



Scientific Conference on Multidisciplinary Studies

Hosted online from Bursa, Turkey

Website: econfséries.com

11th November, 2025

CAUSES OF WEAR OF IMPELLER BLADES IN CENTRIFUGAL PUMPS OF PUMPING STATIONS

Shakirov Bakhtiyor Makhmudovich

Doctor of Technical Sciences, Professor

Andijan Institute of Agriculture and Agrotechnologies

Abdukhalilov Obomuslim, son of Abdumajid

Assistant Andijan Institute of Agriculture and Agrotechnologies

Omonov Golib Almatovich

Doctoral candidate Scientific Research

Institute of Irrigation and Water Issues

Khalilov Nurdiyoy Oybekovich

Doctoral candidate Scientific Research

Institute of Irrigation and Water Issues

Abstract:

Pumps are hydraulic machines widely used in various fields. There are different types of pumps depending on the area of application, and centrifugal pumps are among the most common. Over time, pumps face various problems and require technical maintenance. Among them, impeller wear is one of the most common issues that reduce pump efficiency. Cavitation, corrosion, and erosion are also major problems encountered in centrifugal pumps. To minimize these problems, frequent maintenance strategies are required. Many researchers have used different methodologies to address these issues. This work presents various problems observed in centrifugal pumps and their causes.

Keywords: pump optimization, impeller, corrosion, erosion, cavitation, design.



Scientific Conference on Multidisciplinary Studies

Hosted online from Bursa, Turkey

Website: econfséries.com

11th November, 2025

Introduction:

Pumps are used to move liquids from one place to another. There are various types of pumps depending on their application and field of operation. Among them, centrifugal pumps are the most common due to the simplicity of their operating principle and relatively low production cost [1]. Because of these advantages, centrifugal pumps have found widespread use in various sectors of agriculture and industry.

Despite their wide use and demand, the efficiency of pumps decreases over time. Cavitation, corrosion, erosion, and mechanical damage are the main problems that pumps face [2]. Many researchers have studied the causes of such problems, and some have developed their own preventive measures. Therefore, this study examines the causes of failures in centrifugal pumps.

The study of friction and wear began in the late 1930s. Surface damage or material removal from one or both solid bodies during sliding, rolling, or impact relative to each other is called wear [3]. Wear occurs due to interactions at small contact surfaces. When two materials move relative to one another, the contacting surfaces may shift or change their properties without causing erosion. Later, over time, the same material may undergo erosion. Because of this, it was historically difficult to formulate an accurate definition of wear. Most common definitions focus on the progressive loss or destruction of material as a result of mechanical interaction between components [4].

Based on the mechanisms of embrittlement described in the literature, six main embrittlement processes have been identified, each representing a separate phenomenon, but having one common characteristic—loss of solid material due to cavitation [3]. It is estimated that cavitation-hydroabrasive erosion accounts for two-thirds of the factors that reduce the performance of irrigation pumping stations. Centrifugal pumps are also exposed to various types of wear that limit their service life. The most common types are hydroabrasive, cavitation, corrosive, and erosive wear. In real conditions, several processes may occur simultaneously [5]. However, the most common types of wear in centrifugal pumps are cavitation, corrosion, and erosion, which are described below.

Scientific Conference on Multidisciplinary Studies

Hosted online from Bursa, Turkey

Website: econfseries.com

11th November, 2025

Cavitation erosion can be defined as the formation and subsequent collapse of vapor bubbles under any flow conditions in a medium where the liquid pressure is equal to or lower than the vapor pressure of the fluid. When vapor bubbles collide with metal surfaces, deposits form on the surface film. Cavitation is characterized by constant shaking, vibration, and increased noise levels in the suction area of the pump impeller, as well as a reduction in total pressure and output power. It should be understood that cavitation can be difficult to detect when there is significant background noise or improper acoustic signal calibration [10].



Figure 1. Effect of cavitation on the blades of a centrifugal pump at pumping station KAK-1.

Cavitation can occur in various parts of centrifugal pumps. The liquid flows between the blades into the inlet section, and then into the pressure or suction zone of the blade, where the pressure drops again.

Cavitation creep is a serious problem for centrifugal pumps and other hydraulic systems. Cavitation can lead to pressure drop and strong cavitation shocks, which damage the blades and other components.

To analyze the cavitation process, the following formulas can be used:

Cavitation occurs as a result of changes in the pressure of the liquid flowing onto the blades. The cavitation pressure (P_v) is calculated using the following formula:



Scientific Conference on Multidisciplinary Studies

Hosted online from Bursa, Turkey

Website: econfseries.com

11th November, 2025

$$P_v = \frac{2 \cdot \sigma}{r}$$

here:

P_v - cavitation pressure

σ - surface tension of the liquid

r — bubble radius.

To determine the rate of cavitation creep, the following formula is used:

$$E = k \cdot (P_{atm} - P_v) \cdot t$$

Here:

E — bending value,

k - bending coefficient

P_{atm} - atmospheric pressure,

P_v - cavitation pressure,

t — time

Cavitation pressure arises due to the boiling point of water:

$$P_v < P_{sat}$$

Here:

P_{sat} - boiling pressure.

To prevent cavitation, it is important to optimize the pump design and consider high hardness and corrosion resistance when selecting materials. If the pressure in the suction section falls below the saturated vapor pressure of the liquid, vapor bubbles form. These bubbles are carried by the flow and collapse only in zones of relatively high pressure [12]. Figure 1 shows typical blade damage caused by cavitation. Cavitation is not limited to the area between the blades but also spreads into the air ducts. At the initial stage, the bubbles collapse in the inter-blade passages.

Another way to reduce the likelihood of cavitation is to use a larger-diameter suction pipeline, which increases vacuum pressure and reduces the chance of pressure loss between the blades. Suction pipelines are usually one or two sizes larger than the pump inlet, but never smaller. Proper pipeline layout helps maintain a constant flow velocity and prevents cavitation. Obstructions in the pipeline change the flow velocity, which in turn changes the liquid pressure and may lead

Scientific Conference on Multidisciplinary Studies

Hosted online from Bursa, Turkey

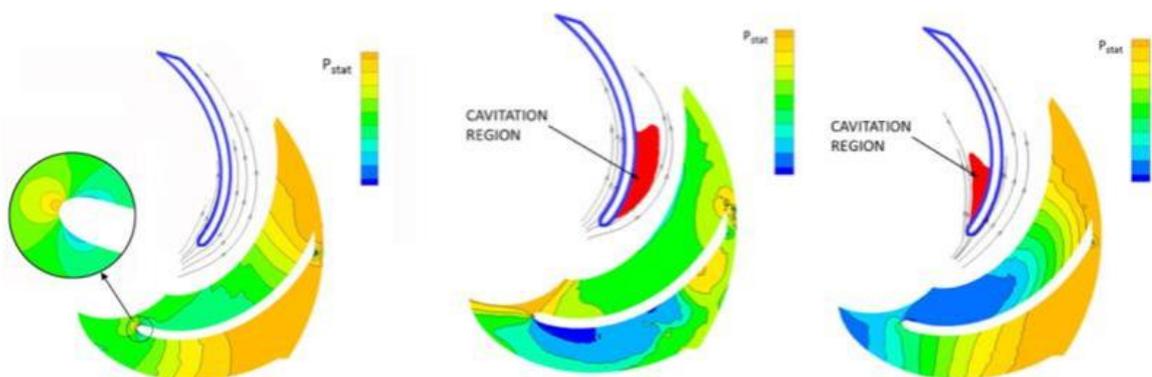
Website: econfseries.com

11th November, 2025

to cavitation. Under high-intensity flow conditions, the pipe length should be five times greater than its diameter to ensure a steady flow into the pump inlet [16].

Operation of the pump must follow the manufacturer's instructions. The main factors affecting cavitation during pump operation include the condition of the pumped liquid, pressure and flow ranges, pump rotational speed, temperature, etc. It is not recommended to operate the pump outside of its operating parameters. It should operate at the flow rate recommended by the manufacturer, without surging, and close to its rated value, which may differ slightly from the point of maximum efficiency [14]. Regarding flow conditions, there are four main terms associated with cavitation: partial load, overload, and circulation.

a centrifugal pump operates at partial load, the flow inside the impeller moves in the same direction as the impeller blades [17] .



2. Cavitation Processes in a Centrifugal Pump under Full Load, Overload, and Partial Load

Figure 4 shows the flow direction based on the point of maximum efficiency, which coincides with the direction of the blade. However, the presence of the blade obstructs the incoming flow, creating zones of low static pressure on both sides of the blade. Even if the flow direction perfectly matches the blade direction, cavitation may occur if there is a significant drop in static pressure at the inlet.

According to the data, the shape of the leading edges has a major impact on pump inlet requirements. Based on these findings, the impeller should have a sharp leading edge to reduce inlet stresses. Many standard pumps have semi-circular inlet



Scientific Conference on Multidisciplinary Studies

Hosted online from Bursa, Turkey

Website: econfséries.com

11th November, 2025

edges, mainly to simplify design and ensure efficient impeller performance at high flow rates.

When the pump construction causes inlet velocity to mismatch the impeller, the flow separates at the impeller entrance and forms a separated wave zone at constant pressure. When the pump operates in overload mode, impellers typically fail at the point where the cavitation zone ends on the discharge side, usually located at the initial cross-section. Under heavy overload conditions, cavitation may appear on the diaphragm surface between impellers due to acceleration caused by curvature in those regions.

If the pump operates under significant overload, damage may occur to the volute, cutting the water on the discharge side. These conditions are rarely detected because inspection of the volute is far more limited than inspection of the impeller blades.

Under partial load conditions, damage most often occurs on the suction side of the impeller. Cavitation pits form on the suction side near the impeller inlet. In general, for energy-efficient and stable operation, pumps should have an effective efficiency of 80% to 100% [20].

Among the problems examined in this study, wear is a phenomenon that can occur due to the contact of two solid bodies and is always harmful to hydraulic machines. It cannot be completely prevented in equipment that involves contact between multiple surfaces. Cavitation, erosion, corrosion, and other phenomena are widely present in centrifugal pumps, especially in their impellers.

The most important strategy to reduce this problem is the proper selection of the pump according to operating conditions and the type of pumped liquid. In addition, the pump's performance curve provided by the manufacturer must be followed completely. Material selection and optimization are methods to minimize wear, but they increase cost, requiring a balance between cost and pump function. Design optimization is another method that many researchers have used to improve the efficiency of centrifugal pumps using numerical models. However, experimental validation for such applications has been insufficiently studied and has not yet been widely implemented in industry. Therefore, more attention should be paid to verifying optimized designs under real field conditions.



Scientific Conference on Multidisciplinary Studies

Hosted online from Bursa, Turkey

Website: econfseries.com

11th November, 2025

REFERENCES

1. Mamazhonov M., Improving the efficiency of centrifugal and axial pumps at irrigation system pumping stations. /Dissertation/ Andijan, 2005.
2. Mamazhonov M., Hakimov A., Majidov T., Uralov B., *Practical exercises on pumps and pumping stations*, Andijan, 2005, No.1, pp.72-73.
3. Shakirov B.M., Ermatov K.M., Abdukhalilov O.A., Shakirov B.B., Experimental setup for studying cavitation and hydro-abrasive wear in centrifugal pumps. // *International Scientific Journal*, 2022, No. 5, pp.692-697.
4. Shakirov B.M., Abduxalilov O.A., Sirochov A.M., Carrying out the hydraulic calculation of aquifers of pumping stations and working with sediments (example of Ulugnor pumping station) // *Eurasian Journal of Engineering and Technology*, 2022, No.4, pp.88-92.
5. Shakirov B.M., Abdukhalilov O.A., Teshaboev B.R., Improving the method of calculating hydraulic resistance in the water intake structure of the Ekin–Tikin pumping station. // *Proceedings of International Conference*, 2023, No.6, pp.210-217.
6. Shakirov B.M., Abduxalilov O.A., O‘rinov I.Sh., Makhmudov D., Botirova N.M., Evaluation of the technical and economic efficiency of centrifugal pumps at irrigation pumping stations // *Universum Technical Sciences*, No.10(127), October 2024, pp.52–54.