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Identification of induce draft fan damage using fault tree analysis

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Abstract

Steam Power Plants (PLTU) are a type of generator that is widely used by the State Electricity Company (PLN) to meet national electricity needs, the hope of which is to reduce dependence on Diesel Power Plants (PLTD) PT. generating unit. The coal-fired Alamraya Semesta Energy with an installed capacity of 1x15 MW and a production target of 10 MW for utilities and 5 MW for wood processing has an Availability Hour of 82.9% and Unavailability of 17.1% during the period January to December 2013. Unavailability of 17.1% occurred either due to disturbances, inspection and repair of generating unit systems. Based on field findings, the outage occurred due to damage to the brush generator which had been discontinued, requiring fabrication and causing downtime of 32 days and repetitive failure in the IDF (Induced Draft Fan) which was used by the generator maintenance team to remove bottom ash. To determine action to improve the performance of the generating unit, an analysis is carried out of the main causes of IDF damage, as well as the financial losses that arise. Fault tree analysis shows that abrasion and perforation on fan blades and cones, as well as damage to motor bearings automatically reduce IDF efficiency.

Keywords

Fan damage, Induced draft fan, Fault tree analysis

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Introduction

West Aceh Regency and Nagan Raya Regency established the low-calorie coal-fired power station known as PT Generating Unit EAS to address their electricity needs. With a capacity of 1x15 MW, the generating unit is not operating at full condensing. This is due to the fact that the producing unit is built to accommodate 5 MW of wood processing and 10 MW of utilities (electricity consumption). The generator runs at a peak load of 10 MW and a base load of about 8 MW [1].

The boiler in the producing unit installation is a Stoker Fired boiler, which typically has lower efficiency when compared to other boiler types. The furnace is equipped with a balance-draft [2][3][4]. Fuel (coal) is injected into the furnace with the use of a traveling fire grate and spreader [5]. When the spreader cannot feed fuel near the front ash discharge or at the farthest point from the traveling grate, combustion efficiency is reduced [6]. Additionally, in the event that the trip shoe breaks, the fuel with its relatively fine mesh falls in the direction of the plenum water without going through the combustion process [7].

Primary and secondary air support combustion in the furnace. The Primary Air Fan (PAF) provides primary air, which is blown into the coal grinding tool (pulverizer) and subsequently flows into the furnace with the coal powder [8]. An air stirrer, a fixed dumper, aids in the mixing of coal and air by generating turbulence that permits effective burning. Air movement in the furnace is referred to as turbulence, and it is essential because it can enhance the way that fuel and air are mixed. The boiler has two forced draft fans (FDF and IDF) that produce secondary air to meet the furnace's needs for combustion air [9]. The generating unit has two IDFs that can run either simultaneously or alternately. The producing unit automatically goes out when one type of fan is damaged, especially if the damaged fan has no backup or backup power source [10]. If both backup and on-duty equipment is damaged. In comparison to the typical projected life of IDFs, damage to IDFs occurred very frequently in 2013. This resulted in outages as well as costs associated with IDF replacement and maintenance.

An Electrostatic Precipitator with a high efficiency design (above 90%) and a wide spectrum of particles collected is also fitted with the PLTU generating unit PT. EAS as a fly-ash catcher. It is anticipated that the quantity of waste exiting the chimney will only be about 0.16% when employing ESP.

Due to damage to the high-voltage transformer, the ESP in the producing unit was not able to work in 2013, which prevented the ESP from collecting dusty flue gas, a byproduct. There were 365 days of scheduled operations from January 1 to December 31, 2013, or 8,760 duration hours, with January 2014 being the planned outage month. The goal is to identify the source of damage to the two IDF components in the generating unit, which can be operated concurrently or alternately, from operational plan failure to generator damage.

Methods

There are various steps in the research process for the techno-economic study of PLTU EAS. The following is the general study methodology used to identify the primary causes of repetitive shutdowns that result in lost production:

Identify problems

As a result of the ESP's malfunction, there were nine IDF damage incidents and 8,894.4 hours of operational downtime

Data collection

The following step is to gather the information required to assist in resolving issues that emerge from the study topic. The researcher chose a specific time period over which to collect the data. Direct observation and interviews with operational and maintenance managers on the current production system were the two approaches used to gather the necessary data. Direct data collection was used to gather information on coal consumption, power production, own use, and customer transactions, as well as actual sales and production of electricity during the months of January through December 2013.

Data processing

After the data collection stage is complete, the next stage is the data processing stage of the damage that occurs.

Fault Tree Analysis

To determine if situations had transpired in line with initial assumptions, data analysis and field observations were conducted.

Analysis of corrective action plans

Following the identification of the primary cause of the disturbance in the generating unit, this procedure is carried out. During this procedure, the steps that must be performed to address persistent disruptions will be analyzed.

Once the primary cause of the disturbance in the generating unit has been identified, this step is executed. During this procedure, the steps that must be performed to address persistent disruptions will be analyzed.

Results and Discussion

There are five major factors that affect the generating unit's performance, as determined by fault tree analysis, which provides a broad overview of the Nagan Raya PLTU's status. The study concentrated on the factors that led to outages in 2013. Nine of the 80 interruptions resulted in the producing units ceasing to operate. A generator slide ring failure resulted in a single outage that shut down the system for 576 hours. This occurs because fabrication needs to be done and there are no spare parts in the warehouse. In the meantime, since the Nagan Raya PLTU was operational in 2011, this damage to the slip ring is the first. The type of damage to the fan blade and cone is depicted in Figure 1.

In the meantime, a fault tree analysis was performed on the eight IDF failures in order to understand the sequence of problematic events in the IDF up until the generating unit's shutdown. Figure 2 illustrates how damage to the motor bearings, abrasion and perforation on the fan blade and cone, and IDF efficiency are all automatically reduced [11]. Even though the FDF, PAF, and cooling tower are operating at maximum efficiency, the decline in IDF efficiency causes a decrease in fan efficiency [12]. To ensure that the air supply to the combustion chamber is met and the oxygen requirement for the coal combustion process is met, FDF and PAF work together. The IDF must continually remove the combustion exhaust gas from the combustion chamber while the combustion chamber volume is fixed.

Figure 1. Damage to IDF fan blade and cone

The blade surface on the lip and cone sides will become abrasive if the ESP fails to perform as a dust collector and fly ash containing dust and big particles is drawn in by the IDF. The formation of a perforation on the blade surface causes the IDF to become unbalanced, vibrate more, and lose its capacity to suction coal-burning exhaust gas. Under these circumstances, fly ash pollution of the air will increase and combustion efficiency will drop. The producing unit operations commander will choose to shut down in such circumstances.

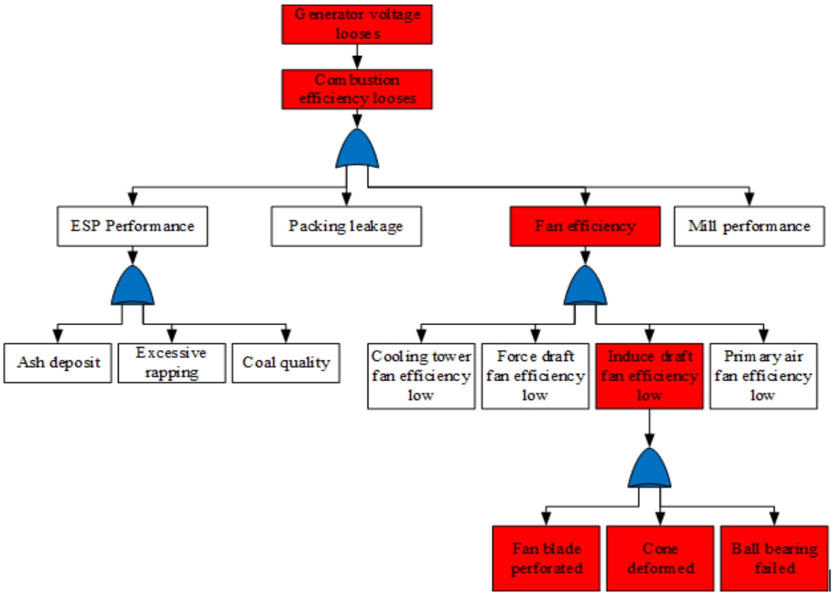

Figure 2. Fault tree analysis

The IDF damage cycle occurred eight times, resulting in 911 hours of downtime or 61% of the total downtime. This does not include the eight hours required to start up the generating unit each time a shutdown occurs until the PLTU is able to export electricity to customers. Additionally, the short-term or temporary repair expenses came to Rp. 775,215,870.

Abrasion and perforation on the fan blade and cone by fly ash were confirmed via field observations on operating data and maintenance of the generating unit, documentation of damage and failed IDF components. This was because the ESP was not functioning as a dust collector. In theory, the PLTU NR administration concurs that the ESP's malfunction is the reason for the regular IDF damage. Where the fan blade's abrasive substance (Fe_2O_3) in the flue gas comes into contact with the blade surface, leading to abrasion and perforation that causes IDF damage. The criteria for coal utilized is lignite, which has a content of Fe_2O_3 and falls within the range of chemical composition (4–15%). The grate bar is harmed by an 8.23% ash content rather than the IDF. When the ESP malfunctions, abrasive material (Fe_2O_3) in the flue gas flows in the direction of the IDF, damaging the blade. It is necessary to revitalize the generating unit's dust collector in order to prevent harm to the IDF and a reduction in the amount of electricity produced the next year. Periodic coal quality testing can be used to analyze this harm and mitigate damage due to coal specifications. Nevertheless, a decision regarding how to handle this issue has not yet been reached. The vendor has offered to repair the current ESP for 6 billion rupiah, or adding a cyclone as a dust collector at an estimated cost of 2.4 billion rupiah is one option

Because there is a dearth of experience in managing PLTUs and because the corrective measures required to address issues arise are correlated with a sizeable investment value. The lack of a cost analysis that offers estimates of Profit and Loss for a specific time frame further complicates decision-making for PLTU NR management. Whether to install a cyclone system in its place or revive the ESP.

Conclusion

Eight IDF damage cycles took place in 2013, accounting for 911 hours of downtime, or 61% of all downtime. This excludes the eight hours needed to bring the generating unit back online after every shutdown, which is necessary before the PLTU can export power to consumers. Moreover, in 2013 Rp 775,215,870 was spent on short-term or temporary repairs. The combination of motor bearing deterioration and IDF fault tree analysis automatically reduces the IDF efficiency in PLTU NR. The reasons of IDF efficiency are: 1) Fan blade performance failure; 2) Cone deformation; and 3) Ball bearing failure. Dust and bigger particle fly ash are drawn in by the IDF; the ESP does not function as a dust collector. The IDF loses its ability to suction exhaust gas from burning coal and becomes imbalanced due to the creation of perforations on the blade surface. Abrasive material (Fe_2O_3) in the flue gas flows in the direction of the IDF when the ESP malfunctions, harming the blade.

References

[1] IESR, “Indonesia Energy Transition Outlook 2023: Tracking Progress of Energy Transition in Indonesia: Pursuing Energy Security in the Time of Transition,” p. Please cite this report as: IESR (2022). Indonesia, 2022, [Online]. Available: www.irena.org

[2] A. Technical, “Total Dietary Fiber--Rapid Gravimetric Method,” in *AACC International Approved*

Methods, 2009. doi: 10.1094/aaccintmethod-32-06.01.

[3] J. Taler and D. Taler, "Slag monitoring system for combustion chambers of steam boilers," *Heat Transf. Eng.*, vol. 30, no. 10–11, pp. 903–911, 2009, doi: 10.1080/01457630902754175.

[4] J. Benáčková, L. Frýba, M. Pavlas, and M. Hejl, "Determination of lower heating value of municipal solid waste by mathematical analysis of a plant production data from a real waste-to-energy plant," *Chem. Eng. Trans.*, vol. 29, pp. 721–726, 2012, doi: 10.3303/CET1229121.

[5] M. Nazar *et al.*, "Techno-economic and environmental assessment of rice husk in comparison to coal and furnace oil as a boiler fuel," *Biomass Convers. Biorefinery*, vol. 13, no. 3, pp. 1671–1679, 2023, doi: 10.1007/s13399-020-01238-3.

[6] U. Shafiq, A. Mukhtar, A. F. Khan, H. M. Quladuz Aziz, and I. Shamshad, "Thermodynamics Analysis of Natural Gas Fuel Based Furnace / Boiler Integrated with Steam Power Plant : A Theoretical Approach," *Res. J. Chem. Sci. Res . J . Chem . Sci*, vol. 5, no. 12, pp. 2231–606, 2015.

[7] *et al.*, "Failure Analysis of the Furnace Scotch Boiler," *Int. J. Eng. Adv. Technol.*, vol. 9, no. 1, pp. 3698–3704, 2019, doi: 10.35940/ijeat.a9855.109119.

[8] H. L. Huang, W. M. G. Lee, and F. S. Wu, "Emissions of air pollutants from indoor charcoal barbecue," *J. Hazard. Mater.*, vol. 302, pp. 198–207, 2016, doi: 10.1016/j.jhazmat.2015.09.048.

[9] A. F. Mohamed, M. E. Habash, M. S. Alsoufi, and M. K. Hassan, "Failure analysis of flue gas duct in a steam power plant," *Int. J. Mech. Mechatronics Eng.*, vol. 20, no. 1, pp. 48–58, 2020.

[10] M. H. Waldner, R. Halter, A. Sigg, B. Brosch, H. J. Gehrmann, and M. Keunecke, "Energy from Waste - Clean, efficient, renewable: Transitions in combustion efficiency and NOx control," *Waste Manag.*, vol. 33, no. 2, 2013, doi: 10.1016/j.wasman.2012.08.007.

[11] A. Morad and Y. Shash, "Nickel Base Superalloys Used for Aero Engine Turbine Blades," *Int. Conf. Appl. Mech. Mech. Eng.*, vol. 16, no. 16, pp. 1–22, 2014, doi: 10.21608/amme.2014.35549.

[12] H. Yudisaputro, W. Caesarendra, M. N. Yuniarto, and Yohanes, "A study on the Performance and Reliability Effect of Low-Rank Coal to the Steam Power Plant," *J. Phys. Conf. Ser.*, vol. 1845, no. 1, 2021, doi: 10.1088/1742-6596/1845/1/012053.