INFLUENCE OF MICROSTRUCTURE ON FRACTURE TOUGHNESS IN THE H 75 - 3 BAINITIC STEEL GRADE

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INTRODUCTION

Advancement in the field of the construction of equipment and apparatus, new constructional solutions and better utilization of the available raw materials require, among others, enhanced application of high-strength weldable constructional steel grades. While, on the basis of extensive experimental results and practical experience, clear concepts exist on the properties and limits of application of ferritic-perlitic and waterquenched structural steel grades, the concept of bainitic steel grades remains still rather incomplete.

The low carbon bainitic steel grade H 75-3 /C = 0.08%/ developed by the Department of Metallurgy and Material Engineering of the Bergakademie Freiberg is thermomechanically treated /low austenitization, controlled high-temperature deformation, and low-temperature final deformation at a high degree of deformation/; afterwards, it is characterized by a microstructure consisting of grained bainite and a percentage of pre-bainitic ferrite increasing with increasing plate thickness (1).

Fracture toughness is primarly controlled by the dispersion of the microstructure, the percentage of pre-bainitic ferrite V_{pF}, the percentage and form of sulphides, as well as the amount and distribution of oxydic inclusions (2).

According to Peisker (3), the specific austenite grain boundary area S_V which is a measure for dispersion, i.e. the total boundary surface in relation to the volume unit 1 mm^3, shall attain values above 150 $mm^2 mm^{-3}$ immediately before the $\gamma - \alpha$ transformation.
This contribution characterizes the crack propagation resistance behaviour in dependence on the microstructure on the basis of static crack initiation toughness J^R_{Ic}, employing a multi specimen technique.

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Various melts and H 75 - 3 plates /thickness 1o-12 mm, yield strength 6oo-68o MPa/ produced in small-scale and large scale rolling were included into our investigations.

RESULTS

The influence of the sulphur content on crack initiation toughness K^{J}_{Ic} is shown in Figure 1. Very low sulphur contents were attained in one melt by ladle metallurgical treatment /LF process/ in combination with slag treatment and argon flushing. With an S content of about o.oo4%, the highly desulphurized melt of H 75 - 3 is characterized by markedly improved crack propagation resistance /Figure 2/. In case of identical metallurgical treatment during melting, crack propagation resistance is controlled by thermomechanical treatment. Thus, an increase of the specific austenite grain boundary area from S_{VR}=15o $mm^2 mm^{-3}$ to 28o $mm^2 mm^{-3}$ leads to an increase of J^{R}_{Ic} from 13o to 18o kJm^{-2}, i.e. an increase of S_V by 1o $mm^2 mm^{-3}$ leads to an increase of the crack initiation toughness J by about 4 kJm^{-2} /Figure 3/. In case of identical dispersion of the microstructure the resistance to crack initiation and propagation is controlled by the percentage of pre-bainitic ferrite /Figure 4/.
For active design of the properties of H 75 steel grade, one can assume an increase by 5% within the range shown to increase crack initiation toughness by about 12 kJm^{-2}.

REFERENCES

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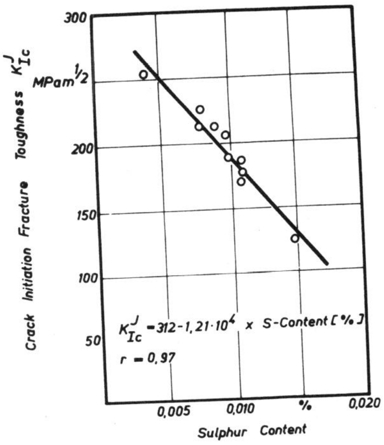

Figure 1 K^J_{ic} vs. s content

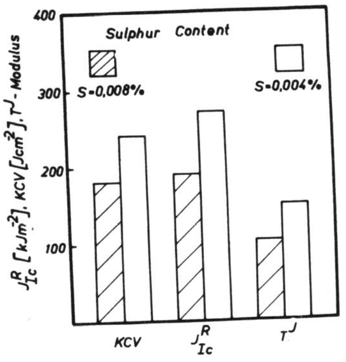

Figure 2 Toughness vs. S content

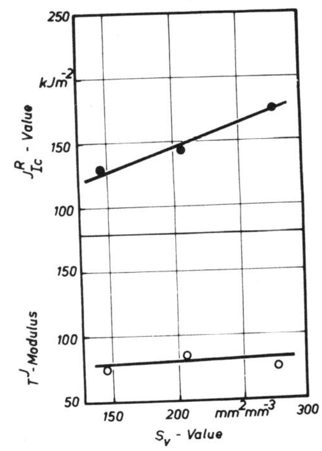

Figure 3 Crack propagation resistance vs. Sv

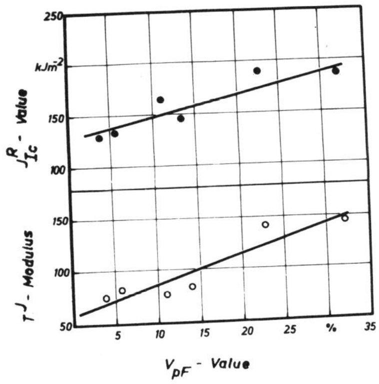

Figure 4 Crack propagation resistance vs. VpF