UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS ◆

JUDUL: **ANALYSIS OF VENTILATION AND HEAT REMVING SYSTEM FOR WAJA CAR**

SESI PENGAJIAN: 2009/2010

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ANALYSIS OF VENTILATION AND HEAT REMOVING SYSTEM FOR WAJA CAR

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2009

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We certify that the project entitled *Analysis Of Ventilation And Heat Removing System for Waja Car* is written by *Wan Mohd Kamil bin Wan Yacob*. We have examined the final copy of this project and in our opinion, it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfilments of the requirements for the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

………………………….

Examiner Signature

ANALYSIS OF VENTILATION AND HEAT REMOVING SYSTEM FOR WAJA CAR

WAN MOHD KAMIL BIN WAN YACOB

Report submitted in partial fulfillment of the requirements
for the award of the Bachelor of
Mechanical Engineering with Automotive Engineering

Faculty of Mechanical Engineering

UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2009

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

Signature : ……………………...
Name of Supervisor : MOHD YUSOF BIN TAIB
Position : Lecturer
Date :

STUDENT'S DECLARATION

I, Wan Mohd Kamil bin Wan Yacob declare that this report entitled *Analysis Of Ventilation and Heat Removing System for Waja Car* is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : WAN MOHD KAMIL BIN WAN YACOB

ID Number: MH06059

Date :

…dedicated to beloved Wan Yacob b Wan Mamat, Fatimah bt Jusoh, Wan Dasuki b Wan Yacob, Wan Zalina bt Wan Yacob, Wan Zakiah bt Wan Yacob, Wan Zool Helmi b Wan Yacob, Wan Ismail b Wan Yacob, Wan Syawaluddin b Wan Yacob, Wan Mohamad Hafiz b Wan Yacob, Wan Nor Hidayah bt Wan Yacob and Wan Siti Hajar bt Wan Yacob…

ACKNOWLEDGEMENT

First of all, I want to thank The Almighty Allah S.W.T for the beautiful life that has been given to me in the past 22 years and the present. I am very thankful to be given the time and chances to finally complete this research.Throughout two semesters, I met numbers of lecturers and professionals who have assisted me in many ways towards completing my research.

Firstly, I would like to express my sincere appreciation to my supervisor, Mr. Mohd Yusof Taib, who generously shared his insights and suggestions, for his critics, trust, encouragement, and attention. Without their continued support and interest, this project report would not have been the same as presented here. I also would like to express my gratitude to the Faculty of Mechanical Engineering and Universiti Malaysia Pahang, for their assistance in supplying the relevant literatures.

I am also obliged to express my appreciation towards my beloved mom and dad and also my family members for their enduring patience, moral and financial supports. My fellow friends should also be recognised for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. Thank you to all. Thank you for everything. May God bless all of you.

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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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.

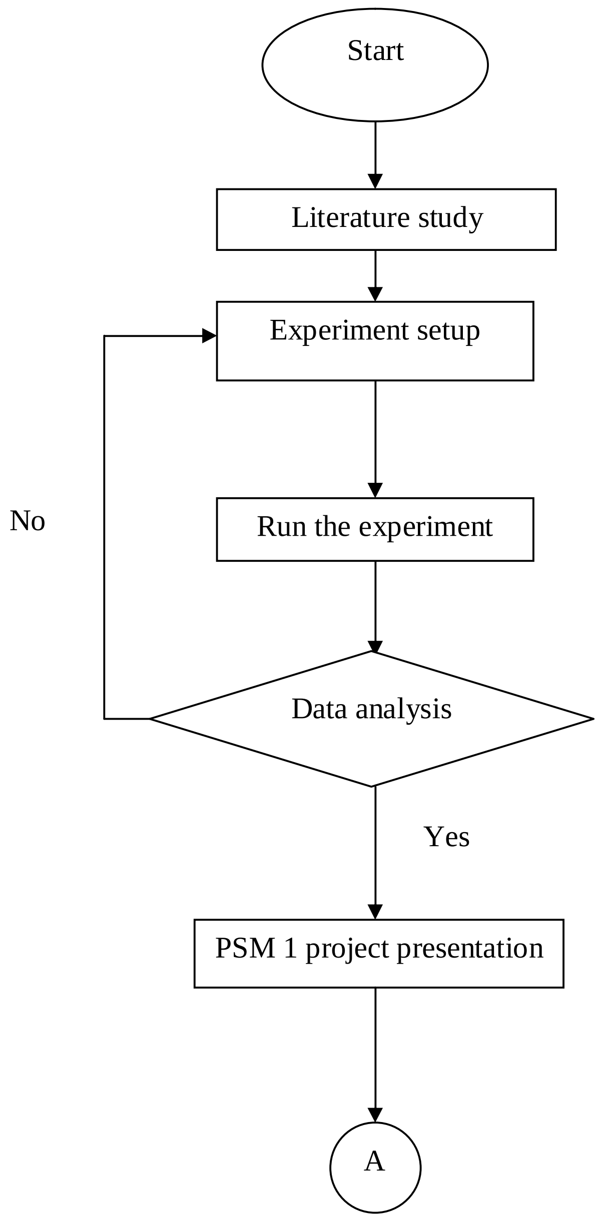
1.4 SCOPE

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.



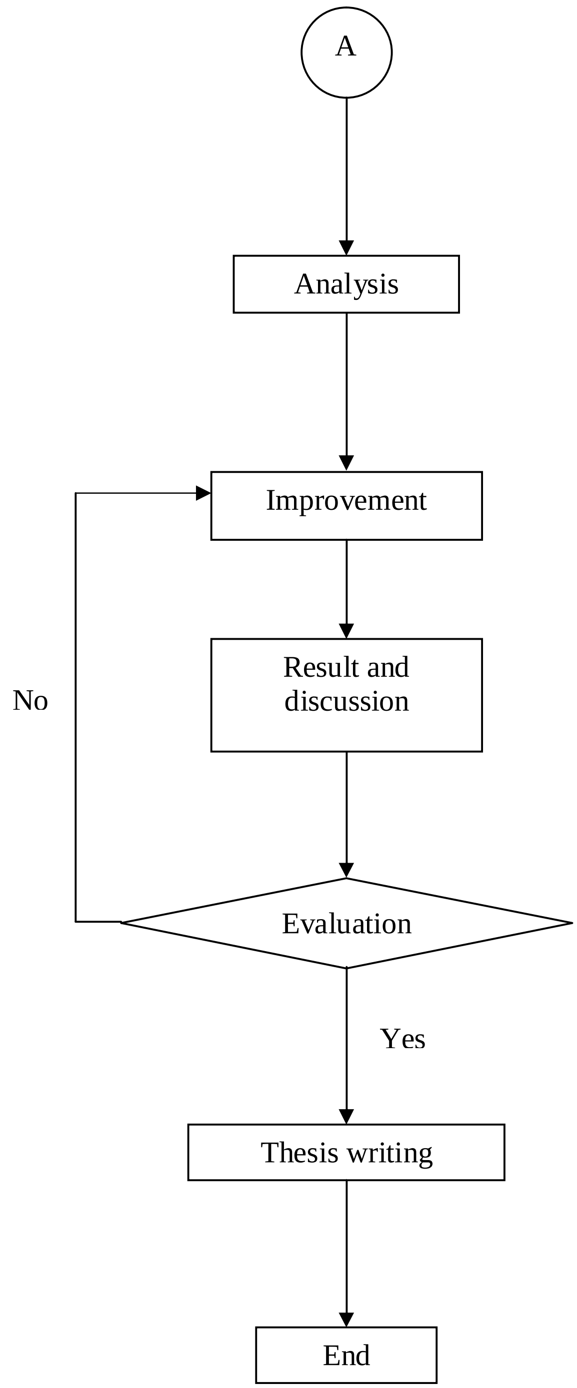


Figure 1.1: Flow chart for final year project

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.

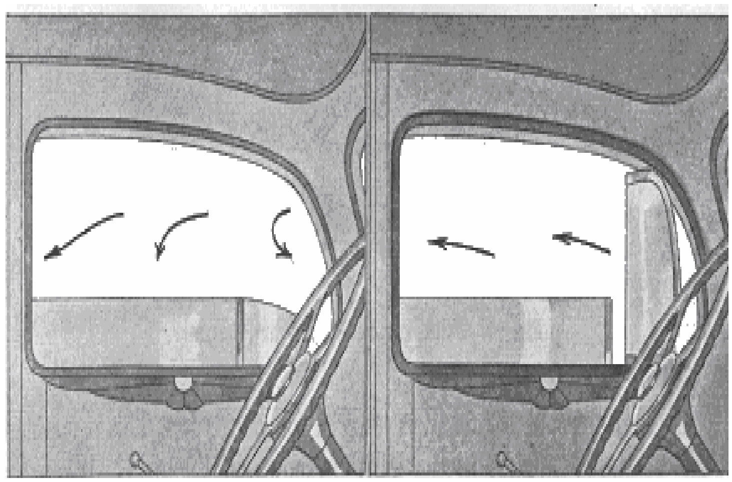


Figure 2.1: Flow of air when the vehicle moves forward

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.

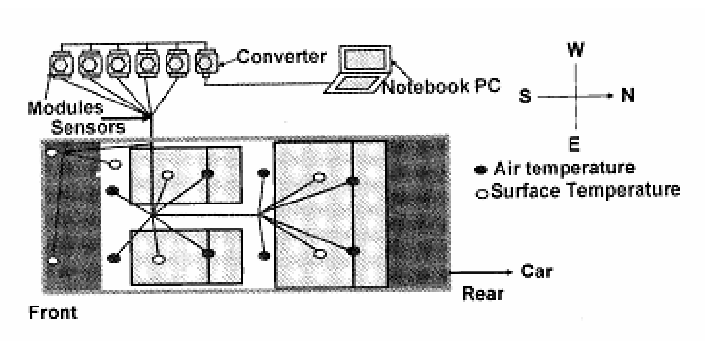


Figure 2.3: Schematic diagram of experiment setup for temperature measurement

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.

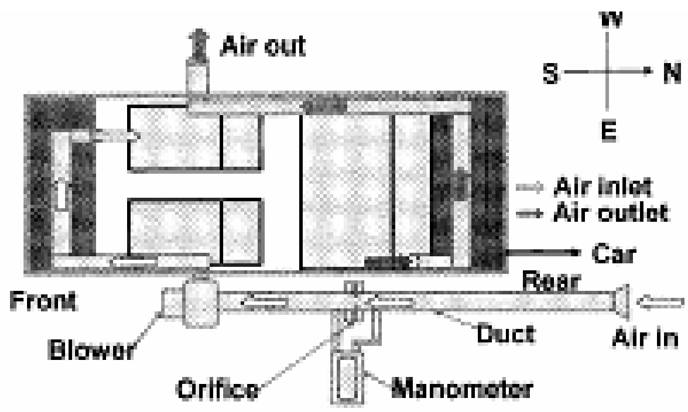


Figure 2.4: Suction type ventilation

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.

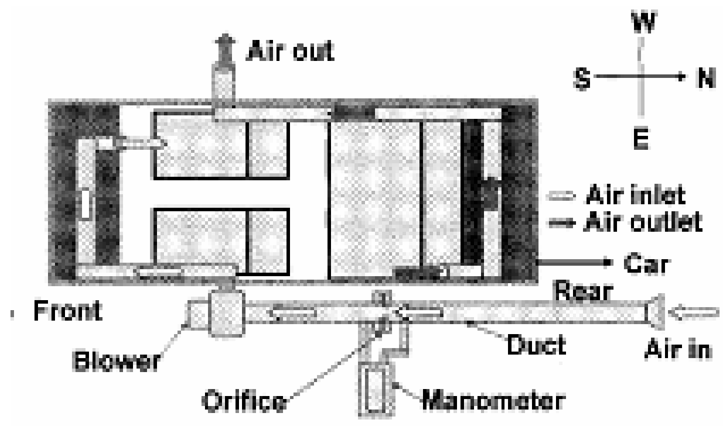


Figure 2.5: Discharge type ventilation

Source: Khan M.U et al.

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

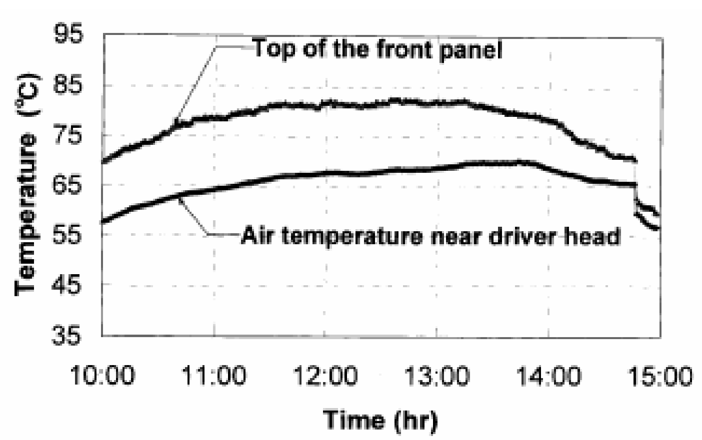


Figure 2.6: Temperature variations with time at different locations (without cooling)

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 (m³/hr)

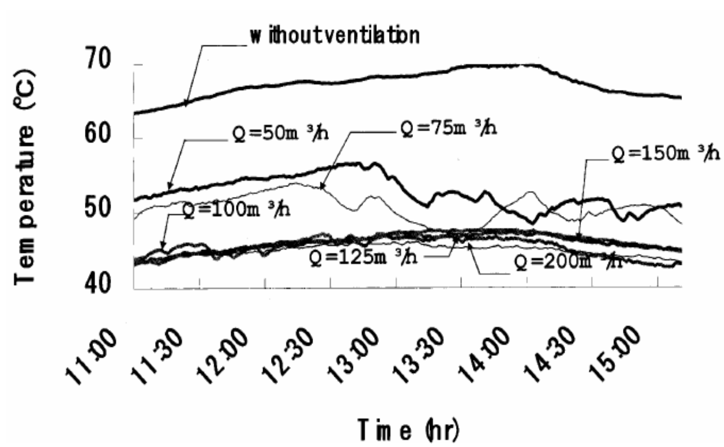


Figure 2.7: Temperature variations with time at different flow rates (m³/hr)

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 75m³/hr while airflow rates of 100, 125 and 200m³/hr can suppress temperature below 50˚C. This figure suggests air flow rates of 100m³/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

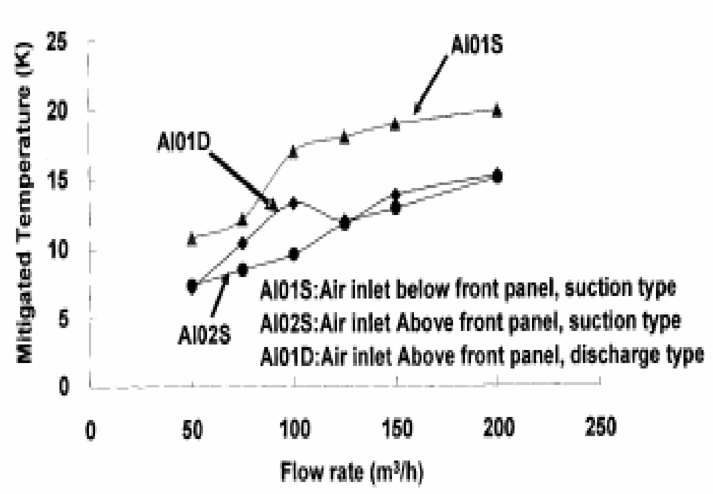


Figure 2.8: Effect of different location of air inlet and ventilation methods on ventilation

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 75m³/hr. About 20K temperature mitigated at 100, 125, 150 and 200m³/hr airflow rate. Air inlet above front panel and suction type ventilation, less than 10K temperature mitigated for airflow rate 50 and 75m³/hr. Above 10K temperature mitigated for airflow rate of 100, 125, 150 and 200m³/hr. Air inlet above front panel and discharge type ventilation mitigated 7K and 10K temperature for airflow rate 50 and 75m³/hr respectively. About 15K temperature mitigated for airflow rate of 100, 125, 150 and 200m³/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.

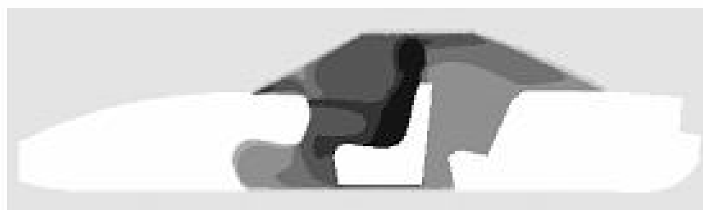


Figure 2.9: Steady state case with a lower outside temperature

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.

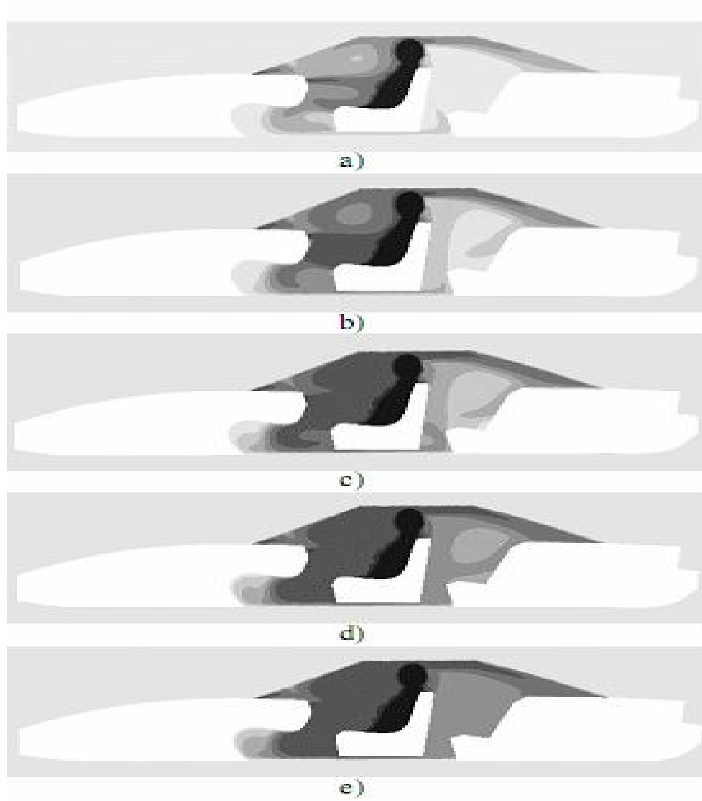


Figure 2.10: Transient heating of a car

Source: A. Alexandrov et al. (2001)

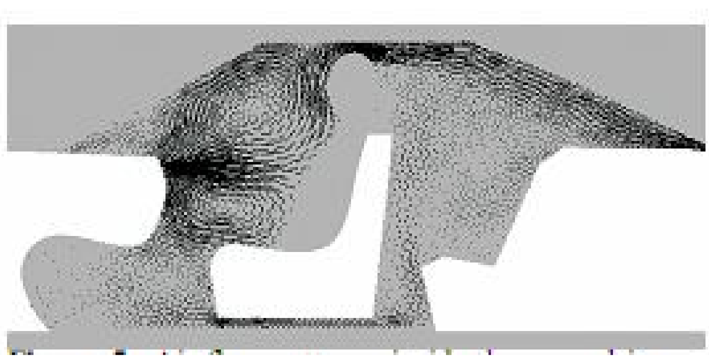


Figure 2.11: Air flow patterns inside the car cabin

Source: A. Alexandrov et al. (2001)

2.4.3 Inlet Locations

Case One

There are three inlets in the cabin. The first, slot shaped (3 X 80 cm), inlet is located below the windshield. The second and third (both 10 X 5 cm) inlets are located symmetrically on the dashboard 15 cm away from the sidewalls. Two equally sized (7.5 X 3.5 cm) outlets are located below the rear window 30 cm away from the sidewalls.

Case Two

There is the same windshield inlet plus four dashboard inlets. The dashboard inlets are equally sized (10 X 5 cm) and located symmetrically 7cm and 60cm away from the sidewalls. The outlets are the same as in the first case.

Case Three

The set-up for the third case is the same as for the second case with exception to the outlets. Only one slot shaped (2 X 70 cm) outlet is located in the front seat leg area. In order to visualize three-dimensional results we make three indicative cross-sections as shown in Figure 2.12. The direction of this probe coincides with the direction of the passenger’s body. The temperature distributions along the probe, to some degree, can substitute for distributions along the passenger’s body that, in turn, may determine the level of passenger’s comfort.

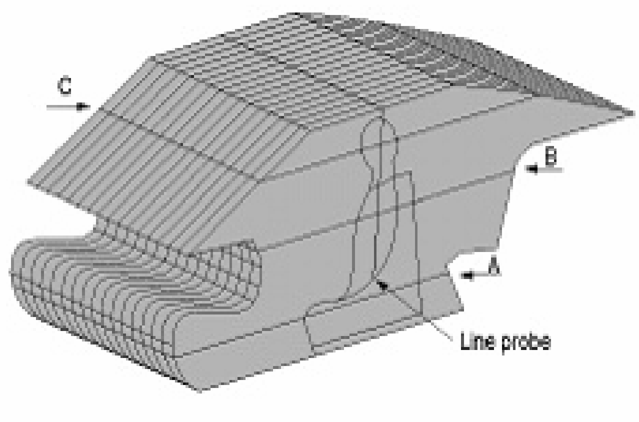


Figure 2.12: Schematic of the representative cross sections

Source: A. Alexandrov et al. (2001)

2.5 TEMPERATURE DISTRIBUTION FOR DIFFERENT POSITION OF AIR INLET

Table 2.1 shows the position of air inlet and outlet in green house ventilation system.

	Position of air inlet	Outlet pressure	Inlet pressure
Case I	Rear shelf board (near front of rear windshield)	0 Pa	-6 Pa
Case II	Placed vertically at top support	0 Pa	-6 Pa
Case III	Placed laterally at front of top	0 Pa	-10 Pa
Case IV	Placed laterally at front of top support (near to front of front windshield)	0 Pa	-10 Pa

Table 2.1: Set simulated air outlet and inlet in greenhouse ventilation system

Source: K. D. Huang et al. (2004)

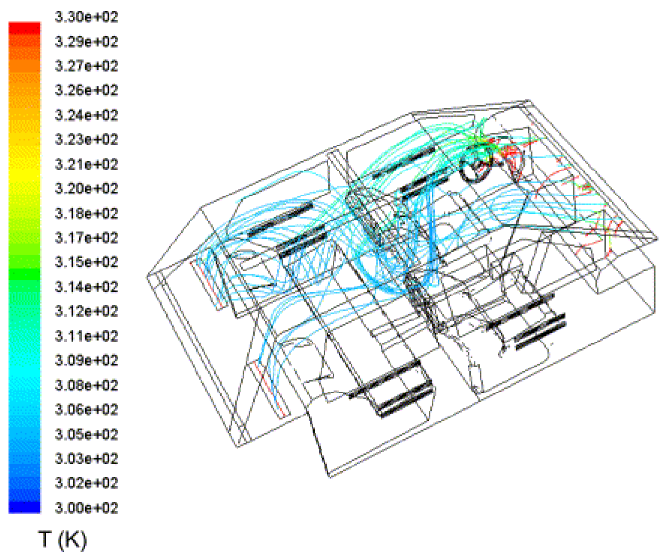


Figure 2.13: Air flow path from steering wheel and dashboard to air inlet in case I

Source: K. D. Huang et al. (2004)

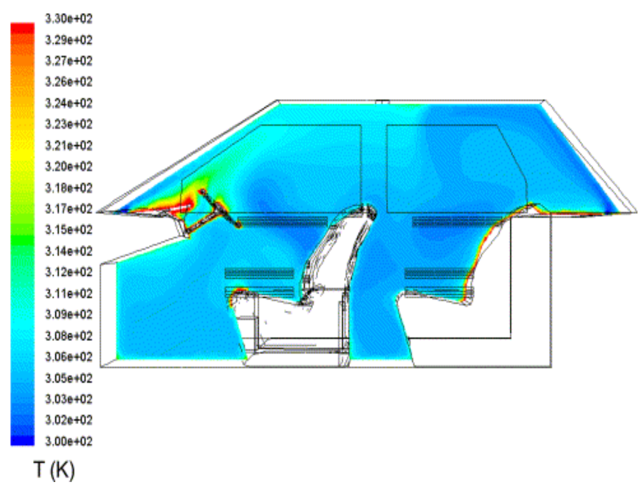


Figure 2.14: Temperature distributions in the central section to the left of the steering wheel in case II

Source: K. D. Huang et al. (2004)

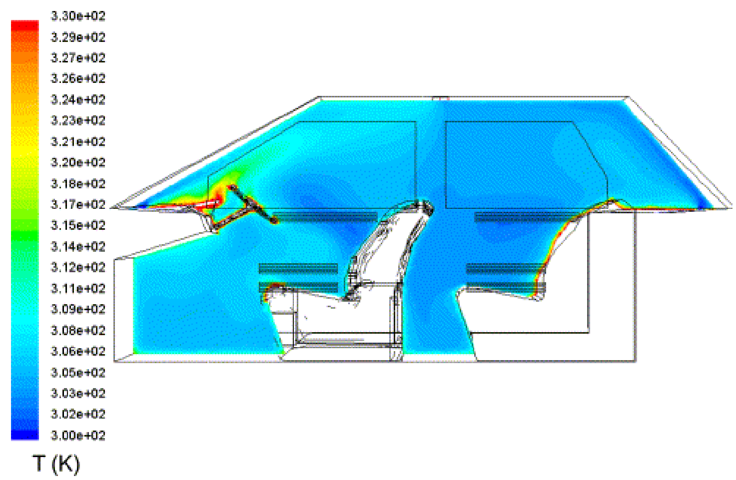


Figure 2.15: Temperature distributions in the central section of the automobile in case III

Source: K. D. Huang et al. (2004)

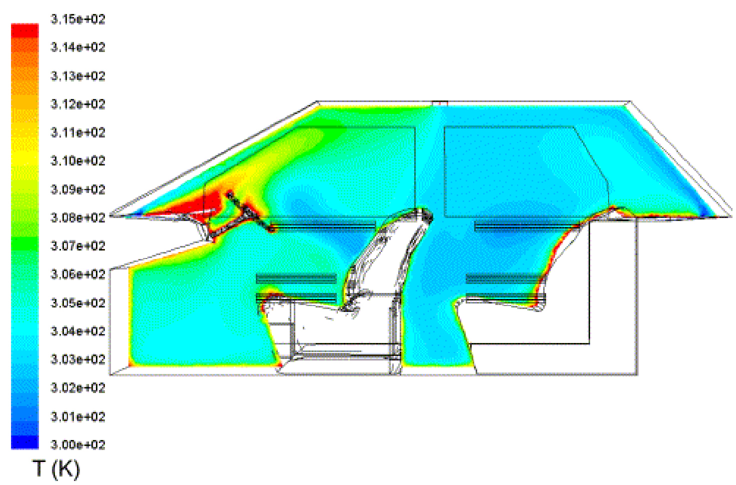


Figure 2.16: Temperature distributions in the central section to the left of the steering wheel in case IV

Source: K. D. Huang et al. (2004)

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Methodology need to be decided in order to ensure that the objective of the project is achieved. This is also important to ensure that the project is completed within the given time. Gantt chart is recommended to be created to determine all of requirement works over the year. In this project, the data gathering was done by experiment method. The car is parking under direct sunlight, and data is taken from three manipulated condition which is fully closed cabin, with the air conditioning blower is switch on and with heat removing devices attach to the windows.

3.2 APPARATUS

3.2.1 Thermocouple Monitor

Figure 3.1 shows the thermocouple scanner model SR630. The unit can digitize 16 rear panel differential inputs with a resolution of 15 bits plus sign

Figure 3.1: Thermocouple monitor

Gains and offsets are controlled to microvolt levels. The dual slope integrating converter is synchronized to the line frequency for high noise immunity. The unit completes 10/12 conversions per second when used on a 50/60 Hz line. The unit determines the temperature of a thermocouple junction by measuring the voltage and computing the temperature from the known characteristics of B, E, J, K, R, S or T type thermocouples.

Additional junctions are formed where the thermocouples connect to the back panel of the instrument, but the SR630 compensates for these by measuring the temperature of the connector block and subtracting the expected voltages (which depend on the thermocouple type and connector block temperature) before computing the thermocouple temperature. Four analog outputs on the rear panel of the instrument may be used to drive strip chart recorders or to adjust proportional temperature controllers. Small offset voltages at the outputs may be null from the front panel or via the computer interfaces. The front panel has three display windows. Generally, the left display indicates the selected channel, the middle display an instrument or channel parameter value such as GPIB address or temperature alarm limits, and the right display the measured value, in the appropriate units.

The CHANNEL up and down buttons selected one of sixteen rear panel inputs. Pressing the up and down buttons simultaneously causes the instrument to begin scanning selected channels. A channel is selected by setting its SCAN ENABLE parameter to “yes”. In scan mode, the SCANNING LED will be lit and selected channels will be read as rapidly as possible, beginning with the lowest channel number. PARAMETER is selected for display and modification using the parameter up and down keys. The first six are "instrument parameters" which may be modified regardless of the selected channel the rest are channel specifics.

Parameters may be entered using the 15-button keypad. The entered parameter becomes valid when the EXC key is pressed or when a parameter up and down key is pressed. The backspace key (BKSP) may be used to delete a key press or to return to the previous value if all of the new key presses are deleted.

Thermocouples may be connected to the instrument by removing the thermal shield on the rear panel. This shield is important for accurate temperature measurements and should be replaced after the thermocouples are attached. Type B, E, J, K, R, S or T thermocouples may be used. The thermocouple type must be specified for each channel, either by front panel entry, or via one of the computer interfaces.

Six parameters affect the entire instrument while eight are channel-dependent. Instrument parameters are GPIB address, RS232 baud rate, printer mode, dwell time, logging mode, time and date. Channel parameters are units (volts or temperature), scan enable, thermocouple type, nominal temperature, chart span, alarm enable and alarm limits. Parameters are selected with the PARAMETER SELECT up and down keys. Once selected, the current parameter value will be displayed. Some parameters, such as UNITS, become effective as soon as the key is pressed. Others, like GPIB address or time and date become effective only after the EXC key is pressed, or when another parameter is selected. This allows editing of entered values from the front panel before they take effect. The BKSP (backspace) key may be used to delete entered values. Backspacing through all the entered values for a new parameter will cause the previous value of that parameter to appear. All parameters may be set or read via the front panel or computer interfaces.

Eight parameters may be set for each of the 16 channels. Parameter settings for each channel are independent of the settings for all the other channels. To set these parameters for any particular channel, first select the channel from 1 to 16 by using the CHANNEL SELECT up and down keys. Then select the channel parameter of interest with the PARAMETER SELECT up and down keys. The PARAMETER ENTRY keypad may be used to modify the displayed parameter.

Display units for a measurement may be set when UNITS is selected in the parameter list. Degrees, Kelvin, Centigrade, Fahrenheit, Volts or Milivolts may be selected by pressing the corresponding key along the top row of keys in the PARAMETER ENTRY section. Selected units become effective immediately. Units are indicated by an indicator to the right of the MEASUREMENT window, and are abbreviated in the PARAMETER window.

3.2.2 J-Type Thermocouple

Figure 3.2 shows the J-Type thermocouple used in this experiment. They can be used over a large temperature range, from about -250°C up to about 1800°C.

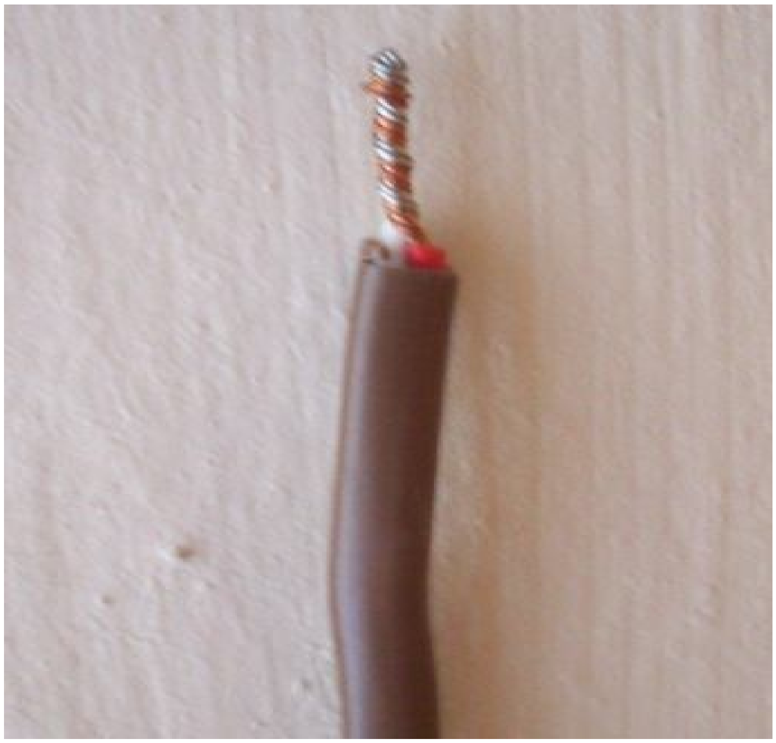


Figure 3.2: J-Type thermocouple

There are several reasons for the popularity of thermocouples. Perhaps most importantly, they are relatively inexpensive and easy to make. Although they aren't the most accurate means of measuring temperature, they have plenty of accuracy for most applications, with only one or two degrees of error across their operating range. Thermocouples are also passive devices that produce an electric signal without having to be powered. Finally, they are very robust and durable, making them ideal for harsh industrial environments. Table 3.1 shows the properties of the J-Type thermocouple that use in this experiment.

Type	J
Positive material	Fe
Negative material	Cu/Ni
Positive color (USA)	White
Negative color (USA)	Red
Lowest temperature	0˚C
Highest temperature	750˚C
Minimum standard error	±2.2˚C

Table 3.1: Properties of J-Type thermocouple

3.2.3 Fan as Heat Removing Devices

Figure 3.3 shows the fan that used as a heat removing devices. A Fan is a type of flow boundary condition. It is considered as an ideal device creating a volume or mass flow rate depending on the difference between the inlet and outlet static pressures averaged over the selected face. An Inlet Fan has a flow direction from fan to fluid. An Outlet Fan has a flow direction from fluid to fan. Internal Fans have outlet (from fluid to fan) and inlet (from fan to fluid) faces. The static pressures needed at the faces for determining the fan flow rate are obtained during the flow calculation as values averaged over these faces.

Figure 3.3: Fan

3.2.3.1 Fan Related Calculations

Fans of the same basic design operate theoretically in accordance with certain fan laws. In practice, these laws do not apply exactly because of design considerations and manufacturing tolerances, but they are useful in estimating approximate outputs of similar fans of different diameters and speeds as applied to normal ventilation work, and can be summarized as follows:

1) Volume of air flow varies as fan diameter and as rpm.
2) Pressure developed varies as fan diameter and as rpm.
3) Power absorbed by the fan varies as fan diameter and as rpm.

3.2.3.2 Fan velocity

Fan Velocity (m/s) = Radius of Fan (m) x Fan RPM

$$V = r\ \omega$$

3.2.3.3 Fan Mass Flow Rate

Pressure(kPa) x Velocity(m/s) = Mass(kg) x Gas constant(kJ/kg.K) x Temperature(K)

$$PV = mRT$$

$$P = mRT / V$$

$$P / RT = m / V = \rho \text{ (air density, kg/m}^3\text{)}$$

Fan mass flow rate (kg/s) = air density (kg/ m^3) x Fan area (m^2) x Fan velocity (m/s)

$$M = \rho\ A\ V$$

3.3 TEMPERATURE MEASUREMENT LOCATIONS

Temperature measurement for this experiment is done in three different conditions which are in fully closed cabin, with the air conditioning blower is switched on, and with the heat removing devices attached to the windows.

3.4 TEMPERATURE MEASUREMENT IN FULLY CLOSED CABIN

The car is parked directly under the sunlight. Eight J-Type thermocouples are attached inside the car cabin and was label from number 1 to 8. Figure 3.4, Figure 3.5, Figure 3.6, Figure 3.7, Figure 3.8, Figure 3.9, Figure 3.10 and Figure 3.11 shows the position of thermocouple attached at front dashboard (thermocouple number 1 and 2) , at the front seat (thermocouple number 3 and 4), at the rear seat (thermocouple number 5 and 6), and at the rear panel (thermocouple number 7 and 8). Another one thermocouple was attached outside the car to measure the ambient temperature.

At the beginning of the experiment, all doors are open to allow the cabin temperature to equal to ambient temperature. When the cabin temperature had stabilized close to the ambient temperature, all doors were closed and cabin temperature is monitored by using thermocouple reader. The data was taken every 30 minutes, for eight hours from 9a.m to 5p.m. The experiment is run two times.

Figure 3.4: Thermocouple attach at front dashboard (position 1)

Figure 3.5: Thermocouple attach at front dashboard (position 2)

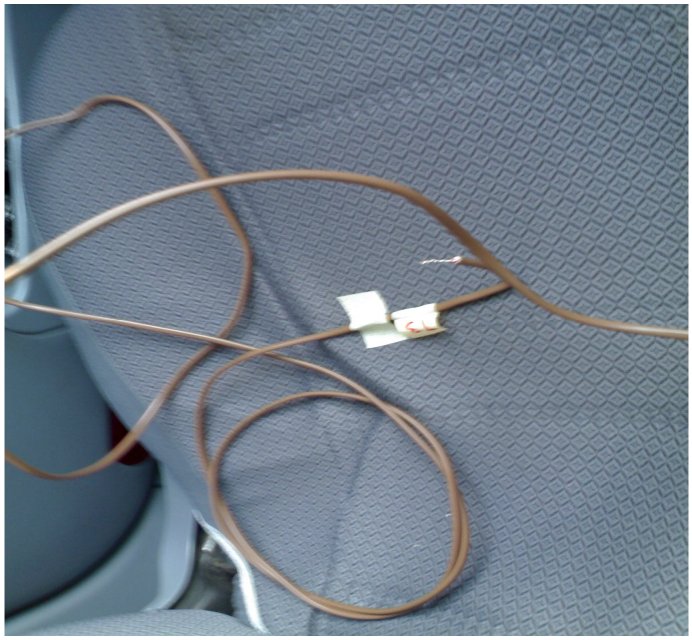


Figure 3.6: Thermocouple attach at front seat (position 3)

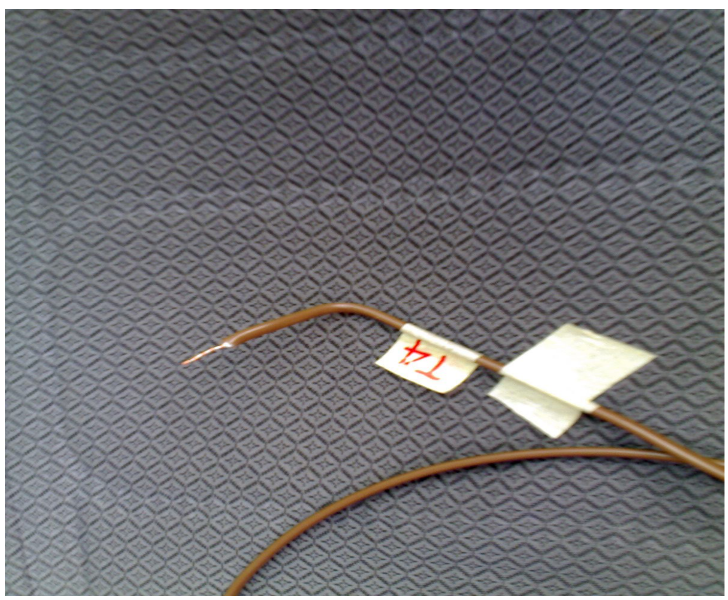


Figure 3.7: Thermocouple attach at front seat (position 4)

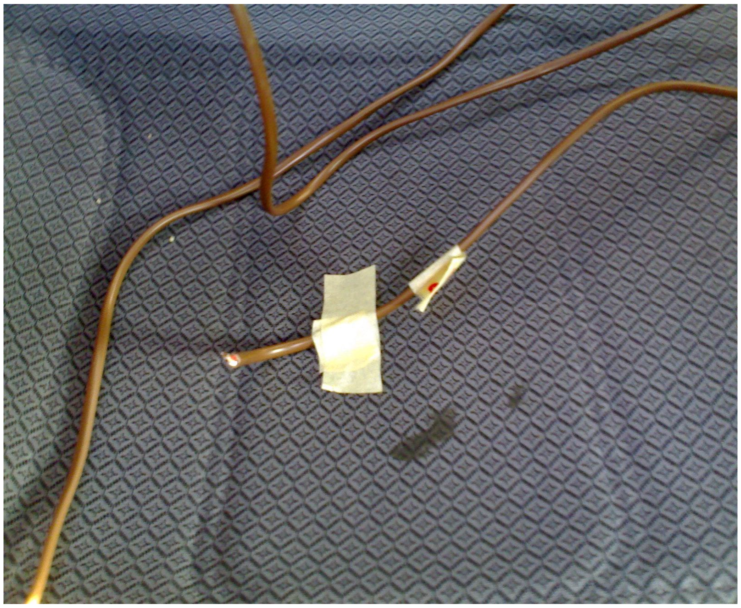


Figure 3.8: Thermocouple attach at rear seat (position 5)

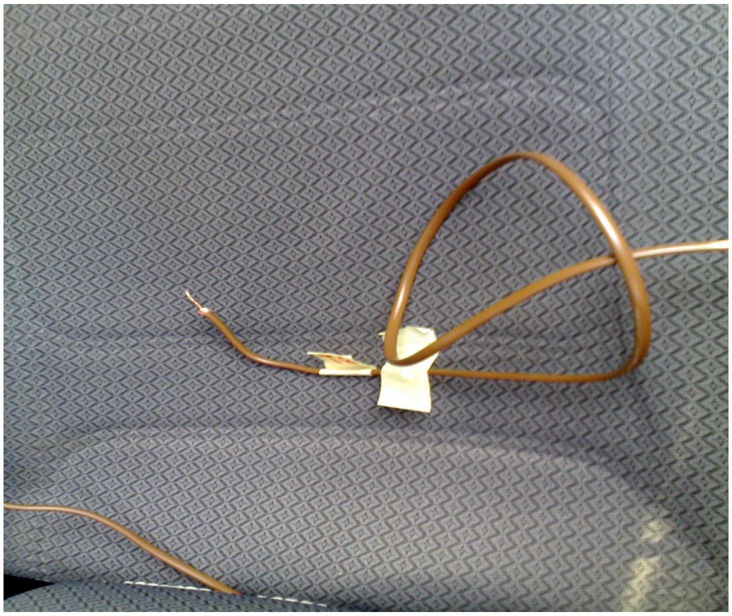


Figure 3.9: Thermocouple attach at rear seat (position 6)

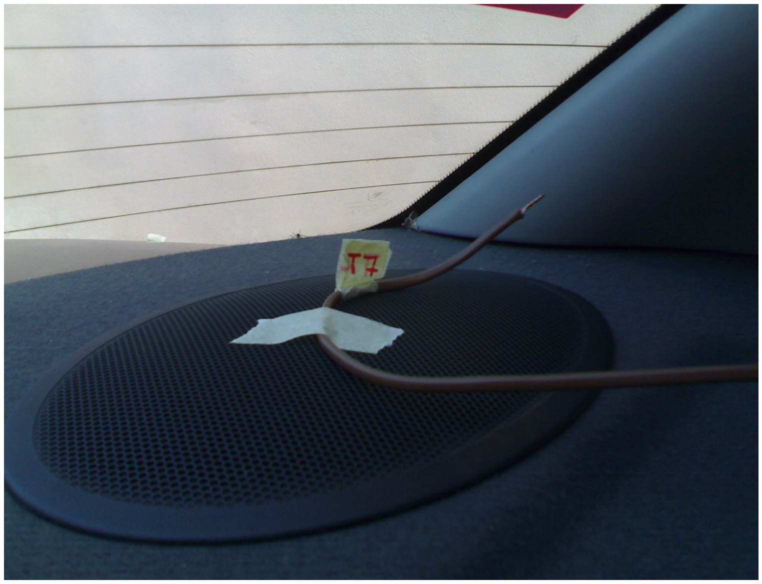


Figure 3.10: Thermocouple attach at rear panel (position 7)

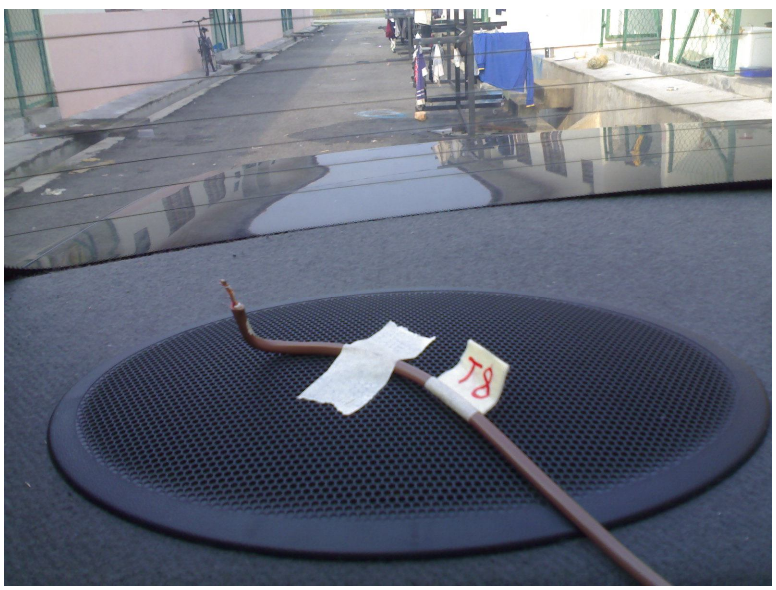


Figure 3.11: Thermocouple attach at rear panel (position 8)

3.5 HEAT REMOVING METHOD

3.5.1 Air Conditioning Blower Switched On

The step of experiment is same with the experiment in the fully closed cabin condition. The only different is, if the temperature inside the cabin exceeds 40˚C, the blower is switch on manually. The data is taken every 30 minutes, for eight hours from 9a.m to 5p.m.

3.5.2 Heat Removing Devices Attach To the Windows

Figure 3.12 shows the fan that used as heat removing devices. The fan is operate by connect it to 12V power supply. Increment of temperature at each point is monitored, if the temperature exceeds 40˚C, the fan is switched on. The data is taken every 30 minutes, for eight hours from 9a.m to 5p.m.

Figure 3.12: Fan use as heat removing devices

Figure 3.13 shows the fan that attach to the car windows. Four fans was attached at every windows of the car and acted as the heat removing devices.

Figure 3.13: Fan is attached to the car windows

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

The main objective of this project is to determine the temperature increment inside the car cabin under direct sunlight and carry out analysis of temperature increment in three different conditions which is fully closed cabin, with air conditioning blower is switch on and with the heat removing devices attach to the windows.

The main characteristic taken into consideration is the addition of fans as the heat removing devices. This experiment will determine whether there is any change or improvement before and after installing the fans to the vehicle, and make comparison between three conditions that manipulated.

4.2 EXPERIMENT RESULT

4.2.1 Experiment 1: Fully Closed Cabin

Table 4.1 shows the temperature data taken at different position inside the cabin. There are eight different positions which are two at the front dashboard, two at the front seat, two at the rear seat and two at the rear panel. The data of ambient temperature is also taken.

No: / T(min)	1	2	3	4	5	6	7	8	Ambient (˚C)
0	36.0˚C	37.6˚C	33.7˚C	32.5˚C	32.1˚C	32.5˚C	33.8˚C	34.0˚C	30.6˚C
30	37.8˚C	39.1˚C	35.5˚C	34.4˚C	33.5˚C	33.9˚C	36.1˚C	36.7˚C	31.1˚C
60	40.2˚C	42.2˚C	37.9˚C	36.2˚C	34.8˚C	35.5˚C	39.4˚C	40.4˚C	30.6˚C
90	45.9˚C	47.7˚C	43.3˚C	39.5˚C	37.8˚C	39.1˚C	44.9˚C	48.3˚C	30.7˚C
120	48.6˚C	53.3˚C	46.8˚C	42.9˚C	40.8˚C	42.2˚C	50.5˚C	57.2˚C	31.7˚C
150	50.3˚C	54.5˚C	46.6˚C	46.6˚C	42.3˚C	43.5˚C	51.2˚C	54.8˚C	32.2˚C
180	55.0˚C	60.2˚C	47.0˚C	49.3˚C	44.8˚C	46.2˚C	56.0˚C	61.1˚C	32.4˚C
210	55.6˚C	61.6˚C	47.4˚C	47.9˚C	45.6˚C	46.7˚C	57.6˚C	62.7˚C	32.7˚C
240	58.3˚C	64.3˚C	48.5˚C	49.3˚C	47.4˚C	48.5˚C	62.5˚C	66.4˚C	32.9˚C
270	60.7˚C	65.7˚C	50.2˚C	50.6˚C	50.0˚C	51.1˚C	66.5˚C	68.9˚C	33.0˚C
300	61.1˚C	65.5˚C	51.2˚C	52.2˚C	51.6˚C	52.8˚C	67.1˚C	69.2˚C	33.0˚C
330	55.9˚C	59.1˚C	50.1˚C	51.6˚C	51.1˚C	51.6˚C	61.1˚C	63.1˚C	32.5˚C
360	57.8˚C	60.5˚C	50.5˚C	51.6˚C	54.4˚C	52.6˚C	64.5˚C	66.5˚C	32.4˚C
390	55.5˚C	57.2˚C	49.7˚C	51.5˚C	51.9˚C	51.7˚C	61.4˚C	63.5˚C	32.0˚C
420	52.6˚C	55.5˚C	48.8˚C	50.4˚C	50.8˚C	50.6˚C	62.4˚C	64.4˚C	30.3˚C
450	48.8˚C	50.1˚C	48.6˚C	49.7˚C	50.1˚C	50.5˚C	61.7˚C	63.0˚C	29.7˚C
480	46.6˚C	47.0˚C	47.7˚C	48.2˚C	49.0˚C	49.0˚C	57.6˚C	59.4˚C	30.6˚C

Table 4.1: Temperature taken in different position inside cabin in first experiment of fully closed cabin

The ambient temperature is varied between 29.7˚C and 33.0˚C. Inside the cabin, minimum temperature that taken is at the beginning of the experiment is 32.1˚C, which is at position 5. After 300 minutes of the experiment, the maximum temperature taken is 69.2˚C at the position 8, which is at the rear panel, near to the rear windscreen. From the table, position 1, 2, 7, and 8, shows the large increment of temperature. Position 2, 3, 4, 5 also shows an increment but the increment is not high compare to the position 1, 2, 7, and 8.

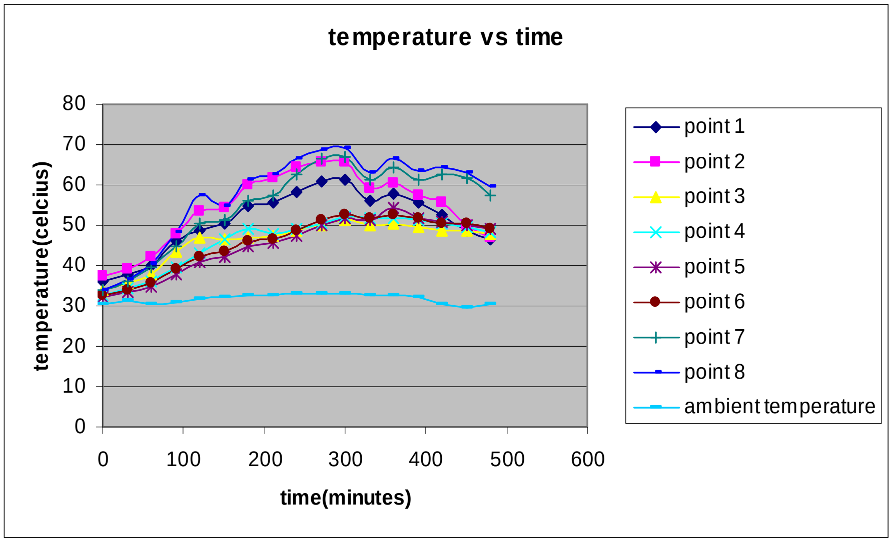


Figure 4.1: Temperature distributions in fully closed cabin

Figure 4.1 shows the graph of temperature in different position versus time in the experiment 1 of fully closed cabin. From the graph, the temperature was increase as the time increase. Point 1, 2, 7, and 8 shows the high increment compare to the point 3, 4, 5, and 6. After 390 minutes, temperature at all point was decrease. Ambient temperature range varied between 29.7˚C to 33.0˚C

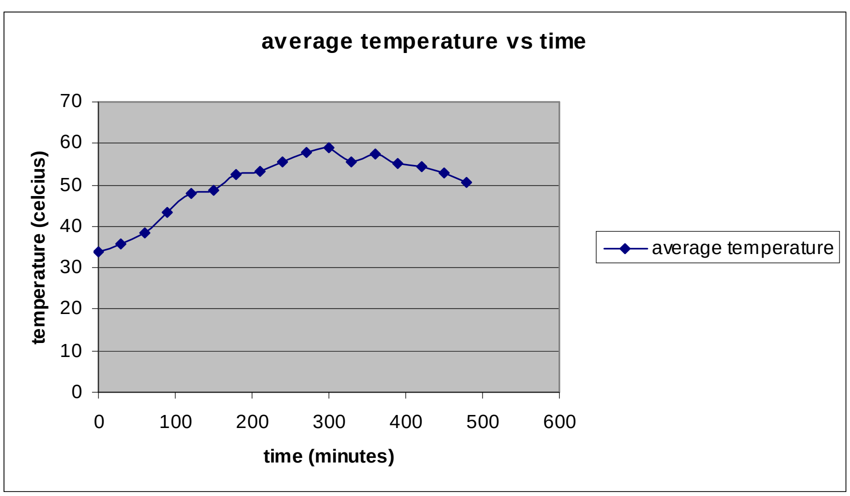


Figure 4.2: Average cabin temperatures in fully closed cabin

Figure 4.2 shows the graph of average temperature versus time in experiment 1. From the graph the minimum temperature taken is 34.03˚C, which is at the beginning of the experiment. The maximum temperature taken is 58.84˚C at minutes of 300.

4.2.2 Experiment 2: Fully Closed Cabin

Table 4.2 shows the temperature data taken at different position inside the cabin in experiment 2. There are eight different positions which are two at the front dashboard, two at the front seat, two at the rear seat and two at the rear panel. The data of ambient temperature is also taken.

No: / T(min)	1	2	3	4	5	6	7	8	Ambient (˚C)
0	34.1˚C	35.6˚C	31.7˚C	32.2˚C	31.1˚C	31.6˚C	33.8˚C	33.7˚C	29.7˚C
30	35.3˚C	37.0˚C	32.2˚C	32.4˚C	31.0˚C	32.0˚C	34.1˚C	34.0˚C	30.7˚C
60	35.7˚C	37.2˚C	33.2˚C	33.9˚C	31.3˚C	32.2˚C	36.7˚C	37.3˚C	31.6˚C
90	45.1˚C	48.0˚C	45.0˚C	40.8˚C	36.4˚C	38.3˚C	45.0˚C	48.6˚C	31.7˚C
120	45.3˚C	48.7˚C	48.1˚C	44.2˚C	42.2˚C	43.2˚C	47.2˚C	48.8˚C	31.7˚C
150	53.4˚C	57.7˚C	53.1˚C	50.0˚C	45.0˚C	47.3˚C	56.6˚C	59.6˚C	32.2˚C
180	57.7˚C	62.1˚C	50.3˚C	50.0˚C	47.6˚C	50.4˚C	61.7˚C	63.4˚C	32.8˚C
210	62.0˚C	65.1˚C	51.6˚C	51.9˚C	50.6˚C	53.2˚C	66.5˚C	67.8˚C	33.0˚C
240	62.7˚C	65.8˚C	52.2˚C	52.3˚C	51.1˚C	53.6˚C	67.0˚C	67.4˚C	33.2˚C
270	65.3˚C	67.2˚C	52.9˚C	53.7˚C	52.9˚C	54.6˚C	70.1˚C	70.5˚C	33.0˚C
300	68.1˚C	68.6˚C	54.2˚C	55.6˚C	54.8˚C	56.2˚C	72.5˚C	72.7˚C	33.3˚C
330	65.2˚C	66.6˚C	54.2˚C	57.5˚C	55.7˚C	56.6˚C	70.4˚C	70.4˚C	32.9˚C
360	61.2˚C	62.1˚C	53.0˚C	55.8˚C	54.3˚C	54.6˚C	65.0˚C	65.6˚C	32.0˚C
390	55.2˚C	57.7˚C	54.8˚C	54.2˚C	52.4˚C	53.1˚C	57.4˚C	56.8˚C	32.3˚C
420	52.0˚C	55.1˚C	52.1˚C	53.5˚C	51.8˚C	51.7˚C	56.3˚C	55.4˚C	31.4˚C
450	48.6˚C	50.2˚C	48.6˚C	49.7˚C	50.1˚C	50.5˚C	56.0˚C	54.2˚C	32.2˚C
480	46.6˚C	47.3˚C	47.7˚C	48.2˚C	49.0˚C	49.0˚C	55.6˚C	53.5˚C	32.0˚C

Table 4.2: Temperature taken in different position inside cabin in second experiment of fully closed cabin

The ambient temperature is varied between 29.7˚C and 33.3˚C. Inside the cabin, minimum temperature that taken is at the beginning of the experiment is 31.1˚C which is at position 5. After 300 minutes of the experiment, the maximum temperature taken is 72.7˚C at the position 8, which is at the rear panel, near to the rear windscreen. From the table, position 1, 2, 7, and 8, shows the large increment of temperature. Position 2, 3, 4, 5 also shows an increment but the increment is not high compare to the position 1, 2, 7, and 8.

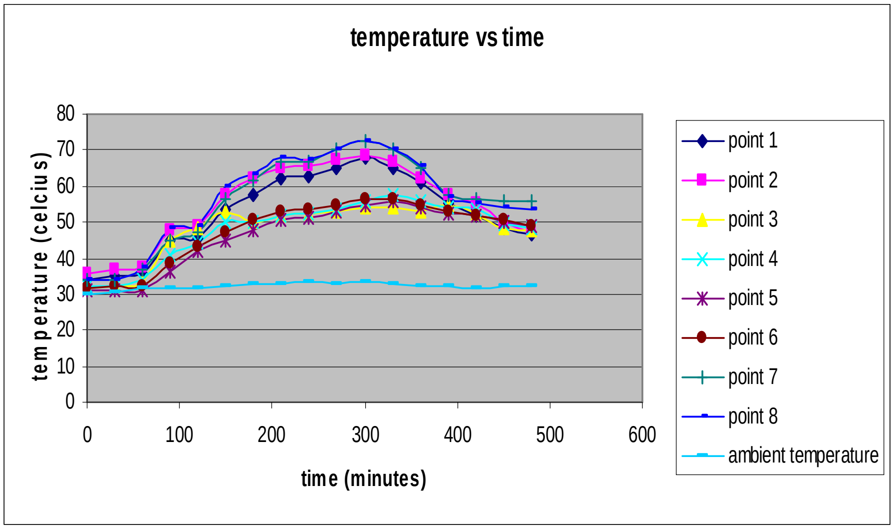


Figure 4.3: Car cabin temperature distributions in fully closed cabin

Figure 4.3 shows the graph of temperature in different position versus time in the experiment 2 of fully closed cabin. From the graph, the temperature was increase as the time increase. Point 1, 2, 7, and 8 shows the high increment compare to the point 3, 4, 5, and 6. After 330 minutes, temperature at all point was decrease. Ambient temperature range varied between 29.7˚C to 33.3˚C.

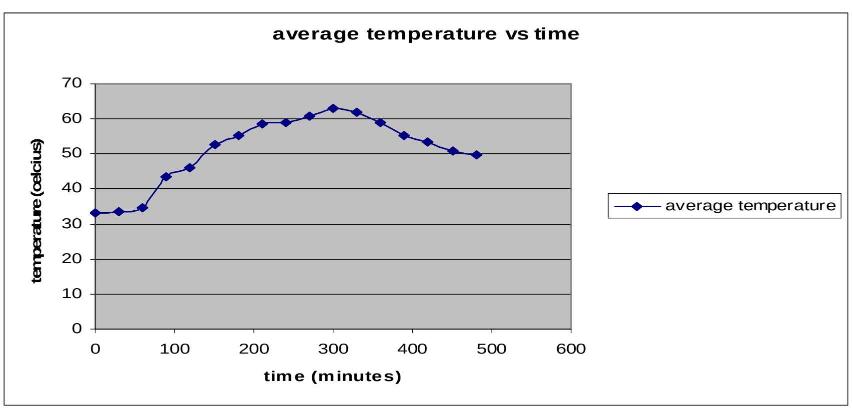


Figure 4.4: Average cabin temperatures in fully closed cabin

Figure 4.4 shows the graph of average temperature versus time in experiment 2. From the graph the minimum temperature taken is 32.98˚C, which is at the beginning of the experiment. The maximum temperature taken is 62.84˚C at minutes of 300.

4.2.3 Experiment 3: Air Conditioning Blower Switched On

Table 4.3 shows the temperature data taken at different position inside the cabin when the air conditioning blower is switched on. There are eight different positions which are two at the front dashboard, two at the front seat, two at the rear seat and two at the rear panel. The data of ambient temperature is also taken.

No: / T(min)	1	2	3	4	5	6	7	8	Ambient (˚C)
0	36.5˚C	37.3˚C	33.2˚C	31.4˚C	31.6˚C	32.0˚C	34.1˚C	34.0˚C	29.2˚C
30	40.7˚C	42.0˚C	37.2˚C	34.6˚C	34.1˚C	35.0˚C	38.2˚C	38.4˚C	30.1˚C
60	39.7˚C	42.8˚C	40.4˚C	37.0˚C	37.0˚C	37.6˚C	37.7˚C	38.8˚C	31.3˚C
90	48.4˚C	51.5˚C	48.0˚C	42.2˚C	40.1˚C	41.8˚C	47.7˚C	50.1˚C	31.8˚C
120	46.4˚C	48.5˚C	48.3˚C	44.5˚C	43.0˚C	43.8˚C	45.7˚C	46.3˚C	31.7˚C
150	53.7˚C	54.9˚C	48.8˚C	44.3˚C	43.4˚C	44.8˚C	54.9˚C	55.8˚C	32.2˚C
180	50.9˚C	57.3˚C	49.4˚C	47.5˚C	46.2˚C	46.8˚C	49.2˚C	49.1˚C	32.8˚C
210	58.1˚C	60.8˚C	52.1˚C	51.2˚C	50.3˚C	52.4˚C	60.8˚C	62.0˚C	33.0˚C
240	55.4˚C	60.0˚C	54.0˚C	54.4˚C	53.1˚C	54.2˚C	57.3˚C	57.6˚C	32.4˚C
270	61.5˚C	63.6˚C	53.5˚C	54.3˚C	51.5˚C	53.6˚C	65.4˚C	65.5˚C	33.1˚C
300	56.3˚C	58.1˚C	54.9˚C	55.3˚C	53.6˚C	53.9˚C	57.6˚C	58.4˚C	32.0˚C
330	58.1˚C	58.0˚C	53.7˚C	54.3˚C	51.4˚C	52.4˚C	59.1˚C	58.5˚C	31.9˚C
360	56.3˚C	59.4˚C	55.0˚C	55.8˚C	55.4˚C	55.5˚C	58.1˚C	58.6˚C	32.0˚C
390	55.2˚C	57.7˚C	54.8˚C	53.2˚C	52.0˚C	53.1˚C	57.4˚C	56.8˚C	32.3˚C
420	52.0˚C	55.1˚C	52.1˚C	51.5˚C	51.8˚C	51.7˚C	56.3˚C	55.4˚C	30.0˚C
450	48.9˚C	50.5˚C	51.6˚C	49.7˚C	50.1˚C	50.6˚C	54.5˚C	55.1˚C	29.7˚C
480	47.0˚C	47.2˚C	49.4˚C	48.3˚C	49.0˚C	49.7˚C	53.1˚C	53.6˚C	30.6˚C

Table 4.3: Temperature taken inside cabin when blower switched on

The ambient temperature is varied between 29.2˚C and 33.1˚C. Inside the cabin, minimum temperature that taken is at the beginning of the experiment is 31.4˚C which is at position 4. After 270 minutes of the experiment, the maximum temperature taken is 65.5˚C at the position 8, which is at the rear panel, near to the rear windscreen.

From the table, position 1, 2, 7, and 8, shows the large increment of temperature. Position 2, 3, 4, 5 also shows an increment but the increment is not high compare to the position 1, 2, 7, and 8.

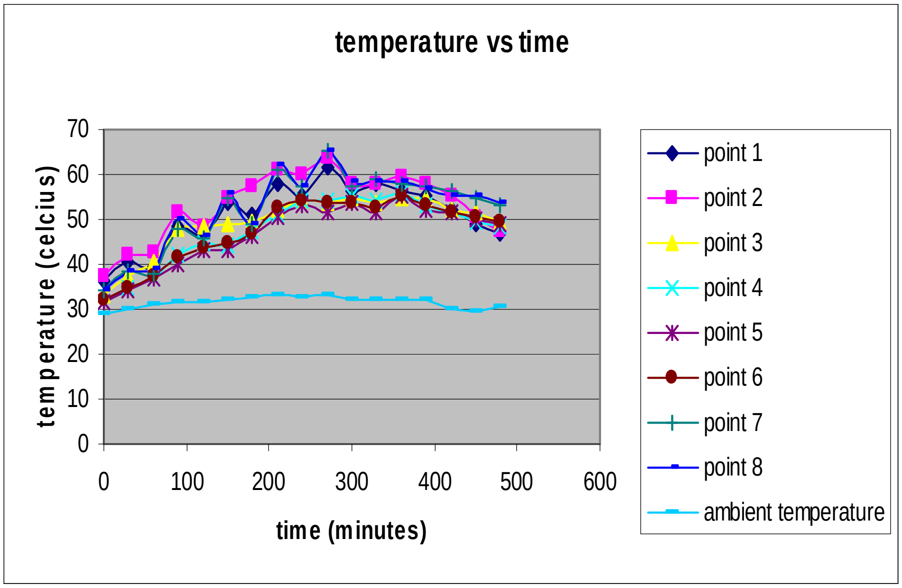


Figure 4.5: Car cabin temperature distributions when blower is switch on

Figure 4.5 shows the graph of temperature in different position versus time in the experiment 3, when the air conditioning blower is switched on. From the graph, the temperature was increase as the time increase. Point 1, 2, 7, and 8 shows the high increment compare to the point 3, 4, 5, and 6. Point 1 and 2 shows the up and down temperature patterns. After 360 minutes, temperature at all point was decrease. Ambient temperature range varied between 29.2˚C to 33.1˚C

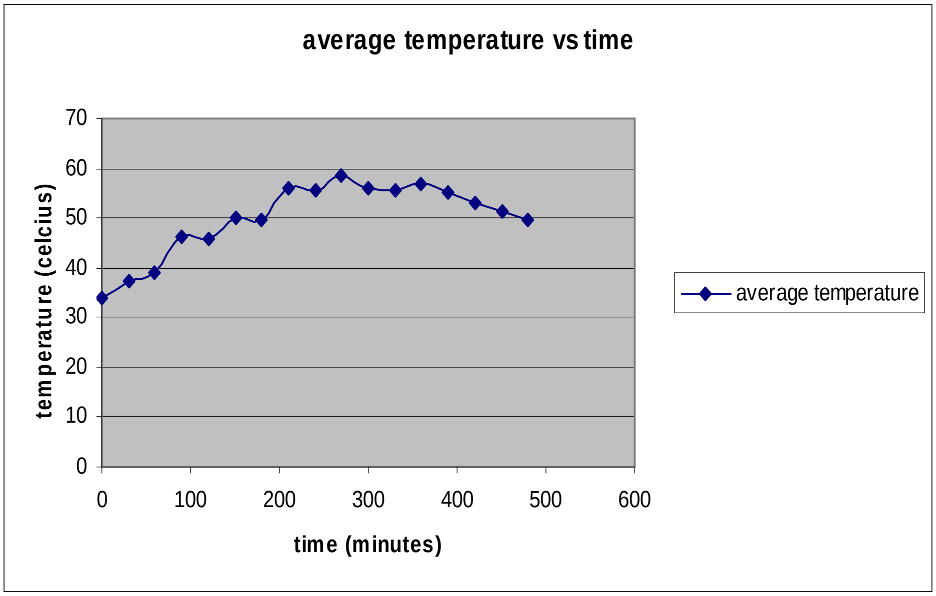


Figure 4.6: Average cabin temperature when blower switch on

Figure 4.6 shows the graph of average temperature versus time when the air conditioning blower in switched on. From the graph the minimum temperature taken is 33.76˚C, which is at the beginning of the experiment. The maximum temperature taken is 58.61˚C at minutes of 270.

4.2.4 Experiment 4: Heat Removing Devices Attach To the Windows

Table 4.4 shows the temperature data taken at different position inside the cabin when the heat removing devices attached to the windows. There are eight different positions which are two at the front dashboard, two at the front seat, two at the rear seat and two at the rear panel. The data of ambient temperature is also taken.

No: / T(min)	1	2	3	4	5	6	7	8	Ambient (˚C)
0	38.5˚C	38.9˚C	35.6˚C	34.0˚C	33.7˚C	34.1˚C	37.8˚C	38.0˚C	30.0˚C
30	38.6˚C	40.3˚C	35.0˚C	34.5˚C	34.0˚C	34.7˚C	38.2˚C	39.0˚C	29.7˚C
60	41.7˚C	45.1˚C	38.5˚C	37.4˚C	35.6˚C	36.8˚C	41.8˚C	43.2˚C	30.6˚C
90	41.8˚C	43.8˚C	37.5˚C	37.2˚C	36.6˚C	37.2˚C	42.3˚C	43.1˚C	30.7˚C
120	46.2˚C	50.3˚C	44.4˚C	42.8˚C	38.0˚C	39.4˚C	47.5˚C	49.8˚C	30.7˚C
150	53.6˚C	59.2˚C	50.4˚C	45.0˚C	42.6˚C	45.2˚C	56.1˚C	59.2˚C	31.2˚C
180	53.1˚C	56.1˚C	45.1˚C	44.6˚C	43.2˚C	44.8˚C	55.1˚C	56.5˚C	31.8˚C
210	53.5˚C	58.5˚C	46.1˚C	46.9˚C	44.1˚C	47.2˚C	56.9˚C	58.2˚C	32.0˚C
240	55.3˚C	57.8˚C	47.4˚C	47.8˚C	46.4˚C	48.2˚C	57.2˚C	58.6˚C	32.4˚C
270	53.6˚C	55.6˚C	46.1˚C	46.0˚C	45.9˚C	45.3˚C	56.7˚C	55.8˚C	32.1˚C
300	50.8˚C	52.8˚C	44.4˚C	45.6˚C	43.5˚C	44.9˚C	52.9˚C	54.5˚C	32.0˚C
330	46.1˚C	48.1˚C	42.3˚C	42.7˚C	41.6˚C	42.2˚C	47.1˚C	48.8˚C	31.9˚C
360	44.7˚C	46.4˚C	41.8˚C	41.9˚C	41.8˚C	42.1˚C	45.8˚C	47.0˚C	32.0˚C
390	43.3˚C	45.0˚C	41.3˚C	41.2˚C	41.2˚C	41.2˚C	44.4˚C	45.3˚C	32.3˚C
420	43.0˚C	45.7˚C	40.8˚C	41.0˚C	40.4˚C	40.6˚C	43.2˚C	44.7˚C	31.8˚C
450	42.8˚C	44.8˚C	40.7˚C	39.7˚C	39.9˚C	38.8˚C	43.1˚C	44.1˚C	30.7˚C
480	41.6˚C	44.1˚C	38.9˚C	39.5˚C	39.2˚C	38.4˚C	42.7˚C	43.6˚C	30.1˚C

Table 4.4: Temperature taken inside cabin when heat removing devices attached to the windows

The ambient temperature is varied between 29.7˚C and 32.4˚C. Inside the cabin, minimum temperature that taken is at the beginning of the experiment is 33.7˚C which is at position 5. After 150 minutes of the experiment, the maximum temperature taken is 59.2˚C at the position 8, which is at the rear panel, near to the rear windscreen. From the table, position 1, 2, 7, and 8, shows the large increment of temperature. Position 2, 3, 4, 5 also shows an increment but the increment is not high compare to the position 1, 2, 7, and 8.

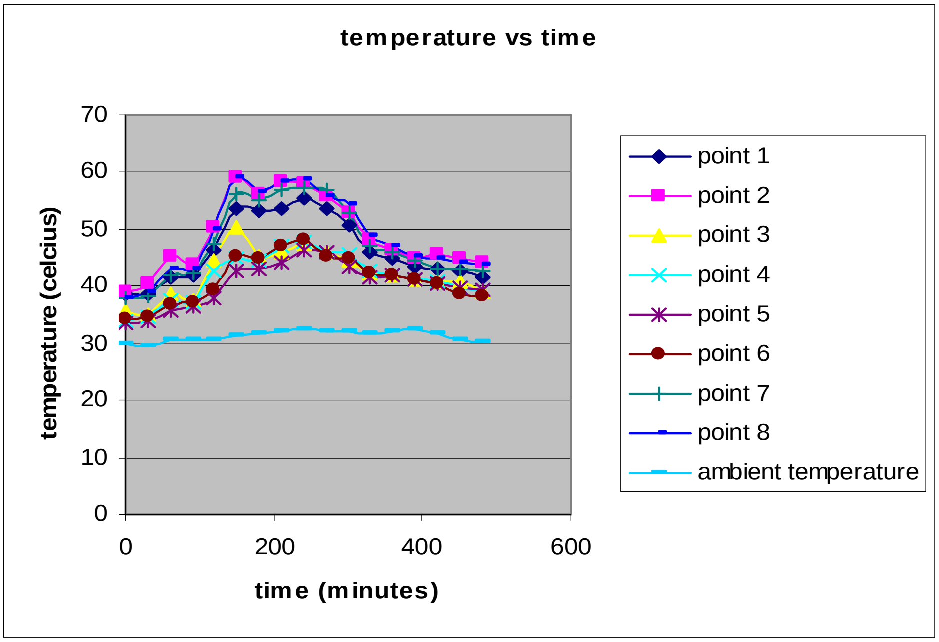


Figure 4.7: Temperature distribution in car cabin when heat removing device is attach

Figure 4.7 shows the graph of temperature in different position versus time when the heat removing devices is attached to the windows. From the graph, the temperature was increase as the time increase. Point 1, 2, 7, and 8 shows the high increment compare to the point 3, 4, 5, and 6. After 240 minutes, temperature at all point was decrease. Ambient temperature range varied between 29.7˚C to 32.4˚C

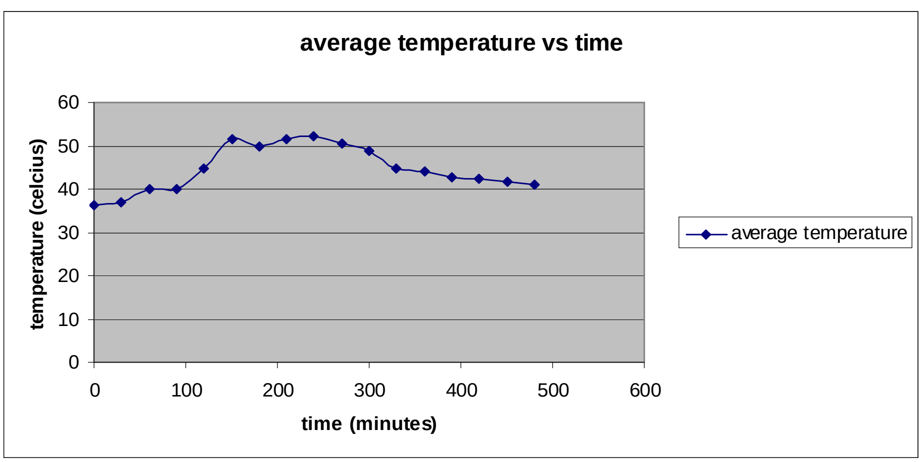


Figure 4.8: Average cabin temperature when heat removing devices is attach

Figure 4.8 shows the graph of average temperature versus time in when the heat removing devices is attached to the windows. From the graph the minimum temperature taken is 36.33˚C, which is at the beginning of the experiment. The maximum temperature taken is 52.34˚C at minutes of 240.

4.2.5 Comparison Between Manipulated Condition

Figure 4.9 shows the comparison between temperatures in three different conditions that manipulated. There is three conditions that manipulated which is fully closed cabin, with the air conditioning blower is switched on, and with the heat removing devices attach to the windows. For the fully closed cabin, the experiment is run two times.

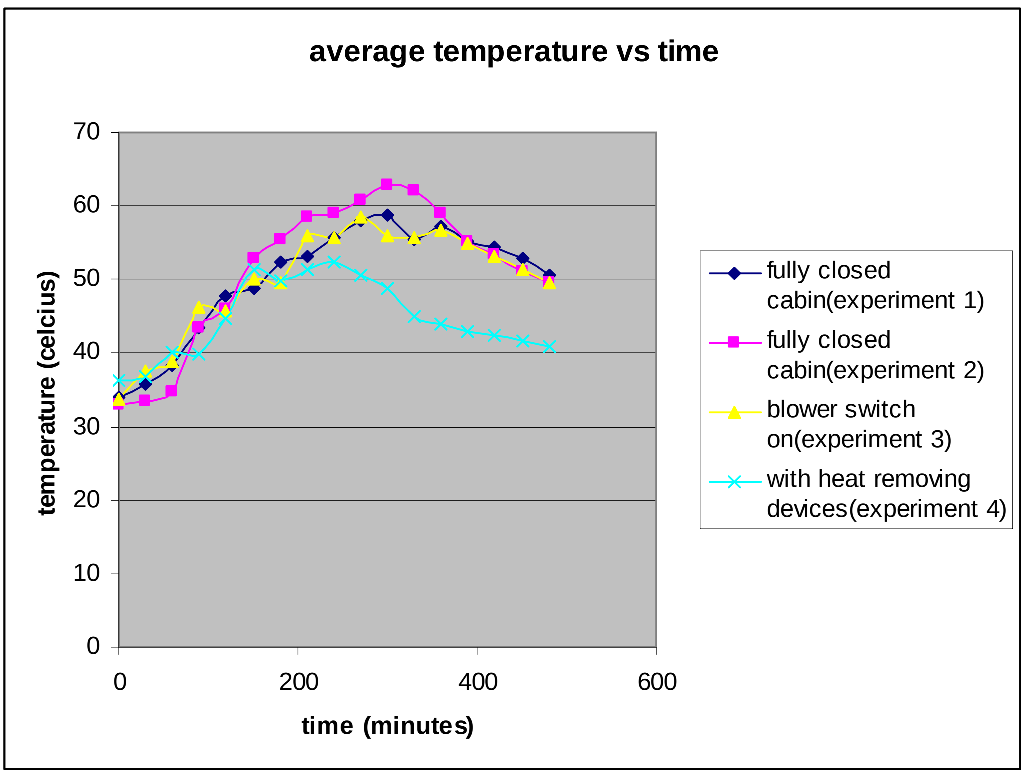


Figure 4.9: Comparison average temperatures between three different conditions

For the experiment 1, the maximum temperature taken is 58.84˚C. The temperature shows a high increment until minutes of 300. After 300 minutes, the temperature was decreased to 50.56˚C at the end of the experiment. For the second experiment of fully closed cabin, the maximum temperature taken is 62.84˚C at minutes of 300. After 300 minutes, the temperature was decreased to 49.61˚C at the end of the experiment. Compare to the first experiment, the increment of temperature more high in the second experiment.

For the third experiment, the maximum temperature taken is 58.62˚C. Compare to the experiment 1, the different between the maximum temperature is very small. Although the blower is switch on, the hot air is just circulated inside the cabin, not removed outside.

For the fourth experiment, the heat removing devices is attached to the windows. The maximum temperature taken is 52.34˚C. By adding the devices, the hot air is removed to the outside. Although the temperature in the cabin still increase, but the maximum temperature taken is more low compare to the previous experiment. The temperature taken at the end of the experiment is also low compare to the previous experiment, which is 41.0˚C.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Reducing the cabin temperature of vehicle parked under direct sunlight has been one of the key issues in the invention process over the years. Reduced temperature results in improved passenger comfortness and lifetime of vehicle interior particularly accessories and leather parts. It is well known that significant difference is noticeable at rear window at all considerations and time. One of the most significant discoveries in the last decade in this area of research has been the finding of a heat extractor which could assist in reducing cabin temperature.

The experiment prove the fact that the cabin temperature of vehicle left stationary under direct sunlight increases substantially above ambient temperature. There is also an improvement by adding heat removing device to the windows of the vehicles, which results decreased temperature variation and distribution in the cabin. The temperature distribution inside the cabin is also determined. After all experiment and analysis completed, the objectives of the project achieved and all the scopes successfully fulfilled.

5.2 RECOMMENDATION

For future researches, different flow rate and type of heat removing fans can be compared by simply attached to vehicle to see the temperature distribution and cooling rate.

Some other recommendations;

- Run experiment and make analysis using complete interior and accessories.
- Analysis using other CFD software such as Fluent.
- Designing electrical and electronic circuit for the heat extractor.
- Building duct for the heat extractor.

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APPENDIX A

PROJECT GANTT CHART 1

TITLE / WEEK	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14	W 15	W 16
1. Project beginning - Receive project title - First appointment with supervisor, arrange weekly appointment and general briefing about the project - Get a log book	■															
2. Fundamental theory - Get understand about the project. - Search the article and journal that is related to project. - Determination of method, design and the analysis to used		■	■	■	■	■										
3. Identify project objective, scope, and make a synopsis and requirement proposed by students and lecturers. 4. Report writing which include literature review and methodology.							■	■	■	■	■	■	■			
5. Draft 1 submission of with log book. 6. Submission of proposal for required component.										■	■	■	■	■		
7. Preparation for Final Year Project presentation.															■	
8. Final Year Project presentation																■

APPENDIX B

PROJECT GANTT CHART 2