EURASIAN JOURNAL OF TECHNOLOGY AND INNOVATION

Innovative Academy Research Support Center

Open access journal www.in-academy.uz

WAYS TO IMPROVE THE ENERGY EFFICIENCY OF DYNAMIC PUMPS BASED ON MODERN COMPUTER TECHNOLOGIES

Bobur Ergashev

Chirchik State Pedagogical University

ARTICLE INFO

Received: 02nd November 2023
Accepted: 08th November 2023
Online: 09th November 2023

KEY WORDS

Dynamic pumps, optimization, verification, computational fluid dynamics.

ABSTRACT

The main methods used to optimize flow parts of dynamic pumps, increase energy efficiency and reliability of hydraulic machines are briefly described. The results of the test are reviewed by comparing the calculated correlations with the data.

Introduction. Dynamic and vane pumps are a type of equipment, the improvement of which is one of the highest priority tasks in the energy saving strategy both in Uzbekistan and abroad. According to some estimates, up to 25% of all energy produced by humanity is spent on driving vane pumps, which means that there is a significant reserve of energy savings in this field of technology[1-3].

At the same time, in the life cycle cost of pumping equipment, the component of the cost of electricity consumed by the pump over its entire service life can reach 80% or more. Thus, it is necessary to look for opportunities to save energy[4-7] both in the design of the pump and in its operation.

Currently, in the field of operation of pumping equipment, there are significant positive changes associated with the introduction of new methods of pump regulation (including frequency regulation), as well as systems for remote monitoring of operating modes and condition of pumping equipment. This allows you to reduce operating costs and increase the proportion of pumps operating in conditions close to optimal.

No less potential for increasing energy efficiency and reliability lies in the design of the pumps. Most currently produced pumps were developed more than 30 years ago and have relatively low efficiency and service life. Nevertheless, such pumps are in demand on the market, since manufacturing enterprises often do not have the funds to significantly modernize pump designs. Consumers of pumping equipment are forced to choose between cheap but non-energy efficient domestic equipment and expensive imported equipment, which is not always successfully integrated into existing equipment monitoring and repair systems.

However, there are also positive development trends in the Uzbek pumping equipment market. Due to the increase in the cost of electricity and stricter requirements for energy efficiency of production, equipment consumers need more advanced pumps; Those domestic manufacturers that invest in modernizing production and pump designs compete more successfully in the pumping equipment market.

One of the main directions in the modernization of pump designs is improving the geometry of its flow path. Since both the efficiency of the pump (its energy efficiency) and the hydrodynamic loads on the rotor of the hydraulic machine (pump operating life) depend on the nature of the fluid flow in the flow part of the pump, significant reserves for improving pumping equipment lie precisely in optimizing the geometry of the pump flow part.

Method for optimizing the geometry of pump flow parts. For several years, work has been underway to modernize and develop the geometry of the flow parts of various dynamic pumps. In particular, a line of flow parts for oil main pumps of the NM type (six types of sizes), high-power soil pumps, jet devices for various purposes, was created. The method used for optimizing the geometry of pump flow parts or developing new flow parts includes the following steps:

- parameterization of the geometry of the flow part, allowing for automated construction of both the elements of the flow part (inlet and outlet devices, impeller, upstream screw, etc.) and the flow part as a whole;
- optimization of the flow part, carried out on the basis of numerical modeling of flows in the flow part of the pump; in this case, optimization criteria and optimization method are selected depending on the formulation of the problem;
- complex hydrodynamic modeling of flows in the flow part of the pump and its elements, and the problem can be solved in both stationary and non-stationary formulations;
- experimental verification based on the production of pump models using a 3D printer, taking the integral parameters of the models (normal, cavitation, balance), as well as using the differential method with measuring pressures at 50-60 characteristic points of the pump flow path.

The choice of variable geometric parameters of the pump flow path and the method for constructing its 3D model depend on the specific task. Thus, for a jet pump (Fig. 1), parameter values can be specified and changed directly when creating a 3D model in the CAD system used (SolidWorks, CATIA, etc.). However, some parameters (for example, the throughput of the design cross-section of the outlet device) are not parameterized in the form of specific dimensions, and the shape of the flow path itself is not automatically rebuilt in the CAD system when this parameter is changed. Therefore, it is necessary to use special systems for designing flow systems of hydraulic machines.

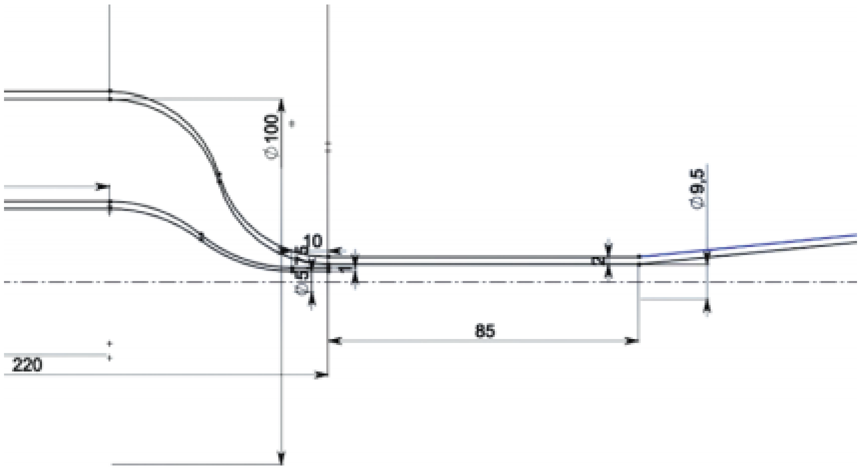

Fig 1. Parameterization of the jet pump

For example, a two-helix spiral discharge device of an NM type oil main pump has a complex shape and integral control parameters that cannot be described by a specific size in a 3D model. The outlet device includes the following elements with parameterizable geometry: spiral part; bypass channel; diffuser. Allows you to build sections of each element based on Bezier curves or B-splines (Fig. 2)

Bezier curves are a special case of B-spline:

$$C(t) = \sum_{i=0}^{n} N_{ip}(t) P_i.$$

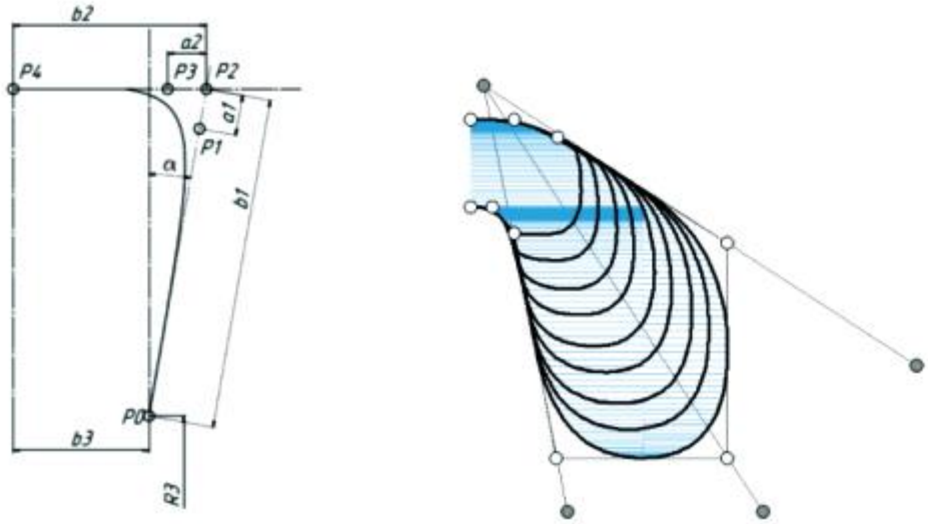

Fig. 2. Section of the spiral part of the outlet device of an NM type pump, constructed using Bezier curves (a), and the section of a semi-spiral supply device, constructed using a B-spline (b)

To reduce the production time of models and reduce the weight of the structure, instead of metal cast parts of the flow part, shell models are used (Fig. 3), made on a 3D printer, with external reinforcement to absorb forces from fluid pressure. In this case, the impeller is made in the form of a full-volume model or cast from metal.

Figure 3. Shell shape of the pump model during assembly

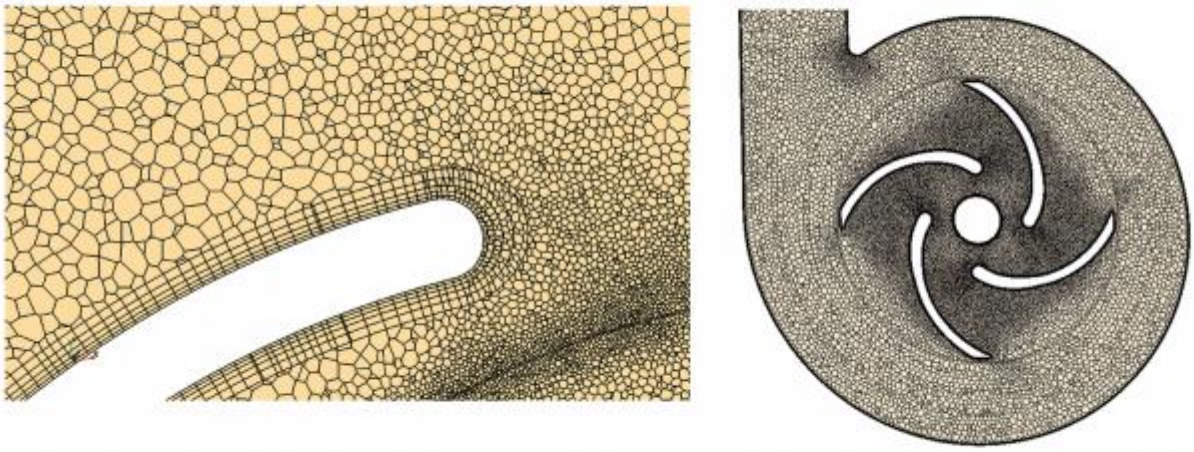

Figure 4. Calculation mesh near a solid wall(s) and the mesh

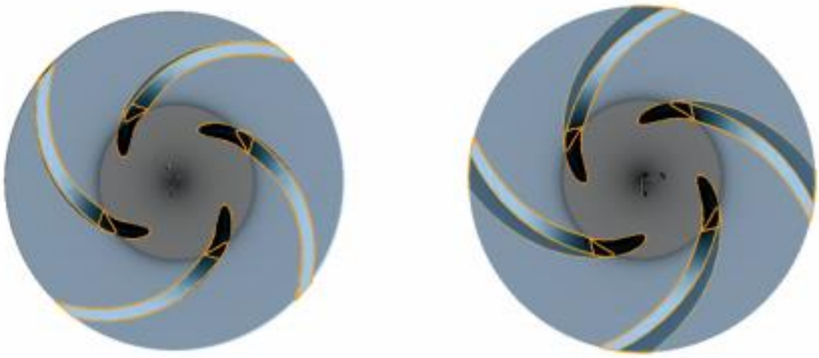

Figure 5. The original impeller and the impeller with changed blade angles at the inlet

This allows you to create models of the pump casing and impeller directly from 3D models of the flow path obtained using solid modeling programs, without wasting time on the manufacture of foundry equipment and subsequent processing of castings, as well as relatively lightweight model designs that are easy to assemble. Holes for measuring pressure are made in the walls of the housing during its manufacturing process on a 3D printer. Pressure is measured at different points in the pump flow path using plastic tubes, some ends of which are connected to existing holes for measuring pressure at various points in the pump model body, the other ends are connected to a sensor block.

Conclusion. Currently, there is a complex calculation and optimization of the flow parts of dynamic pumps, which makes it possible to calculate the parameters of centrifugal pumps, jet devices, pre-connected axial wheels, etc. The method was developed using the most modern software packages and makes it possible to solve a wide range of problems in the design and modernization of dynamic pumps. A method has been developed for manufacturing pump prototypes using a 3D printer, which makes it possible to manufacture and test flow parts of pumps that exactly match the calculated ones in geometry.

References:

1. Borst F., Theisinger L., Weigold M. Energy-efficient Pump Control in Industrial Cooling Water Systems Using a Multi-Agent System //Procedia CIRP. – 2023. – T. 116. – C. 41-46.
2. Glovatskii O. et al. Experience in using methods for monitoring the energy efficiency of hydraulic systems //IOP Conference Series: Earth and Environmental Science. – IOP Publishing, 2023. – T. 1142. – №. 1. – C. 012004.
3. Yan X. et al. Strategies to improve the energy efficiency of hydraulic power unit with flywheel energy storage system //Journal of Energy Storage. – 2023. – T. 59. – C. 106515.
4. Chen Z. et al. Study on heat-exchange efficiency and energy efficiency ratio of a deeply buried pipe energy pile group considering seepage and circulating-medium flow rate //Renewable Energy. – 2023. – T. 216. – C. 119020.
5. Abdullabekov I., Sapaev K. An energy efficient control system for water lifting units of the Ramadan pumping station based on frequency controlled electric drives //AIP Conference Proceedings. – AIP Publishing, 2023. – T. 2552. – №. 1.
6. Wang W. et al. Energy efficiency optimization of water pump based on heuristic algorithm and computational fluid dynamics //Journal of Computational Design and Engineering. – 2023. – T. 10. – №. 1. – C. 382-397.
7. Zhou S. W. et al. Digital Twin-Based Pump Station Dynamic Scheduling for Energy-Saving Optimization in Water Supply System. – 2023.