SPECIAL FEATURES OF THE TECHNOLOGY FOR PARTS MADE OF ALUMINUM ALLOYS FOR NEW VAZ PASSENGER CARS

V. A. Ivlev

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The tendency for using aluminum alloys in the Volzhskii Automobile Plant is analyzed. The strengthening treatment of a complicated part, namely, a sixteen-valve head of a cylinder block, is considered. The special features in manufacturing pistons for new VAZ engines are described.

In the development of Zhiguli cars of a new generation special attention is devoted to parts made of aluminum alloys, which decrease the mass of the car. It is now considered expedient to produce car parts (of both the engine and the body) from aluminum alloys instead conventional steels and cast irons.

In European countries more and more parts are produced from aluminum alloys (on the average one automobile contains 50 – 70 kg of aluminum). VAZ is planning to use aluminum alloys for body parts, cylinder blocks, and cast wheel disks [1].

Alcan Aluminiumwerk Nurberg GmBH (FRG) has announced that the mass of parts made of aluminum alloys in engines of passenger cars of intermediate class amounts to 50 kg. A new U8 engine for Mercedes Benz has been developed in the FRG with a block made of aluminum alloys.

VAZ uses about 39 kg of aluminum alloys in its car of a similar class [1].

Today the company uses four aluminum alloys for casting preforms of various kinds. Experience of 25 years in using such parts in VAZ passenger cars has shown their reliability. Therefore, we believe it expedient to broaden the use of aluminum alloys in future models. The alloys have stable strength and technological parameters because they are produced from primary aluminum.

The chemical composition of aluminum alloys used in VAZ is presented in Table 1. AK12M2 is used for complicated and thin-walled parts cast under pressure, AK6M2 is used for the head of the cylinder block and the brake cylinder (permanent-mold casting), AK10M2N is used for pistons (permanent-mold casting), and AK9T is used for the exhaust pipe and the case of the steering system (permanent-mold casting).

The requirements on the properties of the materials for new cars have become stricter. This problem can be solved by two methods, namely, (1) by replacing the alloys traditionally used by new ones and (2) by improving the properties of existing materials.

The head of the cylinder block for VAZ 2103 and 2108 cars arrives at the assembling line in a cast state, i.e., without heat treatment.

The newly developed engines for the VAZ 2110, VAZ 2112 family are equipped with a new more complicated sixteen-valve head for the cylinder block with improved mechanical properties. For example, the hardness of this part should be at least 100 HB.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Content of elements,* %</th>
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<tr>
<td>Alloy</td>
<td>Si          Cu          Mg          Ti          Ni    Mn        Fe    Zn</td>
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<tr>
<td>AK12M2</td>
<td>11 – 13     1.8 – 2.5  –           –          –     –         1.1     –</td>
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<tr>
<td>AK6M2</td>
<td>5.5 – 6.5   1.8 – 2.3  0.3 – 0.45  0.1 – 0.2   –     –         &lt;0.6   –</td>
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<tr>
<td>AK9T</td>
<td>8.8 – 9.5   –          0.3 – 0.45  0.05 – 0.20 –     0.4 – 0.6  &lt;0.4   –</td>
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<tr>
<td>AK10M2N</td>
<td>9.5 – 10.5  2.0 – 2.5  0.8 – 1.2  &lt;0.05       0.8 – 1.2  &lt;0.05   &lt;0.6   &lt;0.06</td>
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<tr>
<td>AK12MMgN</td>
<td>11 – 13     0.8 – 1.5  0.8 – 1.3  –          0.8 – 1.3  &lt;0.2   &lt;0.7   &lt;0.2</td>
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*The remainder is Al.

Note. In addition to the listed elements AK12MMgN alloy contains at most 0.05% Pb and 0.01% Sn.
We studied the possibility of manufacturing a perform for this part from standard AK6M2 alloy (see Table 1) with subsequent heat treatment.

AK6M2 alloy is commonly treated by regime T6 (hardening with subsequent artificial aging) [2, 3].

We studied sixteen-valve heads of cylinder blocks produced by foreign firms. The hardness of these parts turned out to be 95 - 109 HB and the chemical composition of their material was close to AK6M2 alloy but had a lower iron content (0.12 - 0.19%). The low concentration of iron in aluminum alloys improves the fillability of the casting mold and decreases the susceptibility to cracking in casting and operation [4].

It has been established that a change in the magnesium content affects but little the hardness of the alloy in the cast state. If the casting has to be heat treated (hardened and aged), the content of magnesium should be maintained within 0.30 - 0.45%. The amount of the strengthening phase Mg2Si segregated in aging is sufficient only under this condition [2].

Castings subjected to hardening are placed onto the shelves of special mesh containers in a single row in a vertical position at a distance of at least 100 mm from one another. This provides uniform circulation of the hot air in heating for hardening, which is conducted in an electric furnace. The total mass of the charge is about 1200 kg. Castings in mesh container are placed in the furnace heated to 520 ± 5°C, are heated to the requisite temperature for 1.5 - 2.0 h, and are held for 4 h. The container with the castings is transported by an overhead crane to a tank with water heated to 90°C. This eliminates the appearance of “quenching” microcracks. In order to avoid interim cooling of the castings heated for hardening, the time of their transportation from the furnace to the water tank is strictly regulated and should not exceed 30 sec.

Aging of hardened castings is also conducted in an electric furnace. The castings are heated for 1 - 1.5 h to 225 ± 5°C and held at this temperature for 4 h. After the artificial aging the container with the castings is unloaded from the furnace by a crane, and the castings are cooled in still air.

The microstructure of AK6M2 alloy after hardening is presented in Fig. 1a. It consists of grains of α-solid solution (light) of medium size that group into individual blocks. After a full cycle of heat treatment the structure still contains grains of the α-solid solution (Fig. 1b) but the blocks are partially destroyed. A eutectic (α + Si + intermetallic compounds) is observed along grain boundaries of the α-solid solution.

We measured the hardness of castings for the head of the cylinder block after the heat treatment and determined the mechanical properties (σu and δ) for separately cast blank specimens heat treated together with the castings.

The technology described is used as a temporary variant. The project envisages a more progressive regime of heat treatment of heads of cylinder blocks combined with the operation of removing the rods from the castings. The internal cavities of the casts of the sixteen-valve head of the cylinder block are formed with the help of sand rods with furan resins. The removal of the rods by the conventional method in impact kicking-out devices can cause the appearance of microcracks, and therefore an individual (longer) regime is being developed for kicking out the rods.

Another part of the new VAZ cars that is of interest is the piston, whose cast preform is produced by a special technology developed in VAZ. A specific feature of it is that the combustion chamber on the bottom of the piston is formed during casting.

The piston is manufactured from AK10M2N alloy of the complicated multicomponent system Al - Si - Cu - Mg - Ni. The producer plants base it on primary aluminum and ship it in the form of selected ingots ready for use. Experience of many years at VAZ shows that the use of ready alloys in the form of ingots as a charge material has many advantages. For example, castings made of selected AK10M2N alloy have a stable chemical composition, and the technological process of preparing the melt is simplified substantially. In other automobile plants in Russia similar castings are produced from AK12MMgN alloy (AL30 in accordance with the old classi-