

**CONMECHYDRO 2021**

**April 1-3,  
Tashkent, Uzbekistan**

# **Irrigation pumping stations according to the hydraulic and operational indicators of pumping units**

**Makhmudjon Mamajanov<sup>1</sup>, Bakhtiyor Uralov<sup>2</sup>**

<sup>1</sup>Andijan Institute of Agriculture and Agricultural Technologies, Andijan, Uzbekistan

<sup>2</sup>Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent, Uzbekistan

Authors' names

**Abstract.** The paper presents the conditions and the degree of reduction of water supply and pressure of pumping stations (PS) depending on the hydraulic resistance of the water supply channels and structures of the PS and other various factors. And also, the results of studies of the hydraulic and operational modes of water-supplying machine channels and structures of irrigation pumping stations are presented. Analyzing the operating conditions of the pumping units, it was found that the reasons for the decrease in their operating parameters are the following: a) an increase in the hydraulic resistance of the suction line due to sediment deposition in the intake chamber, as well as due to siltation and clogging of the PS suction pipeline; b) an increase in hydraulic resistance due to the accumulation of air at elevated points of the pressure pipeline, in particular, on the crest of the siphon outlet of the PS; c) a decrease in the hydraulic efficiency of pumping units due to an increase in the surface roughness of the parts of the flow path, it due to the effect of solid abrasive particles entering through the suction line of the PS. Also, the work presents the results of complex laboratory and field studies to study the intensity of wear of the elements of the flow path of centrifugal and axial pumps. The alternating pulsating load leads to an increase in the force of interaction of the hydroabrasive flow with the surface of the chamber and increases its wear by 10%, and also reduces the productivity of the pumping unit to 9%.

**Keywords:** irrigation pumping stations, pumping units, axial flow pumps, hydraulic resistance PS, water supply structures of the PS

## Introduction

Carrying out research work to improve the methods for calculating the head loss in the channel bed and improve the technologies for preventing an increase in the pressure loss in the channels of open machine channels of pumping stations, taking into account the hydraulic resistance of the supply channels and structures of pumping stations, are considered one of the main tasks in channel hydraulics [1–5]. Providing the necessary water demand for irrigation of agricultural crops is considered one of the urgent tasks in the world. In the world, agricultural products are grown on an area of 4 billion 886.3 million hectares, of which 43.2 percent of the land for irrigation of crops is used by systems of irrigation pumping stations. With the increase in the area of agricultural crops, in order to provide the necessary amount of water with its growing demand, ensuring the reliability of the culvert and the operation of pumping stations is of particular importance [6–8]. The most important element of these pumping stations (PS) are water supply and water supply machine channels and structures of pumping stations (PS), research and clarification of hydraulic processes, accurate determination of water supply and manometry pressure of PS, taking into account the hydraulic resistance of the machine channels and the technical and economic indicators of which in many respects determine the reliability, durability and efficiency of pumping stations of irrigation, industrial and agricultural enterprises. In this regard, there is a need to increase the efficiency of pumping stations (PS) operation by developing specific measures to reduce the hydraulic resistance of water supply and water supply machine channels, by improving the hydraulic characteristics of water intake structures of pumping stations (PS), and with the best organization of metering water supply and gauge pressure of pumping stations [9–13]. With the development of a complex of such measures, it is possible to ensure the economy of water, energy and material resources.

**•Method**

**Full-scale and laboratory studies were carried out depending on the hydraulic resistance of the water supply channels and structures of the PS. On the basis of the theory of vane hydraulic machines, a calculation method and a method for determining the water supply and pressure of pumping units are proposed. In carrying out experimental and field studies, the generally accepted standard methods of laboratory-bench tests of pumps were used according to the recommendations of the International Energy Commission (IEC).**

### •Results and Discussion

In order to assess the impact of hydraulic processes occurring in the water supply and water supply structures, and hydromechanical processes occurring inside the pump, to reduce its water supply, units 1 and 2 of the PS "Turakurgan-1" and units 6 and 7 of the PS "Irrigator" (Namangan region , Uzbekistan) equipped with the same D4000-95 centrifugal pumps (22NDs with

Measurements and calculations of the main technical indicators of the pumps were carried out on the basis of the existing standard research methodology [1, 2, 11, 14].

To determine the pump head, exemplary vacuum gauges and manometers were used, connected respectively to the suction and discharge nozzles, the water supply was determined by the value of the flow rate in the pipeline, which was measured using a Pitot tube, the shaft power was calculated by the formula based on the readings of the voltmeter and ammeter, the rotation frequency the shaft was measured using a tachometer. The head loss of the suction pipeline was determined according to the readings of two vacuum gauges installed: the first - in the initial section after turning the axis of the pipeline, the second - in the inlet pipe of the pump. The head loss of the suction line was calculated using the formula:

## •Results and Discussion

- where; - readings of vacuum gauges № 1 or № 2; - geodetic heights from the tail water level to vacuum connection; - flow rate at the pressure measuring point.
- The resistance coefficient of the suction pipe is determined by the following expression:
- Figure 1 shows a comparison of the factory characteristics with the data of field tests of the unit № 1 of the PS "Turakurgan-I". As can be seen from Figure 1, the test points are slightly lower from the pressure line of the factory characteristic, but the pump consumes sufficient power. With a fully open valve, the pump head is , the water supply was instead of the design l/s, i.e. operating point *A* shifted to point *B* and the difference was . Due to the decrease in water supply, the efficiency of the pump was 12-15% lower [14–19].
- Analyzing the operating conditions of the pumping units, it was found that the reasons for the decrease in their operating parameters are the following:
- a) an increase in the hydraulic resistance of the suction line due to sediment deposition in the water intake chamber, as well as due to siltation and clogging of the suction pipeline;

# Results and Discussion

- ***b)* increase in hydraulic resistance due to the accumulation of air at elevated points of the pressure pipeline, in particular on the crest of the siphon outlet;**
- ***v)* decrease in the hydraulic efficiency of the pump due to an increase in the surface roughness of the parts of its flow path due to the effect of solid abrasive particles;**
- ***g)* a decrease in the volumetric efficiency of the pump due to an increase in the size of the clearances in the impeller seals due to the effect of hydroabrasive flow;**
- ***d)* a decrease in the volumetric efficiency of the pump due to an increase in the gap between the "tongue" of the spiral diverter and the impeller from the action of solid particles.**
- **This means that the displacement of the design operating point "A" to the actual operating point "B" in figure 1 depends on many factors, the degree of their influence on the reduction of water supply and pressure can be established by conducting a detailed analysis of all technical indicators of the pump, suction and pressure pipelines of the pumping unit [20–24].**
- **Figure 2 shows the dependence of the resistance coefficient on the water supply of the pump with a dirty water intake chamber and after its partial flushing. Partial washing of sediment deposits in the chamber was achieved by increasing the bottom flow rates, forming a gap by covering its upper part with wooden shields. As can be seen from figure 2 the coefficient of hydraulic resistance of the suction pipeline  $\zeta$  decreases in all operating modes of the pump after partial flushing of the water intake chamber. As a result of a decrease in hydraulic resistance, the pump flow increased from before, т.е. на (see figure 1).**

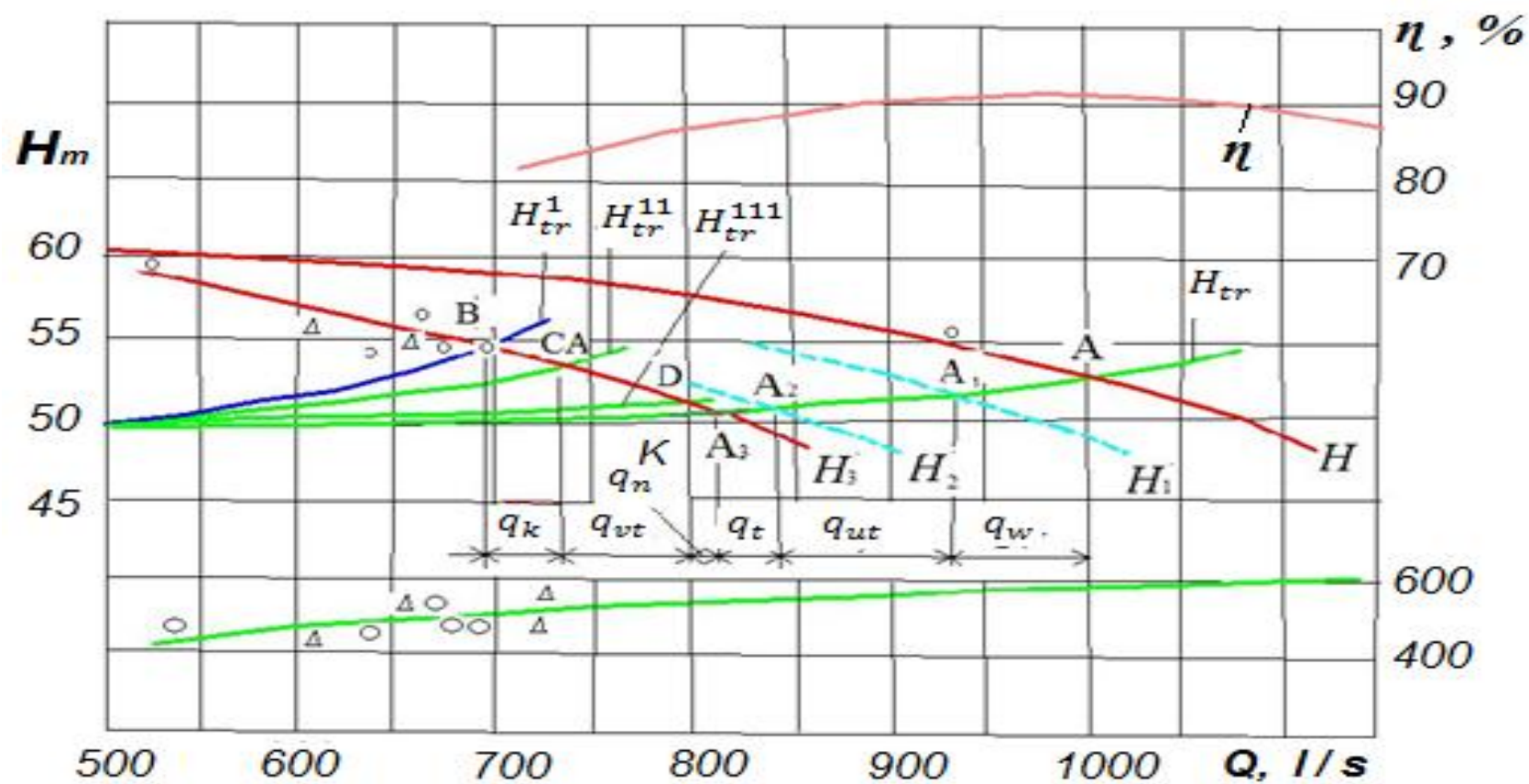
# Results and Discussion

- After flushing the chamber between the hydrodynamic curve and design curve there was also a significant difference, i.e. the difference in pressure between points "C" and "E" has a significant value, which confirms the increased values of the pressure loss in the pipelines. To determine the actual values of the pressure loss in the pipelines, we used the readings of two vacuum gauges installed in the initial and final sections of the pumping unit. Multiple measurements of the vacuum values in the suction pipelines of the 1st and 2nd units were made. According to the measurement data, the head loss between the sections of measuring the pressure of the suction pipelines was calculated, which amounted to , and according to the calculation should be (head difference in Figure 1).  $\eta, \%$

-



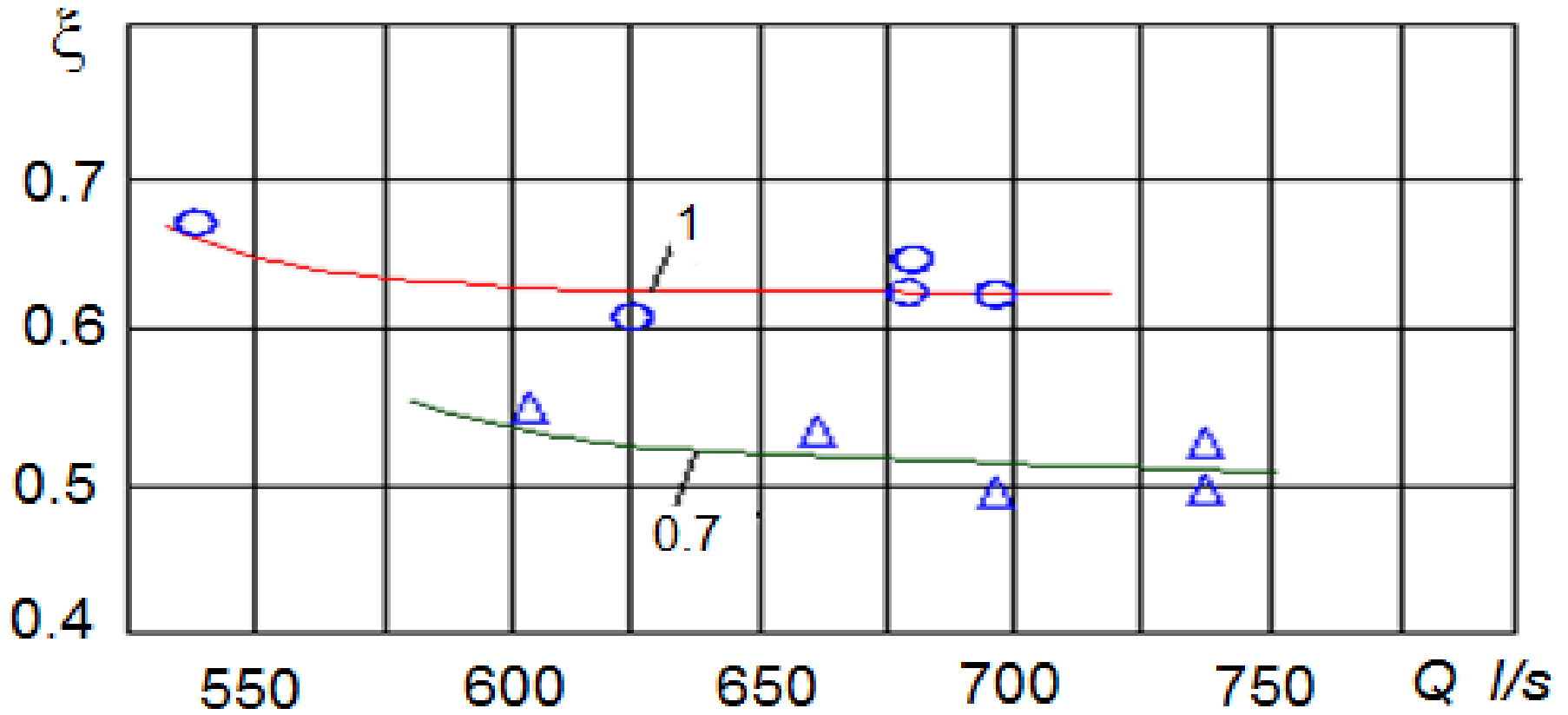
figure 1.



# Results and Discussion

- **Figure 1.** Comparison of the design operating mode of the pump D4000-95 (22NDs) with the data of field tests ( $n = 730$  rpm):  $H$ ,  $N$ ,  $\eta$  - curves of pressure, power and efficiency according to the factory characteristic,  $h$ ,  $Q$ ,  $\eta$  - hydrodynamic curves,  $A$  - design operating point,  $B$  and  $C$  - respectively operating points before and after flushing the water intake chamber (according to field tests),  $A_1$ ,  $A_2$ ,  $A_3$ ,  $D$  - predicted operating points.
- Received values  $\eta$  show that cleaning of the suction line is required, and thus it is possible to increase the pump flow to (that is still on).

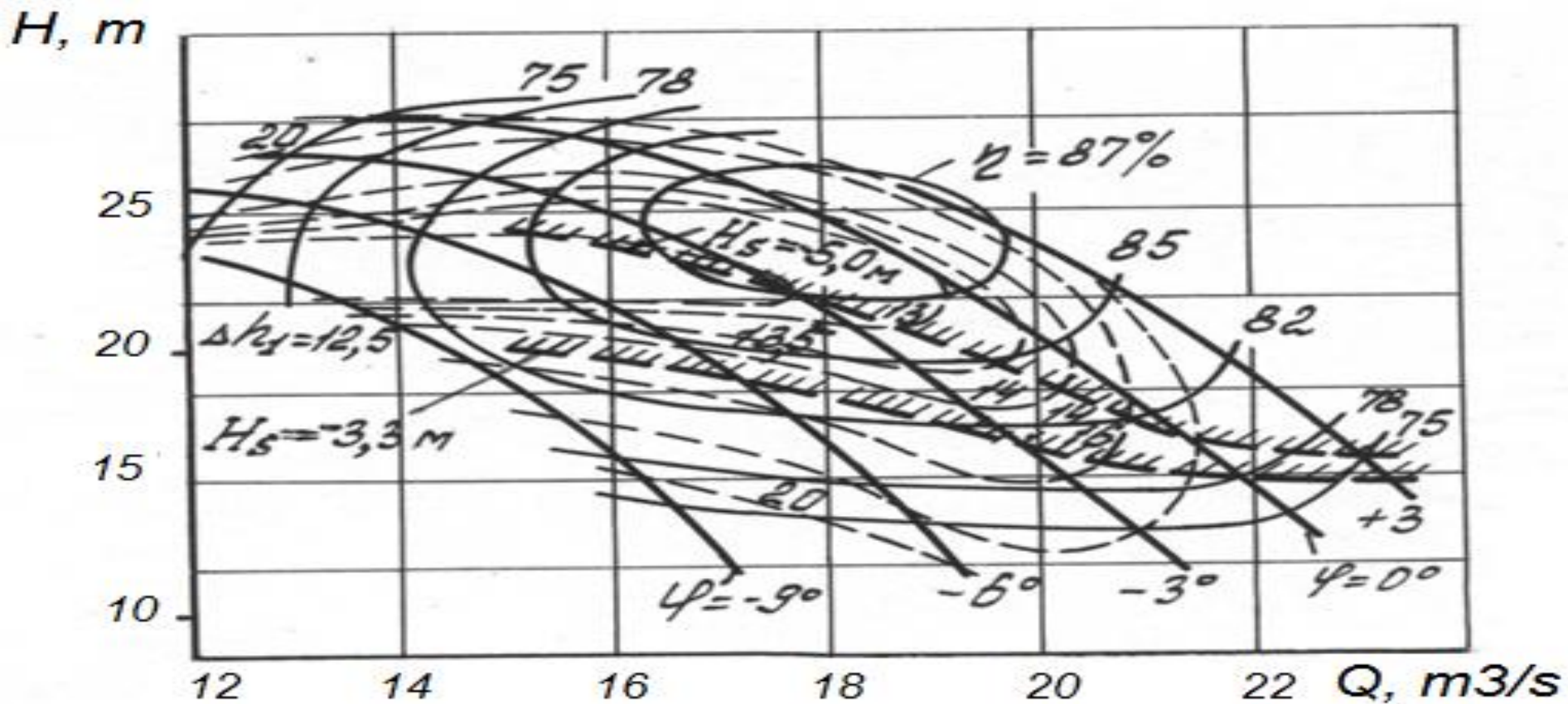
Figure 2.



## Results and Discussion

- **Figure 2.** Dependences of the resistance coefficient of the suction pipeline on the water supply of the centrifugal pump: 1-2, respectively, the curves obtained before and after flushing the water intake chamber of the pumping unit.

Figure 3.



## Results and Discussion

- **Figure 3.** Universal characteristic of the OP10-185 pump with isolines of the beginning of crevice cavitation and hydroabrasive wear.

-

# Results and Discussion

- Deferring the value from point  $A_1$  to the pump characteristic (see figure 1), we find point  $A_2$ . As you can see, there is a difference between points  $A_2$  and  $A_3$ , which means an increase in the amount of water leakage through the gap between the "tongue" of the diverting device and the impeller, as well as in the stuffing box. The permissible size of the gap in the "tongue" area must be . During long-term operation (more than 15 years), the actual value of the gap in the "tongue" area increased to , which is the reason for the increase in reverse leakage through this gap. On the basis of the above analysis, it is possible to compare certain reasons that affect the degree of decrease in water supply and pump pressure (Table 1).
- To reduce the hydraulic resistance of the flow path, in order to reduce the value of , it is necessary to treat the surfaces of the parts in order to clean and eliminate the roughness of the blade and the inner surface of the walls of the spiral diverter or to replace the pump casing, which is difficult to do under operating conditions, since this requires a lot. As can be seen from Table 1, an increase in the hydraulic resistance of the suction line ( and an increase in the gaps in the seals and in the area of the "tongue"

-

## Results and Discussion

- It should be noted that, depending on the operating conditions of the pumping station, the percentages of reducing the water supply and pump head under the influence of individual factors may be different. For example, for the PS "Irrigator" there were no increases in the hydraulic resistances of the intake, suction and discharge pipelines, and the sum of the values . At this station, the decrease in water supply and pressure was associated only with hydromechanical processes taking place inside the pump, i.e. due to wear of the working parts of the pumping unit.



# Conclusions

- **1. Based on the above analysis, it follows that it is required to develop a set of specific measures to improve the design of water supply channels and water intake structures of pumping stations (taking into account their hydraulic resistance), as well as to reduce wear of parts of the flow path and sealing elements of the impeller of the pumping unit.**
- **2. The volumes of siltation of water supply canals, water intake structures and water intake chambers for individual PS are from 20 to 55%, which leads to an increase in hydraulic resistance of the pump suction lines, and in some cases to the formation of air funnels in the water intake chambers. Due to the increase in hydraulic resistance of the suction lines, the water supply of the D4000-95 pumps decreased to 10%. Therefore, it is necessary to improve the design of water supply channels and water intake chambers of the PS operating at water sources with a high sediment content.**
- **3. As a result of siltation of the water intake chambers, as well as an increase in the roughness of the surfaces of parts and the size of the sealing gap of the impeller due to hydroabrasive wear, the efficiency of the D4000-95 pumps was 12-15% lower than the design one.**
- **4. From the above analysis, it follows that more intensive wear of the chamber than the end part of the impeller blades of an axial pump (Figure 3), although the outflow rate of the hydroabrasive flow relative to the chamber will be much less than relative to the end part of the pump blade. The variable pulsating load leads to an increase in the force of interaction of the hydroabrasive flow with the surface of the chamber and increases its wear by 1.1 times, and also reduces the productivity of the pumping unit to 9%.**

# CONMECHYDRO 2021

April 1-3,  
Tashkent, Uzbekistan



E-mail:  
[bakhtiyor1956@mail.ru](mailto:bakhtiyor1956@mail.ru)



Tashkent, 2021