PERFORMANCE INVESTIGATION OF CONDENSATE ASSISTED VEHICLE AIR CONDITIONING SYSTEM UNDER DIFFERENT CONDENSATE TEMPERATURE

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This report is submitted
in fulfillment of the requirement for the degree of
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DECLARATION

I declare that this project report entitled “Performance Investigation of Condensate Assisted Vehicle Air Conditioning System Under Different Condensate Temperature” is the result of my own work except as cited in the references.

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature : .....

Name of Supervisor : .....

Date : .....

ABSTRACT

Vehicle air conditioning system is a necessity for consumers. It can be said that all vehicle will be suited with air conditioning systems. Compare to the current problem of global warming potential, main causes pollution is caused by vehicles. Accessories like air conditioning are improved to reduce the problem of climate. As such condensate assisted is proposed to improve efficiency of air conditioning with low energy uses. This condensate water is reused by the water spray system to the condenser. This project represents the experiment of performance of vehicle air conditioning system under different condensate temperature. Compressor speed is fixed to 1500 rpm. Heat load temperature is maintained to 30°C. Ambient temperature is constant at 30°C. The water volume flow rate is calculated between 140 ml/min to 540 ml/min. The volume flow rate change according to the speed of jet pump. It is carried to measure and discuss about the several parameters such as the cooling capacity, the compressor power consumption and coefficient of performance. Overall result of the experiment, it is found that reuse the condensate water through spray system may increase the COP of system by 5.85%.

ABSTRAK

Sistem penyaman udara kenderaan adalah keperluan untuk pengguna. Ia boleh dikatakan bahawa semua kenderaan akan sesuai dengan sistem penghawa dingin. Bandingkan dengan masalah semasa pemanasan global yang meningkat, penyebab utama pencemaran disebabkan oleh kenderaan. Aksesori seperti penyaman udara dibaiki untuk mengurangkan masalah iklim. Oleh itu, bantuan air kondensat dicadangkan untuk meningkatkan kecekapan penghawa dingin dengan penggunaan tenaga yang rendah. Air kondensat ini diguna semula melalui kaedah sistem penyembur air ke kondenser. Projek ini mewakili eksperimen prestasi sistem penyaman udara kenderaan dibawah suhu kondensat yang berbeza. Kelajuan pemampat ditetapkan pada 1500 rpm. Suhu beban haba ditetapkan pada 30 °C. suhu ambient adalah malar pada 30 °C. kadar aliran isipadu dikira antara 140 ml/min hingga 542 ml/min. kadar aliran isipadu berubah mengikut kelajuan semburan air.Ia dijalankan untuk mengukur dan membincangkan tentang beberapa parameter seperti kapasiti penyejukan, penggunaan kuasa pemampat dan pekali prestasi. Hasil keseluruhan eksperiman, didapati bahawa penggunaan semula air kondensat melalui sistem semburan dapat meningkat kecekapan sistem sebanyak 5.85 %.

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LIST OF ABBREVIATION

COP	Coefficient of Performance
Q_e	Heat Absorbed
Q_c	Heat Rejected
W_{in}	Compressor work (work in)

CHAPTER 1

INTRODUCTION

1.1 Background

Condensate water happens caused by condensation process. Condensation is the process where the water vapor in the air is transformed into liquid water. This process can be related to the vehicle air conditioning system because it produces condensate water. Condensate water occurs by the gas in the air from outside. The outside temperature is in contact with the refrigerant gas in the evaporator (colder surface) which later changes the water from gas to liquid.

It is well known in vehicle air conditioning system, gas is compressed by compressor. The refrigerant gas enters the condenser is in high pressure. Then, gas is converted into liquid to enter expansion valve. The expansion valve will control liquid of refrigerant gas. It is because in evaporator, liquid will be in low pressure before it turn into gas. Not all of this gas will be transfer to the cabin car. Half of the gas will flow through cooling coil in the cabin car which is then cooled by the blower. However, the other half of gas is released to be in contact with hot air to form water droplets. The gas in the air turns as liquid is known as condensate.

Condensate water commonly is treated as wastewater after discharge from air conditioning system. The condensate collected can be uses for different alternative water source. There are many applications to use condensate water in industrial and commercial process. The possible uses of condensate water are such as drinking, irrigation and cleaning. It is because the collected water generated from air conditioning system is clean.

Issam (2013) found that condensed water does not contain elements of heavy metal. The low concentration level of metal are found less than maximum to be drink. One of the alternatives is recycling for use to cool the hot condenser coils of the air conditioning itself. It helps to reduce released heat by condenser. Chun Wang (2015) explained types of major method to cool condenser by using condensate water such as spraying method, wet membrane method and adding of condenser method. The spraying water is the best method to apply in this experiment. The spraying method is to collect condensate water into a tank before sprayed to the coil of condenser. The changes of condensate water temperature are observed to get the suitable temperature to apply in spraying method.

The condensate water used provides benefit such as energy saves and emission reduces. The method of using condensate is an effective way to improve the efficiency of an air conditioning. It is because the condensate water that produced by cooling system has a low temperature for reused in water spray to condenser. When condensate water is sprayed to the coil, the temperature of condenser is reduced. The condensate water produced by vehicle air conditioner has high capacity of refrigerating. The condensate water is used to cool the air which is released to the environment through coil in the condenser. This is can reduce the heat release by the system and energy consumption in the operation. The condensate water lowers the temperature outdoor by cooling the condenser.

1.2 Problem Statement

The emission of human made gases such as methane, carbon dioxide, nitrous oxygen and etc into environment are potential of global warming. The causes of global warming is rising temperatures on Earth's atmosphere because of the emission of man-made carbon dioxide. The emission of carbon dioxide is used in air conditioning system in road transport vehicles. Increasing emission of global warming gases from the

transportation sector is the main cause of global warming pollution. It is because emission from the transportation sector may become have larger percentage of total pollution in coming years.

In Figure 1.1, the main source of vehicle is caused by air conditioning. The air conditioning system is assisted by the engine to operate. The engine needs more energy to operate efficiently. This is due to the increase of amount fuel uses during combustion. High amount of fuel consumption is needed to ensure engine operate at the high efficiency. Then the concentration of carbon dioxide is increase caused of high fuel consumption.

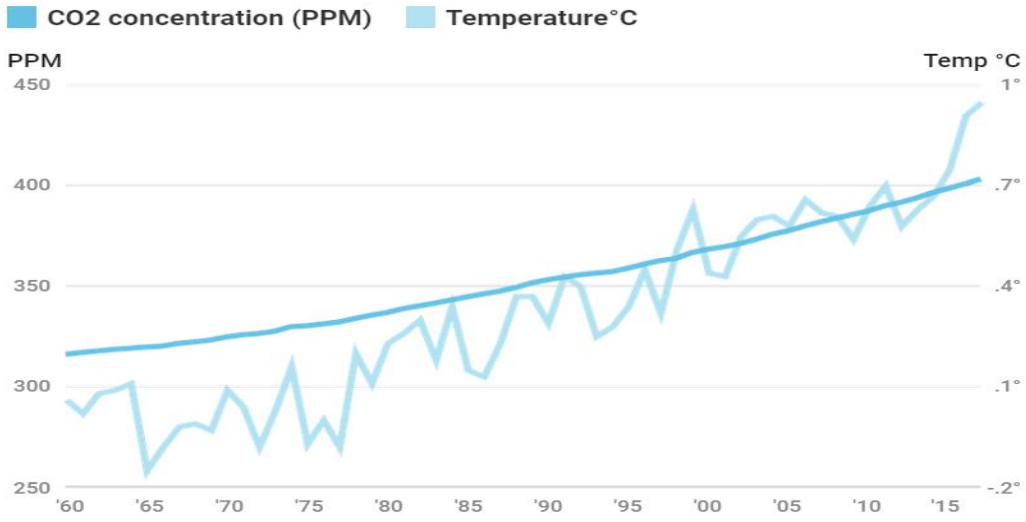

Figure 1.1: Temperature and Carbon Dioxide Concentration Level from 1959 to 2016, (Kevin Loria,2018)

In other way, many methods are recommended to improve Vehicle Air Conditioning system. It can be reduced fuel consumption while improving performance efficiency. One of them is condensate assisted Vehicle Air Conditioning system. A study is proposed to investigate the performance of coefficient of performance vehicle air conditioning system with condensate assisted.

1.3 Objective

The objectives of this project are as follows:

a. To determine the system temperature, pressure, cooling capacity and compressor work at different condensate temperature.

b. To justify the best coefficient of performance of the condensate assisted air conditioning system.

c. To justify the suitability of the condensate assisted air conditioning system compared to conventional system.

1.4 Scope of Project

Scopes of this project is divided into three categories: research method, data collection and results. The research method used in this project is experimental work. An experiment is a process to study the results in the collection of data. This project will cover experimental works only by using basic components namely the compressor, condenser, expansion valve and cooling coil. This experiment is conducted in situation which researchers can manipulate the conditions and control the factors that are related to the objective of the project.

A data collection plan consists four important variables; constant variable, uncontrolled variable, control variable and fit into system that will meet the objectives of the experiment. Constant variable can be controlled or measured but for some reason will be constant on the duration of the study as the example speed of the compressor. Uncontrolled variables are variable that is measured in the experiment. The value of uncontrolled variable must accurate or precise evaluations of the effects because the experimental error is depend of uncontrolled variables. during experiment, following parameters will be checked; evaporator temperature outlet (T1), evaporator temperature

inlet (T4), condenser temperature outlet (T3) and condenser temperature inlet (T2) to get control variables. Control variables are independent variables that are possible source of variation in the response. The variables analyzed are power of the compressor W, cooling capacity Q, and coefficient of performance COP of the air conditioning system due to the different condensate temperature. These types of variables should be controlled in the experiment to get accurate value in the final results.

The last scope is validation of results. The experiment result is expressed through comparison of charts, graph and table between parameter that have been measured, charted and discussed in the following chapter. The results of COP for overall system and the results for COP of temperature which depends on condensate water are expressed in table.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Automotive Air Conditioning

The air conditioning system works with the seven components which are a compressor, a condenser, an expansion valve, a condenser fan, an evaporator, blower evaporator and a receiver drier. These components are connected by a flexible hose and tube to form a closed circuit. In closed circuit, the air conditioner coolant works by flowing to the coolant from the gas pressure compressor. The basic parts of the vehicle air conditioning are a compressor, a condenser, an expansion valve, an evaporator, a filter, a receiver drier and a blower fan.

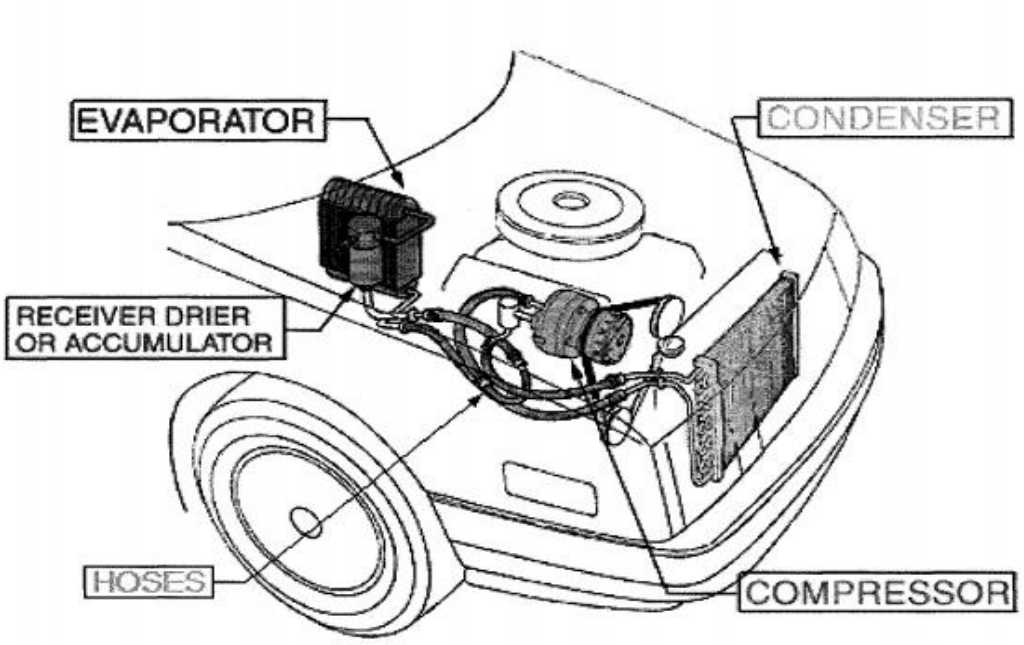

Figure 2.1: Introduction of automotive air conditioning (Shujun, 2007)

2.2 Working of Cycle

The compressor produces energy to be used by engine. In vapor compression cycle, the thermodynamic processes contain four processes: compression, condensation, expansion and evaporation.

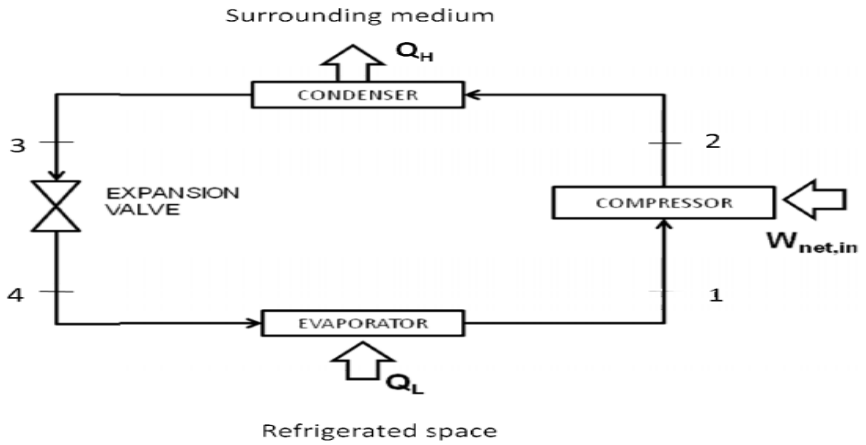

Figure 2.2: Simple vapor compression cycle (Amirudin, 2009)

2.3 Compression Thermodynamic Cycle

Figure 2.3 illustrates the typical T-s diagram of vapor compression cycle. The compression process occurs in line 1-2. In this stage, the compressor compress the refrigerant from low temperature and pressure to superheated vapor at high temperature and pressure. The condensation process occurs in line 2-3. In this stage, high pressure and temperature of gas is carried from compressor to cross the condenser. The three phases of cooling gas: desuperheating, condensing and sub cooling. Initially, the hot gas in compressor transfers its heat to cool air in the condenser. The superheated gas becomes saturation gas after it cools to its condensing temperature.

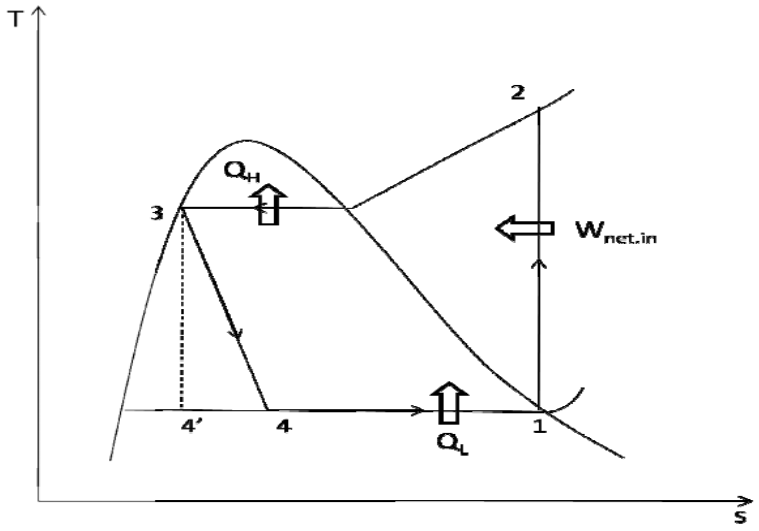

Figure 2.3: T-s diagram of vapor compression cycle (Amirudin, 2009)

Next, the gas becomes saturated liquid due it condenses at constant temperature. Finally, the saturation liquid sub cools achieved its normal condensing temperature by absorbing heat from liquid refrigerant. The expansion process occurs in line 3-4. In this stage, high pressure and temperature of liquid are flows from condenser to expansion valve. Then, it expands adiabatically to low temperature and pressure mixture of liquid and gas. No heat is transfer or move from the refrigerant at this stage. The evaporation process occurs in line 4-1. In this stage, the mixture of liquid and gas from expansion valve transfer low temperature and pressure to the evaporator. In evaporator, the liquid fraction is evaporated while gas increases temperature. Warm ambient in cabin heats the refrigerant as well it is blown by a blower through evaporator surface.

The coefficient of performance (COP) is the ratio of heat released to surrounding to the work done. The COP of vehicle air conditioning can be expressed as:

$$Q_L = h_2 - h_3 \qquad (2.1)$$

$$Q_H = h_1 - h_4 \qquad (2.2)$$

$$W_{in} = h_2 - h_1 \qquad (2.3)$$

$$\text{COP} = Q_L \ / \ W_{in} = Q_e \ / \ W_c = (h_2 - h_3) / (h_2 - h_1) \qquad (2.4)$$

Where Q_e = cooling capacity of the evaporator (kJ), W_c= power of the compressor (kJ), h_1 = enthalpy on compressor inlet (kJ/kg), h_2 = enthalpy on compressor exit (kJ/kg). (Henry et.al, 2016)

2.4 Components of Automotive Air Conditioning

2.4.1 Condenser

The condenser removes the heat of the coolant received from the compressor with the help of fan. Otherwise, the refrigerant gas is moving in hot temperature and that will cause the desired temperature of the water vehicle cannot be reached. The gas cooling substances will lose heat and will convert it to liquid after passing condenser. Its operation receives a high pressure gas from the compressor and transmits a high pressure liquid to the Receiver Drier.

Figure 2.4: Condenser

2.4.2 Compressor

The compressor function is to move the coolant in the system by compressing the coolant from low pressure to high pressure. When compressed, according to the gas law PV = mRT, it states that the temperature will increase if pressure is increase. Its operation receives low pressure gas from the evaporator and transmits high pressure gas to the condenser.