TECHNOLOGY FOR HEAT TREATMENT OF ENGINE VALVES OF VAZ PASSENGER CARS

A. N. Cherdantsev, A. N. Makar'ev, V. P. Akhant'ev, and I. N. Kapfina

In operation, valves are subjected to high dynamic loads and high temperatures. The fitting camfers of the valve and the ends of its rod are affected by an impact load at the moments when the valve is closed and when it begins to open. The rod and the head of the valve are subjected to the action of variable tensile stresses and bending moments of the springs and to the gas pressure [1].

The surface of the head comes in contact with gases whose combustion products attain a temperature of 2100°C. The surface temperature of the inlet valve head increases to 250 – 450°C in operation and that of the discharge valve can attain 700 – 950°C. These operating conditions have a negative effect on the properties and geometrical dimensions of the valves, causing erosion and gas corrosion of the surface and warping of the head. The development of these processes can result in poor fitting of mating parts and sticking of the valve in the guide bush. The side surface of the valve rod wears in the case of insufficient lubrication and in the presence of carbon particles, combustion products, oil, scale, and salts in the clearing [1].

Taking into account the special features of their operation the valves are manufactured from high-temperature (scale-resistant) steels and alloys that resist chemical damage of the surface in gaseous media at a temperature exceeding 550°C. The higher the content of Cr, Al, and Si in the metal the higher its scale-resistance, operating temperatures, and stability in sulfur-containing media [2].

Valves of the gas-distributing mechanism of VAZ passenger cars are made of scale-resistant high-temperature steels. The inlet valve is produced from steel 40Kh9S2, the head of the discharge valve is made from steel 55Kh20G9N4A (EP303) with a fused-on camfer made of steel EP616A, and the feet are produced from steel 40KhGNM (see Table 1) [3].

The operating capacity of the valves is improved substantially by heat treatment.

INLET VALVE

The technological process for the inlet valve (steel 40Kh9S2) consists of the following operations:

1. cutting preforms from rods 23 mm in diameter (with heating in an induction heater to 500 – 650°C);
2. heading on a 700-ton press at 1150 – 1180°C (heating in an inductor by a high-frequency current to 1130 – 1180°C);

TABLE 1

<table>
<thead>
<tr>
<th>Steel</th>
<th>Content of elements, %</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>Mn</td>
</tr>
<tr>
<td>40Kh9S2 (TU 14-1-3795-84)</td>
<td>0.37 – 0.48</td>
<td>0.30 – 0.60</td>
</tr>
<tr>
<td>55Kh20G9N4A (EP303) (TU 14-1-3241-81)</td>
<td>0.50 – 0.60</td>
<td>8.0 – 1.0</td>
</tr>
<tr>
<td>40KhGNM (TU 14-1-3271-81)</td>
<td>0.37 – 0.43</td>
<td>0.50 – 0.80</td>
</tr>
<tr>
<td>616A (TU 6-261)</td>
<td>0.70 – 1.2</td>
<td>&lt; 0.40</td>
</tr>
</tbody>
</table>

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Fig. 1. Welding zone of a discharge valve, × 5.

Fig. 2. Head of a discharge valve after "freezing-in" ÉP616A alloy, × 5.

Fig. 3. Microstructure of the fused ("frozen-in") layer of the head of a discharge valve, × 100.

(3) preliminary heat treatment, namely, annealing in a through muffle-free furnace in an atmosphere of exogenic gas at 680 – 700°C for 3.5 h in order to obtain a structure of spheroidized pearlite with a hardness of 23 – 35 HRC₆;

(4) preliminary mechanical treatment, straightening of the preform, and cutting over the length;

(5) stabilizing annealing at 600 – 620°C with a total hold time of 2.5 h (for removing stresses and eliminating warping in the nitriding process);

(6) mechanical processing to the basic geometric dimensions;

(7) ion nitriding;

(8) mechanical sizing;

(9) hardening of the rod ends with heating by an HF current in the line for mechanical processing of parts; the power of the installation is 30 kW, the frequency is 440 kHz, the inductor is bipositional; in each position the part is held for 3 sec; in the first position it is heated to 850 – 870°C, in the second position to 1050 – 1070°C;

(10) controlling the quality of the hardening with respect to two parameters, namely, the hardness of the end face and the thickness of the hardened layer.

For steel 40Kh9S2 the surface hardness should be at least 50 HRC₆. The thickness of the hardened layer should be 1.5 – 3.0 mm. The hardness of all the parts is controlled in an automatic installation built into the line.

The thickness of the hardened layer is controlled visually from microscopic polished sections. The control is conducted once in a shift and additionally after each corrective adjustment of the installation.

DISCHARGE VALVE

The discharge valve consists of two parts, namely, a head of steel S5Kh20G9N4A and a rod of steel 40KhGNM. It is manufactured using the following technological operations.

Head:

(1) cutting a rod preform 21 mm in diameter (with heating in an inductor to 650 – 700°C);

(2) heading on a 700-ton press at 1150 – 1180°C (heating in an inductor by a high-frequency current to 1130 – 1180°C);

(3) annealing in an atmosphere of endogenic gas at 870 – 890°C with a total hold time of 3 h (to a hardness of 30 – 35 HRC₆) .

Rod:

(1) cutting a rod preform 8.7 mm in diameter;

(2) hardening treatment (hardening in an endogenic gas from 850 – 870°C with a 1-h hold and tempering at 560 – 580°C for 1.5 h to a hardness of 28 – 35 HRC₆).

Discharge valve:

(1) welding the head and the rod on a frictional welding machine (Fig. 1);

(2) deburring (in a hot state);

(3) tempering and dressing (tempering of the weld at 500 – 600°C with subsequent straightening in the mechanical-process line);

(4) preliminary mechanical treatment of the preform and cutting it over the length;

(5) surfacing ÉP616A high-temperature alloy onto the functional camfer of the valve by the method of "freezing-in" in an atmosphere of protective gas on an automatic line using water as the cooling liquid;

(6) finishing mechanical treatment;

(7) ion nitriding;

(8) grinding of the sealing conical camfer;

(9) hardening the end of the rod after heating by a high-frequency current in the line for mechanical treatment; the operation is conducted by a regime similar to that for the inlet

1 This operation is conducted in order to obtain a homogeneous microstructure and eliminate warping in the nitriding process.