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"CRITICAL VOLUME FOR MAXIMUM EFFICIENCY OF EXHAUST FAN"

LOGANATHAN A/L SIVAJOTHY

Laporan ini diserahkan kepada Fakulti Kejuruteraan Mekanikal
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"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya jelaskan sumbernya"

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ABSTRAK

Projek ini adalah berkaitan dengan "Ciritical Volume For Maximum Efficiency Of Exhaust Fan". Dengan mencari tempat yang paling sesuai untuk kipas yang mengeluarkan asap dan stim air apabila mamasak di salah sebuah dapur rumah..Dalam hal ini, dapat mencari tempat paling sesuai untuk kipas dengan membuatnya di dalam CFD program.

Sebelum membuat CFD program , perlulah membuat ujikaji bagi mendapat bacaan yang sesuai untuk masukkan dalam CFD program nanti.Bacaan akan diambil dengan peralatan Digital Anemometers bagi memgetahui bacaan sebenar.

Sebelum menghasilkan program ini, pemerikassan terperinci dan pencarian butir-butir tentang bacaan bagi memudahkan membuat program dijalankan nanti. berjaya. Segala butir-butir yang penting tentang kipas perlulah diambil kira untuk menghasilkan program ini.

ABSTRACT

This project is carried out with the purpose to find or get the critical volume of ventilation fan maximum efficiency of exhaust fan. The main point of this project is to determine the critical of ventilation fan so as a maximizes its efficiency. The scopes of this study are chosen a using one type of mechanical ventilator exhaust fan.

This project also does literature study and discussion about ventilation exhaust fan. This study also was focus on kitchen. The mechanical ventilation exhaust fan are using for this study is Propeller Sidewall Exhaust Ventilation Fan. Volume is a measure of the amount of air that flows through a fan and this capacity is expressed is cubic feet per minute.

Determining the best location for a ventilation exhaust fan depend on the airflow pattern desired and the physical characteristics of the kitchen.

CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

SYMBOL	DEFINITION
cfm	- cubic feet per minute
Ps	- static pressure
mm	- millimeter
hr	- Hour
%	- Percentage
°F	- Fahrenheit
hp	- horsepower
V	- volume
CFD	- computational fluid dynamics
ft	- feet

CHAPTER 1

INTRODUCTION

CRITICAL VOLUME FOR MAXIMUM EFFICIENCY OF EXHAUST FAN

1.1.1 General

Ventilating a building simply replaces stale or foul air with clean, fresh air. Although the ventilation process is required for many different applications, the airflow fundamentals never change: Undesired air out, fresh air in. The key variables that do change depending on applications are the fan model and the air volume flow rate (cfm). Other considerations include the resistance to airflow (static pressure or Ps) and sound produced by the fan .Occasionally, a customer will require a fan to perform a particular function, yet does not know which model to use or even what cfm is necessary. In this case, some fan specification work must be done.

Fans all perform the basic function of moving air from one space to another. But the great diversity of fan develops many different models. Each model has benefits for certain applications, providing the most economical means of performing the air movement function. The trick for most users is sorting through all of the models available to find one that is suitable for their needs. Here are some guide lines. Fan specification is usually not a precise science and can be done confidently when the fan application is understood. Based on the application, four parameters need to be determined. They are:

1. Fan Model
2. Cubic feet per minute (cfm)
3. Static Pressure (Ps)
4. Revolutions Per Minute (rpm)

Fan models are designed to be mounted in three common locations: on a roof, in a wall, or in a duct. Whatever the location, the basic fan components do not change. Only the fan housing changes to make installation as easy as possible. Determining the best location for a fan depends on the airflow pattern desired and the physical characteristics of the building. By surveying the building structure and visualizing how the air should flow, the place to locate the fan usually becomes evident.

Selecting the fan that will best fit the application for which it is intended. With the large number of different fan types and sizes available it's necessary to know which fan model does the best job in certain applications and then to be able to select the most economical fan size for the job. With that in mind, this guide is constructed in three sections.

Section One describes how to select a fan using catalog performance tables with a given air volume and static pressure. This section also interprets. The model numbers and illustrates the relationship between fan speed and airflow.

Section Two covers the basics of fan selection is determining the proper fan model, air volume, static pressure and loudness appropriate for a given application. This is important when your customer does not know the amount of air to be moved or the resistance to airflow that will be encountered. This section also illustrates proper fan installation and proper wheel rotation.

Section Three goes beyond fan selection with information of a more comprehensive and technical nature about air movement and air systems.

1.1.2 Fan Model

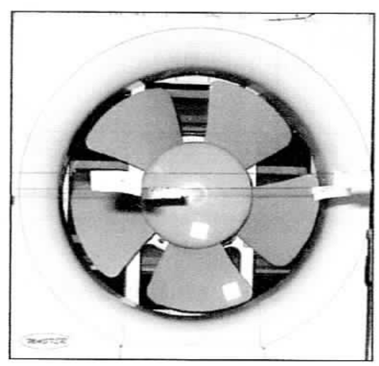

Figure 1.0 : Ventilation Exhaust Fan

Propeller Sidewall

Model : Master VF-20CW

Size : 200MM

Voltage : 240V/50HZ

Watt : 32W

Size	A	B
150	172x172	200x200
200	240x240	265x265
250	290x290	310x310
300	340x340	360x360

Table 1.0 Measurement Of Fan

Specification (mm)	Voltage (v)	Frequency (Hz)	Power (w)	Air Volume Flow Rate (m3/min)	
				OUT	IN
150	200-240 110-120	50-60 60	25	4.5	-
200	200-240 110-120	50-60 60	30	7.8	5.5
250	200-240 110-120	50-60 60	40	11.4	8.6
300	200-240 110-120	50-60 60	55	16.4	12.3

Table 1.1 Technical Data For Fan

1.1.3 Cubic feet per minute (cfm)

After the model is known, the cfm must be determined. Consult local code requirements or the table below for suggested air changes for proper ventilation. The ranges specified will adequately ventilate the corresponding areas in most cases. However, extreme conditions may require "Minutes per Change" outside of the specified range. To determine the actual number needed within a range, consider the geographic location and average duty level of the area.

For hot climates and heavier than normal area usage, select a lower number in the range to change the air more quickly. For moderate climates with lighter usages, select a higher number in the range. To determine the cfm required to adequately ventilate an area, divide the room volume by the appropriate "Minutes per Change" value.

Suggested Air Changes for Proper Ventilation

$$cfm = \frac{\text{Room Volume}}{\text{Min./Chg.}} \qquad \text{Room Volume} = L \times W \times H \text{ (of room)}$$

Area	Min./Chg.	Area	Min./Chg.	Area	Min./Chg.
Assembly Hall	3-10	Dance Hall	3-7	Machine Shop	3-6
Attic	2-4	Dining Room	4-8	Mill	3-8
Auditorium	3-10	Dry Cleaner	2-5	Office	2-8
Bakery	2-3	Engine Room	1-3	Packing House	2-5
Bar	2-4	Factory	2-7	Projection Room	1-2
Barn	12-18	Foundry	1-5	Recreation Room	2-8
Boiler Room	1-3	Garage	2-10	Residence	2-6
Bowling Alley	3-7	Generator Room	2-5	Restaurant	5-10
Cafeteria	3-5	Gymnasium	3-8	Rest Room	5-7
Church	4-10	Kitchen	1-5	Store	3-7
Classroom	4-6	Laboratory	2-5	Transfer Room	1-5
Club Room	3-7	Laundry	2-4	Warehouse	3-10

Table 1.2 Air Changes for Proper Ventilation Fan

1.1.4 Sample problem

A building requires an exhaust fan to ventilate a general office (see Diagram 1.0) which measures 30' x 40' x 8'.The office is often crowded.

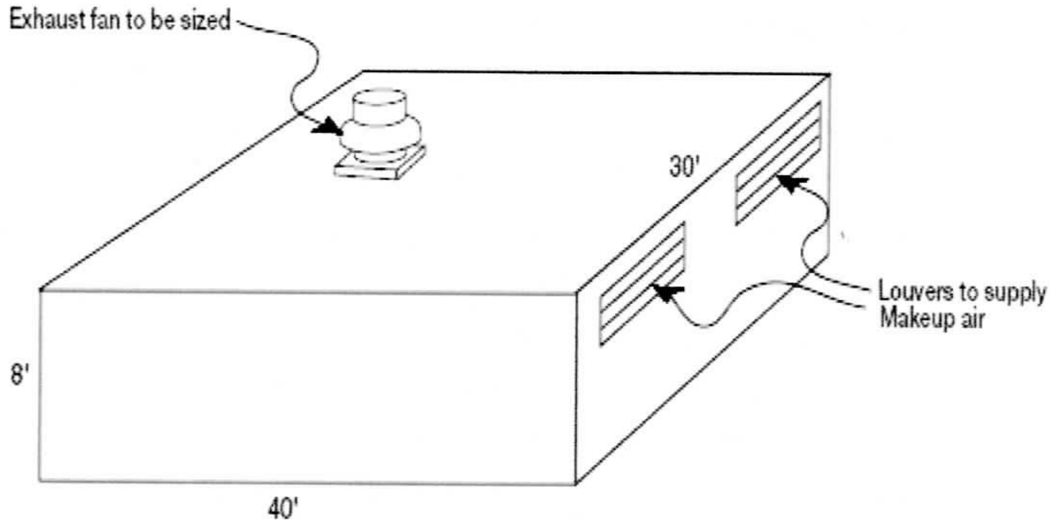

Diagram 1.0 General Office

Solution: The total room volume is 30' x 40' x 8' = 9600 cubic feet. From the chart, the range for general offices is 2-8 minutes per change. Since the office has heavier than normal usage, 4 minutes per change is recommended.

Therefore, the required exhaust is:

9600 ft3 / 4 min .= 2400 cfm

Since the air to be exhausted is relatively clean, this is an ideal application for a model GB fan.

Note: In this example, make-up air was provided through a set of louvers at the wall farthest from the exhaust fan. If there were no provisions for make-up air in this room, a supply fan would also have to be sized. The supply cfm should equal the exhaust cfm. Supply fan location should be as far as possible from the exhaust fan.

1.1.5 Static Pressure

The pressures generated by fans in ductwork are very small. Yet, accurately estimating the static pressure is critical to proper fan selection. Fan static pressure is measured in inches of water gauge. One pound per square inch is equivalent to 27.7" of water gauge. Static pressures in fan systems are typically less than 2" of water gauge, or 0.072 Psi. The drawing to the right illustrates how static pressures are measured in ductwork with a manometer. A pressure differential between the duct and the atmosphere will cause the water level in the manometer legs to rest at different levels. This difference is the static pressure measured in inches of water gauge. In the case of the exhaust fan at right, the air is being drawn upward through the ductwork because the fan is producing a low pressure region at the top of the duct. This is the same principle that enables beverages to be sipped through a straw. The amount of static pressure that the fan must overcome depends on the air velocity in the ductwork, the number of duct turns (and other resistive elements), and the duct length.

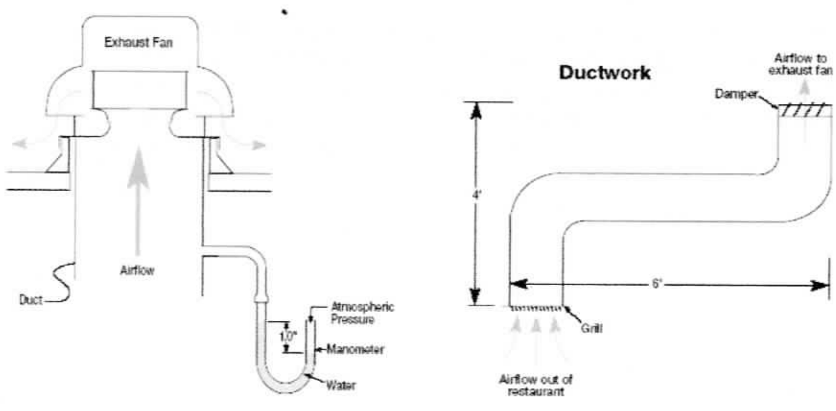

Diagram 1.1 System Configuration

To calculate the system losses, one must know the ductwork system configuration (see Diagram1.1).This duct is sized for air velocities of 1400 feet per minute. Referring to the static pressure chart, that will result in about 0.3" per 100 feet. Since we have 10 feet of total ductwork, our pressure drop due to the duct is:

.3" x 10ft. = .03" 100 ft.

There is also a 0.08" pressure drop for each resistive element or fitting. For this example, there are 5 fittings: one grill, two duct turns, one damper and louvers in the wall of the office. The total pressure drop for fittings is:

5 x 0.08" = 0.4"

Therefore, the total pressure drop is:

0.03" + 0.40 " = 0.43"

For convenience in using selection charts, round this value up to the nearest 1/8", which would be 0.50" Ps.

STATIC PRESSURE GUIDELINES	
Non-Ducted:	0.05" to 0.20"
Ducted:	0.2" to 0.40" per 100 feet of duct (assuming duct air velocity falls within 1000-1800 feet per minute)
Fittings:	0.08" per fitting (elbow, register, grill, damper, etc.)
Kitchen Hood Exh.:	0.625" to 1.50"
Important: Static pressure requirements are significantly affected by the amount of make-up air supplied to an area. Insufficient make-up air will increase static pressure and reduce the amount of air that will be exhausted. Remember, for each cubic foot of air exhausted, one cubic foot of air must be supplied.	

Table1.3 Static Pressure Guidelines

1.1.6 Fan horsepower

The energy required to operate these fans is measured in brake horsepower or bhp. Rating power needs are important because of cost of energy. Also, some fan designs are clearly more energy efficient than others.

1.1.7 Speed

Fan volume is also a function of rotational speed. In general, the faster a fan turns, the more air it can move. Fan speed is expressed is revolutions per minute or rpm. Fan speed is affected by the motor capacity, pulley diameter, air density and the duct pressure.

1.1.8 Efficiency

The power input to a fan is always greater than the fan output because of friction losses in the system. The ratio of output to input horsepower is called efficiency.

1.1.9 Type of ventilation fan

This fan can be used in offices, reception rooms, bazaars, hospitals, warehouses, garages, and kitchens for changing the air..

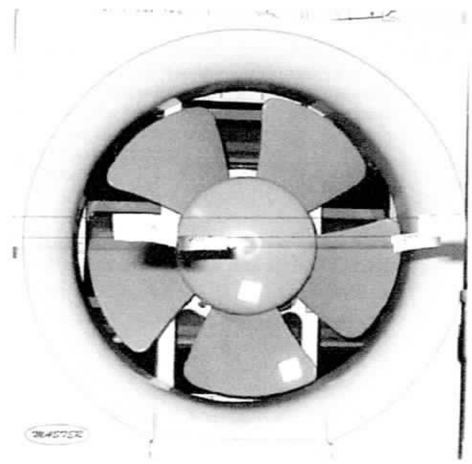

Figure 1.1: Propeller Sidewall Ventilation Exhaust Fan Model Master

1.1.10 Fan inlet connections.

In order to assure proper fan performance, caution must be exercised in fan placement and connection to the ventilation system. Obstructions, transitions, poorly designed elbows, improperly selected dampers, etc., can cause reduced performance, excessive noise, and increased mechanical stress. For performance to be as published, the system must provide uniform and stable airflow into the fan.

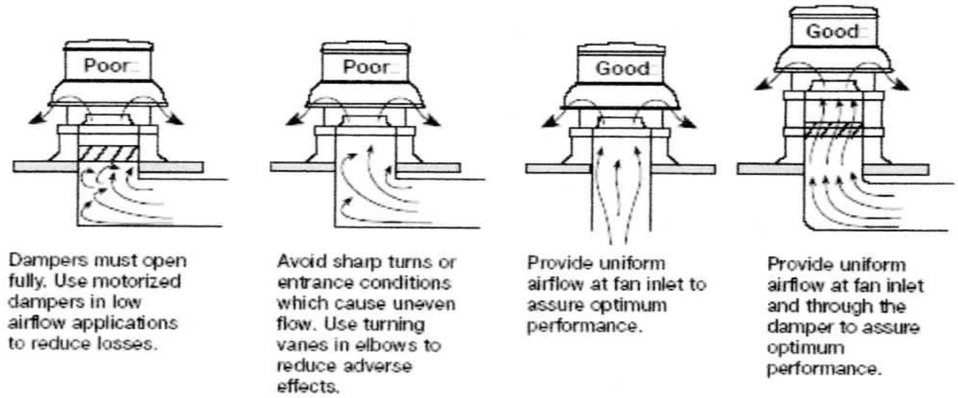

Figure 1.2 : Fan inlet connections

1.1.11 The Importance of Kitchen Fans

Kitchen fans are an important part of your home's ventilation system. They remove odors from your house, which improves indoor air quality. They also remove moisture, which can increase the level of humidity in your house. High humidity can damage building materials. Worse, high humidity can cause mold growth and mold may harm your family's health.

1.1.12 Kitchen Range Hoods

A kitchen range hood must move more air than a bathroom fan about 50 to 140 L/s (100 to 300 cfm). As a result, they are noisier, with the lowest rating about 4.5 sones.

The most useful units have a low noise rating, an energy-efficient fan, fluorescent lights, sound insulation, anti-vibration mounts and duct connections. For heavy duty use, select non-corrosive materials such as aluminum or stainless steel. High quality hoods may have heat sensors and a safety shut-off.

Kitchen exhaust systems should discharge outdoors. Recirculating range hoods rely on filters to capture some odors and grease. The filters are generally made of carbon which must be replaced frequently to be effective. Grease will coat carbon, making it ineffective. With recirculating fans, cooking moisture and odors will usually remain in the house.

1.1.13 Range Hood Shape

Range hoods are most effective when they extend out over the stove surface and are close to the stove top. Island units are less effective than wall units.

1.1.14 Cleaning

Range hoods usually have washable, aluminum-mesh grease filters. Better quality filters have a smaller diameter mesh over a larger surface area and can be cleaned in the dishwasher.

1.1.15 Fire

There is always the possibility of a grease fire with a kitchen range hood exhaust. Smooth metal ducting, preferably galvanized steel, is safer in a fire than lighter assemblies.

1.1.16 Installation

Install fans and exhaust systems so they make the least possible noise, vibrate as little as possible and leak as little air as possible. Anti-vibration pads or foam tape can isolate the fan housing from wood joists and drywall. You can wrap fan housings and some duct sections in rubber or vinyl noise barrier mats.

1.1.17 Ducts

Install exhaust systems according to the building code and manufacturer's recommendations. Straight, short duct runs, with few turns, will result in the highest fan flow. Seal all duct joints and connections with aluminum duct tape or duct mastic (available at contractors supply shops) to prevent air, moisture and noise leakage. Standard cloth duct tapes tend to dry out and fall off. Seal and then insulate all ductwork running through unheated areas to avoid moisture problems. The best practice is to slant horizontal runs of duct down toward the exterior outlet to drain any condensation outside. Exhaust air should not be released into the attic, into a wall or ceiling cavity, crawl space, and basement or in the roof soffit. These locations can promote condensation damage and mold growth.

1.1.18 Background: Kitchen ventilation systems

Mechanical ventilation systems in kitchens are often not required by building codes (Kimball 1998; Manclark 1999). For example, a New York study found that only 67 percent of homes surveyed had kitchen exhaust fans (NYSERDA 1998). Although a window may be adequate to meet code requirements, most kitchen designers, as well as indoor air quality experts believe that a mechanical ventilation system is necessary in the kitchen.

In contemporary kitchens, the choices are usually between a fan mounted above the cook top or range, usually with a hood (updraft), or a proximity system, installed in the cook top, or adjacent to the cooking surface (downdraft). Some kitchens may have a ceiling or wall mounted exhaust fan, but that type of system is generally not considered as effective as the updraft or downdraft systems.

Kitchen ventilation systems are usually located over the cook top, considered the primary source of odors, grease, and moisture. An oven in a range typically vents through a burner on the cook top, putting moisture and odors in the vicinity of the ventilation system. A built-in or wall oven typically vents to the front of the appliance, into the room air. A microwave oven, which may vent to the front, side, or back, is usually not placed near the kitchen ventilation system.

Canopy or updraft ventilation systems can be a recirculating system or an exhaust system. Downdraft ventilation systems are all exhaust systems. A recirculating system pulls the air through a filter then returns the air to the room. The filter may be a simple grease filter screen or include a carbon type filter to remove odors. Moisture and heat are not removed. Combustion pollutants from gas cooking, including carbon monoxide and water vapor, may not be removed. Recirculating systems are less expensive and easier to install, but less effective. Exhaust systems, on the other hand, remove air as well as heat, moisture, odors, and grease from the kitchen to the outside.

There are many variables involved in designing an effective exhaust ventilation system for the cooking area in a kitchen. The authors recommend that the following variables be considered:

- Type of cooking
- Type of cooking appliance
- Type of cooking fuel