EFFECT OF HEAT TREATMENT ON THE FRACTURE TOUGHNESS, THE NOTCH TOUGHNESS AND THE FATIGUE LIMIT OF SOME HSLA STEELS

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INTRODUCTION

The purpose of the following investigations was to examine the changes in mechanical properties, fracture toughness, fatigue strength and the fracture surface morphology by heat treatment of 15G2ANb steel plates.

EXPERIMENTAL PROCEDURE

The 12 mm thick plates used in these investigations were of fully killed aluminium treated 15G2ANb steel according to the standard PN-86/H-84018. Their chemical composition in wt% were: C=0.14, Mn=1.35, Si=0.34, P=0.016, S=0.018, Nb=0.035, Al=0.02 and N=0.010. The plates were used in the following heat treatment conditions: hot-rolled, normalized and quenched and tempered.

COD specimens of 12x24x110 mm were cut out traversely the rolling direction of the plates and were prepared according to the BS 5762:1979. Initiating notches were produced by sawing and the sharp cracks were developed by fatigue at a loading ratio R=0.1 and stress intensity factor $K \leq 0.63 \sigma_y B^{1/2}$ at room temperature in laboratory air. The COD tests were carried out in three-point bending with a loading span of 96 mm and in a temperature range of -40 ^{o}C to -120 ^{o}C according to the BS5762:1979.

The Charpy V notch specimens 10x10x55 mm were preparated according to the standard PN-79/H-04370/BS 131: Part 2:1972/. The testing was carried out in a range of temperature to establish a transition curve.

The fatigue strength was determined on 12 mm thick and 25 mm wide flat specimens of working part, which were taken from plates transversely the rolling direction. The specimen surfaces remained rolled ones, without machining. The fatigue tests were carried out using a 10 kN servohydraulic testing machine at 25 Hz and by asymmetric tension-compression of constant load amplitude with a stress ratio R = -0.3. All fatigue

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tests were performed at room temperature in laboratory air.

The fracture surfaces of Charpy V test specimens were examined by scanning electron microscope. Area fractions for different fractographic features were evaluated by point counting technique using three fractographs for one observation.

EXPERIMENTAL RESULTS AND DISCUSSION

The tensile tests of transverse specimens resulted the following average values of mechanical properties for the plates: hot-rolled: Y.S.=580 MPa, U.T.S.=710 MPa, E = 20.0 %, R.A. = 52,5 %, HV10 = 198, normalized: Y.S.=410 MPa, U.T.S.=550 MPa, E=27.5%, R.A.=50,5 %, HV10=159, quenched and tempered: Y.S.=540 MPa, U.T.S. = 630 MPa, E =23.0%, R.A.=53,0%, HV10=206.

Figure 1a shows the Charpy V impact transition curves for the three heat treatment conditions of the steel. The results of COD tests are shown in Figure 1b.

The results of fatigue tests are given in Figure 2. For normalized plate we elaborated a regression equation: $\sigma = 362-18.3 \times \lg N_f$, the coefficient of correlation was: $\varrho = -0.87$, and the fatigue strength at 2×10^6 cycles was 245 Mpa. For quenched and tempered plate the equation was: $\sigma = 400-23.4 \times \lg N_f$, the coefficient of correlation was $\varrho = -0.84$ and the fatigue strength at 2×10^6 cycles 253 MPa. It can be seen that the difference between the fatigue strength of normalized and quenched and tempered plates is very slight. This confirms that quenching and tempering has no influence on the fatigue strength of HSLA steels (1).

The fracture surfaces obtained in the impact tests at -40 ^{o}C exhibit the smallest area fractions of intergranular facets in quenched and tempered plate, as these area fractions were the larges in hot-rolled plate.

All results of these investigations confirm that the quenching and tempering have a very advantageous effect on the plastic properties of HSLA steel plates (2).

CONCLUSIONS

The results obtained in this study for 12 mm thick plates of 15G2ANb steel are as follows:

(1) The optimal combination of mechanical properties is found in the quenched and tempered state.

(2) The greatest fracture toughness and notch toughness was found in the quenched and tempered state.

(3) The fatigue strength of plates is only very slightly influenced by heat treatment.

REFERENCES

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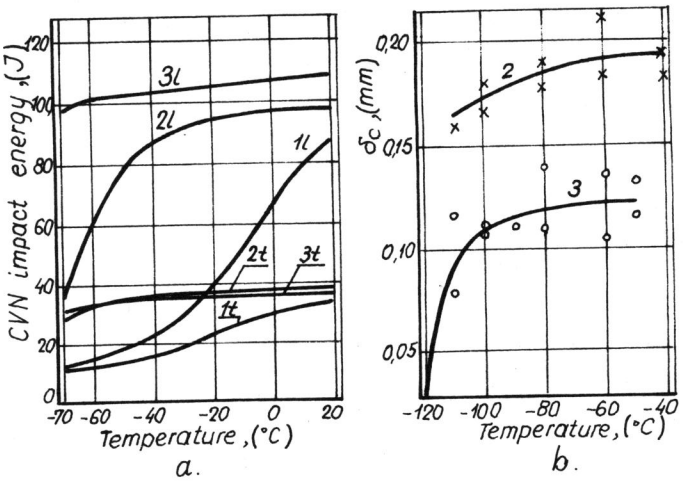

Figure 1 Charpy impact energy vs temperature (a) and COD values vs temperature (b) for 15G2ANb steel plates of 12 mm thickness: 1-hot-rolled, 2-normalized, 3-quenched and tempered, l-longitudinal, t-transverse

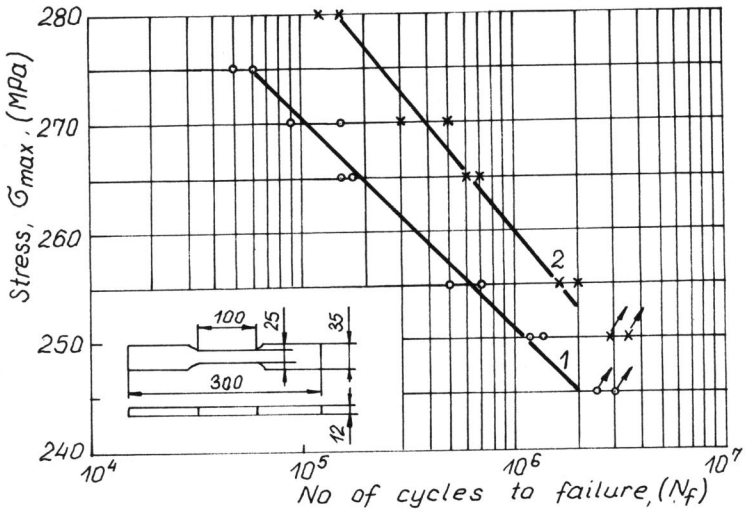

Figure 2 S/N curves for 15G2ANb steel plates of 12 mm thickness: 1-normalized, 2-quenched and tempered, R=-0.3