

STUDY OF INTERNAL HEAT EXCHANGER EFFECTS  
ON CAR AIR CONDITIONING SYSTEM

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This report is presented in  
partial fulfilment of the requirements for the  
Degree of Bachelor of Mechanical Engineering (Thermal Fluid)

Faculty of Mechanical Engineering  
University Technical Malaysia Melaka

MAY 2010

## VERIFICATION

I have read this thesis  
and from my opinion the thesis  
is sufficient in aspects of scope and quality for awarding  
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Signature : .....

Name of Supervisor : .....

Date : .....

## DECLARATION

“I hereby, declare this thesis is the result of my own research  
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Date : .....

**PENAKUAN**

“Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya telah jelaskan sumbernya”

Tandatangan : .....

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Tarikh : .....

## **DEDICATION**

To  
My Beloved Family

*Mom & Dad*

## ACKNOWLEDGEMENT

I would like to express the deepest appreciation to my supervisor of this Final Year Project (*Projek Sarjana Muda*), Mr. Faizil bin Wasbari. Without his guidance and generously advices on my entire project; this Final Year Project report's accomplishment would not have been possible. Besides, I thank the Turbo machinery Laboratory technician Mr Razmi bin A. Razak for his knowledge and assist in the field of technical. In addition, a thank you to my helpful course mate, Miss Fasiha bt Nazirmuidin, who assisted me throughout the experiment section.

Special thank goes to Mr John J. Yarrish and Visteon Company for their sponsorship on the internal heat exchanger sample used in my experimental test. Besides, I appreciate the Faculty of Mechanical Engineering, University Teknikal Malaysia Melaka (UTeM) for giving opportunity and provide facilities for my project. Lastly, I would like to thank my friends whose have helped and give contribution for my project and report accomplishment.

## ABSTRACT

Internal or suction line heat exchangers (IHX) are used in some car air conditioning systems with basic objective to optimize the liquefaction process of the refrigerant before entering the expansion device. This purpose is achieved by exchanging thermal energy between the cool gaseous refrigerant in the low pressured suction line and the warm liquid refrigerant in the high pressured liquid line in the A/C system. These devices can have either positive or negative influences on the Coefficient of Performance (COP) of the car air conditioning system, depending on the working fluids, the operating condition and the configuration of heat exchanger. The finding from the experimental test indicated the COP of the system with adoption of IHX will be up to 7.92% increment than the system without adoption of IHX if rotational speed of engine was increased.

## **ABSTRAK**

*Penukar haba dalaman atau saluran sedutan (IHx) selalunya digunakan dalam sistem penyamanan udara dengan objektif asalnya menyempurnakan proses pencecairan bahan penyejuk sebelum memasuki peralatan ekspansi. Tujuan tersebut dicapai dengan menukarkan tenaga haba di antara gas bahan penyejuk sejuk di salur sedutan yang tekanannya rendah dan cecair bahan penyejuk panas di salur cecair yang tekannya tinggi di dalam sistem penyamanan udara. Penukar haba boleh membawa impak positif atau negatif ke atas COP(Coefficient of Performance) sistem penyamanan udara kereta, bergantung dengan bahan penyejuk digunakan, syarat operasi, dan rekabentuk penukar haba. Kesimpulan dari kajian menyatakan bahawa COP sistem yang menggunakan penukar haba dalaman akan lebih tinggi sebanyak 7.92% daripada COP sistem yang tidak menggunakan penukar haba dalam sekiranya laju putaran enjin ditingkatkan.*



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## LIST OF SYMBOLS

|               |   |  |
|---------------|---|--|
| COP           | = | Coefficient of Performance                           |
| $c_p$         | = | Specific heat capacity at constant pressure, kJ/kg K |
| $h$           | = | Enthalpy, kJ/kg                                      |
| $\dot{m}$     | = | Mass flow rate                                       |
| $n$           | = | Polytrophic index                                    |
| $P_c$         | = | Compressor electrical power consumption, kW          |
| $P$           | = | Pressure, kPa  |
| $q_o$         | = | Refrigerating effect, kJ/kg                          |
| $Q_o$         | = | Refrigerating capacity, kW                           |
| $t$           | = | Compression ratio                                    |
| $T$           | = | Temperature, °C or K                                 |
| $v$           | = | Specific volume, m <sup>3</sup> / kg                 |
| IHX           | = | Internal heat exchanger                              |
| SLHX          | = | Suction-line heat exchanger                          |
| $\varepsilon$ | = | Effectiveness  |
| $\Delta p$    | = | Pressure drop, kPa                                   |
| $\Delta T$    | = | Temperature difference, °C or K                      |

### *Subscripts*

|     |   |               |
|-----|---|---------------|
| $g$ | = | Gaseous       |
| $K$ | = | Condenser     |
| $l$ | = | Liquid        |
| $o$ | = | Evaporator    |
| $R$ | = | Refrigeration |

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## NOMENCLATURE

**Temperature** - A measure of the average kinetic energy of the particles in a sample of matter, expressed in terms of units or degrees designated on a standard scale.

**Degree Celsius** - A temperature scale (also called *centigrade*) in which 0° represents freezing and 100° represents the boiling point. To convert Celsius temperatures to Fahrenheit scale, multiply the Celsius figure by 9, divide by 5 and add 32.

**Absolute Temperature** - The reading on a scale with zero at the thermodynamic null, most particularly the Kelvin scale.

**Pressure** - It is defined as force per unit area. It is usually more convenient to use pressure rather than force to describe the influences upon fluid behaviour. The standard unit for pressure is the Pascal, which is a Newton per square meter.

**Specific volume** - The volume occupied by a unit of mass of a material. It is equal to the inverse of density.

**Heat** - The energy which is spontaneously flowing from an object with a high temperature to an object with a lower temperature.

**Conduction** - The transfer of thermal energy between the neighbouring molecules in a substance due to temperature gradient.

**Convection** – The process by which heat is transferred by movement of a heated fluid such as air or water.

**Radiation** - The process by which heat is transferred between bodies by electromagnetic radiation.

**Latent heat** – the characteristic amount of energy absorbed or released by a substance during a change in its physical state that occurs without changing its temperature.

**Specific heat** - the measure of the heat energy required to increase the temperature of a unit quantity of a substance by unit degree.

**Critical Temperature** – The maximum point at which a gas can be liquefied or condensed by raising the pressure.

**Critical Pressure** – The pressure that is necessary to liquefy a gas at that temperature.

### **Phases of Refrigerant**

a) *Compressed liquid* – Pure liquid, at less than saturation temperature (boiling point at pressure)

b) *Saturated liquid* – Pure liquid, but at the saturation temperature (any additional of heat will cause some vaporization)

c) *Saturated liquid/ vapour mixture* – A mixture of liquid and vapour at the temperature and pressure of saturation.

d) *Saturated vapour* – Purely vapour, but at the saturation temperature (any loss of heat will cause some condensation to occur)

e) *Superheated vapour* – Purely vapour, above the saturation temperature.

**Subcritical System** – The refrigeration system where condenser and evaporator operate with temperature below the refrigerant's critical temperature.

**Transcritical System** – The refrigeration system where the cycle incurs temperatures and pressures both above and below the refrigerant's levels.

**Humidity** – the amount of water in the ambient air. The amount of water vapour suspended in air can vary from a perfectly dry 0% to foggy 100%.

**Relative Humidity (RH)** – The amount of water vapour air hold varies with temperature.

## CHAPTER I

### INTRODUCTION

#### 1.1 Background Study

Internal heat exchanger (IHX) also known as Suction-line/Liquid-line heat exchanger (SLHX) is a derivation from the traditional heat exchangers. Its purpose/concept is similar with other type of heat exchangers, which is a device to build for efficient transfer heat from one place to another. However, it has several notable differences with other traditional heat exchanger in term of size, shape, structure, usage, etc.

Nowadays, the developments of internal heat exchanger are rapid. It has an important role on air-conditioning system based on the vapour compression cycle. The internal heat exchanger often use in automotive air conditioning, with the basic objective of assuring the subcooling of refrigerant before entering the expansion device. This process is achieved by exchanging enthalpy (energy) between the cool gaseous refrigerant in the suction line and the hot liquid refrigerant at liquid line. However, according to previous research result, the devices can have positive or negative influences on the overall efficiency, depending on it design and configuration.