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THE EFFECT OF SOLUTION TREATMENT REGIME ON TEMPERATURE DEPENDENCE OF 0.2% OFFSET YIELD STRENGTH IN V-ALLOYED HIGH-NITROGEN AUSTENITIC STEEL

[1]Astafurova E.G., [1]Maier G.G., [1]Moskvina V.A., [1]Melnikov E.V., [1]Astafurov S.V., [1]Gordienko A.I., [1]Mironov Yu.P., [1]Galchenko N.K., [2]Smirnov A.I., [2]Bataev V.A.

[1]Institute of Strength Physics and Materials Science SB RAS, Tomsk, Russia

[2]Novosibirsk State Technical University, Novosibirsk, Russia

We investigated the effect of solid solution temperature (1100°C and 1200°C) on microstructure, phase composition and temperature dependence of 0.2 offset yield strength, $R_{0.2}$, in the temperature range of 77 K to 673 K for high-nitrogen austenitic Fe-19Cr-21Mn-1.5V-0.3C-0.9N (wt. %) steel. Two sets of steel bars were hot-rolled at 1150ºC steel following by air cooling. Specimens were 1h-solution-treated at 1100°C (HNS1100 specimens) and 1200°C (HNS1200 specimens) and water-quenched. Uniaxial tension of the specimens was carried out in a wide temperature interval (77-673) K at strain rate of 1×10^{-4} s^{-1}.

After SS-treatment, steel possesses fine-grained austenitic structure with the mean grain size of d=9.9±6.0 μm for HNS1100 and d=10.9±4.8 μm for HNS1200. The reflections corresponded to γ-phase only were evaluated using XRD researches and the volume fraction of precipitates is less than 5%. According to TEM research, steel possesses mainly austenitic structure with (V,Cr)(N,C) precipitates, which are randomly distributed as along grain boundaries as in grain bodies. In HNS1100 specimens, particles based on Cr_2N were rarely observed, and they dissolved with increasing in SS temperature. The mean size of (V,Cr)(N,C) precipitates slightly increases with increase in SS temperature, because of primarily dissolution of small particles during treatment, but total volume fraction of the particles gets lower. Therefore, a partial dissolution of (V,Cr)(N,C) particles also happens at higher SS temperature (1200°C). The lattice parameter of the austenitic phase changes with variation of SS treatment: the value a_γ=3.6340 Å for HNS1200 is higher than that for HNS1100 specimens, a_γ=3.6300 Å. This fact testifies to increase in concentration of solute atoms in austenite with growth in SS-temperature.

Decrease in test temperature below room temperature is accompanied by a substantial growth of $R_{0.2}$-value. The effect of different strengthening mechanisms on yield strength can be formulated by complex influence of lattice fraction stress, σ_0, particle strengthening, σ(PH), grain boundary strengthening (Hall-Petch effect), $\sigma(d)$, and solid solution hardening, σ(SS):

$$R_{0.2}=\sigma_0+\sigma(\mathrm{PH})+\sigma(d)+\sigma(\mathrm{SS}).$$

The increase in SS-temperature weakly changed grain size of the steel. Therefore, the increase in $R_{0.2}$-value during change in SS-temperature can be associated mainly by SS hardening and particle strengthening:

$$\Delta R_{0.2}=\Delta\sigma(\mathrm{PH})+\Delta\sigma(\mathrm{SS}).$$

The strong temperature dependence of the $R_{0.2}$ was observed for both treatment regimes. A yield strength drastically increases in low-temperature deformation regime (below room temperature) of steel quenched after SS treatment at 1100°C. Increase in SS temperature provides partial dissolution of precipitates and increases concentration of interstitial atoms in solid solution of austenite, which promotes to further increase in $R_{0.2}$-values in whole temperature interval. On the basis of microstructural parameters, estimated from XRD and TEM data, it was shown that the growth in the yield strength is associated with joint hardening and softening effects: increase in solid solution hardening of austenite, $\Delta\sigma(\mathrm{SS})>0$, and decrease in particle strengthening at the expense of increase in SS-temperature, $\Delta\sigma(\mathrm{PH})<0$.

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