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Using Hydraulic Jet Pumps in Pumping Stations

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ABSTRACT: We demonstrate a pumping unit diagram with a hydraulic jet pump, designed to supply water to different heights. The hydraulic jet pump is designed to supply water to a low height, receiving a working flow from the pressure pipe of centrifugal pump with a higher pressure. We show the results of calculations of the main parameters for hydraulic jet pump that provides the required water flow.

KEYWORDS: pumping unit, hydraulic jet pump, pump pressure, water consumption, pump power.

I. RELATED WORK

Pumping stations are large energy-intensive objects in any irrigation system, in this regard, the issues of operating pumping equipment with minimal energy costs with full provision of the water supply schedule are among the important issues.

II. INTRODUCTION

Note that the issues of energy efficiency of pumping stations and increasing the reliability of water supply could play an important role in increasing requirements for the operation of pumping equipment in the case of rising prices for energy resources [1,2].

It is sometimes forced for pumping stations to supply water to consumers located at different heights and distances, and thus different pumps that differ in parameters, especially the pressure, will be installed in the station building. In Fig. 1. We show the pumping unit diagram with the hydraulic jet pump used to supply water to a low height.

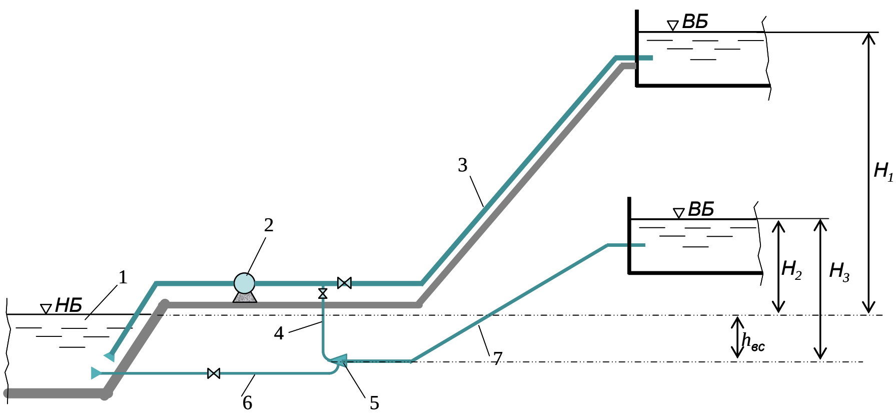

Fig. 1. Pumping unit diagram with hydraulic jet pumps
1 – water source; 2 – pump; 3 –discharge pipeline; 4 – pressure water supply pipe to the hydraulic jet pump; 5 – hydraulic jet pump; 6 – suction pipe of hydraulic jet pump; 7 – pressure pipe of the hydraulic jet pump

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Replacement of centrifugal pumps having low pressure on hydro-jet ones is carried out in order to reduce capital and energy costs. Some variants of similar hydraulic jet pumps have been applied for hydraulic structures to increase the flow of the pumping unit [3]. In the mentioned variants, the ejector is installed behind the pump at the beginning of the pressure pipeline, i.e. its initial part refers to the pipeline that supplies the working flow to the displacement chamber of the hydraulic jet pump, and the intake of water from the water source is carried out on the basis of a suction pipe having a larger diameter than the suction pipe of the pump. In this case, the productivity of the pumping unit increases as that of the ejection of flows behind the pump, as a result of which an additional amount of water can be pumped, received through the suction pipe of the hydraulic jet pump. The author of the above work presented the results, according to which the flow rate increases up to 13 ... 20% at ejector pressures equal to the pump pressure and up to 2 ... 3 times at low pressures (3.0 ... 6.0 m) in the case of using hydraulic jet pumps.

III. METHODS AND MATERIALS

Based on the diagram shown in Fig. 1, having received water with a flow rate Q1 from the pressure pipeline, the hydraulic jet pump sucks in the required amount of water with a flow rate Q2 from the source and supplies mixed water in the amount of Q1 + Q2 = Q3 to the consumer system located at the height of H2. The point to be noted here is that the flow rate of the supplied water Q3 must be sufficient to satisfy the needs of the consumer's system. To achieve this goal, the recommendations given by Ref. [4] can be used to determine the three main parameters of the hydraulic jet pump: q – relative consumption, f – relative size and h - relative pressure. These parameters are related by the following relation [4]

$$h = \frac{1}{1{,}39(1+q)^2 - 0{,}91 \cdot n \cdot q^2} \tag{1}$$

where n = f/ (f – 1), q=Q2/Q1, h= (H2 – Нвс)/ (H1 – Нвс) with Q1 being flow rate of supplied water to the GOS, Q2 being flow rate of the sucked-in GOS water, H1 being the pressure of the flow of water supplied to the nozzle, Нвс being suction pressure and H2 – hydraulic jet pump pressure. The values of H1 and H2 can be calculated as follows: H1 =HГ1 +Δh1 and H2 =HГ2 +Δh2 with Δh1, Δh2 respectively refer to the pressure loss in pipelines.

According to [4], the main parameters of the hydraulic jet pump can be determined using the following relations:

$$f = 0{,}88/h \qquad f \approx 3{,}9 \cdot q \tag{2}$$

$$Q_1 = Q_3/(1+q) \qquad \omega_c = 0{,}288\,\frac{Q_1}{\sqrt{H_1}} \tag{3}$$

IV. RESULTS

We use the above mentioned method to calculate the parameters of the water supply on the diagram shown in Fig. 1 under the following conditions: H1 = 20,9 m, H2 = 8,5 m, Нвс=1,0 m and Q3 = 0,072 m3/s.
One can then calculate the values of h = (H2 – Нвс)/ (H1 –Нвс) = (8,5 –1,0)/ (20,9 – 1,0) =0,377.

Taking into consideration (3) we calculate f and q as follows:

f = 0,88·/h = 0,88·1/0,377 = 2,33; q= f /3,9 = 2,33/3,9 = 0,6.

Following (4) we determine the values of Q1, Q2 and ωc

Q1 = Q3/(1+q) =0,072/ (1+0,6) =0,045 m3/s; Q2= Q3 – Q1 =0,027 m3/s

ωc = 0,288 =0,288 =0,00283 m2

Hence, one can find the nozzle diameter at the velocity coefficient φ1=0,95

The results obtained show that energy savings can be up to 6200 kWh per year in the case of using the hydraulic jet pump for 2000 hours per year.

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V. CONCLUSION

Replacing centrifugal pumps with hydraulic jet pumps has the following advantages:
- it is possible to reduce energy consumption while supplying water;
- it is possible to reduce the operating costs associated with the use of centrifugal pumps;
- reliability of water supply increases as that of the absence of downtime for repairs and elimination of failures associated with the operation of centrifugal pumps;
- the cost of the hydraulic jet pumps as compared to the cost of centrifugal pumps would be much cheaper.

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