PERFORMANCE INVESTIGATION OF VEHICLE AIR CONDITIONING SYSTEM UNDER DIFFERENT COMPRESSOR SPEED

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A report is submitted
In fulfilment of the requirements for the degree of
Bachelor of Mechanical Engineering

FACULTY OF MECHANICAL ENGINEERING

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I declared that this project report entitled “Performance Investigation of Vehicle Air Conditioning Under Different Compressor Speed” 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 (Thermal-Fluids).

Signature : .....

Supervisor's Name : .....

Date : .....

DEDICATION

This thesis are dedicated to whoever shows me their love even during the hard times, gave the pure kindness when things fall apart and endless support when things seems impossible to get through. Dedication is sincerely made for the beloved family, supporting friends and dedicated lecturers

ABSTRACT

This performance investigation of vehicle air conditioning system under different compressor speed aims to justify the best coefficient of performance (COP) of the air conditioning system while operate in vary compressor speed. Hence, the temperature, pressure, mass flow rate, enthalpy and cooling capacity are determined. By referring to the objectives, this project basically shows the interaction between the compressor speed, energy consumption and coefficient of performance (COP). The experimental work was carried out on air conditioning test rig and R134a was used as refrigerant. Based on compressor capacity, the compressor speed was controlled between 1500 rpm until 1900 rpm. While others parameter such as ambient temperature, heat load and amount of condensate water are maintained. The analysis of data was done by used thermodynamic software (REFPROP). From this project, it is found that when the compressor speed at 1700 rpm, it is work at optimum because it has highest COP which is 4.40.

ABSTRAK

Penyiasatan prestasi sistem penyaman udara kenderaan pada kelajuan pemampat yang berbeza ini bertujuan untuk mewajarkan pekali prestasi (COP) sistem penyaman udara yang terbaik ketika beroperasi dalam berbagai kelajuan pemampat. Oleh itu, suhu, tekanan, kadar aliran jisim, entalpi dan kapasiti penyejukan bagi sistem tditentukan. Merujuk kepada objektif, projek ini secara dasarnya menunjukkan interaksi antara kelajuan pemampat, penggunaan tenaga dan pekali prestasi (COP). Kerja eksperimen dijalankan pada rig ujian penyaman udara dan R134a digunakan sebagai bahan pendingin. Kelajuan pemampat dikawal antara 1500 rpm sehingga 1900 rpm. Manakala, parameter lain seperti suhu ambient dan beban haba dimalarkan. Analisis data dilakukan dengan menggunakan perisian termodinamik (REFPROP). Akhir sekali, didapati bahawa apabila kelajuan pemampat adalah 1700 rpm, ia bekerja pada keadaan yang optimum, di mana COP pada kelajuan tersebut adalah paling tinggi iaitu sebanyak 4.40.

ACKNOWLEDGEMENTS

Deepest appreciation should be delivered to Dean for Faculty of Mechanical Engineering of Universiti Teknikal Malaysia Melaka (UTeM), Dr Ruztamreen Bin Jenal and my project supervisor, Dr Mohamad Firdaus Bin Sukri for giving the opportunity and patient guidance until this project report is completed. Thanks again to my supervisor for all the time spent, comment given and his kindness to pour the knowledge that he had to ensure that I be able to understand every work flow of this project until it is done perfectly. Great appreciation to assistant engineer of air conditioning laboratory, Mr. Asjufri bin Mujahir for gave the technical support and permission for my team and I used the equipments and machine needed during performed the experimental work. Furthermore, I would like to thanks the panels for their comment on the project presentation that has improved our presentation skills.

Not to be forgotten, to express my sincere gratitude to my whole family member as my pillar strength who always showed me their eternal love and support especially throughout this degree journey in order to ensure that I be able to pursue my dreams and completed my studies successfully. Without them I would never make it this far.

Special thanks to all my friends and my classmates that always lend me their hand whenever needed and it seem impossible to survive this degree journey without a persistent helps from them.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

COP	Coefficient of Performance
CTC	Compact Tube and Centre Condenser
FOT	Fixed Orifice Tube
GHG	Greenhouse Gases
HTC	Headered Tube and Centre Condenser
HVAC	Heating Ventilation Air Conditioning
ICE	Internal Combustion Engine
RON	Research Octane Number
RPM	Rotation per Minute
SOP	Standard of Procedure
TFC	Tube and Fin Condenser
TXV	Thermostatic Expansion Valve
VCRS	Vapour Compression Refrigerant System

LIST OF SYMBOLS

h	-	enthalpy
$\dot{m}$	-	mass flow rate
N	-	Number of revolutions per minute
P	-	Pressure
$\dot{Q}$	-	Heat
T	-	Temperature
$\dot{W}$	-	Work done

CHAPTER 1

INTRODUCTION

1.0 Background

Air conditioning was first proposed to automobile industry by the Packard Motor Car Company during 1940 and followed by Cadillac in 1941. The acceptance of the air conditioner to the automobile industry as a car accessory does not get a high demand when first it was introduced. However, the popularity of air conditioning keeps increasing by the year until the early 1960s where it becomes a famous option (Schnubel, 2009).

Air conditioning is the adjustment or regulation of air in a closed space by the process cooled, heated, cleaned or filtered, humidified or dehumidified and circulated or recirculated either by heating or refrigerating (cooling by removal of heat). It is important to control the quantity (volume) and quality (temperature and humidity) of conditioned air at any time in varies condition (Schnubel, 2009).

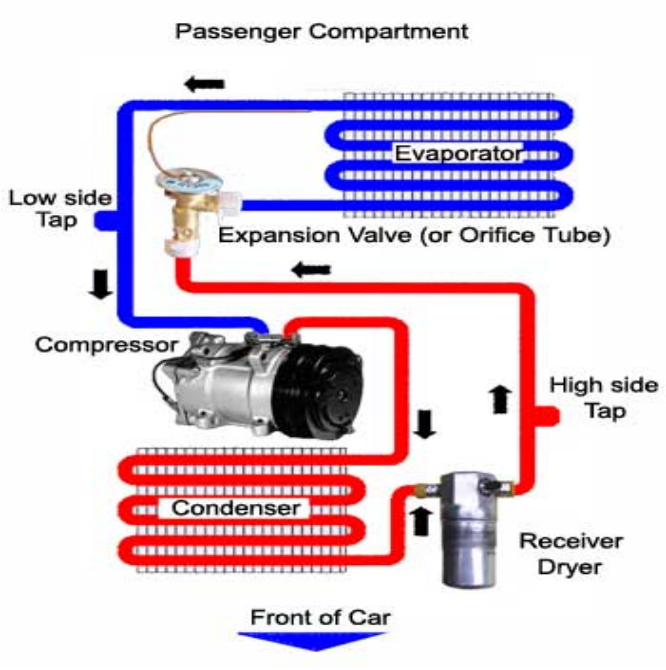

Figure1.1: Process flow diagram of the vehicle air conditioning system (Parker, 2016)

Air conditioning of vehicle is equipped with the compressor, condenser, metering devices and evaporator. Figure 1.1 shows the operation of air conditioning system of the vehicle which divided into two sides: high-pressure side, which has higher pressure and temperature, and the low-pressure side, which has low pressure and temperature (Birch, 2010). The evaporator and the expansion device are the components of the low sides while for the high sides, it major components are the compressor and the condenser.

In overall, this study is to investigate the performance of the vehicle air conditioning system that focuses more on the compressor components at various speeds. The relationship between the compressor speed, the coefficient of performance (COP) and the energy consumption is concluded at the end of the study.

1.2 Problem Statement

In the automotive industry, air conditioning is one of the important systems that widely used as the accessory for the vehicle such as the car that its main function is to provide thermal comfort for the users either by heating or cooling depends on the environmental condition. Geographically Malaysia is located in equatorial region which made it a hot and humid country. In this cases, air conditioning system has to work efficiently according to the climate changing which to be specified it is affected by factors; temperature, humidity and air velocity. The challenge is to ensure the air conditioning system achieve the optimum thermal comfort by control the parameter of compressor speed.

Fluctuation of fuel prices over the times in oil and gas industry especially in Malaysia made the saving in energy consumption very important. Energy consumption significantly in automobile industry tends to affect by the air conditioning system. Differ from four season country which used the heating system, in Malaysia cooling system is used in air conditioning system due to hot weather. Thus, due to low-temperature settings in the cooling system it required the compressor to work in the higher capacity which increases the fuel consumption. The compressor is known as the heart of air conditioning system is controlled by adjusting temperature of the thermostat at the relevant level to save energy consumption.

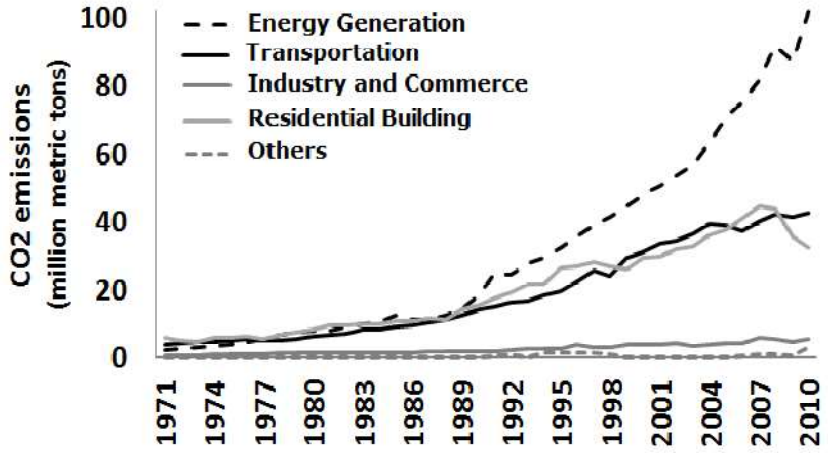

Figure1.2: Carbon emission in million metric tons by different sectors in Malaysia (1971-2010) (Tradingeconomics.com, 2013).

The annual trends in Figure1.2 showed the increment of carbon dioxide emission throughout the year (1971-2010) caused by different sectors. In 2010, the emission of CO_2 produced by transport sector of Malaysia is 42.43 million metric tons which equivalent to 22.9% of CO_2 emission in total at Malaysia (Shahid, Minhans, & Puan, 2014). The emission of CO_2 majorly causes by incomplete combustion of fuel. In an internal combustion engine (ICE), energy from fuel and air mixture is released by the chemical reaction of oxygen in air and hydrocarbons fuel to produce work. Type of fuels that typically used for combustion is diesel and gasoline. For example, Malaysia widely used RON95 and RON97 which contained hydrocarbons which caused the emission of greenhouse gases (GHG). GHG in the earth's atmosphere is exist in the form of water vapour which contains the small mixture of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Abdullah, 2017). Although it seems impossible to completely prevent the emission of gases, by hope the control of compressor speed can decrease the pollutants that emit to air by lower the requirement of work with the highest efficiency.

Therefore, as major energy consumption in typical land vehicle, it is crucial to understand how to operate the air conditioning system in the most efficient way. Due to this reason, this study is proposed to investigate the effect of compressor speed on the characteristics of the air conditioning system especially its performance.

1.3 Objectives

To accomplish this project with huge success the objective has been set. The purposes of the project are:

I. To determine the system temperature, system pressure, cooling capacity and compressor work at different compressor speed.

II. To justify the best coefficient of performance (COP) of the air conditioning system.

1.4 Scope of Project

Scopes are the limitations of the study that covered from three aspects of methodology, variables covered and validity of results.

The methodology is a way that used in the project to collect the data and how to obtain the result with high accuracy. Out of analytical and simulation method, the project are conducted by the experimental method where all the work is done in a laboratory by following the standard of procedure (SOP) for ensure the safety. The data was obtained by adjusted, fixed and observed specified parameter.

For the study of air conditioning under different compressor speed, the variable that was manipulated was the speed of the compressor in the unit of rotation per minute (rpm) which the ideal value varies from 1200 rpm up to 1900 with tolerance ± 0.01. After few trials was made, the value of 1500, 1700 and 1900 rpm was chose for this experiment. Since if the speed was at 1300 rpm, the system tend to shut down by itself in the middle of operation while if the speed was less than 1200 rpm, the speed was not enough to drive the motor and compressor together. The speed supposed not exceeding 2000 rpm to prevent the motor from overheated. Meanwhile, the fixed variable of this study are maintained the ambient temperature of surrounding around 28 ºC with natural increment up to 2 ºC. The temperature of inlet evaporator was also fixed at 30 °C ± 1 ºC.

Lastly, results obtained from this project were only valid or applicable for studies air conditioning for the cooling system in Malaysia.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The main function of air conditioning in automobile industry are provided the thermal comfort to the occupants while operate efficiently. Hence, this research is focussed on the performance investigation of air conditioning by identify the most suitable speed of compressor which has greater COP.

HVAC is defined as technology of high indoor air quality that widely used in residential buildings, commercial building, industry and vehicular. The operation of heat removal from the passenger compartment of air conditioning system is divided into low side (low pressure and low temperature) and high side (high pressure and high temperature). The ultimate goal of the system is to properly regulate the temperature and humidity in order to provide the thermal comfort to living environment either by cooling or heating load.

Figure 2.1, it shows the overall overview study of this research which has been more specified. This chapter will discussed about the basic components of air conditioning, basic operations, how to achieve the best COP value in order the system can perform optimally and the experimental investigation by previous researcher.

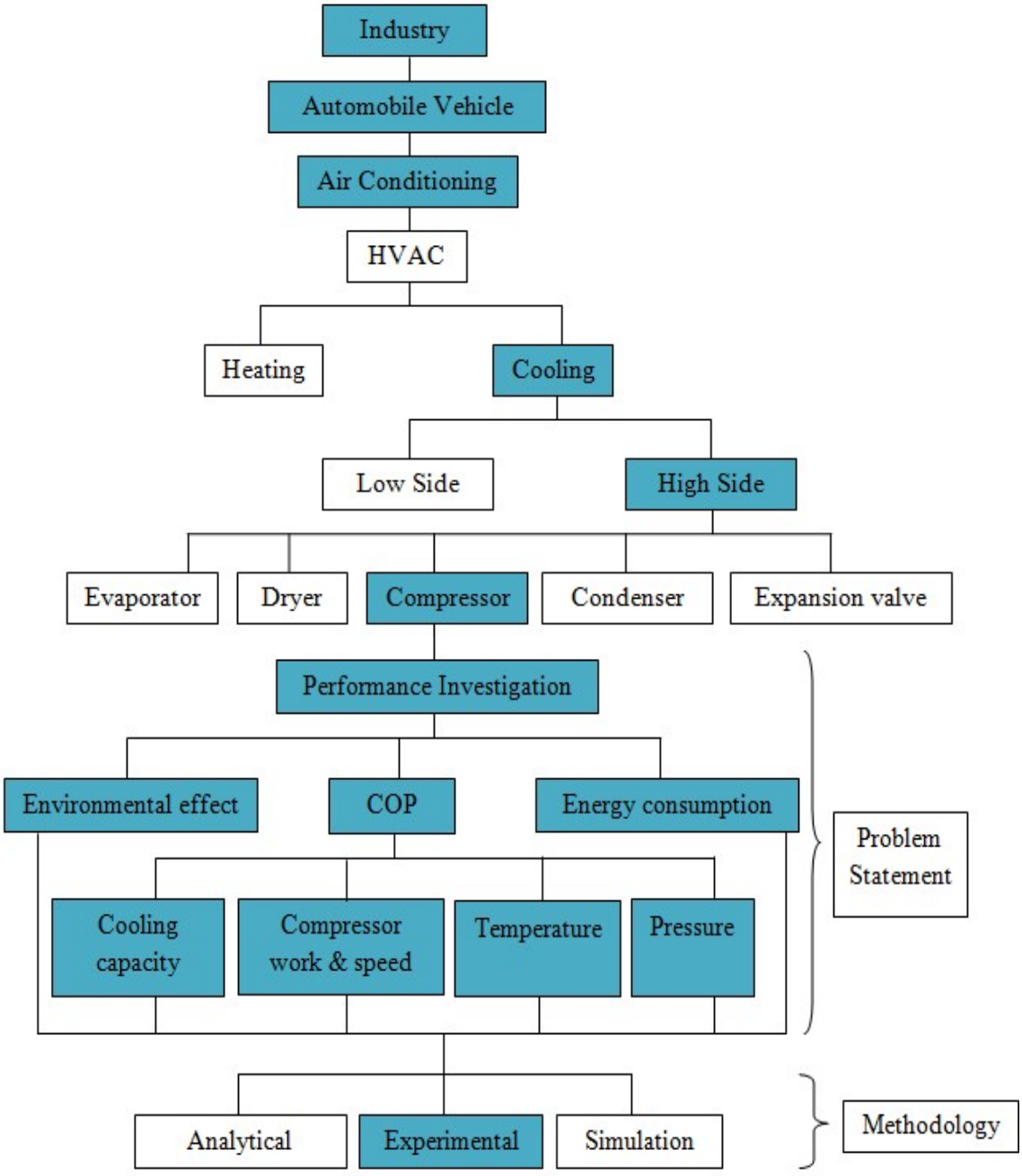

Figure 2.1: Overview study of Vapour Compression System (VCRS)