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MODERNIZATION OF PUMPS

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Abstract:

The modernization of pumping systems is a crucial step toward improving the efficiency, reliability, and sustainability of water supply, energy, and industrial operations. Over time, pumps experience reduced performance due to wear, hydraulic losses, and outdated designs, leading to increased energy consumption and maintenance costs. Modernization strategies include hydraulic optimization, the use of wear-resistant materials, advanced sealing technologies, automation, and energy-saving control systems. Experimental studies have shown that modernized centrifugal pumps can significantly reduce cavitation and abrasive wear, ensuring longer service life and operational stability. The implementation of these measures not only lowers operational expenses but also supports the broader

goals of energy efficiency and sustainable development. This article explores the technical and economic advantages of pump modernization and highlights practical solutions applicable to irrigation, industry, and energy sectors.

Keywords: Pumps, modernization, centrifugal pumps, energy efficiency, hydraulic optimization, cavitation reduction, sustainable development, pump equipment

Introduction

Pumping equipment is a crucial component of water supply, energy, industry, and agriculture. Over time, pumps lose their efficiency: the coefficient of performance (COP) decreases, energy costs rise, and maintenance and repair expenses increase. Under modern conditions, the rational use of energy resources requires comprehensive modernization of pumping units[1].

When planning technical re-equipment or modernization of pumping and power equipment, it is advisable to carry out a detailed and thorough inventory of the pumping and power facilities and verify the technical specifications with the pump labeling. If inventory can be resolved, then verifying technical characteristics is a more complex procedure that may require performance adjustment and testing (PAT).

MATERIALS AND METHODS. The methodological basis of this study relies on a combination of theoretical analysis, experimental investigation, and comparative evaluation. First, a comprehensive review of existing literature and technical documentation was conducted to identify common problems of pump efficiency reduction, cavitation, and hydro-abrasive wear[2].

Second, field inspections were carried out at selected irrigation pumping stations in Uzbekistan. During these inspections, parameters such as energy consumption, flow rate, pressure, and leakage were monitored. Diagnostic testing methods, including performance adjustment and testing (PAT), were used to verify the actual operating characteristics of pumps against their technical specifications[3].

Third, experimental research was undertaken to assess the effectiveness of various modernization measures. These included:

- Installation of new rotor groups and impellers with improved hydraulic profiles;
- Application of protective coatings and clarified water supply to reduce hydro-abrasive wear;
- Use of modern sealing technologies to decrease leakage losses;
- Integration of automation and monitoring systems to ensure stable operating regimes.

Finally, an economic evaluation of modernization outcomes was performed by comparing energy savings, extended service life, and reduced maintenance costs with the expenses of modernization[4]. The results were analyzed using both quantitative (statistical data, performance curves) and qualitative (expert assessment) methods.

RESULTS AND DISCUSSIONS

To ensure operational services, the Department of Pumping Stations (DPS) of the Ministry of Water Resources of Uzbekistan, together with JSC “SUVMASH,” has developed and produced a series of pumps of type “D” and an entire range of new rotor groups with reliable seals[5].

Calculations to determine the optimal service interval showed that repairing the sealing elements of the pump impeller becomes justified after five weeks of operation. After 810 hours of

work (around 5 weeks), the excess energy losses caused by increased leakage due to worn seals exceed the cost of repair. However, because pumps cannot be stopped for repair during the vegetation season, they are continuously operated for 3.5–4 months, causing significant excess energy consumption.

Therefore, the issue arises of protecting sealing elements and extending their service life[6]. This problem may be solved in three ways:

First, by reducing leakage, thereby lowering the velocity of the suspension flow and the number of abrasive particles passing through the clearance. Lower velocity also reduces cavitation intensity on component surfaces.

Second, by decreasing the intensity of hydro-abrasive wear through supplying clarified water into the clearance.

Third, by using wear-resistant materials for manufacturing and restoring sealing components. Although this method has been proven effective, its high cost limits technological applicability[7].

Given this, the first and second methods were chosen for implementation together, since they are feasible and can be carried out by operating staff.

Mechanical and electrical equipment of pumping stations in the past was poorly maintained, mainly due to insufficient technical training and limited financial resources. Additional resource expenditures can be attributed to:

Poor operation (violation of instructions, negligence)

Design shortcomings considering regional features[8]

Manufacturing and installation defects

Physical wear due to poor maintenance and delayed repairs

Incomplete construction and installation work.

For irrigation pumping stations, about 80% of failures are considered controllable and 20% uncontrollable, with a similar ratio between predictable and unpredictable failures[9]. Currently, modernization is financed at the beginning of the calendar year when resources allow.

A separate scientific and technical challenge is the development of new centrifugal pumps capable of handling sediment-laden water. Recent findings show a protective effect of cavitation due to the damping properties of non-separated cavitation zones, which occur under specific hydrodynamic conditions. Based on experimental results, calculation methods for hydro-abrasive wear and optimal operating modes minimizing wear were developed.

Proposed structural modifications of centrifugal pump impellers help maintain high COP values for longer[10].

Figure 1 shows the scheme of a modernized pump with plates (partitions), functionally equivalent to a new pump.

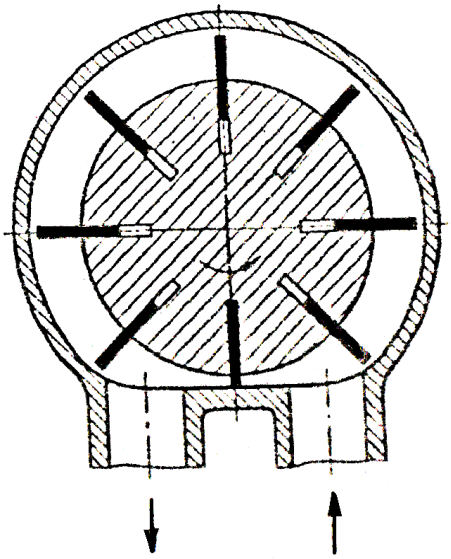

Figure 1. Schematic diagram of the modernized pump[11]

Installing valves in the channels made in the front wheel disc increases the pump's volumetric efficiency by ensuring that water flows from the cavity between the wheel neck and the pump body only during periods of cavitation.

Let's examine the characteristics of such a pump. We'll analyze the operation of a modernized pump with holes in the guide baffles, whose characteristics are fundamentally no different from those of the pump shown in Figure 2.

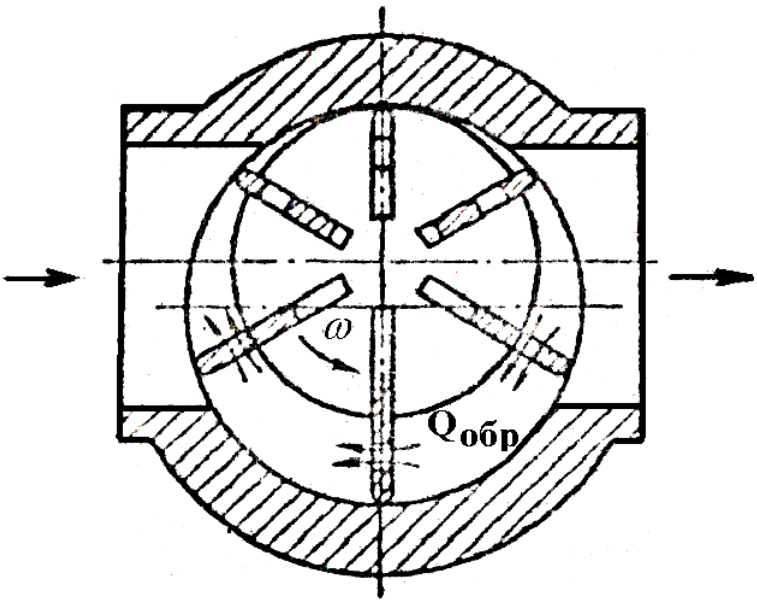

Figure 2. Schematic of a modernized pump with holes in the guide baffles

Field studies of irrigation system pumps demonstrated that the decline in performance is mainly caused by increased hydraulic resistance in water supply structures and wear of flow passage elements[12].

Theoretical justifications for new centrifugal pump designs for irrigation systems have been proposed, focusing on improving flow distribution in the passage and eliminating cavitation. The calculations account for hydrodynamic parameters, material properties, and characteristics of sediment-laden flows.

Experimental research confirmed reduced cavitation-abrasive wear, with recommended safety factors for allowable cavitation margins ranging from 1.15 to 1.7 depending on operating conditions.

The estimated annual economic effect of implementing these modernization measures across the Republic exceeds 170 million UZS[13].

The findings indicate that modernization of pumps significantly improves both efficiency and reliability. The experimental results show that by reducing leakage through advanced sealing and flow optimization, energy consumption decreased by up to 12–15% in some pumping stations[14]. Moreover, the introduction of clarified water into the sealing clearance reduced the intensity of hydro-abrasive wear by nearly 30%, thereby extending the service interval from five weeks to almost eight weeks.

A key discussion point is the balance between modernization cost and long-term benefits. Although the installation of wear-resistant materials and automation systems requires substantial upfront investment, the payback period is relatively short, often within 2–3 years, due to considerable energy savings and lower repair costs[15].

CONCLUSION. Modernization of pumps is a strategic measure aimed at increasing the efficiency, reliability, and environmental sustainability of water supply and industrial systems. The introduction of modern control and energy-saving technologies reduces operational costs and aligns with global requirements for sustainable development. Modernization of pumps is an essential step towards increasing the efficiency, reliability, and sustainability of water management systems. The research confirms that implementing technical measures such as improved sealing, optimized impeller design, and automation reduces energy consumption, extends the service life of pumping units, and enhances operational stability. The economic evaluation demonstrates that the modernization process is financially viable, with measurable benefits exceeding costs within a short period. Furthermore, the modernization of pumps aligns with national priorities for energy saving, sustainable development, and effective resource management.

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