METHODOLOGY FOR CONDUCTING RESEARCH ON THE EXPERIMENTAL DEVICE

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МЕТОДОЛОГИЯ ПРОВЕДЕНИЯ ИССЛЕДОВАНИЙ НА ЭКСПЕРИМЕНТАЛЬНОЙ УСТАНОВКЕ

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Abstract: The purpose of this study is to analyze the design data, operating conditions, and usage aspects of the experimental device, and based on this, to develop scientifically grounded measures and recommendations for improving the efficiency of the pump's operational mode.

Keywords: Experimental research device, performance indicators, cavitation observation chamber, manometer, vacuum meter, ultrasonic water flow measurement device.

INTRODUCTION

Relevance of the topic: Experimental research plays a significant role in the development of new ideas, methods, and technologies in scientific and engineering fields. The methodology of conducting research using an experimental device includes identifying problems, testing hypotheses, and reliably evaluating results. In this scientific work, we focus on the key stages and methodological approaches to conducting research with experimental devices.

MAIN PART

The methodology for conducting research on an experimental device is of great importance for identifying problems and developing innovations. Properly conducting research and reliably assessing results is crucial for achieving effective outcomes in scientific and technical fields. The results of experiments serve as the basis for drawing reliable and accurate conclusions and for developing new programs and methods.

In our current research work, we have developed a laboratory setup designed to observe flow dynamics in centrifugal pumps using the above-mentioned methodological recommendations.

This laboratory device can be used to study cavitation processes occurring inside the pump and to observe fine hydraulic particles in the flow. It is well known that one of the main factors causing wear on the pump's impeller is the cavitation process.

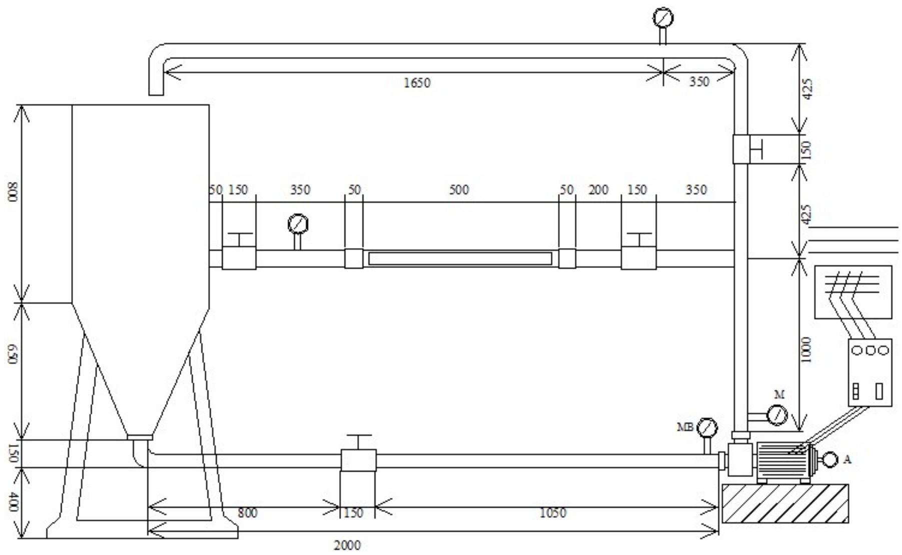

Figure 1. Schematic of the laboratory device.

In the laboratory device, either full-scale or scaled-down models of pumps are tested to establish their characteristics, i.e., experimental trials are conducted. Pump testing can be carried out for various purposes, such as initial factory testing, state acceptance testing, specified group testing, delivery-acceptance testing, periodic testing, reliability testing of components, standard testing, etc.

Figure 2. General view of the laboratory setup.

During the tests, the main performance indicators of the pumps (Q – flow rate, H – head, N – power, η – efficiency, and H_{jvak} – suction head) are determined in the following manner.

This device, which operates as a closed circulation system with a constant liquid volume, enables research to be conducted on determining the pump's performance characteristics and examining the cavitational and hydro-abrasive wear of its components. The operating parameters of the pump can be adjusted by changing the valve position in the pressure pipeline. The pressure head HHH generated by the pump is determined using the readings of the vacuum gauge (MV) installed on the suction side and the pressure gauge (M) mounted on the discharge side, based on the following formula.

$$H=\frac{P_{вак}+P_{ман}}{\gamma}+Z+\frac{V_x^2-V_s^2}{2g} \qquad (1)$$

$$H = h_{вак} + h_{ман} + Z + \frac{V_x^2 - V_s^2}{2g} \qquad (2)$$

Here, $h_{вак} = \frac{P_{вак}}{\gamma}$ and $h_{ман} = \frac{P_{ман}}{\gamma}$ are the readings of the vacuum gauge and the pressure gauge, respectively, expressed in meters of water column

Figure 3. Application of flowmeter and ultrasonic flow measuring device in laboratory conditions.

As previously mentioned, the pump flow rate can be determined using devices with narrowed cross-sections installed on the pressure pipe (Venturi tubes, conical tubes, diaphragms), volumetric vane meters, Pitot tubes, and induction or ultrasonic water flow meters. When using devices with narrowed cross-sections, the flow rate Q is calculated using the following formula:

$$Q = \mu F \sqrt{2 g \Delta h} \qquad (3)$$

When using a volumetric vane meter (e.g., BT-50), the volume W (m³) recorded during time t (s) is used to calculate the flow rate:

$$Q = \frac{W}{t}, \qquad (4)$$

In cases where installing flow measuring devices is not possible, the flow rate *Q* for electrically powered pump systems can be determined using the simplified formula:

$$Q = K\sqrt{(JUm-\mu)^{2/3} - (h_{м.вак} + h_{ман} + Z)} \tag{5}$$

where J and U are the current (A) and voltage (V); $h_{m.vak}$ and h_{man} are vacuum and pressure head readings; Z is the elevation difference; k, m, μ are coefficients related to the geometry, kinematics, dynamics of the pump, and motor characteristics.

The power *N* (kW) on the pump shaft is calculated through the electrical power supplied to the motor using the following formula:

$$N = \frac{\sqrt{3}\,JU}{1000} \cdot \cos\phi \cdot \eta_{дв} \tag{6}$$

where I is current (A), U is voltage (V), $cos\varphi$ is power factor, and $\eta_{дв}$ is motor efficiency.

In cases where a balancing motor or a torque dynamometer is installed, the shaft power *N* can be determined using:

$$N = \frac{\pi n M}{30000}; \tag{7}$$

where M is the torque (M = G · ℓ), G is the applied force (N), ℓ is the lever arm (m), and n is the rotational speed (rev/s).

The shaft speed n is measured using a tachometer or special counter. The experiments are repeated by adjusting the throttle valve in up to 16 positions, from Q=0 to Q_{max}. At each position, Q, H, N, and η are recorded.

Pump efficiency η is calculated using the formula:

$$\eta = \frac{9,81\,QH}{N} \tag{8}$$

The allowable vacuum and geodetic suction heads are calculated using the formulas:

$$H^{ж}_{вак} \le H_a - h_{буг} - \Delta h_{ж} + \frac{V_s^2}{2g}; \qquad (9)$$

$$h_{s.ж} \le H_a - h_{буг} - \Delta h_{ж} - \Sigma h_{ws}; \qquad (10)$$

For this, the critical cavitation margin Δh_{crit} is determined from cavitation testing conducted to obtain the pump’s cavitation characteristic curve (see Figure 4).

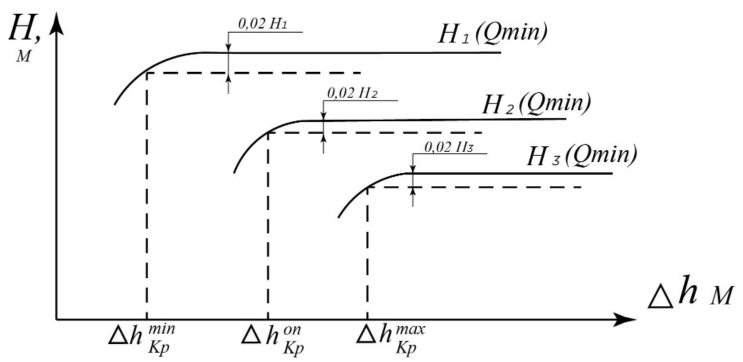

Figure 4. Pump’s specific cavitation characteristic curve

During cavitation testing, the volumetric tank is sealed hermetically, and the throttle valve on the pressure pipe is partially closed to set the pump to a working regime corresponding to a certain **Q_1 = const** and **H_1 = const**. By using a vacuum pump, the atmospheric pressure H_a in the volumetric tank is altered, and the corresponding values of **Δh** are calculated using the formula below. Based on these values, the cavitation characteristic curve is constructed. The experiment is repeated for other operating conditions of the pump, such as **Q_2, H_2**, etc.

$$H_{вак} = H_a - h_{буг} - \Delta h + \frac{V_s^2}{2g}, \qquad (11)$$

In open systems, where H_a remains constant, cavitation characteristics are constructed by maintaining the pump's operation at $\mathbf{Q_1 = const}$ and $\mathbf{H_1 = const}$ using throttle valves installed on the suction and pressure pipelines.

CONCLUSION

The study emphasizes the importance of selecting effective experimental setups and understanding their operating principles when conducting research. It also highlights the necessity of properly planning the experiment, choosing suitable measurement and observation methods, and applying statistical analysis techniques for evaluating results. It is noted that from a scientific perspective, each step in the experimental process must be carefully planned and executed.

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