


HEAT TREATMENT TECHNOLOGY

EFFECT OF AUSTENITIZATION CONDITIONS ON THE PLASTICITY OF 10GN2MFA STEEL IN REPEATED HEATING

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10GN2MFA steel is extensively used in the manufacture of large power units of nuclear power stations. This steel is characterized by high strength and plasticity due to optical alloying of the solid solution and to high deep-hardening properties.

It has been established [1] that after repeated heating to 600-650°C and thermal welding (annealing to eliminate welding stresses) the plasticity of the 10GN2MFA steel decreases. This is due to the separation of special vanadium and molybdenum carbides at 600-650°C, to the dispersion hardening of the grain body caused by relative softening of the grain boundaries, and to the localization of plastic strain on the boundaries during stress relaxation.

In the manufacture of vessel parts the 10GN2MFA steel is subjected to high-temperature technological heating processes (in welding, forging, stamping, heat treatment) which results in the austenite grain growth and in the formation of metastable structures during cooling.

In the work being described we have investigated the effect of the austenitization conditions on the properties of 10GN2MFA steel subjected to repeated heating.

The investigation was carried out on 80 × 25 × 200-mm plates made from commercial 10GN2MFA steel remelted by the electroslag process (0.090% C, 0.14% Si, 0.78% Mn, 0.13% Cr, 1.9% Ni, 0.42% Mo, 0.036% V, 0.012% Al, 0.008% S, and 0.01% P).

The plates were heated in laboratory furnace by selite heaters to 900, 1000, and 1200°C with the temperature maintained for 3 h and subsequently cooled in water and air. The mechanical properties were determined in tensile tests on standard 5-fold 6-mm diameter specimens at 20, 500, 600, and 650°C.

The rise of the austenitization temperature from 900 to 1200°C resulted in an increase of the austenitic grain size and in a reduction of the strength properties at room temperature (Fig. 1a). The dependence of strength properties of hardened 10GN2MFA steel at elevated temperatures on the preliminary austenitization temperature is extremal. The maximum yield point (at 500°C it is 645 MPa, at 600°C it is 545 MPa, and at 650°C, 480 MPa) is connected with the dissolution of secondary dispersion phases in austenite at 1000°C.

The reduction of strength and plasticity characteristics of the 10GN2MFA steel (Figs. 1a and 1b) at rising austenitization temperature from 1000°C, and to 1200°C can be attributed to...
Fig. 1. Effect of austenitization temperature (cooling in water) on mechanical properties after repeated heating of 10GN2MFA steel specimens: a, b) $V_{st} = 2$ mm/min; c) $V_{st} = 0.062$ mm/min; e) test temperature 650°C; o) 600°C, A) 500°C, D) 20°C.

<table>
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<th>Annealing temp., °C</th>
<th>Duration of annealing, h</th>
<th>$\sigma_a$</th>
<th>$\sigma_{0.2}$</th>
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<th>$\psi$</th>
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