Heat treatment of pipe makes it possible to improve the structure of the weld seam and thus substantially increase the mechanical properties and corrosion resistance.

"Black" quenching of pipe in air is used at the present time. The scale formed is enriched in alloying elements, while the metal beneath the scale is impoverished in these elements.

After quenching, the pipe is subjected to pickling and brightening.

Considering the relatively high quenching temperature of 1050–1100°C and the necessity of long holding (30 min), it is logical to heat treat pipe in a protective atmosphere.

Hydrogen or dissociated ammonia (75% H₂, 25% N₂) are used as protective atmosphere in quenching steel Kh18N10T. Dissociated ammonia is used more often, since the cost of hydrogen is two or three times higher.

The deciding factor in heat treating chromium-nickel steels in atmospheres of the H₂-N₂ type is the following reaction:

\[
\begin{align*}
2/3 \text{Cr} + H_2O & \rightleftharpoons 1/3 \text{Cr}_2O_3 + H_2, \quad K = \frac{P_{\text{H}_2}}{P_{\text{H}_2O} \times a_{\text{Cr}}^{2/3}}; \\
2/3 \text{Cr} + 1/6 \text{N}_2 & \rightleftharpoons 1/3 \text{Cr}_2\text{N}; \\
4 \text{Cr} + 2\text{NH}_3 & \rightleftharpoons 2 \text{Cr}_2\text{N} + 3\text{H}_2,
\end{align*}
\]

where \( a_{\text{Cr}} \) is the activity of chromium in steel Kh18N10T.

With reduction of the temperature the equilibrium constant of reaction (1) increases rapidly, assuming enormous values when the temperature at which the pipe is withdrawn from the furnace is 100–150°C.

However, the cooling rate, characterized by constant \( K' \), decreases exponentially with temperature, as follows:

\[
K' = 31.5 e^{-66000 / RT}.
\]

If it is assumed that the growth of the oxide film is described by a parabolic relationship then, according to Eq. (4), a film will be visible (temper colors) in 3 sec at 900°C, 45 sec at 800°C, and 410 sec at 700°C.

According to these data, thermodynamic equilibrium conditions cannot be attained at temperatures below 800°C, since the cooling rate is larger than the rate at which the film is formed.

At low partial pressures of oxygen and with the chromium activity smaller than unity (for example, with use of protective gases and actual steels instead of pure chromium) the formation energy of oxides decreases and the time increases.

If steel Kh18N10T is cooled in dissociated ammonia at 900-800°C at a rate of at least 3 deg/sec (a rate possible in the cooling chamber of a continuous furnace) then to obtain a bright surface it is sufficient that the gaseous medium satisfy the equilibrium constant of reaction (1) at 1100°C.

Thermodynamic analysis of reactions (2) and (3) at 1100°C indicate that Cr₂N is formed with a concentration of \( N₂ > 4\% \) and \( NH₃ > 0.001\% \).

The concentration of residual ammonia in the gaseous mixture at the outlet of the dissociator is 0.02-0.05%, and thus the thermodynamic probability of the formation of Cr₂N is fairly high.

In the presence of titanium or niobium the reaction capacity of NH₃ and N₂ increases still more.

The effect of residual ammonia can be prevented by use of the special TsÉChM-U absorber, which lowers the concentration of NH₃ to 0.001% and less.

The data concerning the effect of nitrogen on the corrosion resistance of stainless steels are contradictory. In small amounts nitrogen improves the resistance to intercrystalline corrosion of corrosion resistant Cr—Ni, Cr—Mn, and ferritic chromium steels [1]. Austenite is stabilized in austenitic steels with nitrogen.

The precipitation of nitrides causes impoverishment of austenite in chromium and nitrogen, the formation of ferrite, and incomplete combining of carbon with titanium, and therefore the form in which nitrogen exists in the metal is of considerable importance.

The corrosion characteristics of steel Kh18N10T in air if the steel has not been thoroughly degreased. The structure of the steel after black quenching and intercrystalline corrosion tests is shown in Fig. 1. Degreasing is particularly important with heat treatment in a protective atmosphere, since considerable carburizing occurs in a reducing atmosphere. With the use of dissociated ammonia, even when free of NH₃, titanium partly combines with nitrogen molecules and thus increases the susceptibility of steel Kh18N10T to carburizing. Therefore it is advisable to have a higher ratio of Ti/C for heat treatment of steel Kh18N10T in protective atmosphere.

Liquid ammonia is contaminated with oil, the concentration of which depends on the type of ammonia and the means of transporting it (tanks, cylinders, etc.).

According to [2], the concentration of oil in liquid ammonia used in heat treating stainless steels should not exceed 5 · 10⁻⁴%. Ammonia of this purity can be obtained in only a few plants in the USSR. No dependable commercial means exists for removing oil from ammonia. The oil, entering the dissociator, is transformed mainly into methane. The permissible amount of CH₄ in the gas can be calculated from experimental data [3] on the basis of Henry's law. The calculation indicates that if the concentration of CH₄ does not exceed 0.05% the carbon content of the steel amounts to 0.10%.

According to data in [4], a given carbon concentration is ensured with 0.01% CH₄ (in the given case the gas also contains CO and CO₂ in amounts of 0.02 and 0.002%, respectively).