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OPTIMIZING HVAC SYSTEM USING VEHICLE PASSENGER
THERMAL COMFORT MODEL


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This thesis is submitted to Mechanical Engineering Faculty in partial fulfillment of the requirements for the award of Bachelor Degree in Mechanical Engineering (Thermal-Fluids)

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May 2006

I declare that this thesis entitled “Optimizing HVAC System Using Vehicle Thermal Comfort Model” is the result of my own research except as cited in the references.

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For my beloved parents, Arpiah Haji Awang & Yusoff Omar, and dearest sister
Tasnim Yusoff

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ABSTRACT

Human comfort in passenger compartment is a prime concern for designers, owners and passengers. Interior climate is one of the main comfort factors during a trip. Besides, it is also very important for interior safety because temperature humidity affect the driver's well-being and thus his or her level of alertness and of course the heating and ventilation system is also responsible for demisting the windscreen and side windows. Recently, there has been a major development in the area of HVAC system using passenger thermal comfort to ensure that the occupants are comfortable staying in the vehicle. More investigation of the design parameters space is conducted to bring the final design closer to the optimum. For this purpose, a model car is selected to perform analysis for thermal comfort inside the model car as well as to investigate the occupant thermal comfort in order to support automotive climate control systems. Based on the experiment, simulation and questionnaire, it is found that the most comfortable condition inside the passenger compartment is where blower is set at the third level speed. At this condition, most of the occupants claimed to be in comfortable state with the temperature around 20°C to 25°C and the highest velocity around 1.5 m/s.

ABSTRAK

Keselesaan penumpang di dalam kenderaan adalah faktor utama bagi pereka-cipta, pemilik kenderaan dan pengguna kenderaan. Persekitaran dalaman adalah faktor utama dalam menjamin keselesaan terutamanya bagi perjalanan yang jauh. Selain itu, ia penting dari segi keselamatan kerana suhu adalah aspek utama yang boleh mempengaruhi kesihatan, dan tahap fokus dan kewaspadaan pemandu. Kepanasan dan pengudaraan di dalam kenderaan juga adalah faktor penting yang patut diambil kira bagi memastikan cermin kereta tidak berada dalam keadaan kabur yang boleh menjejaskan penglihatan dan pandangan pemandu di mana keadaan ini boleh membahayakan pemandu. Kini, pelbagai usaha dalam bidang sistem *HVAC* (*heating, ventilating and air-conditioning*) menggunakan keselesaan terma bagi penumpang dijalankan untuk memastikan penumpang tahap keselesaan di dalam kenderaan. Pelbagai kajian tentang ruang rekaan parameter telah dijalankan untuk mendapatkan nilai rekaan rekaan yang paling optima. Bagi tujuan ini, sebuah kereta telah dipilih sebagai model kes kajian untuk menganalisis keselesaan terma di dalam kereta sebagai salah satu usaha di dalam membangunkan sistem kawalan terhadap persekitaran automotif. Berdasarkan kajian, simulasi dan soal selidik, didapati bahawa kebanyakan pengguna berpendapat bahawa tahap keselesaan di dalam kenderaan ialah apabila kelajuan “*blower*” ditetapkan pada kelajuan ketiga di mana suhu berada pada kira-kira 20°C to 25°C dan halaju udara pula berada pada kira-kira 1.5 m/s.

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LIST OF SYMBOL

SYMBOL	DEFINITION
P	Pressure inside of the car (Pascals)
V	Volume of the interior of the car (cubic meters)
n	Number of moles of air inside the interior of the car (moles)
T	Temperature inside of the car (Kelvin)
R	Universal gas constant ($8.314 \text{ Pa}\cdot\text{m}^3/\text{mol}\cdot\text{K}$)
MW	Molecular weight of air (kilograms/moles)
Cp	The heat capacity of air at the temperature specified (kilojoules/kilograms*Kelvin)
m	Mass of air inside of the vehicle
Q	Heat load inside of the vehicle (kilojoules)
A	Area
L	Length

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CHAPTER 1

INTRODUCTION

1.1 Research Background

The heating, ventilating and air conditioning system (HVAC) includes all of the components and controls responsible for keeping the interior of the car at a comfortable temperature. The HVAC system provides heating and cooling as needed and as where directed by the system controls. HVAC is not only important for comfort; it is also a key safety system for maintaining good visibility.

To many of us, of the term air conditioning connotes well-circulated blasts of cool, dehumidified air to take the sting out of our hot and humid climate. Without a doubt, air conditioning is one of the most significant inventions ever made in terms of driving comfort particularly for climates like us. However, few realize that air conditioning is a broad, all encompassing term and includes the capability to provide warm as well as cool air although the former has little benefit to us locally.

Another popular misconception in our local context is that air conditioning systems produce cold air. What they really do is produce the means to remove heat from the immediate environment rather than cold outright. Obviously, air conditioning systems (now sometimes also referred to as climate control systems) have great benefits for automotive applications, helping to cool and dehumidify the passenger cabin, as well as sapping it of the majority of airborne dust particles and odours.

Simply put, air conditioning is environmental control of a car's passenger cabin where temperature, humidity and circulation are maintained at the desired level with added benefits of cleanliness as well.

1.2 Objectives Of The Study

The objectives of this study are :

- a) To perform analysis for thermal comfort inside the model car as well as to investigate the occupant thermal comfort in order to support automotive climate control systems.
- b) To study the guidelines of optimizing HVAC system design based on the model that can be applied for the temperature and relative humidity in Malaysia.