UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PROPOSE NEW DUST SUCTION SYSTEM TO SOLVE THE MALFUNCTIONING OF EXISTING SYSTEM IN THE TRIM BOOTH AT MANUFACTURING INDUSTRY

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours.

by

CAROL PAN ZI TING

B071410250

940615-12-5484

FACULTY OF ENGINEERING TECHNOLOGY

2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **PROPOSE NEW DUST SUCTION SYSTEM TO SOLVE THE MALFUNCTIONING OF EXISTING SYSTEM IN MANUFACTURING INDUSTRY**

SESI PENGAJIAN: **2017/18 Semester 1**

Saya **CAROL PAN ZI TING**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☐ TIDAK TERHAD

Disahkan oleh:

_______________________ _______________________

Alamat Tetap:

96, Taman Sinar Baru,

Lrg Kenawai 7D, 88450 Jln Damai

Kota Kinabalu, Sabah.

Cop Rasmi:

Tarikh: _______________________

Tarikh: _______________________

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAKULTI TEKNOLOGI KEJURUTERAAN
Tel : +606 234 6623 | Faks : +606 23406526

Rujukan Kami (Our Ref) :
Rujukan Tuan (Your Ref) :

18 DIS 2017

Pustakawan
Perpustakaan UTeM
Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya,
76100 Durian Tunggal,
Melaka.

Tuan/Puan,

PENGKELASAN LAPORAN PSM SEBAGAI SULIT/TERHAD LAPORAN PROJEK SARJANA MUDA TEKNOLOGI KEJURUTERAAN PEMBUATAN (PROCESS & TECHNOLOGY): CAROL PAN ZI TING

Sukacita dimaklumkan bahawa Laporan PSM yang tersebut di atas bertajuk ***"Propose New Dust Suction System to Solve The Malfunctioning of Existing System in Manufacturing Industry"*** mohon dikelaskan sebagai *SULIT / TERHAD untuk tempoh LIMA (5) tahun dari tarikh surat ini.

2. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian dimaklumkan. Terima kasih.

Yang benar,

____
Tandatangan dan Cop Penyelia

* Potong yang tidak berkenaan

NOTA: BORANG INI HANYA DIISI JIKA DIKLASIFIKASIKAN SEBAGAI SULIT DAN TERHAD. JIKA LAPORAN DIKELASKAN SEBAGAI **TIDAK TERHAD**, MAKA BORANG INI **TIDAK PERLU DISERTAKAN** DALAM LAPORAN PSM.

DECLARATION

I hereby, declared this report entitled “Propose New Dust Suction System to Solve the Malfunctioning of Existing System in Manufacturing Industry” is the results of my own research except as cited in references.

Signature	:	
Author’s Name	:	Carol Pan Zi Ting
Date	:	

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours. The member of the supervisory is as follow:

………………………………

Cik Nur Farah Bazilah binti Wakhi Anuar

ABSTRAK

Bahagian manual trim telah dilaksanakan oleh CTRM sejak empat tahun lalu. Habuk karbon telah dihasilkan semasa proses pemangkasan. Walau bagaimanapun, semua debu masih terperangkap di dalam longkang dan tidak boleh disedut oleh sistem habuk sedutan yang sedia ada. Oleh itu, masa dan tenaga kerja untuk menjalankan kerja pembersihan debu perlu dijalankan selepas proses pemangkasan. Namun begitu, ini amat mengancam kesihatan pekerja seperti penyekatan dalam saluran darah ekoran daripada penyedutan habuk karbon ke dalam saluran darah. Di samping itu, sisa-sisa debu akan terperangkap dalam udara atau melekat pada dinding dan lantai kerana ketiadaan perkhidmatan peryaluran udara ke luar kawasan. Ini akan menyebabkan ketidaksempurnaan dalam bahagian yang diproses. Konkusinya, cara penyelesaian yang berkesan dan ekonomik amat diperlukan untuk memastikan kesihatan para pekerja dan juga dapat memastikan kekurangan pembaziran masa dan tenaga kerja untuk proses pembersihan ini. Selepas beberapa kajian di internet dan perbandingan antara setiap sistem pengumpul habuk, Airwall dicadangkan kepada CTRM kerana ia mempunyai kecekapan tertinggi dan ia adalah sistem pengumpul habuk yang paling kos efektif di kalangan semua sistem.

ABSTRACT

Current manual trim booth has been used for the past four years in CTRM. Carbon dust are produced during the trimming process. However, the dust are all trapped in the drain and cannot be sucked up by the existing dust suction system. Therefore, time and manpower to carry out a manual cleaning up of the dust are required. However, the manual cleaning up will bring a hazardous health effect to the workers as the carbon dust will block the blood circulatory system if it accidentally enter the blood vessels of the workers. Besides that, the dust particle will be trapped in the air and stick to the wall and floor. This will contaminate the part surface because there is no blowing system or air outlet system. Hence a poor quality of part is being produced. Therefore, an effective and budget solution is needed to solve the problem so that the health of the CTRM staffs can be guaranteed and to make sure the time and manpower are not wasted and can be used in the right position. After several researches on the internet and comparison between each of the dust collector system, Airwall is proposed to CTRM because it has the highest efficiency and it is the most cost effective dust collector system among all the systems.

DEDICATION

To my beloved parents

ACKNOWLEDGEMENT

First of all, I would like to thank God for blessing me and giving me wisdom and strength to overcome all the struggles and hardships throughout this Final Year Project.

Secondly, I would like to express thousand thanks to my two supervisors, Mr Mazlan bin Ahmad and Miss Nur Farah Bazilah binti Wakhi Anuar for their guidance and patience to me throughout this Final Year Project. I have gained lots of new knowledge from them.

Thirdly, I would like express my gratitude to the person in charge, Kak Mariyah for letting me to do my Final Year Project at the trim booth at Building 3 CTRM. Thanks to her as she gives full commitment and cooperation regarding to all the information that I need.

Last but not least, I would like to thank my family and friends for their caring and support throughout this Final Year Project.

TABLE OF CONTENT

Abstrak		vi
Abstract		vii
Dedication		viii
Acknowledgement		ix
Table of Content		x
List of Tables		xiii
List of Figures		xiv
List of Abbreviations, Symbols and Nomenclature		xvi
CHAPTER 1: INTRODUCTION		**1**
1.0	Introduction	1
1.1	Background	1
1.2	Problem Statement	3
1.3	Project Objective	4
1.4	Scope	5
CHAPTER 2: LITERATURE REVIEW		**6**
2.0	Introduction	6
2.1	Current Trim Booth System and Specification	6
2.2	Carbon Dust Hazards	7
2.3	Dust Explosion	9
	2.3.1 Power effect Safety Measures to Prevent Dust Explosion	10
	2.3.2 Quantitative Risk Analysis Methods	11
	2.3.3 Secondary Dust Explosion	11
2.4	Efficiency of Dust Collector System	12
2.5	Type of Dust Collection System	13
	2.5.1 Gravity Separators (Drop-Out Boxes)	14
	2.5.2 Centrifugal Collectors or Cyclones	15

2.5.3 Baghouse Collectors 16
2.5.3.1 Mechanical Shaker Collectors 17
2.5.3.2 Reverse Air Collectors 18
2.5.3.3 Pulse Jet Collectors 19
2.5.4 Cartridge Collectors 23
2.5.5 Wet Scrubbers 24
2.5.5.1 Venturi Scrubbers 25
2.5.5.2 Impingement Plate Scrubbers 26
2.5.6 Electrostatic Precipitators (ESPs) 26
2.6 Biomass Gasification 27
2.6.1 Updraft Gasification 28
2.6.2 Downdraft Gasification 29
2.6.3 Fluidised Bed Gasifier 30
2.7 Cause and Effect Diagram 31

CHAPTER 3: METHODOLOGY 33
3.0 Introduction 33
3.1 Project Planning 33
3.1.1 Duration of the Project 34
3.1.2 Gantt Chart 35
3.2 Research Methodology 37
3.2.1 Problem Formulation 38
3.2.2 Objective Setting 38
3.2.3 Literature Study 39
3.2.4 Data Collection 39
3.2.5 Data Analysis 40
3.2.6 Results 41
3.2.7 Discussion 41
3.2.8 Conclusion 41

CHAPTER 4: RESULT AND DISCUSSION 43
4.0 Introduction 43

4.1 Company Background 43
4.2 System Description 44
4.3 Conceptualization of Problem 45
4.3.1 Cause and Effect Diagram 45
4.3.1.1 People 46
4.3.1.2 Material 47
4.3.1.3 Method 49
4.3.1.4 Environment 53
4.3.1.5 Machine 53
4.4 Development of Problem 54
4.4.1 Comparison between Existing and Proposed Dust Collector System 57
4.4.2 Interpretation of results 63

CHAPTER 5: CONCLUSION & FUTURE WORK **68**
5.0 Introduction 68
5.1 Conclusion 68
5.2 Recommendation 69

REFERENCES **72**

APPENDIX
A Airwall Manual

LIST OF TABLES

4.1 Comparison between downdraft system and Airwall 57

LIST OF FIGURES

2.1	Current dust collector system in CTRM	7
2.2	Dust explosion pentagon (Kauffman, 1982)	9
2.3	Graph of dust concentration versus dust collector efficiency	13
2.4	Gravity separator (Cecala et al., 2012)	14
2.5	Cyclone (Cecala et al., 2012)	16
2.6	Baghouse (Cecala et al., 2012)	17
2.7	Mechanical shaker collectors (Cecala et al., 2012)	18
2.8	Reverse air collector (Cecala et al., 2012)	19
2.9	Pulse jet baghouse (Cecala et al., 2012)	22
2.10	Cartridge collector (Cecala et al., 2012)	23
2.11	Wet scrubber collector (Cecala et al., 2012)	24
2.12	Venturi scrubber collector (Cecala et al., 2012)	25
2.13	Impingement plate scrubber collector (Cecala et al., 2012)	26
2.14	Electrostatic precipitator collector (Cecala et al., 2012)	27
2.15	Updraft gasification (Neathery, 2010)	29
2.16	Downdraft gasification (Neathery, 2010)	30
2.17	Fluidised bed gasifier (Neathery, 2010)	31
2.18	Example of a cause and effect diagram (adapted from Dr Kaoru Ishikawa)	32
4.1	Components of dust collector system (adapted from OSH)	44
4.2	Principle of dust collector system in terms of airflow	45
4.3	Cause and effect diagram	46
4.4	Categorisation of dust particle size	48
4.5	Characteristic of dust (Source from CTRM)	49
4.6	Current air flow process in trim booth, CTRM	50
4.7	Air flow rate of the current LEV system (Source from CTRM)	51
4.8	The relationship between the distance of hood and emission point and the effectiveness of the LEV system	52
4.9	Current layout and process in the trim booth, CTRM (Photo source from CTRM)	53

4.10 Dust ventilation chamber from Envirosystems LLC (Photo source from Envirosystems LLC) 64
4.11 Interior view of Envirosystems dust ventilation chamber (Photo source from Envirosystems Inc.) 64

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CO	-	Carbon Monoxide
CSB	-	Chemical Safety Board
CTA	-	Chicago Transit Authority
CTRM	-	Composites Technology Research Malaysia
DESC	-	Dust Explosion Simulation Code
DOE	-	Department of Environment
ESPs	-	Electrostatic Precipitators
FTA	-	Fault Tree Analysis
HEPA	-	High Efficiency Particulate Air
HVAC	-	Heating, Ventilation and Air Conditioning
I.S.	-	Intrinsically safe
Inc.	-	incorporated
LEVs	-	Local Exhaust Ventilation system
N/A	-	Not Applicable
NEMA	-	National Electrical Manufacturers Association
NEP	-	National Emphasis program
OSHA	-	Occupational Safety and Health Administration
PE	-	Professional Engineer
QC	-	Quality Control
QRMF	-	Quantitative Risk Management Framework
R&D	-	Research and Development
R&T	-	Research and Technology
USEPA	-	United States Environmental Protection Agency
kW	-	kilowatt
V	-	Volt
Hz	-	Hertz
dB	-	decibel
l	-	length

w	-	width
h	-	height
<	-	less than
°	-	degree
°C	-	degree Celcius
%	-	percent
Kg	-	kilogram
µm	-	micrometer
mm	-	millimeter
m	-	meter
m^2	-	meter squared
m/s	-	meter per second
m^3/hour	-	meter cube per hour
mg/ m^3	-	milligram per meter cube
g/Nm^3	-	gram per Newton metre cube
L/min	-	litre per minute
CFM	-	cubic feet per minute
FPM	-	feet per minute
PSI	-	pounds per square inch
"wg	-	inch water gage

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter gives an overall review of the paper which include the project background, problem statement, objectives, scope and limitations. This chapter gives the paper a situation and sees how it adapts to the previous study in the related field. Project background is based on the history and cases that happened before, from the first study in the related field until today.

1.1 Background

Manufacturing industry are industries which involve in the manufacturing of a raw material into a value added final product. The final product is in term of finished goods that will sell to customers or in term of product or part that will be used in production process. As every aerospace manufacturers of carbon fibre composite knows, one of the most annoying and difficult aspect is that, whenever there is a manufacturing process such as trimming and chamfering of carbon fibre composites, there will be hazardous fine dust produced during the process.

Carbon fibre is made up of crystals of carbon that arranged in a straight line in a long axis with shape of honeycomb carbon crystals organized in ribbons which are long and flat. The straight line arrangement of the carbon crystals strengthen the ribbons. This is the reason why carbon fibre has high specific strength. Carbon fibre is corrosion resistant and chemically stable. Carbon fibre is electrically conductive. Its conductivity causes galvanic corrosion. Its dust can cause sparks or short circuits in electrical appliances. Carbon fibre is non-flammable. However, its dust is flammable as it is carbon, which will flare up easily and cause a flame when reacted with oxygen or any other oxidizing agents.

An explosion occurred at the West Pharmaceutical facility in Kingston, North Carolina killed 6 workers and injured 38 workers, including 2 fire fighters in January 2003. The culprit was the inadequate control of the dust hazards at the plant. Another explosion occurred at the CTA Acoustics manufacturing plant in Corbin, Kentucky fatally injuring 7 workers in only a month later. It was found that the accumulated dust in a certain area of the production was most likely ignited by a malfunctioning oven which released flames, causing the explosion.

There were three most recent cases of dust explosion in 2010, two cases happened in United States and one case in Douglas County, Oregon that killed 19 people and injured 53 people, which proved that dust explosion is severe and dreadful. The reason for the happened of dust explosion is the high concentrations of the combustible carbon dust. Dust clouds have a high potential to ignite then cause explosion. During housekeeping routines, sweeping or blowing dust will cause the dust to remain at the small areas which are difficult to reach, such as walls or areas hidden behind the equipment.

There are several cases of secondary dust explosion. Many accidents that occurred in the United States in the past few years prompted the Chemical Safety Board (CSB) to specially write a report that emphasized the dust explosions. The massive secondary dust explosion that occurred on 7 February 2008 at the Imperial Sugar Company in Port Wentworth, Georgia causing 14 deaths and 36 people injured, caused by a fatal blast and fire from a dust cloud.

OSHA (Occupational Safety and Health Administration) strongly discourage the sweeping or blowing of dust during housekeeping routines for all industries as the hazardous flying dust particles can cause hazardous health and life threatening problems such as deterioration of respiratory system and other health hazards, as well as malfunctioning blood circulatory system. Under the NEP (National Emphasis Program), sweeping and blowing of dust during housekeeping routines ranked second in violations according to the Status report. Besides the sweeping and blowing of dust during housekeeping routines being among the violations, the use of air compressor to blow dust is also among the top violations set by the organizations.

OSHA practice the “hierarchy of controls” framework to choose the most suitable and effective methods to reduce hazards in workplace. The “hierarchy of controls” states that the most suitable and effective methods to reduce hazards in workplace is to eliminate it systematically from the workplace. Engineering control is the most suitable and effective type of measures to protect laboratory workers by making permanent changes to the work environment to reduce hazards in workplace. It does not depends on the behaviour of worker. Examples of the permanent changes include eliminate hazard materials from the workplace by forced ventilation, use operations that are remotely controlled and install high efficiency particulate air (HEPA) filters in heating, ventilation and air conditioning (HVAC) equipment.

The implementation of industrial vacuum cleaners is highly recommended by OSHA as it is a cost effective method to remove dust and hence the previously mentioned hazards can be prevented rather than redistributing dust. It also avoid some of the most cited violations of OSHA. The implementation of industrial vacuum cleaners not only remove dust particles as small as 1 micron, and it also reduces the quantity of dust in the areas that are hardly reach as the vacuum cleaner is portable and it can suck the dust wherever the vacuum cleaner goes. Housekeeping cost can be reduced as less time and manpower are required to reduce the quantity of suspended airborne dust. By using the industrial vacuum cleaner, the possibility of dust explosion is reduced, and a better and healthier working environment for the laboratory workers can be provided.

1.2 Problem Statement

Current dust suction system in the manual trim booth at Building 3, CTRM is not functioning. Carbon dust are produced during the trimming and chamfering process. However, the dust are all accumulated and trapped in the drain and cannot be sucked up by the existing dust suction system. Therefore, time and manpower to carry out a manual cleaning up of the dust are required. It takes a long time and a huge manpower to manually clean the dust in the drain. The time and manpower are wasted to do the cleaning, instead, they can be used for a better purpose, such as continuing the process and production to make sure that there is not a single profit loss to the company. However, the manual cleaning up will bring a hazardous health effect to the workers as the carbon dust will block the blood circulatory system if it accidentally enter the blood vessels of the workers. Besides that, the dust particle will be trapped in the air and stick to the wall and floor. This will contaminate the part surface because there is no blowing system or air outlet system. Hence a poor quality of part is being produced.

1.3 Project Objective

The project objective pictures the outcome of a project. It lies within the scope of the project, and is directly affect the project. It is also a goal that need to be achieved in this project. The objectives of this project are:

1. To propose a solution to solve the dust suction problem
2. To suggest a cost effective suction system
3. To validate the proposed solution is capable of solving the dust suction problem.

By setting these three objectives, the project's outcome can be foreseen and to make sure the goals can be achieved. By proposing a solution in the way of changing the existing dust suction system to a whole new better system, the issues of malfunction of existing dust collector system can be solved. In addition, by suggesting a cost effective suction system, the overall cost can be reduced and money can be saved in the meantime solving the suction problem. Moreover, the health and safety of CTRM staffs is can be ensured by eliminating the flying particles of carbon dust during the trimming process by validating the proposed solution is capable of solving the dust suction problem so that the staffs are free from any life threatening probability.

1.4 Scope

This project focuses on the comparison in terms of cost and technical specifications between different types of dust suction system, without the simulation and installation of the chosen suction system. Therefore, the result of how effective is the chosen suction system to solve the issue can only be evaluated through the research of the suction system in terms of technical specifications of each suction system and the research on the industry that use that particular suction system.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This section discusses published knowledge in a certain study area at a certain period of time. It is an abstract and synthesis of the origin in an organization pattern without adding any new contributions. It acts as a foundation and support for a new insight that has contributed. Last but not least, it also provide a solid background for an investigation.

2.1 Current Trim Booth System and Specification

The space of the trim booth in CTRM is 24000mm x 8383mm. The trim booth is currently using down draft type of dust suction. The size of the system is 22m x 8m x 3m. Its motor capacity is 45kW and it has flow rate of 20,000 CFM. However, the actual flow rate needed is 52,800 CFM to completely suck the dust based on the theory calculation of flow rate below:

Volume	=	Cross sectional area of pit, m^3
	=	22m (length) x 8m (width) x 3m (height)
	=	$528m^3$
$1m^3$	=	100 CFM
$528m^3$	=	52,800 CFM

There is only 1 unit of filtering system and retractable flexible arms system for the semi down draft dust collecting system. There are 20 units of trim booth compressed air outlet connector, 24 units of fluorescence light and 2 buffer tank of air compressor.

Figure 2.1: Current dust collector system in CTRM

2.2 Carbon Dust Hazards

The first experiment by Holt and Horne (1978) showed that carbon fibre dust contains mainly non-fibrous particles. An experiment is carried out to model the lungs of guinea pigs to surrogate the human lungs that inhaled the dust killed the animals after 27 weeks of inhalation of the dust. A confirmatory experiment is carried out by Holt 2 years later using the similar method. The experiment was about nine guinea pigs inhaled carbon fibre dust for 100 hours. The guinea pigs were then lived in a normal atmosphere after first inhaling the dust. It was found out that one by one of the guinea pigs were killed at a short time intervals. Sections of 5µm of the lungs of the animals were cut to carry out some chemical reaction. Macrophage, a critical cell in the immune system that are formed whenever there is an infection, possessing dust particles were found in the sections of the lungs. The number of dust particles in each macrophage increased with time and this will slowly bring