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Centrifugal Pump Maintenance Planning with a Capacity of 650 Liters/Minute for 2026

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Abstract. The problem faced is the decline in the performance of a 650 liter/minute centrifugal pump due to wear on components, especially the impeller, rolling bearings, and mechanical seals in supplying process water and clean water in industrial production systems. The planning objective is to obtain a maintenance schedule for a 650 liter/minute centrifugal pump for the operational period of 2026 and the ratio between maintenance costs and profits generated by the machine. The maintenance planning method includes collecting maintenance data from previous maintenance periods, reviewing centrifugal pump specifications, applying the inspection, replace, repair, and overhaul (IRRO) approach, estimating the age and price of components that are expected to be damaged, estimating the cost and duration of dismantling and installing components that have been repaired in accordance with the provisions of the requirements for usable components or replacement parts, scheduling maintenance and repairs, estimating maintenance and repair costs for the 2026 period, and determining the ratio of maintenance costs to profits. The planning results are in the form of a maintenance schedule for the 2026 period worth IDR 4,290,000,-, a maintenance cost to profit ratio of 7.44% and the implications indicate that the machine is still suitable for use and prospective for operations in the next few years.

Keywords: Capacity 650 Liter/Minute; Centrifugal pump; Impeller; Maintenance planning; Mechanical seal.

1. INTRODUCTION

Essentially, all machines have an effective lifespan. Maintenance can extend their lifespan. However, there are times when a machine reaches a point where repair is no longer an option. Without exception for centrifugal pumps, maintenance programs are designed and planned to maintain performance. In order to minimize such problems frequent maintenance strategies are required (Pokharel et al., 2022). Pumps are the machines that convert the mechanical energy they receive from the power supply into hydraulic energy. Pumps allow the fluid to reach the pump impeller by bringing the low- pressure field to the suction line. The impeller directs the fluid to the outlet pipe and transmits it to the desired point. All pumps are divided into two main groups. These are displacement (positive displacement) and dynamic (non-positive displacement) type (Güner & Özbayer, 2020).

Maintenance is an effort to prevent or eliminate the causes of damage before they occur. Cleaning, lubrication, inspection, maintenance, and adjustment are examples of maintenance actions. Meanwhile, repairs address the impact of damage after failure occurs (Hadi, 2019). Proper maintenance is essential for keeping production facilities and machinery operational,

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when machines or components fail, production is disrupted, potentially halting processes, missing targets, and jeopardizing the company's ability to satisfy consumer expectations. Regular inspections, lubrication, and component checks (bearings, seals, impellers, motors) are essential. Daily visual checks, weekly lubrication and seal inspections and motor checks are recommended. Annual in-depth maintenance should follow manufacturer guidelines. Such failures can lead to negative perceptions of the company's reliability, impacting customer loyalty (Nusraningrum et al., 2024).

In industrial practice, component-based maintenance methods such as IRRO (Inspection, Replace, Repair, Overhaul) are effective approaches for organizing maintenance activities, predicting component life, and predicting spare part costs, particularly for machines operating continuously.

Maintenance activities carried out in workshop environments involve considerable occupational hazards, requiring a structured approach to risk identification and also must comply with the principles of occupational health and safety (OHS) (Nugroho et al., 2024). A pump is a device or machine used to move water from one location to another, either from lowlands to higher elevations or vice versa, through a piping system. Pumps operate by creating a pressure difference between the inlet and outlet. The pump converts mechanical energy into kinetic energy, which can then move the fluid and overcome resistance (Yahya & Mulyadi, 2024). Due to the structure and working principle of the centrifugal pump, as the equipment ages or the fluid is abnormal, some mechanical and fluid failures will occur (Chen et al., 2022). The key parts prone to failure include the motor (highest MTTR at 58 hours, RPN 384), mechanical seal (highest failure rate 8.06E- 04/hr, RPN up to 160), shaft, and impeller. These drive most breakdowns from issues like overheating, misalignment, erosion, and cavitation (Funmilayo & Saturday, 2023).

Degradation increases both operation costs and failure probability. Upon failure, the machine is either replaced by a new one or subject to a thorough repair that takes it back to a pristine state (Ruiz-Hernández et al., 2020). Considering the pump's operating life span has reached over seven years and the increasing need for production efficiency, developing an IRRO-based maintenance plan is highly relevant for implementation in 2026. In addition to maintaining performance and extending component life, proper maintenance planning can also reduce potential downtime and optimize operational costs. Optimal pump performance not only ensures service to customers, but also directly reduces financial losses due to energy inefficiency and unexpected breakdowns (Manullang et al., 2025).

Preventive Maintenance (PM) policy is a proactive technique that has been used since the inception of maintenance systems research (Basri et al., 2017). The efficiency of PM when applied to leased objects is considered the determinant of revenue for the next rental period (Ben Mabrouk et al., 2016). To analyze the reliability parameters of the centrifugal pump system from which a maintenance plan, centered on the analyzed centrifugal pump system's reliability, was generated, that reduces the operational cost (Igbeghe et al., 2024)

The total average cost per unit time, including production, warranty, and maintenance expenses, needs to be optimized throughout the equipment's useful life; where the application of multi-objective genetic algorithm models can increase availability, reduce maintenance costs, and improve plant profitability in continuous operating systems, while increased predictive maintenance levels reduce quality control costs, and an effective balance between preventive and corrective maintenance is required to minimize overall expenditure (Nourelfath et al., 2016).

Therefore, this study was conducted to design a maintenance plan for a 650 liter/minute centrifugal pump using the IRRO method and to estimate the machine's feasibility for rejuvenation by calculating the rejuvenation cost against the machine's rental cost. The output of this planning is expected to improve equipment efficiency and operational efficiency. The continuous assessment and prediction of the level of performance degradation of manufacturing equipment, as well as the complex interaction between the production process and maintenance operations is the essential mechanism in determination of maintenance scheduling (Patrício et al., 2025).

A predictive and preventative maintenance (PPM) program for centrifugal pumps incorporates four areas and six parameters that define a pump's performance (Yahya & Mulyadi, 2024). In the case of closed impeller-type centrifugal pumps, wear rings (wearing components) are installed to provide a clearance between the impeller and the casing, preventing physical contact during operation. The size of this clearance significantly affects pump performance (Putra & Soriarta, 2025).

2. METHODS

This 650-liter/minute centrifugal pump experienced damage in 2022. Bearing wear occurred due to misalignment between the motor shaft and the pump body, causing excessive friction. Bearing replacement and shaft alignment were necessary.

Because the centrifugal pump is currently experiencing symptoms similar to those experienced during the last engine upgrade in 2022, this plan was developed and will be implemented in 2026 using the IRRO method. The detailed specifications of the centrifugal pump ais shown in Table 1.

Table 1. The Centrifugal Pump Specifications.

Technical specifications	
Maximum flow	40 m^3/h (650 l/min)
Impeller	Brass (Ø 200 mm)
Power	1.5 HP – 15 kW
Temperature	-25 ±130 ºC
Rotation speed	2900 rpm (50 Hz) 3450 rpm (60 Hz)
Material	Cast iron

Components to be maintained and repaired are shown in Figure 1.

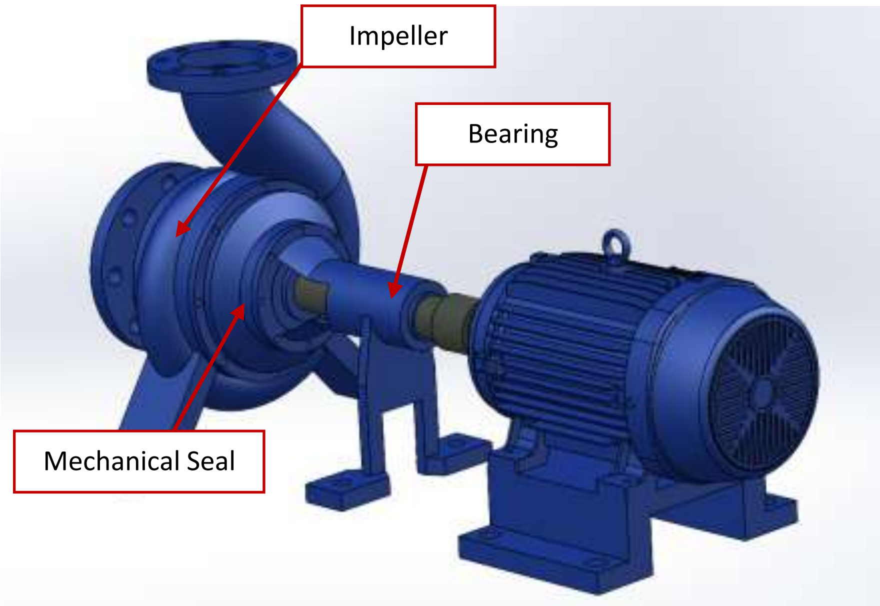

Figure 1. Components to be replaced.

3. RESULT AND DISCUSSION

Maintenance for the 650 L/min centrifugal pump is designed to maintain stable and reliable operating performance through scheduled inspection and minor repair activities. Inspection procedures for the centrifugal pump include assessing overall cleanliness, evaluating the physical condition of internal and external components, and checking for abnormalities in the pump. So, when it comes to the IRRO maintenance schedule is shown in Table 2.

Table 2. Centrifugal Pump Maintenance Schedule in the 2026 Period.

No.	PART	YEAR OF 2026																									
		JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OKT		NOV				DES	
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
3	Bearing		Rc		I		I		I		I		I		I		I		I		I		I		I		I
4	Mechanical seal		Rc		I		I		I		I		I		I		I		I		I		I		I		I
5	Impeller		Rc		I		I		I		I		I		I		I		I		I		I		I		I

Remarks: I: inspection, Rc: Replace, Rr: repair, O: Overhaul

The 2026 IRRO table was developed to regulate the maintenance of critical centrifugal pump components: the impeller, bearing, and mechanical seal, through a biweekly inspection schedule and planned replacement activities. Inspections were conducted every two weeks because this interval aligns with industry practice, which recommends a 1–4 weekly inspection for rotating equipment under process load. Replacement of the bearing and mechanical seal was scheduled for the first week of July because the service life of both components had reached four years since the last replacement in 2022. At the same time, the impeller was replaced because inspection results indicated a decline in pump performance. After replacement, inspections continued periodically to ensure the new components adapted to operational conditions, verify the absence of misalignment, initial leaks, or increased vibration, and ensure the effectiveness of the measures.

To determine further action, knowing every cost that will be spent on this planning is a must, as it will be used as our guideline for choosing between maintaining the machine or buying a new machine by calculating the ratio between the rent cost (profit) and maintenance cost. Due to that, the cost of the components, supporting tools, and technicians is shown in Table 2, Table 3, and Table 4.

Table 2. Cost of the components.

Component	**Qty**	**Price (IDR)**	**Total (IDR)**
Impeller	1	2,000,000	2,000,000
Bearing	2	50,000	100,000
Mechanical seal	1	100,000	100,000
Total Cost (IDR)			**2,200,000**

Table 3. Cost of the supporting tools.

Support Tool	**Price (IDR)**
Grease	200,000
Cloth rag	10,000
Total cost	**210,000**

Table 4. Cost of the technicians.

Activity	Total Cost
Inspecting	1,560,000
Parts Replacing	160,000
Total Cost (IDR)	**1,720,000**

The technician cost here is based on the average hourly wage of a vocational high school graduate technician, which is IDR 20,000/hour.

After the component, supporting tool, and technician costs are known and determined, the next step is to calculate the operational cost or rental cost when the machine is rented to someone, as well as the maintenance cost. The calculation is shown below.

Operational/Rent Cost/Profit

8 Hours/day, 6 days/week, 4 weeks/month, 12 months/year. So, the total hours per year are 2,304 hours.

The rent cost is IDR 25,000/hour = 2,304 x 25,000 = **57,600,000.**

So, per year, the machine rental cost is **IDR 57,600,000.**

Maintenance Cost = Component Cost +Supporting Tool cost + Service Cost

Maintenance Cost = IDR 2,200,000 + IDR 210,000 + IDR 1,880,000 = IDR 4,290,000.

When all costs are known, the next step is calculating the ratio between Profit and maintenance cost. The result of this will be our main base factor to determine whether or not the maintenance action is worth doing.

Ratio = (Maintenance Cost/Profit) x 100% = IDR 4,290,000./IDR 57,600,000. = **7.44%**The whole calculation was based on the brand new 2018 pump price, at that time it was IDR 15.000.000. When it comes to 2026 planning, it is a must to comparing old 2018 price to the current 2026 price after asset depreciation and current inflation. Short calculation about inflation from 2018 to 2025 is 2018 kurs USD → IDR is around **IDR 14,200 per USD**. Today IDR currency (04/12/2025): 1 USD ≈ **IDR 16,650.**

IDR Conversion rupiah 2018 to USD: 15,000,000 (2018 pump)/14,200 (2018 IDR/USD) ≈ 1,056.34 IDR.

USD conversion to current IDR (2025/2026) ~ Rp 16.650/USD: 1,056.34 USD× 16,650 (IDR/USD) ≈ **17,590,000 IDR.**

This is the 2018 to 2025 inflation calculation (brand new price). If we assume 2026 inflation will increase just like the previous year, it could be higher than this calculation, but the difference could be minor. Asset depreciation for the centrifugal pump is assumed 5%/year based on pump life time (20 years). In this case, the pump has been used for nearly 7 years so it will be 35% depreciated. 17,590,000 x (1-35%) = **IDR 11,435,000,-**

4. CONCLUSION

Based on the recalculated asset value after depreciation and inflation, the pump originally valued at IDR 15,000,000 in 2018 is estimated to have a remaining economic value of IDR 11,435,000 in 2026 as a used machine. With the maintenance cost ratio of only 7.4% of the profit, the maintenance investment is still significantly lower than the residual machine value, indicating that operation in 2026 remains economically justified and pump renewal is not required.

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