

CUTTING TOOL CARBONITRIDING IN SALT BATHS

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UDC 669.155.3:621.9.02:621.78.066.6

It has been established that nitriding (gas nitriding with or without additions of carbon-containing gases and others) increases the wear resistance of cutting tools. However, the disadvantage of these processes is their high cost, the complexity of operating equipment, and insufficient productivity.

There are undoubted advantages in using low-temperature liquid processes for impregnating the surfaces of steel cutting tools with nitrogen and carbon using nontoxic salts, i.e., cyanates and carbonates. These processes are well known under the name of "Carbonitriding"* (USSR), "Tenifer-1" (FRG), "Melonite" (USA), and others.

According to [1, 2] there are large numbers of installations for liquid impregnation operating in factories of many countries, pointing to the high reliability and low production cost of these processes.

In our country also carbonitriding of fast-cutting tool steels is used successfully and with considerable technical and economic effect [7]. However, in spite of considerable quantitative data about the theoretical bases and technology of this process [3-6] sometimes there are unacceptable incorrect departures from optimum schedules. This reduces its effectiveness or leads to undesirable results [8]. One of the technological faults is substitution of the complete carbonitriding cycle by exposure in molten potassium cyanate for a certain time. It should be noted that the carbonitriding process involves a series of successive operations: degreasing, preheating the tool to 300-350°C, heating in molten potassium cyanate (containing 15-25% potash) at 540-560°C with continuous aeration at a rate of 2-3 liters/h per kg of melt, slow cooling and transfer of the tool to molten sodium hydroxide and sodium nitrite at 300°C in order to produce a marketable article and complete breakdown of $[CNO^-]$ or $[CN^-]$ ions, then water washing followed by drying and oiling.

Bath aeration makes it possible to obtain uniform results independent of the depth of immersion of the tool in the melt, and the presence of oxygen in the air prevents formation of $[CN^-]$ ions in the bath.

Use of titanium vessels makes it possible to prevent formation in the bath of $K_4[Fe(CN)_6]$ type compounds of iron which have a deleterious effect on the structure of carbonitride layers.

Considering the possibilities for carbonitriding in industry the N. É. Bauman Moscow Higher Technical College and the Scientific-Research Institute of Work Hygiene and Occupational Diseases studied this process with the aim of determining optimum schedules for carbonitriding and the level of harmful effects on working conditions and the environment.

Technological parameters for the carbonitriding process are given below.

KCNO content in the bath, %	75-85
K ₂ CO ₃ content in the bath, %	15-25
Melt temperature, °C	530-570
Aeration of the melt, liter/h per kg of melt	2-3
Vessel and equipment material	Titanium and its alloys
Treatment time for a tool in the bath (depending on shape of the tool treated), min	5-30

A necessary condition for carbonitriding is maintenance of a given level of $[CNO^-]$ ions in the bath since during operation oxidation of cyanate occurs in the bath accompanied by accumulation of potassium carbonate in the melt:

* Inventor's Certificate No. 576350.

TABLE 1

Sampling point	Concentration, mg/m ³		
	minimum	maximum	average
In the exhaust system (without ventilation or melt aeration)	0,13/0,002	0,4/0,06	0,26/0,036
In the exhaust system (with ventilation and without melt aeration)	0,13/0,012	0,6/0,11	0,31/0,04
In the exhaust system (with ventilation and melt aeration)	0,25/0,008	0,5/0,045	0,41/0,014
In the exhaust system (without ventilation and with melt aeration)	0,13/0,023	0,6/0,076	0,34/0,051
Beside the furnace with open shutters	0/0,012	0/0,05	0/0,027
Beside the furnace with closed shutters	0	0	0
Neutral points.	0	0	0

Notes. 1. No hydrogen cyanide was quantitatively detected.
 2. Number of samples was 15.
 3. The numerator gives nitrogen oxide concentration, and the denominator trivalent chromium.

As a result of this reaction the activity of the bath decreases and it thickens.

In order to rejuvenate the bath and to top it up after salt removal with the tools it is necessary to periodically add additional portions of cyanate and also special organic compounds, e.g., melamine for chemical conversion of carbonate to cyanate, and this makes it possible to maintain the concentration of $[\text{CNO}^-]$ ions at a given level and eliminates the necessity of removing potash from the bath.

Addition of new salt portions to the bath is based on chemical analysis data for the melt.

Carbonitriding may be carried out on different tools made from steels whose tempering temperature during normal heat treatment is not below 520°C.

The resistance to brittle fracture of surface layers on carbonitrided fast-cutting steels is much higher than for nitrided steels.

An increase in surface layer ductility is to a considerable extent facilitated by soaking the tool in molten $\text{NaNO}_2 + \text{NaOH}$ at 300°C after carbonitriding.

Numerous industrial tests on tools showed that their endurance after carbonitriding increased by a factor of two to five.

It should be noted that carbonitriding may be carried out in any heat treatment shop where there are normal conditions for operating furnaces and baths with appropriate ventilation.

Analysis of the atmosphere over salt baths used for carbonitriding tools and components was carried out in a number of factories.

The level of air pollution was evaluated with different bath operating schedules with minimum and maximum heating for the potassium cyanate bath, also with the ventilation switched on and off, and with or without aeration.

Air sampling for hydrogen cyanide concentration was carried out at a rate of 0.8 liter/min over 40 min; for nitrogen oxides it was 0.1 liter/min for 15 min, and for trivalent chromium it was 10 liter/min for 10 min.

Studies carried out showed that even in the exhaust system no hydrogen cyanide was detected (Table 1), and the concentration of nitrogen oxides and trivalent chromium was much lower than the tolerable limit.

Determination of the level of wash and waste water pollution showed that cyanides were absent with the carbonitriding schedules used. If the carbonitriding procedure is not followed exactly then a certain amount of

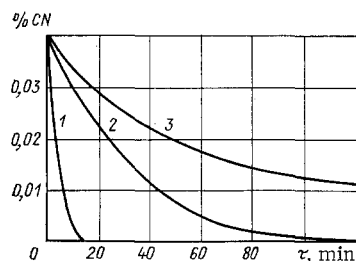


Fig. 1. Decomposition kinetics for cyanides in oxidation baths: 1) molten NaOH + NaNO₂ (300°C); 2) aqueous solution of NaOH + NaNO₂ (150°C); 3) molten NaNO₂ + NaNO₃ (400°C).

cyanide water pollution may occur. With insufficient or no aeration of the melt it is possible to accumulate small amounts of CN⁻ ions, as a result of which it becomes necessary to neutralize waste waters. However, this may be avoided by using a cooling bath operating at 300°C. In this case complete decomposition of CNO⁻ and CN⁻ ions is guaranteed in 20 min (Fig. 1), and tool cooling in the melt after carbonitriding guarantees a good quality treated surface in a commercial form.

Thus, carbonitriding in molten potassium cyanate is not dangerous for the health of operators.

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BORIDING STEEL 38KhNM WITH THE USE OF HIGH-FREQUENCY CURRENT HEATING

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UDC 621.785.539:661.65:621.785.545

Intensification of processes for impregnating metals and alloys during chemicothermal treatment (CTT) is of considerable theoretical and also practical value. In view of this electrical heating, particularly high-frequency current heating (HFC), is widespread [2, 3].

Currently impregnation of working surfaces with boron is used extensively to obtain coatings for operation in corrosive agents, at elevated temperature, and for increased wear resistance. However, formation of a boride eutectic has not been sufficiently studied.

The present study concerns a process for obtaining a boride eutectic coating on steel 38KhNM using HFC heating, its structure, formation, kinetics, microhardness, phase content, and also the effect of a boride eutectic layer on steel mechanical properties and wear resistance.

Boriding was carried out on pipes of steel 38KhNM with a diameter of 55 mm and length of 200 mm with a 5 mm wall thickness. Heating was accomplished by means of an industrial high-frequency generator VChI

Moscow Institute of Steels and Alloys. Translated from *Metallovedenie i Termicheskaya Obrabotka Metallov*, No. 4, pp. 23-24, April 1981.