INFLUENCE OF NICKEL AND NITROGEN ON THE STRUCTURE, PRODUCTION PROPERTIES, AND MECHANICAL PROPERTIES OF HIGH-CHROMIUM FACED METAL

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Materials faced on the surface of parts operating in friction in aggresive media must have high hardness [1]. In the majority of cases the faced metal has high hardness in the original condition after facing, which frequently makes machining of faced surfaces difficult. As a rule, such materials are technologically difficult in facing since they require the use of special production measures for the prevention of crack formation including preliminary and accompanying heating, retarded cooling, etc.

A promising direction in the development of facing materials providing a sufficient level of production properties in facing and good machinability of the faced surfaces is the use of the effect of hardening of a high chromium austenitic—ferritic alloy during tempering as the result of formation of σ-phase [2].

The level of hardness of such an alloy is determined by the quantity of σ-phase in its structure (the more σ-phase, the higher the hardness but also the greater the brittleness and the lower the production properties). To obtain the high hardness reached as the result of alloying with σ-forming elements (as a rule, active ferritizers) in combination with sufficient production properties it is necessary to obtain the optimum ratio of austenite and ferrite in the structure of the alloy.

In this work a study was made of one of the possible means of regulation of the properties of a sigmatizing alloy — alloying of it with austenitizing elements for the purpose of increasing the plasticity to the level necessary for facing without preliminary and accompanying heating with preservation of the hardness necessary for service, over 40 HRC. The investigation was made on Kh32N8M2 alloy with a hardness of 50-52 HRC, which in facing without the use of special production measures is prone toward crack formation.

As austenitizing elements nickel (additional alloying) and nitrogen were used. The investigated alloy was faced on 12Kh18N9T steel (8-10 layers) with electrodes with type UONI-13 coating (calcium fluoride type alloying coating), which provided the obtaining of a certain chemical composition of the faced metal (Table 1).

The microstructure of the investigated alloys in the original condition after facing is shown in Fig. 1. The results of measurements made on a Ferritgehaltmesser 1.053 ferritometer (Institute Dr. Förster) showed that in comparison with Kh32N8M2 alloy in the alloys alloyed with nitrogen or nickel the quantity of austenitite is significantly greater.

The results of many investigations [3, 4, etc.] indicate that the austenitizing capacity of nitrogen is 20-30 times greater than of nickel but calculations show that for the investigated alloys it is only 8-12 times greater since a significant portion of the nitrogen is combined in carbides and carbonitrides. There is a qualitative difference in the character of the austenite formed: in the alloys alloyed with nitrogen the austenite has a rounded form while in those alloyed with nickel it has a rhomboid or acicular form.

With the change in the ratio of the austenite and ferrite in alloying of Kh32N8M2 alloy with the two elements there is an improvement in its mechanical properties, especially the plasticity, and the action of nitrogen is significantly more effective (Fig. 2). Therefore, not only the absolute quantity of austenite in the structure but also its disposition and form influence the mechanical properties. The rounded form and equilibrium distribution of the austenite constituent in the structure of the alloys alloyed with nitrogen are more favorable for plastic deformation than the acicular form of austenite in the alloys with nickel. This is especially important since the capacity of the metal to deform plastically may be to a certain degree a criterion of its reliability [5].

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TABLE 1

Alloy	Chemical composition, wt. %								Quantity of austenite after facing, %
	C	Si	Mn	Cr	Ni	Mo	N*	Ni*	
1(Kh32N8M2)	0,11	0,46	0,76	30,6	6,9	2,2	—	—	8...10
2	0,12	0,24	0,58	30,2	6,9	1,7	0,18	—	16...19
3	0,11	0,27	0,58	29,4	6,9	1,8	0,32	—	36...40
4	0,11	0,24	0,66	30,3	6,9	1,8	0,38	—	43...46
5	0,10	0,28	0,61	31,0	6,9	1,7	0,46	—	50...52
6	0,12	0,38	0,65	29,0	6,9	2,1	—	2,4	21...26
7	0,12	0,42	0,58	29,1	6,9	2,1	—	3,9	47.. 51

*Additional austenitizing alloy elements.
Note. In all cases the remainder is Fe.

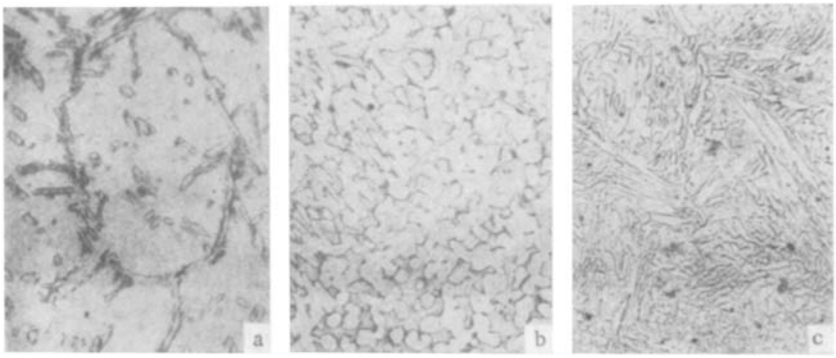

Fig. 1. Structure of faced metal in the original condition (after facing) (400 ×): a) Kh32N8M2 alloy; b) Kh32N8M2 alloy additionally alloyed with 0.46% N; c) Kh32N8M2 alloy additionally alloyed with 3.9% Ni.

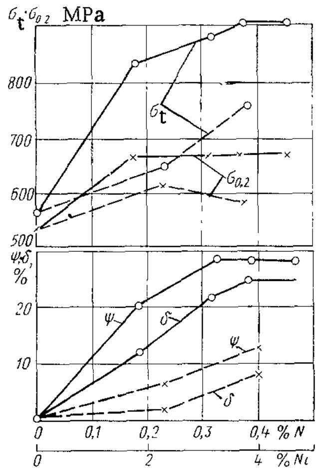

Fig. 2. Influence of nitrogen (solid lines) and nickel (broken lines) contents on the mechanical properties of faced Kh32N8M2 alloy.

The checking of the production properties in facing with alloys alloyed with nickel and nitrogen was done by the method used in fitting production, by facing of these alloys in a blind hole of a sample, where the criterion of acceptability of the material for facing of a fitting of a certain type is the absence of cracks in the sample. The plan of a typical sample is shown in Fig. 3. The rigidity of the sample is determined by the difference between

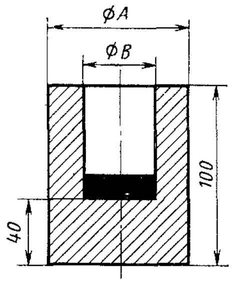

Fig. 3. Plan of a typical sample for determination of the production properties of a faced metal.

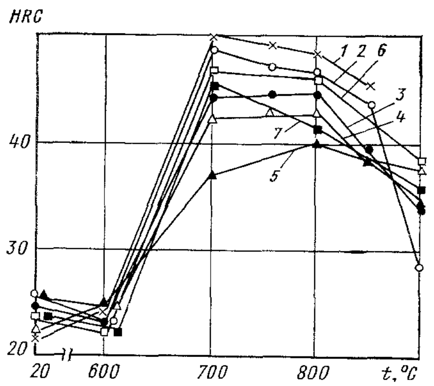

Fig. 4. Influence of nitrogen and nickel content on the hardness of type Kh32N8M2 alloy after tempering for 4 h at different temperatures. The numbers of the alloys are shown at the curves.

the outer A and inner B diameters. The facing of the samples was done without preliminary and accompanying heating with air cooling. A sample with diameters of A = 60 mm and B = 20 mm possesses the greatest rigidity. In facing of such a sample all of the faced surface is a molten pool. As the result of simultaneous circular solidification the maximum tangential stresses occur in the center of the sample, leading to crack formation.

The tests conducted showed that in metal containing 0.32% N and more, cracks do not form during facing, that is, the metal has good production properties in facing of a fitting with any diameter of nominal passage. The reserve of production properties of Kh32N8M2 in alloying of it with nickel is lower. The metal additionally alloyed with 3.9% Ni is resistant to crack formation only in facing of samples with diameters of A = 60 mm and B = 40 mm.

As was shown above, metal intended for operation in rubbing in aggressive media must possess a hardness of more than 40 HRC.

The influence of nitrogen and nickel content on the hardness of Kh32N8M2 alloy after tempering for 4 h at different temperatures is shown in Fig. 4.

While in alloying with nickel the reduction in hardness is determined by the quantity of austenite in the structure of the alloy, in alloying with nitrogen two factors influence the hardness of the alloy in sigmatizing, the interaction of the chromium carbonitrides with the solid solution in relation to tempering temperature and the quantity of austenite. In the structure of the alloys containing nitrogen, type $M_{23}(C, N)_6$ carbonitrides and chromium nitrides were detected by phase analysis. After tempering at 700°C with practically the same quantity of austenite the alloys alloyed with nickel possess a higher hardness than those alloyed with nitrogen. A reduction in the effective chromium content in the solid solution as the result of formation of carbonitrides and nitrides and also retarding of its diffusion by the nitrogen atoms dissolved in the ferrite lead to a decrease in the rate of formation of σ-phase [4-6], which strengthens the effect of reduction in hardness of the alloy. With an increase in tempering temperature, the rate of the diffusion processes increases and the effective chromium concentration in the ferrite increases as the result of dissociation of the carbonitrides. Therefore, with an increase in nitrogen concentration there is a tendency toward a shift in the maximum in hardness in the direction of higher tempering temperatures. The necessary level of hardness is reached in alloys the structure of which contains less than 50% austenite.

Analyzing the results of the investigation conducted it may be noted that the best combination of properties (high production properties with an acceptable reduction in hardness) is obtained in alloying the alloy with nitrogen. The optimum nitrogen content in type Kh32N8M2 alloy is 0.32-0.38.*

Therefore, to improve the production properties with an insignificant decrease in hardness after heat treatment it is more desirable to alloy the investigated facing alloys with nitrogen than to increase the nickel content in them.

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