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ASSESSMENT OF HEALTH HAZARD & OPTIMIZATION OF FUME EXTRACTION SYSTEM IN MANUFACTURING INDUSTRY

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ABSTRACT

In most of the manufacturing industries, welding is one of the major processes involved in the fabrication, but fumes from welding process may lead to adverse health effect. Concerns with the potential health effects of fume emissions during various welding processes have prompted investigations of methods for reducing fumes accumulated in the manufacturing facility and the concentration of hazardous metals in the evolved fume.

It is decided to use a suitable Engineering control with the principle of push and pull with the help of fume hoods may to eliminate the accumulated welding fumes generated in the welding facility. To reduce the health hazards of the workers in welding facility due to the exposure of the welding fumes also, to improve the well-being of the workers and to meet the legal compliance of the industry.

Keywords: Welding, Welding Fumes, Fume Hoods, Health Effect.

1. INTRODUCTION

Welding is defined as “a joining process that produces coalescence of materials by heating them to the welding temperature with or without the application of pressure or by the application of pressure alone, and with or without the use of filler metal”.

A weld is defined by the American Welding Society (AWS) as "a localized coalescence (the fusion or growing together of the grain structure of the materials welded) of metals or nonmetals produced either by heating the materials to the required welding temperatures, with or without the application of pressure, or by the application of pressure alone and with or without the use of filler material.

2. LITERATURE SURVEY

R.F.Heile and D.C.Chill (2013) have published artice on **"Particulate fume generation in arc welding processes"**, According to this article they developed a technical method to determine the fume formation and composition rate in the arc welding, which used to characterise the particulate emission in the various arc welding processes like shielded metal arc (SMA), gas metal arc (GMA), flux cored arc (FCA), and gas tungsten arc (GTA) welding, and has permitted a ranking of these processes according to their relative "cleanliness". The continuous electrode processes studied, GMA welding with argon-based shielding gas produced the least fumes, while self-shielding FCA welding produced the most. The data indicate that the mechanism of fume formation is one of elemental vaporization-condensation and oxidation enhanced vaporization-condensation of the consumable constituents. By this a model for fume formation rate and consumables composition can be predicted so that fume control systems can be predicted.

K.V.Satheesh Kumar, M.Dharmaraj, P.Thangavel, K.A.Srikishore, R.Sudharsan, and M.Vimal (2020) have published a conference article **"A critical review on fume extraction system for pipe and plate welding"** According to them for both pipe and plate welding, fixtures plays a crucial role. They investigate exposure among welders employed in the shop floor area, the welding fumes extractor has an exhaust ventilation setup to track sensitivity to welding fumes using glass fibre filter paper. To acquire the most effective way, the system fitted to the closed atmosphere so that the gases do not disperse beyond the welding chamber fixtures outside the fumigation hood were installed for both pipe and platform welding. By using a lathe chuck with 4 jaws fixed at both ends that keep the pipe, is the concept of the fixture is constructed so, that area to be welded without any deflections. The main vision for them is to control the welding fumes in a closed chamber and to fabricate a lightweight fume extraction hood with pipe and plate welding fixtures.

Mayur Bhaskarrao Wanjari, Pratibha Wankhede (2020) have published a research article **"Occupational Hazards Associated with Welding Work That Influence Health Status of Welders"** According to them The welding job has numerous risk factors, including physi¬cal, chemical, and psychological. Exposure to these conditions may contribute to specific health problems and occupational hazards. According to them most welders learned to weld by apprenticeship, without any structured educational system in health and safety and a small number of welders is trained by trainers and certification course. Among some of the health-related problems that are led by welding work like skin burn, lung diseases, eye problems, hearing problems, heart problems, and musculoskeletal disorder are not known by them. Welding work has various occupational health hazards because of the lack of using personal protective equipment. Personal protective equipment is a significant contributor to the prevention of various occupational health hazards. Physical morbidity profile of welders estimated 562000 employees are at risk for exposure to chemical and physical hazards according to Occupa¬tional Safety and Health Administration research. In 1993, the Bureau of Labor Statistics reported 58 deaths from welding and cutting accidents involving fires, electrocutions, asphyxiation, falls, and crushing injuries. Present overview of physical morbidity of welders are a low number of Publications about apprentices welding are a requirement for knowledge improving and give health promotion education to welders.

Pankaj Kumar.J. Mistry (2015) has published a article **"Impact of Welding Processes on Environment and Health"** According to them Environment considerations today tend to control, guide and develop engineering processes affecting both men and environment. The melting of filler metal, base metal and the coating on base metal during welding processes and subsequently the gases formed release minute, solid particles into the air creating a plume and is called welding fume. Compared to other industrial production processes, welding is fairly dangerous. Welding processes involve the potential hazards for inhalation exposures that may lead to acute or chronic respiratory diseases. Risks include asphyxiation due to dangerous inhalants, damage to skin and eye due to ultraviolet light, chemical or electrical fires, and long-term negative effects from fumes. This article is adapted from recent print and online resources to provide an overview of welding fumes, health effects and the measures to protect welders from welding fumes. This review describes the information currently available on air pollutant effects in welders, as the result of experimental studies. Results from the analysis shows that most of the welders' posses limited knowledge of welding fumes hazard. The aim of this review is to gather the potential toxic effects of welding fumes documented by individual efforts and spread awareness about the environmental and health hazards of welding fumes.

Ratih Pramitasari, Haikal1, MG Catur Yuantari, Kristin Ishak Kurnia Dwi, Chalobon Treesak (2022) has published an article on **"Job Safety Analysis and Hazard Identification of Welding Process in Semarang –JSA Method AS/NZS4360:2004"** They aimed to study and analyze occupational safety and health risks in the informal welding workshop in welding workshop in Semarang City using the JSA AS/NZS 4360:2004 Risk Management method. They conducted this research using semi-quantitative method with descriptive analysis and cross-sectional research design was used because data were collected at a particular time. This study was conducted in Semarang, Central Java, and the population was all informal welding workshops. The result of this study showed that there are 8 types of welding tasks, 21 potential hazards, and 24 health consequences in a welding process. The total score calculated by multiplying "chance" by "severity" shows that 11 health consequences were acceptable risk while 13 others were high risk. The conclusion shows the highest score of occupational health hazards was electric shock due to chipped cable, electric shock due to a chipped short circuit, and wet/rain/cloudy work area. Welders are recommended to follow the proper instruction in the welding process, and each workshop must provide a first aid box for its workers

Sebsibe Tadesse, Kassahun Bezabih, Bikes Destaw and Yalemzewod Assefa (2022) has published an article on **"Awareness of occupational hazards and associated factors among welders in Lideta Sub-City, Addis Ababa, Ethiopia".** According to them Welding is a manufacturing industry where workers could be exposed to several hazards. However, there is a dearth of studies clarifying the situation in Ethiopia. Their study determined the level of awareness of occupational hazards and associated factors among welding employees at Lideta Sub-City, Addis Ababa, Ethiopia. The methods used by them were A work site-based cross-sectional study was conducted among welding employees Lideta Sub-City, AddisbAbaba, Ethiopia from April to May 2015. Stratified sampling followed by simple random sampling techniques was used to select the study participants. A pilot tested and structured questionnaire was used to collect data. Multivariable analyses were employed to see the effect of explanatory variables on workers' awareness of occupational hazards. The results obtained for them According to their criteria of awareness 86.5 % of surveyed workers were aware of occupational hazards. A higher work experience, presence of work regulation, job satisfaction, being married, being single, and a higher educational status were factors significantly associated with workers' awareness of occupational hazards. Thus study revealed that the level of awareness of occupational hazards among welders was high. However, this does not mean that there will be no need for further strengthening of the safety measures as significant proportions of the workers still had low awareness. Interventions to boost workers awareness of occupational hazards should focus on areas, such as provision of safety trainings, promotion of safety advocacy, and enforcement of appropriate workplace safety regulation.

Hisaa Nassir Abdulla Lotah, Anoop Kumar Agarwal, Razia Khanam (2021) has published an research article on **"Heavy metals in hair and nails as markers of occupational hazard among welders working in United Arab Emirates"**. Their studies showed that hair and nail samples can be used as a marker to assess occupational exposure to heavy metals. Their objective of the study was to estimate the levels of heavy metals such as Lead (Pb), Nickel (Ni), Cadmium (Cd), and Manganese (Mn) in hair and nail samples of welders working in United Arab Emirates and to find an association between the heavy metal concentration with the parameters like smoking habits, exposure/day, years of experience and use of protective personal equipment (PPE). Hair and toes nail samples were collected from exposed and non-exposed subjects with respect to, social habits, exposure/day and years of welding experience. The levels of Pb, Cd, Mn, and Ni, in hair and toenails, assayed by atomic absorption spectrophotometer. They observed that the metal concentration was higher in toenail as compared to hair samples in both the groups. Cd was significantly high in both the groups whereas, Mn in the hair was high in the exposed group. The Mn in hair was notably higher among smokers and the Cd in hair and Ni in the nail samples was significantly higher in the subjects with > 8 h/day exposure. The concentration of Cd and Ni in hair increased with increasing years of experience and was maximum in the subjects with welding experience of > 20 years. Our results signify that hair and nail samples can be used as an indicator to heavy metal exposure. Given that the present study shows high level of some metals in the hair and nail of welders, awareness of occupational hazards and annual assessment of welder's health is necessary.

P.J. Witt, C.B. Solnordal, L.J. Mittoni, S. Finn, J. Pluta (2016) has published an research article on **"Optimising the design of fume extraction hoods using a combination of engineering and CFD modelling"**. According to them Fume and hygiene hoods are widely used to prevent fugitive emissions from charge ports, tap holes and many other openings in mineral processing and smelting vessels. The highly buoyant nature of the fume combined with often complex geometries make the design of these hoods difficult with traditional engineering tools. However, by combining the traditional engineering approach with computational fluid dynamics (CFD) techniques, a clear understanding of the shortfalls of an existing system can be obtained, and an optimised hood design can be achieved. This paper reports on a combined engineering and CFD analysis of a fume extraction system for a zinc slag fumer charge port. The engineering model revealed that the existing plant components (bag house and fan) were not capable of capturing the required amount of fume, and that the original hood design was flawed. The CFD model was then used to predict the fume capture and emission from the existing hood. CFD model predictions showed that increasing the draft flow rate by an order of magnitude would only give a marginal improvement in fume capture. Using findings of both the models enabled a new fume capture hood to be designed. CFD analysis of the new hood revealed that a significant improvement in fume capture is possible. Construction and installation of the hood has been performed and a 65% reduction in fume emission was achieved, thus significantly mitigating a long-standing emission problem.

Ramakrishnan, H. and P. Vinoth (2017) has published an article in the name of **"design, fabrication and analysis of fume extraction and filtration equipment"**. According to them Often, Human kind is permitted to inhale the emission of fumes is in the range of 2 to 3 mg/m3. However, it is the most challenging task for the human safety and environmental pollution. It induced to do the work for reducing the toxic content in the fumes released from chemical manufacturing, metal production process and metal joining process. Thus, the investigation carried out in this work to safeguard the human kind by introducing the new design of filter setup as layers. The filtration is done by using different filters, each having the tendency to absorb the toxic particles that are present in the fumes. The filters used are Silicone crystal, Alum filter and layer of cotton. This work helps the industry to reduce the particulate matter and heavy smoke produced by the fumes of metal joining process.

L. Els, P. Cowx, P. Smith, and R. Nordhagen (2014) have published in article in conference in the title **"Analysis and optimization of fume extraction from a ferromanganese furnace tapping operation"** they made a study using CFD and validated against site observations to ensure the accuracy of input parameters. Thereafter several modification concepts were modelled and suitable combinations were investigated to ensure robust solutions. The concepts were Considered by them were Air curtains, Ladle hood aspect ratio and position, Increase of ladle extraction volume, Extension of the length of the tapping garage structure. The results of a performance test on a working ferromanganese tapping area fume extraction system and the results of CFD modelling as compared by them. Upgrade options are evaluated and an integrated robust upgrade of the system was described by them.

L. G. Cena, W. P. Chisholm, M. J. Keane and B.T. Chen (2015) have published the article in the name of **"A Field Study on the Respiratory Deposition of the Nano-Sized Fraction of Mild and Stainless Steel Welding Fume Metals"**. They conducted a study to to estimate the amount of Cr, Mn and Ni deposited in the respiratory system of 44 welders in two facilities. Each worker wore a nanoparticle respiratory deposition (NRD) sampler during gas metal arc welding (GMAW) of mild and stainless steel and flux-cored arc welding (FCAW) of mild steel. Several welders also wore side-by-side NRD samplers and closed- face filter cassettes for total particulate samples. The NRD sampler estimates the aerosol's nano-fraction deposited in the respiratory system. Mn concentrations for both welding processes ranged 2.8-199 μg/m3; Ni concentrations ranged 10 -51 μg/m3; Cr concentrations ranged 40-105 μg/m3. Cr(VI) concentrations ranged between 0.5-1.3 μg/m3. For the FCAW process the largest concentrations were reported for welders working in pairs. As a consequence this often resulted in workers being exposed to their own welding fumes and to those generated from the welding partner. Overall no correlation was found between air velocity and exposure (R2=0.002). The estimated percentage of the nano-fraction of Mn deposited in a mild-steel-welder's respiratory system ranged between 10 and 56%. For stainless steel welding, the NRD samplers collected 59% of the total Mn, 90% of the total Cr and 64% of the total Ni. These results indicate that most of the Cr and more than half of the Ni and Mn in the fumes were in the fraction smaller than 300 nm.

3. PROBLEM IDENTIFICATION

During Welding operation, the fumes and metallic gases are emitted from the work piece, which cause the pollution and hazard to workers, when gases were inhaled or ingested. This usually cause respiratory effects such as lung disease, bronchitis and possible of lung cancer. Welding hazardous fumes are generated during welding processes at least 13 metals, including manganese (Mn), Beryllium (Be), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Mercury (Hg), Antimony (Sb), and Vanadium(V) (OSHA, 1995). Welders are known to be at risk, particularly for chronic exposure to airborne manganese, which is one of the major coating materials in welding products. The existing way of eliminating the welding fumes is the Natural Ventilation. At present the fumes are eliminated by the side opening shutters and the air vent provisions provided at the top of the roof, during high volume productions the fume generated is increased and thus the natural ventilation is not sufficient so, the control measure is required to eliminate the accumulated fume. Primarily, the purpose of the welding fume extractor is to ensure that the system installed meet the minimum ventilation requirement of building regulation and the challenges pose by welding fumes to welders in the workshop. Welding fumes inhaled is a health hazard for welders and other people in the welding shop.

4. OBJECTIVE OF THE PROJECT WORK

The preliminary goal of the project work is to study on the reason for the welding fumes accumulation in the manufacturing facility and to find the various ways to evacuate the accumulated welding fumes and to reduce the risk associated with the fumes generated during the welding process while fabricating the essential parts of the critical steam turbine like shell, cutting processes, etc.,

Based on the goal the following specific objectives were chosen for the study:

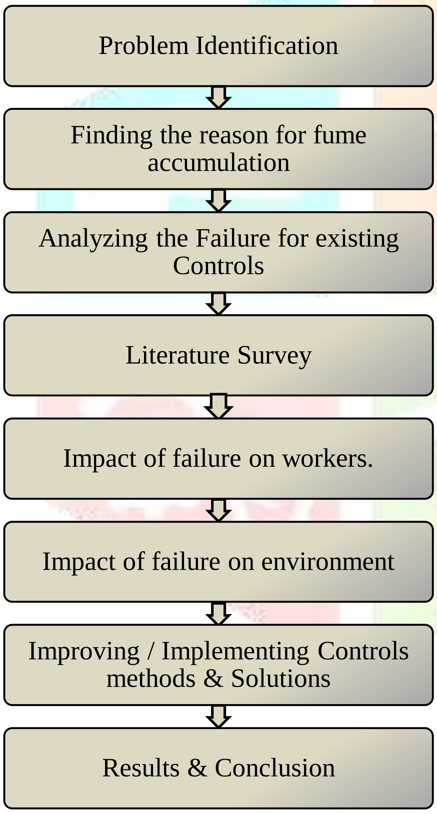
- To maintain the health and well-being of the worker.
- To provide the cleaner work environment for professional work.
- To improve the Business image among the industries.
- To enhance the Employer and Employee relationship.
- To meet the Legal requirements, Guidelines & Regulations.
- To reduce the Energy usage.

5. SCOPE OF WORK

In phase – I of the project work the parameters for the welding fume accumulation is found and the failure for the existing control is analyzed and identified. In phase – II of the project work has been planned to implement the fume extraction system. At first we decided to implement the industrial blower ventilation fan at various stages so as to pull the accumulated welding fumes to evacuate the fumes. After installing the industrial blower ventilation fan the effectiveness will be verified.

6. METHODOLOGY

The methodology for the present work is as follows, the problem is identified by the physical visit and the communication with the workers in the facility. According to the problem identified analysis was made to find the reason for the accumulation of the fume in the facility and the controls already using and present in that facility also for the ineffectiveness of the controls. Then a research was made how the welding fumes affect the workers and then various control measures were analyzed to find the suitable control measure according to the hierarchy of control. After feasibility test the control measure is planned to implement in that facility.



7. APPROACH

Hierarchy of Controls is a system used to prioritize and implement measures to control workplace hazards. It consists of five levels, listed from most effective to least effective in reducing or eliminating hazards:

- Elimination: Completely removing the hazard from the workplace. In the case of welding fumes, this could involve using alternative welding processes that produce fewer fumes or eliminating welding entirely if possible.
- Substitution: Replacing the hazardous process or material with a less hazardous one. This might involve using different welding consumables or processes that produce fewer fumes.
- Engineering Controls: Implementing physical changes to the workplace or process to minimize exposure to the hazard. For welding fumes, this could entail using local exhaust ventilation systems to capture and remove fumes at the source before they disperse into the working area.
- Administrative Controls: Establishing work procedures and policies to reduce exposure to the hazard. This could include limiting the duration of welding tasks or rotating workers to minimize exposure.
- Personal Protective Equipment (PPE): Providing workers with protective gear, such as respirators, to reduce their exposure to the hazard. While necessary, PPE is considered the least effective control measure because it relies on the worker's proper use and may not eliminate the hazard at its source.

For the implementation of a welding fume extraction system based on the Engineering Controls Hierarchy of Controls, the most effective approach would be to install a well-designed local exhaust ventilation system. This system would capture welding fumes at the source and prevent their release into the worker's breathing zone. The effectiveness of the system will depend on factors such as the ventilation system's design, maintenance, and adherence to occupational health and safety guidelines.

8. VENTILATION SYSTEM

8.1 Capture Hood or Nozzle:

Hood is to capture and remove hazardous fumes, dust, or particulates directly at the source before they disperse into the working environment. The capture hood or nozzle is the primary component responsible for collecting the fumes at the source of emission. It is positioned as close as possible to the point where the fumes are generated near process. The design of the capture hood can vary depending on the specific application and the nature of the emitted pollutants.

8.2 Ducting System:

The captured fumes are then transported away from the source through a network of ducts. These ducts are made of durable materials that can withstand the type of fumes and particulates being conveyed. The ducting system ensures that the captured pollutants are directed towards the next stage of the extraction system.

8.3 Scrubbing System:

In the wet scrubber unit, the fumes are exposed to a liquid medium, usually water. The water can be sprayed or dispersed into the path of the fumes. As the fumes come into contact with the liquid, a series of physical and chemical processes take place:

a. Absorption:

The scrubbing liquid acts as a medium to capture and remove particulates from the fumes. The fine particles adhere to the liquid, which effectively removes them from the air stream.

b. Particle Entrainment:

Particulate matter, such as dust and metal particles, are entrained in the liquid as well. The liquid acts as a medium to capture and remove the solid particles from the fumes.

c. Chemical Reactions (Neutralization):

Some welding fumes contain acidic or basic gases that can be harmful to health and the environment. In a wet scrubber, the scrubbing liquid can neutralize these acidic or basic gases through chemical reactions, making them less harmful.

8.4 Treatment and Disposal of Liquid:

The scrubbing liquid, now containing the absorbed pollutants, is collected at the bottom of the scrubber unit. The scrubbing liquid can be re-circulated back into the scrubber unit until the scrubbing liquid reaches a certain pH level after that the scrubbing liquid may require treatment as it contains harmful substances and disposal in accordance with environmental regulations.

8.5 Clean Air Discharge:

After passing through the scrubber unit, the cleaned air is separated from the scrubbing liquid using eliminators or demisters, which allow the cleaned air to pass while retaining the liquid droplets so that the exhaust air should meet regulatory requirements and be safe for workers and the environment.

9. EQUIPMENT SPECIFICATION WET SCRUBBER SPECIFICATION

Make	: JIFAMITRA
Flow Rate	: 24 to 26 m/s
Capacity	: 40000CFM
Scrubbing Medium	: Water

10. EQUIPMENT IMAGES

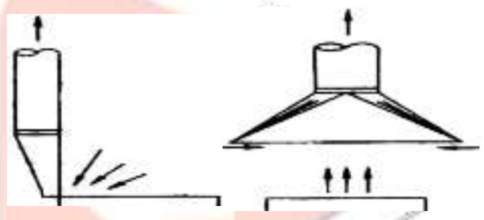


Fig 10.1 Fume Hood Structure

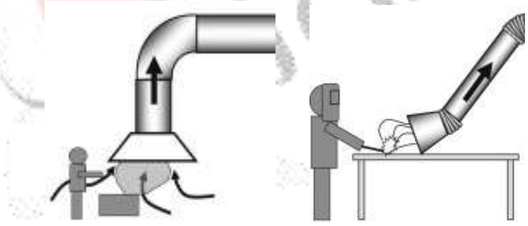


Fig 10.2 Fume Nozzle

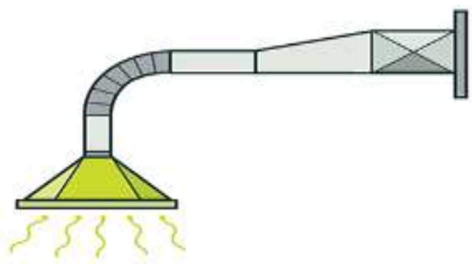


Fig 5.3 Duct Structure

11. CONCLUSION

The integration of a new welding fume extraction system alongside the existing wet scrubber system has proven to be a transformative solution, significantly enhancing the workplace environment, worker safety, and overall efficiency. This comprehensive approach to air quality management has demonstrated numerous advantages, underscoring its value and importance for industrial facilities.

One of the most significant benefits of this integration is the substantial improvement in air quality. Welding processes release hazardous fumes and particulates that can be detrimental to both the environment and human health. The welding fume extraction system has efficiently captured these pollutants at their source, ensuring that they are not released into the ambient air. By working in tandem with the wet scrubber system, the facility has achieved remarkable levels of air purity, meeting and often surpassing stringent environmental regulations.

The enhanced air quality translates directly into improved worker safety and health. Welding fumes contain toxic elements such as metal oxides, ozone, and volatile organic compounds, which can lead to respiratory problems and long-term health issues. With the implementation of the welding fume extraction system, employees are now shielded from these harmful substances, reducing the risk of respiratory ailments and enhancing overall well-being. This, in turn, fosters a safer working environment, boosts employee morale, and lowers absenteeism rates, ultimately leading to higher productivity.

The successful integration of the welding fume extraction system with the existing wet scrubber system has also yielded notable economic advantages. While there is an initial investment in the new system, the long-term benefits far outweigh the costs. By reducing the workload on the wet scrubber system, energy consumption has decreased, resulting in substantial operational cost savings. Additionally, the reduced need for maintenance and downtime further contributes to increased cost-effectiveness, improving the facility's bottom line.

From an operational standpoint, the integration has optimized the performance of both systems. The welding fume extraction system is designed specifically for capturing and removing welding-related pollutants, ensuring that the wet scrubber system can focus on efficiently handling other types of contaminants. By streamlining the treatment process, equipment efficiency has been maximized, minimizing wear and tear, and extending the operational lifespan of the systems.

Beyond the immediate benefits to the facility and its employees, the integration of the welding fume extraction system and the wet scrubber system showcases the company's commitment to sustainable practices and environmental responsibility. By effectively managing and eliminating hazardous pollutants, the facility acts as a model for environmental stewardship, setting higher standards for other industrial players in the region. This aligns the company with growing demands for eco-conscious operations and enhances its reputation as a responsible corporate entity.

In conclusion, the new installation of a welding fume extraction system alongside the existing wet scrubber system has been a resounding success, demonstrating its value through improved air quality, enhanced worker safety, and increased operational efficiency. The integration's economic advantages, boosted worker morale, and sustainable practices reinforce the wisdom of this decision. As industrial facilities continue to prioritize worker safety and environmental consciousness, the adoption of such integrated systems will undoubtedly become a standard in the industry. By taking proactive steps towards safeguarding the well-being of employees and the environment, the company has not only secured its future but also set a benchmark for excellence in the field of industrial air quality management.

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