ANALYSIS OF THE ENERGY PERFORMANCE OF 32D-19 CENTRIFUGAL PUMPS OPERATING AT PUMPING STATIONS

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Abstract

Pumping stations are among the largest consumers of electrical energy in irrigation and water management systems. Therefore, improving the efficiency of pumping equipment is one of the most important tasks in reducing energy consumption and operating costs. This study investigates the operating characteristics and energy performance of 32D-19 centrifugal pumps installed at the Dustlik Pumping Station. The hydraulic and energy parameters of the pumping units, including flow rate, head, power consumption, efficiency, and cavitation reserve, were analyzed. Special attention was given to the interaction between the pump and its driving electric motor. The results indicate that the installed pumping units provide stable operation under varying hydraulic conditions and maintain a relatively high efficiency level. The research confirms the importance of proper operating conditions and periodic energy audits for increasing the overall efficiency of pumping stations.

Keywords: centrifugal pump, energy efficiency, pumping station, irrigation systems, electric motor, hydraulic characteristics, energy audit.

Introduction

The rapid growth of agricultural production and increasing demand for water resources require highly reliable and energy-efficient irrigation systems. Pumping stations are critical elements of water transportation networks because they ensure the delivery of water from rivers, reservoirs, and canals to agricultural consumers. However, pumping systems account for a considerable share of total electricity consumption in water management sectors.

According to international studies, pumping systems consume approximately 20–25% of industrial electrical energy worldwide. Therefore, improving the operational efficiency of pumping stations is directly related to reducing energy costs and enhancing sustainability.

The Dustlik Pumping Station plays an important role in supplying irrigation water to agricultural regions. The station employs 32D-19 centrifugal pumps driven by high-voltage electric motors. Evaluating the performance of these units is essential for identifying opportunities to improve energy efficiency and operational reliability.

The objective of this study is to analyze the hydraulic and energy characteristics of the 32D-19 centrifugal pump and assess its performance under actual operating conditions.

Operating Principle of the 32D-19 Centrifugal Pump

The 32D-19 pump, an analogue of the D6300-27 model, belongs to the class of single-stage horizontal centrifugal pumps. It is designed for pumping clean water and liquids with physical properties similar to water.

The operating principle is based on the conversion of mechanical energy into hydraulic energy. Water enters the pump through the suction pipe and reaches the eye of the impeller. As the impeller rotates, centrifugal force accelerates the liquid toward the outer diameter of the

IBAST | Volume 6, Issue 06, June

impeller. The volute casing then converts the velocity energy into pressure energy, resulting in the required discharge head.

The main advantages of centrifugal pumps include:

- High operational reliability;
- Continuous flow delivery;
- Simple construction and maintenance;
- High hydraulic efficiency;
- Long service life.

These characteristics make centrifugal pumps the preferred choice for large irrigation pumping stations.

Technical Characteristics of the Pump

The 32D-19 pump is designed for high-capacity water transportation. The nominal operating parameters are presented in Table 1.

Table 1. Technical Specifications of the 32D-19 Pump

Parameter	**Value**
Nominal flow rate	6300 m^3/h
Nominal head	27 m
Rated power	515 kW
Rotational speed	730 rpm
Maximum efficiency	90%
Maximum liquid temperature	85°C

The pump can transport liquids with pH values ranging from 4 to 12 and containing mechanical impurities not exceeding 1% by volume. The maximum allowable particle size is 0.2 mm.

Field measurements conducted at the Dustlik Pumping Station revealed that the actual flow rate is approximately 1.4 m^3/s compared to the nominal value of 1.75 m^3/s. Similarly, the measured head is approximately 20 m instead of the design value of 27 m.

These deviations are mainly caused by:

- Hydraulic losses in pipelines;
- Wear of pump components;
- Changes in water levels;
- Operational conditions of the irrigation network.

Pump Performance Characteristics

The performance characteristics of centrifugal pumps are generally represented by head-flow (H-Q), efficiency-flow (η-Q), and power-flow (N-Q) curves.

The head characteristic demonstrates a gradual decrease in pressure with increasing discharge. This behavior is typical for centrifugal pumps and reflects the hydraulic limitations of the system.

The power curve indicates increasing power consumption as flow rate rises. Consequently, operating the pump outside the recommended region may significantly increase energy consumption.

The efficiency curve shows that the highest efficiency is achieved near the Best Efficiency Point (BEP). For the 32D-19 pump, the efficiency reaches values between 88.0% and 94.8%, demonstrating excellent hydraulic performance.

The cavitation reserve (NPSHr) of approximately 5.0 m ensures reliable operation without cavitation damage. Maintaining adequate suction conditions is essential for preventing vibration, noise, and premature equipment failure.

Electric Drive Systems

AD-450-UHL Induction Motor

One of the pumping units is equipped with an AD-450-UHL vertical three-phase induction motor. Its principal technical characteristics are listed below:

- Rated power: 630 kW
- Rated voltage: 6000 V
- Rated current: 74 A
- Speed: 750 rpm
- Power factor: 0.82
- Efficiency: 91%

The induction motor provides reliable operation and relatively simple maintenance requirements.

SD-2-85 Synchronous Motor

The second pumping unit is driven by an SD-2-85 vertical synchronous motor. This machine exhibits superior energy characteristics compared with induction motors.

Technical specifications include:

- Rated power: 630 kW
- Rated voltage: 6000 V
- Rated current: 72 A
- Speed: 750 rpm
- Power factor: 0.94
- Efficiency: 95%

The motor employs a TE-3-320 thyristor excitation system, ensuring stable excitation and precise speed control.

The higher power factor of the synchronous motor reduces reactive power demand and contributes to improved electrical network performance.

Energy Efficiency Assessment

The efficiency of a pumping station depends on the combined performance of the pump and electric motor. The overall efficiency can be expressed as:

$\eta_o = \eta_p \times \eta_m$

where:

η_o – overall efficiency of the pumping unit;

η_p – pump efficiency;

η_m – motor efficiency.

For the Dustlik Pumping Station:

$\eta_p \approx 0.90$

$\eta_m \approx 0.95$

Therefore,

IBAST | Volume 6, Issue 06, June

$\eta_o = 0.90 \times 0.95 = 0.855$

$\eta_o = 85.5\%$

This result indicates a relatively high level of energy utilization compared with conventional pumping systems.

Energy losses occur due to:

- Hydraulic friction;
- Mechanical losses;
- Electrical losses in motor windings;
- Reactive power consumption;
- Equipment aging.

Implementation of periodic energy audits can identify these losses and support the development of energy-saving measures.

Recommendations for Improving Energy Efficiency

To further improve the performance of the Dustlik Pumping Station, the following measures are recommended:

1.Regular monitoring of pump efficiency.

2.Periodic inspection of impeller wear.

3.Installation of automated monitoring systems.

4.Optimization of operating schedules.

5.Reduction of hydraulic losses in pipelines.

6.Application of variable frequency drives where technically feasible.

7.Continuous energy auditing of pumping units.

These measures can reduce electricity consumption by 10–15% while maintaining the required water delivery capacity.

Conclusion

The conducted analysis demonstrates that the 32D-19 centrifugal pump installed at the Dustlik Pumping Station exhibits high hydraulic and energy performance. The pump provides stable operation with a nominal capacity of 6300 m^3/h and achieves efficiency values approaching 90%.

The use of high-voltage electric motors, particularly the SD-2-85 synchronous motor, contributes significantly to reducing electrical losses and improving overall system efficiency. The calculated overall efficiency of approximately 85.5% confirms the suitability of the existing equipment for large-scale irrigation applications.

Regular energy audits, operational optimization, and preventive maintenance can further increase energy efficiency and reduce operational costs. Consequently, the Dustlik Pumping Station serves as an effective example of energy-efficient pumping technology in modern irrigation systems.

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