

STUDY OF LAYER COMPOSITION DURING NITRIDING AND STEAM
OXIDATION OF COMPOSITE STEELS.*Sh.A.Berdiev – senior lecturer**Karshi Engineering and Economic Institute, Karshi*

Abstract. The article examines the structural and phase changes in surface diffusion nitride-oxide coatings obtained during nitriding in a gas environment followed by oxidation of ferrite-pearlite steels in water vapor, as well as the influence of phase changes on the corrosion properties.

Key words: *ferrite, pearlite, nitriding, oxidation, diffusion coating, nitride layer, corrosion resistance.*

Introduction. When the nitride layer is oxidized in the vapor of oxyethylidene biphonic acid solution by nitriding at a high nitrogen potential, in addition to iron, in the presence of carbon in the steel matrix, a high nitrogen nitride layer ϵ -phase ($Fe_{2-3}N$) can be obtained. As a result, the carbonitride ϵ' phase ($Fe_{2-3}(NC)$) is formed, and at the next stage, due to the dissociation of high nitrogen nitride by oxidation, creating a barrier oxide layer, the nitrogen layer carbonitride γ' -phase ($Fe_{2-3}(NC, \text{oxycarbonitride})$) consists of a mixture of ϵ'' -phase ($Fe_{2-3}(NSO)$), γ' -phase (Fe_4N) (Fig. 1).

Methods. As the duration of oxidation increases, the thickness of the oxide layer due to the release of dispersed nitride particles in the inner nitride zone and dissociation with the nitride zone leads to a mixture of ϵ' -, ϵ'' -phases and γ' - decrease in the thickness of the nitride layer (Fig. 1).

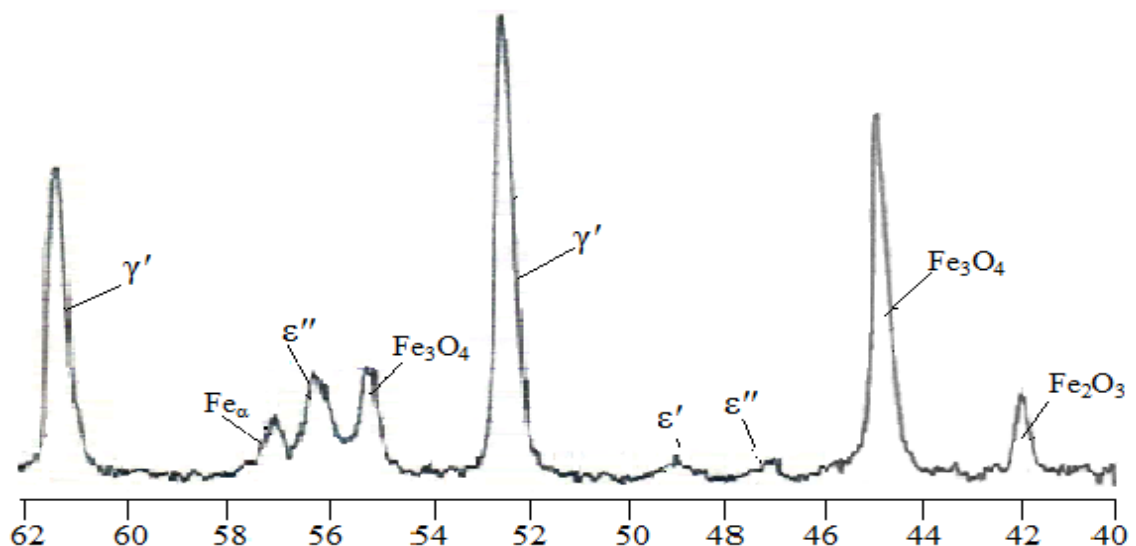


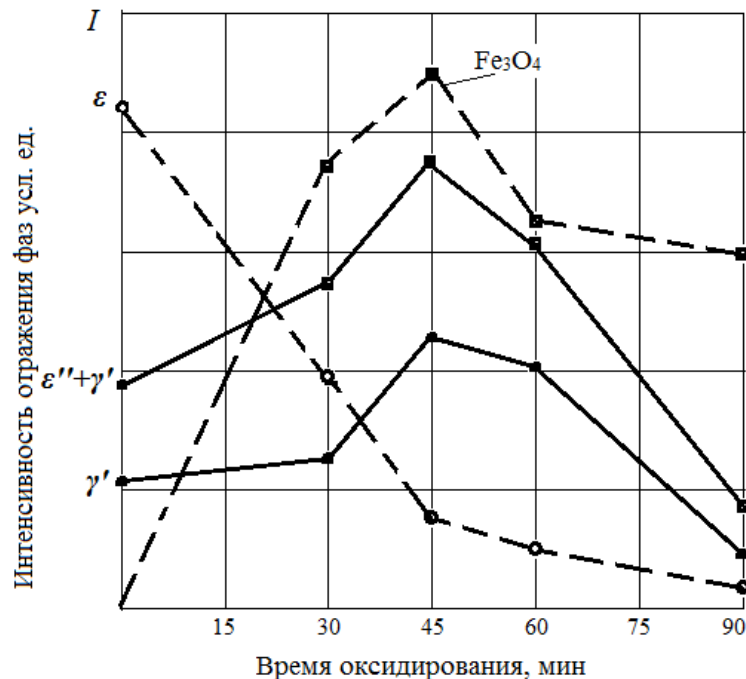
Figure 1. Diffractogram of the nitride-oxide coating surface

Nitriding and oxidation of Stal 45 at $580^{\circ}C$ for 3 hours, and nitriding and oxidation at $550^{\circ}C$ for 2.5 hours. *FeK α* radiation.

The desired structure and composition of the phase composition of the nitride phases in the nitride-oxide coating can be achieved by changing individual technological conditions at each stage of the nitro-oxidation process.

Results and its discussion

Dissociation of the γ' -phase takes place through the partial separation of the ε' -phase and the formation of a low-nitrogen ε'' -phase at the expense of carbon from the matrix, as well as the formation of the ε'' -phase at the expense of carbon and saturated atmospheric oxygen.



Picture. 2. Changes in the intensity of the $\varepsilon(101)$, $\varepsilon'+\gamma'(101)$, $\gamma'(200)$ and $Fe_3O_4(110)$ lines of the nitride layer depending on the duration of oxidation.

Nitriding of steel 45 at a temperature of $580^{\circ}C$ for 3 hours and oxidation at a temperature of $550^{\circ}C$. $FeK\alpha$ radiation.

By forming a barrier oxide film on the surface, it is possible to ensure interdiffusion of nitrogen in the nitride layer, which allows changing the concentration of nitrogen between the phases, thereby achieving the desired composition and structure of the composition of the nitride phases.

The nitrided part of the nitride-oxide coating can obtain an oxide layer with the desired composition of Fe_3O_4 , which is responsible for the formation of anti-corrosion oxide coatings on the surface of metal objects.

As a result, the ε -phase is present in the concentration range of 4.55-11% with the γ' -phase, and undergoes dissociation of nitrides during isothermal exposure. [1].

Currently, there is very little information about the effect of the quantitative ratio of ε - and γ' -nitrides on the physico-chemical and physico-mechanical properties of the joint zone. At the same time, for the layers of compounds with a large proportion of the γ' -phase, it is possible to determine a higher corrosion resistance than the layers with a higher proportion of ε -nitrides in the composite nitride-oxide coating [2].

In the first stage of nitrification, nitrogen dissociation rate (nitrogen potential) during nitrogen oxidation at a temperature of $580^{\circ}C$ according to the regime of two-stage change: $\alpha = 30-45\%$ in 1 hour and $\alpha = 45-60\%$ in 2 hours (total duration 3 hours) and in the second step, after oxidation at $550^{\circ}C$ for 1 hour, a nitride layer is obtained, which is as follows:

- ε -phase, $\varepsilon+\gamma'$ -phase, γ' -phase, as well as the surface layer of Fe_3O_4 oxide (Fig. 2). [3].

A wide range of individual nitride phases lies between the saturation temperature and the eutectoid temperature of nitridation. By changing the degree of dissociation of ammonia on the surface of the treated part, it is possible to achieve the formation of high-nitrogen ϵ -phase, γ' -phase and supersaturated or low-nitrogen α -solid solution. In particular, stable nitrides consisting of separate phases are formed at wide dissociation levels in the temperature range of 560-580°C. [4].

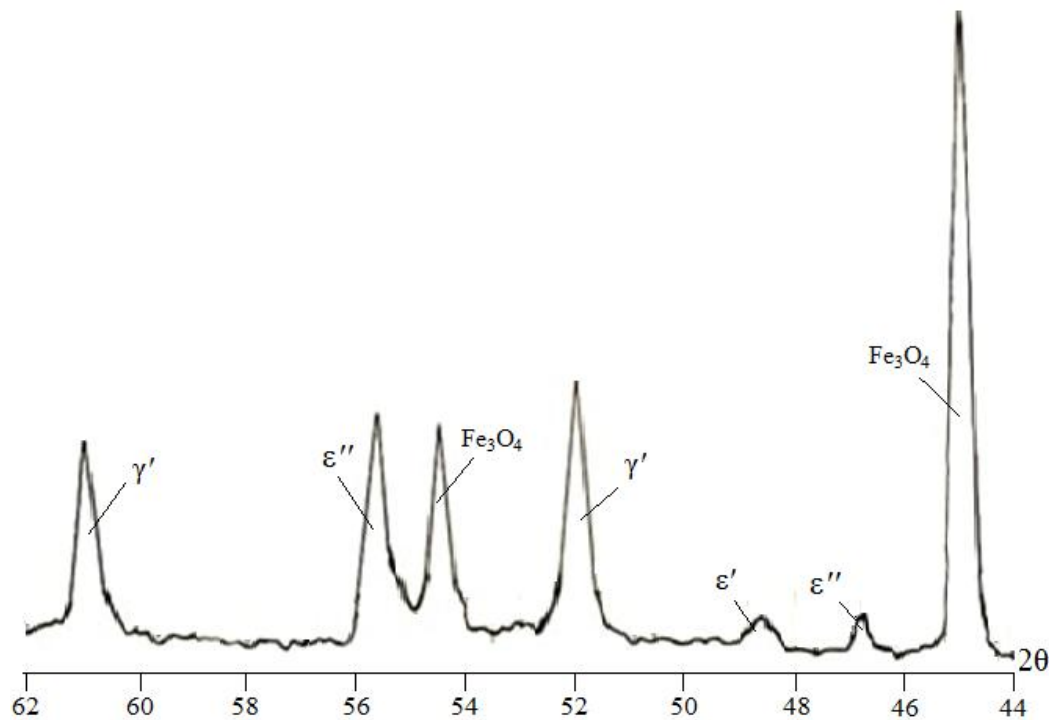
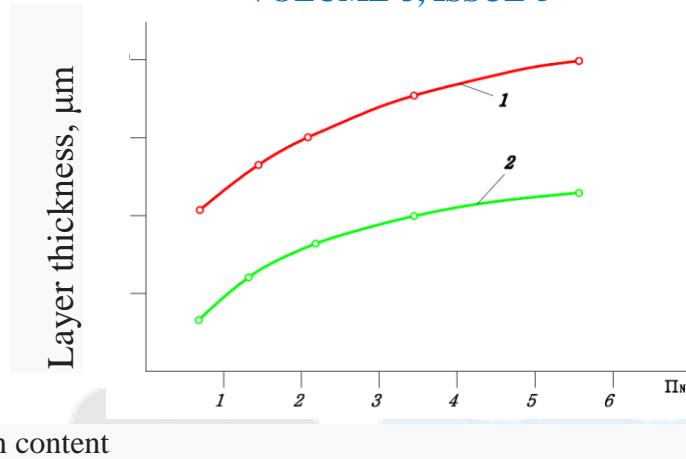


Figure 3. Diffractogram of the nitride-oxide coating surface

Nitriding at a temperature of 580°C in a two-step change in the degree of dissociation of Stal 45: 2 hours at $\alpha = 30-45\%$ and 1 hour at $\alpha = 45-60\%$ (3 hours in total) and 1 hour at 550°C oxidation. It is cooled in a vessel to 400°C, and then in oil. $FeK\alpha$ radiation.

Regulating the phase composition of the nitrided layer is also achieved by changing the nitrogen potential of the saturated atmosphere [5]. By keeping the nitrogen potential at the level of nitrogen solubility in one or another phase, it is possible to form γ' -phase (low nitride) or ϵ -phase with low nitrogen content on the surface. It is known from the obtained data that the thickness of the formed diffusion nitride layer increases with the increase of nitrogen potential. Therefore, the sample saturation conditions can be selected based on obtaining an optimal non-porous quality ϵ -phase during the nitriding step (Fig. 3) [6].



Nitrogen content

The saturation temperature is 580°C, the duration is 3 hours.

1 – the total thickness of the nitride layer; 2 is the thickness of the high-nitrogen ϵ -phase.

Figure- 4. Change of the total thickness of the nitride layer depending on the nitrogen potential of the atmosphere during nitriding

At $\pi_H > 1$ values of nitrogen potential, a quality nitride layer consisting of ϵ - and $(\epsilon + \gamma')$ - phases is obtained on the surface; with a further increase in nitrogen potential, the nitride and high-nitrogen ϵ -phase in it increase accordingly. As the nitrogen potential increases to $\pi_H < 6$, the share of the γ -phase in the nitride layer decreases, and the ϵ -phase increases. According to the phase composition of ϵ - and $(\epsilon + \gamma')$ -phases, the optimal nitride layer is formed at nitrogen potential values from 2 to 4. [7].

An increase in the thickness of the nitride layer results in blocking the diffusion of nitrogen through the nitride layer. If it is necessary to increase the duration of nitridation, due to the increase in the percentage of nitrogen potential, when $\pi_H > 5$ exceeds the high nitrogen nitride layer, the brittleness of the layer and the porosity of the ϵ -phase are determined.

Oxidation in the first stage of nitriding, reducing the duration of the nitriding process, saving ammonia and reducing the amount of nitrogen in the ϵ -phase, which increases the density of the nitride layer and reduces its brittleness.

The atmosphere in the furnace does not directly affect the process of deep absorption of nitrogen from the nitride layer to the metal surface, in this case the temperature and composition of the processed material (the amount of carbon in the steel matrix) are the decisive factors [8].

The potential of the atmosphere is then realized by reducing the amount of ammonia supplied to the furnace to a minimum and increasing the degree of dissociation.

During nitrogen saturation, a sufficient concentration gradient of nitrogen appears in the nitride layer for further diffusion processes to occur, and in the second stage of saturation, under conditions of reduced nitrogen potential, they can separate in two directions until equilibrium is reached:

Nitrogen is deeply absorbed from the nitride layer into the metal and diffuses into the external environment.

The atmosphere in the furnace does not directly affect the process of deep absorption of nitrogen from the nitride layer into the metal, in this case the temperature and composition of the processed material (the amount of carbon in the steel matrix) are the decisive factors [9].

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