DESIGN OF FUME EXTRATOR FOR SMAW WELDING IN NUSA PUTRA UNIVERSITY MECHANICAL ENGINEERING WORKSHOP

Erik Suwandana[1]*, Dida Kadarisman[1], dan Qodratullah[1], Fabrobi Ridha[1]

[1]Universitas Nusa Putra, Sukabumi, Indonesia
erik.suwandana_tm21@nusaputra.ac.id

Abstract. Nusa Putra University has a mechanical engineering workshop with various tools including the SMAW welding machine. Students use this machine to do practicum and learn how to increase the welding skills. However, the air circulation does not support welding fume release. A Fume Extractor is a system that is designed to reduce and control the emissions of gases and particles generated during the welding process. This research aims to design and implement a specialized Fume Extractor system for welding activities in the Mechanical Engineering Workshop of Nusa Putra University. The research method includes literature review, surveys, and interviews with relevant personnel in the Mechanical Engineering Workshop, as well as the collection of data and parameters related to airflow. This data will be used to analyze the airflow requirements needed to effectively capture and eliminate emissions. Subsequently, based on the requirements analysis, a Fume Extractor design concept that meets the necessary specifications will be developed. The results of this research to provides an optimal Fume Extractor with a fan extraction rate of 807.84 m^3/hr. The design recommendation is able to address emission issues in the Mechanical Engineering Workshop of Nusa Putra University.

Keywords: SMAW Fume Extractor, Mechanical Engineering Workshop, Extractor Design Analysis,

1 Introduction

The Nusa Putra University Workshop is an environment where various metal welding activities are frequently carried out, both as part of educational programs and research and industrial projects. During the welding process, different types of metals are heated until they melt and combine, producing smoke, vapors and harmful particles. This smoke and particles contain toxic substances which can cause various health problems for workshop workers and users.

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Smoke or dust is a danger that can cause reduced work comfort, impaired vision, impaired lung function and can even cause general poisoning. If the dust in welding fumes is inhaled, it will be retained by nose hairs or breathing pipe hairs, while the finer dust will be carried into the lungs, and some will be exhaled back out. In addition, smoke and particles inhaled by workers and workshop users can spread to the surrounding area and disrupt air quality throughout the campus environment [1].

Maintaining air quality and safety in campus workshops is an important priority in ensuring a healthy and safe working environment for all parties involved [1]. One effective solution to overcome this problem is to use fume extractor for welding. The fume extractor is a device specifically designed to capture and remove smoke, vapors and harmful particles from the air before they are released into the external environment [7].

The fume extractor works by sucking smoke and dangerous particles from the welding source through the air duct, then filtering it using a special filter, and finally expelling it to the outside environment or returning clean air to the workshop. Fume extractor welding can reduce the exposure of workers and workshop users to dangerous pollutants, thereby protecting their health and improving air quality in the surrounding environment [2].

The existence of an efficient welding extractor fan is vital in a workshop environment that carries out routine welding processes. Without an adequate welding extractor fan, smoke and dangerous particles produced by the welding process can spread and accumulate in the air, potentially disrupting air quality and endangering the health of workers in the workshop [1]. This research focuses on how to find an appropriate welding fume extractor design to handle the volume of fume produced by the SMAW welding process at the Mechanical Engineering Workshop at Nusa Putra University.

By designing an efficient welding fan fume extractor, this research will help reduce emissions of smoke and harmful particles into the air at the Mechanical Engineering Workshop at Nusa Putra University. This will contribute to improving air quality in the surrounding environment and protecting the health of workers and workshop users.

2 Theoretical Basis

2.1 Workshop Ventilation

Workshop ventilation or air exchange in the workshop is a method used to maintain and create air in a room that suits the needs of the practical process or worker comfort. Apart from that, it is also used to reduce the level of a contaminant in the workplace air to a level that is not harmful to the health and safety of workers.

Workshop ventilation is an alternative for controlling work environment conditions or engineering control tools by supplying a flow of clean air to the work area to remove contaminants, or an air exchange process by removing contaminated air from the work area, through ducts. exhaust, and intake of fresh air through the inlet [2].

Procedures for designing general ventilation objectives include:
• Eliminates unpleasant gases produced by sweat and so on and combustion gases (CO_2) produced by breathing and combustion processes.
• Eliminates water vapor that arises when cooking, bathing and so on.
• Eliminates excess heat.
• Helps to achieve thermal comfort.

There are several purposes of an industrial ventilation system, including:
• Provide a continuous supply of fresh air from outside.
• Maintain temperature and humidity at comfortable levels.
• Reduces potential fire or explosion hazards.
• Dilutes the concentration of contaminants in the air in the workplace environment
• Controlling contaminants, such as eliminating the use of hazardous chemicals or materials and replacing them with less toxic chemicals or changing processes [3].

2.2 Fume Extractor for Welding

Fume extractor welding is the process of extracting and filtering smoke, steam and dangerous particles produced during the welding process. During welding, metal materials are heated to high temperatures and cause chemical reactions between the metal and gases in the air, producing smoke, steam and dangerous particles.

The fumes and harmful particles produced during welding contain a variety of harmful substances, including toxic metals, metal oxides, and toxic gases such as carbon monoxide and nitrogen dioxide. Exposure to these fumes and particles can cause respiratory problems, lung irritation, chronic health problems, and pose a high risk to the health of workers involved in the welding process [10].

Fume extractor welding aims to overcome this problem by using a special system that can capture, take and filter smoke, steam and dangerous particles. Fume extractor welding usually consists of a fan that produces air flow, air ducts to direct smoke and particles from the welding source into the fume extractor, as well as a filtering system to filter harmful substances from the air before the air is released back into the environment or out of the workshop [11].

By using fume extraction welding, the level of exposure to hazardous substances can be reduced significantly, and the air quality in the workshop environment can be improved. This helps improve the safety and health of workers involved in the welding process and reduces negative impacts on the environment and other users around the workshop [11].

2.3 Design Methodology

When we talk about the design or designing process, methodology can be understood as simply regarding the stages in carrying out the design process. Robin Landa provides a methodology to provide an overview of the five stages in the design process. Robin Landa's design methodology can be seen as follows [6]:

Firstly, there's the orientation stage, during which designers engage closely with the project's objectives, gathering essential design materials and seeking comprehensive information. Next comes the analysis stage, where designers sift through gathered data, determining its relevance to their work, often culminating in the creation of a creative brief. Following this, the concepts stage involves the synthesis of information and data into visual solutions, serving as the foundation for visual execution in subsequent phases. Here, designers may generate multiple design concepts, referred to as design alternatives. The design stage itself is where the visualization process unfolds, translating earlier design concepts into visual representations, including thumbnail sketches, rough drafts, and refined designs. Designers might also introduce variations based on previously conceived concepts, resulting in design iterations. Finally, the implementation stage involves executing the final design, which in this case making a prototype, marking the technical culmination of the design process while remaining a critical aspect of the overall design endeavor.

2.4 Calculating Air Flow Rate Capacity

Regarding the calculation of air flow rate capacity in the context of room ventilation, there is a critical formula that plays a central role in designing an effective system [3]. This formula is:

$$Q = V \times ACH$$

$Q = \text{Required air flow rate capacity } \left(\frac{\text{m}^3}{\text{hr}}\right)$
$\text{V} = \text{Volume of Room } (\text{m}^3)$
$\text{ACH} = \text{Air Changes per Hour}$

In the world of ventilation engineering, the use of the air changes per hour (ACH) formula is important in designing ventilation systems that meet indoor air quality standards. By understanding the ACH concept, accurately measuring room volume, and ensuring a scalable and appropriate ventilation system, this formula helps create a comfortable and safe environment for residents or workers. In the context of welding exhaust fans, this formula has strong relevance in designing effective ventilation systems. The welding fume exhaust fan aims to remove smoke, harmful particles and other pollutants produced during the welding process. The ACH formula allows the calculation of the air flow rate capacity required to achieve the desired air change rate in the room where welding takes place. Room volume plays a major role in this formula, where the larger the room volume, the greater the airflow capacity required.

2.5 Research on Fume Extractor for Welding

In developing the welding fume extractor system, it is important to refer to previous studies that have examined the creation of similar devices. Several earlier studies have provided valuable insights into the development of welding fume extraction systems.

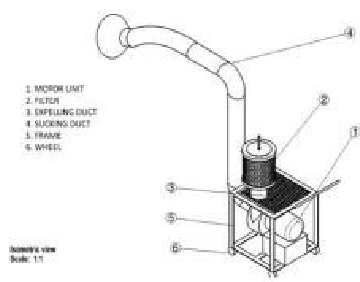

Figure 1. Rokhade Fume Extractor for Welding Design [7].

In his research, Kiran Kumar Rokhade has primarily concentrated on the design and performance analysis of welding fume extraction systems. Rokhade delves into various aspects related to the control of gas emissions and particles during the welding process [7].

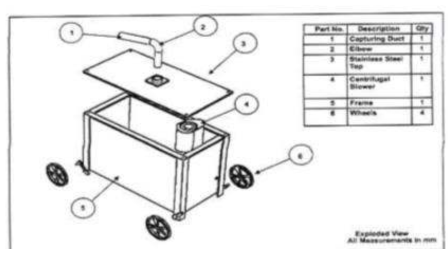

Figure 2. Omoregie Fume Extractor for Welding Design [8].

Furthermore, M.J. Omoregie has conducted research on the design and fabrication of a portable smoke extractor device. This study provides a crucial mobility solution for addressing diverse welding situations in different locations [8].

Figure 3. Zaidi Fume Extractor for Welding Design [9].

Shakeel Zaidi has also made a contribution through his research on the development of local exhaust ventilation systems. Zaidi's study focuses on reducing exposure to welding fumes for welders. This study underscores the importance of an effective ventilation system in safeguarding the health of workers in welding environments [9].

3 Methodology

In the Literature Study stage, we searched and examined sources such as books, diktats, scientific publications, final assignments, and internet sources related to industrial ventilation, fume extractor systems, and smoke exhaust fan designs. Surveys and interviews were conducted to understand current ventilation needs and welding fume problems at the Nusa Putra University Mechanical Engineering Workshop. Data and parameters regarding workshop characteristics, such as area size, number of welding machines, type of welding, and smoke volume are collected. Followed by Air Flow Requirements Analysis to determine the required air flow speed. The Fume Extractor Concept Design is then conducted using 3D CAD design aiming to meet ventilation needs and overcome emission problems during the SMAW welding process. The next stage is fan selection based on room characteristics, ventilation needs and desired air flow speed. Finally, we perform a Standards Based Analysis, including analysis of fan characteristics, operator safety and efficiency based on relevant industry standards.

4 Results and Discussion

4.1 Design Concept

The results of this research produced a concept drawing of the Fume Extractor system design for the Welding Workshop at Nusa Putra University. This design includes an air suction unit, a filter system and an adjustable support frame. This concept image provides a visual view of how this system is integrated in a workshop environment..

The design of the Fume Extractor concept is a key element of this research. The main objective of this design is to meet ventilation needs and overcome emission problems that occur during the SMAW welding process at the Mechanical Engineering Workshop at Nusa Putra University. The following are details of the Fume Extractor design concept:

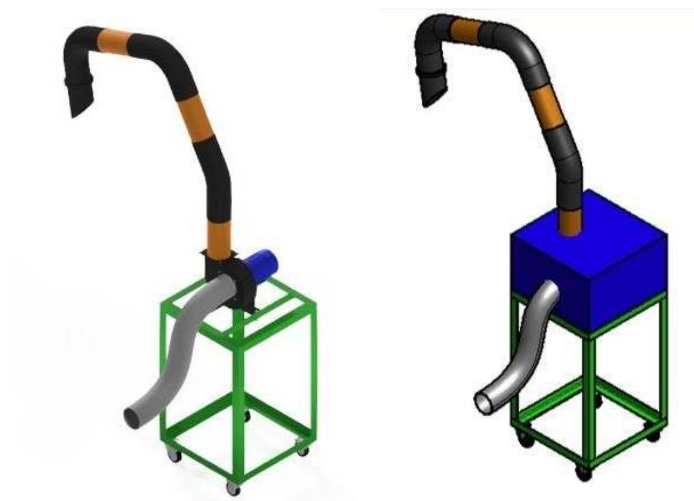

Figure 4. Fume Extractor Concept Design Before and After Using a Cover

In Figure 4 above is a concept design which consists of several components, namely:

- Fan: Located at the top of the center as the main component to maximize air flow. The main reason the fan is placed at the top is to maximize air suction efficiency. By placing the fan on top, air and particles lifted from the welding area will be directly sucked into the system.
- Ducting: Equipped with a ducting system that directs contaminated air from the welding area to the Fume Extractor. Pipes are used to direct air flow from the welding area to the filter system. Correct and efficient pipe placement will ensure that the inhaled air is focused and directed into the filter system.
- Filter: There is a filter system to capture and filter particles from the air. Placing a filter system in the middle or below the fan allows the inhaled air to be filtered of harmful particles before returning to the workshop environment.
- Motor: There is a motor that functions to move the fan.
- Support: Sturdy support structure to support the entire Fume Extractor system. The frame is placed below to provide a stable and solid foundation for the entire system. This is important to prevent vibration and shock which can affect

the performance of the Fume Extractor. This support is equipped with wheels, its placement under the frame allows the Fume Extractor to be more mobile and easy to move as needed.

- Fan Cover: The cover on the fan in the Fume Extractor system functions as a physical protector for the fan, preventing foreign objects from entering and disrupting its operation. In addition, the cover also ensures operator safety by avoiding direct contact with rotating or moving parts of the fan. Other functions are to efficiently direct air flow, reduce noise levels, provide an orderly layout, and prevent air contamination. Thus, the cover on the fan has a crucial role in maintaining optimal operation of the Fume Extractor system.

4.2 Airflow Capacity Calculation

Based on the size of the Mechanical Engineering workshop at Nusa Putra University which has a length of 10.48 meters, a width of 5.1 meters and a height of 2.5 meters, and the need for air changes 6 times every hour [3], a centrifugal fan is needed that can meet the air flow capacity as follows:

$$Q = V\ X\ ACH = (10.48\ x\ 5.1\ x\ 2.5)\ x\ (6) = 134.64\ x\ 6 = 807.84\ \frac{m^3}{hr}$$

From the calculation based on the Indonesian standard, we get that with the determined dimensions, the room requires 807.84 m^3/hr for the device to be accepted for a good airflow.

4.3 Fan Specifications

The selection of a fan is a crucial step in designing a Fume Extractor system. To meet the specified requirements, a mini centrifugal fan with the brand CKE and the type MC-DE/M150R/1-NO has been chosen. This fan was selected due to its characteristics aligning with the needs of the workshop at Universitas Nusa Putra.

The mini centrifugal fan, type MC-DE/M150R/1-NO, from the brand CKE, provides a sufficient air flow capacity of approximately 807.84 m^3/hr, meeting the requirement for air changes of 6 times per hour [3]. With low noise levels, this fan creates a more comfortable working environment for operators and nearby workers. Additional safety features such as a grill or cover are included to prevent direct contact with the fan blades or other moving components, enhancing safety.

The MC-DE/M150R/1-NO mini centrifugal fan from CKE is also compatible with the layout of the workshop at Universitas Nusa Putra, allowing for efficient installation without disrupting welding activities. With a good reputation and assured technical support from the CKE brand, the fan selection is expected to significantly contribute to the effectiveness of the Fume Extractor system in controlling gas and particle emissions during the welding process at the Universitas Nusa Putra workshop.

Table 1. Specification of fan and fume extractor

Specifications	Value	Physical Specifications	Value
Inlet Hole:	12 cm	Motor Material:	Copper Wire
Outlet Hole:	12 cm		
Real Power:	200 W	Fan Blade Material:	Steel
Voltage:	220 V		
Speed:	2800 rpm	Recommended Max	80°C
Air Volume:	800 - 1000CMH	Temperature:	
Pressure:	580 – 525 Pa	Weight:	6.55 kg
Noise:	62 dB		

From the specifications, we achieve that the air volume, noise and pressure is sufficient for the workshop. Voltage and output power can be adjusted and the workshop has the working input for the mechanism designed. It is also appropriate as the device is portable enough for a local exhaust ventilation system [12].

4.4 Frame Specifications

In the development of the Fume Extractor system, the selection of material for the frame plays a crucial role in ensuring the reliability and durability of the system. Therefore, it was decided to use steel as the primary material for the frame. Steel was chosen for its high strength and resistance to mechanical loads, allowing it to provide robust structural support for the entire system. By integrating steel angle plates with dimensions of 40×40 mm and a thickness of 3.4 mm, we can ensure that the frame possesses sufficient stability to bear the load of all system components. The dimensions of 500 mm in length, 500 mm in width, and 750 mm in height were carefully chosen to ensure that the frame can be efficiently accommodated in the Mechanical Engineering Workshop at Nusa Putra University, in line with the existing layout. With steel as the main material for the frame, we are confident that this Fume Extractor system will operate optimally and endure in the welding workshop environment.

5 Conclusion

An extractor system concept has been successfully designed for the Mechanical Engineering Workshop at Nusa Putra University. This design includes an air suction unit, a filter system and adjustable automatic controls. It provides a strong initial foundation for further development and implementation of a physical prototype. It is hoped that with the implementation of this system, there will be a significant improvement in controlling gas and particle emissions during the welding process, which in turn will improve working environmental conditions and the welfare of workers. The next step is to take action to turn this design into a physical prototype and conduct further testing to validate its performance.

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