Progress in Engineering Application and Technology Vol. 2 No. 1 (2021) 972–978
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PEAT

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Portable Local Exhaust Ventilation Unit for Welding Fumes

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DOI: https://doi.org/10.30880/peat.2021.02.01.094
Received 13 January 2021; Accepted 01 March 2021; Available online 25 June 2021

Abstract: Exposure to harmful contaminants, especially in welding can cause nausea, fainting or dizziness if there is no proper personal protective equipment and extraction of fumes produced from the welding process. There are no existing local exhaust ventilation unit in Makmal Teknologi Mekanikal Loji UTHM Pagoh, leading to difficulties in conducting welding processes to students and lectures. The harmful fumes from welding will be inhaled by students and lecturers that could lead to a series of health risk. Nowadays, the price of a new local exhaust ventilation unit is expensive. Thus, leading the idea of fabricating portable LEV unit for the laboratory. Local exhaust ventilation unit is very important to avoid unwanted health risk. This study aims to design three LEV model using SOLIDWORKS, fabricate LEV prototype and test performance of the prototype. The scope study are testing is conduct in 1m x 1m x 1m cupboard, arc welding is used with 0.4 A, three types of hood will be used, ducting with a size of 38.8 mm and 3 ply facemask as filter. The conical hood shows better suction compared to other types of hood. Several parameter can be observed for better performance of LEV: selection of hood must be suitable for the types of work, placed hood 45 ^{o} from workpiece and placed hood not greater than 100mm from workpiece for better capture efficiency.

Keywords: Local Exhaust Ventilation, Hood, Welding Fumes

1. Introduction

Welding and related hot processes such as thermal cutting can generate a variety of potentially hazardous airborne contaminants including metal fumes containing manganese (Mn) and/or hexavalent chromium (CrVI), ozone, oxides of nitrogen, and carbon monoxide among others [3]. LEV removes the polluted air and transmits the pollutants away from the work environment [6]. In order to help in eliminating this contaminant, an engineering method such as local exhaust ventilation was introduced. LEV helps to reduce the contaminant that makes it into the breathing zone and may initiate a progression of clean air for extra assurance. Welding process can affect welders whether in short or long term if no proper safety precautions are taken. The exposure to welding fumes can cause respiratory

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effects. Respiratory effects observed have included acute and chronic bronchitis, airway irritation, chemical pneumonitis, and occupational asthma [2].It is important to design local exhaust ventilation unit that is suitable for the work purpose. Generally, the local exhaust ventilation system consists of hood, duct system, air cleaner and fan. Proper design and selection of each components are important for effectiveness of local exhaust ventilation unit by following the Guideline on Occupational Safety And Health On The Design, Usage And Maintenance to ensure the efficiency of the local exhaust ventilation system (DOSH), 2008) [1]. Proper and details inspection, testing and examination are needed to make sure the LEV unit can be functioning. Zare et al study on Designing, Constructing and Installing a Local Exhaust Ventilation System to Minimize Welders' Exposure to Welding Fumes where the result shows reduction exposure of copper fumes, chromium fumes, manganese fumes and iron fumes. This study shows the installation of LEV helps to minimize exposure of welding fumes towards worker. Figure 1 shows two types of local exhaust ventilation.

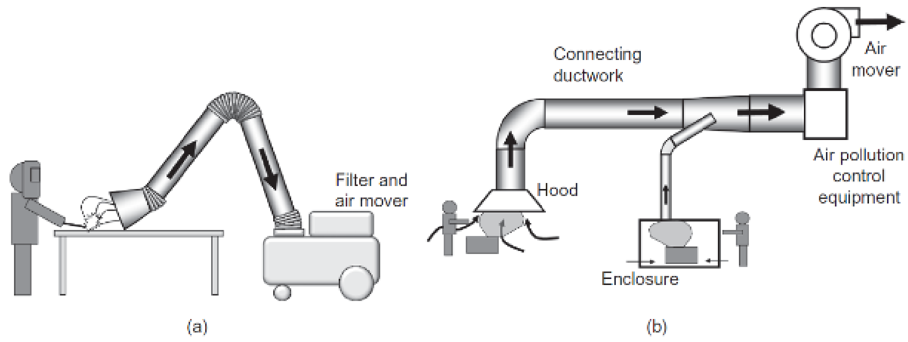


Figure 1: Local Exhaust Ventilation a) Portable LEV b) Large LEV [7]

2. Materials and Methods

2.1 Materials

The LEV prototype was fabricated by using material as follow:

- OBS Board and plywood
- Electronic components (12 V DC 120 mm x 120 mm fan, LED, toggle switch, DC jack socket plug, 38.8 mm duct, three types of hoods, resistor and wire)

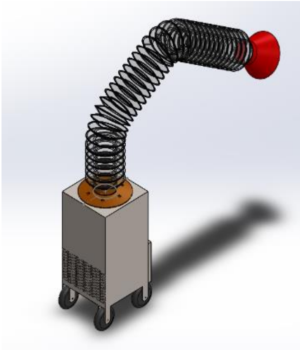
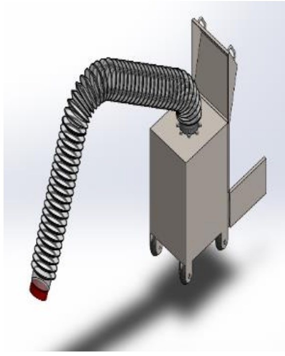
The size of the prototype body is 140 mm height, 130 mm width and 190 mm length. The LEV prototype is shown in Figure 2.

Figure 2: LEV prototype

2.2 Design

Three model were designed using SOLIDWORKS. In Table 1 shows comparison between three model.

Table 1: Comparison between three model

Design	Model 1	Model 2	Model 3
			
Advantages	1. Filter 2. Airvent 3. Circular duct - easy to purchase 4. Conical hood help to capture more efficient (ACGIH recommended)	1. Centrifugal fan 2. Circular duct - easy to purchase 3. Easy to fabricate 4. Cheap	1. Filter 2. Circular duct – easy to purchase
Disadvantages	1. Need to change filter frequently if heavy work 2. Difficult to fabricate 3. Expensive	1. No filter 2. Half plain hood less efficient (Based on ACGIH)	1. No airvent 2. Need to change filter frequent;u of heavy work 3. Difficult to fabricate 4. Expensive 5. Plain or no hood less efficient (Based on ACGIH)

2.3 Experiment setup

Experiment setup of LEV prototype was conducted in 1m x 1m x 1m cupboard on the metal workpiece, as shown in Figure 4. The timer starts once the electrode start to spark until it completely burned. Three reading were taken for each type of hood. The three types of hoods are shown in Figure 5.

Figure 3: Experiment setup

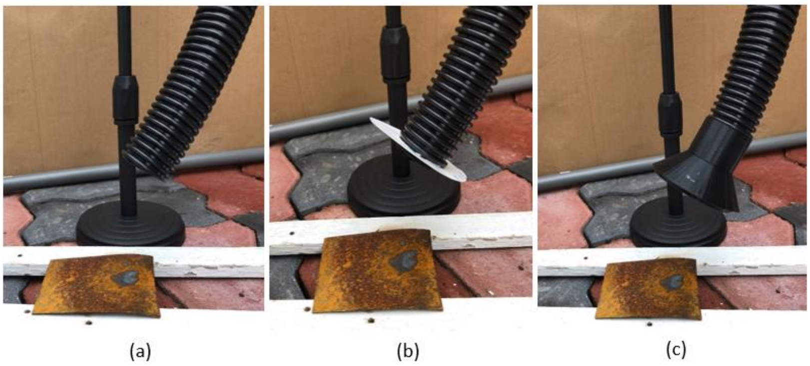


Figure 4: Hood setup a) No hood b) Flanged hood c) Conical hood

2.4 Equations

Continuity equation can be used to calculate airflow rate of fan if V is known as express below:

$$Q = AV \quad Eq. 1$$

3. Results and Discussion

3.1 Hood types

The prototype was tested by using three types of hoods in to study the performance of LEV. Based on Figure 5, when conical hood was used, the time taken to extract fumes was shorter than other hoods. This shows that hood selection is important for LEV performance. Based on the American Conference of Governmental Industrial Hygienists (ACGIH), conical hood type is a better choice compared to any other types of hoods.

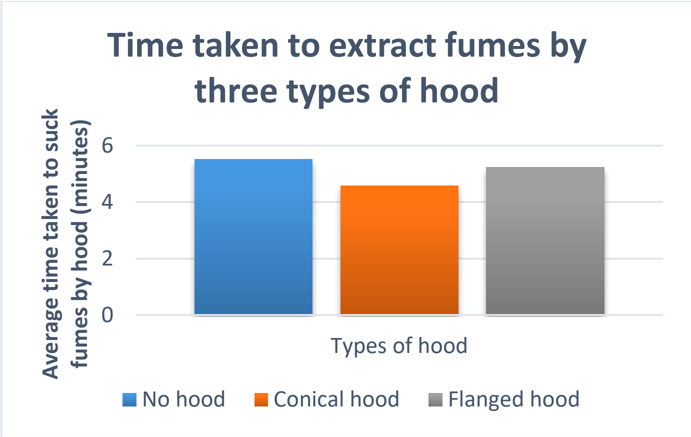


Figure 5: Time taken to extract fumes by three types of hoods

3.2 Hood opening and workpiece position

The hood was placed 45 degrees to the contaminated source show 100.00 % capture efficiency [5]. Thus, in this study, the hood was placed 45 degrees to the workpiece for all types of hoods for better capture performance, as shown in Figure 6. The distance between hood and workpiece is 58 mm for every testing. When the contaminated source and hood distance was greater than 100 mm, the capture efficiency will drop rapidly [4]. The maximum capture distance used was by multiplying 1.5 to duct diameter, which was 38.8 mm. Due to lack of equipment, the testing cannot be done by using guideline from Department of Occupational Safety and Health Malaysia.

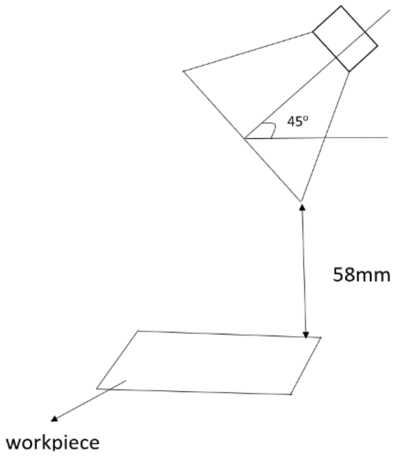


Figure 6: Hood and workpiece position

3.3 Motion of fumes during testing

The motion of hood can be observed in Figure 7. Some fumes flow upward and around the ducting during no hood testing, only some fumes can be captured. When flanged hood was used, the fumes motion moved into the hood but some fumes move around the duct. The conical hood show better fumes exhaust as two other types of hoods. Welding fumes can be very harmful to human body. Thus, it is important to make sure the LEV is working to remove harmful contaminants from the human breathing zone. A study from Leung et al (2005) shows similar hood shape to this study where it showed better performance compared to other types of hood shape.

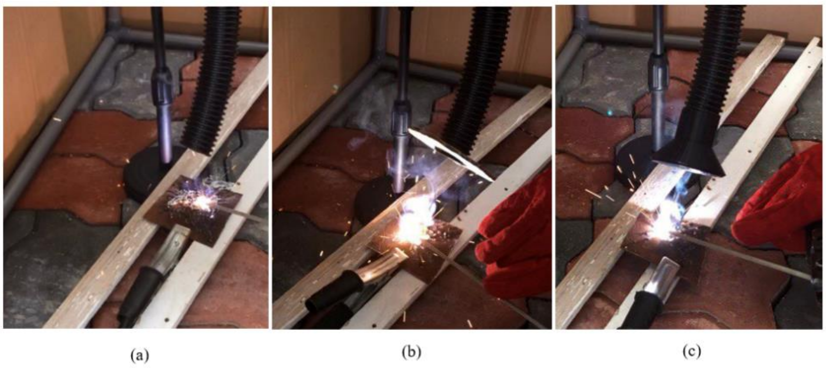


Figure 7: Testing on hood performance a) No hood b) Flanged hood c) Conical hood

3.4 Concentration of filter

During no hood testing, the filter shows a little different as there were little fumes that the hood extracts into the LEV system. Flanged hood shows a bit darker concentration of deposited welding fumes while filter during conical hood testing shows more concentration of deposited welding fumes. The weight of the filter for conical hood shows the fumes deposited on the filter and go through it. Table 2 shows the weight of filter for three types of hoods. The deposited fumes during conical hood testing shown in Figure 8.

Table 2: Weight of filter

Types of hoods	Weight of filter after three reading (g)
No hood	5
Conical hood	20
Flanged hood	10

Figure 8: Filter use during conical hood testing

4. Conclusion

The objectives of this study is successfully achieved. The first objective is to a design local exhaust ventilation unit for welding fumes. Three types of LEV are designed and only one design is selected to be fabricated. The second objective is to fabricate LEV. Due to some circumstances; a similar design is being fabricated as a prototype to test three types of hoods: no hood, circular hood and flanged hood. The third objective is to test the performance of LEV prototype. The conical hood performance shows better performance in terms of fumes exhaustion through hood. Several parameters can be observed for more better performance of LEV as follow:

- The selection of hood must be suitable for the types of work
- Placed hood 45 ^{o} from workpiece for more efficient capture
- Placed hood not greater than 100 mm height from workpiece for better capture efficiency

For better result in observing the performance of LEV, the following parameter can be considered in the future study:
- The air flowrate and air velocity should be measured by using anemometer.
- The fan selection must be able to extract as much as possible fumes
- Use different filter inside LEV and observe before and after testing
- Measured face velocity of hood by using velometer

Acknowledgement

The authors would like to thank Faculty of Engineering Technology, Univerisiti Tun Hussein Onn Malaysia for its support.

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