SUBMERSIBLE AXIAL-FLOW PUMPS FOR DREDGES

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Control of cavitation of pumps and an increase of their suction capacity became one of the main ways to increase the operating efficiency of dredges in recent years. It is known that for intake of a soil-and-water mixture with a high concentration from a depth of more than 10-12 m the positive suction head of the pump becomes insufficient [1], and for a soil excavation depth of 15-25 m it is required to increase the pressure at the pump inlet by 3-4 m \( H_{2O} \). Until recently this problem was solved by means of ejection, but for all the simplicity of this method the ejecting devices have a low efficiency. In the best models the efficiency of the ejector can be brought to 30-35%, but this is half that of a centrifugal pump [2].

At present this problem has begun to be solved by submerging a centrifugal pump underwater with its placement on the soil-intake frame of the dredge [1, 3]. However, in this case problems arise with the drive of the powerful unit underwater, and design changes of the dredge itself are inevitable in view of the shift of the center of mass of the soil-intake device underwater. Whereas it is possible to take into account these requirements in the design of a new dredge, in the case of modernizing existing dredges it is difficult to realize them and almost impossible in the case of keeping the cutter.

It is known that low heads of 3-8 m \( H_{2O} \) with large deliveries and high efficiency can be obtained by an axial-flow pump, but axial-flow pumps for pumping a soil-and-water mixture have not been developed in domestic hydraulicking practice. There are a number of foreign patents in this direction, but there is no information about their practical use. The expediency of developing axial-flow dredge pumps is based on the fact that at a small head the pump will have a small mass, substantial alterations of the dredge will not be required for its installation, and the small power will considerably simplify the underwater drive.

On the initiative of the article’s authors, in 1988 the Tver' Polytechnic Institute contracted with the hydraulicking trust "Energogidromekhanizatsiya" to develop a submersible axial-flow pump for a 350-50L dredge with a 20R-11M pump. The parameters of the axial-flow pump in the assignment was up to 5000 m\(^3\)/h with respect to delivery and 6 m \( H_{2O} \) with respect to head with a drive through shafting from an above-water electric motor at \( n = 6000 \) rpm.

At first a model of the pump was made and tested in the institute's laboratory. The model impeller included three blades, an outer rim along their tips, and cup packing on the rim to prevent leaking of the mixture. Water was fed into the cavity between the cup packings to squeeze out the soil particles.

As a result of the tests the characteristics of the models with various blade angles were recorded and the main technical decisions were checked. On the basis of this, institute workers S. P. Ogorodnikov, I. I. Mikheev, and A. E. Kulakov designed a submersible axial-flow pump OPGN 5000/6, which was manufactured in Moscow at the plant of the experimental industrial enterprise "Promgidromekhanizatsiya."

The fundamental decisions made for the model were repeated in the prototype pump (Fig. 1). The impellers were made with blades of ordinary foundry steel 35L welded to the rim and hub, the flow sections between blades were 180 mm like the main pump 20R-11M, the impellers were made with three different blade angles. The drive was from a commercial electric motor with \( n = 600 \) rpm and \( N = 250 \) kW through intermediate and main shafts in the pump housing. The total length of the shafting was about 7 m, which made it possible to submerge the pump to 4-5.5 m underwater. The supports of the shafting were made on rubber ship bearings and the thrust assembly was made on a rubber—metal collar bearing with forced water lubrication. The inlet pipe into the impeller and the cleanout had a diameter of 700 mm, the pressure branch was made with a transition to \( D_{nom} = 600 \) mm. Unlike the axial-flow water pump, the guide apparatus in the axial-flow dredge pump was not installed to reduce the probability of clogging its water passageway.
The pump, manufactured in 1989, was mounted on a dredge-test bed, where it underwent run-in with recording of the characteristic $Q-H-N-\eta$, shown in Fig. 2. The hydraulic efficiency of the pump was from 0.55 to 0.71, which should be considered normal in the absence of the guide apparatus and thickening of the blades.

Comprehensive field tests of the pump were carried out in 1990-1991 on a 350-50L dredge at the Cheboksary construction administration during hydraulic filling of embankments. The sand borrow bit was entirely underwater with an excavation depth to 21 m with an elongated frame of the dredge, the face was considerably cluttered with wood inclusions and bushes. An ejector—hydraulic ripper, developed by the All-Russian Research Institute of Nonmineral Construction Materials and Hydraulicking (VNIINerud), with a D2700/60 $N = 630$ kW pump was installed earlier on this dredge, after installing the axial-flow pump a D2000/30 $N = 250$ kW pump installed in the dredge’s hold was used.

The OPGN-5000/6 pump was installed on the frame of the intake device (Fig. 3) of the dredge without a change in its design, and the electric motor of the pump drive was mounted in its above-water part over the hinge. The dredge was equipped additionally with a set of instruments: induction flowmeter, segmental meter, consistometer, device for measuring...