EFFECT OF PRIOR AUSTENITE GRAIN SIZE ON THE NOTCH TOUGHNESS AND THE FRACTURE SURFACE MORPHOLOGY OF EHSLA STEEL

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INTRODUCTION

It is known that the mechanical properties and notch toughness of EHSLA steels are influenced by the austenitizing temperature, cooling rate after austenitizing and the tempering temperature. In order to determine the acceptable quenching and tempering temperatures the effects of the prior austenite grain size and tempering temperature on the mechanical properties, notch toughness and fracture surface morphology of EHSLA steel are examined.

EXPERIMENTAL PROCEDURES

The material used in this study is low alloy bainitic 10GHMBA steel which was supplied as hot-rolled and annealed at 680 °C for 2 hours flats with 110 x 12 mm cross-section. Ladle analysis of steel has shown: 0.11% C, 0.59% Mn, 0.33%Si, 0.020% P, 0.020% S, 1.40% Cr, 0.51 % Mo, 0.41 % Cu, 0.004 % B, 0.03% Ti, 0.04% Nb, 0.05% Zr, 0.04 % Alm and 0.01% N_2.

From the received flats 200 mm long sections were cut out, then austenitized in laboratory at 880, 930, 980, 1050 and 1150 °C for 3 hours and water quenched, tempered at 620 °C or 680 °C for 0.5 hour and air cooled. After quenching the pieces were cut out from the test sections to perform the hardness testing and microstructural examination. After tempering the pieces were cut out from the test sections to perform the hardness testing and microstructural examination, and the longitudinal specimens for tensile test and Charpy V test.

Revealing the austenitic grain boundary and estimating the average austenitic grain size were performed according to PN-84/H-04507/ASTM E112-82 or ISO 643-83. The fracture surface morphology of Charpy V test specimens were examinated by SEM. Area fractions of specific fractographic features were evaluated by the point counting technique.

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RESULTS AND DISCUSSION

Figure 1 illustrates the results of the tensile testing of 10GHMBA steel, austenitized at 880-1150 °C for 3 hours, water quenched, then tempered at 620 °C for 0.5 hour and air-cooled. The results of the Charpy tests at 40 °C and metallographic testing of prior austenite grain size of 10GHMBA steel austenitized at 880-1150 °C for 3 hours, water quenched then tempered at 620 °C for 0.5 hour, air cooled, are shown in Figure 2.

Prior austenite grain size influences the transformation temperature and the type and variety of transformation products by controlling the availability of grain boundary sites and intragranular super cooling 1.

The results show that increasing average prior austenite grain size causes the growth of the hardness, yield stress and tensile strength of steel and the decrease of its alongation, reduction of area and Charpy impact energy. The changes of mechanical properties can be associated with the growth of hardenability of steel by increasing austenite grain size(2). At the increasing austenite grain size the transformation gives less favourable microstructures with respect to low temperature toughness. Also the increasing austenite grain size decreased the notch toughness of steel as can be seen in Figure 2. This confirms the previous statement (3). Increasing austenite grain size also caused the growth of the fraction of intergranular facet area in the fracture of Charpy test specimens.

CONCLUSIONS

The results obtained in this study for the quenched and tempered 10GHMBA steel are the following:

1 The growth of austenite grain size increased the hardness, yield stress and tensile strength and decreased the elongation, reduction of area and notch tougness of steel.

2 The growth of austenite grain size the fracture surface obtained in Charpy V tests exhibited the larger fraction of intergranular facet area.

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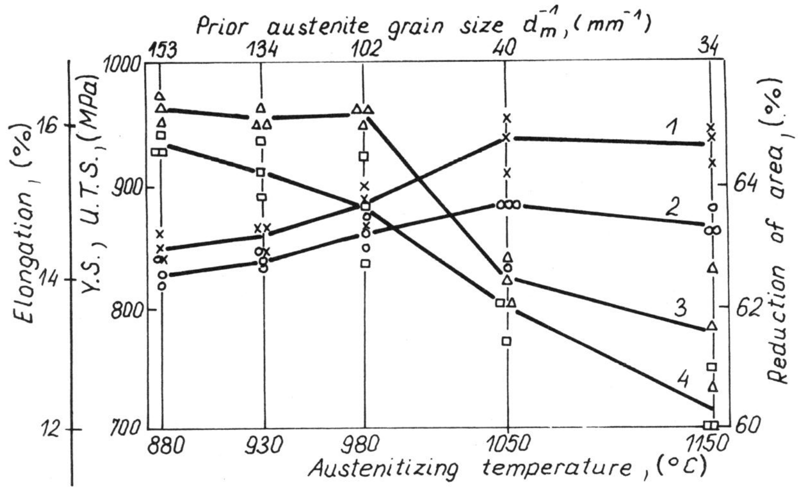

Figure 1 Mechanical properties of 10GHMBA steel austenitized at 880-1150°C for 3 hours, water quenched then tempered at 620°C for 0.5 hours, air-cooled: 1-U.T.S., 2-Y.S., 3-Elongation, 4-Reduction of area

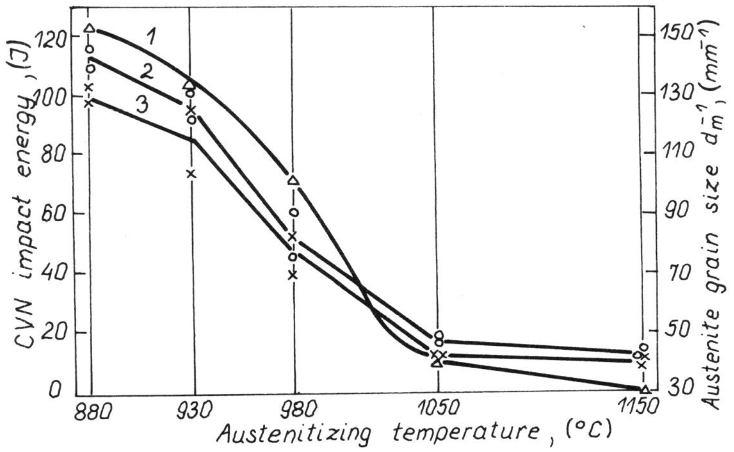

Figure 2 Charpy impact energy at -40°C and austenite grain size vs austenitizing temperature for 10GHMBA steel austenitized at 880-1150°C for 3 hours, water quenched then tempered for 0.5 hours, air-cooled: 1-Austenite grain size, 2-Charpy impact energy for flats tempered at 680°C, 3-Charpy impact energy for flats tempered at 620°C