by tool-makers and users. Owing to relative cheap material as against the whole cost of the manufacture, there's the risk of carelessness of the producers forcing them to lay aside material's selection which is often fundamental for the quality of the final product.

The goal of our work is to get knowledge about the general mechanical behaviour of high hardened tool steels using concepts from low cycle fatigue and fracture mechanics. It was our purpose to show that to give a tool the highest hardness the material can attain is by no means wise even though the tool geometry permits it. There's a limited group of heat treatment and hardness for each material for which softening or hardening under cyclic plastic strain can occur, as well as significant loss or increase in material's resistance to fracture.

The research was conducted on materials and heat treatments currently used by the tool industry: X 210 Cr 12 according DIN 17350 "Tool steels" and CK 45 according DIN 17200 "Heat treating steels".

In the literature (1,2,3) there are only a few results concerning steels of a very high hardness degree where this sort of research has been conducted. There are indeed some difficulties not only with machining but also with testing these materials. In spite of these difficulties some results have been achieved in this study.

MATERIAL, SPECIMEN AND EXPERIMENTAL PROCEDURE

X 210 Cr 12 was austenized at 970°C for 30 min, quenched in oil and tempered at 120°C to 550°C (obtaining 50 to 64 HRC respectively).

CK 45 was austenized at 850° C quenched in water and tempered at 200°C (54 HRC).

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Low cycle fatigue tests were carried out using cylindrical specimens (8 mm diameter); taking into account rolling direction of raw material, 3 point bending SEN specimens were used to determinate fracture toughness, K , in the direction TL and LT.

RESULTS AND CONCLUSIONS

When X210 Cr 12 is tempered under 500^0C (HRC > 51) it is observed a competition between softening mechanisms and hardening resulting from the transformation of the residual austenite in martensite that happens specially in the first demanding cycles at high imposed extension levels, as observed on similar high hardness steels (1,4).

Either for X210 Cr 12, HRC 51 or for CK 45, HRC = = 54 steel, there is a significant softening under cyclic plastic deformation which can avoid their use in most tool applications. Fig. 1 show the cyclic stress--strain curves for the two steels for several hardness.

The fatigue life law for X210 Cr 12 and CK 45 has an elastic component which is always higher than the plastic component, as can be seen on Fig. 2 and 3. This is a typical behaviour of very high hardness steels for which 2N is less than 10 cycles.

Finally, Fig. 4 shows results of fracture tests for X210 Cr 12 at several hardnesses; it can be seen that fracture toughness does not linearly vary with hardness of material as it is generally assumed and that it may occur a slight increase in fracture toughness by means of an increase in hardness. This behaviour can be attributted to the presence of ledeburitic carbides wich are not affected by tempering temperatures.

REFERENCES

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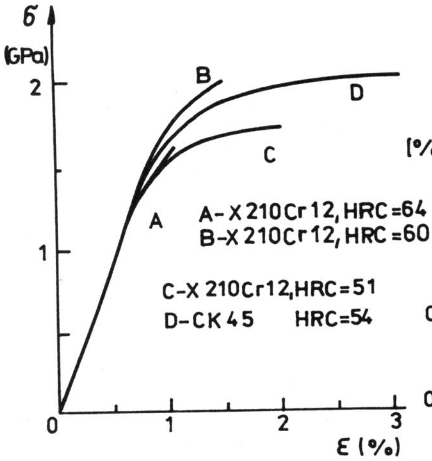

Figure 1 Cyclic stress - strain curves for CK 45 and X210 Cr 12

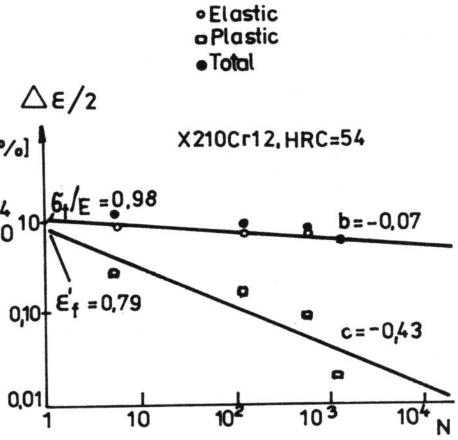

Figure 2 Fatigue life law X210 Cr 12 at HRC = 54

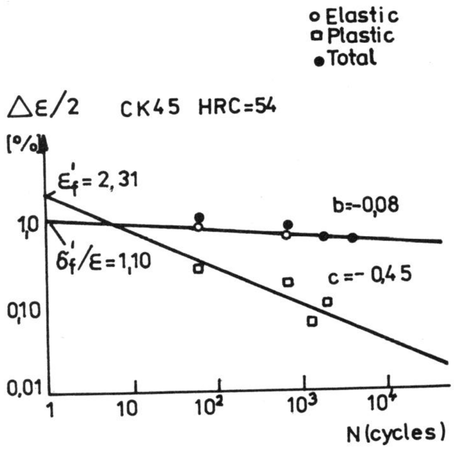

Figure 3 Fatigue life law for CK 45 at HRC = 54

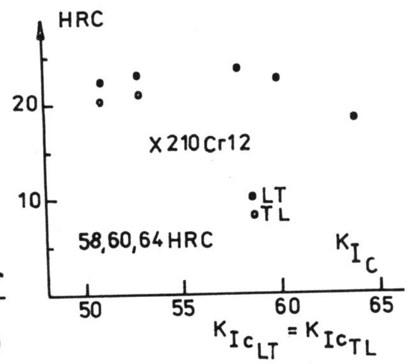

Figure 4 Fracture toughness of X210 Cr 12 at several hardnesses