DREDGE WITH AN EJECTOR

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One of the most important problems in the area of hydromechanization—an increase of the output of dredges—is inevitably associated with an improvement of the suction capacity of the suction dredge and with an increase of consistency of the mud. A possible solution to this problem when excavating sand and sand-gravel materials and when excavating from a depth exceeding 12-15 m is the use of the ejection principle, which greatly improves the conditions of excavation, suction, and transportation of the mud. Soviet and foreign experience indicates the efficiency of using ejectors on dredges operating under certain pit and service conditions.

Since 1966 the "Gidromekhanizatsiya" Trust of the Ministry of Assembly and Special Construction Works has been successfully using dredge ejectors designed by the All-Union Research Institute of Nonmetallic Building Materials and Hydraulic Mechanization. The unit consists of a centrifugal pump, tip (or head) with an ejecting device, and a pipeline conveying water from the pump to the tip of the suction pipe of the suction dredge. The pump is mounted on the deck of the dredge or on the frame of the cutter. The ejector head (Fig. 1a, b) is fastened to the suction pipe by the flange of diffuser 6. The water from the centrifugal pump passes through connecting pipe 4 of the pressure pipe into pipe space 3 formed by two coaxially arranged pipes 1 and 2. Passing through the pipe space, the water under pressure goes through circular opening 8 into the mixing chamber of the ejector head 9. To protect the hydraulic system against entrance of oversized materials (boulders, stones, sweepwood), the size of the mud-receiving hole 5 is made smaller than the size of the hydraulic transportation system.

Tests were carried out on one of the dredges of the Yaroslav Construction Administration of the "Gidromekhanizatsiya" Trust in 1966. A ZGM-1-350A suction dredge with an 820-mm-diam. impeller combined with an AK-13-62-8 motor, N = 650 kW, n = 740 rpm, was installed on the dredge. The ejection system consisted of a 12NDs pump with a motor N = 200 kW, n = 1450 rpm, and an ejector head.

The investigations were carried out in the following stages: a) recording of the characteristic of the ZGM-1-350A suction dredge; b) same for the 12NDs pump and determination of the rate of flow at different sections of the pressure pipe; c) recording of the characteristic of the ZGM-1-350A dredge operating with a circular ejector at different pressures in the pressure pipe of the pump (H\text{man} = 2, 3, 4 kg/cm²).

When recording the characteristics of the 12NDs pump (Fig. 2) the main motor of the dredge was disconnected and the suction pipe of the dredge was 2-2.5 m below the water level. The magnitude of the delivered flow, regulated by a slide valve, was varied in the range 100-1100 m³/h at a pump head that varied within 34-57 m (curve 1 in Fig. 2). As a result of the ejection effect a greater flow of water passed through the suction dredge into the pressure pipe of the dredge than from the pump of the ejector plant (curve 2 in Fig. 2). In the investigations this increase amounted to 13-15%, i.e., \( Q_2 = 1.13-1.15 Q_1 \), where \( Q_2 \) is the flow rate of water entering the pressure pipe during operation of the ejector pump (with the motor of the suction dredge disconnected), m³/h; \( Q_1 \) is the rate of flow entering the ejector from the 12NDs pump, m³/h; 1.13-1.15 are the coefficients of increase of the flow obtained under field conditions.

It is necessary to note that at some values of \( Q_1 \) and \( H \) (in the given case, 650 m³/h and 53 m water) ejection does not lead to an increase of flow in the pressure pipe of the suction dredge. The ejection effect is largely determined by the magnitude of the delivered flow and to a lesser extent by the magnitude of the head.

When recording the operating characteristics of the suction dredge working together with the ejector, the pressure in the pressure pipe of the ejector pump was maintained constant (Fig. 3, curves 2, 3, 4). As seen from the graphs, the flow of the suction dredge when working without the ejector changes from 1000 to 1600 m³/h and the head changes from 59.4 to 57.2 m water (curve 1 in Fig. 3). The lower branch of the characteristic curve of the suction dredge corresponds to cavitation conditions. When the ejector is switched on, the cavitation properties of the suction dredge improve and its suction capacity increases. The ejection effect greatly increases the flow.

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Fig. 1. Dredge ejector head. a) Basic diagram: 1, 2) coaxially installed pipes of the head of the suction pipe; 3) pipe space; 4) connecting pipe through which water enters from the centrifugal pump; 5) mud-receiving hole; 6) diffuser; 7) connecting pipe of hydraulic cutter; 8) circular opening; 9) mixing chamber of ejector; b) General view (the top tube is used as framing to increase the stiffness of the suction pipe. The pipe for delivering water runs along the side and is not seen in the photograph).

Fig. 2. Characteristic of 12NDs pump. 1) Operating characteristic of ejector plant pump without consideration of suction (flow was measured at the pump pressure pipe); 2) same, with consideration of suction (flow was measured at the pressure pipe of the suction dredge).

Fig. 3. Characteristic of ZGM-1-350A suction dredge. 1) Operation without ejector; 2) during operation with ejector and at a pressure of the pipeline conveying water of $H_{man} = 2$ kg/cm²; 3) same, at $H_{man} = 3.8$ kg/cm²; 4) same, at $H_{man} = 4$ kg/cm².

The vacuum in the suction pipe dropped considerably when the dredge was operating with the ejector. Under the test conditions the drop was 1.5-4 m, depending on the operating conditions of the suction dredge and ejector pump (at the same values of the flow). Thus, at a flow of 2000 m³/h, when only the suction dredge was operating, the vacuum was $H_v = 0.5$ kg/cm² (cavitation conditions). When the ejector pump with $H_{man} = 2$ kg/cm² was switched on, the reading of the vacuum meter was $H_v = 0.1$ kg/cm² and, respectively, at $H_{man} = 3.8$ kg/cm² it was $H_v = 0.2$ kg/cm² and at $H_{man} = 4$ kg/cm², $H_v = 0.35$ kg/cm².

When conducting the field tests, the dredge operated in a sand pit in the channel of the Volga. The output per hour of was 154 m³ at an average annual output at this plant of 115 m³/h before assembly of the ejector. Consequently, the increase in excavation amounted to 34%.

The following was done to determine more precisely what factors had an effect on increasing the output of the dredge. On the basis of refined geodetic measurements of the excavated volumes, the hourly output was determined, which amounted to 170 m³.