
Analysis And Evaluation Of The Performance Of A Low-Pressure Boiler Feed Pump Induction Motor Based On Temperature Increase

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Abstract

The induction motor in the Low Pressure Boiler Feed Pump (LP BFP) system plays a crucial role in ensuring the smooth operation of the power generation process at the combined cycle power plant. An increase in motor temperature is a key indicator for evaluating performance and detecting potential operational issues at an early stage. This study aims to analyze and evaluate the performance of the LP BFP induction motor based on temperature rise and motor vibration conditions at PT PLN Nusantara Power UP Gresik. The research method employs a descriptive quantitative approach through field observations, temperature measurements, vibration analysis, and the collection of motor operational data. The results show that the motor temperature on the Drive End (DE) side is 56.8°C and on the Non-Drive End (NDE) side is 47.6°C, which are still within normal operating limits. However, the vibration analysis results indicate bearing damage with an ALARM status based on ISO 10816-3. Therefore, regular temperature monitoring and preventive maintenance are crucial to maintaining the motor's operational reliability.

Keywords: Induction Motor, Lp Bfp, Motor Temperature, Motor Vibration, Preventive Maintenance.

INTRODUCTION

The demand for electricity in Indonesia continues to rise in tandem with growth in the industrial and technology sectors, as well as public needs. These conditions require power generation systems to operate reliably, efficiently, and sustainably. One type of power plant that plays a crucial role in maintaining the stability of the electricity supply is the Combined Cycle Gas and Steam Power Plant (CCGSP). In this system, the continuity of the power generation process depends not only on main units such as turbines and generators but is also influenced by the performance of supporting equipment that operates continuously, one of which is the Low-Pressure Boiler Feed Pump (LP BFP). (Kurang et al., 2018)

The LP BFP is a critical component in the PLTGU power generation cycle, functioning to supply feedwater to the boiler system prior to the steam generation process. The reliability of the LP BFP is significantly influenced by the performance of the induction motor, which serves as its primary drive. Induction motors are chosen because they feature a simple construction, reasonably good efficiency, and a high level of reliability for long-term operation in power plant environments. However, induction motors still have the potential to experience malfunctions during operation, particularly those related to temperature increases. (Nova & Hardani, 2018)

Rising temperatures in induction motors are a key indicator in assessing motor condition, as they are directly related to performance, efficiency, and equipment lifespan. Temperatures exceeding operating limits can lead to increased power losses, reduced efficiency, and accelerated degradation of the motor winding insulation. If these conditions persist without proper intervention, they can cause disruptions in the LP BFP system and impact the continuity of power generation at the combined-cycle power plant (CCPP). (Pratama et al., 2020)

In addition to operational load factors, increased motor temperature can also be influenced by suboptimal cooling conditions, voltage imbalances, bearing damage, and high-temperature operating environments. Therefore, temperature monitoring is an important preventive maintenance method to implement in power generation systems. Temperature analysis can serve as an initial step to detect signs of a fault before more serious damage occurs to the induction motor. (Pengajar et al., n.d.)

Several previous studies have shown that temperature is closely related to the performance of induction motors. A study conducted by Pratama found that rising temperatures in industrial pump motors can affect operational stability and reduce motor efficiency. Additionally, research by Antono and Gunawan explains that induction motors operating continuously in industrial systems require periodic condition monitoring to maintain operational reliability and prevent overheating. These findings underscore the importance of fieldwork or internships as a means of applying theoretical knowledge to real-world industrial conditions, particularly in the field of evaluating power generation equipment performance. (Motor et al., 2024)

The internship at PT PLN Nusantara Power UP Gresik provides an opportunity to gain firsthand understanding of power generation systems, particularly in combined-cycle power plant (CCPP) units, and to analyze the operational conditions of LP BFP induction motors based on temperature parameters. Through this activity, students can learn about the application of monitoring systems and the evaluation of induction motor performance used in industrial-scale power generation processes. (Ayankoso et al., 2026)

Based on the above description, the objective of this internship is to evaluate the performance of induction motors in the Low Pressure Boiler Feed Pump (LP BFP) system at the PT PLN Nusantara Power Gresik Combined Cycle Power Plant (CCPP) based on an analysis of temperature increases, as well as to determine the effect of temperature on the efficiency and operational reliability of induction motors during the power generation process. (Setiono et al., 2020)

RESEARCH METHODS

Flow Chart

A research flowchart is used to systematically illustrate the stages of the research process, from problem identification to drawing conclusions. The research process began with the identification of a problem in the LP BFP induction motor related to temperature increases during operation. Next, a literature review was conducted to establish the theoretical foundation supporting the research.

The next stage involves field observations and the collection of operational data on the motor, including measurements of temperature, vibration, current, and voltage. The collected data is then processed and analyzed to determine the effect of temperature on the performance of the induction motor. After the analysis is complete, an evaluation of the motor's condition is performed, and the research findings are compiled into a discussion, conclusions, and recommendations for improvements and preventive maintenance.

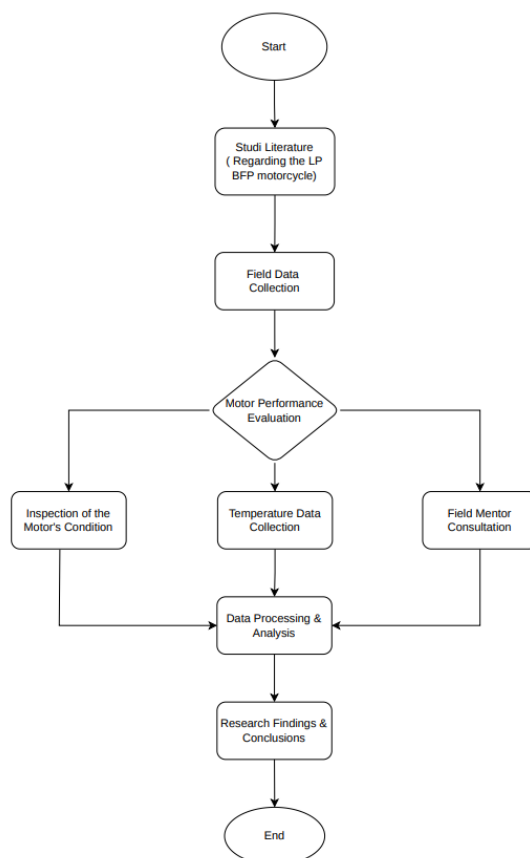


Figure 1. Flow Chart

Field Observation

Field observations were conducted directly at the LP BFP system area within the PT PLN Nusantara Power gas-fired combined-cycle power plant (PLTGU). The purpose of the observations was to understand the actual operating conditions of the induction motors and to examine the LP BFP system's operation during the electricity generation process. During the observation, several operational conditions of the motor were examined, including:

- Motor operating environment
- Motor cooling system
- Motor rotational speed
- Motor operating noise
- Motor vibration
- Motor load during operation
- Condition of the LP BFP pump

The observation was conducted while the power generation unit was in normal operating condition (online) so that the data obtained could reflect actual field conditions. Through this observation, it is also possible to identify potential early signs of malfunction, such as increased temperature, abnormal noise, or excessive vibration in the motor.

Motor Temperature Measurement

Temperature measurements were taken to determine the heat levels generated in the induction motor during operation. Motor temperature is a key parameter in this study because excessive temperature increases can affect the motor's efficiency and service life. Measurements were taken using a temperature gun or thermal monitoring device at several critical points on the motor, namely:

- Drive End (DE) or pump side
- Non-Drive End (NDE) or fan side

- Bearing housing
- Motor body

Temperature data is collected periodically while the motor is operating normally to obtain actual temperature readings during the load test. The temperature data is then recorded and analyzed to determine the heat distribution in each part of the motor.

Motor Vibration Measurement

Vibration measurements are performed to assess the mechanical condition of induction motors and detect potential issues in the motor's rotating system. Excessive vibration can cause temperature increases and accelerate the wear and tear of motor components, particularly the bearings and motor shaft. Vibration measurements are taken using a vibration meter at several measurement points on the motor bearings, both on the Drive End (DE) and Non-Drive End (NDE). The vibration data obtained is then analyzed to determine the motor's operating condition. Vibration measurements are performed because several mechanical issues in induction motors are typically indicated by increased vibration levels, such as:

- Shaft misalignment
- Rotor imbalance
- Bearing damage
- Mechanical looseness
- Motor rotational imbalance

Through vibration measurements, the mechanical condition of the motor can be identified early, allowing potential damage to be prevented through preventive maintenance.

Motor Operational Data Collection

Motor operational data is obtained from the control room and the power plant's monitoring unit. This data is used to determine the operating conditions of the induction motor while the LP BFP is in operation. Some of the operational data collected includes:

- Motor voltage
- Motor current
- Motor power
- Power factor
- Frequency
- Motor speed (RPM)
- Pump operating load

This operational data is used to support the analysis of induction motor performance and to calculate technical parameters such as motor efficiency, motor slip, and power losses. Data collection is performed under stable operating conditions to ensure that the data obtained is more accurate and representative of the motor's actual operating conditions.

Data Analysis Techniques

Data analysis techniques in this study were employed to determine the effect of temperature increase on the performance of an induction motor in a Low Pressure Boiler Feed Pump (LP BFP) system. Data obtained from observations, temperature measurements, vibration measurements, and motor operational data were then analyzed step-by-step to describe the actual condition of the motor during operation in a gas and steam power plant (PLTGU).

The analysis was performed by comparing field measurement results with induction motor theory, industrial motor operational standards, and references from supporting journals and literature. The analysis process focused on the relationship between motor temperature and operational performance, motor efficiency, power losses, and the mechanical condition of the induction motor. The stages of data analysis in this study are described as follows:

Analysis of Synchronous Speed of a Motor

Synchronous speed is used to determine the rotational speed of the stator field in an induction motor. This analysis is performed to determine the basic rotational characteristics of the motor based

on the supply frequency and the number of motor poles. The equation for the synchronous speed of an induction motor is:(Ashfahandika et al., 2025)

$$N_s = \frac{120f}{P} \quad (1)$$

Explanation:

- N_s = Synchronous speed of the motor (rpm)
- f = Power supply frequency (Hz)
- P = Number of motor poles

The synchronous speed equation is used to determine the speed of the rotating magnetic field generated by the stator of an induction motor. The value of the synchronous speed is influenced by the frequency of the power source and the number of motor poles. The higher the frequency used, the faster the magnetic field rotates; conversely, the greater the number of motor poles, the lower the synchronous speed. This equation serves as the basis for determining the rotational characteristics of an induction motor before comparing them with the actual rotor speed.

Motor Slip Analysis

Motor slip is used to determine the difference between the stator's rotational speed and the rotor's rotational speed in an induction motor. In an induction motor, the rotor never rotates at synchronous speed because a speed difference is required to generate electromagnetic induction. The motor slip equation is:(Suhu & Arus, 2025)

$$s = \frac{N_s - N_r}{N_s} \times 100\% \quad (2)$$

Explanation:

- s = Slip motor (%)
- N_s = Synchronous speed (rpm)
- N_r = Rotor speed (rpm)

The slip equation is used to determine the difference between the synchronous speed and the rotational speed of the rotor in an induction motor. In an induction motor, the rotor cannot rotate at the same speed as the synchronous speed because a speed difference is required for the electromagnetic induction process to occur. The slip value indicates the motor's load level during operation. The higher the slip value, the higher the motor load tends to be, which can lead to increased current, rising temperature, and reduced motor efficiency.(Chen et al., 2015)

Analysis of Motor Input Power

Motor input power is used to determine the amount of electrical power entering an induction motor during operation. The equation for three-phase motor input power is:(Zaini & Natasha, 2023)

$$\eta = \frac{P_{out}}{P_{in}} \times 100 \quad (3)$$

Explanation:

- η = Motor efficiency (%)
- P_{out} = Motor output power
- P_{in} = Motor input power

The input power equation is used to calculate the amount of electrical power entering a three-phase induction motor while it is operating. The amount of input power is influenced by the voltage, current, and power factor of the motor. This equation is used to determine the amount of electrical energy required by the motor to operate the LP BFP system. As the current increases due to an increase in the motor's workload, the required input power also increases.(Narayanasamy, 2021)

Analysis of Copper Losses

Copper losses occur due to resistance in the motor's stator windings when an electric current flows through them. This analysis is used to determine the amount of electrical energy converted into heat in the motor windings. The equation for copper losses is:(Habetler & Ran, 2023)

$$P_{cu} = I^2 R \quad (4)$$

Explanation:

- P_{cu} = Copper losses (Watts)
- I = Motor current (Amperes)
- R = Winding resistance (Ohms)

The copper loss equation is used to determine the amount of electrical energy converted into heat in the motor windings due to electrical resistance. The magnitude of copper losses is influenced by the current flowing through the stator windings and the resistance of the conductors. The higher the motor current, the greater the heat generated in the windings. This condition can cause the motor temperature to rise, affecting the performance and insulation life of the induction motor.(Rahyadi et al., 2025)

RESULTS AND DISCUSSION**Data from the LP BFP Motor Nameplate**

Based on direct field observations, data on the specifications of the induction motor used to drive the Low Pressure Boiler Feed Pump (LP BFP) at PT PLN Nusantara Power was obtained from the motor nameplate attached to the equipment. Although the physical condition of the nameplate has deteriorated slightly due to age and the operating environment, several key parameters remain clearly legible.

Tabel 1. Data from the LP BFP Motor Nameplate

Parameter	Value
Manufacturer	ACEC Motors (Belgium)
Standard	IEC 34-1
Power	80 kW (\pm 75 HP)
Voltage	380 V
System	3 fasa
Current	\pm 146 A
Speed	\pm 2940 rpm
Frekuensi	50 Hz
Power Factor	\pm 0.86
Insulation Class	F
Environmental Type	Tropicalised

Based on the nameplate data, the induction motor used is a three-phase motor with considerable power and is designed for continuous duty in industrial power generation systems. The motor has a speed approaching 3000 rpm, indicating that it falls into the category of a 2-pole motor with high-speed characteristics. This condition causes the motor to have a greater potential for temperature rise compared to low-speed motors because the mechanical losses and friction losses that occur during operation tend to be higher. Additionally, the use of Class F insulation indicates that the motor is designed to operate at relatively high temperatures. However, temperature stability must still be maintained to ensure it does not exceed the insulation's operating limits, as this can accelerate the degradation of the motor windings and reduce the equipment's service life.

Motor Temperature Analysis Based on Field Measurement Data

The motor temperature analysis was conducted based on direct measurements taken on the Low Pressure Boiler Feed Pump (LP BFP) induction motor at PT PLN Nusantara Power using an infrared thermometer. Measurements were taken while the motor was operating normally to determine the actual surface temperature of the motor during the power generation process. Temperature data was collected at several measurement points representative of the motor's thermal conditions, specifically at the Drive End (DE) / Pump Side and the area around the Non-Drive End (NDE) / Fan Side. Measurements were taken while the motor was under operational load, ensuring that the obtained temperatures accurately reflect the motor's actual operating conditions. (Filho et al., 2025)

Motor Temperature Measurement Results

Temperature measurements of the LP BFP induction motor were taken at two main points: the Drive End (DE) or pump side, and the Non-Drive End (NDE) or fan side. Data was collected using an infrared thermometer while the motor was operating normally within the combined cycle power plant system. Measurements at these two points were intended to determine the motor's temperature distribution and evaluate the thermal conditions between the motor's load side and cooling side. Based on the field measurement results, the following temperature data was obtained:

Table 2. Motor Temperature Measurement Results

Measurement Point	Temperature
Drive End (DE) / Sisi Pompa	56,8 °C
Non Drive End (NDE) / Sisi Fan	47,6 °C

Based on the measurement results in Table 4.2, the temperature on the Drive End (DE) side was recorded as higher than that on the Non-Drive End (NDE) side. This indicates that the DE side a greater mechanical load because it is directly connected to the BFP LP pump. Meanwhile, the temperature on the NDE side tends to be lower because it is located in the area of the fan or motor cooling system, which aids in heat dissipation while the motor is operating.

Drive End (DE) Temperature Analysis

Based on temperature measurements taken at the Drive End (DE), a temperature of 56.8 °C was recorded. This temperature indicates that the DE side is hotter than the Non-Drive End (NDE) side. This is because the Drive End is the part of the motor directly connected to the BFP LP pump, causing it to bear the greatest mechanical load while the motor is operating.

The temperature increase on the DE side is influenced by several factors, such as the pump's rotational load, bearing friction, high rotor speed, and power losses within the motor. Additionally, heat transfer from the pump shaft and coupling causes heat accumulation in that area to be greater than on the other side.

Although the temperature on the DE side is higher, a value of 56.8 °C remains within the safe operating limits for industrial induction motors. Based on various references and journals regarding induction motor temperature monitoring, the normal operating temperature range for industrial motors is generally between 40 °C and 80 °C during continuous operation. Thus, the temperature condition on the DE side indicates that the motor is operating normally and has not yet experienced overheating. In addition, the stable temperature indicates that the motor's cooling system is still capable of effectively managing heat dissipation, ensuring that heat generated during operation does not accumulate excessively on the drive end.

Tabel 3. Drive End (DE) Temperature Analysis

Parameter	Result
Measurement Point	Drive End (DE)
Temperature	56,8 °C
Operating Condition	Normal
Overheating Indication	None

The results of the evaluation indicate that the thermal conditions on the drive end are still within safe limits to support continuous operation of the BFP LP motor in the power generation system.

Non-Drive End (NDE) Temperature Analysis

Temperature measurements on the Non-Drive End (NDE) side indicate a temperature of 47.6 °C. The temperature on the NDE side is lower than that on the DE side because this section is located in the area of the fan or motor cooling system, which helps dissipate heat while the motor is operating. The lower temperature on the NDE side indicates that the motor's ventilation and cooling systems are still functioning properly. Airflow from the motor fan helps maintain temperature stability, allowing heat generated by the motor to be optimally dissipated into the surrounding environment.

In addition to being influenced by the cooling system, the relatively stable temperature on the NDE side also indicates that the bearings on that side are still in good condition and have not experienced excessive friction that could cause a temperature rise. Based on the operating temperature standards for induction motors, a temperature of 47.6 °C is still within the normal and safe range for a motor operating continuously in a power plant environment. This condition indicates that the motor's heat distribution remains sufficiently even and there are no indications of serious thermal issues.

Tabel 4. Non-Drive End (NDE) Temperature Analysis

Parameter	Result
Measurement Point	Non Drive End (DE)
Temperature	47,6 °C
Operating Condition	Normal
Overheating Indication	None

Based on the results of the evaluation, it can be seen that the temperature on the non-drive end remains stable and the motor cooling system continues to function optimally in maintaining the thermal conditions of the LP BFP motor throughout the operation.

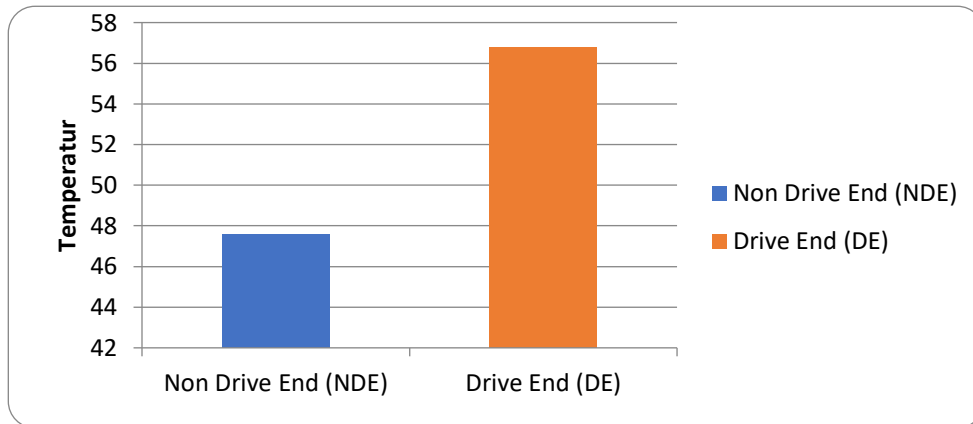


Figure 2. Motor Temperature Comparison Chart

Based on the results of the evaluation, it can be seen that the temperature on the non-drive end remains stable and the motor cooling system continues to function optimally in maintaining the thermal conditions of the LP BFP motor throughout the operation.

Based on the chart showing the measured temperatures of the LP BFP motor, it can be seen that the temperature on the Drive End (DE) side is higher than that on the Non-Drive End (NDE) side. The temperature on the DE side is 56.8 °C, while on the NDE side it is 47.6 °C. This temperature difference occurs because the Drive End is directly connected to the pump, thus receiving a greater mechanical load while the motor is operating. Meanwhile, the temperature on the Non-Drive End tends to be lower because it is located in the area of the fan or the motor cooling system, which aids in heat dissipation.

This condition indicates that the motor's cooling system is still functioning properly and the motor's heat distribution remains sufficiently stable. Overall, the temperature measurement results show that the motor's condition is still within normal operating limits and has not yet experienced overheating. Additionally, the temperature difference between the two sides of the motor is still considered reasonable, so the performance of the LP BFP induction motor can still be categorized as good and safe for use in power plant operations.

Vibration Analysis of the LP BFP Motor

A vibration analysis was conducted to assess the mechanical condition of the induction motor in the Low Pressure Boiler Feed Pump (LP BFP) system based on predictive maintenance data from PT PLN Nusantara Power. Vibration measurements were taken as part of equipment condition monitoring to detect motor malfunctions early on before more serious damage occurs. Based on the measurement results and the recommendation report from the Technology Owner at UP Gresik dated January 13, 2025, the condition of the LP BFP 3A motor is at the ALARM status according to ISO 10816-3 standards. This condition indicates that the motor's vibration level has increased and requires further attention. Additionally, the analysis results also indicate a bearing defect in the motor, characterized by the appearance of non-harmonic vibration patterns in the vibration spectrum and an increase in the motor's peak vibration value.

Equipment Condition and Vibration Status Analysis

The first page of the predictive maintenance report shows the condition of the LP Boiler Feed Pump 3A equipment with an ALARM status based on the ISO 10816-3 standard. This status indicates that the motor's vibration level has increased and requires further attention. Additionally, the report explains that there is noise or abnormal sound from the motor during operation. The analysis results in the report indicate signs of a bearing defect in the motor, marked by the appearance of non-harmonic patterns in the vibration spectrum and the motor's vibration peaks. This condition indicates that the motor bearings are beginning to fail, causing increased motor vibration during operation. Furthermore, the recommendations section explains that the motor vibration trend continues to rise compared to previous data. Therefore, the Engineering & QA team recommends replacing the inner and outer motor

bearings to prevent the damage from worsening and disrupting LP BFP operations.


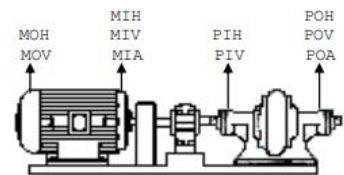

Data Equipment			Status	
Nama equipment	: LP Boiler Feed Pump 3A		ALARM	
Area	: ST #3.0			
MPI	--			
Jenis Tes	RUTIN			
Daya	75	KW	VIBRATION CHART ISO 10816-3 Load Test 	
Kelas Vibrasi	2	ISO 2372		
Arus Normal	146	Ampere		
Bearing Motor	6219 C3	Outboard		
	6219 C3	Inboard		
Bearing Pompa	RB 7310 BG	Inboard		
	RB 310 E	Outboard		
Gambar				Foto Equipment
				
Analisa				Rekomendasi
<ul style="list-style-type: none"> - Terdapat Noise pada Motor. - Terdapat indikasi bearing defect pada motor yang ditandai non harmonic pada spectrum maupun peak vu. - Trend vibrasi peak vu motor mengalami kenaikan. 			<ul style="list-style-type: none"> - Ganti bearing motor sisi inside dan outside. - Segera dilakukan perbaikan untuk menghindari kerusakan yang lebih parah. 	

Figure 3. Equipment Condition

Analysis of the Overall Vibration Graph

Based on the overall vibration graph for the LP BFP 3A motor, it can be seen that vibration values at several measurement points have increased compared to previous data. The highest vibration value was recorded at the PIH point at 3.872 mm/sec, while other points such as POV, POH, and PIV also showed relatively high vibration values. This increase in overall vibration values indicates that the motor’s mechanical condition is beginning to degrade during operation. Increased vibration in a motor is generally influenced by several factors, such as bearing damage, rotor rotational imbalance (unbalance), shaft misalignment, and mechanical friction occurring within the motor’s components. Additionally, increased vibration can also be caused by a decline in bearing lubrication quality, resulting in less stable motor rotation. Based on the monitoring results, the rise in overall vibration indicates that the motor bearings are beginning to experience issues and require further attention. Although the motor is still operational, this condition must be addressed immediately to prevent more serious damage to the LP BFP system.

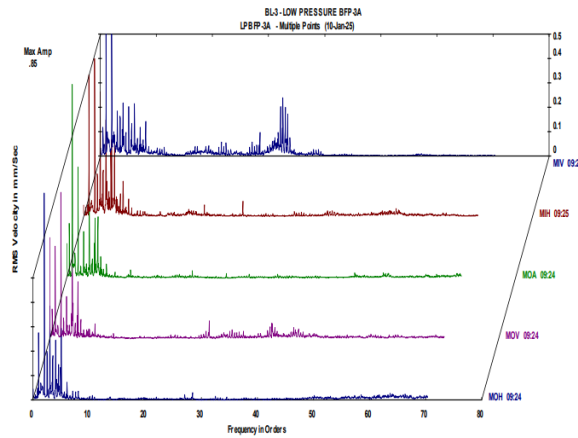


Figure 4. Overall Vibration Graph

Multiple Spectrum Graph Analysis

Based on the Multiple Spectrum graph, a non-harmonic vibration pattern is observed on the LP BFP motor side. This vibration pattern serves as an early indication of a bearing defect in an induction motor. The appearance of a non-harmonic pattern indicates that the motor’s vibration is no longer stable and that mechanical issues are beginning to occur in certain components.

This condition is generally caused by damage to bearing components, such as damage to the inner race, outer race, or rolling elements, as well as suboptimal bearing lubrication. When the bearing begins to fail, the rotor’s rotation becomes unbalanced, resulting in abnormal vibration patterns in the motor’s vibration spectrum.

The spectrum graph also shows an increase in vibration amplitude at certain specific frequencies. This condition indicates that the vibration energy in the motor is beginning to rise due to friction and rotational instability in the motor bearings. The larger the vibration amplitude that appears, the more the motor’s mechanical condition tends to deteriorate.

Additionally, the non-harmonic vibration patterns in the spectrum indicate that the disturbances are not merely due to normal motor loading but point toward mechanical component failure. This is further supported by an upward trend in vibration and a humming noise from the motor during operation. If this condition is left unaddressed, it can lead to an increase in bearing temperature

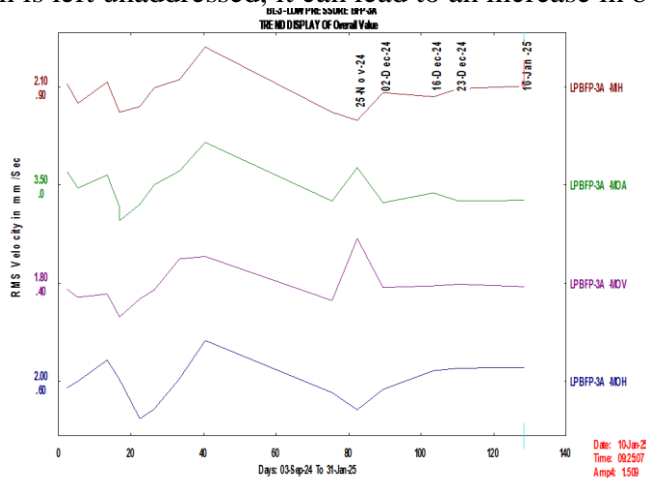


Figure 5. Multiple Spectrum Graph

Analysis of Preventive Maintenance and Operational Data

Based on the preventive maintenance and operational data of the LP BFP 3A motor, the Motor Current Signature Analysis (MCSA) results indicate that the motor electrical condition is still within normal limits, with no signs of rotor faults or current imbalance. However, during maintenance inspections, abnormal humming noise was detected during motor operation, indicating mechanical

issues in the motor bearings. This finding is consistent with the vibration analysis results, which also showed indications of bearing defects.

In addition, vibration monitoring data revealed a gradual increase in vibration levels, indicating that the bearing condition has started to deteriorate due to continuous motor operation. If this condition is not handled immediately, it may lead to higher motor temperatures, excessive mechanical friction, and damage to other motor components. Operational data also shows that the LP BFP system is still operating normally according to the power plant requirements. Therefore, the detected issues are more related to the mechanical condition of the motor, particularly the bearings, rather than problems in the electrical system or pump operation. Continuous operating loads and long operating hours are also contributing factors that accelerate bearing wear over time.

No.	Asumsi kejadian:	(a)Parah (Pompa Rusak)	(b)Sedang (Shaft Rusak)	(c) Ringan (Impeller Rusak)	Keterangan
Biaya Produksi					
1	Total Down Time (jam)	120	48	24	
2	Biaya rata-rata downtime (Rp/jam)	0	0	0	
3	Biaya Down time (1 x 2)	0	0	0	
OR					
4	Tambahan vakum untuk mencapai target (hari)				
5	Biaya teknisi (normal atau lembur in Rp/hari)				
6	Biaya Premium Time (4 x 5)				
7	Total Biaya Produksi (2 + 6)	0,00	0,00	0,00	
Biaya Pemeliharaan					
8	Parts (Rp)	18.847,280	11.520,637	17.500,000	so shaft : 255945 so impeller : 553020 so pompa : 272686
9	Man-hours (waktu kerja) teknisi (hari)	5	2	1	
10	Biaya teknisi (normal atau lembur in Rp/jam)	336,000	336,000	336,000	(1 Teknisi x 2 helper
11	Total teknisi (3x12) (Rp)	1.680,000	672,000	336,000	
12	Total Biaya Pemeliharaan (8 + 11)	192.527,280	11.792,637	17.836,000	
Total Biaya					
13	Total biaya produksi dan pemeliharaan (7+12)	192.527,280	11.792,637	17.836,000	
14	Biaya aktual kejadian yang terdiagnosa (12d) (Rp)	0	0	0	
15	Selanjutnya biaya (12-13) (Rp)	192.527,280	11.792,637	17.836,000	
16	Kemungkinan kejadian (%)	5,00%	15,00%	80,00%	
17	Biaya terhindari berdasarkan kategori (14x15)	9.626,363	1.768,986	14.268,000	
18	Total Biaya terhindari (16a + 16b + 16c)	25.664,058			

Figure 6. Preventive Maintenance and Operations Data

Evaluation and Preventive Maintenance of Motor Temperature

The evaluation results indicate that the temperature condition of the LP BFP induction motor is still within the safe operating category. Temperature measurements showed that the Drive End (DE) side reached 56.8°C, while the Non-Drive End (NDE) side was 47.6°C. These values indicate that the motor cooling system is still functioning properly and capable of maintaining temperature stability during operation. The higher temperature on the DE side is considered normal because this section is directly connected to the pump system and experiences greater mechanical loading and friction compared to the NDE side.

However, the evaluation of motor condition is not only based on temperature measurements but also supported by predictive maintenance and vibration analysis data. The vibration monitoring results revealed that the LP BFP motor is in ALARM status according to ISO 10816-3 standards, with indications of bearing defects characterized by non-harmonic vibration patterns and abnormal noise during operation. Although the motor has not yet experienced overheating, these mechanical issues may potentially increase motor temperature if not handled properly.

As part of preventive maintenance, periodic monitoring of motor temperature and vibration is necessary to detect early indications of equipment deterioration. Routine inspections of the motor bearings, lubrication conditions, vibration trends, and abnormal operating sounds are also important to prevent excessive friction that could lead to higher temperatures and reduced motor performance. Overall, integrating temperature monitoring, vibration analysis, and regular mechanical inspections is essential to maintain the reliability and operational stability of the LP BFP induction motor in the power plant system.

CONCLUSION

Based on the results of the analysis and evaluation conducted on the Low Pressure Boiler Feed Pump (LP BFP) induction motor at PT PLN Nusantara Power UP Gresik, it can be concluded that the motor's operational condition is generally still in good condition and suitable for supporting continuous power generation. Temperature measurement results show that the temperature on the Drive End (DE) side is 56.8°C and on the Non-Drive End (NDE) side is 47.6°C. These temperature values remain within the normal operating limits for industrial induction motors, thus showing no indication of overheating. The temperature difference between the two sides of the motor occurs because the Drive End side receives a greater mechanical load due to its direct connection to the LP BFP pump, while the Non-Drive End side receives cooling assistance from the motor fan system. In addition to the temperature analysis, the vibration evaluation results indicate that the motor's condition is in the ALARM status according to ISO 10816-3 standards. Vibration spectrum analysis indicates signs of bearing defects, characterized by non-harmonic vibration patterns, an increase in overall vibration levels, and the presence of abnormal sounds during motor operation. However, the results of the Motor Current Signature Analysis (MCSA) still indicate normal conditions, suggesting that the issues are primarily mechanical in nature rather than electrical. Overall, the evaluation results indicate that the LP BFP induction motor can still operate properly, but requires special attention to bearing condition to prevent potential more serious damage in the future. Therefore, preventive maintenance activities—including temperature monitoring, vibration monitoring, lubrication, and periodic mechanical inspections—must be consistently carried out to maintain motor reliability, improve operational efficiency, and ensure the continuity of the power generation system at the combined-cycle power plant remains optimal.

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