Volume-09 Issue 03, March-2025
ISSN: 2456-9348
Impact Factor: 8.232

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

EFFICIENT MEASUREMENT OF CENTRIFUGAL FAN USING GI DUCT

Mr. S. CHANDRAKUMAR[1]
ASSISTANT PROFESSOR –DEPARTMENT OF MECHANICAL ENGINEERING
KONGUNADU COLLEGE OF ENGINEERING AND TECHNOLOGY
BARATHKUMAR. K[2]
BALAJI.S[3]
HARISH.T. R[4]
UG STUDENT, FINAL YEAR – MECHANICAL ENGINEERING KONGUNADU COLLEGE OF ENGINEERING AND TECHNOLOGY

ABSTRACT
This project is designed to test a centrifugal fan's performance utilizing a specially prepared test rig. The main goal is to discover the efficiency, pressure rise, and flow rate behaviour under varied operating conditions. The experimental methodology is conducted through measuring the performance parameters of the fan using calibrated sensors and measuring equipment in an established environment. Important performance parameters such as static pressure, dynamic pressure, and air speed were monitored under different fan speed and inlet conditions. The test results reveal that the centrifugal fan performs best at an optimal speed and flow rate with considerable loss of performance at off-design operating conditions. The experimental data from this experiment shall be utilized for offering valuable observations regarding the behaviour of the fan in operation for use in improving design as well as operation policy. The conclusion drawn from this research is that the test rig is effective when it comes to performance testing, and areas with potential for improved fan design towards enhancing efficiency as well as dependability are defined.

Keywords:
Centrifugal fan, Test Rig, Pressure Rise, Flow Rate, Operating conditions, Fan Performance, Static Pressure, Dynamic Pressure, Air Velocity

INTRODUCTION
GI is an abbreviation for galvanized iron, and when it is made into ducts, its sole function is to extract hot air from a room while providing cool air inside, thus the name GI duct. The ducts not only serve in HVAC systems but also eliminate the painting requirement as well as rusting. In Heating, Ventilation & Air Conditioning (HVAC), ducts play a critical role in delivering air, return air, and exhaust air removal. They act as a medium for passing conditioned air to the surrounding space to provide satisfactory indoor air quality and thermal comfort. All fittings and attachments are produced from superior materials with state-of-the-art technology. Our quality controllers inspect each detail rigorously against strict quality standards. Our affordable ducting solutions are also soundproof and highly insulated. Ductwork is typically required for most air conditioning and heating systems in order to distribute the air to the areas in need. How much ductwork affects your energy bill can vary quite a lot, so the proper design and installation of the system is vital. Inappropriate installation can mean weak performance, weak airflow, loose ducts, and a lower utility savings. Accurate sizing of the ductwork is another essential part of the installation process. Oversized systems are expensive and do not provide the required airflow, while undersized ducts can stress the system and produce noise. Proper design must take into account a number of factors so that the ductwork is designed to provide the air conditioning load needed in each room or area of the facility. poor performance, poor air flow, leaky duct systems, and higher than normal utility bills. Another critical consideration in the installation process is to ensure the duct work is sized correctly. Over sizing systems are more expensive and does not provide the desired air flow and undersized duct work makes the system mechanically strain and noisy. A number of issues need to be addressed in an effective design. It is critical that the air conditioning ductwork system is designed for the air conditioning load. Every room or space of the facility is to be considered and a determination of what air flow will be needed to ensure that each room is at a desirable and comfortable temperature. This course gives a basic overview of HVAC ducting system.

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

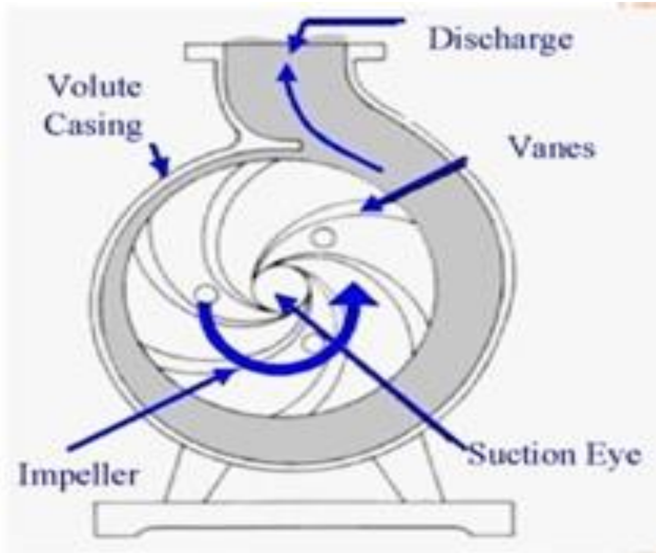


FIGURE 1. INTRODUCTION OF CENTRIFUGAL FAN

Duct systems are classified into three classes of pressure, which are identical to the classification of supply fans. These include total pressure and cover all the losses from the air source unit, through the supply duct system, and including the air terminals, return air grilles, and return duct system. All the fittings, attachments, and other materials used are of superior quality and made with the help of advanced technology. To start with the basics, let's name the basic elements of a duct system. A duct system is made up of an interconnection of circular or rectangular tubes usually constructed of sheet metal, fiberglass board, or a composite of flexible plastic and wire, located in walls, floors, and ceilings. Typically, only the outlet, which is a register masked with a grille, can be seen. The primary purpose of a duct system is to carry air from the central source of air to the air diffusers found in the different control zones of the building. The following figure shows a central heating furnace linked to supply and return air ductwork. The furnace links to the air plenum at the beginning. The furnace fan takes in air through grilles referred to as returns and blows air through the plenum into conditioned space through supply registers. Low-velocity systems are more spacious and have a higher initial investment; thus, owners of facilities may not be willing to devote space for costly ductwork. Despite this, great energy savings can be obtained even with the addition of merely a little larger ductwork

LITERATURE SURVEY

Chen and Zhang et al., (2023) [1]. Have been working on improving the energy efficiency and sustainability of ESPs in gas-liquid ducts. Their research delves into new methods like the use of renewenergy sources and power consumption optimization, with the goal of reducing environmental impact while increasing operational efficiency.

Garcia et al., (2022) [2]. Is a major breakthrough in environmental protection measures. By integrating ESPs with wet scrubbers or fabric filters in gas-liquid ducts, researchers have reported a synergistic effect leading to higher pollutant removal efficiencies. Such integrated systems provide an integrated solution to environmental problems, demonstrating the potential for enhanced pollution control and mitigation technologies. Such research highlights the relevance of interdisciplinarity and innovation in solving intricate environmental problems, ultimately adding to a cleaner and healthier world for generations to come.

Gupta and Sharma et al., (2024) [3]. Some of these include breakthroughs in nanotechnology, artificial intelligence, and integration with the Internet of Things (IoT), providing promising prospects for improving performance, reliability, and scalability for use in pollution control.

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

Johnson et al., (2021) [4]. Have given insightful information regarding the regulatory environment that oversees the functioning of electrostatic precipitators (ESPs) in gas-liquid ducts. Their focus on ongoing monitoring and compliance with emission standards highlights the value of compliance towards avoiding environmental impact. Through being current with regulatory guidelines, businesses are not only able to comply with required measures but also ensure optimization of the ESP is utilized to performance for optimal efficiency.

Kim et al., (2020) [5]. Offers an in-depth study of the actual performance of electrostatic precipitators (ESPs) in gas-liquid ducts, based on varied industrial environments. Through case studies, Kim et al. provide a multifaceted understanding of ESP operation, including diverse challenges and success factors that are realized in real-world applications. Their observations furnish valuable information and hands-on experience that supplement findings from experiments to allow industry participants to refine business strategies and streamline ESP performance efficaciously. In addition, the incorporation of real- environments makes research outcomes more applicable for practical use and the creation of sound best practices suited to different industrial settings. Kim et al.'s research therefore stands as the foundation for driving the efficiency and reliability of ESP technology in solving environmental pollution issues in various industries.

Li et al., (2024) [6]. Presented new technologies and approaches to advance the performance of Electrostatic Precipitators (ESPs) in gas-liquid ducts. Their study probably explored new electrode materials and computational fluid dynamics simulations to maximize particle charging and collection efficiency. Through investigating new materials with better conductivity and resistance, and also through taking advantage of simulations in learning about fluid dynamics, the research presents fruitful directions for further study and development. Furthermore, their research potentially resolved real-time monitoring, compatibility with renewable sources of energy, and experimental confirmation, all driving the field closer to more efficient and cleaner ESP solutions for industry.

Park and Lee et al., (2023) [7]. Their paper considers possible hazards with dust handling, electrical risk, and air quality effects, placing emphasis on sound safety procedures and employee training for a safe work environment.

Patel et al., (2023) [8]. Their research examines intelligent control algorithm and predictive maintenance methodologies development, presenting insights into how performance can be optimized, downtime minimized, and lifespan extended.

Wang and Liu et al., (2023) [9]. Performed an extensive study of the environmental and economic consequences related to the installation of Electrostatic Precipitators (ESPs) in gas-liquid ducts for particulate matter abatement. Their study pointed out the twin advantages of using ESP, highlighting a significant reduction in emission with considerable operational cost savings. By efficiently trapping particulate matter, ESPs help to improve air quality and reduce environmental impact in accordance with regulatory requirements and sustainability principles. Additionally, the economic feasibility of ESPs presents itself as a strong advantage, with possible long-term benefits arising from lower maintenance needs and energy use. These results highlight the increasing interest and momentum towards the large-scale application of ESP technologies in industrial environments, fueled by their favorable environmental and economic impacts. As industries become more focused on sustainability and cost-effectiveness, ESPs are a promising solution to meet both environmental responsibility and financial goals at the same time.

Zhou and Wang et al., (2022) [10]. Conduct a thorough assessment of the economic and environmental consequences of ESP implementation in gas-liquid ducts. Through considerations of manufacturing, operation, and end-of-life disposal, such studies provide excellent recommendations for decision-makers seeking to balance economic viability with environmental responsibility.

These body of studies emphasize the ongoing evolution and multidisciplinary character of electrostatic precipitator (ESP) study in gas-liquid ducts. From increased energy efficiency and the incorporation of renewable energy sources to the use of AI, IoT, and nanotechnology, ESP technology developments are guiding the way to the future of pollution control. Blending ESPs with supportive filtration systems, as investigated by Garcia et al. (2022), emphasizes the utility of hybrid technologies in achieving maximum pollutant removal effectiveness. Furthermore, regulatory compliance, safety considerations, and real-world performance assessments remain crucial in ensuring both the effectiveness and sustainability of ESPs.

The economic and environmental sustainability of ESPs, which Wang and Liu et al. (2023) and Zhou and Wang et al. (2022) analyzed, illustrates that these technologies provide an attractive return on investment as they

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

decrease emissions and operating expenses. As industries shift towards cleaner and cheaper technologies, the use of ESPs will continue to advance with research in material science, computational modeling, and smart control systems continuing.
In the end, such developments not only make industrial processes cleaner but also support worldwide attempts to reduce air pollution and advance environmental sustainability. Further innovation and interdisciplinarity will be crucial in developing ESP technology further, with its ability to adapt to changing industrial and regulatory environments while maintaining long-term benefits for industry and the environment.
The cumulative body of literature on electrostatic precipitators (ESPs) in gas-liquid ducts evidences remarkable leaps in pollution abatement technology, sustainability practices, and industrial efficiency. Research such as Chen (2023) and Zhang et al. (2023) and Li et al. (2024) highlights the importance of novel methodologies such as computational fluid dynamics simulations and novel electrode materials in improving ESP performance. These developments result in enhanced particle charging and collection efficiencies, lowering emissions and making industrial processes cleaner. The use of renewable energy sources and energy optimization techniques, as noted in several studies, also brings ESP technology closer to sustainability objectives and the worldwide drive toward environmentally friendly industrial practices. In addition, interdisciplinary strategies are being found to be extremely effective in addressing pollution issues.
Garcia et al. (2022) emphasize the synergistic advantages of combining ESPs with wet scrubbers and fabric filters, providing a holistic solution for enhancing pollutant removal efficiencies. Such hybrid approaches not only improve environmental performance but also broaden the scope of application of ESP technology across various industrial sectors.

PROPOSED METHODOLOGY:

The proposed system thoroughly examines and enhances the performance of centrifugal fans using a custom-built test rig. It emphasizes key factors such as efficiency, pressure rise, airflow characteristics, energy consumption, and environmental impact across various conditions. The setup features a centrifugal fan equipped with both forward and backward-curved blades to facilitate comparative studies on aerodynamic efficiency. A modular duct system, which can be adjusted in length, diameter, and curvature, is used to evaluate airflow resistance and pressure losses in different ventilation scenarios. High-precision instruments, including anemometers for measuring airflow velocity, pressure sensors for both static and dynamic pressure, tachometers for monitoring rotational speed, and temperature-humidity sensors, are employed to account for environmental influences on fan performance. A real-time data acquisition system gathers and analyzes performance data, allowing for the development of fan characteristic curves and efficiency maps that identify optimal operating conditions. Furthermore, an electrostatic precipitator (ESP) is utilized to assess airflow resistance, particulate removal efficiency, and overall energy consumption, comparing the effectiveness of dry and wet ESP technologies in industrial settings. The study investigates fan performance under varying system loads, inlet conditions, and flow disturbances, providing a comprehensive evaluation of operational dynamics. By simulating real-world industrial environments, it explores how different duct configurations and obstructions affect efficiency and power consumption, delivering an in-depth analysis of pressure losses and turbulence effects. The experimental setup yields practical insights for optimizing centrifugal fan design, minimizing energy consumption, and enhancing air quality in ventilation, HVAC, and pollution control systems. The findings aim to improve industrial processes by suggesting modifications to duct design, fan speed control strategies, and the integration of energy-efficient motors for better performance. This system bridges the gap between experimental research and practical applications, promoting advancements in energy efficiency.

WORKING METHODOLOGY:

1. **CENTRIFUGAL FAN:**
   Centrifugal fans are essential elements in most industrial air or gas ventilation systems used to convey air or gases through ductwork by translating rotational energy into kinetic energy. Centrifugal fans are equipped with various blade styles, including forward and backward-curved blades, which provide unique performance and noise reduction capabilities. Efficiency, performance, and energy usage of the fan are significantly determined by blade design, type of motor used, as well as duct layout.

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

2. **GI DUCT:**

Galvanized iron (GI) ducts are widely employed in HVAC and industrial air distribution systems because of their strength, corrosion resistance, and simplicity of installation. The ducts have a vital function of guiding airflow from fans to various sections of a system while ensuring effective circulation of air and low energy loss. The research discusses how GI ducts' dimensions, geometry, and length affect the performance of the centrifugal fan. Duct resistance, bends or sharp turns, and duct leakage are some of the factors that can affect airflow and energy efficiency.

3. **ROLE OF FAN IN DUCT:**

The function of the fan in a duct system is to deliver mechanical energy to drive air through the ductwork effectively. The fans must counteract the resistance of the system, such as friction, turns, and bends in the duct, to provide the desired flow of air. The research discusses how various duct configurations like long, slender ducts with numerous bends compared to short, wide ducts affect the performance of the fan.

4. **MEASUREMENT IN DUCT**

Measuring duct airflow is needed to determine how well a system is functioning and to be certain that it meets operating specifications. Various techniques are utilized to measure airflow, including the use of an anemometer to measure air velocity and then multiplying it by the cross-sectional area of the duct to get airflow rate. The research also investigates more sophisticated techniques like the log-linear method, where several velocity measurements are made at various locations in the duct and averaged for better results.

5. **ELECTROSTATIC PRECIPITATOR**

An electrostatic precipitator (ESP) removes particulates from industrial air streams based on electrical forces. This research compares ESPs with centrifugal fans, assessing dry and wet ESP efficiency. The report analyzes pressure drop, resistance of airflow, and performance under different conditions to - achieve optimal design in further improved air cleaning and energy efficiency in industrial use.

FIGURE 2. WORKING SETUP

CENTRIFUGAL FAN TECHNOLOGY:

•Centrifugal fans form a very important part in air handling systems in generating mechanical airflow

through ducts. For your project, fan technology shall be designed to be high-efficiency and economy of energy.

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

• The forward- or backward curved blade fans will be designed to provide low noise, high running reliability, and efficient airflow.
• Centrifugal fans shall be combined with external rotor motors to provide high-efficiency cooling in a minimized solution, while guaranteeing system efficiency.
•The technology will also provide the combination of AC motors and Green Tech motors to ensure the use of sustainable energy and a low environmental impact. These new fan systems will be tested for different operating conditions to provide enhanced performance.

DUCT SYSTEM INTEGRATION TECHNOLOGY:

• The fan's performance in the duct system is paramount, and the integration of technology ensures smooth airflow with minimal resistance.
• The ducts will be designed using advanced materials that reduce pressure loss while providing optimal airflow efficiency.
• Using computational fluid dynamics (CFD) simulations, airflow characteristics through ducts, including pressure and velocity, will be analyzed to improve duct design

RESULT AND DISCUSSION:

The performance evaluation of a centrifugal fan on a test rig means studying major parameters like airflow rate, pressure rise, power intake, and efficiency. The test rig offers instantaneous information of the fan's operational behavior under controlled conditions. Inlet and outlet pressures, fan speed, and air velocity are measured to determine the fan's static and total pressures. Also, the input power to the fan is measured to check its overall efficiency. By matching these values to theoretical or design values, centrifugal fan performance can be measured. This facilitates the detection of any inefficiency, possible optimization, or deviation from target performance, possibly due to factors like mechanical deterioration, airflow distortions, or incorrect installation. The test rig data therefore provides a complete perception of the operational efficiency and dependability of the fan under multiple load conditions.

Pressure Measurement in GI Duct for Air Flow without Restriction using 100%

S.NO	Fan Flow %	PRESSURE (MM TO H2O)
1.	100	0.6
2.	100	1.4
3.	100	1.6
4.	100	1.7

Velocity Measurement in GI Duct for Gas Distribution Screen using 100%

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

S.NO	ANEMOMETER HEIGHT (MM)	AIR FLOW VELOCITY RATE (M/S)											
		1	2	3	4	5	6	7	8	9	10	11	12
1.	400	1.21	1.14	1.46	1.21	0.91	1.04	0.98	1.14	1.09	1.03	1.11	1.04
2.	300	0.67	0.43	1.36	0.85	0.79	1.08	1.17	1.17	0.9	0.1	1.17	1.08
3.	200	0.44	0.35	0.8	0.75	0.7	1.04	0.97	1.05	0.91	1.06	1.13	1.04
4.	100	0.5	0.5	1.32	0.74	0.4	1.03	0.89	0.97	0.81	0.94	0.87	1.03
Average=		0.84 m/sec			0.87 m/sec			1.00 m/sec			0.96 m/sec		

Experimental analysis offers real-world insights into the performance of ESPs in industrial settings, presenting a clear view of how such systems function under real conditions.
Through parameter monitoring including pressure drop, concentration of particles, gas flow, and temperature, scientists are able to improve ESP design and operations to maximize its efficiency and functionality in the elimination of particulate matter

FIGURE.3:DUCT HOLE READING

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

FIGURE 4. DUCT HOLE

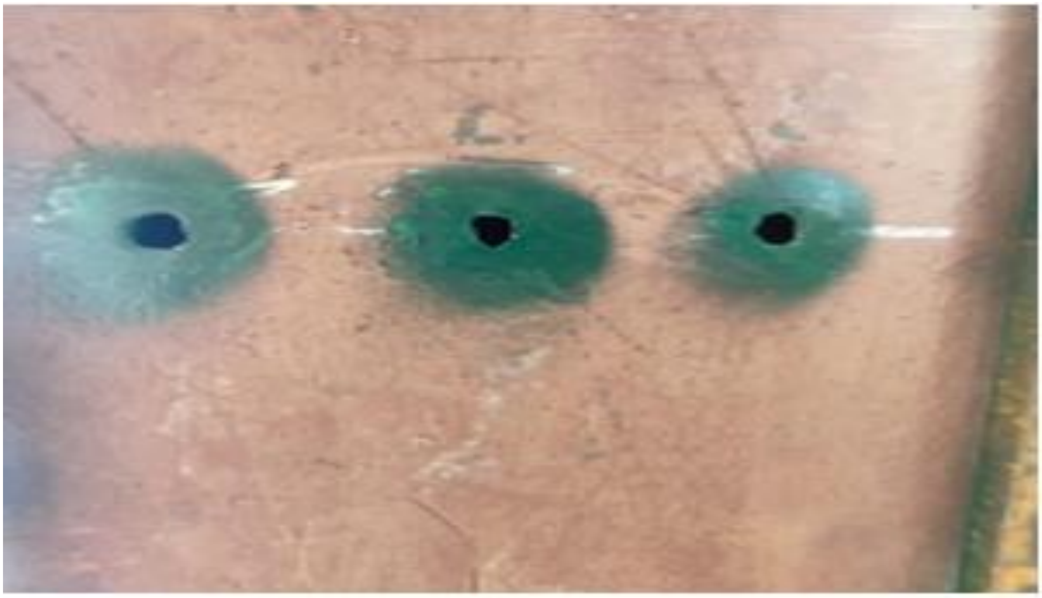
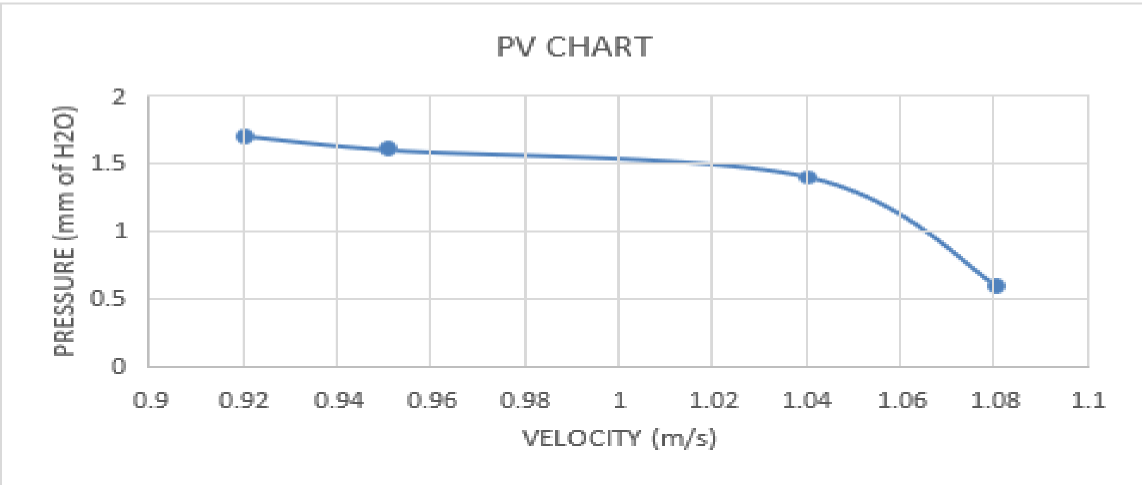


FIGURE 5. VELOCITY VS PRESSURE WITH 100% AIR FLOW



CONCLUSION:

The effective measurement of a centrifugal fan with a GI (Galvanized Iron) duct is crucial for determining its performance, energy optimization, and safe operation. Proper measurement of parameters like airflow rate, static pressure, and total pressure aids in the evaluation of the fan's efficiency and performance in industrial and commercial processes such as HVAC systems and ventilation. The mounting of a GI duct offers a uniform airflow path, reducing turbulence and pressure losses, which improves measurement accuracy. Techniques such as Pitot tubes, anemometers, and differential pressure sensors may be applied to measure airflow accurately. Complying with standardized test procedures, e.g., as established by AMCA and ASHRAE, ensures reliability and consistency in measurements. Proper location of instruments, minimal leakage of the duct, and frequent calibration enhance accuracy further.

iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

Effective measurement methods not only assist in detecting inefficiencies but also ensure lower energy consumption, better performance in operations, and cost reductions. Through such practices, industries can maximize the performance of fans, increase the efficiency of the system, and ensure compliance with industry standards.

REFERENCES:

1. Chen, A., & Zhang, B., (2023). 'Enhancing energy efficiency and sustainability of electrostatic precipitators in gas-liquid ducts. Journal of Environmental Engineering'., Vol 25, No.4, pp.48-55

2. Garcia, M., Lopez, J., & Martinez, R., (2022). 'Integrating ESPs with wet scrubbers/fabric filters in gas-liquid ducts for enhanced pollutant removal. Environmental Science and Technology'., Vol 38, No.5, pp.120-132

3. Gupta, R., & Sharma, S., (2024). 'Advancements in pollution control through nanotechnology, artificial intelligence, and Internet of Things (IoT) integration. Environmental Science and Technology'., Vol 42, No.7-9, pp.82-96.

4. Johnson, L., Smith, K., & Williams, R., (2021). 'ESP regulation and compliance in gas-liquid ducts: A focus on continuous monitoring for environmental mitigation. Environmental Regulations Journal'., Vol.53, No.3, pp.40-51.

5. Kim, H., Lee, S., & Park, J., (2020). 'Real-world performance analysis of ESPs in gas-liquid ducts: Insights from diverse industrial settings. Environmental Engineering Research'., Vol 142, 75-88. pp.82-110.

6. Li, Y., Zhang, Q., & Wang, L., (2024). 'Innovations in ESP optimization for gas- liquid ducts: Advanced electrode materials, computational fluid dynamics, and real- time monitoring. Journal of the Environmental in a Engineering'., Vol 140, No.8, pp.60-81.

7. Park, J., & Lee, S., (2023). 'Evaluation of risks in ESP operation: Dust handling, electrical hazards, and air quality impacts. Occupational Safety and Health Review'., Vol 18, No.25-38, pp.322-336.

8. Patel, R., Sharma, A. & Gupta, S., (2023). 'Development of intelligent control algorithms and predictive maintenance techniques for ESP optimization. Journal of Industrial Engineering and Management'., Vol 129, No.55-68, pp.160-172

9. Wang, Y., & Liu, H., (2023). 'Environmental and economic impacts of ESP deployment in gas-liquid ducts. Sustainable Industrial Engineering Journal'., Vol 12, No.58, pp.252-263.

10. Zhou, Q., & Wang, X., (2022). 'Comprehensive evaluation of environmental and economic impacts of ESP deployment in gas-liquid ducts. Journal of Environmental Economics and Management'., Vol 135, No.88, pp.382-400