ANALYSIS OF VENTILATION AND HEAT REMOVING SYSTEM FOR WAJA CAR

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ABSTRACT

This report is an outcome of the final year project which the title is Analysis Of Ventilation and Heat Removing System for Waja Car. The main objective of this project is to determine temperature increment inside the cabin under direct sunlight. Second objective is to carry out an analysis of temperature increment inside the cabin in three different conditions which is in fully closed cabin, with the air conditioning blower switched on, and with heat removing devices attached to the car windows. For this project, data gathering was done by experiment method. The car is parked under direct sunlight, and data is taken from three manipulated condition for eight hours. Main apparatus that use in this project is thermocouple monitor, CPU fan, and J-Type thermocouple. Eight point of thermocouple is set inside the car cabin which is reacted as the temperature sensor. The result of the experiment shows that temperature inside car cabin can quickly rise to a level that is not suitable for people to enter the car. The highest temperature taken in the first experiment of fully closed cabin is 69.2˚C and the minimum temperature taken is 29.7˚C. For the second experiment of fully closed cabin, maximum temperature is 72.7˚C, and the maximum temperature is 31.1˚C. Maximum temperature taken when the blower switched on is 65.6˚C and the minimum temperature is 31.4˚C.For the last experiment, which is heat removing attached to the windows, the minimum temperature taken is 33.7˚C and the maximum temperature is 59.2˚C. The result also shows that attachment of the heat removing devices can reduce the maximum temperature inside the cabin.

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ABSTRAK

Laporan ini adalah hasil daripada projek tahun akhir yang bertajuk Analysis Of Ventilation and Heat Removing System for Waja Car. Objektif utama projek ini ialah untuk menentukan kenaikan suhu dalam ruangan penumpang kereta apabila ianya diletakkan di bawah sinaran matahari. Objektif kedua ialah untuk menjalankan analisis berkaitan kenaikan suhu dalam tiga keadaan yang berbeza iaitu dengan ruangan penumpang ditutup sepenuhnya, dengan kipas penghawa dingin dihidupkan, dan dengan alat penyedut haba dipasang pada tingkap kereta. Pengumpulan data kenaikan suhu dijalankan secara eksperimen. Kereta diletakkan di bawah sinaran matahari, dan data diambil berdasarkan tiga keadaan yang dimanipulasi selama lapan jam. Alat yang digunakan dalam eksperimen ini ialah monitor thermocouple, kipas CPU, dan thermocouple jenis-J. Lapan set thermocouple diletakkan di dalam ruangan penumpang yang bertindak sebagai pengesan suhu. Keputusan eksperimen menunjukkan suhu di dalam kereta boleh meningkat sehingga tahap yang tidak sesuai untuk penumpang masuk ke dalam kereta. Suhu maksimum yang dicatatkan pada eksperimen pertama untuk ruangan kabin ditutup sepenuhnya ialah 69.2˚C dan suhu minimumnya ialah 29.7˚C. Untuk eksperimen kedua ruangan kabin tertutup sepenuhnya, suhu maksimum yang dicatatkan ialah 72.7˚C dan suhu minimumnya ialah 31.1˚C. Apabila kipas penghawa dingin dihidupkan, suhu maksimum yang dicatatkan ialah 65.6˚C dan suhu minimum yang dicatatkan ialah 31.4˚C. Untuk eksperimen terakhir, dimana alat penyedut dipasang pada tingkap kereta, suhu minimum yang dicatatkan ialah 33.7˚C dan suhu maksimum yang dicatatkan ialah 59.2˚C. Keputusan juga menunjukkan kenaikan suhu di dalam kereta boleh dikurangkan apabila alat penyedut haba dipasang.

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LIST OF SYMBOLS

V	Fan velocity
r	Radius of fan
ω	Fan speed in RPM
P	Pressure
m	Mass of air
T	Temperature
R	Gas constant
ρ	Air density
A	Fan Area

LIST OF ABBREVIATIONS

GPIB	General purposes interface bus
EXC	Execute
BKSP	Backspace
RS232	Recommended standard-232
TC TYPE	Thermocouple type
RPM	Rotational per minutes
CFD	Computational fluid dynamics
CPU	Centre processing unit

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Most of the vehicle nowadays has very efficient and reliable heating ventilating, and air conditioning (HVAC) system. Ventilation was simple to arrange by opening the window. However the air entering was as hot, cold, or dusty as the air outside. Sheathing paper, weather windows and shading curtains can be used to control an automobile's temperature, but they are not very effective. When the weather turned hot, most drivers simply put up with the discomfort. Moreover, the instrumentation panel, leather seats and plastic accessories, among other items, age rapidly if exposed to these temperatures for a long period Ventilation system is design to provide comfort for the driver and passenger. It is intended to maintain in-car temperature and humidity within a range that is comfortable for the people inside and provide fresh, clean air for ventilation. This temperature range helps keep the driver alert and attentive.

1.2 PROBLEM STATEMENT

Temperature inside the vehicle cabin is very important to provide comfortness to the car passenger. The temperature can be controlled by using air conditioning system that can be operated when the car engine is in operation. However, when the car is left or parked directly under the sunlight, temperature inside the cabin will be increased.

1.3 OBJECTIVES

The objectives of this project is divided into two, which is:

1) Determine temperature increment inside the vehicle cabin under direct sunlight.
2) Carry out analysis of temperature inside the car cabin in three conditions: fully closed cabin, with air conditioning blower is switch on, and with heat removing devices attach to the windows.

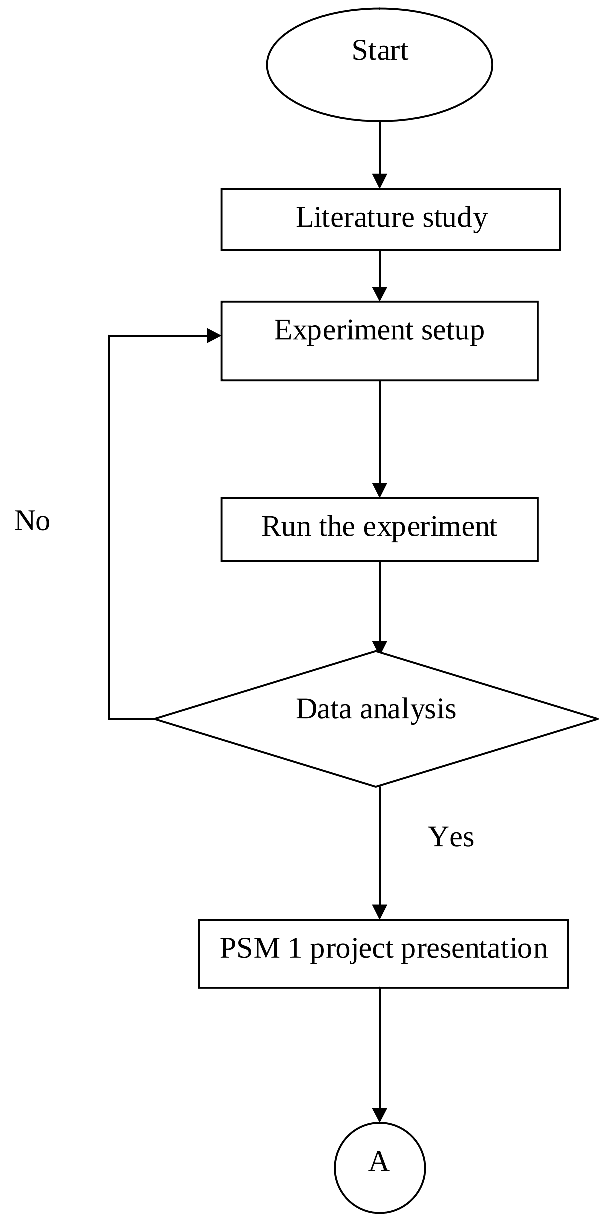
1.4 SCOPE

The scopes of this project is divided into two, which is:

1) Search, review and gather information about literatures reviews of car cabin ventilation from journals and references book.
2) Run the experiment to determine the temperature distribution and its increment inside car cabin.
3) Analysis of data from all condition that manipulated.
4) Documentation of result.

1.5 FLOW CHART

Figure 1.1 shows the flow chart from the beginning of the project until the end of the project.



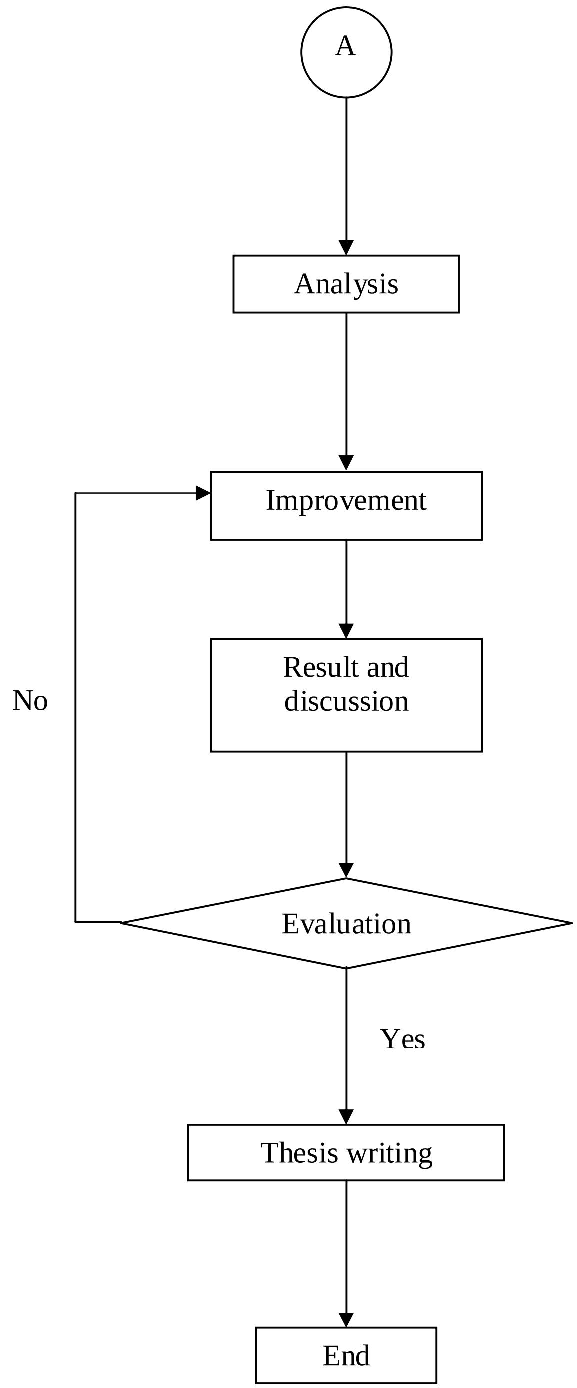


Figure 1.1: Flow chart for final year project

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION TO VENTILATION SYSTEM

By definition, ventilation is the process by which ‘clean’ air (normally outdoor air) is intentionally provided to a space and stale air is removed. This may be accomplished by either natural or mechanical means. Automobile ventilation system is used to keep the passenger compartment at a comfortable temperature. For health and comfort, some fresh air must pass through the passenger compartment. This replaces the stale and sometimes smoke-filled air inside the vehicle. The process is called ventilation. There are two methods which is uncontrolled ventilation and controlled ventilation. Uncontrolled ventilation occurs when windows are open. Controlled ventilation is either ram-air or power. In the ram air system, opening vents or ducts admits air to the car cabin. Forward movements then forces or ram air into the vehicle as shown in Figure 2.1. However when the vehicles stopped or move slowly, just a little fresh enters. This is one reason most vehicles have a power ventilating system which actually used a fan or blower and the fan is located in the dashboard. A blower assembly is attached to the motor shaft and the entire unit is placed inside the blower housing. As the squirrel cage blowers as shown in Figure 2.2 rotates, its produces a strong suction in the intake. A pressure is also created on the output. When the fan motor is energized by using the temperature control on the dashboard, air is moved through the passenger compartment.

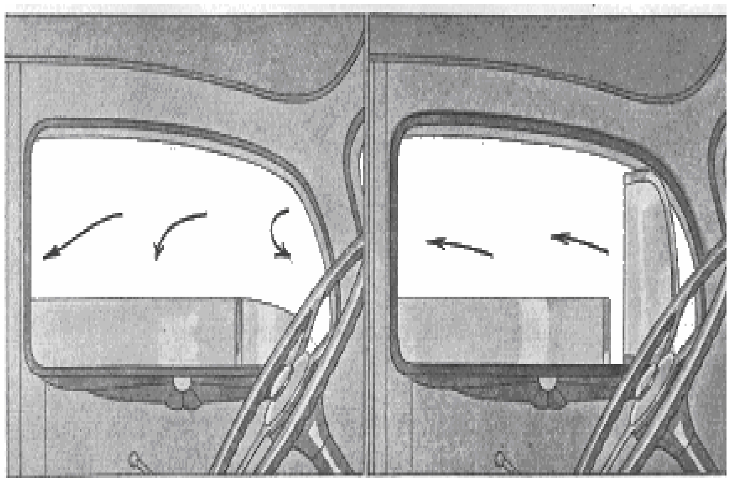


Figure 2.1: Flow of air when the vehicle moves forward

Source: Carbasic (1950)

Figure 2.2: Squirrel cage fan that used to help move air throughout the passenger compartment.

Source: Lambert (2002)

2.2 HEAT GENERATED

A medium through which heat is conducted may involved the conversion of mechanical, electrical, nuclear, or chemical energy into heat or thermal energy. In heat conduction analysis, such conversion process is characterized as heat or thermal energy generation. Heat generation is a volumetric phenomenon. That is, it occurs throughout the body of a medium. Therefore the rate of heat generation in a medium is usually specified per unit volume. Heat loss or gain mainly occurs on a car cabin by three primary mechanisms:

1) Conduction
2) Convection
3) Radiation

2.2.1 Conduction

Conduction is the transfer of energy from the more energetic particles of a substance to the adjacent less energetic one as a result of interactions between the particles. Conduction can take place in solids, liquids or gases. In gases and liquids, conduction is due to the collisions and diffusion of the molecules during their random motion. In solids, it is due to the combinations of vibration of the molecules in a lattice and the energy transport bye free electron.

2.2.2 Convection

Convection is the mode of energy transfer between a solid surface and the adjacent liquid or gas that is in motion, and it involves the combined effect of conduction and fluid motion.

2.2.3 Radiation

Radiation is the transfer of heat from one object to another by means of infra-red waves. Radiation heat transfer does not require that objects be in contact or that a fluid flow between those objects. Radiation heat transfer occurs in the void of space.

2.3 TECHNICAL PAPER REVIEW

2.3.1 Experiment Setup for Temperature Measurement

Outline of the experimental set-up for temperature measurement was shown in Figure 2.3. This Figure 2.3 the top view of the experimental set-up. Temperatures were measured in the different locations of the car cabin and shown by the black and white circle. T-type thermocouple was used for this purpose. Five analog modules were used for data acquisition. This analog data was converted into digital data by analog/digit converter. Digitized data was analyzed by the computer.

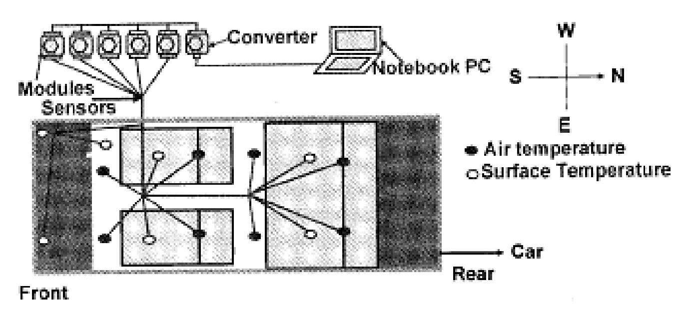


Figure 2.3: Schematic diagram of experiment setup for temperature measurement

Source: Khan M.U et al.

2.3.2 Experiment Setup for Flow Rate Measurement

Two types of ventilation method were used. One was suction type and other is discharge type. Figure 2.4 shows the diagram of the experimental for suction type ventilation. Atmospheric air was sucked by the blower to pass into the car cabin. Before entering into car cabin air flow rate was measured by the orifice/manometer combination. Two air inlets were used, one was setup on the top of the front panel and another one was setup below the front panel. Air outlet was set up on the passenger side rear panel for both cases.

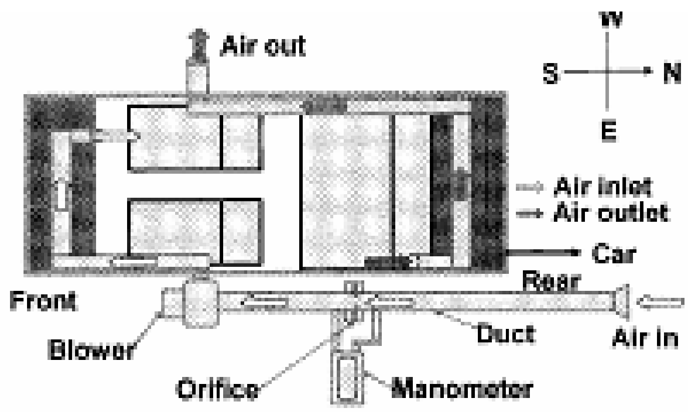


Figure 2.4: Suction type ventilation

Source: Khan M.U et al.

For the discharge type ventilation as shown in Figure 2.5, atmospheric air was enters into the car air inlets and discharges it by blower. Before discharging from the blower air flow rate was measured by the manometer combination. Air inlet was set up on the top of the front panel and air outlet was set up on the passenger side rear panel.

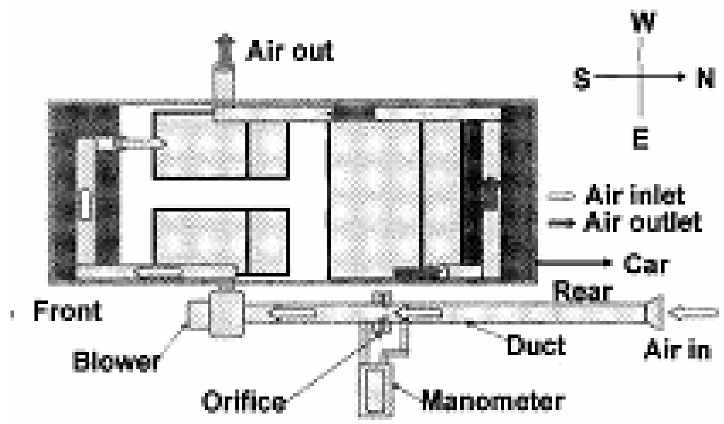


Figure 2.5: Discharge type ventilation

Source: Khan M.U et al.

2.3.3 Temperature Variations with Time at Different Locations (Without Cooling)

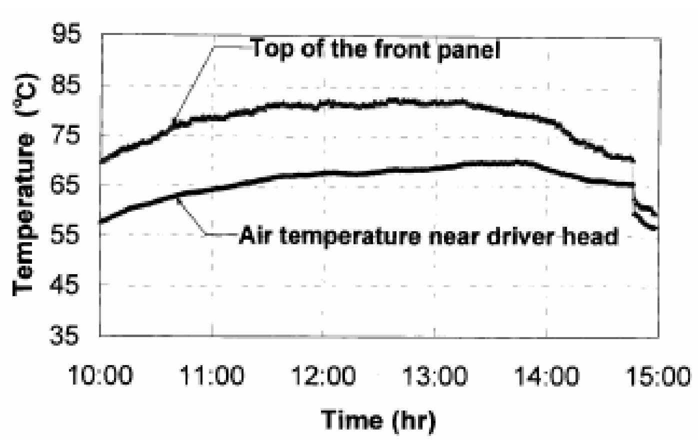


Figure 2.6: Temperature variations with time at different locations (without cooling)

Source: Khan M.U et al.

Figure 2.6 shows temperature variation of the front panel surface and air space temperature near drivers head without ventilation. While this experiment was carried out, the atmospheric temperature was 32˚C during 10:00am to 3:00pm. Front panel surface had the maximum temperature of car cabin which is 83˚C while the maximum air space temperature near driver head was found 67˚C.

2.3.4 Temperature Variations with Time at Different Flow Rates (m^3/hr)

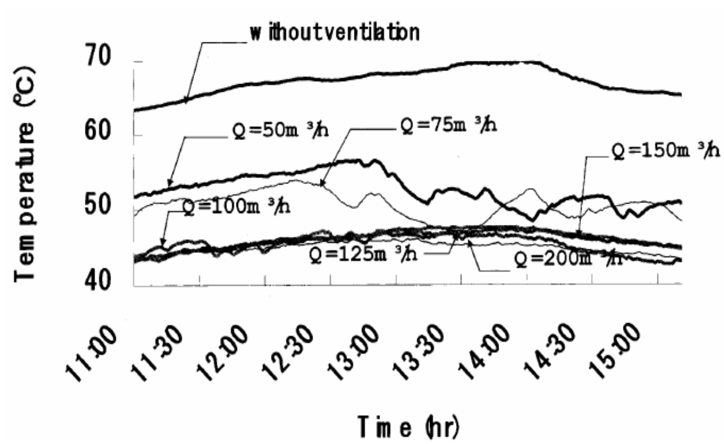


Figure 2.7: Temperature variations with time at different flow rates (m^3/hr)

Source: Khan M.U et al.

Influence of air flow rate effects temperature variation near drivers head. This is shown in Figure 2.7. Temperature around 55˚C can be suppressed at air flow rate of 50 and 75m^3/hr while airflow rates of 100, 125 and 200m^3/hr can suppress temperature below 50˚C. This figure suggests air flow rates of 100m^3/hr will be sufficient to mitigate temperature within comfortable range.

2.3.5 Effect of Different Location of Air Inlet and Ventilation Methods On Ventilation

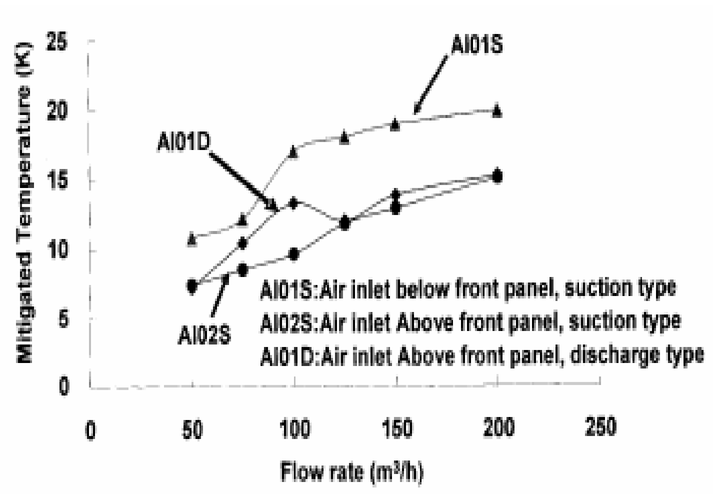


Figure 2.8: Effect of different location of air inlet and ventilation methods on ventilation

Source: Khan M.U et al.

Temperature mitigation at different air inlet locations and different ventilation method of air space temperature near drivers head shown in Figure 2.8.At air inlet below front panel and suction type ventilation, 12K of temperature mitigated for airflow rate 50 and 75m^3/hr. About 20K temperature mitigated at 100, 125, 150 and 200m^3/hr airflow rate. Air inlet above front panel and suction type ventilation, less than 10K temperature mitigated for airflow rate 50 and 75m^3/hr. Above 10K temperature mitigated for airflow rate of 100, 125, 150 and 200m^3/hr. Air inlet above front panel and discharge type ventilation mitigated 7K and 10K temperature for airflow rate 50 and 75m^3/hr respectively. About 15K temperature mitigated for airflow rate of 100, 125, 150 and 200m^3/hr. In conclusion, this analysis shows that air inlet below front panel with suction type ventilation have better temperature mitigation.

2.4 PARAMETER THAT AFFECT HVAC SYSTEM

2.4.1 Outsides Temperature

Another parameter that significantly affects car HVAC system performance is the temperature outside the car. For Figure 2.9, it can be seen that for the case with a lower outside temperature, the car interior temperature is also lower.

Figure 2.9: Steady state case with a lower outside temperature

Source: A. Alexandrov et al. (2001)

2.4.2 Inlet Condition

Air temperature and at the inlets play an important role in determining cabin climate. Another observation is that within the realistic range of inlet temperatures, there is a constant presence of “cold” or “hot” areas. This trend is more pronounced at the beginning of heating/cooling. Figure 2.10 illustrates this effect for a transient case of heating. There are two main locations of the “cool” areas, being behind the front seats and in the front seat leg areas. These cool areas typically coincide with areas of slow air circulation as in Figure 2.11.