UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CORRELATION BETWEEN SURFACE ROUGHNESS AND DUST BUILD-UP IN FABRIC DUCT AND GALVANIZED STEEL DUCT: A COMPARISON

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Mechanical Engineering Technology (Refrigeration and Air Conditioning System) with Honours

by

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DECLARATION

I hereby, declared this report entitled "Correlation between Surface Roughness and Dust Build-up in Fabric duct and Galvanized Steel duct: A Comparison" is the results of my own research except as cited in references**.**

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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 Mechanical Engineering Technology (Refrigeration and Air Conditioning System) with Honours. The member of the supervisory is as follow

……..

(Norain Binti Idris)

ABSTRAK

Sistem salur udara digunakan terutamanya untuk menyalurkan udara sejuk ke ruang yang didiami. Sumber pencemaran udara dalaman mungkin berpunca dari sistem saluran udara iaitu merupakan peralatan yang memainkan peranan penting dalam pengedaran udara di dalam bangunan. Zarah habuk adalah bahan pencemar utama yang ditemui dalam sistem HVAC terutamanya dalam sistem salur udara. Jumlah besar debu yang masuk akan menjejaskan kebersihan sistem salur udara dengan itu memberikan kualiti udara yang buruk kepada manusia bukan sahaja mengurangkan kadar aliran udara dan boleh meningkatkan penggunaan tenaga. Makalah ini memberi tumpuan kepada pembentukan debu, jenis bahan saluran udara dan mencari korelasi antara kekasaran permukaan dan pembentukan debu. Dua jenis saluran udara dipilih iaitu salur kain dan salur keluli tergalvani untuk membuat perbandingan. Purata kekasaran profil kedua-dua saluran yang diukur dengan menggunakan penguji kekasaran permukaan mudah alih dan kekasaran permukaan saluran kain adalah 2.173 μm yang empat kali lebih tinggi berbanding dengan salur keluli tergalvani yang hanya menunjukkan 0.478 μm profil kekasaran permukaan. Hasil pembentukan habuk di dalam kedua-dua saluran udara HVAC yang diukur dengan menggunakan kaedah ujian vakum. Ujian vakum didapati kaedah yang berkesan untuk mengumpul sampel debu pada permukaan saluran. Debu di tiga jarak jarak yang berbeza akan dikosongkan di kawasan tertentu 100cm^2. Jumlah min debu yang dibina pada saluran kain adalah sedikit lebih tinggi berbanding dengan saluran keluli tergalvani. Jumlah min yang paling tinggi dalam pembentukan debu ditemui pada akhir saluran dan jumlah yang paling rendah terletak berhampiran saluran kipas.

ABSTRACT

The ductwork system was primarily used for conduit conditioned air to the living space. The sources of indoor air pollution may be present from our air duct system which is the equipment that plays a major role in air distribution inside the building. Dust particles are the major contaminants encountered in the HVAC system especially inside the ductwork system. Large amount of dust entering will affect the cleanliness of the ductwork system thus provides bad air quality to the human not only just decrease air flow rate and may increase energy consumption. This paper focuses on dust build-up, type of air ducts material and find the correlation between surface roughness and dust build-up. Two types of air duct was selected which is fabric duct and galvanized steel duct in order to make a comparison. The mean roughness profile of both duct measured by using portable surface roughness tester and the surface roughness of fabric duct is 2.173 μm which is four times higher compared to the galvanized steel duct that only shows 0.478 μm of surface roughness profile. The results of dust build-up inside the both of HVAC air ducts measured using vacuum test method. The vacuum test was found to be an efficient method of collecting dust samples on the duct surface. The dust at three different interval of distance are vacuumed at a specific area of 100cm^2. The mean amount of dust build-up on fabric duct was slightly higher compared to the galvanized steel duct. The highest mean amount of dust build-up was found at the end of the ducts and the lowest amount is near the duct fan outlet.

DEDICATION

I dedicate this project to Allah Almighty my creator, my strong pillar, my source of inspiration, wisdom, knowledge and understanding. He has been the source of my strength throughout this program and on His wings only have I soared. I also dedicate this work to my family who has encouraged me giving me chance to prove and improve myself all the way and throughout the journeys I have been through to complete this report. This project also is especially dedicated to my supervisor, for her willingness to guide me to the success of this research for my degree.

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The success of a project depends on the contributions and supports of many persons. There were many people that I would like to appreciate for their support for the duration of this project.

First of all, I would like to express my gratitude to my supervisor Mrs. Norain Binti Idris. She was responsible to supervise and monitor my progress of this project thesis. She has been patiently monitoring my progress and guided me in the right path and offering her encouragement to me. I am grateful to my supervisor who always being my guidance and advisor throughout the duration of the project. Otherwise, this project has not been possible. I have learnt a lot under her guidance, be it practically or theoretically. My special appreciation and thanks to my family especially to my parents Mohd Rosli Bin Derahman and Rehan Binti Omar that always stands by me no matter what happens. Their full support and encouragement were such a boost for my capabilities and confidence to undergo this period.

Last but certainly not least, I also want to thank all my friends for their invaluable assistances towards this project thesis. Not forget to mention everyone who involve in this project either direct or indirectly. I must admit here that it was impossible for me to complete my project thesis without the supports of them that I mentioned above.

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AHU	-	Air Handling Unit
CCWS	-	Central Chiller Water System
CFM	-	Cubic Feet Per Minute
HEPA	-	High Efficiency Particulate Arrestance
HVAC	-	Heating, Ventilation and Air-Conditioning
IAQ	-	Indoor Air Quality
PMI	-	Prihoda Premium (Air-permeable) fabric
mm	-	milimetre
m/s	-	Meter per second
g/cm^2	-	grams per centimetre square
ft/min	-	feet per minute
m	-	metre
RPM	-	Revolution per minute
PM	-	Particulate Matter
Ra	-	Roughness average
µm	-	micrometre
<	-	Less Than
>	-	More Than

CHAPTER 1
INTRODUCTION

1.0 Introduction

In this chapter, introducing the title of my Bachelor Degree Project 1 (BDP 1) as well as little background on why such title is chosen and how the problem came about. The title of my project is "Correlation between Surface Roughness and Dust build-up in Fabric duct and Galvanized steel duct: A comparison".

1.1 Background

Air-Conditioning is a system that functioning to supply cool air, fresh air and provide thermal comfort to the conditioned space (Viswambharan, Patidar, & Saxena, 2014). In a heating and ventilation air conditioning (HVAC) system, the air distribution system such an important component to supply the amount of air to the room in a building. Air distribution system (ADS) is a system used to deliver the conditioned forced air made by an external device such as blower to carry heat and circulate it in building space to achieve required of thermal comfort. Air-distribution framework include air handlers, ductwork, and associated components for distributing air which is damper and diffusers. They provide fresh air to maintain acceptable indoor-air quality while providing conditioned air to balance heating or cooling loads (Int-Hout 2015). For large air-conditioning system usually use air handling unit (AHU) as a device to contribute the cool air to the conditioned space.

Lately, the pollution control has become a great concern issues. According to Liu et al. (2015) indicated that to prevent the growth of cultural fungi and bacteria in HVAC systems, the dust accumulation, humidity and temperature should be properly controlled. Air duct is the one of HVAC system components that plays a major role in the perceived indoor air quality of a commercial building (Pitarma et al. 2016). Therefore, protection of indoor air quality and human health can be achieved via a clean duct system, which has becomes one of the most important requirement to supply good air quality for the buildings. According to U.S. Environmental Protection Agency, (2012) has listed the major source of indoor air pollution are from dirty air duct systems where every time the heating and cooling system runs, the airborne contaminants are pulled into the air ducts. With increasing period, the level of indoor air quality inside the conditioned space decreases if these contaminants build-up inside the ductwork. Some studies have suggested that routine duct cleaning is an effective strategy for improving indoor air quality (Mensah-Attipoe et al. 2015), while others have proposed applying a coating film to the duct surface in order to improve microbial pollution conditions (Tsay et al. 2016). Based on the statement, it can be concluded that the ductwork material also plays a role in order to control the build-up of contaminants through air duct system. Therefore, the focus of this study is to investigate the surface roughness of ductwork material and its capability to reduce the effect of air contaminants build-up.

1.2 Problem statement

The sources of indoor air pollution may be present from our air duct system which is the equipment that plays a role in air distribution inside the building (U.S. Department of Energy 2015). In Malaysia, the ductwork system that principally used for conduit conditioned air is galvanized steel duct, fibreglass duct board and flexible duct. However in 2014, a new technology in ductwork system named fabric duct has been introduced in Malaysia from Prihoda Company. The word fabric air dispersion system would be the more definitive designation for fabric duct. Since Malaysia has focusing to green building technology, the fabric duct had become

popular because it provide more environmental friendly due to the used of high quality material, unique design, low cost installation and offer excellent comfort on air distribution system. However, the assessment of cleanliness and IAQ level of these material are in question. Based on literature review, the Prihoda fabric duct currently has limited data on their product according to the advantage and disadvantages compared to the conventional duct. Therefore, the idea then comes to look for and make this research. The material of the air duct system must take into account especially its capability to control the presence of air contaminants. So, the significant of this study is to provide a cleanliness result for fabric duct compared with galvanized steel duct in terms of the capability of both material to control the presence of dust. Thus, the Prihoda Company can referred to the result that will be collected in order to deal back with their product for improvement.

1.3 Objective

Based on research title, "Correlation between Surface Roughness and Dust build-up in Fabric duct and Galvanized steel duct: A comparison", the objectives below are pursued.

a) To measure the surface roughness of galvanized steel duct and fabric duct.
b) To measure dust build-up at the inner surface of galvanized steel duct and fabric duct in increasing distance.
c) To find the correlation between surface roughness and the amount of dust build-up at increasing distance surface of the duct.

1.4 Scope of the research

This project is only focus on evaluation of inner duct surface roughness and its effect on dust build-up in duct. Two duct materials which are galvanized steel duct and fabric duct will used for analysis. Besides, the both duct has round shape, 1.2 m length, and 10 inch diameter. The real dust that usually encountered in ductwork system was replaced by talcum powder. The parameter in this study context is the influence of distance on the resulted weight of dust along the duct. Data collection was taken in every 10 minutes of different amount of dust introduced into the duct.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter will focus on the theory and terms mainly related to this research. The sources of theory are from previous research, related articles and from the global standard. This chapter aim to give better understanding about this research and give strong evidence, support and reasons why this research should be done. Figure below show the overall topic that will covered in this study context and has simplified into K-charts.

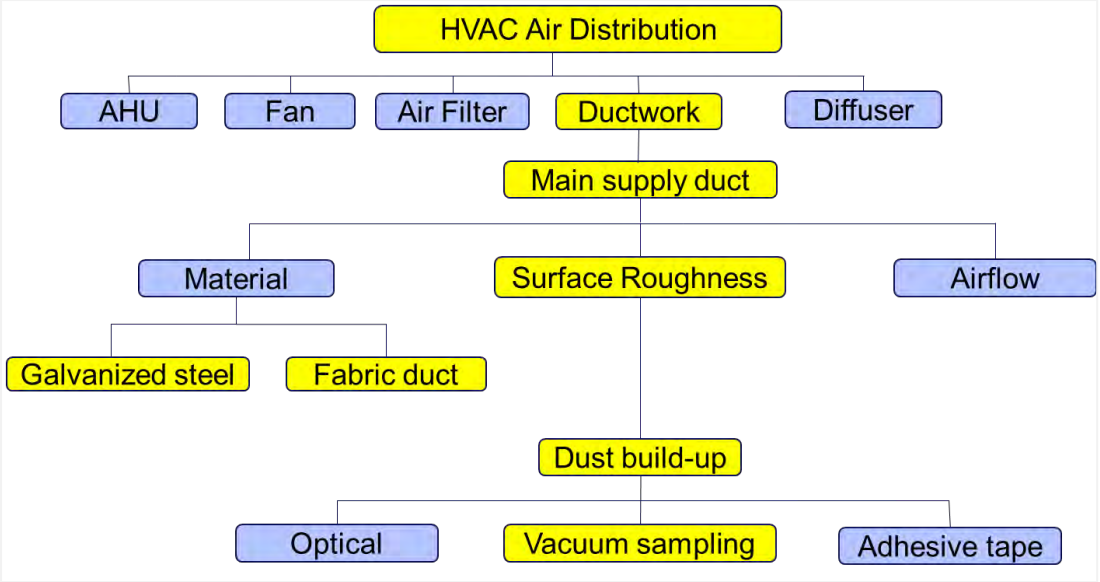

Figure 2.1: K-charts

2.1 Air Distribution System

An air distribution system is a process centrally to produce a desired temperature and humidity, then distributed to the conditioned space and zone such as in commercial office buildings and industrial facilities. Air-handling unit (AHU) is a place where the air is conditioned and includes of damper, plenum chamber, heating and cooling coil, and a fan. Damper use to regulate the return and outdoor air flow while the plenum chamber is the place where recirculation and ventilation air mixed. The conditioned air is distributed through supply ducts to all of the zone after leaving the air-handler unit.

According to (John W. Mitchell and James E. Braun, Principle of HVAC in Buildings, 2013), the design of the air distribution system is important to meet the comfort and air quality criteria in the occupied space. The ducting must be sized according to the desire flow to each space in an economical fashion. Since the air flow are often varied to meet the actual load, each zone must have a variety design flow rate. Figure 2.2 shows the schematic of an air distribution system.

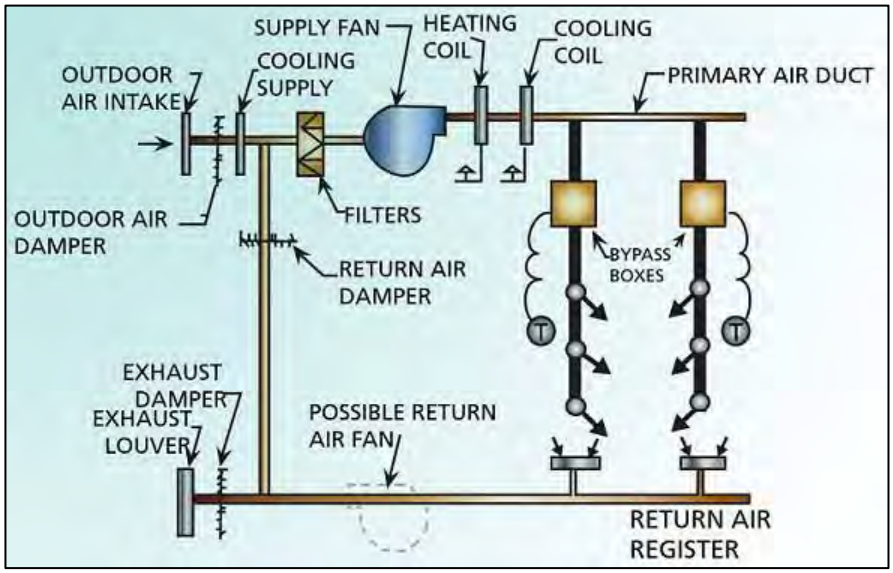

Figure 2.2: Schematic of an air distribution system.

(Sources: https://www.myodesie.com/wiki/index/returnEntry/id/2990)

2.1.1 Air Filter

Air filter is the component that should have in HVAC system to provide good indoor air quality. The air filter plays a significant role in HVAC system. Every place with ventilation system will needs an air filter. For example, occupants need the air filter because of many environments that have been affected by airborne particle that cannot be seen with the naked eye. It can be said that the air filter acts as a clean process and air pollution control. Particulate matter or also known as particle pollution that associated with increased respiratory symptoms is a complex mixture of extremely small particles and liquid droplets (Environmental Protection Agency, 2012). The symptoms of sick building syndrome has been reported that it is associate with the concentration and build-up of dust in the indoor environment (Zhou et al. 2011). This is precisely explained that the dangerous of particulate matter such as dust particle is spread to the conditioned space contributes to worsen health of occupants in a building.

The length of the intervals between cleaning can be increase if the supply air ducts is protected by highly efficient filtration during operation of the system (Pasanen et al. 2007). Inadequate of HVAC filtration in air handling unit side is a cause of dust particle and other contaminants entering the ductwork system. Poor design and efficiency of HVAC air filter will lead the small particles such as dust is transported with air through the ductwork (Quang et al. 2013).

Figure 2.3: Bad AHU air filter.

(Source: http://globalnews.ca/news/1621011/what-you-need-to-know-about-furnace-filters/)

2.1.2 Air Handling Unit (AHU)

The air handling unit (AHU) is one of the most crucial and critical units to take in account when designing HVAC system. As defined by (Koh et al. 2015), air handling unit (AHU) is a set of modular components that mainly consist of a fan in a cabinet with a motor. It regulates and circulating the air as part of a HVAC system. Other component that can be found in an AHU are cooling coil, heating coil, filter and damper. AHU are connected to the ductwork of the HVAC system whereas it distributes the conditioned air to the building through the duct. The general purpose of AHU is to collect and mix outdoor air with that return air from the building space.

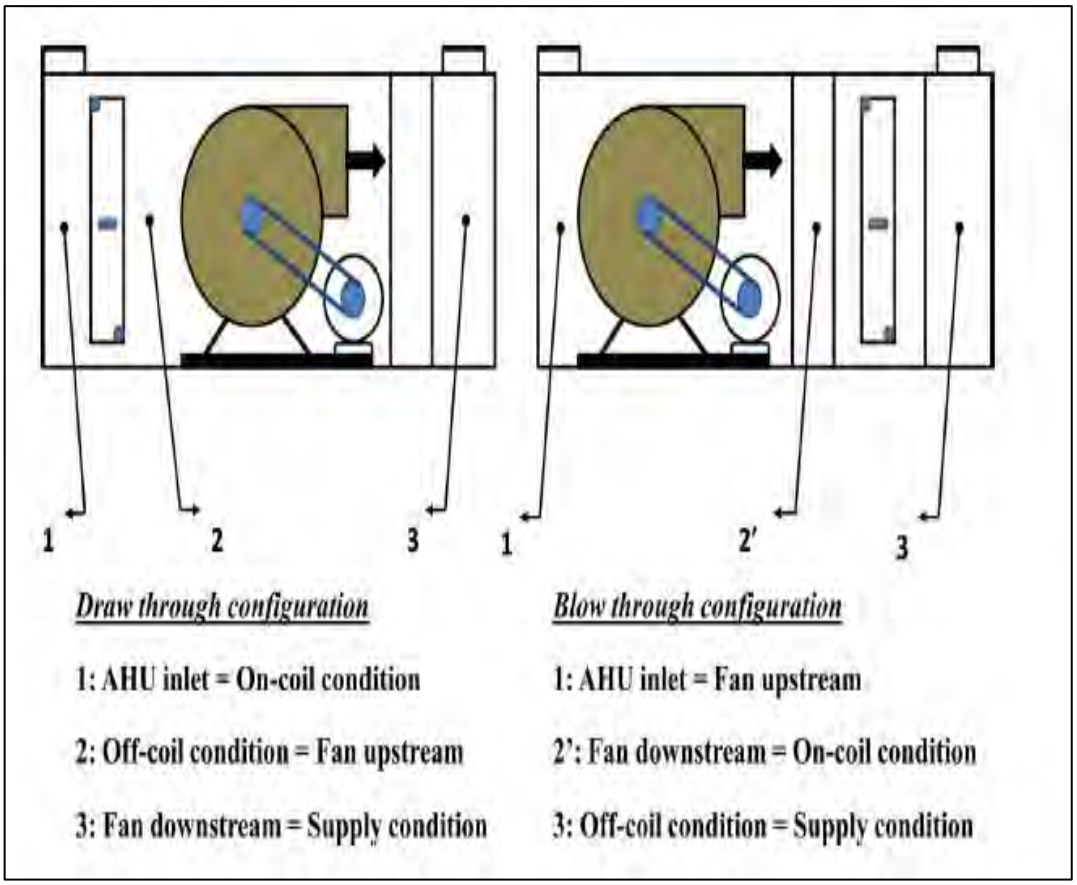

Figure 2.4: Draw through and Blow through AHU basic configuration

(Sarkar 2013)

The AHU size are depends on the number of equipment size used at a specific design. AHU can be devided into two basic configuration based on the fan location with the coil section. The two configuration are draw through and blow through. Draw thorugh type of AHU has a higher cooling load compare to blow through types, however from energy efficiency point of view blow through type is better (Sarkar 2013) . He state that it should consider the pros and con to make the best decision depending on many factor when making selection for HVAC system used.

2.1.3 Fan/ Blower

A fan is the prime mover of air in the HVAC system. It provides continuous circulation of air throughout the system and conditioned the spaces area. AHU is the complete unit where the fan can be found. The fan convert the rotational mechanical energy to a total pressure increase of a moving air (Units 2007). The total pressure consist of static pressure and velocity pressure. Selecting the appropriate fan is needed accurate calculation of static and velocity pressure in the duct work. There are many types of fan used in HVAC system. The types of fan used are depends on the application or requirement characteristic. The common types of fan used for HVAC systems are axial and centrifugal fan.

An axial fan used a propeller to draw the air into the fan and blow it in the same direction. The air flow within the fan wheel parallel to the fan shaft. The common type of axial flow fan are propeller, tube axial flow and vane flow fans. Centrifugal fan draw the air into the inlet of the blower housing and discharges the air 90 degrees out of the housing inlet. The working principle of this fan is the air are radially discharged from the impeller. Centrifugal fan types are forward curved, backward inclined, backward curved and airfoil fans. These two types of fan increase the total pressure of the air by producing the velocity pressure.

2.1.4 Diffuser & Dampers

A diffuser is a supply air outlet generally found in the ceiling with various deflectors arranged to promote mixing of primary air with secondary air. The types of diffusers that can be found are round, square, rectangular, linear and light troffers. Some diffusers have a permanent air flow pattern while others have field-adjusted patterns.