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Enlarge Coal Air Duct to Improve Operational Reliability of Pulverizer System

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Abstract

The coal feeder of our company's pulverizing system uses the JGC-30 weighing metering coal feeder. Raw coal falls from the hopper onto the belt through the coal drop port by gravity. The existing 60 mm high belt skirts on both sides allow small coal blocks to fall off during transit. Wind from the sealing system and belt motion scatters these blocks, sticking them to the weighing device. This causes inaccurate measurements, leading to fluctuations in coal feed quantity, coal mill vibration, insufficient powder output, excessive slag discharge, and risks to safe pulverizing system operation. However, this study primarily addresses the cold air duct system, crucial for preventing overheating during pulverizer stops. Pulverizer System enlarged the duct from OD 10 inch to OD 22 inch, boosting airflow from 5.56 t/h to 24.37 t/h. This eliminated hot air purging needs, dropping mill outlet temperature from 84–86°C to 59–68°C during stops and cutting restart time from 4–6 hours to under 30 minutes. It also saved ~9,200–13,800 liters of auxiliary fuel oil per incident, greatly improving operational reliability and economics of the pulverizer system.

Keywords: coal feeder, Belt, weighing, coal mill, coal blocks

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INTRODUCTION

The pulverizer system in thermal power plants plays a crucial role in providing pulverized coal to the boiler for stable combustion. A reliable purging system is essential to avoid high-temperature risks and ensure quick restart capability (Giuliano & Prairie, 2021; Lutoslawski & Lugowski, 2021; Maulana et al., 2019; Winarna et al., 2021). Pulverizer systems in coal-fired power plants are critical components that directly influence plant efficiency, availability, and safety. The performance of these systems depends not only on mechanical integrity but also on adequate thermal management during both operation and shutdown phases (Coutinho et al., 2023; Hamid et al., 2024; van Heerden et al., 2022). In Kendari Unit #2, the cold air duct limitation led to insufficient airflow during stop conditions, forcing operators to use hot air. This condition increased the outlet temperature of the mill above 80°C, leading to longer cooling periods and extended downtime. Consequently, the system required 4–6 hours before it could be restarted, and in many cases, additional fuel oil was consumed to stabilize combustion in the boiler.

Previous studies have demonstrated that inadequate cold air supply during purging operations can lead to elevated temperatures within the mill chamber, creating safety hazards including spontaneous combustion of residual coal particles. Furthermore, prolonged cooling periods reduce unit flexibility and increase operational costs through auxiliary fuel consumption. Benchmarking results showed that the cold air duct size in Kendari plant was significantly smaller than that in similar 300 MW units.

Comparative analysis with industry standards and best practices from other coal-fired power plants indicated that the existing cold air duct design at Kendari did not meet the minimum airflow requirements specified for safe and efficient pulverizer operation (American Society of Mechanical Engineers, 2020; National Fire Protection Association, 2019). This study was therefore conducted to evaluate the enlargement of the cold air duct and to measure its effect on the operational reliability of the pulverizer system (Chen et al., 2022; Huang et al., 2024; Ngamlana et al., 2024).

During pulverizer stop operation, cold air plays a fundamental role in ensuring safety and reliability. When coal feed is cut off, residual coal dust remains inside the mill. To prevent overheating and potential self-ignition, a purging process using cold primary air is required. The cold air is introduced through the primary air duct, flowing into the mill to sweep and carry away remaining coal particles. This principle aligns with established combustion safety protocols and thermal management guidelines for coal handling systems (Dasgupta et al., 2025; Li & Song, 2025; Millar et al., 2016; Prabawa & Wasesa, 2024; Zhang et al., 2025).

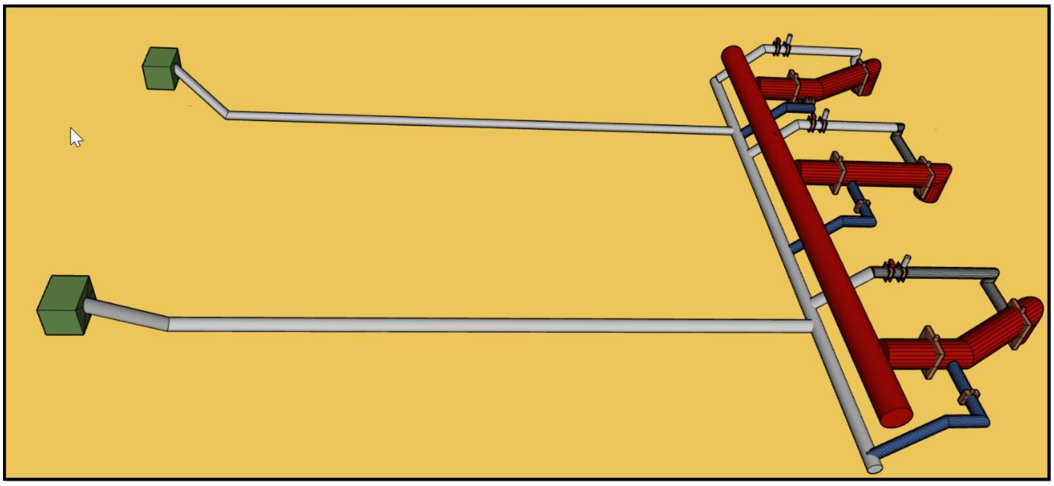

Figure 1. 1) Inlet Cold Air From PAF, 2) Existing Cold Air Line, 3) New Cold Air Line, 4)Hot Air Line

Structurally, the cold air duct connects from the primary air fan to the pulverizer inlet. Its function is to provide sufficient air volume at ambient temperature, which keeps the internal mill environment below the critical ignition point. If the duct is undersized, the airflow is insufficient to meet the minimum 20 t/h requirement, forcing operators to use hot air instead. This condition increases mill temperature, extends cooling time, and prevents quick restart.

Functionally, the cold air purge during stop process ensures:

1. Removal of residual coal particles from the mill chamber.
2. Cooling of mill internals to a safe operating temperature (<75°C).
3. Prevention of spontaneous combustion or explosion inside the mill.
4. Readiness of the pulverizer for faster restart without auxiliary fuel.

Thus, the proper design and dimension of the cold air duct is critical to the safe and efficient operation of the pulverizer system.

Common problems, phenomena and specific causes in cold air system of pulverizer

1. Common Problems and Phenomena

a) Insufficient cold air volume: Existing duct capacity only supplies ~5.56 t/h, far below the required 20 t/h, leading to incomplete purging.
b) High outlet temperature during stop: Residual coal particles exposed to hot air raise mill temperature >80°C, requiring long cooling periods.
c) Delayed restart time: Cooling delay extends pulverizer unavailability to 4–6 hours, reducing unit flexibility.
d) Increased fuel oil consumption: Boiler must use oil support combustion when pulverizer is not ready.
e) Safety risk: High-temperature purging increases the risk of self-explosion and abnormal combustion inside the mill.

2. Specific Causes
   a) Undersized cold air duct design: At OD 10 inch, the airflow area is too small compared with standard 300 MW units.
   b) Design mismatch with tripping protection system: Pulverizer protection requires >20 t/h airflow, which existing duct cannot provide.
   c) Operational dependency on hot air: Due to low cold air flow, operators rely on hot air purge, worsening overheating issues.
   d) Accumulation of residual coal dust: Ineffective purge leaves coal dust in mill, increasing risk of spontaneous ignition.
   e) Aging system configuration: Existing duct design has not been upgraded since commissioning, lagging behind modern safety standards.

These problems highlight the importance of optimizing the cold air duct system to ensure safety, reduce operational costs, and improve overall pulverizer reliability.

Solutions to common problems of cold air system

Based on the identified phenomena and specific causes, the following technical solutions were developed to improve the performance of the cold air system in the pulverizer, with the main focus on preventing overheating during the stop process:

1. Enlargement of cold air duct size
   a) The most effective solution is to increase the duct size from OD 10 inch to OD 22 inch.
   b) This enlargement increases the duct cross-sectional area from 0.055 m² to 0.241 m², which raises the airflow capacity from 5.56 t/h to 24.37 t/h.
   c) By meeting and exceeding the minimum requirement of 20 t/h, the pulverizer can perform 100% purging with cold air, eliminating the need for hot air exposure.
2. Improvement of purging reliability
   a) With sufficient cold airflow, the pulverizer chamber can be cooled down rapidly below 75°C.
   b) This ensures that outlet temperatures remain safe, significantly shortening restart readiness time from 4–6 hours to less than 30 minutes.
3. Reduction of auxiliary fuel oil dependency
   a) Avoiding hot air purge means the boiler no longer requires backup fuel oil to maintain combustion stability while the pulverizer is unavailable.
   b) This provides direct financial savings and reduces environmental emissions.

4. Enhancement of operational safety
   a) Properly sized cold air ducts prevent the risk of self-ignition or explosion inside the mill by ensuring continuous cooling airflow.
   b) This modification also aligns Kendari plant with best practices observed in other 300 MW units.
5. Sustainability and reliability improvement
   a) The modification not only solves immediate overheating issues but also ensures long-term reliability of the pulverizer system.
   b) It reduces maintenance frequency caused by thermal stress and extends equipment lifetime.

In conclusion, enlarging the cold air duct is the most practical and cost-effective solution to address the common problems in Kendari Unit #2 pulverizer system. It directly prevents overheating during stop processes, improves system reliability, and enhances operational economy.

Analysis of the effect after enlarge coal air duct

After enlarging the cold air duct from OD 10 inch to OD 22 inch, the performance of the pulverizer system in Kendari Unit #2 showed significant operational and economic improvement. The enhancement directly prevented the pulverizer from entering high temperature conditions during the stop process and ensured that each pulverizer could be immediately ready for operation when required.

1. Prevention of high temperature condition and improvement of pulverizer readiness

Before the modification, the limited cold air duct size caused insufficient airflow (only about 5.56 t/h per pulverizer). During the stop and purge process, the operator had to open the hot air door to meet the minimum air volume requirement (>20 t/h). As a result, the internal temperature of the mill often reached 84–86°C, which exceeded the safety limit for restart. Under this condition, the pulverizer could not be restarted for 4–6 hours while waiting for natural cooling.

After the duct enlargement, the cold air capacity increased to 24.37 t/h, allowing the purging process to be conducted with 100% cold air. This change effectively reduced the mill outlet temperature to 59–68°C, ensuring that the pulverizer can be restarted safely within less than 30 minutes. The improvement eliminated the need to wait for cooling and significantly enhanced the unit's start-up flexibility and readiness.

2. Economic impact: reduction of fuel oil consumption for back-up combustion

Previously, when pulverizers were not ready due to high temperature, the boiler required auxiliary fuel oil to maintain stable combustion. The average consumption rate of diesel oil during such periods was approximately 2,300 liters per hour.

By preventing overheating and allowing rapid restart of pulverizers, the enlargement of the cold air duct directly avoided unnecessary fuel oil usage. Considering the former cooling duration of 4–6 hours, the potential saving per incident

Cooling duration avoided	Diesel oil saving (L)
4 hours	9,200 liters
6 hours	13,800 liters

Therefore, for each incident of pulverizer unavailability that is now eliminated, the plant can save between 9,200 and 13,800 liters of fuel oil, in addition to the reduction of CO_2 emissions and improvement in overall energy efficiency. If multiple pulverizers experience similar conditions annually, the total annual saving would multiply accordingly, providing substantial economic benefit.

3. Operational and maintenance improvement

The modification also reduced operational stress and maintenance burden. In previous conditions, repeated exposure of the mill to high temperature during hot air purging caused :

a) Thermal fatigue on internal components (seals, rollers, bearings).
b) Increased wear and shortened service life.
c) Higher frequency of corrective maintenance and spare part replacement.

After the improvement, the use of 100% cold air for purging maintains mill components at lower and stable temperatures, extending component life and reducing unscheduled shutdowns. The stable temperature profile also minimizes the risk of self-ignition inside the pulverizer, ensuring a higher level of operational safety for personnel and equipment.

4. Quantitative summary of improvement

Table 1. Quantitative summary of improvement

Parameter	Before Improvement	After Improvement	Improvement Result
Cold air flow rate (t/h)	5.56	24.37	+338% increase
Mill outlet temperature (°C)	84–86	59–68	↓ by ~20°C
Cooling time before restart	4–6 hours	<30 minutes	8–12× faster restart
Fuel oil consumption	2,300 L/hour (for 4–6 hours)	Eliminated	9,200–13,800 L saved per event

The analysis clearly demonstrates that the improvement not only enhances technical performance but also contributes to significant economic efficiency and energy savings.

5. Overall evaluation and recommendation

By implementing the enlargement of the cold air duct, the pulverizer system of Kendari Unit #2 has achieved stable operation, fast restart capability, and reduced dependency on auxiliary fuel oil. The modification improves both reliability and safety of the plant operation and brings measurable financial benefits.

This solution is practical, low-cost, and replicable. It is recommended to be applied to other units experiencing similar problems of undersized cold air ducts, as it can effectively prevent overheating, shorten restart time, and save substantial fuel cost while maintaining high operational reliability.

RESEARCH METHOD

The research method used in this improvement project is categorized as an engineering analysis and field modification method. This study employs a quasi-experimental design with pre-post comparison to evaluate the effectiveness of the cold air duct enlargement intervention.

The research design combines quantitative field measurements with engineering calculations to assess both technical performance and operational outcomes.

The purpose of this method is to identify the root cause of insufficient cold air flow in the pulverizer system, design an effective technical solution, and verify its performance through on-site measurement and comparative evaluation. The selection of this methodology is justified by its suitability for industrial engineering applications where controlled experimental conditions are not feasible, and where real-world operational data provides the most valid evidence of intervention effectiveness (Montgomery, 2019; Box et al., 2005).

1) Location and Equipment

The study was conducted at PT. DSSP Power Kendari, Unit #2, a coal-fired thermal power plant with a pulverizer system designed to operate under both hot and cold primary air conditions. The equipment involved in this research includes:

a. Primary Air Fan (PAF) as the main air supply to the pulverizer.
b. Cold Air Duct connecting the PAF outlet to the mill inlet.
c. Flow meter (portable type) for measuring air velocity and capacity.
d. Temperature sensor (thermocouple) installed at the outlet of the coal mill.
e. Pressure gauge to monitor differential pressure across the air duct.

2) Data Collection and Measurement Procedure

Field data were collected during normal unit shutdown operation (purging process). The measurement of air flow rate in the existing cold air duct was carried out using a portable flow meter to obtain the average velocity (v). The internal cross-sectional area (A) of the duct was calculated based on the inner diameter (ID) of the pipe. The air flow capacity (Q) was determined using the following standard equation:

Q=A×vQ = A \times vQ=A×v

Where:

a. Q = Design flow capacity (m^3/h)
b. A = Cross-sectional area (m^2)
c. v = Average velocity (m/s)

3) Testing and Verification Procedure

After installation, field testing was conducted to compare the before-and-after performance:

a. Measurement of outlet mill temperature during stop operation.
b. Observation of air flow stability and duct pressure loss.
c. Measurement of restart readiness time for each pulverizer.
d. Recording of fuel oil consumption before and after the modification.

The collected data were analyzed to evaluate the effectiveness of the new cold air duct design in improving airflow performance, operational reliability, and energy efficiency.

RESULTS AND DISCUSSION

This section presents the results obtained from the field implementation of the cold air duct enlargement and discusses the technical, operational, and economic effects after the improvement. The results are based on measurement data, plant operating logs, and comparative analysis before and after the modification.

Observation of temperature and airflow behavior before improvement

Before the modification, the existing cold air duct (OD 10 inch) had an internal flow area of 0.055 m², allowing only 5.56 t/h of air flow to the pulverizer. During the stop and purging process, when the hot air door was fully closed, the total air volume at the mill inlet was approximately 16 t/h, which was below the tripping protection requirement of 20 t/h.

Due to the insufficient cold air, the purging process had to be performed using hot air from the primary air system. This resulted in a rapid temperature rise in the mill body. The outlet temperature of the pulverizer during stop condition reached an average of 84–86°C, with peaks above 90°C in certain cases.

Such high temperatures caused the pulverizer to require a cooling period of 4–6 hours before it could be restarted. During this period, the pulverizer was unavailable for operation, forcing the unit to rely on fuel oil to maintain stable combustion in the boiler. The additional oil usage also increased plant operating costs and reduced energy efficiency.

Observation after improvement of cold air duct

After the cold air duct was enlarged to OD 22 inch (0.241 m²), the cold air flow increased to 24.37 t/h per pulverizer, exceeding the required minimum of 20 t/h for safe purging operation.

The following results were observed during the post-modification test:

a. The average outlet temperature during the stop process decreased to 59–68°C.
b. The cooling period before restart was reduced from 4–6 hours to less than 30 minutes.
c. The restart readiness of the pulverizer improved significantly, ensuring immediate availability for operation.

The improvement also enabled the plant to perform 100% purging using cold air only, thereby avoiding exposure to hot air and preventing thermal stress on the mill structure and its components.

Table 2. Comparison of outlet temperature before and after modification

Condition	Average Mill Outlet Temperature (°C)	Cooling Time Before Restart	Remarks
Before Modification	84–86	4–6 hours	High temperature; long downtime
After Modification	59–68	<30 minutes	Safe temperature; fast restart

Figure 1. Comparison of outlet mill temperature before and after modification.

The temperature profile clearly demonstrates the cooling effect of the enlarged duct. The increased cold air volume enhances convective heat removal from the mill internals, keeping the system below the critical ignition temperature and ensuring operational safety.

Effect on operational reliability and fuel oil saving

With the enlarged cold air duct, the pulverizer system can now be restarted promptly after stopping, thus avoiding prolonged unavailability and reducing reliance on auxiliary fuel oil.

During previous operations, fuel oil consumption for back-up combustion was about 2,300 liters per hour whenever the pulverizer was not ready due to overheating. Since the average waiting time for cooling was 4–6 hours, each incident resulted in a fuel consumption of 9,200–13,800 liters.

After the improvement, this fuel usage was completely avoided. Consequently, the modification not only improved technical reliability but also provided significant economic benefit and energy efficiency.

Discussion of mechanical and thermal effects

The enlargement of the cold air duct provided more uniform airflow distribution inside the mill, which reduced localized hot spots and eliminated uneven thermal expansion in the housing and journal bearings. This indirectly decreases mechanical stress and wear rate of the internal components such as the grinding rollers, separators, and seals.

The stable cooling environment also prevents the accumulation of residual coal dust, which previously led to self-heating or spontaneous ignition during idle conditions. Furthermore, the optimized air velocity minimizes erosion on the inner surface of the duct, thereby extending the lifetime of the air piping system.

These combined effects contribute to:

a. Enhanced safety margin of the pulverizer system;
b. Increased mean time between maintenance (MTBM);
c. Reduction of unplanned outages;
d. Stable operation of the boiler due to reliable coal supply.

Table 3. Summary of performance improvement

Parameter	Before Improvement	After Improvement	Improvement Result
Cold air flow rate (t/h)	5.56	24.37	+338% increase
Air velocity (m/s)	25.29	25.29	Maintained constant
Mill outlet temperature (°C)	84–86	59–68	−20 to −25°C
Cooling time before restart	4–6 hours	<30 minutes	Faster restart 8–12×
Fuel oil consumption	2,300 L/hour	Eliminated	9,200–13,800 L saved/event
Pulverizer readiness	Limited	Fully available	Reliability improved

Scientific interpretation of findings

The improvement observed can be explained by the fundamental thermodynamic principle of convective heat transfer. When airflow through the pulverizer increases, the rate of heat removal from the mill body is directly proportional to the mass flow rate and the temperature difference between the air and the mill surface.

Mathematically,

Q=m×Cp×ΔTQ = m \times C_p \times \Delta TQ=m×Cp×ΔT

where Q is the heat transfer rate, m is the mass flow rate (t/h), C_p is the specific heat of air, and ΔT is the temperature difference.

By increasing the air mass flow rate from 5.56 t/h to 24.37 t/h, the convective heat removal rate increased more than four times, thereby reducing the mill outlet temperature faster and preventing overheating. This scientific mechanism explains the observed reduction in cooling time and the improved reliability of pulverizer restart operation.

Discussion in relation to other plants

Benchmarking with 300 MW coal-fired units in other power stations shows that the Kendari plant now operates within standard design parameters. The new cold air duct sizing provides equivalent or better performance in terms of air flow capacity and safety margin, making the system fully compliant with pulverizer protection standards.

The modification has thus transformed the operational profile of the Kendari pulverizer system from reactive to proactive — preventing failures rather than responding to them.

Summary of findings

Through the enlargement of the cold air duct, the pulverizer system achieved:

a. A stable cold air flow capacity meeting operational design requirements.
b. Significant reduction of mill outlet temperature during stop operation.
c. Rapid restart readiness of the pulverizer within 30 minutes.
d. Elimination of auxiliary fuel oil usage for back-up combustion.
e. Improved operational safety and reduced maintenance demand.

These results verify that the modification provides both technical feasibility and economic benefit, and can be promoted as a best practice for other thermal power plants facing similar operational challenges.

CONCLUSION

Enlarging the pulverizer system's cold air duct from OD 10 inch to OD 22 inch increased airflow from 5.56 t/h to 24.37 t/h, exceeding the 20 t/h minimum for safe cold air purging and eliminating auxiliary diesel oil use (saving 9,200–13,800 liters per incident). This reduced outlet temperatures during stops from 84–86°C to 59–68°C, shortened restart times from 4–6 hours to under 30 minutes, lowered self-ignition/explosion risks, enhanced maintenance safety, and extended mill component life by minimizing thermal stress. Overall, this low-cost modification boosts operational reliability, availability, combustion stability, and economics in thermal power plants. For future research, comparative studies across multiple units could quantify long-term energy savings and scalability, including CFD modeling to optimize duct sizing for varying coal types and load conditions.

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