SQUARE VENTILATION AIR DUCT MODELLING AND VALIDATION AND THE EFFECT OF ANGLE CHANGE

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B091910172

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

2023

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical and Manufacturing EngineeringTechnology

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor Of Mechanical Engineering Technology (Refrigeration and Air Conditioning System) with Honors

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DECLARATION

I declare that the title "Modeling of square ventilation airways and the effect of confirmation of angular changes using variable airflow" is the result of my own research except as quoted in the reference. Select an unaccepted title for any degree and is not simultaneously submitted in the nomination of any other degree.

Signature :

Name : NORAIMAN NAIM BIN CHE IBRAHIM

Date : 07/06/2023

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 System) with Honors.

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Date : 07/06/2023

DEDICATION

This thesis is dedicated to my father, Che Ibrahim Bin Mamat, told me that the finest form of knowledge to acquire is that which is learned for its own reason. It's also dedicated to my mother, Siti Robiah Binti Ibrahim, who showed me that even the most difficult endeavour can be completed if approached in little steps. Both of them have supported me throughout the process, and their encouragement has ensured that I give it everything I have to finish what I have begun.

ABSTRACT

Due to the high degree of design and installation flexibility, ventilation ducts are extensively utilized. However, excessive use may increase pressure drop and increase energy use. This study used experimental measurements to analyze the pressure drop in ventilation ducts with bending angles. This study began by measuring the pressure drop in 90 degree with different compression ratios and airflow rates. The pressure for 90 degree ducts was adversely related to the compression ratio. Next, the pressure drops in single-bend ducts with bending angles ranging from 45°, 65° and 90° at airflow speeds were measured. For single-bend duct works, the predictedloss coefficient of the bend increased with bending angle. This study's findings can be used to quantify the total pressure loss in building ventilation ducting systems.

ABSTRAK

Oleh kerana tahap reka bentuk dan fleksibiliti pemasangan yang tinggi, saluran pengudaraan digunakan secara meluas. Walau bagaimanapun, penggunaan yang berlebihan boleh meningkatkan penurunan tekanan dan meningkatkan penggunaan tenaga. Kajian ini menggunakan ukuran eksperimen untuk menganalisis penurunan tekanan dalam saluran pengudaraan dengan sudut lentur yang berbeza-beza. Kajian ini bermula dengan mengukur penurunan tekanan dalam 90 degree dengan nisbah mampatan dan kadar aliran udara yang berbeza. Faktor geseran yang ditentukan untuk saluran lurus adalah berkaitan dengan nisbah mampatan. Seterusnya, penurunan tekanan dalam saluran satu lentur dengan sudut lentur antara 45°, 65° dan 90° pada kelajuan aliran udara diukur. Untuk saluran selekoh tunggal, ramalan pekali kehilangan selekoh meningkat dengan sudut lentur. Dapatan kajian ini boleh digunakan untuk mengukur jumlah kehilangan tekanan dalam membina sistem salur pengudaraan.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I want to express my gratitude and thanks to Allah the Almighty, my Creator and Sustainer, for everything that I have received from the beginning of my existence. I'd like to express my gratitude to Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform as well as financial support.

My principal supervisor, TS. MOHD FARUQ BIN ABDUL LATIF , deserves my gratitude for all of his help, counsel, and inspiration. His unwavering patience in mentoring and imparting invaluable insights will be remembered for the rest of his life. He also helps in financial form.

I would also like to thank my beloved parents for their endless support, love, and prayers. Finally, thank you to all the individuals who have provided me with the assistance, support, and inspiration to embark on my studies.

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1.1 Background

The ability of humans to maintain a tolerable body temperature has been and will continue to be essential to their survival. Numerous studies have been undertaken to determine the ideal balance between warmth and mobility. Ducts are the conduits responsible for eliminating warm or stale air and transporting cooled air from the air conditioning unit to different areas in the home. The duct work constructed for central air conditioning can be used for various functions, such as heating and filtration. Ducts are one of the most ignored components of a heating, ventilation, and air conditioning (HVAC) system, even though they play a key role in ensuring our comfort regardless of the temperature. Despite being one of the most neglected components of an HVAC system, this is the case. Air ducts are responsible for distributing conditioned (either cooled or heated) air to each room in a structure. The remaining components of the HVAC system would be rendered ineffective without air ducts. For ventilation purposes, users have access to a variety of duct systems in both residential and commercial structures. It is not needed that you know everything there is to know about any duct system on the market, but it would be to your benefit if you did. It will be of great service, especially in terms of the maintenance of the duct system in your residential or commercial building.

There are two distinct forms of duct work, rigid and flexible, each with its function. Rigid ducts, also known as spiral ducts, are metal pipes utilized in permanent ventilation, heating, air conditioning systems, and massive dust and exhaust extraction plants. Rigid ducting is adaptable to a wide range of applications and building configurations.

Additionally, it is more durable than its flexible sibling. However, the size and strength of rigid ducting make it less suitable for close locations and smaller applications and increase installation costs and duration. For non-corrosive applications, PVC plastic and polypropylene duct work can be used in place of rigid metal duct work, such as stainless steel or galvanized carbon steel.

Figure 1.1. Rigid duct

Flexible ducts are an alternative to the standard rigid ducts used in heating, ventilation, and air-conditioning (HVAC) systems in buildings or vehicles. When it comes to attaching air supply outlets to rigid trunk duct work, also known as flex duct work, it is a highly convenient form of ducting. In many circumstances, the entirety of the duct system is made up of a flex duct. Flex duct explicitly manufactured for use in HVAC systems consists typically of a plastic inner liner attached to a metal wire helix (or coil) to form a round shape. A layer of insulation made of fiberglass blanket is already bonded to the duct so that it surrounds the duct. A vapor barrier made of polyethylene or foil is placed over the insulation to cover and protect it. Insulation ratings of R-4, R-6, and R-8 are typically the ones that are available for flex ducts. Insulated flex duct typically comes in diameters ranging from 4 inches to 10 inches for use in home HVAC systems. Above 10 inches in diameter, it is available in even numbers of 12, 14, 16, etc., all the way up to 22 inches when measured at the radius of the metal helix.

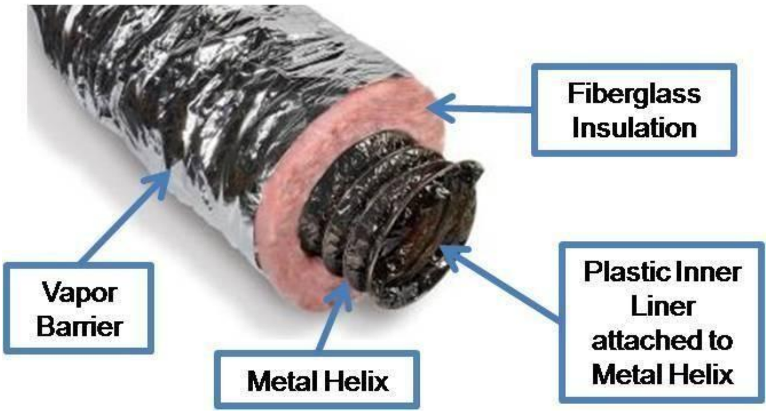

Figure 1.2. Flex duct comprises a plastic inner liner attached to a metal coil, a layer of fiberglass blanket insulation, and a plastic or foil vapor barrier.

Figure 1.3 Because flex duct is flexible, contractors are frequently tempted to bend it too much or squeeze it through too tiny spaces. Compression can limit airflow, reducing HVAC system performance and causing homeowner comfort complaints.

Insulated flex duct can be an economical air duct material. Flex duct is capable of effortlessly bending over minor impediments. Flexibility is both the greatest strength and weakness of the flex duct. Due to how easily it bends, there is a temptation to disregard HVAC placement in framing designs. Then, when HVAC is placed after framing, the duct work may be unduly bent or squeezed to accommodate obstructions. Compression restrict airflow to impacted rooms and increase pressure on the system fan, resulting in increased energy consumption and premature fan damage. See Supply Return Static Pressure to learn more about HVAC fan static pressure and pressure drop in HVACsystems.

Figure 1.4 Cooperation with plumbing and electrical crews is necessary to prevent the crushing of flex ducts by plumbing and wiring installations.

Due to the increased resistance, the routing of flex duct, the number of bends, the degree of the bends, and the amount of sag between supports will negatively impact the overall pressure drop across the duct system. When making a curve or turn in the flexible duct, avoid sharp corners and do not exceed 90-degree turns. Instead, use gradual curves. Avoid accidental contact with metal fittings, pipes, and conduits, especially in humid environments where squeezed insulation can cause moisture problems. The most effective method for avoiding conflicts between the HVAC duct system and other services, such as plumbing and wiring, is to arrange the HVAC system architecture at the initial design phase.

However, the pressure loss in flexible ducts tends to be higher than in traditional rigid ducts. It resulted in increased energy expenses for fan operation. In addition, the installation of flexible ducts typically results in complex ducting system geometry with needless bends due to their flexibility. This would make it more challenging to anticipate the air pressure distribution within these ducts. It is crucial to comprehend the pressure drop characteristics to optimize the design and installation of flexible ventilation ducts.

This study undertook experimental measurements to characterize the pressure drop in square ventilation ducts over a broad range of compression ratios and bending angles. This study began by measuring the pressure drop in ducts with four different compression ratios and varying airflow rates. Under varied airflow rates, the pressure decreases in single-bend square ducts with bending angles ranging from 45° to 90° were measured. Then, the loss coefficients of the bends were determined. The influence of intermediate duct length on the pressure decrease across bends was explored experimentally. This study's findings can calculate the total pressure loss in buildings' flexible ventilation ducting systems.

1.2 Problem statement

In heating, ventilation, and air conditioning (HVAC), ducts are used to distribute and remove air. Airflow such as supply air, return air, and exhaust air are required. Commonly, ducts deliver ventilation air in addition to supply air. Consequently, air ducts are a means of guaranteeing appropriate indoor air quality and thermal comfort. There are two types of duct works, rigid and flexible. Rigid ducts are available in a variety of materials, sizes, and shapes, including cylindrical and rectangular. As its name implies, rigid ducts are inflexible and are not susceptible to bends or kinks that hinder airflow. In contrast to flexible ducts, they cannot be pierced or ripped. However, the primary disadvantage of stiff ducts is that they do not function well in awkward places. Sheet metal ducts, fiberglass-lined ducts, and fibreboard ducts are the three most common forms of rigid ducting depending on their respective construction materials. When ductwork is installed at an angle, the air pressure and flow are affected. When this occurs, the cabin cannot reach thermal comfort.

It is vital for management to do baseline inspections and monitor channel data in order to maintain track of conditions and validate the present performance of the established channel work system. A thorough evaluation of the area's performance is required to ensure thermal comfort and adequate ventilation.

1.3 Research objective

The main aim of this research is to estimate the square ventilation air duct modelling and validation effect of angle change using variable air flow. Specifically, the objectives are as follows:

- To develop validation methods for grid sensitivity analysis.
- To study the flow mechanism of duct work.
- To study the impact of airflow velocity variations to the duct work flowmechanism.
- To study the relation of turbulence kinetic energy with ducting geometry.