__Original Research Article__

Design of an Extraction System to attain the Maximum Fume Removal Capacity for a Welding Company in Guyana.

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ABSTRACT

The arc welding operation results in harmful fumes being emitted. Welders are exposed to the dangerous metallic gases and fumes for 6 to 8 hours daily. The workers inhaled and ingest the welding fumes which can result in dizziness, respiratory issues such as irritation of air passage, chronic and acute bronchitis, occupational asthma, and the potential increase of cancer in the lungs. Furthermore, the inhaled fumes enter the welder nerve cells in the brain, bloodstream, spinal cord and lungs resulting in serious short term and long term health effects. Therefore, it is paramount that welding companies have an effective and efficient method of removing welding fumes from the work environment to ensure it is safe for the workers. The purpose of this paper is to design a welding fume extraction system for the welding area at INFAB welding company in Guyana.

Keywords: Arc Welding; Fume Extraction System.

1. INTRODUCTION

Employees exposure to welding fumes can lead to severe health problems and affect organs in the body such as the kidney, liver and brain. The welder's health will be dependent on the concentration, composition and the length of time being exposed to the fumes. [1,2]. Epidemiological findings show that respiratory illness is common in many welders. The observed respiratory effects include irritation of air passage, chronic and acute bronchitis, occupational asthma, and the potential increase of cancer in the lungs. [3].

Manual metal arc welding (MMAW) is one of the most common welding technology which used a coated flux electrode. Using this type of welding process, the electric arc produces extremely high temperature used to melt the metal and fuse the two parts together which results in fumes caused by the electrode flux components and core metal vaporization. The air reacts with the vaporized metals forming metal oxides which condenses to form fumes [4]. The fumes emitted from welding are complex because it is made up of different metals, the configuration and the rate at which the welding fumes are generated depend on the type of electrode and coating, the metal components to be welded, the temperature and current of the welding unit, the technique used in the welding process and the skill level of the welder. The welding fumes generally consist of metals such as copper, cadmium oxides, chromium, beryllium, iron oxide, manganese, lead, aluminum, fluorides, zinc oxides, nickel, molybdenum and vanadium. Further, mild steel welding generates fumes which contains mainly iron, however, it has small amounts of copper, manganese and molybdenum. [5,6].

The welding fumes are inhaled by the welder which enters the nerve cells in the brain, bloodstream, spinal cord and lungs resulting in serious short and long term health effects. In addition, the fumes can cause throat, nose and eye irritation, nausea, chills, fever and muscle pain [7,8]. Researchers indicated that implementing an exhaust ventilation system can result in reduced exposure to welding fumes and can be used in an effective way to control the fumes [9,10].

The aim of this study is to determine the various arc welding performed at INFAB, the number of hours' welders are exposed to the fumes and to design an extraction system to attain the maximum fume removal capacity for the arc welding processes.

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

The INFAB welding shop was selected to carry out the research and design of the ventilation system. The arc welding processes were observed, the various arc welding done was recorded and the length of time welders were exposed to welding fumes was documented. An analysis was done of the welding area to determine the optimum design of the extraction system.

2.1 Welders' Worktime, types of welding and materials welded

The company has six (6) fulltime welders. These welders work an 8 hour shift each day, during which they take a half hour lunch and for the rest of the 7 ½ hour they will take 5 min break every hour.

So each welder will be welding for = $(7.5 \times 60) - (7.5 \times 5)$

= 412.5 min or 6.875 hr.

That is, each welder will be exposed to the harmful fume for 6.875 hr. each day.

Types of welding operation done by INFAB:

- Tungsten Inert Gas (TIG)
- Metal arc welding (MMA)
- Metal Inert Gas (MIG)

Types of material welded

- Mild steel
- Stainless steel

- ➢ Aluminum

3. LOCATION OF THE VENTILATION SYSTEM

In the selection of an appropriate location for the system several factors were considered. Thesource, availability of space and easy access to the system.

Fig. 1.Outside view where the extraction system will be mounted

Fig. 2.Inside view of the extraction system and its easy access to the welding station

4. DESIGN APPROACH

Galvanized and mild steel are the two types of material used for the design of the ventilation system. Mild steel material was considered for the frameworks while galvanized was used for the ducting. Galvanized has many advantages when used as a ducting material, hence this type of material was chosen.

4.1 Part #1

The ducting body is the central part of the system, with the purpose of receiving the inlet fume and releasing it the atmosphere. This part is design to be position outside of the building to help with the limited space available within the workshop, it will be bolted on to the wall along with additional supports. This part was design with three openings on the front and two on the top. A frame work design was firstly done via solid works along with the material estimation and a cost analysis. Additionally, a design was done to cover the framework with galvanized sheet metal, the design was done using the solid works software.

4.2Part #2

The fume outlets ducting is that part of the system where the fume exists. There are three inlets, therefore, the system was design with two fume outlets to allow the fumes to exist the ducting body more easily. These outlets are position perfectly between the three inlets to achieve maximum disposal of the fume and will be fitted directly to the ducting body. A frame work design was done via solid works software along with the material estimation and a cost analysis. Subsequently, a design was done to cover the framework with galvanized sheet metal, also via solid works along with the material estimation and a cost analysis.

4.3 Part #3

The fume inlets ducting is that part of the system where the fume is captured. Because INFAB has six welders, the system was designed with three inlets, where each inlet has two capturing hoods. These inlets are position inside the workshop and bolted directly to the wall. Each inlet has a 12’’ axial fan, filter, and a one-way flow control attached to it. The fume inlets are also design with a maintenance access door, it is positioned by the fan and filter. A frame work design was done using solid works software along with the material estimation and a cost analysis. Subsequently, a design was done to cover the framework with galvanized sheet metal, also via solid works along with the material estimation and a cost analysis. A 12’’ axial flow fan was selected based on certain criteria’s; the amount of fumes needed to be extracted, the distancebetween the hood and the welding operation, and the duct velocity. Once the fan was selected the CFM (cubic feet per minute) is determined. Finally, the power consumption was calculated at 6.875 hr. for a 20 working days’ month. The next step was to select the appropriate filter for the extraction system. The filter was chosen based on the welding fume particles size for the three welding operations. The H14 High efficiency particulate air (HEPA) Air Filter was the best match for the design criteria’s and was chosen for this design.

The one-way fume flow control design, this component will be attached directly to the fume inlet frame. It will be positioned just after the filter, which will move upwards by the fan force. The one-way movement will ensure that the fume doesn’t feedback to the other inlets. For the fume inlet hoods, several factors had to be considered; mainly hood shape and capture velocity. For the fume hood a spherical design was used, this allows for a greater capture velocity. The theory of frustum of a cone was used to determine the surface area. The capture velocity was computed at various distances to determine how efficient the system will work with the selected fan, it was determined that if the hood is moved two feet away from a source to four feet away (twice the distance), the airflow required to provide the same degree of capture will be four times greater. The calculated values are proven to be well within the recommended capture velocity. For the fume inlet ducting; a combination of smoke pipe and semi rigid flexible ducting was used in the design. The design of this type of ducting allows for easy maintenance, in that it can be disassemble and assemble easily. The galvanized smoke pipe has a snap-lock mechanism and crimp ends, these pipes are very light in weight and will work well with semi-rigid ducts. The aluminum flexible duct is semi-rigid, this semi-rigid feature will help position the hood in different location and hold it in place because of the rigidity. The smoke pipe and the flexible duct is joined together by means of a duct connector, which is also crimped at the ends. After they are assembled together, they are clamp by means of duct connector clamps. The crimp ends help the clamps secure the flexible duct to the smoke pipe even better. A cost analysis was performed for the amount of smoke pipe, flexible duct, connectors, and clamps needed to complete the project.

Finally, with all major components established, next came the challenge of getting this system to operate by a manual control system. Each fans will be operated by an individual switch thatwill be placed on the wall. The design of the fume extraction system was done using publish materials on all parameters needed for this system. Therefore, this ventilation system willefficiently serve the purpose of removing the harmful fumes from the welder's breathing zone for INFAB welders.

5. PART 1
5.1 Ducting Body

Figure 3 shows the framework design of the ducting body; this was created using SolidWorks. This body is 22 ft. long by 3 ft. wide and 3 ft. high. It is constructed using 1 ½ and 1-inch square section, all the square sections are welded together using 6013 electrodes. The rectangular cuboid is welded together using 1 ½ square sections. On the front side, it has three openings for the fume inlet, the framework for those inlet is constructed with 1-inch sq. sections. On the top of the body it has two openings for the fume exist, the framework for those exist is constructed with 1-inch sq. sections. All the other supports are to accommodate the sheet metal is constructed of ½ inch sq. sections.

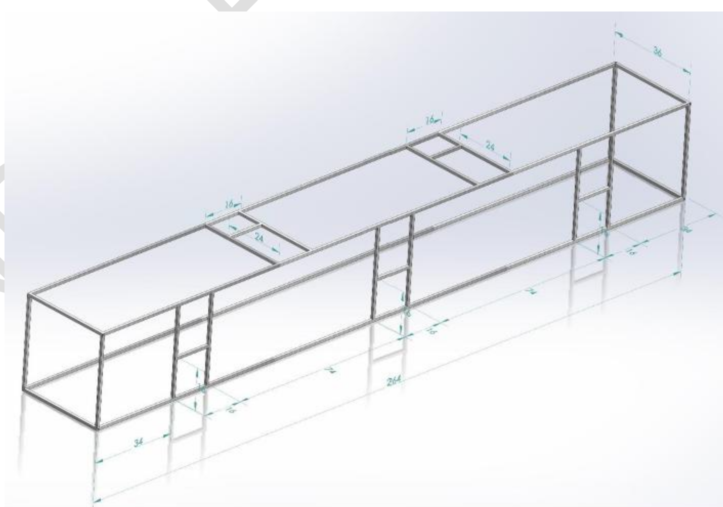

Fig. 3.Frame work design of the body

Table 1. The rectangle cuboid

No.	Description (Inch)	Length (ft.)	Quantity	(Length x Quantity)
1	1 ½ sq. section	22	4	88 ft.
2	1 ½ sq. section	3	8	24 ft.
Total				112 ft.

Table 2. The three fume inlet

No.	Description (Inch)	Length (ft.)	Quantity	(Length x Quantity)
1	1 sq. section	2 ft. 10 inches	6	17 ft.
2	1 sq. section	1 ft. 2 inches	3	3 ft. 6 inches
Total				20 ft. 6 inches

Table 3. The two fume outlet

No.	Description (Inch)	Length (ft.)	Quantity	(Length x Quantity)
1	1 sq. section	2 ft. 10 inches	4	11 ft. 4 inches
2	1 sq. section	1 ft. 2 inches	2	2 ft. 4 inches
Total				13 ft. 8 inches

Table 4. Sheet metal supports (front)

No.	Description (Inch)	Length (ft.)	Quantity	(Length x Quantity)
1	1 ½ sq. section	2 ft. 8 inches	4	10 ft. 8 inches
2	1 ½ sq. section	6 ft.	4	24 ft.
3	½ sq. section	10.7 inches	16	14 ft. 3 inches
Total				48 ft. 11 inches

Table 5. Sheet metal supports (top)

No.	Description (Inch)	Length (ft.)	Quantity	(Length x Quantity)
1	1 ½ sq. section	6 ft. 5 inches	4	25 ft. 8 inches
2	1 ½ sq. section	6 ft.	2	12 ft.
3	½ sq. section	10.7 inches	34	30 ft. 4 inches
Total				68 ft.

Table 6. Sheet metal supports (back and bottom)

No.	Description (Inch)	Length (ft.)	Quantity	(Length x Quantity)
1	1 sq. section	21 ft. 10	4	87 ft. 4 inches

		inches		
2	½ sq. section	10.7 inches	66	58 ft. 10 inches
Total				146 ft.

Table 7. Sheet metal supports (ends)

No.	Description (Inch)	Length (ft.)	Quantity	(Length x Quantity)
1	½ sq. section	2 ft. 10 inches	4	11 ft. 4 inches
Total				11 ft. 4 inches

Table 8. Total square sections needed for the ducting body

Square section size (Inch)	Amount	Total
1 ½ sq. section	112 ft.	112 ft.
1 sq. section	(20 ft. 6 inches + 13 ft. 8 inches + 87 ft., 4 inches)	121 ft. 6 inches
½ sq. section	(48 ft. 11 inches + 68 ft. + 58 ft. 10 inches +11 ft. 4 inches)	187 ft. 1 inch

5.1.1 Ducting Body covered with sheet metal

Figure 4 shows the sheet metal covering design for the ducting body; this was created using SolidWorks software. This body is 22 ft. long by 3 ft. wide and 3 ft. high. It is constructed using 30 gauge galvanized sheet metal. The sheet metal is held in place by 1⁄8 rivets.

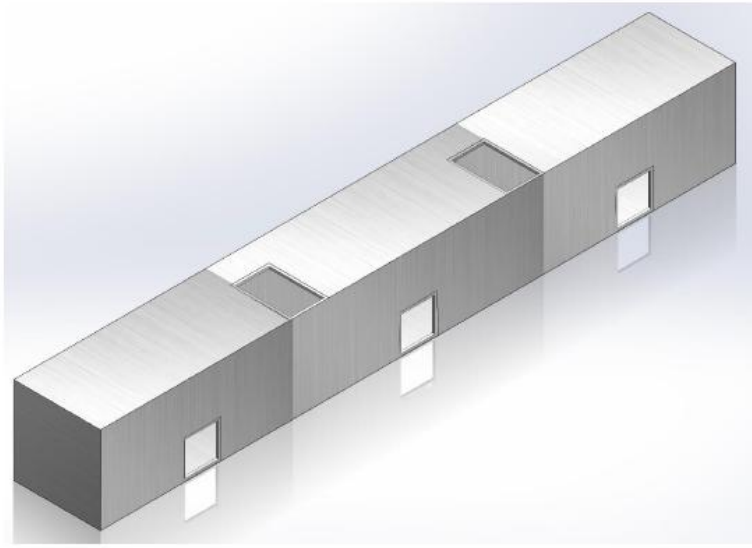

Fig. 4.The design of the cover sheet metal body

5.1.2 Materialsfor the covered body

The 30-gauge sheet galvanized sheet metal (Available in 4 ft. width) was used for the analysisSince the Galvanized sheet metal thickness for 30 gauge is only 0.0157 inch, then the benddeduction is negligible for this type of sheet metal.

To cover the front, back and ends with a ¾ inch lap.

Total length = [(22×2) + (3×2) + (0.0625×2)]

Approx. = 51 ft.

To cover the top and bottom with a ¾ inch lap.

Total length = [(22×2) + (0.0625×2)]

Approx. = 45 ft.

Total amount of sheet metal needed to cover the ducting body

= 51 ft. + 45 ft.

= 96 ft. of sheet metal is needed at 4 ft. width

6. PART 2
6.1 Fume outlet ducting

Figure 5 shows the framework design of the fume outlet ducting; this was created using SolidWorks software. This L-shaped fume outlet is 3 ft. long by 16-inch-wide and 3 ft. high. It is constructed using 1 inch and ½ and mild steel square section, all of the square sections are welded together using 6013 electrodes. The L-shaped is welded together using 1 inchsquare sections. All the other supports to accommodate the sheet metal is constructed of ½ inch sq. sections.

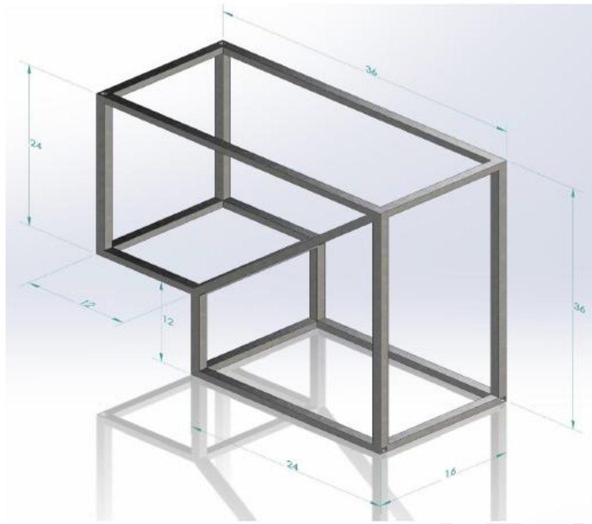

Fig. 5.Frame work design of the fume outlet

Table 9. The L-shape box

No.	Description (inches)	Length (ft.)	Quantity	(Length x Quantity)
1	1 sq. section	1 ft. 4 inches	6	8 ft.
2	1 sq. section	3 ft.	4	12 ft.
3	1 sq. section	2 ft.	4	8 ft.
4	1 sq. section	1 ft.	4	4 ft.
Total				32 ft.
Total for 2 parts				64 ft.

Table 10. Sheet metal supports

No.	Description (inches)	Length (ft.)	Quantity	(Length x Quantity)
1	½ sq. section	2 ft. 10 inches	2	6 ft. 8 inches
2	½ sq. section	3 ft.	2	6 ft.
3	½ sq. section	10 inches	2	1 ft. 8 inches
4	½ sq. section	2 ft.	4	8 ft.
Total				22 ft. 4 inches
Total for 2 parts				44 ft. 8 inches

Table 11. Total square sections needed for the outlet ducting

Square section size (Inches)	Amount	Total
1 sq. section	64 ft.	64 ft.
½ sq. section	44 ft. 8 inches	44 ft. 8 inches

6.1.1 Fume outlet covered with sheet metal

Figure 6 shows the sheet metal covering design for the fume outlet ducting; this was created using SolidWorks software. This L-shaped box fume outlet is 3 ft. long by 16-inch-wide and 3 ft. It is constructed using 30 gauge galvanized sheet metal. The sheet metal is held in place by 1/8 rivets.

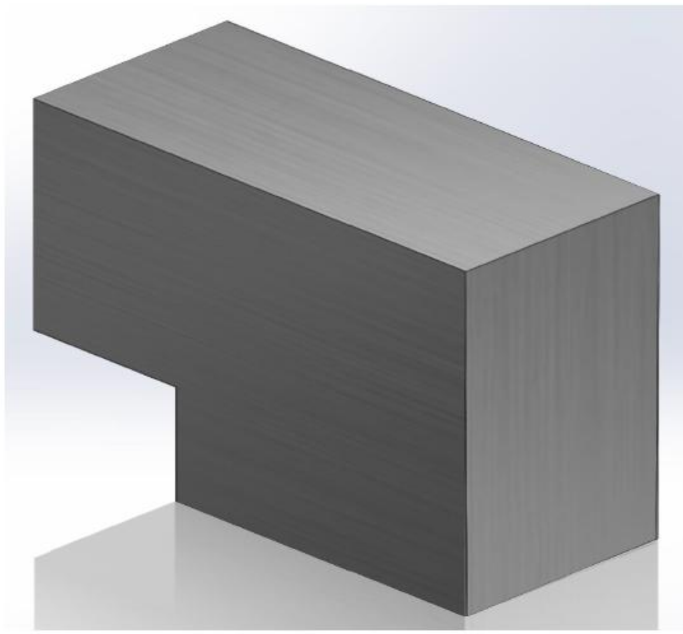

Fig. 6.Frame work design of the fume outlet

6.1.2 Materials for the covered fume outlet

Using 30-gauge galvanized sheet metal (Available in 4 ft. width) Since the Galvanized sheet metal thickness for 30 gauge is only 0.0157 inch, then the bend deduction is negligible for this type of sheet metal.

To cover the top, one side, and the two ends with a ¾ inch lap.

Total length = [(3×2) + (2×2) + (0.0625×2)]

Approx. = 11 ft.

To cover the bottom and one side with a ¾ inch lap.

Total length = [(3×2) + (0.0625×2)]

Approx. = 7 ft.

Total amount of sheet metal needed to cover the ducting body

= 11 ft. + 7 ft.

= 18 ft. of sheet metal is needed for one outlet at 4 ft. width

= 36 ft. of sheet metal is needed for the two outlet at 4 ft. width

7. PART 3
7.1 Fume inlet framework

Figure 7 shows the framework design of the fume inlet ducting; this was created using the SolidWorks software. This L-shaped fume inlet is 3 ft. 4-inch-high by 1 ft. 4-inch-wide and 1 ft. 5 inches long. It is constructed using 1 inch and ½ and mild steel square section, all the square sections are welded together using 6013 electrodes. The L-shaped is welded together using 1 inch square sections. All the other supports to accommodate the sheet metal is constructed of ½ inch sq. sections.

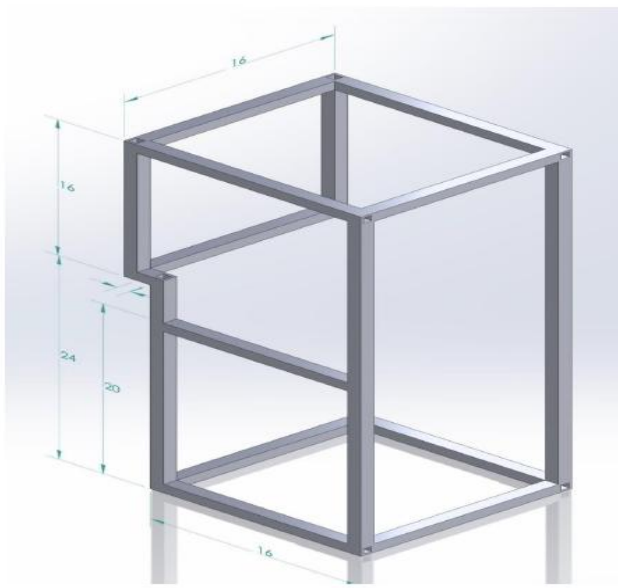

Fig. 7.Frame work design of the fume inlet

Table 12. The L-shape box

No.	Description (inches)	Length (ft.)	Quantity	(Length x Quantity)
1	1 sq. section	3 ft. 4 inches	2	6 ft. 8 inches
2	1 sq. section	2 ft.	2	4 ft.
3	1 sq. section	1 ft. 4 inches	12	16 ft.
4	1 sq. section	1 inch	2	2 inches
Total				26 ft. 10 inches
Total for 3 parts				80 ft. 5 inches

Table 13. The filter box

No.	Description (inches)	Length (ft.)	Quantity	(Length x Quantity)
1	½ sq. section	1 ft. 4 inches	6	8 ft.
Total				8 ft.
Total for 3 parts				24 ft.

Table 14. The maintenance door

No.	Description (inches)	Length (ft.)	Quantity	(Length x Quantity)
1	½ sq. section	1 ft. 8 inches	2	3 ft. 4 inches
2	½ sq. section	1 ft. 4 inches	2	2 ft. 8 inches
Total				6 ft.
Total for 3 parts				18 ft.

Table 15a. Sheet metal supports

No.	Description (inches)	Length (ft.)	Quantity	(Length x Quantity)
1	½ sq. section	3 ft. 4 inches	2	6 ft. 8 inches
2	½ sq. section	2 ft.	1	2 ft.
3	½ sq. section	16 inches	3	4 ft.
4	½ sq. section	2 ft.	1	2 ft.
5	½ sq. section	1 ft. 8 inches	1	1 ft. 8 inches
Total				16 ft. 4 inches
Total for 3 parts				49 ft.

Table 15b. Total square section for the outlet ducting

Square section size (inches)	Amount	Total
1 sq. section	80 ft. 6 inches	80 ft. 6 inches
½ sq. section	24 ft. + 18 ft. + 49 ft.	91 ft.

7.1.1 Fume inlet covered with sheet metal

Figure 8 shows the sheet metal covering design for the fume inlet ducting; this was created using SolidWorks software. This L-shaped fume inlet is 3 ft. 4-inch-high by 1 ft. 4-inch-wide and 1ft. 5 inches long. It is constructed using the 30 gauge galvanized sheet metal. The sheet metal is held in place by 1/8 rivets.

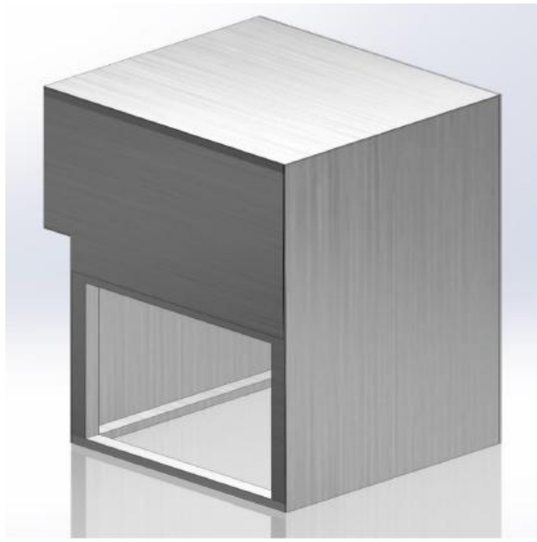

Fig. 8.Frame work design of the fume inlet

7.1.2 Fume inlet covered with sheet metal

Materials for the covered fume inlet

The 30-gauge sheet galvanized sheet metal (Available in 4 ft. width) was used in the analysis. Since the Galvanized sheet metal thickness for 30 gauge is only 0.0157 inch, then the bend deduction is negligible for this type of sheet metal.

To cover the top, one side, and the two ends with a ¾ inch lap.

Total length = [(3 ft. 4 inch×1) + (1 ft. 4 inch ×3) + (0.0625×2)]

Approx. = 8 ft.

To cover the bottom and one side with a ¾ inch lap.

Total length = [(3 ft. 4 inch×1) + (0.0625×2)]

Approx. = 3 ft. 6 inch

Total amount of sheet metal needed to cover the ducting body

= 8 ft. + 3 ft. 6 inch

= 11 ft. 6 inch of sheet metal is needed for one inlet at 4 ft. width

= 34 ft. 6 inch of sheet metal is needed for the three inlet at 4 ft. width

8. COMPLETE DUCTING ASSEMBLY

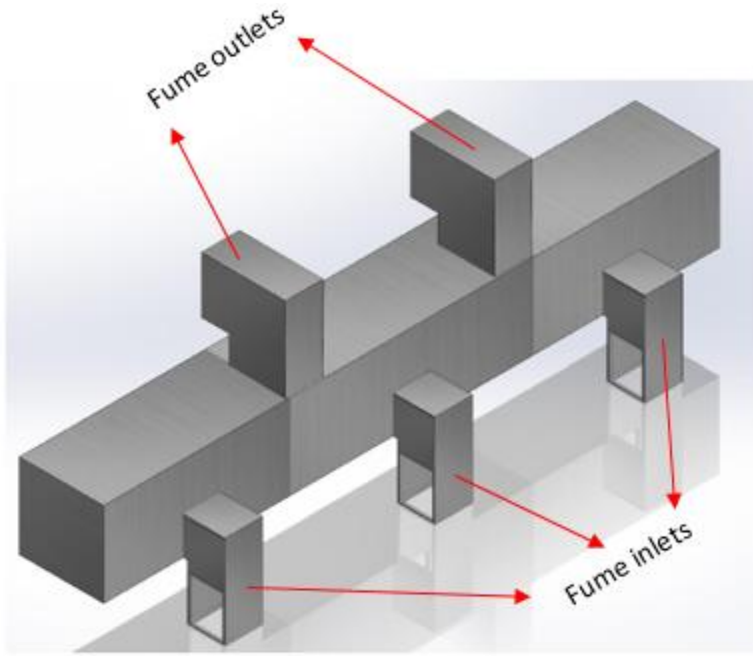

Fig. 9.Complete assembly

9. FAN

The axial flow fans are especially suited for handling air at relatively low pressures and when in large volumes. Contributing factors for the amount of air flow are speed at which the blades turn, overall fan design, the diameter and blade shape and the horsepower (hp). The cubic feet are used to measure the fan capacity. Cubic feet per minute (CFM) is determined below.

9.1 12-inch-high velocity utility blower fan multi-function axial fan 3300 rpmspecifications:

Color: Orange
Diameter of the fan: 300mm (12 inch)
Power supply: AC: 110v / 50-60 Hz
Input power: axial motor 520 w/ 0.7 hp
Speed (rpm): 3300r/min
Material: steel
Air flow: $65m^3$/ min 2295CFM
Noise: 71db
Body pressure: 373 pa
Protection grills protection grade: ip54

Dimensions:
Length: 430mm/16.93inch
Height: 355mm/17.13inch
Depth: 420mm/25.36 inch

Net weight of the unit: 11.5kg/ 25.35 inch
The efficiency is typically 75 to 90 %.

9.1.1 Performance specification

Air flow: 65m^3/min 2295 CFM

Velocity = CFM / Duct area (in Sq. ft.)

Duct area = $\pi D^2 / 4$

Duct diameter = 5” = 5/12 = 0.4167 ft.

Duct area = $\pi (0.4167)^2 / 4$

= 0.1364 ft^2

Velocity = 2295 / 0.1364

= 16825.5 ft./min or 280.42 ft./sec

Table 16. Power consumption of the three fans at 520 watts

Equipment type	Quantity	Rating (watts)	Running hours/semester (hrs.)	Energy consumption (kWh)	GYD @ $56.38
12 “ axial fan	3	520	6.875	10.725	$604.67

9.1.2 Three fans will be adding to INFAB power consumption:

Monthly cost = $604.67 × 20 days

= $ 12,094

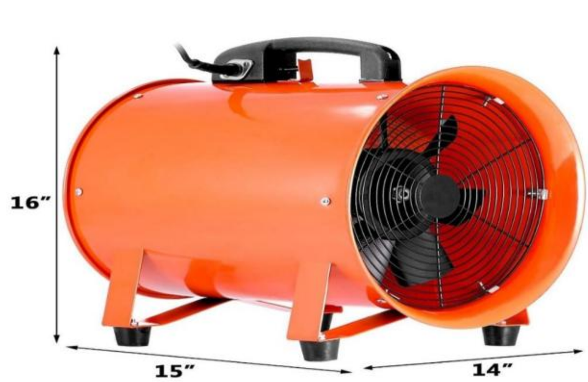

Fig. 10.12” axial fan

10. FILTER SELECTION
10.1 H14 HIGH efficiency particulate air (HEPA) air filter

Outer frame: Galvanized steel
Filter material: Water resistance fiberglass
Filter material separate: Hot melt glue
Filter efficiency: H14 (EN 1822)

Protecting Net: White steel mesh coating (according request)
Sealing gasket: Joint less Polyurethane
Sealing gum: Polyurethane
Operating temperature: ≤70℃；
Operating humidity: ≤ 95% RH；
Suggestion finally resistance: ≤ 600 Pa
HEPA air filters needed:
Each hood ducting need = 1 filter
For six hood ducting = 1 × 6
= 6 HEPA filters are needed

11. ONE WAY-FUME FLOW CONTROL

Figure 11 shows the one-way fume flow control design, which will be attached directly to the fume inlet frame itself. It will be position just after the filter, which will move upwards by the fan force. The one-way movement will ensure that fume doesn't feedback to the other inlets. The hinges are shown in the drawing, but three hinges will be placed on the end without the notches. These hinges will allow for the up and down movement.

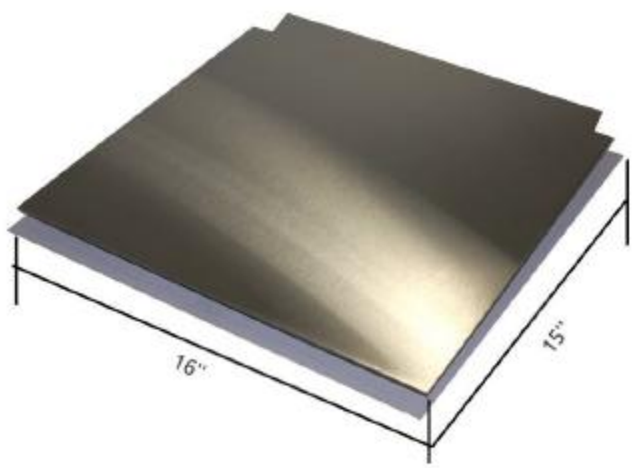

Fig. 11.One-way fume flow control

Table 17. Materials for the flow control

No.	Description (inches)	Length (ft.)	Quantity	(Length x Quantity)
1	1 sq. section	1 ft. 4 inches	1	1 ft. 4 inches
2	28 Gauge sheet metal	1 ft. 4 inches	1	1 ft. 4 inches

11.1 Materials needed for the hood

Using 30 gauge galvanized sheet metal

$A = \pi (R + r) L$

$= \pi (4.5 + 2.5) 5.66$

= 124.5 sq. inches of sheet metal is needed

12. DUCT CONNECTOR
12.1 DAC_C-Duct connector – Aluminum with bead and clamp

General Information

Part Number DAC5C

Item Weight 6.8 pounds

Product Dimensions 5 x 3 inches

Item model number DAC5C

Color Aluminum

Material Aluminum

Thickness 30 gauge

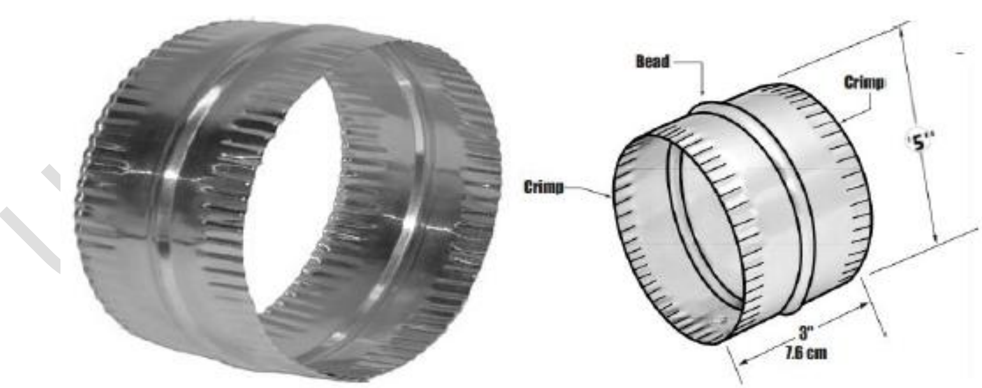

Fig. 12.Duct connector

12.1.1 Connectors needed

Each hood ducting need = 5 connectors

= 5

For six hood ducting = 5 × 6

= 30 connectors are needed

12.2DUST CONNECTOR CLAMPS

MC525 5" metal worm drive clamp
General Information
Part Number MC525
Item Weight 0.11 pounds
Product Dimensions 7/16"(11mm) wide x .030(.7mm) thick

12.2.1 Connector clamps needed

Each connector need 4 clamps

Each hood ducting need = 5 connectors × 4 clamps

= 20 clamps

For six hood ducting = 20 × 6

= 120 connectors clamp are needed

13.ELECTRICAL CONTROLS

The entire operation of the Fume Extraction System is controlled from a Control Panel by the means of a circuit breaker, motor circuit protector, fuse, electrical copper wires, and a start and a stop bottom. To carry out this, the following are integral items are used.

Fuse – 20 Amp

Circuit breaker – 25 Amp

Wire – 105 ft. AWG 14

Conduit size – ¾

Ground wire – AWG 14

13.1Uxcell a11091700ux0059 Two 2 Poles DIN Rail Mount Miniature Circuit Breaker2P, AC, 400V, 32 Amp, 6000 Amp

It is applicable to a line of AC 50-60HZ, for protecting overload and short circuit, and rated current up to 32a.It can also be used for infrequent line conversion under the normal condition.

Fig. 13.Uxcell a11091700ux0059 Two 2 Poles DIN Rail Mount Miniature Circuit Breaker.

13.2Littelfuse FLNR Cartridge Fuse, 30A, Speed T, 14.3 x 50.8mm

The Littelfuse FLNR/FLSR series are UL Class RK5 dual-element time-delay fuses. The series provide excellent protection for all circuit types especially those containing motors.

Fig. 14.Littelfuse FLNR Cartridge Fuse

13.3RS Pro ETFE Single Core Harsh Environment Wire, 14 AWG 100m, Tinned Copper 37 Strands RoHS

This ethylene tetrafluoroethylene (also known as Tefzel) insulated wire in manufactured to meet the requirements of defence standard 61-12 Part29/1. Its outer sheath resists temperatures up to +270 °C and has good chemical and abrasion resistance. The wire conductors are made from tin plated copper wire.

Fig. 15.Allen Bradley RS Pro ETFE Single Core Wire

13.4Schneider Electric Harmony XALD Enclosed Push Button

13.4.1 Start/Stop I/O Pushbutton Switches

Flush Green and flush red spring return pushbutton

Stop button fitted with 1 N/C contact block, start button fitted with 1 N/O contact

Each actuator will accept an additional contact block (see accessories)

Double insulated

IP65 rated

Polycarbonate construction

Fig. 16.Schneider Electric Harmony XALD Enclosed Push Button

14.TOTAL COST

The following is an analysis of the components of the Fume Extraction System. The cost of material and labor is considered. For all welding, sheet metal, wire, and fitting works, external contractors will be utilised. Internal contractors charge a rate of 40% the material cost.

Table 18. Total Cost for system

Item	**Description**	**Cost (GYD $) Material &Labour**
1	Ducting Body	$150,127
2	Fume ducting outlet	$34,298
3	Fume ducting inlet	$55,241
4	One-way flow control	$3,519
5	Fume inlet hood	$110,092
6	Fan and Filter	$180,204
7	Controls	$75,554
	Sub Total	$609,035
	Transportation (15 %)	$91,355.25
	Miscellaneous (15%)	$91,355.25
	Total	**$791,745.5**

15.CONCLUSION

The goal of this research was to develop a design for a fume Extraction System that will attain maximum fume removal capacity for INFAB welding shop. A systematic approach was taken in the design of the Fume extraction system for INFAB welding shop. The implementation of the fume Extraction System to remove the dangerous fumes and gases formed when welding operations are done in INFAB welding shop will attain maximum fume removal capacity, therefore causing less health and environmental impacts within the immediate area. This will ensure that INFAB meet the occupational health and safety requirements for the welding shop. The ventilation system from a financial standpoint is that it is a viable project not just for INFAB but any other welding company. Importantly, for the design of the fume extraction System, all technical parameters were considered and it will efficiently serve the purpose of removing the harmful fumes from the welder's breathing zone and the entire work environment for the INFAB company.

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