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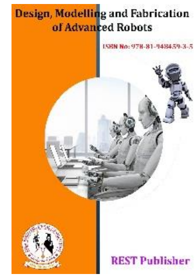


# Development of Sustainable Dust Compression System for Coal Yard Safety

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**Abstract:** *A sustainable water mist spray system for a closed coal yard. The project aims to address the need for dust suppression in the coal yard to mitigate environmental and health risks. The design specifications will be determined by considering the coal yard's size, layout, and specific requirements. The system will utilize a pneumatic air vane motor powered by residual dry steam from the plant's operation and, coupled with a fan for effective mist dispersion. Ro Reject water, a byproduct of reverse osmosis water treatment, will be used as the water source. The project will involve collaboration with mechanical engineering, fluid dynamics, and environmental studies to develop an optimized system design. Field tests will be conducted to validate the system's functionality, mist spray effectiveness, and coverage area. Safety features will be installed to ensure operator protection, and training programs will be developed to educate operators on safe system operation. The effectiveness of the mist spray system will be evaluated and monitored through regular assessments and data collection. Maintenance activities will be conducted to ensure system functionality, and safety features will be updated as necessary. The successful implementation of this sustainable water mist spray system will contribute to dust suppression, environmental sustainability, and safety in the coal yard.*

***Key words****: Coal yard safety, dust suppression system, sustainable water mist system.*

## 1. INTRODUCTION

Coal yards play a critical role in the storage and transportation of coal, serving as key hubs in the energy supply chain. However, one of the significant challenges associated with coal yards is the generation of airborne dust particles during handling, storage, and transportation processes. These dust particles can pose serious risks to both the environment and the health and safety of workers. Dust control is a crucial aspect of coal yard management, aiming to mitigate the adverse effects of dust emissions. An effective dust suppression system plays a vital role in reducing airborne dust, enhancing operational efficiency, complying with environmental regulations, and promoting a safe working environment. A dust suppression system is designed to minimize or eliminate the release of dust particles into the atmosphere by implementing various techniques and technologies. These systems employ a combination of equipment, such as dust collectors, misting systems, foam generators, and sprinklers, along with advanced control mechanisms to address specific dust generation points and achieve optimal dust control. The benefits of a well-designed dust suppression system are multifaceted. Firstly, it helps to protect the environment by reducing air pollution and preventing the dispersion of harmful particles, which can have detrimental effects on both human health and ecosystems. Secondly, it ensures compliance with local and national regulations governing air quality standards. By actively managing dust emissions, coal yards can avoid fines and legal complications related to environmental non-compliance. Scope of Study The scope of the project involves the development and implementation of a sustainable water mist spray system at a closed coal yard. The project encompasses several stages, including identifying the need for dust suppression, determining design specifications, developing the system design, testing its functionality, installing safety features, training operators, evaluating effectiveness, and maintaining/updating the safety features. During the work, various factors will be considered, such as the environmental impact of dust emissions, compliance with regulations, and the health risks associated with dust particles. Design specifications will be determined based on the specific requirements of the coal yard, including mist spray capacity, coverage area, pneumatic air motor requirements, and the suitability of Ro Reject water. The development of the mist spray system will involve collaboration with experts in mechanical engineering, fluid dynamics, and environmental studies. Computational fluid dynamics and engineering principles will be utilized to optimize the system's performance and efficiency. Laboratory and field tests will be conducted to validate the system's functionality, mist spray effectiveness, and coverage area. Installation of safety features will be a crucial part of the project to protect operators and prevent accidents. Operator training programs will be developed to ensure safe operation and maintenance of the system. The effectiveness of the mist spray system will be evaluated and monitored through regular assessments, inspections, and data collection. The scope also includes the maintenance and update of the safety features to ensure continued functionality and compliance with regulations. Regular maintenance activities, such as inspections, cleaning, and replacement of parts, will be performed. Updates to safety features will be implemented as necessary to enhance operator safety and adapt to changing regulations. Overall, the scope of the project encompasses all stages from identifying the need for dust suppression to the maintenance and update of the system's safety features, with a focus on developing an efficient, sustainable, and safe water mist spray system for the closed coal yard.

## 2. LITERATURE REVIEW

A sustainable dust compression system is crucial for ensuring the safety of coal yards. Using a steady-state compression system not only reduces dust emissions, but also minimizes the need for additional energy consumption (Dindorf, 2012).Compressed air, which is typically one of the most expensive utilities in industrial facilities, plays a key role in this system (Saidur et al., 2010). By implementing energy-saving measures and optimizing the production, distribution, and application equipment of compressed air, significant cost savings can be achieved in the operation and maintenance of the compressed air system. This can be achieved by considering the demand of compressed air for different production steps and adjusting them based on fluctuating electricity prices. This approach not only reduces energy losses and minimizes energy consumption but also ensures that production steps with high demand for compressed air are executed during times of low compressed air cost (Böhm et al., 2017). Zhuwei Xie , Chen Huang , Zhongtai Zhao Review and prospect the development of dust suppression technology and influencing factors for blasting construction. With the rapid urbanization and shortage of energy, the construction of underground projects such as urban rail transit, hydropower stations, and coal mines is a general trend. Dust pollution in a work zone after blasting construction causes serious pneumoconiosis in workers. The reason for the large number of new cases of pneumoconiosis every year is that the research conclusions on dust suppression technology are still inconclusive and controversial and fail to provide construction enterprises with scientific and feasible dust suppression solutions. Pengfei Wang, Xuanhao Tan, Lianyang Zhang Influence of particle diameter on the wettability of coal dust and the dust suppression efficiency via spraying is a main technique means for the prevention and control of coal dust in coal mines. The dust suppression efficiency by spraying is highly correlated with the wettability of coal dust. There are many influencing factors for the wettability of coal dust, among which the particle diameter of dust is one of the most significant factors. In order to analyze the influence of particle diameter on the wettability of coal dusts and the dust suppression efficiency via spraying, 18 different samples with 3 different types of coal samples and 6 different particle diameters were selected in this study. Rudolf Klemens, Marian Gieras, Michal Kaluzny Dynamics of dust explosions suppression by means of extinguishing powder in various industrial conditions. In industrial conditions, there are different kinds of installations endangered by an explosion of dust–gas mixtures. In order to prevent them from any consequences of potential explosions, active protection systems which use extinguishing powders, as the suppressing material, are more and more widely applied. It often happens that the industrial installations are additionally endangered by an action of mechanical vibrations. In the above-mentioned conditions, the extinguishing powder tends to aggregate, making the process of dispersing it in the protected areas more difficult. Li Xiaochuan , Air curtain dust-collecting technology: Investigation of industrial application in tobacco factory of the air curtain dust-collecting system. The air curtain system can collect the dust particles from hardto-seal sources, which proves to be a feasible method for satisfying the increasing dust prevention requirements in China. In this study, aiming at addressing the dust escape problem at the tobacco stem loading point in a tobacco factory, a rotational flow air curtain dust-collecting system with a size of 2m x 2m x 2m was used for dust collection.Xiaochuan Li, Mingrui Zhang, Yefeng Jiang, Xinli Zhao, Li Wang, Jianxin Zhu, Xinhao Xu, Zhihao Li, Jifeng Jia, Duolei Zhu Air curtain dust-collecting technology:

An experimental study on the performance of a large-scale dust-collecting system. The escape of dust particles from dust-producing sources in welding, wood-, and crop-processing sites is hazardous for human health and can violate strict technological requirements. This study proposed artificial unloading of dust-producing links in tobacco plants and designed an air curtain dust-collecting system with large size of 2m × 2m × 2m. The dust was first isolated by air curtain jets produced by the air curtain generator and then driven away by the suction airflow on the top of the device to achieve the effective dust collection.

## 3. DESIGN

The design specifications of the mist spray system should be determined based on the specific requirements of the coal yard. This involves conducting an environmental impact assessment to evaluate dust emission rates and their impact. The assessment can include sampling and analysis of dust particles to determine their composition and potential health risks. The size and layout of the coal yard should be considered to optimize the coverage area and system efficiency. Assessing the pneumatic air motor requirements is crucial for ensuring effective mist dispersion under various wind conditions. This can involve analyzing wind patterns and velocities to determine the appropriate power and airflow capacity of the pneumatic air motor. Additionally, the quality of the water used in the system should be evaluated. Ro Reject water, as a byproduct of reverse osmosis water treatment, can be considered for use, but its suitability needs to be assessed based on parameters such as total dissolved solids (TDS), pH level, and the presence of contaminants. Water testing should be conducted regularly to ensure compliance with water quality standards and to assess any potential impact on the environment when using Ro Reject water.

## 4. CALCULATION

**Dust Settling Time:**

Measure the time it takes for dust particles to settle in a specific area before and after implementing the dust suppression system. Done by observing the settling of dust on surfaces. Calculate the reduction in settling time to assess the system's impact on dust dispersion.

**Sample Calculation:**

Settling time before system implementation: 1 hour Settling time after system implementation: 15 minutes Reduction in settling time = (1 - 0.25) / 1 * 100% = 75%

**Dust Particle Concentration**:

Measure the concentration of dust particles in the air before and after implementing the dust suppression system. Done usingPortable Air Quality Meter to estimate PM2.5 presence. Calculate the reduction in dust particle concentration as a percentage to quantify the effectiveness of the system.

Example Calculation:

Dust concentration before system implementation: 500μg/m³

Dust concentration after system implementation: 40μg/m³

## 5. COMPONENTS

**Air Vane Motor**

An air motor, also referred to as a pneumatic motor, is a rotary actuator that converts compressed air or gas energy into mechanical rotational motion. It operates on a straightforward principle where air pressure acts upon blades inside the motor to generate torque and initiate rotation.

**SS Fan Balde**

An SS fan blade refers to a fan blade constructed using stainless steel (SS), which is an alloy known for its corrosion resistance and durability. These blades are frequently employed in various applications where environmental conditions may cause other materials to rust or degrade.

**Mist Spray Nozzle**

A mist spray nozzle is a device that generates a fine mist or spray of liquid. It is used in applications requiring controlled and uniform distribution of liquids. These nozzles break down the liquid into small droplets, typically ranging from 20 to 200 microns in size, allowing for efficient coverage and evaporation. Mist spray nozzles utilize atomization mechanisms, such as pressure or air- assisted atomization, to achieve the desired droplet size. They offer flow control options for adjusting the liquid flow rate, and different spray patterns can be achieved, including full cone, hollow cone, flat fan, or adjustable patterns. Mist spray nozzles are constructed from materials like stainless steel, brass, plastic, or ceramic, depending on the compatibility with the liquid being sprayed. They are mounted in various configurations and find applications in industries such as agriculture, manufacturing, cooling systems, and dust control. Mist spray nozzles provide an efficient and controlled method of delivering liquids in a fine mist form for a range of purposes.

**Air Hose Pipe**

An air hose pipe, also known as an air hose, is a flexible tube designed to transport compressed air from a compressor or pressurized air source to pneumatic tools, equipment, or systems. It serves as a conduit for delivering compressed air in various industrial, commercial, and residential applications. Air hose pipes are constructed using durable and flexible materials such as rubber, PVC, or hybrid blends, providing resistance to abrasion and harsh environmental conditions.

## 6. PROTOTYPE DESIGN

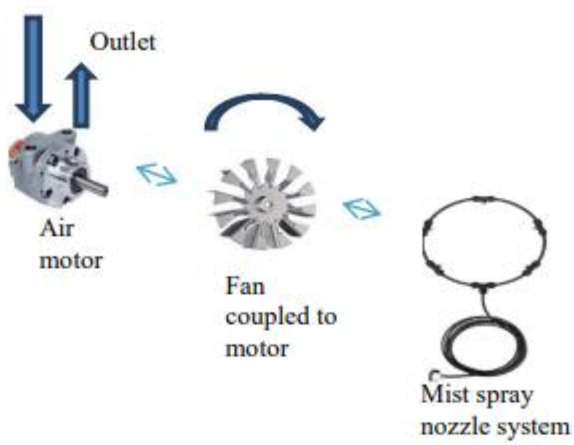


**FIGURE 1.** Dust Compression System

## 7. CONCLUSIONS

In conclusion, the development of a sustainable water mist spray system for a closed coal yard is essential to address the need for dust suppression and mitigate the environmental and health risks associated with dust emissions. The project involves several key stages, including identifying the need, determining design specifications, developing the system design, testing its functionality, installing safety features, training operators, evaluating effectiveness, and maintaining/updating the safety features. By implementing this work, the coal yard can effectively suppress dust emissions, reducing air pollution and minimizing health risks for workers and nearby communities. Compliance with environmental regulations is crucial for maintaining a positive corporate image and avoiding penalties. The design specifications of the mist spray system will be carefully determined, taking into account the specific requirements of the coal yard and optimizing the coverage area and system efficiency. Collaboration with experts in mechanical engineering, fluid dynamics, and environmental studies will ensure the development of an efficient and reliable mist spray system. Testing the system's functionality and performance under various conditions will validate its effectiveness in suppressing dust and conserving water resources. The installation of safety features, operator training, and regular evaluation and monitoring of the system's effectiveness will prioritize the safety of operators and prevent accidents. Ongoing maintenance and updates to the safety features will ensure the system's continued functionality and compliance with regulations. In conclusion, the successful implementation of this sustainable water mist spray system will contribute to a cleaner and healthier environment, enhance workplace safety, and promote responsible practices in the coal industry.

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