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Analysis of Damage to The Induce Draft Fan Component at PLTU. XYZ

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Abstract. Damage to the Induced Draft Fan (IDF) can significantly affect the combustion system, as the IDF functions to supply secondary air required for efficient combustion in the boiler furnace. In this generating unit, there are two IDF fans that operate either simultaneously or alternately. The purpose of this study is to identify the causes of IDF damage in order to prevent a decrease in power generation supplied to the PLN grid. The research employs the fishbone (Ishikawa) analysis method. Based on the analysis, the damage to the IDF was caused by abrasion on the fan blades. This abrasion occurs due to contact between the blade surface and abrasive particles (Fe_2O_3) present in the flue gas. The malfunction of the Electrostatic Precipitator (ESP) allows these Fe_2O_3 particles to pass through instead of being captured, which ultimately leads to erosion and damage of the IDF blades.

Keywords - Induce Draft Fan (IDF); PLN generators; malfunctioning of the Electrostatic

INTRODUCTION

The generating unit of PLTU Nagan Raya PT. XYZ is a low-calorific coal-fired power plant designed to meet the electricity demand of the West Aceh region, with an installed capacity of 1 × 15 MW. Combustion in the boiler furnace is supported by two air systems: Primary Air (PA) and Secondary Air (SA). The Primary Air, supplied by the Primary Air Fan (PAF), is directed into the coal pulverizer, where it mixes with the pulverized coal to form a coal-air mixture. This mixture is then carried into the furnace for combustion [1].

The use of low-calorific coal presents several operational challenges, including high ash content, increased particulate formation, and reduced combustion efficiency. To maintain stable combustion, the air supply system comprising the PAF, Forced Draft Fan (FDF), and Induced Draft Fan (IDF) must operate in a coordinated manner to ensure the correct air-fuel ratio and pressure balance in the boiler [2]. The mixing process is assisted by a fixed damper, which regulates airflow and creates turbulence within the furnace, improving the interaction between air and fuel for more efficient combustion [3].

The boiler is equipped with both FDF and IDF units that supply Secondary Air and control the exhaust flue gas flow [4]. The FDF provides the necessary air for combustion, while the IDF maintains negative pressure within the furnace and ensures proper gas flow through the economizer, air preheater, and Electrostatic Precipitator (ESP) before it exits the stack [5]. The balance between these systems is crucial; any malfunction, particularly in the IDF, can disturb furnace pressure, affect combustion stability, and ultimately reduce overall power output.

From 2011 to 2013, the ESP in the generating unit was non-operational due to a defect in the high-voltage transformer. Consequently, the flue gas containing fine dust particles—a by-product of coal combustion—was not effectively captured and was carried downstream. In this generating unit, two IDFs are installed and can operate either simultaneously or alternately. Damage to one of these fans significantly reduces the plant's performance, especially when no backup fan is available [6].

When the ESP is non-functional, fine particles such as Fe_2O_3 in the flue gas can enter the IDF and erode the fan blades over time. This abrasion not only weakens the blades mechanically but also changes their aerodynamic shape, leading to imbalance, vibration, and reduced efficiency. Continuous exposure to such abrasive environments can result in severe damage and unplanned shutdowns.

Therefore, maintaining the reliability of both ESP and IDF is essential for stable and efficient boiler operation. The purpose of this study is to identify the root causes of IDF damage and propose effective corrective and preventive actions. The analysis employs the Fishbone (Ishikawa) method, supported by mechanical and operational data, to systematically identify the contributing factors such as design parameters, material quality, operating conditions, and maintenance practices. The findings are expected to provide a technical reference for improving fan reliability and ensuring the continuous and efficient operation of coal-fired power plants.

METHOD

Previous studies have shown that torsional vibration anomalies often occur at the smallest shaft diameter under specific design conditions. The reduction of the gutter radius compared to the design specification results in a higher stress concentration, which can accelerate fatigue failure of the rotating shaft [7]. In thermal power plants, the Induced Draft Fan (IDF) plays a crucial role in maintaining flue gas flow from the furnace to the exhaust stack [8]. Any deviation in fan performance, such as vibration, imbalance, or excessive temperature, can directly affect the stability of the boiler operation. Several studies have reported that changes in the air and gas system resistance—especially after the transformation of the denitration (De-NOx) system—can alter the aerodynamic field of the entire system. Such conditions may cause temperature spikes, increased vibration, or even Primary Air Fan (PAF) and IDF malfunctions due to uneven airflow distribution [5]. To analyze these conditions, this study employs a fishbone analysis method combined with a review of mechanical and thermal behavior of the fan components. The approach involves identifying mechanical, aerodynamic, and operational factors contributing to IDF failure, followed by a detailed evaluation of stress distribution, vibration response, and temperature variation in the fan system. This comprehensive analysis is expected to reveal the main root causes and provide recommendations for design and maintenance improvements.

The data collection, measurement, and analysis stages were conducted systematically to identify the root causes of Induced Draft Fan (IDF) damage. Data were obtained through technician and operator interviews, motor ampere log analysis, and visual inspections of the fan components. Interviews provided qualitative insights into operational patterns and previous failures, while the log data offered quantitative information on load variations and performance anomalies. Visual inspection results documented physical symptoms of wear such as blade erosion, unbalanced rotation, and dust accumulation.

During the measurement stage, parameters including motor current, vibration, fan speed, and temperature were evaluated to verify the operating condition of the IDF. Abnormal readings were cross-checked against design specifications and historical maintenance records to confirm potential faults.

The collected data were then analyzed using the Fishbone (Ishikawa) method to determine the root causes of damage. Contributing factors were categorized into Man, Machine, Method, Material, Measurement, and Environment. Each factor was examined through evidence from the field data, inspection reports, and technician feedback. The analysis results were later validated through expert discussions, leading to the identification of key causes and the formulation of corrective actions to prevent recurrence.

RESULT AND DISCUSSION

There is no detailed measurement data available regarding the abrasion level, damage rate, or vibration values of the Induced Draft Fan (IDF) before and after the failure. This limitation occurred because continuous monitoring instruments such as vibration sensors or thickness gauges were not installed on the IDF at the time of operation. As a result, quantitative analysis of the progression of damage could not be performed directly.

To overcome this limitation, qualitative observations and indirect data sources were utilized, including visual inspection records, maintenance logs, and interviews with maintenance personnel. These qualitative findings were then correlated with operational data such as motor current fluctuations and fan performance trends to infer the possible extent and rate of damage. Although this approach does not provide precise numerical data, it allows for a reasonable estimation of the mechanical degradation process and supports the identification of root causes through Fishbone analysis.

Analysis of the generating unit's operational records indicates that approximately 61% of total unplanned shutdowns were attributed to eight incidents of Induced Draft Fan (IDF) failure, resulting in an estimated loss of 911 operating hours. The predominant failure mechanism involved progressive erosion of the fan blade and cone surfaces caused by continuous impingement of fly ash particles. Over time, this erosive wear led to perforations on the blade plates and cone body, which consequently reduced the fan's suction efficiency and disturbed the aerodynamic balance of the system.

The resulting imbalance produced excessive vibration levels, contributing to secondary mechanical failures, including bearing wear and v-belt deterioration. These cascading effects significantly impacted unit reliability and maintenance frequency. Figure 1 illustrates the observed damage morphology on the fan blade and cone components recorded during 2013.

Figure 1. Faulty IDF fan blade and cone

Evaluate the key operational issues affecting the performance of the PLTU Nagan Raya generating unit, a detailed assessment was conducted using the Fishbone (Ishikawa) Analysis method, as illustrated in Figure 5. This analytical framework was applied to identify both direct and indirect factors contributing to the unit's performance degradation and failure events. The Fishbone diagram helps visualize the interrelationship between technical, human, and operational factors that influence the reliability of the power plant. The outcome of the analysis indicates that these factors collectively impact the Operational and Maintenance (O&M) economics of the plant throughout 2013, particularly by increasing downtime frequency and maintenance costs. Based on the analysis, four main areas requiring attention were identified as the primary contributors to reduced efficiency and increased failure risk within the generating unit

Table 1. Coal testing of PT. BELL.

Customer : PT. Bara Energi Lestari
Report No. : 08.12.00209.SP
Date Reported : February 15, 2012

Costumer Sample Id	UNIT	PLTU Gudang 01 Crusher	PLTU Gudang 02 Crusher
Estimate Cargo MT ±		1,000 MT	3,000 MT
Lab Sample Id.		PDG-00383/12	PDG-00384/12
Weight of Sample		104,705 Kg	126,880 Kg
ANALYSIS			
1. As Received Basis (ar)			
Total Moisture	%	39,96	40,76
Gross Calorific Value	Cal/g	3485	3669
2. Air Dried Basis (adb)			
Moisture in the analysis sample	%	12,79	13,41
Ash Content	%	8,23	5,32
Volatile Matter	%	43,06	44,23
Fixed Carbon	%	35,92	37,04
Total Sulphur	%	0,19	0,17
Gross Calorific Value	Cal/g	5062	5363
3. Hardgrove Grindability Index	Index	46	42

1.1 Material

Based on secondary coal data from the Aceh region and surrounding mining areas, the coal supplied to PLTU Nagan Raya is classified as low-rank coal. It contains a high moisture level of approximately 40% and a low calorific value between 3,100 and 3,500 kcal/kg. This type of coal typically has a high volatile matter content and low fixed carbon, which affects its combustion stability and heat release rate.

The high moisture content leads to a lower furnace temperature and reduced combustion efficiency, requiring greater air input from both the Primary Air Fan (PAF) and Forced Draft Fan (FDF) to maintain complete combustion. Consequently, the flue gas volume increases, elevating the operational load on the Induced Draft Fan (IDF). The higher gas velocity, combined with unburned fly ash particles, contributes to enhanced erosive wear on the IDF blades. The coal testing data from 2012, summarized in Table 1, are used to support the analysis of fuel quality and its relation to the observed IDF damage. These data provide essential insight into how the utilization of low-calorific, high-moisture coal can influence boiler performance, emission characteristics, and the mechanical reliability of the air–gas handling system.

1.2 Method

During the research, it was observed that the generating unit operates using a manual control method for both the boiler and the turbine systems. The operation relies entirely on human coordination, as there is no integrated system interface linking the two units. Communication between the boiler and turbine operator teams is carried out using portable radios (handy talkies).

Although this method allows for basic coordination, it introduces significant limitations in operational precision and response time. The turbine operator monitors turbine performance and manually operates the main steam valve, then communicates the required steam conditions to the boiler operator via radio. This manual feedback loop often causes delays in response, leading to temporary pressure fluctuations within the steam system.

The lack of real-time data integration between the two systems can result in inefficient combustion control, unstable steam pressure, and increased mechanical stress on auxiliary components such as the Induced Draft Fan (IDF) and Forced Draft Fan (FDF), which rely on consistent furnace pressure. Moreover, reliance on manual communication increases the potential for human error and complicates performance monitoring and troubleshooting.

To enhance operational reliability, the implementation of an automated control interface such as a Distributed Control System (DCS) or Supervisory Control and Data Acquisition (SCADA) is recommended. Such systems would facilitate synchronized data exchange between the boiler and turbine, minimize communication delays, and improve the overall efficiency and stability of power generation operations.

1.3 Man (labor)

The generating unit is operated by 86 employees, including 30 technical personnel responsible for the operation and maintenance of complex mechanical and electrical systems. According to training and certification records from PT. Indonesia Power, these personnel have completed the “Introduction to PLTU” module, which provides basic operational knowledge but limited exposure to advanced diagnostic and reliability practices.

However, observations during the study indicate that the technical team’s competencies are mostly aligned with routine operation rather than predictive maintenance or root cause analysis. This condition affects the ability to detect early signs of equipment degradation, such as vibration or abnormal temperature in the Induced Draft Fan (IDF). Inadequate monitoring practices and limited technical troubleshooting skills can contribute to delayed corrective actions, leading to recurring mechanical failures.

Therefore, the analysis suggests that human factors—particularly the depth of technical training and the scope of operational responsibilities—play a significant role in equipment reliability. To improve long-term operational performance, a structured training program focusing on vibration monitoring, data interpretation, and reliability-centered maintenance (RCM) should be developed and periodically evaluated.

1.4 Machine

The stoker boiler with a traveling fire grate used at PLTU Nagan Raya is under the specifications of the coal (lignite) used as fuel. This type of boiler can accommodate the combustion of high to low-quality coal. However, coal is used with an ash content of 8.23% [9], which is lower than required, which is between 10-15%, causing the ash layer to form on the grate to be less than 5cm. This caused the damage to the grate bar with an average occurrence of 40 pcs per month Figure 2 during 2013. This damage did not cause the operation of the generating unit to stop, because grate bar replacement could be carried out while the boiler was operating.

Figure 2. Failed grade bar

Based on the literature study, it was found that the due diligence report document stated that ESP had not functioned since 2011. The non-functioning of the dust collector, in this case, the ESP, had a direct impact on the age of the IDF. The concentration of dust in the combustion gas stream is still very high, causing the IDF's operating life to be very short because IDF is not designed to handle gases with high dust concentrations. Also, the combustion gas released by the chimney in dusty conditions is currently polluting the community around the PLTU.

IDF damage begins with an increase in amperage on the electric motor or the motor experiences an overload. This condition was discovered during routine inspections. Damage occurs when the rated ampere is 470 Ampere to 490 Ampere either constantly or hunting. This increase is the result of abrasion on the fan blade so that the blade rotation against the shaft becomes unbalanced. Increasing the ampere in the electric motor will develop a vibration that can be felt by the operator. If the vibrations that occur are not followed up, the IDF's performance will decrease until physical damage occurs to the fan blade and the IDF casing. IDF final failure will also damage the bearing, bearing housing, and v-belt. The IDF damage curve is shown in Figure 3.

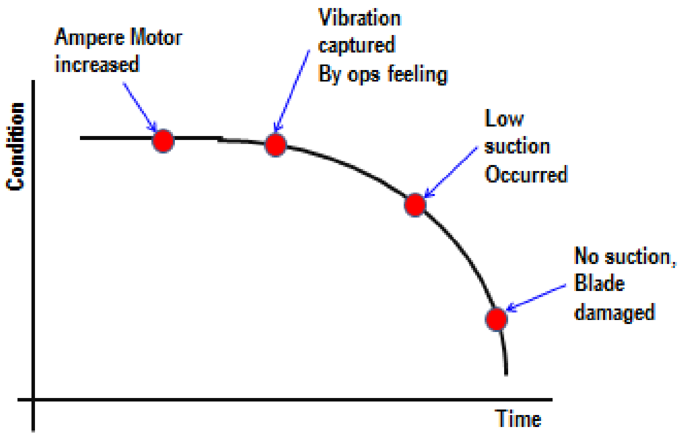

Figure 3. IDF deterioration curve

The damage observed on the Induced Draft Fan (IDF) blades is primarily caused by continuous exposure to combustion dust that was not captured by the non-functioning Electrostatic Precipitator (ESP). The main types of damage identified are abrasion and perforation, as shown in Figure 4.

Abrasion occurs when high-velocity fly ash particles—containing hard minerals such as Fe_2O_3, SiO_2, and Al_2O_3—continuously collide with the fan blade surface [10]. Over time, this erosive contact removes the protective oxide layer and reduces the blade’s thickness, particularly along the leading edge where airflow velocity is highest. Once the material loses sufficient cross-sectional strength, localized thinning evolves into perforation, forming holes on the blade surface.

The perforation indicates a severe stage of material degradation, where the metal has lost its structural integrity. This type of damage alters the aerodynamic balance of the fan, increases vibration amplitude, and leads to mechanical instability. If left uncorrected, it can propagate into shaft imbalance, bearing overload, and even catastrophic fan failure.

In summary, the root mechanism of damage is erosive wear due to high fly ash loading in the flue gas, worsened by the absence of ESP operation. Long-term mitigation should include material selection improvements (e.g., wear-resistant coatings), optimization of gas flow velocity, and ensuring continuous ESP reliability to reduce particulate concentration entering the IDF.

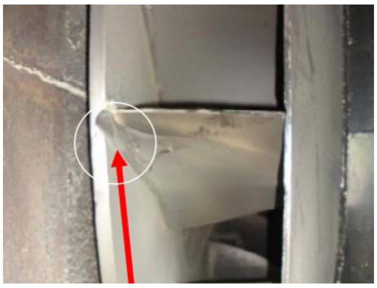

Figure 4a. IDF abrasion blade **Figure 4b**. IDF perforated blade

Abrasion in the Induced Draft Fan (IDF) occurs due to continuous collision between fly ash particles and the fan blade surface [11]. The fly ash contains approximately 12.6–14.2% Fe_2O_3, which possesses high hardness and angular particle shapes, intensifying the erosion effect. Under high-velocity gas flow conditions, these particles strike the blade surface at various impingement angles, causing micro-cutting, surface roughening, and gradual material loss [12].

The problem is further aggravated by the non-functioning Electrostatic Precipitator (ESP), which fails to capture the fly ash effectively. Consequently, the concentration of abrasive particles in the flue gas increases, exposing the IDF blades to prolonged erosion [13]. The continuous reduction of blade thickness alters the aerodynamic profile and induces imbalance, leading to excessive vibration and reduced mechanical efficiency. Over time, these combined effects can cause severe mechanical damage and shorten the operational life of the IDF system [14].

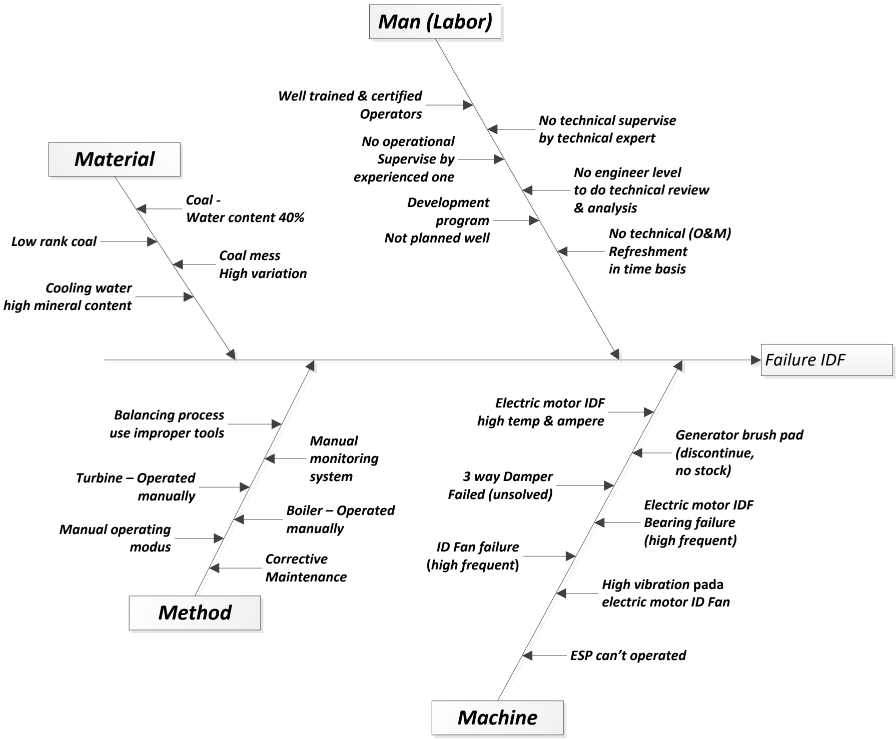

Figure 5. Fishbone analysis

The discussion presented in the study primarily concentrates on identifying the causes of Induced Draft Fan (IDF) damage but lacks an in-depth exploration of long-term technical mitigation measures. While determining the root causes is essential for understanding the problem, developing sustainable solutions is equally critical to prevent recurrence and improve system reliability [15].

A more comprehensive discussion should include technical recommendations such as redesigning fan blades with wear-resistant materials, optimizing the flow path to reduce abrasive particle impact, or implementing protective coatings against Fe_2O_3 erosion [16]. Additionally, the installation of real-time vibration monitoring systems and regular thickness measurements could provide early detection of mechanical degradation. Establishing a predictive maintenance schedule based on operational data analysis would also contribute to extending the IDF's service life and maintaining boiler efficiency.

Incorporating these long-term strategies would not only enhance the operational reliability of the IDF but also minimize unplanned outages and power supply disruptions to the grid.

CONCLUSION

The type of coal utilized in the generating unit is lignite, which contains Fe_2O_3 within the permissible range of 4–15%. The recorded ash content of 8.23% primarily contributes to wear on the grate bar rather than directly affecting the Induced Draft Fan (IDF). However, the malfunction of the Electrostatic Precipitator (ESP) altered the flow characteristics of the flue gas. Without proper dust separation, fine abrasive particles rich in Fe_2O_3 were carried into the IDF section. Continuous contact between these high-velocity particles and the fan blades led to progressive surface erosion, characterized initially by abrasion marks and eventually by localized perforations. This chain of events indicates that the root cause of the IDF damage was not the coal composition itself, but the **ineffective operation of the ESP**, which allowed particulate matter to reach the fan system. Sustained exposure to abrasive-laden gas under high rotational speed accelerated the degradation of the blade surface, reducing its structural integrity and aerodynamic efficiency.

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