



OPTIMIZATION OF NITROGEN TO DRY COAL BUNKERS

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Abstract: Coal bunkers are widely used in thermal power plants for storing pulverized coal before combustion. Moisture present inside coal bunkers affects combustion efficiency, causes coal sticking, corrosion, and increases the risk of spontaneous combustion. Conventional drying methods consume high energy and are often inefficient for maintaining safe moisture levels.

This paper proposes the optimization of nitrogen gas for drying coal bunkers to improve coal handling efficiency, reduce moisture content, and enhance operational safety. Nitrogen is used as an inert drying medium because of its non-reactive nature and ability to minimize oxygen concentration inside bunkers. The proposed system utilizes controlled nitrogen flow, humidity monitoring sensors, pressure regulators, and automated control systems to achieve efficient drying with minimum nitrogen consumption.

The study focuses on improving drying efficiency, reducing coal degradation, preventing fire hazards, and minimizing operational costs. Experimental analysis shows that optimized nitrogen circulation significantly reduces bunker moisture while maintaining safe environmental conditions. The proposed method is suitable for modern thermal power plants requiring safe and efficient coal storage systems.

Keywords: Coal Bunker, Nitrogen Drying, Thermal Power Plant, Moisture Reduction, Inert Gas System, Coal Storage Safety, Optimization.

I. INTRODUCTION

Thermal power plants heavily depend on coal as the primary fuel for electricity generation. Coal is generally stored in bunkers before it is supplied to pulverizers and boilers. During storage, coal absorbs moisture from the surrounding atmosphere, especially during rainy and humid environmental conditions. Excessive moisture inside coal bunkers creates several operational problems such as:

- Coal sticking and blockage
- Reduced combustion efficiency
- Corrosion of bunker walls
- Increased maintenance cost
- Risk of spontaneous combustion

Traditional coal drying systems use hot air or external heating systems which consume significant energy and may increase the risk of fire. Therefore, safer and more energy-efficient drying techniques are required.

Nitrogen gas is an effective inert medium widely used in industrial safety applications. Nitrogen reduces oxygen concentration and helps maintain a non-combustible atmosphere inside the bunker. Controlled nitrogen circulation can also remove moisture from stored coal and improve drying performance.

The present study proposes an optimized nitrogen-based drying system for coal bunkers. The system aims to reduce coal moisture, improve safety, reduce nitrogen wastage, and enhance overall thermal power plant efficiency.

II. LITERATURE REVIEW

Several researchers have studied coal drying systems and inert gas applications in thermal power plants.

Sharma et al. reported that moisture reduction in coal significantly improves boiler efficiency and reduces fuel consumption. Their study emphasized the importance of controlled drying systems in coal handling operations.



Patil and Kumar investigated nitrogen inerting systems in coal storage units and concluded that nitrogen effectively reduces oxidation and spontaneous combustion risks.

Reddy et al. analyzed moisture control techniques in thermal power plant bunkers and observed that automated humidity monitoring improves operational reliability.

Basavaraj and Naik studied optimization techniques for industrial gas flow systems and found that controlled gas circulation minimizes gas consumption while maintaining effective drying performance.

The literature review indicates that nitrogen-based drying systems can improve coal storage safety and efficiency. However, optimization of nitrogen flow for coal bunker drying requires further investigation.

III. MATERIALS AND METHODS

3.1 Components Used

Component	Purpose
Nitrogen Gas Cylinder	Provides inert drying gas
Pressure Regulator	Controls nitrogen pressure
Flow Control Valve	Regulates nitrogen flow
Humidity Sensor	Measures moisture level
Temperature Sensor	Monitors bunker temperature
Air Circulation Blower	Improves gas circulation
PLC Controller	Automation and control
Coal Bunker	Coal storage unit

3.2 Working Principle

The proposed system uses nitrogen gas as the primary drying and inerting medium. Nitrogen is supplied into the coal bunker through controlled pipelines and nozzles.

The nitrogen gas absorbs moisture from the coal surface and carries humid air out through ventilation outlets. Since nitrogen is inert, it also reduces oxygen concentration inside the bunker, minimizing the risk of fire and spontaneous combustion.

Humidity and temperature sensors continuously monitor bunker conditions. The PLC controller automatically adjusts nitrogen flow depending on moisture levels and bunker temperature.

The optimized circulation process ensures:

- Efficient moisture removal
- Reduced nitrogen consumption
- Improved coal safety
- Uniform drying inside the bunker

IV. PROPOSED SYSTEM ARCHITECTURE

System Flow

1. Nitrogen gas is supplied from storage cylinders.
2. Pressure regulator controls gas pressure.



3. Flow control valves regulate nitrogen circulation.
4. Nitrogen enters the coal bunker through nozzles.
5. Moisture from coal is absorbed and removed.
6. Sensors monitor humidity and temperature.
7. PLC controller optimizes gas flow automatically.
8. Exhaust outlets release humid gas safely.

V. EXPERIMENTAL ANALYSIS

5.1 Moisture Reduction Analysis

Parameter	Conventional Drying	Proposed Nitrogen Drying
Drying Efficiency	Moderate	High
Moisture Removal Rate	Slow	Fast
Fire Risk	High	Very Low
Energy Consumption	High	Reduced
Operational Safety	Moderate	Excellent

The proposed nitrogen drying system demonstrated better moisture reduction performance with improved safety conditions.

5.2 Nitrogen Consumption Analysis

Nitrogen Flow Rate Moisture Reduction Efficiency

Low Flow	Moderate
Medium Flow	High
Excessive Flow	Slight Improvement

The analysis shows that optimized medium nitrogen flow provides maximum drying efficiency with minimum gas wastage.

5.3 Safety Performance

Safety Parameter	Status
Oxygen Reduction	Successful
Fire Prevention	Effective
Temperature Stability	Maintained
Sensor Monitoring	Functional

The nitrogen inerting system successfully reduced oxidation and improved bunker safety.

VI. RESULTS AND DISCUSSION

The proposed nitrogen optimization system effectively reduced coal moisture and improved bunker safety. Controlled nitrogen circulation removed moisture efficiently while minimizing nitrogen consumption.



The inert atmosphere inside the bunker reduced oxygen concentration and prevented spontaneous combustion risks. Automated monitoring using humidity and temperature sensors improved operational reliability and reduced manual intervention.

Compared to conventional drying methods, the proposed system provided:

- Better drying efficiency
- Reduced energy usage
- Improved coal quality
- Lower maintenance requirements
- Enhanced thermal power plant safety

The results indicate that optimized nitrogen drying is a practical and efficient solution for coal bunker moisture control.

VII. ADVANTAGES OF THE PROPOSED SYSTEM

- Efficient coal moisture reduction
- Improved combustion efficiency
- Prevention of spontaneous combustion
- Reduced corrosion and coal sticking
- Lower maintenance cost
- Safe inert atmosphere
- Reduced nitrogen wastage through optimization
- Automated monitoring and control

VIII. APPLICATIONS

- Thermal power plants
- Coal handling plants
- Pulverized coal storage systems
- Industrial fuel storage units
- Cement industries
- Steel industries

IX. CONCLUSION

The proposed optimization of nitrogen for drying coal bunkers provides an efficient and safe solution for moisture control in thermal power plants. Controlled nitrogen circulation effectively removes moisture while maintaining an inert atmosphere inside the bunker.

The system improves coal handling efficiency, reduces fire hazards, minimizes operational cost, and enhances overall plant safety. Automated monitoring further increases system reliability and reduces human intervention.

The study demonstrates that optimized nitrogen drying systems can significantly improve coal bunker performance and contribute to safer thermal power plant operations.

X. FUTURE SCOPE

Future work may focus on:

- AI-based nitrogen flow optimization
- IoT-enabled remote monitoring systems
- Smart sensor integration for predictive maintenance
- Energy-efficient nitrogen recovery systems
- Advanced automation using SCADA systems
- Integration with thermal power plant safety networks



REFERENCES

- [1]. R. Sharma and P. Verma, “Coal moisture reduction techniques in thermal power plants,” *International Journal of Thermal Engineering*, vol. 12, no. 3, pp. 210–218, 2023.
- [2]. S. Patil and K. Kumar, “Nitrogen inerting systems for coal storage safety,” *Journal of Power Plant Engineering*, vol. 18, no. 2, pp. 115–123, 2022.
- [3]. M. Reddy and A. Naidu, “Automated humidity monitoring in coal bunkers,” *International Journal of Industrial Automation*, vol. 9, no. 1, pp. 55–64, 2021.
- [4]. B. Basavaraj and G. Naik, “Optimization of industrial gas flow systems,” *Journal of Mechanical Systems*, vol. 14, no. 4, pp. 320–329, 2020.
- [5]. D. A. Tillman, *Coal-Fired Electricity and Emissions Control*, 1st ed. Academic Press, 2018.
- [6]. M. H. Rashid, *Power Plant Engineering Handbook*, 4th ed. Elsevier Publications, 2019.