I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the Bachelor of Mechanical Engineering (Structure and Material).

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MECHANISM DESIGN AND ANALYSIS OF HVAC INSPECTION CRAWLER

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I hereby the author, declare this report entitled "MECHANISM DESIGN AND ANALYSIS OF HVAC INPECTION CRAWLER" is my own except for quotations and summaries which have been duly acknowledged.

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ABSTRACT

Usage of robotic expansion as additional element in any various work recently grow rapidly. This phenomenon happens by existence of many research and development (R&D) for the robot of individuals and parties. Increasing of many researches especially in robotic technologies make most of job and duty have been done by assistance of robot and technologies. Some job only can be perfectly done by technologies. According to the existence of new technologies also affect the method of HVAC inspection. The problem of ducting inspection is un-ability of human to crawl along the ducting to do inspection. This is especially to located the ducting crack or find any problem along the ducting. A new technology is using a robotic crawler to be human eyes to inspect the critical location on the ducting. Various crawlers enter the global market with high value and price. The mechanism of some crawler remains the same but the difference is the body and chassis design. For this project will develop new mechanisms that can apply to the crawler. A simple mechanism is used to reduce the cost but high effective product.

ABSTRAK

Pengunaan robot sebagai elemen tambahan dalam pelbagai kerja kini semakin meningkat. Fenomena ini berlaku kerana kewujudan pelbagai kajian dan pembangunan robot oleh individu atau pihak-pihak tertentu. Peningkatan bilangan kajian tertutama dalam teknologi robot membuatkan kebanyakan kerja dan tugas dilakaukan dengan bantuan robot dan teknologi. Malah, sebilangan kerja hanya boleh dilakukan degan lengkap oleh teknologi. kewujudan teknologi baru ini turut dirasai oleh proses pemeriksaan HVAC. Masalah utama dalam proses pemeriksaan saluran HVAC adalah ketidak-bolehan manusia untuk memasuki sepanjang saluran itu untuk membuat pemeriksaan. Terdapat juga aplikasi kamera kabel untuk pemeriksaan ini. Kaedah terbaru dalam pemeriksaan salur HVAC ini adalah mengunakan perangkak robot atau *'robotic crawler'* yang bertindak sebagai 'mata manusia' bagi memeriksa salur HVAC tersebut. Pelbagai jenis crawler telah berada dalam pasaran. Hampir keseluruhan crawler ini mengunakan mekanisma yang sama tetapi berbeza dari segi badan dan casis. Pada project ini, ia akan memaparkan sebilangan mekanisma baru yang dibagunkan untuk di aplikasikan pada crawler tersebut. Mekanisma mudah digunakan untuk mengurangkan kos tetapi menghasilkan produk yang effective.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

This project is for usage of any air conditioning maintenance team in various building especially HVAC maintenance team. This project is a development in HVAC inspection, maintenance and commissioning.

1.2 DUCTING INSPECTION AND CLEANING

Normally ducting inspection will be done first before do the cleaning progress. But the inspection also will be done for any mounting like to check the malfunction of the ducting, to check any crack etc. This is because the inspection is the method to measure the usage of cleaning. Even for some building, the weekly, monthly or permanently cleaning can be provide but the inspection must be done before the cleaning. This is to view in the ducting for its condition either the cleaning should be done or not at the time. This step can reduce the building cost maintenance.

The inspection also used to find and solves a problem in the duct duty. Like some example of air conditioning leakage problem at KLIA. The leakage happens in the ducting but the actual position of the leakage unable to locate.

The cleaning process is important to maintain the duct in good conditioned and cover its long lasting or life span. Cleaning should be done after an inspection done. How can the cleaning run up without make an inspection before and after the cleaning process? This might be use. But for some building owner, they have to know the progression of the cleaning like before and after the cleaning. This is more to picture or some view of the internal ducting.

However, in some inventor and opinion there is no need for ducting cleaning according to its compact custody and protection. Ducting system is equipped with air filter at the resource. This filter will entrap the dust and hazard as well. The cleaning process only need for this filter by replace it in some period. Thus, the cleaning of the ducting is not an important step for the building safety environment. But, this progress can be done if asked to. The cleaning is suggested by many healthy organizations like OSHA, ASHRAE, and NADCA etc. But for this project I emphasizing on inspection method only.

1.3 PROBLEM STATEMENT

HVAC ducting condition can be done with direct visual inspection. Direct visual inspection means the inspector will check ducting existing. This method only used for existing ducting like under ceiling module. The visual inspection only can inspect the condition of the ducting externally. But the problem occurs in upper ceiling module where it's a difficulty for the inspector to climb in the ceiling and inspect for the whole ducting.

The second problem is on progress to inspect internal condition of the ducting which might full of dust and fragile. This problem can be solves using a cable cam camera or push camera but the distance and it's efficiently is not too good. By using a cable camera, it too difficult to move it to the ducting and don't have a clearly view. The inspector needs to push the camera and reel into the duct.

Some manufacturer and robot expertise have created and produced the moving robot crawler which can be used for inspection in ducting. However the existence product is more compactable and cost more. The entire product is more on flat smooth tracks. There are several robotic crawlers using a tank wheel mechanism but the weight is not suitable and some of them using an ordinary round wheel. This kind of crawler can be used just in smooth flat tracks but the problem happen whenever the crawler moving on non-tabular track.

1.4 OBJECTIVE

This objective of this project is to design a new model of HVAC inspection crawler's mechanism. Beside, this project also does an analysis of the designed mechanism.

1.5 SCOPE OF WORK

In this project, the scope of work will cover a design of new mechanism and analysis. In order to fulfill the objective, the existing crawler in market will be a reference to design the new model and mechanism.

CHAPTER 2

LITERITURE REVIEW

2.1 DUCTING & HVAC SYSTEM

Almost every commercial building and office has an air conditioning unit. It has become a necessity of modern life. For a small office, a window air conditioning unit will suffice. These are self contained units which do not need much skill to install. Nowadays, the trend is to use split air conditioning units in the average sized office and home because they are quieter. However, there are some amounts of drilling, joining of tubes, vacuuming, charging of refrigerant gas, and other installation works to be done. Larger buildings make use of Central Air Conditioning. The basic concept of cooling or heating remains the same. However, the system can be designed to be very complex if necessary. Automatic temperature controls, microprocessor and operation logic controls, building automation controls, and other smart features have made some systems beyond the handling capability of many normal technical people. New types of refrigerant are constantly being developed to produce minimal damage to the environment. New materials have to be used to work with the new refrigerants. Better efficiency methods are adopted for maximum energy savings. Air conditioning is more than just cooling or heating the environment.

In central air conditioning system, usage of chill water is one of important item. The system used chill water from chiller as coolant fluids to reduce the air temperature. Some of the building used a cooling tower to provide chill water while some building used a chiller. The cooling process will be done in Air Handling Unit room (AHU) and the cool air will be transmitting using a ducting. Ducting is the most important and particular component. Ducting act like a conductor and distributor of the cooled air from source to sink like rooms and hall. There 3 type of ducting:

- Air conditioning ducting
- Heating ducting
- Ventilating ducting

According to this 3 type of ducting a general named call heating, ventilating and air conditioning (HVAC) ducting.

2.1.1 AIR CONDITIONING DUCTING

Air conditioning ducting is the most economic and efficient method of distributing warm and cold air. A typical ducting system consists of one or more inflatable ducts suspended overhead from steel wires. Rows of small holes in the sides of the ducts produce jets of air, with enough throw to create continuous gentle air movement throughout the building. Ducting is compatible with most fans, heaters, air conditioners, air handling units, etc. Its adaptability and very low cost make it suitable for use as heating, cooling or ventilation ducting in a wide range of buildings and industries. Ducts are the most cost effective and efficient method of conveying cold air from point to point, and distributing it where it's needed. Most or some of ducts are manufactured from lightweight polythene, and are compatible with most air conditioners, evaporative coolers and fans. Air conditioning ducting is used to improve cold air distribution. Without air conditioning ducting the effect of a fan, air conditioner or cooler is limited to a small area immediately in front of the air outlet. Attaching

ducting allows the cold air to be directed to specific 'hot spots' to provide localized cooling, or diffused over a wide area to reduce temperature gradients. It's also Reduce air velocity by reduced air speed stops cold drafts, and lowers noise levels. Air conditioning ducts are usually suspended overhead from steel wires. Rows of small holes in the sides of the ducts produce jets of cold air that mix with the warmer room air before falling to floor level. Leading to draft free air movement throughout the building and reduced temperatures. Holes normally placed at 10 o'clock and 2 o'clock provide draft free air diffusion. For wide building the hole are placed at 9 o'clock and 3 o'clock. (Please refer to FIGURE 1)

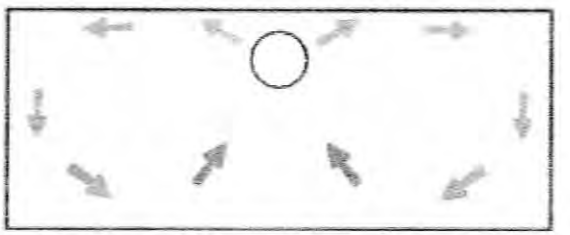

FIGURE 1 The hole located at ducting

In very hot environments, such as foundries, commercial laundries, bakeries, etc. the holes are moved to 4 and 8 o'clock. The jets of cold air are now directed downwards, displacing hot air which is forced up and away from floor level. By using numerous small jets the air velocity is kept low, ensuring the workforce do not complain of uncomfortable cold drafts. Sections of plain and perforated air conditioning ducting can be connected to portable air conditioning units to provide spot cooling. This is very popular where cooling a large area is uneconomic or unnecessary. Cold air is discharged precisely where needed, keeping energy costs low.

2.1.2 HEATING DUCTING

Heating ducts are the most adaptable and efficient method of distributing and diffusing warm air. Heating ducts are compatible with most warm air heaters and air handling systems, and are used in place of metal ductwork to improve air distribution and reduce temperature gradients.

Heating ducts are designed for use in buildings with large open roof spaces, as found in factories, warehouses, workshops etc. They are suspended overhead from thin steel wires. Holes in the sides of the ducts create jets of warm air, which are directed downwards, where they mix with the cold air below eradicating temperature gradients and producing uniform temperatures.

Heating ducts help to reduce heating bills in several ways:

- Reduced heat loss through the roof - By creating air movement throughout the building, temperatures in the roof space are reduced, which in turn lowers the heat loss through it.
- Reduced stratification - Thermostats can be set to a lower level. Constant air mixing reduces the build up of pockets of cold air and stratification, creating a uniform temperature throughout the building.
- Reduced condensation - Improved air distribution, prevents layers of cold air and condensation forming on walls, doors, windows, shelves, etc.
- Spot heating - Holes in the heating ducts are placed only where needed, heating occupied areas without wasting energy on storage areas, loading bays, etc

For a modern building with 5m (16ft.) eaves savings of up to 10% per annum are possible leading to payback is less than two years. Because of air stratification, savings increase with the height of the building. For the wide buildings - one or more heating ducts are suspended overhead on lightweight steel wires.

The heating ducts have rows of large diameter holes positioned at 4 and 8 o'clock (or 5 and 7 o'clock) forcing powerful jets of warm air towards floor level. (Please refer to FIGURE 2).While for the narrow buildings or low level ducts - smaller holes is used. It's positioned at 3 and 9 o'clock to create a gentler diffused air discharge. This reduces the air velocity, stopping strong jets of warm air coming in contact with the workforce.

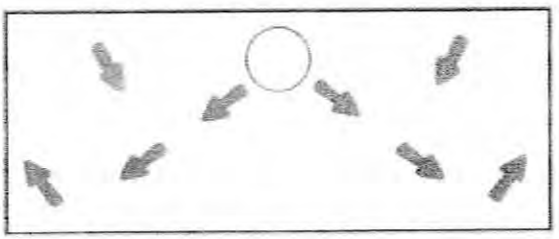

FIGURE 2 The hole located at heating ducting

2.1.3 VENTILATION DUCTING

Ventilation ducting is the most economic, accurate and efficient method of conveying and diffusing fresh air. Manufactured from polythene tubing, ventilation ducting is used in a wide range of industries and applications including:

- Emergency services - delivering fresh air into collapsed buildings
- Petrochemical industry - ventilating storage tanks and pits undergoing maintenance
- Site maintenance - providing fresh air to welders working in enclosed areas
- Agriculture - delivering fresh air into animal houses, mushroom growing rooms, etc.

Ventilation is also used and needed in animal houses to:

- Remove excess heat - High temperatures are unpleasant for workers and animals, although mature cattle and sheep are tolerant of high ambient temperatures, young animals are less so, and air movement helps by encouraging the bodies' natural cooling system.
- Reduce damage by moisture - the average cow breathes out 5 gallons of water vapor a day. Ventilation prevents it settling on surfaces of the structure and damaging it.
- Remove noxious gases - Reduces respiratory problems and pneumonia, and improves the health of animals and workers alike by removing ammonia, hydrogen sulfide and methane.
- Discourage flies - flies prefer still air

A typical installation consists of an axial fan suspended in the roof space at one end of the building which draws fresh air in from outside. Ventilation ducting is connected to the fan and runs down the length of the building (please refer FIGURE 3). Holes cut into the sides of the ventilation ducting distribute the fresh air in a series of high pressure jets.

FIGURE 3 Air movements in Ventilation ducting

Displaced air leaves the building via holes in the structure, cracks, open doors or windows etc. Where necessary additional pressure operated vents should be installed, manufactured from aluminum or plastic, they have flaps which are lifted open by pressure from the inside air as it escapes but stay firmly closed when outside winds blow on them. The total area should be two to three times that of the fan.