PERFORMANCE OF LOCAL EXHAUST VENTILATION (LEV) USING COMPUTATIONAL FLUID DYNAMICS (CFD) BASED ON MOTOR PULLEY ADJUSTMENT OF FAN LAW

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (REFRIGERATION AND AIR-CONDITIONING SYSTEMS) WITH HONOURS

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DECLARATION

I declare that this Choose an item. entitled " PERFORMANCE OF LOCAL EXHAUST VENTILATION (LEV) USING COMPUTATIONAL FLUID DYNAMICS(CFD) BASED ON MOTOR PULLEY ADJUSTMENT OF FAN LAW." is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : CHEW JUN KAI

Date : 19-01-2023

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Refrigeration And Air-Conditioning Systems) with Honours.

Signature : ....

Supervisor Name : TS. DR. AMIR ABDULLAH BIN MUHAMAD DAMANHURI

....

Date : 19-01-2023

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DEDICATION

This research is dedicated to my parents who have never failed to give me financial and moral support, for giving all my needs during the time I developed the research and for teaching me that even the largest task can be accomplished if it is done one step as a time. I dedicate this research to all the people especially my advisor Ts. Dr. Amir Abdullah Bin Muhamad Damanhuri who have worked hard to help us complete this project.

Chew Peng Hong

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Chew Jun Xiang

Chew Wan Qing

Thank You So Much

ABSTRACT

Local Exhasut Ventilation (LEV) is an engineered control system used in manufacturing sector to capture any harmful airborne contaminant. LEV main purpose is to capture and release harmful contaminant to a safe place. It contain 5 main components, hood, ducting, air filter, fan, and exhaust. Numerous medical reports and case study since 1970s have shown exposing to welding fumes will cuase upper respitory symptoms, chronic bronshitis, asthma, Haemoptysis heart rate variablitiy and Basal Cell carcinorma (BCC). LEV systems that lack maintenance, for instance, dirty filters will cause low static pressure that will increase the load and reduce the efficiency and effectiveness of the system. This study aims to monitor and analyse the performance of LEV system using Computational Fluid Dynamic (CFD) based on adjustment motor pulley size based on fan law. A design layout drawing based on the layout in the PSM HVAC Laboratory is created using SolidWork CAD and a simulation is done using Ansys Fluent. Data such as air velocity, air flowrate, and static pressure will be measured real time in the Lab to conduct simulation for analysing the performance of the system. After collecting data from the lab, fan law is use to calculate the increament of static pressure and volume flow rate. According to the standard SPB motor pulley size, the suitable motor pulley size for this study are 118mm, 120mm, 125mm, 132mm, 140mm, 150mm, 160mm, 170mm, 180mm, 190mm, 200mm and 212mm. In Ansys Fluent, edge sizing and inflation meshing is used and the simulation is calculated in pressure-based with standard k-epsilon equation.The result shows the increasing of motor pulley size will increase the velocity and the motor horsepower. The increased of velocity slowed down after 160mm diameter motor pulley (less than 1%) and the horsepower required to run the next motor pulley size (170mm) is much higher (around 20% of increament) compare to the previous size. Therefore the, most suitable size for increasing the LEV system performance is 160mm diameter for motor pulley.

ABSTRAK

Pengalihudaraan Ekzos Setempat (LEV) merupa sejenis sistem mengawal kejuruteraan diguna dalam sektor pembuatan untuk menangkap mana-man bahan cemar bawaan udara. Fungi utama LEV adalah untuk menangkap bahan cemar bawaan udara dan melepas ke tempat yang selamat. LEV mempunyai 5 bahagian penting, tudung ekzos, penyaluran, penapisan udara, kipas dan ekzos. Banyak laporan perubatan dan kajian kes sejak tahun 1970-an telah menunjukkan pendedahan kepada asap kimpalan akan menyebabkan simptom saluran pernafasan atas, bronkitis kronik, asma, variabliti degupan jantung Haemoptysis dan karsinorma Sel Basal (BCC). Sistem LEV yang kurang penyelenggaraan, contohnya, penapis yang kotor akan menyebabkan tekanan statik rendah yang akan meningkatkan beban dan mengurangkan kecekapan dan keberkesanan sistem. Kajian ini bertujuan untuk menantau dan menalisis prestasi sistem LEV menggunakan cara komputasi dinamik berdalir (CFD) berdasarkan saiz rakal motor pelarasan berdasarkan hukum kipas.Satu lukisan reka bentuk mengikut susun atur Lab PSM HVAC menggunakan Solidwork Lukisan Berbantukan Komputer (CAD) dan satu simulasi dijalankan dengan menguna Ansys Fluent. Data seperti halaju udara, kadar aliran udara, dan tekanan statik akan diukur masa nyata di makmal untuk menjalankan simulasi untuk analisis prestasi sistem. Selepas mengumpul data daripada makmal, hukum kipas digunakan untuk mengira pertambahan tekanan statik dan kadar aliran isipadu (CFM). Mengikut saiz takal motor SPB standard, saiz takal motor yang sesuai untuk kajian ini ialah 118mm, 120mm, 125mm, 132mm, 140mm, 150mm, 160mm, 170mm, 180mm, 190mm, 200mm dan 212mm. Dalam Ansys Fluent, saiz tepi dan jalinan inflasi digunakan dan simulasi dikira dalam berasaskan tekanan dengan persamaan k-epsilon standard. Keputusan menunjukkan peningkatan saiz takal motor akan meningkatkan halaju dan kuasa kuda motor. Peningkatan halaju menjadi perlahan selepas takal motor berdiameter 160mm (kurang daripada 1%) dan kuasa kuda yang diperlukan untuk menjalankan saiz takal motor seterusnya (170mm) adalah jauh lebih tinggi (anggaran 20% peningkatan) berbanding saiz sebelumnya. Oleh itu, saiz yang paling sesuai untuk meningkatkan prestasi sistem LEV ialah diameter 160mm untuk takal motor.

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LIST OF SYMBOLS AND ABBREVIATIONS

2D	-	2-Dimensional
3D	-	3-Dimensional
A	-	Ampere
ACGIH	-	American Conference of Governmental Industrial Hygienists
BCC	-	Basel Cell Carcinoma
CAD	-	Computer-Aided Design
CFD	-	Computational Fluid Dynamic
CFM	-	Cubic Feet per Minute
DOSH	-	Department of Occupational Safety and Health
DPM	-	Discrete Phase Model
FP(s)	-	Fine Particle(s)
HEPA	-	High Efficiency Particular Air
HIRAC	-	Hazard Identification, Risk Assesment and Risk Control
Hp	-	Horsepower
HSA	-	Health and Safety Authority
HVAC	-	Heating, Ventilation and Air Conditioning
L	-	litre
LES	-	Large Eddy Simulation
LEV	-	Local Exhaust Ventilation
PEL(s)	-	Permissible Exposure Limit(s)
PPV	-	Push-Pull Ventilation
PSM	-	"Projek Sarjana Muda" (Bachelor Degree Project)
PVC	-	Polyvinyl Chloride
RPM	-	Revolution Per Minute
STEL(s)	-	Short-term Exposure Limit(s)
UD	-	Downside-exhaust system
UDF	-	User Define Functions
UF	-	Upside-supply and Floor-exhaust System
UFP(s)	-	Ultrafine Particle(s)

UM	-	Upside-supple and Multiple-exhaust
VOC(s)	-	Volatile Organic Compund(s)
VOF	-	Volume of Fluid
w.g.	-	Water Gauge
WHO	-	World Health Organization

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CHAPTER 1

INTRODUCTION

1.1 Background

The Local Exhaust Ventilation (LEV) system is an engineered controlling system that protects workers from exposure to hazardous substances by containing or capturing them locally, at the source of the emission. This protects workers from being exposed to potentially harmful substances. LEV is one of many engineering control systems that can be utilised for the purpose of removing and preventing employee exposure to airborne contaminants such as vapour, mist, and dust. This ensures that the employee is adequately protected. LEV removes the airborne contaminants and transmits the pollutants away from the working environment (Morteza et al., 2013).

LEV is one of engineering control method guided in Hazard Identification, Risk Assessment and Risk Control (HIRARC) Guidelines 2008 (HIRARC Department of Occupational Safety and Health Ministry of Human Resources Malaysia, 2008). LEV has a wide variety of applications in the manufacturing sector, including the collection of fumes from welding, laboratory fume, biological safety cabinet, print-spray, down flow booth, ventilated hopper, dust-capturing device at woodworking machine, pouring station, abrasive blasting room or cabinet, kitchen, and many more.

LEV contains five parts which are hood, ducting, air cleaner or filter, fan and discharge or exhaust. Hood is the part used to capture, receive, or contain contaminant and enter the LEV system. The ducting is used to connect branches and all the part together from hood to the exhaust. The filter will ensure the air release to the atmosphere is clean but not system need air cleaning. The fan and motor are the power of the extraction system and lastly the exhaust is to release the extracted air to a safe place.

According to DOSH guidelines, every part of the LEV system should be designed well to ensure the contaminants can be captured well and release safety to a safe space or atmosphere. The hood capture velocity must be sufficient to capture the contaminants and for non-enclosing the location is important to ensure the air direction flow does not interfere with the worker working direction. For instance, the Health and Safety Authority (HSA) suggests that the capture velocities for welding should be anywhere from 0.5 metres per second to 1.0 metres per second. For a variety of applications, the ducting material ought to be able to tolerate the corrosive and abrasive components of the environment. It is essential that the geometry of the duct be considered in order to minimise the friction losses and maximise the efficiency. In addition to the branches, elbows, and transitions, carefully considered design is required to minimise energy loss. When there are multiple branches in an LEV system, the designer needs to find a way to balance the quantity of air that passes through the hood. Additionally posing as an impediment to the movement of air is the air cleaner or filter. Therefore, a suitable filter, such as a cyclone type filter, is appropriate for bigger particles of around 8 micrometres in size. The same is true for the selection of the fan; the flow rate and the fan pressure should be designed according to the circumstances and the kinds of pollutants that are present.

It is possible to gauge how well LEV is working by looking at the static pressure, the dynamic pressure, the face velocity, the capture velocity, and the performance of the fan. By altering the size of the motor pulley or the blower pulley, Fan Law can be utilised to raise the fan speed. The Fan Law is comprised of three fundamental equations that connect blower RPM to fan speed, static pressure, and motor horsepower. The increase in blower RPM will result in varying increases in fan speed, static pressure, and motor power.

Numerical analysis, carried out with the assistance of a computational fluid dynamic (CFD), will be used in order to evaluate the efficiency of the LEV system. There are three different kinds of hoods: those that enclose, those that receive, and those that capture. Enclosing hoods have better effectiveness on extracting air pollutant because their exhaust rates and the effects of room air currents are lower than those of non-enclosing hoods (Posokhin & Zhivov, 2021). Typical applications for non-enclosing hoods include situations in which a working procedure must take place in an open environment. Installing a non-enclosing hood should be done according to the requirements, which could be up draught, side draught, or down draught. It is imperative that the location of the non-enclosing hood be such that the contaminant is pulled away from the breathing zone of the operator (Posokhin & Zhivov, 2021).

1.2 Problem Statement

In manufacturing industries, LEV is used to capture airborne contaminants which are harmful to human respiratory system. Exposing to welding fumes for a long period will cause lung damage and various types of cancer, including lung, larynx, and urinary tract.(Rahul et al., 2021). Therefore, the design or LEV system is important in the working area to ensure the polluted air can be removed (DOSH Guideline, 2008). When the LEV system is lack of maintenance for instance, dirty filter will cause low static pressure that will increase the load and reducing the performance of the system. Apart from cleaning or changing the filter, increasing the fan speed will enhance the performance of LEV system by using fan law. Fan law can adjust the size of motor pulley or blower pulley to increase the static pressure and the CFM. Therefore, the change of motor pulley needs to be done on the system to ensure the system performance.

1.3 Research Objective

The main aim of this study is to determine the performance of LEV system in the PSM HVAC laboratory. Specifically, the objectives are as follows:

a) To monitor LEV system performance at PSM HVAC Laboratory by using HIRAC guideline 2008.

b) To analysis LEV system performance using Computational Fluid Dynamic (CFD) based on motor pulley adjustment based on Fan Law.

1.4 Scope of Research

The LEV system use in this study is designed for the PSM HVAC Laboratory. The round ducting used in the system is Polyvinyl Chloride (PVC) pipe. The fan can create maximum 3500 ft^3/min air volume with 5.5 Horsepower (Hp) and 2500 RPM. The static pressure create by the centrifugal fan is 6” w.g. According to the standard SPB motor pulley size, 0.75”w.g., 0.78”w.g., 0.84”w.g., 0.94”w.g., 1.06”w.g. 1.22”w.g., 1.38”w.g., 1.56”w.g., 1.75”w.g., 1.95”w.g., 2.16”w.g. and 2.43”w.g. static pressure is simulate using computational fluid dynamic (CFD) to calculate the change of velocity in the LEV system. Solidworks 2020 will be used to draw the design and layout of the system. . A CFD will be conducted to simulate the air flow of the LEV system to determine the effectiveness of the system. Ansys Fluent 2022 R1 version will be used to simulate the air flow in the ducting of the LEV system from the hood to the exhaust.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

LEV system is used to control the air contaminants quantity in a workplace to protect workers from harmful substances. In this study, the effectiveness of LEV system in PSM HVAC Laboratory is analyse by using CFD method. In this chapter, the factors affecting the performance of LEV system is discuss and some past studies will include to support this study.

2.2 Local Exhaust Ventilation (LEV) System

In the occupational safety and health management system, the LEV system is an engineering control technology that is used to safeguard workers from inhaling toxins that can injure their respiratory systems (Hasan et al., 2014). The concept of a local exhaust ventilation (LEV) system is to collect a contaminant at or close to its point of origin, prior to the contaminant being released into the working environment. To name a few examples, pollutants can take the form of dust, smoke, mist, aerosol, vapour, or gas. Figure 2.1 depicts the five components that make up an LEV; these components are an inlet/enclosure/hood, ducting, air cleaner/filter, air mover, and discharge or exhaust (Health and Safety Authority, 2014).