UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION ON RELIABILITY OF USING SIGNAL PROCESSING AS REFRIGERANT PRESSURE DETECTOR

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

by

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2017

APPROVAL

This report is submitted to Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirement for the degree of Bachelor of Mechanical Engineering Technology (Refrigeration System and Air Conditioning) With Honours). The member of the supervisory is as follow:

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(Dr. Mohamad Haidir bin Maslan)

DECLARATION

I hereby, declared this report entitled “Investigation on Reliability of Using Signal Processing as Refrigerant Pressure Detector” is the results of my own research excepted as cited in references

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ABSTRAK

Sistem penyaman udara yang baik bergantung kepada beberapa faktor termasuk tekanan penyejuk yang sesuai dalam sistem. Masalah ini mendorong kepada punca utama kebocoran bahan pendingin dan pengecasan bawah atau pengecasan berlebihan. Lazimnya pemantauan tahap caj penyejuk hendaklah membawa kepada pengesanan awal kebocoran penyejuk dan mengelakkan daripada pengecasan bawah atau berlebihan. Ramai penyelidik percaya bahawa pemampat dengan penyejuk yang berbeza akan menghasilkan bunyi yang berbeza. Walau bagaimanapun, perubahan dalam bunyi mungkin tidak disedari oleh pendengaran manusia kerana ketidakpastian dengan bunyi biasa, atau kerana mungkin terganggu oleh bunyi lain dari mesin ataupun sekeliling. Penyelidikan ini bertujuan untuk mempelajari teknik pemprosesan isyarat yang berbeza untuk mendapatkan hubungan bagi menghasilkan isyarat dan tekanan penyejuk. Kajian ini juga dilakukan untuk memperkenalkan teknik baru untuk memantau tekanan bergantung hasil suara oleh pemampat. Telefon pintar OPPO R1L digunakan sebagai peranti peralatan untuk merekodkan bunyi pemampat sebelum menganalisis dengan menggunakan perisian MATLAB untuk mendapatkan perbandingan berbentuk domain kekerapan. Keputusan menunjukkan bahawa, julat amplitud yang lebih tinggi akan menghasilkan bunyi yang lebih kuat. Untuk pendingin udara jenis (*Inverter split unit*) jika terlalu rendah atau terlalu tinggi tekanan penyejuk amplitud yang terhasil akan lebih tinggi daripada amplitud untuk tekanan ideal. Oleh itu, ia menghasilkan bunyi yang lebih kuat berbanding normal pendingin udara jenis (*Inverter split unit*).

ABSTRACT

A good system of air conditioning depends on several factors including the suitable pressure of refrigerant in the system. These faults lead to early detection of refrigerant leakage and undercharging or overcharging. Frequently monitoring of the refrigerant charge level should lead to early detection of refrigerant leakage and avoidance of under or overcharging. Many researchers believed that compressor with different refrigerant will produce different sound. However, a change in sound may go unnoticed by human listeners due to unfamiliarity with the usual sound, or because sound may have interrupted by other sound from others machine surrounding. This research is purposely to study different signal processing technique to get the relation for the signal produce and refrigerant pressure. This study also purposely conducted to propose a new technique to monitor the pressure depending sound produce by compressor. Smartphone OPPO R1L is used as equipment devices to record sound of compressor before analyze using MATLAB software to get pattern in frequency domain. Result show that, as the amplitude range is higher will produce louder sound. For inverter type split unit if too low or too high refrigerant pressure the amplitude generate is higher than amplitude for ideal pressure. Thus, it's produce louder sound.

DEDICATION

Specially dedicated to my parents
My siblings,
My friends.
And to all those who stood beside me
For all your love and support

ACKNOWLEDGEMENT

In the name of ALLAH, the most gracious, the most merciful, with the highest praise to Allah that I manage to complete this final year project successfully without difficulty.

I would like to convey my sincere appreciation to my supervisor, Dr. Mohamad Haidir bin Maslan, for his constant guide along this research writing. It is impossible to for me fulfill this research requirement without his supervision and encouragement. He also has helped me to have better understanding regarding this research. I am truly grateful. I am grateful to all my lecturer for their continuous inspirations.

A special thanks to my beloved parents, Mr. Mirun bin Kasmiri and Mrs. Halidah binti Yunos for all the sacrifices they've done for me since I was a child until now. I also would like to express my heartfelt gratitude to my siblings who are always supporting and encouraging me through all my life. Your prayers and love gave me a lot of strength in order to finish writing this report. I also want to thank my teammates, classmates and friends who always helping, motivating and staying with me through thick and thins along this research. I am truly grateful to them

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Air conditioners are usually divided into two type which is split-type and multi-type air conditioners. Split unit type air conditioners consist of indoor unit and an outdoor unit connected by communication pipes. Multi split unit type air conditioners have many indoor units connected to an outdoor unit. Air conditioners may also be categorized into ones that air conditioners operate a refrigerant cycle in one direction to only supply a room with cool air, and ones that selectively operate a refrigerant cycle in two directions to supply a room with hot or cool air.

The good system of air conditioning depends on several factors including the suitable pressure of refrigerant in the system. These faults lead to early detection of refrigerant leakage and undercharging or overcharging. Both undercharge and overcharge can reduce cooling equipment life span, capacity, and efficiency of system. It showed that about 50 to 67 percent of all air conditioners in Canada suffer from improper charge or air flow problems causing them to operate 20 percent less efficiently than if the refrigerant is properly installed or maintained (Kim and Braun 2012). Compressor will produce different sound due to different pressure in the system.

A normal human listener can detect the changes in sound of a machine. The sound that made by machine can specify the condition of machinery. A change in sound may cause problem and warrant investigation by skilled maintenance personnel. However, a change in sound may go unnoticed by human listeners due to unfamiliarity

with the usual sound, or because sound may interrupted by other sound from other machine surrounding (Rice and Bailey 2005). Thus, a solution has developed that might be considered as machine independent pattern recognition. The general purpose is sound-matching algorithm that compares any sounds and measures their similarity. This algorithm can listen to and compare sounds from any type of machine. After characterizing a baseline recording of a machine, it compares the current sound with the baseline to detect changes in real time (Rice and Bailey 2005). The algorithm is suitable installed in a wireless sensor network, where each wireless node is equipped with a microphone. The wireless nodes can be easily placed by personnel throughout a factory or ship, near machinery to be monitored. Although the algorithm can compare vibration data, avoidance use of accelerometers which are more expensive and more difficult to install than microphones. After some initial configuration, the system begins as real-time monitoring of sounds (Lin and Dou 2016).

The Comparisonic's sound-matching algorithm was developed by S. V. Rice in 1997. Previously, sound effect collections could be searched only by entering a text description for each sound and then performing a keyword search of the text descriptions. According to (Rice,2005) sound is a searching, where by a user can specify any example sound and the system automatically recall the related similar sounds. This unique search capability has been incorporated into FindSounds.com, the first Web search engine for sound effects (Rice and Bailey 2005).

This project, to investigate on reliability of using signal processing as refrigerant pressure detector and compared with conventional pressure detector which is manifold gauge. The investigation have carried out using Advanced FFT Spectrum application to produce the signal processing for Panasonic type of split unit with different pressure. The different signal processing will be analyzed to get the relation for the signal produce and the refrigerant pressure.

1.2 Problem statement

All refrigeration systems have the potential to leak because pressures in the system are usually many times higher than atmospheric. Loss of refrigerant from industrial and commercial refrigeration systems can occur due to continuous leakage from joints or seals that cannot be identified for long periods of time, until sufficient refrigerant has been lost give affect the operation of the refrigeration system. In addition, the losses may occur when mechanical failure involved such as accidental rapture of a pipe or joint takes place and results in a significant loss of refrigerant charge in a short period of time. Loss of refrigerant also can occur during servicing when some refrigerant can be accidentally vented to gain access to a section of pipe or a given piece of equipment for repair (Tassou and Grace 2005).

Frequently monitoring of the refrigerant charge level should lead to early detection of refrigerant leakage and avoidance of under or overcharging. These faults lead to loss of efficiency and increase in costs. Based on tests of more than 4,000 residential cooling systems in California, only 38 percent have correct charge and have indicated that an undercharge of 15 percent is common (Kim & Braun, 2012). Both undercharge and overcharge can reduce cooling equipment durability, capacity, and efficiency. It has been reported that approximately 50 to 67 percent of all air conditioners suffer from improper charge or air flow problems causing them to operate 20 percent less efficiently compare to properly installed or maintained. Another study indicated that improper refrigerant charge amount can reduce the efficiency of systems by 10 to 20 percent in the field (Downey and Proctor, 2002)

Nowadays, the typical refrigerant charge level detector that HVAC technician commonly used is manifold gauge set. Manifold gauge set used to measure air conditioner unit pressure within closed system to evaluate and troubleshoot the central air unit. However, it may leak during servicing air conditioner system. There is a requirement for a real-time performance monitoring approach such as sound monitoring to leak detection and fault diagnosis which overcomes these disadvantages.

1.3 Objective

In this study, some target has been set to ensure that the current study is not stray away from the original target when investigation is conducted. The most important objectives of the current study are:

i. To study different signal processing technique to get the relation for the signal produce and refrigerant pressure
ii. To propose a new technique to monitor the pressure depending sound produce by compressor.

1.4 Scope

In order to achieve the objective of the study, several scopes have been stated.

i. This research is focusing on the air-conditioning split unit non-inverter and inverter type with different pressure to get the different signal processing.
ii. Signal processing will be analyzed on their frequency, amplitude, and the relationship with different refrigerant pressure.
iii. In order to get the signal processing, equipment that will be used is smartphone with Advanced FFT spectrum application.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section described the past researched related to the selected area of the case study. The review of basic refrigerant cycle, refrigerant presssure for the split unit, type of compressor, signal processing technique should be described, summarized, evaluated and clarify for this section.

2.2 Air conditioning system

An air conditioning or HVAC&R, systems is a combination of components and equipments arranged in sequence to conditioned space and control the indoor environmental parameters of a specific space within required limits (Wang 2000). Air-conditioning also treatment of air so its simultaneously control of temperature, moisture content, quality and circulation as required by occupant a process or product in space. The cycle of air-conditioning is consisting of four major component such as compressor, condenser, metering device, and evaporator.

2.2.1 Compressor

Compressor act as the heart in refrigeration and air conditioning system which mean it is the most costly among others component. The compressor is compressed

low-temperature, low-pressure vapour from the evaporator through the suction line. Due to vapour compression, it changes temperature and pressure. Therefore, the compressor change the vapor from a low-temperature vapour to a high-temperature vapour, and increasing the pressure. The vapour is then released from the compressor in to the discharge line (Wang 2000). There are many types of compressor depend on its application.

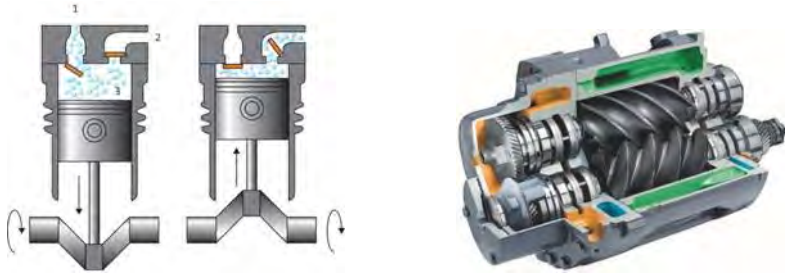

Figure 2. 1 : Types of compressor used in residential, automative and industrial Application

2.2.2 Condenser

The purpose of condenser is to remove heat from the refrigeration gas to the outside air by a cooling medium, usually air or water. Based on the cooling medium used, condensers used in refrigeration systems can be classified into the following three categories water-cooled condenser, air cooled condenser and evaporative condenser. The condenser that commonly used in the outdoor of split unit air conditioner is the coiled copper tubing with one or more rows depending on the size of the air conditioning unit and the compressor load. The higher the load of air conditioner and compressor more the rows and coil turns. As the gas draw through the condenser, it begins to extract heat to the surrounding air which causes gas temperature dropped. The gas continuous cooling until it reaches the proper condensing temperature and the change of state takes place (Wang 2000).

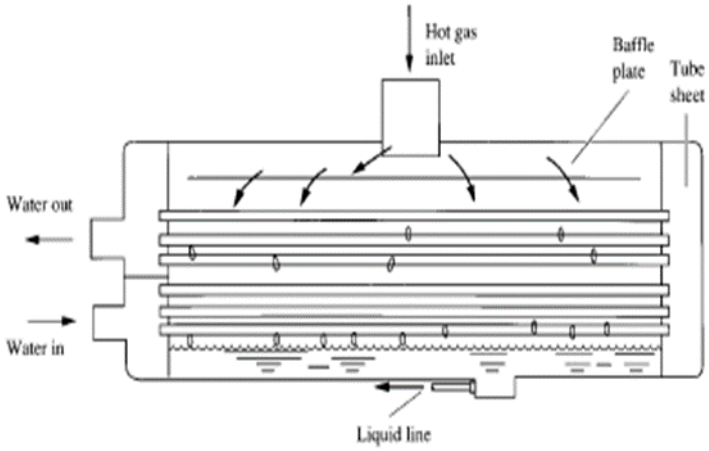

Figure 2. 2 : Shell and tube condenser with two-pass water flow arrangement

2.2.3 Expansion valve

After leaving the condenser, the temperature of the refrigerant has reduced but the pressure still remain high. The device to control the flow of refrigerant called expansion valve. Expansion valve used to throttle refrigerant before entering the evaporator. Expansion valve have different type such as thermostatic expansion valve (TXV). The thermostatic expansion valve is used widely in the refrigeration and air conditioning systems. While the capillary tube is used in the small domestic systems, the thermostatic expansion valve is used in the systems of higher capacities (Wang 2000).

Figure 2. 3 : Thermostatic expansion valve

2.2.4 Evaporator

Evaporator also act as the heat exchanger same as the condenser, but the process of refrigerant occured in evaporator inversely with the process occured in condenser. The purpose of evaporator is to absorb heat from the surrounding air, chilled water, or any subtances in order to change the state of refrigerant from liquid to vapour. Evaporator can be classified into three categories, depend on the medium or subtances to be cooled (Wang 2000). The commonly evaporator that that have been used for residential and commercial application is fin and tube and plate type, while shell and tube evaporator used in industrial application.

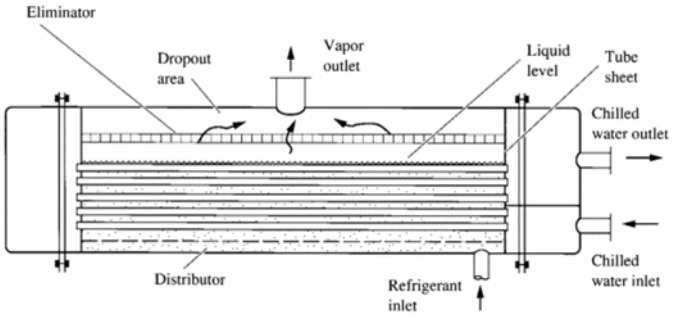

Figure 2. 4: Flooded shell and tube evaporator

2.3 Basic refrigeration cycle

Vapor refrigerant enters the compressor as a gas under low pressure and having a low temperature in the compression stage. The gas leaves the compressor in high pressure and high temperature after it compressed by compressor. The high pressure, high temperature gas from compressor entering the condenser and release heat energy and condensed inside condenser system. Heat is removed from the refrigerant and it is transferred to the ambient, which has a lower temperature. The heat rejected is the heat absorbed during evaporation plus the heat added by compression (Jeong, J., & Kang 2004). The liquid refrigerant leaves condenser as high pressure. Then, the liquid refrigerant is forced through a throttling valve, its pressure is reduced which causes it to expand. Therefore, the refrigerant now in low pressure and lower temperature, but still in the liquid phase. The low pressure, low temperature refrigerant enters the evaporator, which is in contact with the cold reservoir. The refrigerant is able to boil at a low temperature due to low pressure is maintained. So, the liquid absorbs heat from the cold reservoir and evaporates. The refrigerant leaves the evaporator as a low temperature, low pressure gas and is taken into the compressor again, back at the beginning of the cycle.

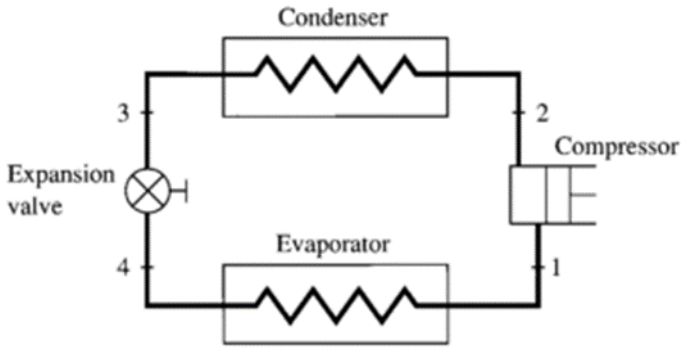

Figure 2. 5 : Basic refrigeration cycle

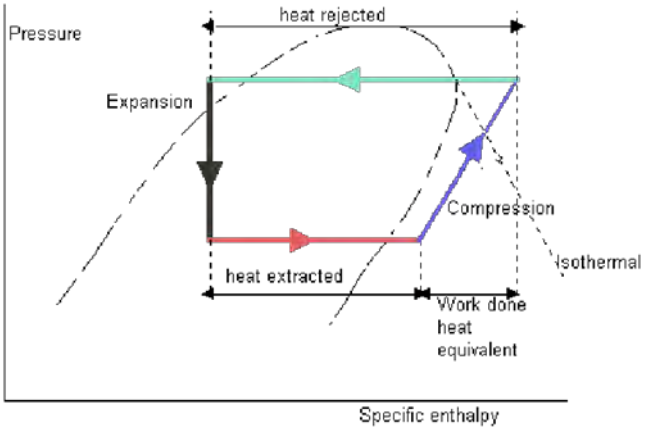

Figure 2. 6 : P-h diagram

2.3.1 Second Law Thermodynamic

The second law of thermodynamics states that the total entropy of an isolated system can only increase over time. It can remain constant in ideal cases where the system is in a steady state or undergoing a reversible process (Uçkan, Yılmaz, and Büyükalaca 2017). It indicates that it is impossible to have 100% efficiency in energy conversion. The classical statement, such as the Clausius statement and Kelvin-Plank statement may help to define the second law. In Clausius Statement it is impossible to construct a device that operates in a cycle and whose sole effect is the transfer of heat from a low-temperature region to a high- temperature region. This statement relates to the refrigerator or heat pump. It states that it is impossible to construct a refrigerator that transfers energy from cooler body to a hotter body without the input of work. While Kelvin-Plank statement it is impossible to construct device that operates in a cycle and produces no other effect than the production of work and the transfer of heat from a single body. In other words, it is impossible to construct a a device operating in a cycle example like heat engine, that accomplishes only the extraction of heat from one source and it complete conversion to work (Ma et al. 2017).