UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PROTOTYPE DEVELOPMENT OF SELF ASSES SPLIT UNIT AIR CONDITIONING SYSTEM MAINTENANCE

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

by

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I hereby, declared this report entitled "Prototype Development Of Self Asses Split Unit Air Conditioning System Maintenance" is the result 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 Engineering Technology (Refrigeration and Air-Conditioning System) (Hons.). The member of the supervisory is as follow:

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(MOHD. FARID BIN ISMAIL)

ABSTRACT

This project will be performed to develop a device that can inform consumer when suitable time to do maintenance for their split unit system. To determine the most suitable time for maintenance on air conditioner is not an easy decision for normal consumer. This project was performed to design and fabricate a device that can help consumer on that problem. Maintenance should be done when the performance of the system dropped below satisfied level. Performance of split air conditioner system was determined by Coefficient of Performance (COP). The project had been conducted by interrupting airflow on condenser and evaporator to simulate low performance of the system. The study had determined the best coefficient of performance of the selected unit was 5.19 while the lowest coefficient of performance was 1.98. From the study also determined the best time to do maintenance on the split unit when the coefficient of performance between 2 to 4.

ABSTRAK

Projek ini akan dilaksanakan untuk membangunkan alat yang boleh memaklumkan kepada pengguna bila masa yang sesuai untuk melakukan penyelenggaraan untuk sistem penghawa dingin mereka. Untuk menentukan masa yang paling sesuai bagi penyelenggaraan penghawa dingin bukan keputusan yang mudah untuk pengguna biasa. Projek ini telah dilakukan untuk merekabentuk sebuah alat yang boleh membantu pengguna mengatasi masalah itu. Penyelenggaraan perlu dilakukan apabila prestasi sistem jatuh di bawah tahap yang baik. Prestasi sistem penghawa dingin telah ditentukan oleh Pekali prestasi (COP). Projek ini telah dijalankan dengan mengganggu aliran udara pada pemeluwap dan penyejat untuk mensimulasikan prestasi yang terendah pada sistem. Kajian ini telah menentukan pekali terbaik prestasi unit yang dipilih adalah 5.19 manakala pekali paling rendah prestasi adalah 1.98. Daripada kajian ini juga telah dipilih masa terbaik untuk melakukan penyelenggaraan pada sistem penghawa dingin apabila pekali prestasi antara 2 hingga 4.

DEDICATIONS

This report is dedicated to my beloved parents, who educated me and enabled me to reach this level.

ACKNOWLEDGMENTS

First and foremost, all praise to Allah the Almighty for giving me the strength, health, knowledge and patience to successfully complete this Finale Year Project report in the given time. I have to thank my parents for their love and support throughout my life. Thank you for giving me strength to climb the stairs and walking towards the paths of life. I would like to address my deepest appreciation to my supervisor, En. Mohd. Farid Bin Ismail for his encouragement, comments, guidance and enthusiasm through the time developing the report. Special thanks to the friends that have been through thick and thin throughout the completion of this project. This project report might be impossible to complete without all of your help. Last but not least, thank you to everyone that directly and indirectly involved in helping me finishing this Finale Year Project report. Thank you.

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CHAPTER 1

INTRODUCTION

1.0 Background

Split unit air conditioner is widely used in residential and commercial building. The statistics show that more than 50% of the electricity bill in a commercial building and more than 30% of total electricity bills in residential areas are contributed by the operating cost of air conditioners (Y.H. Yau, 2014). It consumes very high amount of energy to maintain indoor air temperature. For that, each instrument that used in the system has its own lifetime. The lifetime of the equipment is based on the way of use and care of the equipment. This is why maintenance important for all equipment. One of the common problems for all air conditioner split unit is the system not operating with higher efficiency and waste of cost and energy usage if maintenance of air conditioning split unit is done early from the time supposed to be. To ensure air conditioning operates with higher efficiency, maintenance is required so that the system will not cause problem for long term usage. This project will be designed to help consumers to know the suitable time to do maintenance for their system.

1.1 Problem statement

There are some problems that can be identified for the system not operating with higher efficiency that is:

a) Consumers do not know when is the right time to do maintenance for their air conditioning split unit.

1.2 Aim and Objective

To develop a device that can help consumer to know when is the right time to maintenance split unit air conditioner system. A few objectives have been created:

a) To design and fabricate a device that can be used for consumers to know when is the best time to do maintenance for split unit.
b) To analyse the capability of the device to measure the coefficient of performance for split unit.

1.3 Scope

For this project, the scope that has been selected is constant split unit air conditioner wall mount type with 1 HP.

1.4 Thesis structure

This report has been divided into five chapters. The five chapters are introduction, literature review, methodology, results and discussion and conclusion and recommendation. The introduction for this project is stated in Chapter 1 including background, problem statement, aim and objective and scope. To study the problem and objective for this project, literature review will be made in Chapter 2. Chapter 3 is the methodology that is used for this project as method to collected data and analyses data at Chapter 4. Chapter 5shows the most important conclusion and recommendation for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Split unit air conditioning system

In split unit air conditioning system, compressor and condenser of the refrigeration system is chosen separately from the rest of the system and connected by refrigerant line to the system includes the evaporator unit. Refrigerant line that connecting the system including pipes and insulation only millimetres in diameter. The separation of the two part of the refrigeration system to produce the split diagrammed in figure 2.1. This system is for small residential system for example home, office and others. (McDOWALL, 2007).

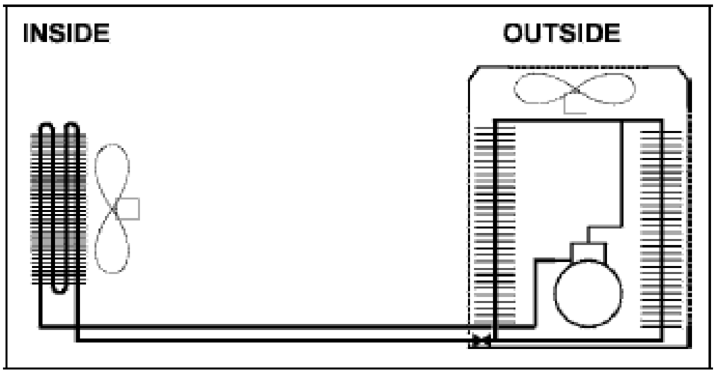

Figure 2.1: Split unit air conditioning system

Room air conditioner has four way reversing valve that added to all room heat pumps. Room air conditioner are separate in two split units that is outdoor unit has condensing unit with compressor and condenser, and indoor unit in more advantageous location and to reduce compressor noise indoors. (Wang, 2000).

The major component in split type air conditioner include evaporator fan pressurize and supplies the conditioned air to the space. In tube and fin coil, the refrigerant evaporates, expands directly inside the tubes, and absorbs the heat energy from the ambient air during the cooling season. Refrigerant react as heat pump when hot refrigerant release heat during heating season. (Wang, 2000).

A compressor will compress the refrigerant from a lower evaporating pressure to higher condensing pressure. After refrigerant being compress from hot gas to liquid it will reject heat through a coil and condenser fan. A temperature sensor that sense space inside air temperature and control starts and stops the compressor and next control it's cooling and heating capacity through a thermostat. (Wang, 2000) .

2.2 Vapor Compression Cycle

Vapor compression cycles (VCC) are widely used in air conditioning systems which is the most energy consuming domestic appliances. All residential electricity consumption in air conditioning shows 13.7% and 16%. Hence, better designs of cooling system are required to minimize the energy consumption. (Mahmoud A. Alzoubi, 2015)

The residential and most other refrigeration system use the same basic process of vapor compression. The vapor compression refrigeration system comprises four components that is compressor, condenser, expansion valve, and evaporator as shown in figure 2.2. A refrigeration process indicates the change of thermodynamic properties of the refrigerant and the energy transfer between the refrigerant and the surroundings. (McDOWALL, 2007).

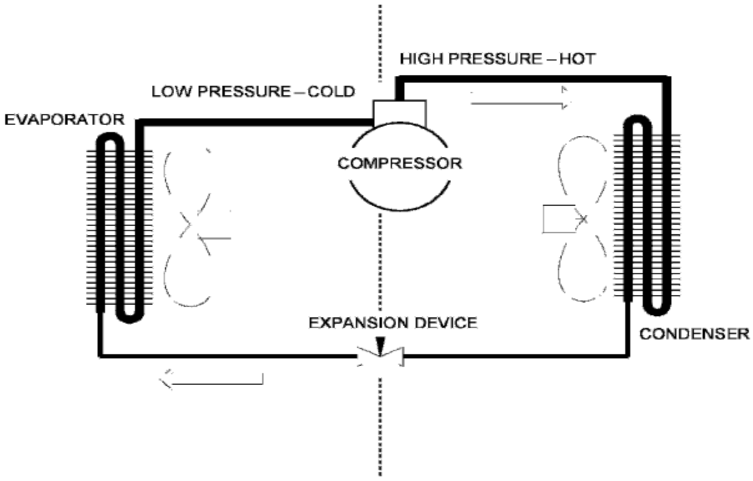

Figure 2.2 : Basic vapor compression refrigeration cycle

Compressor - compresses refrigerant vapor to a high pressure, this process produce hot temperature of refrigerant.

Condenser - air or water reduce temperature of the refrigerant and cause it to condense into liquid.

Expansion valve - allows a controlled amount of the liquid refrigerant to flow through into the low-pressure section of the system.

Evaporator - air or water heats the liquid refrigerant so that it evaporates back into a vapor.

The following refrigeration processes occur during the operation of an air or gas expansion refrigeration system:

1. Compression - Air or gas is compressed to a higher pressure and temperature.
2. Heat releas - Heat is released to the surroundings at constant pressure in order to reduce the temperature of the air or gas.
3. Throttling and expansion - Air or gas is throttled and expanded so that its temperature is lowered.
4. Heat absorption - Heat is absorbed from the surroundings because of the lower air or gas temperature.

Most refrigerants undergo a series of evaporation, compression, condensation, throttling, and expansion processes, absorbing heat from a lower-temperature reservoir and releasing it to a higher temperature reservoir in such a way that the final state is equal in all respects to the initial state. It is said to have undergone a closed refrigeration cycle. When air or gas undergoes a series of compression, heat release, throttling, expansion, and heat absorption processes, and its final state is not equal to its initial state, it is said to have undergone an open refrigeration cycle. (Wang, 2000)

The expansion device is a length of very small-bore tube that restricts the refrigerant liquid flow from the high-pressure side to the low-pressure side. A thermostat turns the compressor “on” when cooling temperature is required, and “off” again when the temperature is cool enough. The evaporator fan draws room air over the evaporator coil to cool space. The condenser is placed outside and the condenser fan draws outside air over the condenser coil to reject heat into the outside air. (McDOWALL, 2007)

The most common graphical tool that used to calculate heat adds work transfer and performance of refrigerant cycle that is pressure-enthalpy diagram or can be known as *p-h* diagram. This diagram is divided by two side of region that is high pressure region and low pressure region. Heat and work transfer can be calculated by change of enthalpy. (Wang, 2000)

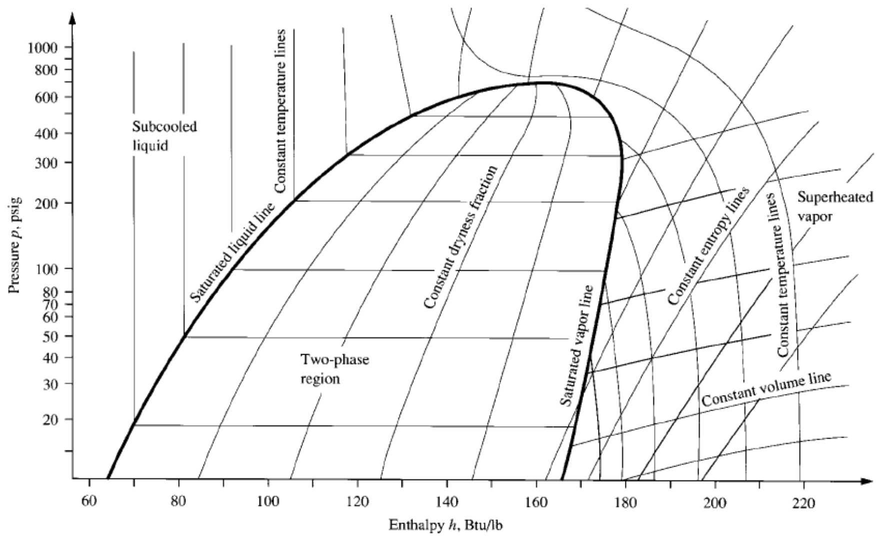

Figure 2.3 : *p-h* diagram

From Figure 2.3, the diagram shows that the saturated vapor line separates the phase which liquid and superheated vapor and saturated liquid separates the phase which vapor and liquid refrigerants. In the two phase region, the mixture of vapor and liquid is subdivided by the constant dryness fraction quality line. The constant temperature lines are nearly vertical in the sub cooled liquid region. At higher temperatures, they are curves near the saturated liquid line. In the two phase region, the constant temperature lines are horizontal. In the superheated region, the constant temperature lines curve down sharply. Because the constant-temperature lines and constant-pressure lines in the two-phase region are horizontal, they are closely related. The specific pressure of a refrigerant in the two-phase region determines its temperature, and vice versa. Also in the superheated region, the constant-entropy lines incline sharply upward, and constant volume lines are flatter. Both are slightly curved. (Wang, 2000).

2.3 Performance of split unit air conditioner system

The coefficient of performance is a ratio of heating or cooling provided to work required. The performance of vapor compression refrigeration system is measured as COP. When the system extracts more heat, the COP is higher and the system is more efficient. (Sheikh Ismail THARVES MOHIDEEN).

Energy consumption and life cycle costs are important to every unit of air conditioner. To achieve the most lower cost there are several thing that will be consider that is operating costs during the life cycle of the asset. This is including the energy used form the system, labour, and operation maintenance costs. Energy consumption can be determined by the performance of the system. More electrical energy is used for split systems because of their lower energy efficiency. (H. Yang, 2001).

Refrigerant cycle that used in split unit system is using gas as the working substance with single-stage vapor compression cycle. As in the gas cycle, there are two isothermal processes 4-1 and 2-3 absorbing heat at temperature T1 and rejecting heat at T2 respectively, and two isentropic processes, one for compression 1-2 and another for expansion 3-4. The cycle are consist of four process that is: (Wang, 2000).

1. An isothermal process 4-1 in which heat q#1 is extracted at constant temperature T1 per lb (kg) of working substance
2. An isentropic compression process 1-2
3. An isothermal process 2-3 in which q#2 is rejected at constant temperature T2 per lb (kg) of working substance
4. An isentropic expansion process 3-4

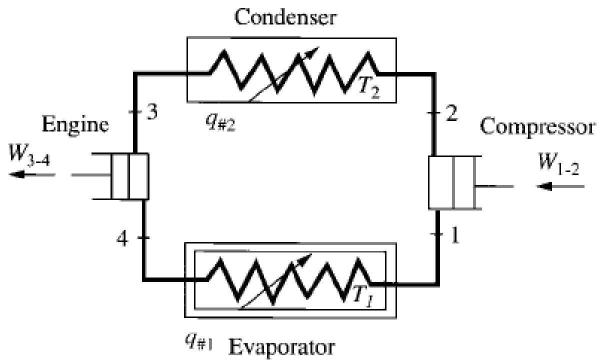

Figure 2.4 : Schematic diagram

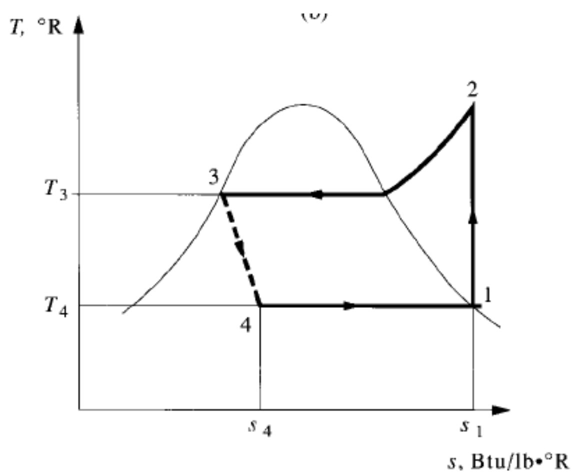

Figure 2.5 : T-s diagram

The COP of the single-stage vapor compression cycle is:

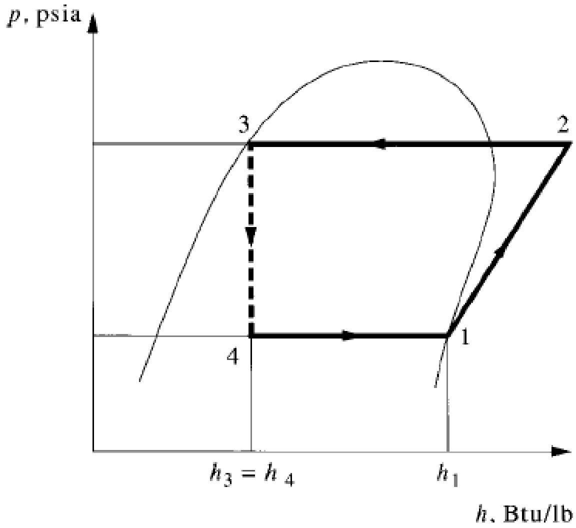

Figure 2.6 : *p-h* diagram

For isentropic compression between points 1 and 2, applying the steady flow energy equation and ignoring the change of kinetic energy:

$$h_1 + 0 = h_2 + W$$

$$-W = h_2 - h_1$$

Work input to the compressor Win. Btu / lb (kJ / kg):

$$Win = h_2 - h_1$$

Similarly, for condensation between points 2 and 3:

$$h_2 + \ q\# = h_3 + 0$$

the heat release by the refrigerant in the condenser –q#. Btu / lb (kJ / kg):

$$-q\# = h_2 - \ h_3$$

For the throttling process between points 3 and 4, assuming that the heat loss in negligible:

$$h_3 + \ 0 = h_4 + 0$$

$$\text{or } h_3 = h_4$$

The COP of the single stage ideal vapor compression cycle is:

$$COP = \frac{refrigerant\ effect\ (q\#)}{work\ input\ (Win)}$$

$$\frac{q\#}{Win} = \frac{h_1 - h_4}{h_2 - h_1}$$

Where,

h_1 = Enthalpy of refrigerant at points 1, respectively, Btu/lb (J/kg)

h_4 = Enthalpy of refrigerant at points 4, respectively, Btu/lb (J/kg)

h_2 = Enthalpy of refrigerant at points 2, respectively, Btu/lb (J/kg)

$q\#$ = Heat supplied per lb (kg) of working substance during evaporation process, Btu/ lb (J /kg)

Win = net work done by system; sign is positive, or if it is a work input to system, sign is negative.

For analyse the performance of the refrigerant cycle, the enthalpy (h) must be determined to calculate the refrigerant effect, work input, and COP. The enthalpy of the refrigerant at saturated liquid and saturated vapor state is a function of saturated temperature and pressure. In other words, saturated temperature Ts and saturated pressure P of the refrigerant are dependent upon each other. (Wang, 2000).

Split air conditioner (SACs) cooling capacity of current available room air conditioner range between 5000 and 34000 Btu/h (1.5 and 10kW). Refrigerant HCFC-22 and alternative refrigerant HFC-407C and HFC-410A are the refrigerant that used in this system. There are many room air conditioner (RACs) manufacturers are using slit-type aluminium fins and grooved or rifled copper refrigerant tubing in the heat exchange coils. Incorporating a large surface area to capacity ratio, it is able to yield rotary compressor efficiencies of 11.1 to 11.3 EER (3.25 to 3.31 W/W). Permanent split capacitor (PSC) motors are the predominant fan motor used in RACs. PSC motors have efficiency between 55 and 70 percent. Some RAC fan motors use shaded pole motors with an efficiency of 30 to 40 percent. ASHRAE/IESNA Standard 90.1-1999 the minimum efficiency requirement for room air conditioners with louvered sides and room air conditioner heat pumps with louvered sides as follows: (Wang, 2000).

Equipment type	Capacity Q_{rc} Btu/h	Minimum efficiency
Room air conditioner	$Q_{rc} < 6000$	8.0 EER
	$6000 \leq Q_{rc} < 8000$	8.5 EER
	$8000 \leq Q_{rc} < 14{,}000$	9.0 EER
	$14{,}000 \leq Q_{rc} < 20{,}000$	8.8 EER
	$Q_{rc} \leq 20{,}000$	8.2 EER
Room air conditioner heat	$Q_{rc} < 20{,}000$	8.5 EER
pump with louvered sides	$Q_{rc} \geq 20{,}000$	8.5 EER

Figure 2.7 : capacity and minimum efficiency

The effect of weather on split unit air conditioning can influence the performance of the total cooling capacity and sensible heat factor (SHF). Based on the studied of Y.H. Yau, it stated that 1◦C incrementing outdoor temperature will cause the COP and the total cooling capacity of the existing system reduce by 2% while the SHF drops less than 2% from 2020 to 2080.this must be considered and analyzed to preserve substantial of energy. (Y.H. Yau, 2014).

2.4 Maintenance requirements

Maintenance is the work of keeping something in proper condition. This action is taken to prevent and to repair a device or component to keep it in proper working order. The practical operation of a component can be measured by time-based function. From the figure Component failure rate over time for component population, the Y-axis represent the failure rate and X-axis is time. From the shape shown, the curve is divided into three distinct that is infant mortality, useful life, and wear-out periods. (G.P.Sullivan, 2004).