SINTERED COMPONENTS OF G12-2 DOUBLE-ACTING VANE PUMPS

L. S. Rabinovich, I. D. Radomysels'kii, V. N. Klimenko, and E. L. Pechentkovskii

The G12-2 double-acting vane pumps, which are intended for supplying pure mineral oils at operating pressures of up to 6.4 MN/m², are widely used in the hydraulic drives of hammers and presses.

The design of the G12-2 double-acting vane pump is illustrated in Fig. 1. The cast iron body 1 with the cover 2 houses the stator 3. On the inner, specially shaped surface of the stator slide the 12 vanes 4, which can move freely in the radial slots of the rotor 5. The latter is held on the grooves of the shaft 6, which rotates on ball bearings. Against the end faces of the stator 3 are pressed the plane distributing disk 7 and the disk 8 with a collar. The latter disk is of a floating type. At first it is held against the stator by the three springs 9 and during subsequent operation also by the oil pressure. The plane disk 7 has two suction openings 10 and the collar disk 8 two openings 11 for the delivery of oil. During the turning of the rotor, the vanes 4 are always forced by the oil pressure and the centrifugal force against the internal surface of the stator. Two full suction and delivery cycles occur during each rotor revolution.

A decision was taken to investigate the possibility of increasing the reliability and life of forging hammers and presses and their ancillary equipment. In this connection, an exploratory study was made of technological measures capable of increasing the life of the G12-2 double-acting vane pumps. Experience with the operation of these pumps has shown that their service life depends on the wear resistance of their stators and disks, which operated under severe friction conditions [1, 2].

The operating conditions of these components are as follows. The vanes 4, which are made of R18 steel (0.7%C, 4%Cr, 18%W, 1% V high-speed steel, 62-64 Rockwell C hardness) and against the end faces of the distributing disks 7 and 8 from 20Kh steel (59 Rockwell C hardness) at a velocity of 2.5 m/sec. In addition, the surfaces of the distributing disks are subject to annular wear due to rubbing against the revolving rotor 5. The configuration of the pump components operating under intensive friction conditions is shown in Fig. 2.

The wear resistance of a rubbing pair depends to a large extent on the mechanical and physicochemical properties and structure of the metals from which the rubbing components are made. The life of the stators and disks may be increased by utilizing new materials whose wear resistance under the conditions of operation of pump components rubbing against R18 steel from which the vanes are made is greater than that of ShKh15 and 20Kh steels.

One method of raising wear resistance is to produce a nonequilibrium structure on the friction surface. In the case of identical surfaces, steels with a structure composed of martensite and carbides are more wear resistant than steels of the same hardness having no excess carbides. Using the powder metallurgy methods it is possible to produce materials having a nonequilibrium structure within the microvolume limits. Individual structural constituents may be expected to exhibit substantial hardness variations at a high over-all macrohardness of materials. The pores in a sintered material, which may be regarded as a specific structural constituent, also contribute to structural heterogeneity. On the other hand, the pores promote relaxation of the stresses generated in an alloy during heating and heat treatment, which also increases its wear resistance.

With the aid of the powder metallurgy methods, it is also possible to decrease significantly the manufacturing costs of components by reducing both the amount of alloy steel required and labor expenditure on machining. With the existing method of manufacture of components from rolled stock, more than 60% of the alloy steel is converted into chips on machining.

On the basis of the above-mentioned principles of preparation of sintered wear-resistant materials, a choice was made of the chemical composition and the component manufacture technology. The chromium
Fig. 1. Design of G12-2 double-acting vane pump. Description in text.

Fig. 2. Vane pump components forming friction pairs in operation: 1) disk with collar; 2) plane disk; 3) stator; 4) vanes; 5) rotor.

content of 20Kh steel is 0.7-1.0% and that of ShKh15 steel 1.3-1.65%. This amount of chromium is insufficient to establish a heterogeneous structure in steel. For this reason the amount of chromium was raised to 3%, while the amount of carbon was kept the same as in ShKh15 steel (up to 1%).

The starting materials for the production of sintered pump components were PZh2M1 iron powder to GOST 9849-61 standard, chilled cast iron powder (3.1% total C), and Kh30 steel powder (31% Cr) prepared by the technique developed by the Central Scientific-Research Institute of Ferrous Metallurgy [3].

The principal characteristic of the production technology of this steel was that chromium and carbon were introduced in the form of high-alloy additions (Kh30 steel, cast iron). Because of the high chromium and carbon concentration in such additions, sintering for 2 h at 1200°C fails to secure a complete homogenization of the alloy, so that the material after sintering is characterized by nonequilibrium structure within the microvolume limits. In this structure, individual alloy grains with a high concentration of the alloying elements and a high microhardness are surrounded by grains with relatively low amounts of these alloying additions and a low microhardness. Such an alloy structure largely meets the requirements of Charpy's rule for antifriction materials. A significant difference in this case is that the structural constituents represent a high hardness level, so that the macrohardness of the alloy after heat treatment is very high [4].

The charge for the production of the components had the following composition: PZh2M1 iron powder 69.5%, cast iron powder 20.0%, Kh30 steel powder 10.0%, and pencil grade graphite 0.5%. The amount of