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JUDUL: **EVALUATION AND OPTIMIZATION OF HEAT EXTRACTION DEVICE**

SESI PENGAJIAN: **2010/2011**

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EVALUATION AND OPTIMIZATION OF HEAT EXTRACTION DEVICE

AZRI AMZARI BIN RAMLI

BACHELOR OF ENGINEERING
UNIVERSITI MALAYSIA PAHANG

2010

UNIVERSITI MALAYSIA PAHANG
FACULTY OF MECHANICAL ENGINEERING

I certify that the project entitled "Evaluation and Optimization of Heat Extraction Device" is written by Azri Amzari bin Ramli. I 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. I herewith recommend that it be accepted in partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

(Mr. Muhammad Ammar Nik Mu'tasim)
Examiner Signature

EVALUATION AND OPTIMIZATION OF HEAT EXTRACTION DEVICE

AZRI AMZARI BIN RAMLI

Thesis submitted in fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical engineering with Automotive Engineering

Faculty of Mechanical Engineering
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DECEMBER 2010

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.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature

Name : AZRI AMZARI BIN RAMLI

ID Number : MH07063

Date : 6 DECEMBER 2010

DEDICATION

...dedicated to beloved father Ramli b. Awang, mother Sabihah bt. Mahmud and the rest of my siblings Azrol Amirol, Saralina Elyani, Muhammad Izhar, Muhammad Amir Amri and especially the little princess, Nurul Aina...

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The appreciation would not less be incomparable for my beloved parents and my whole family that been giving me loads of mental support while I almost crack at University. They has always been my source of happiness and my turning point if there are problems and when I reach my limits. My sincere appreciation also I expand to all my colleagues because they have given their time in sharing opinion with me and provided me an extra shoulder for me to lean on. It is indeed would be the least of space for me to includes all of the name stated but I prayed for your bright future and May Allah bless all of you.

ABSTRACT

This report is an outcome of the final year project entitled Evaluation and Optimization of Heat Extraction Device. The project contains two objectives, first to optimize the heat extraction device in the means of design, way of fabrication and to figure out where is the suitable placement for the fabricated device inside Proton Waja car. Second, the project require researcher to gather as much information available by experimenting on the device in two manipulated condition, heat increment inside Waja car compartment with and without the existent of the heat extraction device. The device is handmade by using a flexible duct and CPU fan to extract heat from the car the environment. Four experiments were done, experiment 1 and 2 is for without the heat extraction device and experiment 3 and 4 with heat extraction device. The device is controlled by heat management system that will acts as a switch to automatically turn the blower on at 40^{o}C. The highest temperature data taken from each experiment are 78.0^{o}C, 75.4^{o}C, 61.3^{o}C and 61.5^{o}C respectively for experiment 1, 2, 3 and 4. The result shows that the existence of heat extraction device can reduce the heat built up inside the car cabin.

ABSTRAK

Laporan ini merupakan hasil dari projek tahun terakhir berjudul Evaluation and Optimization of Heat Extraction Device. Projek mengandungi dua objektif, pertama untuk mengoptimumkan alat penyedut haba dari segi reka bentuk, cara pembuatan dan kedudukan yang sesuai untuk alat dipasang di dalam kereta Proton Waja. Kedua, projek ini memerlukan penyelidikan untuk mengumpul maklumat dengan melakukan eksperimen pada alat tersebut dalam dua keadaan yang dimanipulasikan, kenaikan haba di dalam kereta Waja dengan dan tanpa alat penyedut haba. Alat ini merupakan buatan tangan dengan menggunakan saluran fleksibel dan kipas CPU untuk mengekstrak panas dari dalam kereta ke persekitaran. Empat eksperimen dilakukan, eksperimen 1 dan 2 adalah dangan tanpa alat penyedut haba manakala eksperimen 3 dan 4 dengan alat penyedut haba. Alat ini dikawal oleh mekanisma elektronik yang bertindak sebagai suis untuk menghidupkan kipas penyedut haba pada suhu 40 ^{o}C dan keatas. Data yang diambil adalah seperti berikut, bacaan tertinggi bagi eksperimen 1,2 3 dan 4 adalah 78.0 ^{o}C, 75.4 ^{o}C, 61.3 ^{o}C dan 61.5 ^{o}C. Keputusan yang terhasil daripada eksperimen menunjukkan bahawa dengan adanya alat penyedut haba bacaan suhu tertinggi dapat dikurangkan.

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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
Q	Heat transfer

LIST OF ABBREVIATION

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

A car that been exposed to direct sunlight for extended period will developed a temperature built up inside it. The factors contributing to this is the temperature outside of the car, the temperature inside of the car directly proportional with the temperature outside. It is also depends on the inlet condition of a car, the place with most air circulation will have the highest temperature rise. Heat rise in car cabin effects in reducing comfort while entering the car. It also cause a rise in fuel consumption due to higher power of air conditioning needed to cool down the car cabin, the interior of the car such as the dashboard, leather seats and the plastic accessories will age rapidly under the exposure to high temperature and there are also minor cases of child death while trapped inside the vehicle. Hence the study is important so that a solution for the stated problems can be improved. The conventional heating, ventilating and air conditioning (HVAC) system is reliable but still unsuitable to be use while the car is park and left for a long period. The project is intended for an invention of an independent ventilation system to maintain the thermal comfort range of a car cabin for pleasure of the passenger, for the safety precaution if there a case of self lock happen, and it is also financially positive for fuel consumption and interior investment of the car.

1.2 PROBLEM STATEMENT

The temperature inside the car cabin is easily controlled while the engine if the car is running. This can be achieving by using by the air conditioning system. However, what happens if the passenger is waiting inside the car while the engine is not operating, is the passenger managing to be comfortable inside the car while the car is parked under direct sunlight and the heats inside the car cabin is increasing.

The main question that leads to this research is ‘how to employ an effective system by managing the flow inside the car compartment. The heat built inside car compartment causes below problems:-

i. Reducing comfort when entering the blazing hot compartment
ii. The interior of the car will age rapidly due to the exposure of high temperature
iii. Increase in fuel consumption while cooling down the car cabin using the air conditioning system.
iv. Increase the safety preventing case such child asphyxiated and dehydrated in the car.

1.3 OBJECTIVES

The objectives of this project are divide into two, which is:

i. Optimize the heat extraction device in the scope of design, fabrication and the suitable placement in Proton Waja car.
ii. Determine the temperature inside Proton Waja car cabin under direct sunlight in 2 conditions: fully closed cabin with and without the heat extraction device.

1.4 SCOPE

The scopes of the project:

i. Search, review and gather information about car cabin ventilation, heat generation inside car and way to minimize the heat generation from journals and references book.
ii. Design and fabrication of the heat extraction fan and ducting.
iii. Conduct experiment and analysis to determine the temperature increment under 2 manipulated cabin condition.
iv. Documentation of all results.

CHAPTER 2

LITERATURE RIVIEW

2.1 BRIEF DISCRIPTION OF PROTON WAJA

Proton Waja is the first car designed purely by proton and the first of proton car that has a spacious compartment size. For designing the ducting flows, this car spacious cabin size makes it easy to reach the distant part of compartment space. Table 2.1 stated the dimension of Proton Waja car as to know the real volume of the workspace of the experiment.

Table 2.1: Dimensions of Proton Waja

Dimensions			
Wheelbase		2600 mm	102.4 in
Track	front	1475 mm	58.1 in
	rear	1470 mm	57.9 in
Length		4465 mm	175.8 in
Width		1740 mm	68.5 in
Height		1420 mm	55.9 in

2.2 CAR AIR VENTILATION

Ventilation is a removing process that allows clean air accessing the car cabin and removing stale air. The process starts when a cleaner air, is allows entering the car cabin whether it is force by the mechanical system available or flowing naturally inside to the car. The air will replace the stake air inside car cabin. This air is sometimes smoke-filled air that available inside the car. The stale air allowed flowing out from the car and the process of air entering and moving out is call ventilation. People start to use closed compartment car as a solution on preventing dusty air from entering the car as automotive technology improve. Then, people start to use ducting system to admit air inside their car. The earliest closed cabin ventilation was the cowl air intake (Figure 2.1). When air coming over the hood scooped into the car interior through the space provided when the ventilator raise. The air then filtered by a screen, so this means the ventilation only considering preventing dust and insect from entering inside car cabin. The weakness of this system is that it depends on the forward movement of the car, which is if the car stop moving the passenger will be uncomfortable due no air circulation. This is the reason the next generation of car is install with power ventilation. The ventilating system consists of blower that is located at the dashboard. The blower assembly attached to a motor shaft and all of the assembly placed inside the blower housing. A strong suction produced as the squirrel cage blowers in Figure 2.2 rotate. Air from environment is suck into the car when the fan motor energized using the temperature knob at the dashboard. (Lambert, 2002)

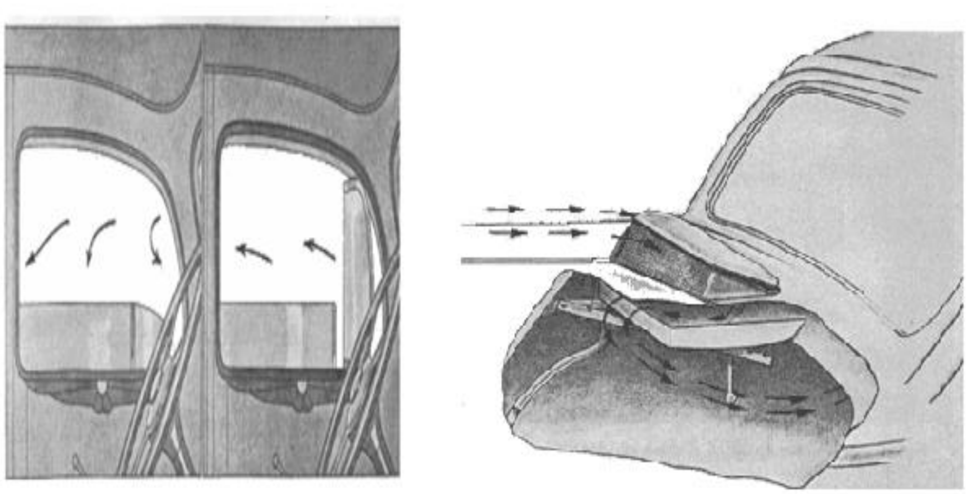


Figure 2.1: Natural ventilation, on the right is the cowl air intake system

Source: Carbasic (1950)

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

Source: Lambert (2002)

2.3 HEAT GENERATION

As the sun rays heats the roof of the car there are heat generation or temperature built up inside the car. The heat may be coming from the conversion of mechanical, electrical, nuclear or chemical energy that is call thermal or heat energy generation. It is a volumetric phenomenon that is occurs throughout the body of a medium. The heat loss or gain mainly occurs by three mechanisms, which is:

i. Conduction
ii. Convection
iii. Radiation

2.3.1 Heat conduction

This is the simplest heat movement. Heat travel through a medium such as a solid and a liquid. Heat transfer as energy transfer from one molecule to the next of the material. Different material has different conductivity (ability to conduct heat) as example metals as built for car body is a good conductor, so it has a good heat conductivity. On the contrary an insulator is a poor conductivity material, it blocks heat and some of the example are wood and Styrofoam. To prevent direct contact of skin and heat from metal body metal body of a car, the metal is wrapped with a plastic insulation. This also can reduce the temperature built-up inside car compartment.

2.3.2 Heat convection

It is a process of transferring heat by moving the heated medium. The medium is fluid, in either gaseous or liquid form. It is the combination of heat conduction with fluid motion. It can happen in two ways, natural or force convection. The movement of hot air rising and cool air move down at the effect of buoyancy is one of the example of natural convection. Air conditioning system a car is the example of force convection as coolant (the medium) is heat in the water jackets next to the cylinders and combustion chambers. Then it is pump to the radiator, where the heat transferred to the air travelling through the radiator. The heat convection concept wills much contributing in this project. The hot air developed inside the car compartment is suck forcibly by using a heat blower then the air gaps will be replace by the cooler air from outside of the car.

2.3.3 Heat radiation

Heat radiation is the transfer of heat from one object to another through infrared waves. Heat radiation does not require the material to be in contact or that is transfer by fluid flow between object and it can be transfer through vacuum. Heat radiation affected by the colour and textures of a car surface. A black coated rough surface will absorb heat radiation and emits it better than light-colour, smooth surface. Radiant heat is beneficial as it can heat up a house and car in the cool winter but detrimental in summer, because it will cause the generation of excessive heat.

2.4 TECHNICAL PAPER REVIEW

2.4.1 Temperature Variation inside Car Cabin

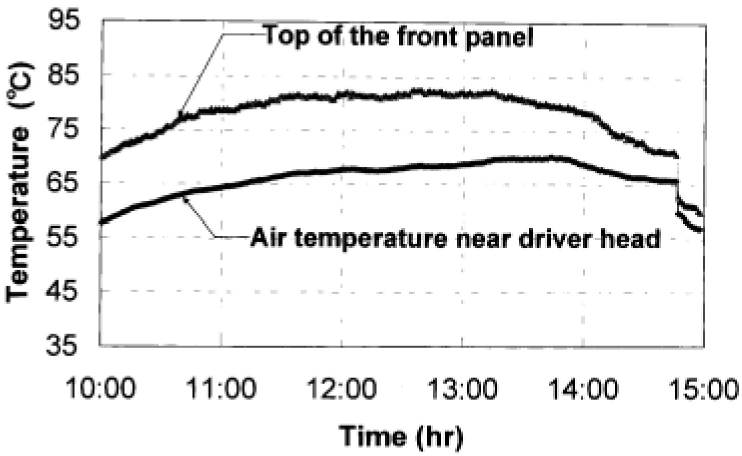


Figure 2.3: Temperature variation with the time at different locations

Source: Khan M.U et al (1991)

From figure above it shows the different of temperature at the top of the front panel and at the air temperature near driver head. These two places are the two highest temperatures in the car cabin. The same result achieved with simulation as shown in figure below. The simulation was did using three-dimensional Navier-Stokes equations. The software used is CFD2000, a Multi-disciplinary CFD and heat transfer software. The boundary condition is set to replicate the actual car used in the experiment. Mesh number is set to be 37x25x31 and the heat was radiate from roof, windows and seats. The air flows of the device also same with the experiment. The airflow rate of the fan is change in each simulation for 50, 100, 150 and 200 m^3/h.

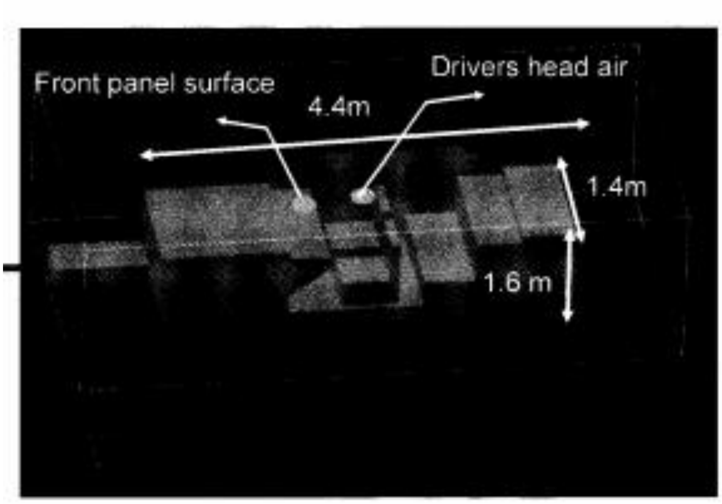


Figure 2.4: Part of the simulation model

Source: Khan M.U et al (1991)

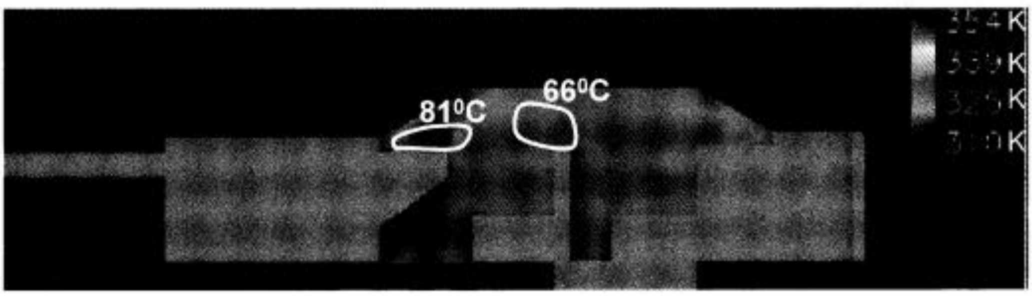


Figure 2.5: Temperature distribution in the car without ventilation rear view

Source: Khan M.U et al (1991)

The results from the simulation show almost the same pattern as experimental data. The maximum temperature taken is at the front dashboard that is 81^{o}C and followed by the air space near the driver head, 66^{o}C.

2.4.2 Suitable Air Flow Rate for Ventilation

A research had been conduct and found out a way to reduce heat development inside the car cabin is to use heat ventilation. From experiment done, the most suitable airflow rate would be 100 m^3/hr to mitigate the temperature within the comfortable range.

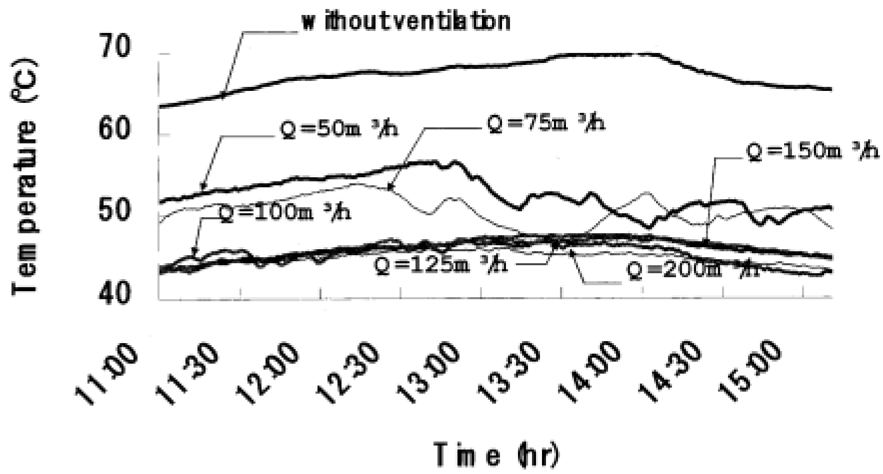


Figure 2.6: Temperature variations with time at different ventilation air flow rate

Source: Khan M.U et al (1991)

From figure above, it shows that using ventilation system improves the comfort inside the car cabin by reducing heat built up. The figure suggests that the flow rate of 50 m^3/hr and 75 m^3/hr can maintain the heat built up to 50 ^oC. For airflow rate 100, 125, 150 and 200 m^3/hr the temperature will be within 45 ^oC. Hence, the optimal flow rate suitable for the ventilation device will be 100 m^3/hr.

2.5 PARAMETER THAT AFFECT CABIN TEMPERATURE

2.5.1 Outsides Temperature

The ambient temperature of the atmosphere will definitely affect the heat built up inside the car cabin. A car parked under direct sunlight will has higher temperature built up compare to a car parking under a shaded area. (A Alexandrov et al, 2001)

2.5.2 Inlet Condition

The inlet condition inside the car cabin is divides by cool and hot area. The factor that creates different climates inside the car is coinciding with the flow circulation of the area. The areas that have higher air circulation or higher turbulence will be an area that has higher temperature or known as a hot zone. The place will less air circulation will takes more time to be heat and the temperature will not rise as high as hot area.

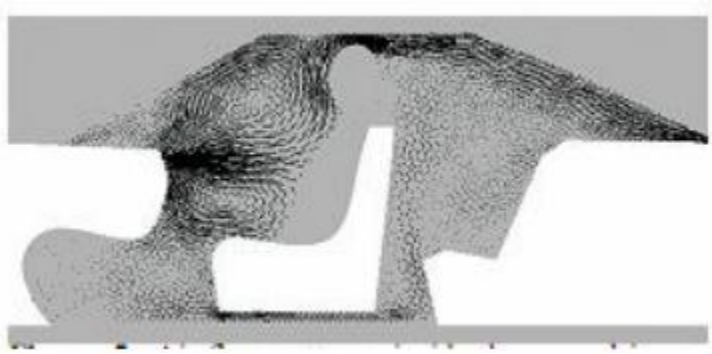


Figure 2.7: Airflow patterns inside the car cabin

Source: A. Alexandrov et al. (2001)

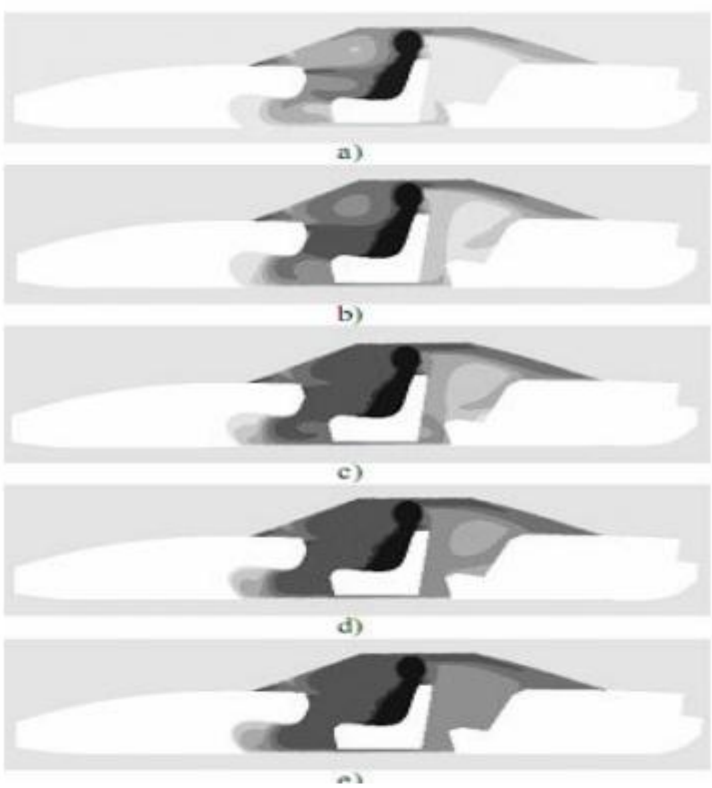


Figure 2.8: Transient heating inside a car cabin

Source: A. Alexandrov et al. (2001)

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Methodology for the project need to be justify so that the progressing work flow smoothly. It also helps to ensure that the project is complete within the given time. The suitable chart such as the flow chart is embedding together at the last page of methodology section. In the project there were two distinctive works done. The first to design suitable heat extraction device and then fabricated it. The second task was to conduct few experiments to verify the literature review and to prove that the device helps in reducing car compartment temperature. The experiment is conducted to determine the temperature increment under 2 manipulative conditions, fully closed cabin and the other is fully closed cabin with heat extraction device functioning.

3.2 DESIGNING AND FABRICATING THE HEAT EXTRACTION DEVICE

For this final year project, the aim for this heat extraction device is that it acts as a suction device. It will remove the hot air flow streams inside car cabin and then it is replaces with a fresher air from the outside environment. The suitable ventilation duct also need to be purpose as to attach the air blower and becomes proper heat ventilation for the car cabin. The device needs to be independent from the available car system so that it will not disturb the fuel consumption of the car and weaken the car structural basis.

The Figure 3.1 below shows the development of the prototype of the heat extraction device. Figure 3.2 shows the original design. Figure 3.3 shows the design after a few alter to fit the purpose and suitable to use as ducting inside car.

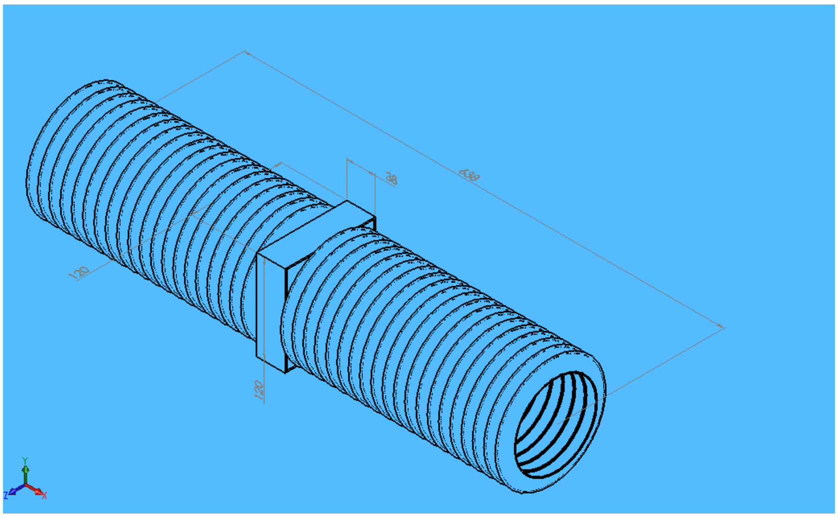


Figure 3.1: Original CAD design

Figure 3.2: Original fabrication

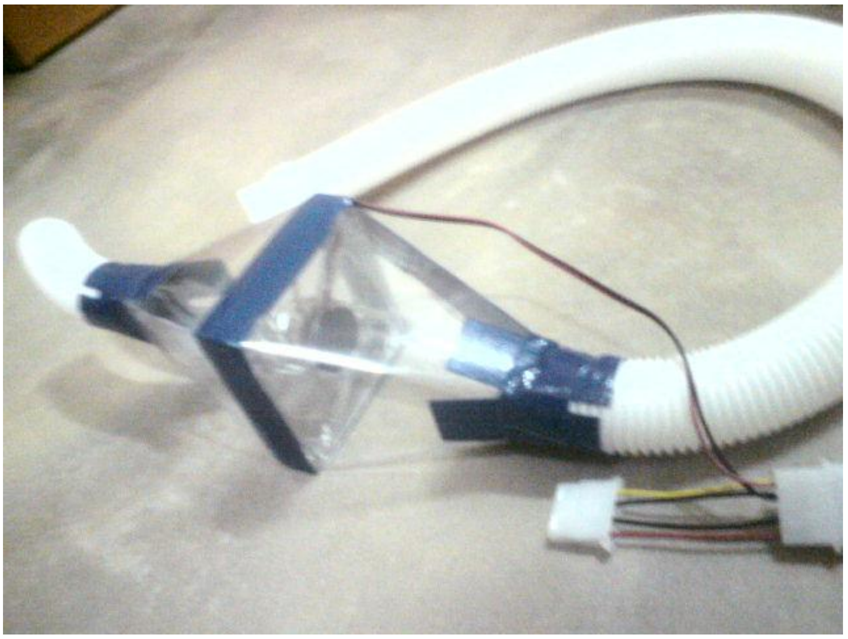


Figure 3.3: Improved fabrication

3.2.1 Fan as a Heat Removing Devices

Figure 3.3 is the fan as a heat-removing device. Fan operates by generating an airflow that transfers the heat from inside the car to the cooler outer environment. A fan is a type of flow boundary condition. Fan is considered an ideal device to create the mass flow rate because its function by differentiating the pressures different between the inlet and the outlet static pressures over the surface. The inlet of the fan will promotes air to move inside it while the outlet will blow air out of it. The static pressures needed at the faces for determining the blower flow rate are obtain during the flow calculation as values averaged over these faces.

Figure 3.4: Fan

3.2.2 Ducting

Flexible ducting is a part of improving the heat extractor efficiency. With ducting, the blower suction and blowing function can be modifies at a suitable placement in the car. The flexible duct is made of extruded moulding plastic. The edge on the shape in do helps when the duct is coil, it form a rigid interlock hence forming a rigid duct. It is also lightweight and durable and can withstand the temperature climate of Malaysia. It has no metal reinforcement, so it will not corrode or oxidize. It is easily trim with knife so adjusting the length will be easy. It is also suitable for permanent or temporary installations.

Figure 3.5: Plastic flexible ducting

3.3 HEAT MANAGEMENT DEVICE

This device has one monitor to show the temperature detect by the heat sensing transistor and a button to set when the blower will function at what temperature the blower will be function. It acts as a controller for the blower to function, response to the heat built up in the car. The heat sensor will evaluate temperature inside the cabin and the device is sets to starts the blower at 40^{o}C. The temperature taken by the heat management device is just for controlling the fan and is not taken for experiment data. Figure 3.6 shows the heat management device.

Figure 3.6: Heat management device

3.4 EXPERIMENT APPARATUS

3.4.1 Thermocouple Scanner

Figure 3.7 shows the thermocouple scanner model SR630. The unit can digitize 16 rear panel differential inputs with a resolution of 15 bits plus sign, the range of it temperature reading is from -200^{o}C to 1700^{o}C.

Figure 3.7: Thermocouple Scanner

From the known characteristics of B, E, J, K, R, and S the unit determines the temperature of a thermocouple junction by measuring the voltage. The Gains and offsets are controls to microvolt levels. The dual slope-integrating converter is synchronizes 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 SR360 contains 3 monitors, the left most monitor is to show which scan port is in use. The middle monitor is for setting each parameter for each channel. The third one is the present reading of the thermocouple that is set earlier.

The thermocouple monitor is designs to read, scan, print and log the temperature or voltage of the reading. It also has a remote function to time-stamp and can store up to 2000 readings in non-volatile memory for later analysis. The accuracy is 0.05 % and 1 µV input offset drift. Each channel data can be view independently in either temperature or voltage reading, it allows more readings that are flexible in the experiment. Four rear panel outputs are also available to provide a voltage proportional to the temperature of the first four input channels. The outputs can be use for drives recorder and control the external instrumentation.

At the back of the thermocouple scanner consists of 16 screws terminal that are mount on an isothermal block for cold junction compensation. SR360 can tackle difficult application such as temperature profiling of electrically live equipment because it has 250 V breakdown level. Each of the 16 channels can independently being set to displays units of ^{o}C, ^{o}F, K, mV or V. It can also apply for setting the nominal temperature, temperature limit and alarms. The distinctive setting for each channel shows flexibility of the SR360 and makes temperature reading practical.

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 use 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 select by pressing the corresponding key along the top row of keys in the PARAMETER ENTRY section. Selected units become effective immediately. Units are indicate by an indicator to the right of the MEASUREMENT window, and are abbreviated in the PARAMETER window.

The thermocouple monitor will be connects to the printer. All the output temperature will be record as in printed data.

3.4.2 J-Type Thermocouple

Figure 3.8 shows the J-Type thermocouple used in this experiment. They could be use at acceptable range of this experiment, from about -40 °C up to about 750 °C and high sensitivity at 55 µV/°C.

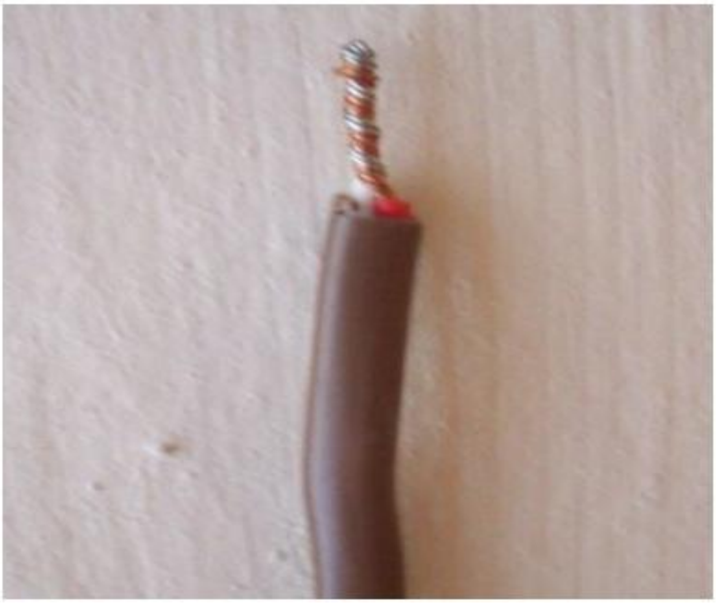


Figure 3.8: J-Type thermocouple

There are several reasons for the popularity of these thermocouples. Importantly, they are relatively inexpensive and easy to make. Although, they are the less accurate means of measuring temperature, but they have plenty of accuracy for most applications, with only one or two degrees of error across their operating range.

Thermocouples works by measuring electrical potential created at a junction of dissimilar metals. If the junction has the at the same atmospheric temperature the temperature different is cause by dissimilar metals use hence it induced an EMF (electromagnetic field) that can be the be process by the thermocouple monitor to produce the output temperature.

Table 3.1: Properties of J-Type thermocouple

Type	J
Positive material	Fe
Negative material	Cu/Ni
Positive colour (USA)	White
Negative colour (USA)	Red

Lowest temperature	0°C
Highest temperature	750°C
Minimum standard error	±2.2°C

3.5 Blower Related Calculations

Fan of the same 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 summarize as follows:

- Volume of airflow varies as fan diameter and as rpm.
- Pressure developed varies as fan diameter and as rpm.
- Power absorbed by the fan varies as fan diameter and as rpm.

3.5.1 Fan velocity

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

$$V = r\,\omega \tag{3.1}$$

3.5.2 Fan Mass Flow Rate

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

$$PV = mRT \tag{3.2}$$

$$P = mRT / V \tag{3.3}$$

$$P / RT = m / V = \rho \text{ (air density, kg/m}^3\text{)} \tag{3.4}$$

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

$$M = \rho\, A\, V \tag{3.5}$$

3.5.3 Heat Transfer

$$Q = mC_p\,(\text{Delta T}) \qquad (3.6)$$

Q = heat transfer in $W/m^2.K$

M = mass flow rate in kg/s

C_p = is the specific heat in J/kg.K

Delta T = temperature different between the outlet and the inlet in K

3.6 TEMPERATURE MEASUREMENT LOCATIONS

Temperature measurement for this experiment is done in two different conditions, which are in fully closed cabin and with the heat removing devices attached to the car and it is controlled by the heat sensor (heat management system).

3.6.1 Heat Removing Use in the Car

Two of the heat removing devices is attach at dashboard and two more is attach at the boot board. The ducting will be going down ward outside of the car. The blower is operating by connecting it to heat management system. The connection is does in parallel as it can allow the electrical circuit to still function although one of the blowers malfunctions. This is to implement real life use of the blower. Increment of temperature at each point is observe, if the temperature exceeds 40 ˚C, the fan automatically switched on. The data is taken every 30 minutes, for eight hours from 9 a.m to 5 p.m. Refer to the Figure 3.9 and Figure 3.10 for ducting of heat extraction device schematic diagram.

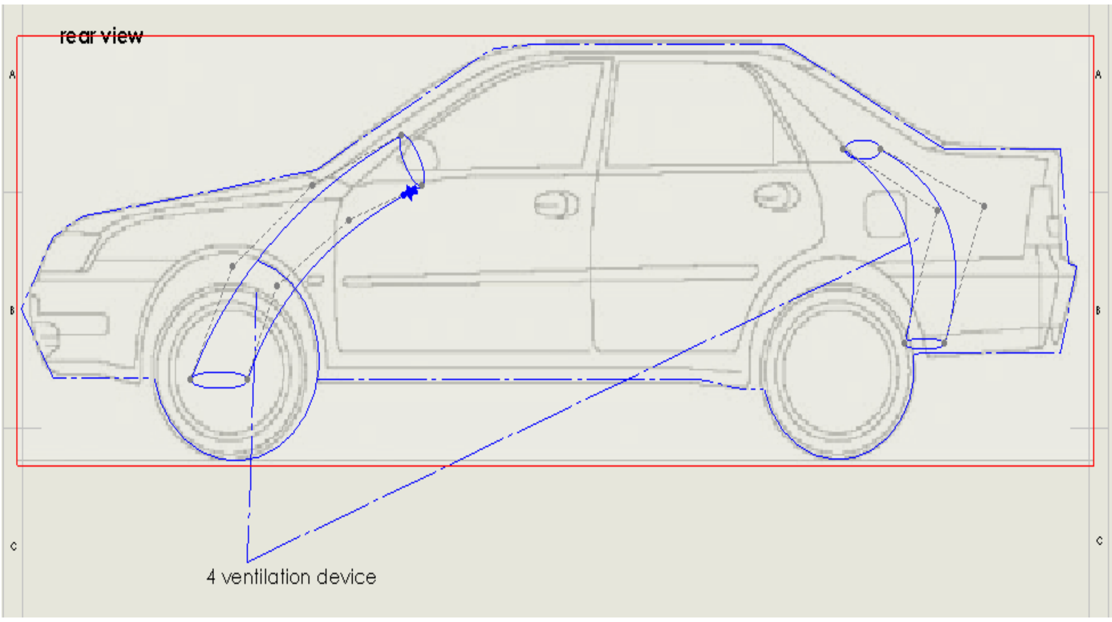


Figure 3.9: Side view for the placement of heat extraction device

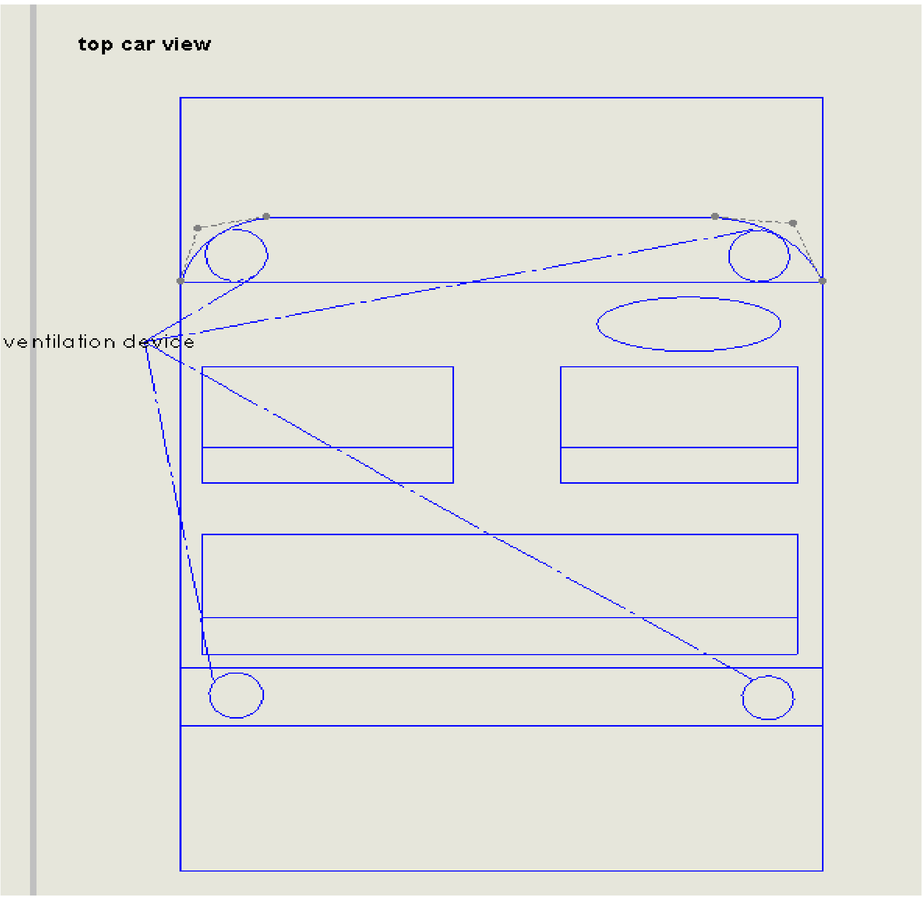


Figure 3.10: Top view for the placement of heat extraction device

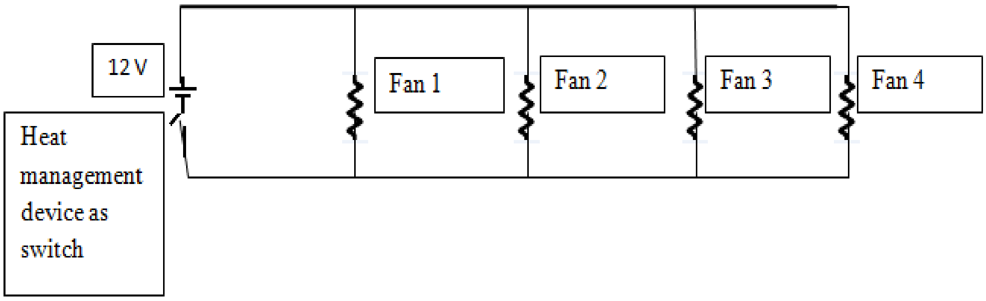


Figure 3.11: Fan wiring connection

The entire fan inside the car cabin is connect with a parallel connection (Figure 3.11) to the battery and heat management device this to make sure the heat extraction device still functioning although of the device malfunction. Each one of the fan are equip with one LED lamp that will switch on to show the device is functioning.

3.7 Flow chart

Flow chart of the project is to make sure the project runs following the schedule. It is also to make sure that all the necessary works related to the faculty is follow. The projects flow is as shown in the figure below.

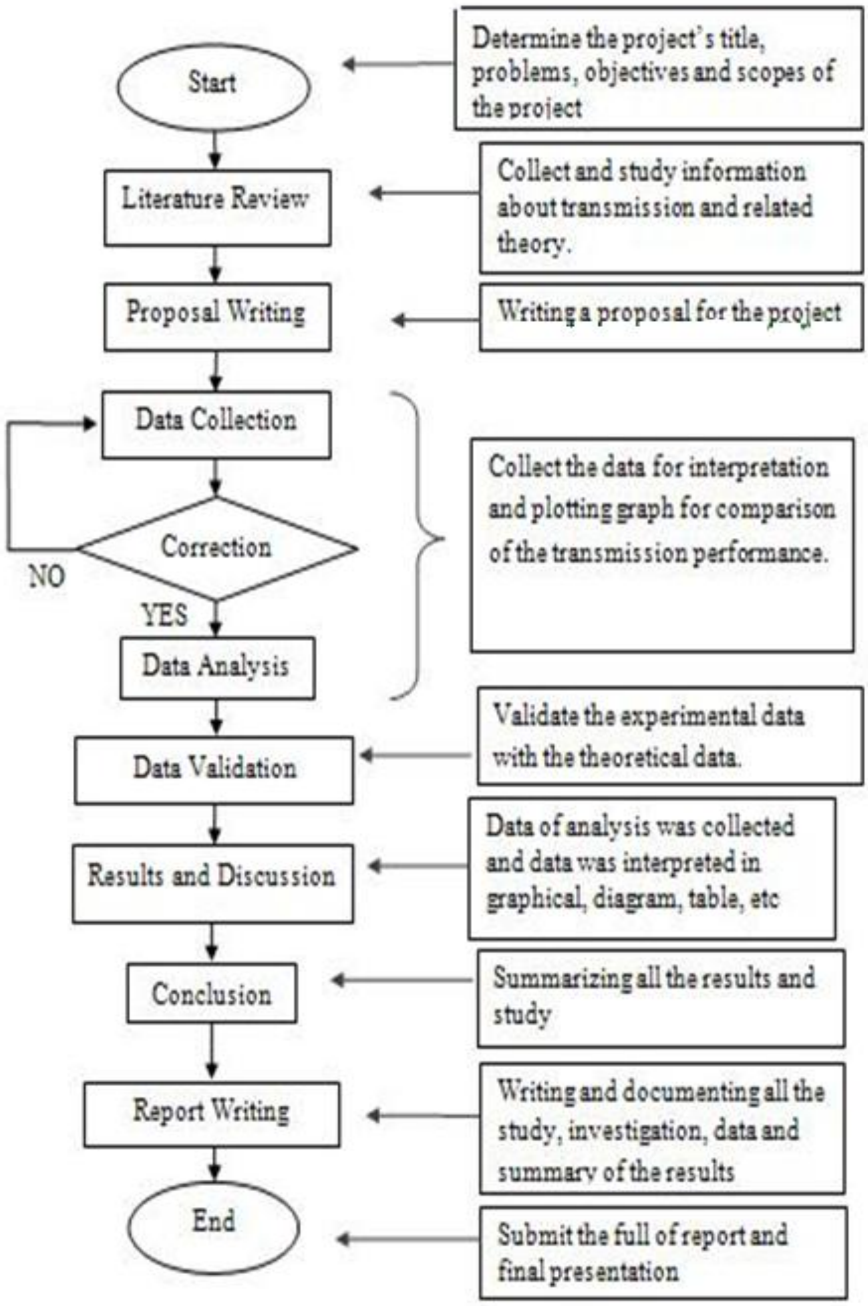


Figure: 3.12: Flow chart of the project

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

By Referring to the objective of this project, the temperature increment inside Waja car cabin under the exposure of direct sunlight need to be determined. Two condition of the experiment was ran, one heat increment inside the cabin without using heat management device and the second is with heat management device that acts as switch for the blower.

The main characteristic taken consideration is the existence of the heat extraction device. The device was the main objective in this project where the fabrication and optimization need to done on it. The experiment will prove the effectiveness of the device and necessary modification had done to improve the effectiveness of the device. This could be notice in the two manipulated experiment condition.

4.2 EXPERIMENT RESULT

4.2.1 Fully Closed Cabin

The experiment have done in a Proton Waja car that all the mirror and doors are completely sealed. Each set of experiment were repeat twice to reduce the error done.

Table 4.1 shows the temperature value taken at eight points inside the car and one at the ambient temperature. Referring to the literature review, the 8 point is, two had taken at front dashboard, 4 at the seat point, and 2 at the rear panel.

Table 4.1: temperature reading inside car cabin without heat extraction device in experiment 1

No: / T(min)	1	2	3	4	5	6	7	8	Ambient T(^oC)
0	35.4	35.0	33.3	32.5	30.4	29.0	34.7	33.6	29.1
30	36.6	36.9	33.2	34.0	31.5	29.7	35.6	34.9	30.2
60	36.7	37.0	34.4	34.9	32.4	30.3	36.8	36.7	29.9
90	37.9	37.6	35.1	35.4	39.8	40.0	36.7	40.0	35.3
120	50.1	49.2	38.4	37.3	41.1	38.0	48.5	45.6	38.7
150	60.0	59.5	40.0	39.8	42.3	41.9	60.1	59.7	42.3
180	64.7	64.0	42.2	40.7	44.6	43.4	64.7	63.9	38.1
210	67.2	67.1	44.6	45.8	45.9	45.2	66.9	67.0	37.5
240	70.0	69.5	47.1	47.0	53.2	54.7	71.5	70.9	38.5
270	76.9	76.4	50.1	50.4	50.1	52.7	75.2	73.6	38.0
300	77.2	76.9	54.3	53.0	55.0	53.1	78.0	77.4	37.0
330	75.6	75.0	53.1	52.9	54.6	54.6	77.6	77.7	37.1
360	75.2	75.3	49.6	49.5	50.5	49.6	69.1	75.3	36.3
390	69.4	68.7	48.8	47.9	48.0	47.0	65.3	69.4	37.0
420	58.0	59.9	48.0	47.3	47.1	46.9	58.1	58.2	36.0
450	57.0	54.1	47.7	47.0	45.5	46.2	54.6	57.1	36.4
480	50.1	53.6	46.8	46.2	44.3	46.0	53.0	55.7	35.4

The ambient temperature varied from 29.1 ^oC to 38.5 ^oC, it increase gradually until minutes 240 then it decrease until 35.4 ^oC. The highest temperature is at minute 300, the reading is 78.0 ^oC at position 7, which is at the real panel. As expected the reading from position 1, 2, 7 and 8 has the highest temperature throughout the experiment. The other part of the car, point 3, 4, 5 and 6 give less increment in temperature reading.

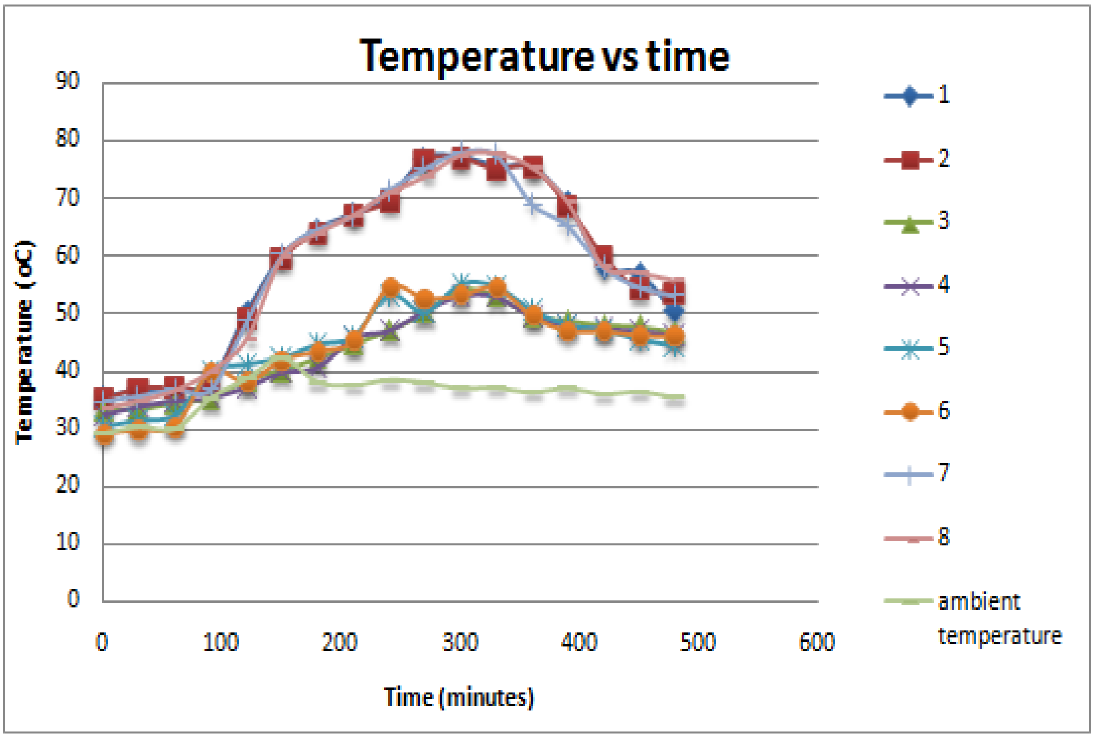


Figure 4.1: Temperature distributions for experiment 1

Figure 4.1 shows temperature distribution during experiment 1. Point 1, 2, 7 and 8 shows a higher gradient than point 3, 4, 5 and 6. Temperature increase as time increase and reach it maximum at 300 minutes after experiment started, then the temperature maintain then after minutes 390 the temperature decrease rapidly. The ambient temperature varies from 29.1 °C and 38 °C.

Table 4.2 shows the temperature value taken at eight points inside the car and one at the ambient temperature. Referring to the literature review, the 8 point is the highest temperature inside the car. 2 had taken at front dashboard, 2 at the driver seat point, 2 the passenger seat and 2 at the rear panel.

Table 4.2: Temperature reading inside car cabin without heat extraction device in experiment 2

No: / T(min)	1	2	3	4	5	6	7	8	Ambient T(^{o}C)
0	35.2	34.9	32.7	32.5	33.1	33.4	34.1	35.0	31.5
30	36.7	34.7	32.4	33.0	34.1	36.5	35.2	35.3	32.6
60	38.9	37.9	36.5	34.5	35.6	37.8	36.8	36.9	32.1
90	46.6	45.1	42.1	42.6	40.1	42.1	44.5	37.8	32.2
120	45.8	45.0	45.7	47.2	45.6	45.7	48.6	49.4	33.2
150	52.6	51.9	48.0	49.6	50.1	54.7	50.1	55.5	33.7
180	57.4	54.5	49.5	49.1	52.6	50.6	56.7	64.3	34.0
210	65.4	63.5	49.9	48.3	53.3	52.8	69.4	68.2	34.2
240	71.2	70.4	50.4	53.2	51.9	52.3	72.0	73.5	36.4
270	73.6	72.9	54.2	54.0	53.4	55.0	74.6	75.4	36.0
300	74.5	73.2	55.6	55.3	54.8	55.6	74.0	72.1	36.0
330	70.9	71.1	51.3	54.1	54.2	53.4	65.3	70.6	35.5
360	71.4	69.7	50.8	51.2	49.7	50.8	64.9	66.6	35.4
390	65.8	63.2	46.5	47.8	42.5	49.7	65.0	66.2	35.0
420	61.6	60.4	45.9	45.5	41.7	45.6	63.1	60.1	34.3
450	59.7	58.6	44.7	46.4	40.0	38.7	55.4	59.8	34.7
480	55.0	54.7	43.1	44.6	39.8	40.6	53.3	55.1	34.8

The ambient temperature varied from 31.5 ^{o}C to 36.4 ^{o}C, it increase until minutes 240 then it decrease until 34.8 ^{o}C. The highest temperature is at minute 270, the reading is 75.4 ^{o}C at position 8, which is at the real panel. As expected the reading from position 1, 2, 7 and 8 has the highest temperature throughout the experiment. The other part of the car, point 3, 4, 5 and 6 give less increment in temperature reading.

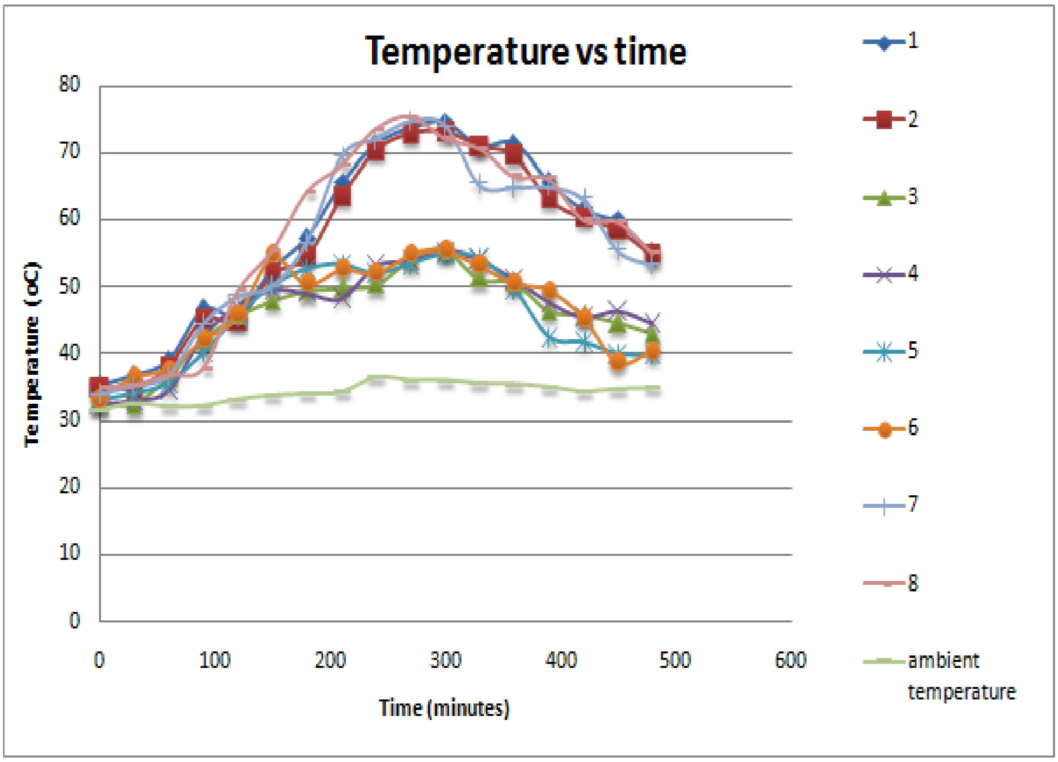


Figure 4.2: Temperature distributions for experiment 2

Figure 4.2 shows temperature distribution during experiment 2. Point 1, 2, 7 and 8 shows a higher gradient than point 3, 4, 5 and 6. Temperature increase as time increase and reach it maximum at 300 minutes after experiment started, then the temperature maintain then after minutes 360 the temperature decrease. The ambient temperature varies from 31.5 ^{o}C and 36.4 ^{o}C.

4.2.2 Fully Closed Cabin with Heat Extraction Device Attach

Two sets of experiment were done while the cabin were close and heat extraction device functioning. 4 heat extraction devices were attach on the dashboard of the front and the back. Thermocouple was attached at 8 selected point. The points were founds in the literature review as the highest heat increment in the car. Heat management device will automatically switch the blower on at 40 ^{o}C.

Table 4.3 shows the reading taken at the 8 point as stated and Figure 4.3 show the temperature distribution throughout the experiment.

Table 4.3: Temperature reading inside car cabin with heat extraction device in experiment 3

No: / T(min)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Ambient T (^{o}C)**
0	35.1	34.1	33.3	32.8	31.4	33.7	34.6	34.9	32.0
30	34.2	34.5	40.1	33.4	32.4	32.4	39.9	35.2	31.2
60	37.3	36.9	35.2	36.1	33.6	33.0	37.4	36.5	33.2
90	36.4	37.5	40.3	37.4	34.0	34.6	37.0	37.1	35.4
120	46.5	46.4	45.3	38.1	36.5	35.7	45.1	48.5	35.5
150	47.7	48.1	46.3	38.5	37.9	36.5	47.9	49.8	35.4
180	51.4	51.6	46.4	39.6	42.5	44.6	52.6	50.5	35.8
210	54.6	55.1	46.9	42.7	46.0	46.5	54.3	56.4	36.7
240	60.7	62.4	47.5	48.1	48.6	47.2	59.7	60.7	37.1
270	58.7	59.8	47.0	46.3	42.1	46.1	60.9	61.3	36.8
300	58.1	57.3	46.1	45.2	43.1	45.3	60.1	58.7	36.7
330	56.3	56.7	45.3	45.3	40.8	44.1	57.1	56.7	35.4
360	57.8	54.6	44.2	44.2	41.0	43.9	56.3	55.4	35.7
390	55.0	55.7	43.0	43.0	40.4	41.7	55.7	54.9	35.2
420	54.6	53.7	42.9	42.9	40.2	41.2	54.6	52.1	35.3
450	48.1	47.1	41.0	41.0	39.3	41.0	49.0	48.7	35.0
480	47.6	48.0	39.8	37.9	38.0	40.0	48.8	48.1	35.2

The ambient temperature varied from 31.2 ^{o}C to 37.1 ^{o}C, it increase rapidly until minutes 270 then it decrease until 35.2 ^{o}C. The highest temperature is at minute 270, the reading is 61.3 ^{o}C at position 8, which is at the real panel. As expected the reading from position 1, 2, 7 and 8 has the highest temperature throughout the experiment. The other part of the car, point 3, 4, 5 and 6 give less increment in temperature reading.

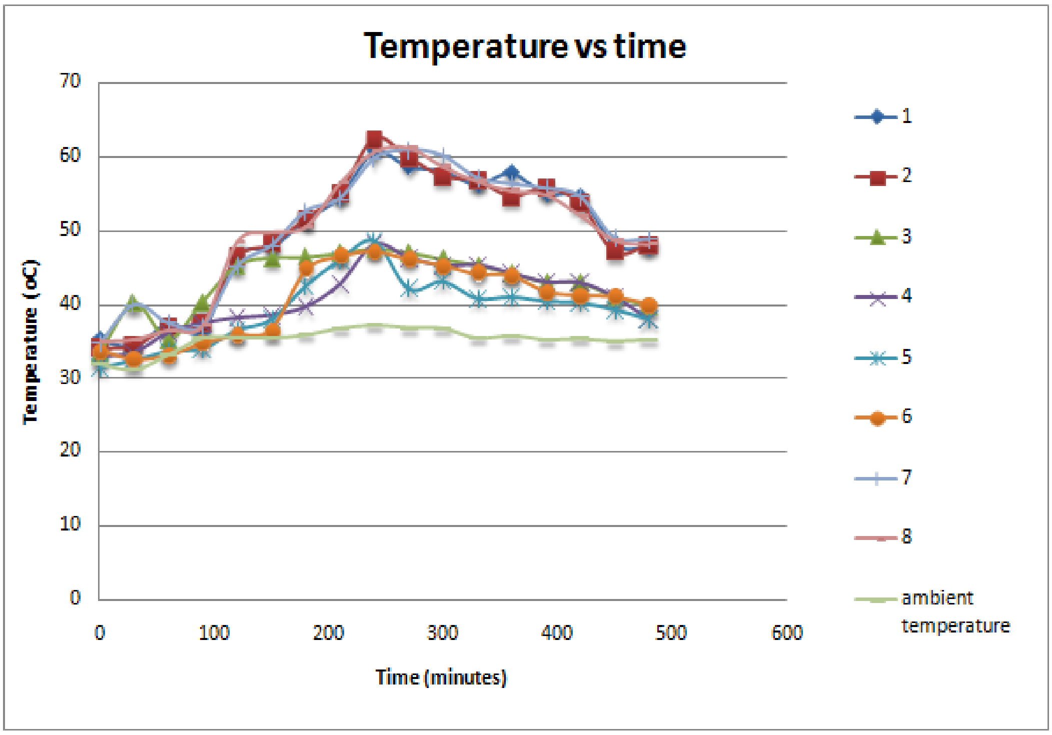


Figure 4.3: Temperature distributions for experiment 3

Figure 4.3 shows temperature distribution during experiment 2. Point 1, 2, 7 and 8 shows a higher gradient than point 3, 4, 5 and 6. Temperature increase as time increase and reach it maximum at 240 minutes after experiment started, then the temperature decrease slowly, after minutes 420 the temperature decrease rapidly. The ambient temperature varies from 31.2 ^{o}C and 37.1 ^{o}C.

Table 4.4 shows the reading taken at the 8 point stated and figure 4.4 show the temperature distribution throughout the experiment.

Table 4.4: Temperature reading inside car cabin with heat extraction device in experiment 4

No: / T(min)	1	2	3	4	5	6	7	8	Ambient T(^{o}C)
0	33.9	36.1	32.0	33.4	31.5	35.8	35.1	35.0	31.4
30	34.5	37.4	33.5	33.5	31.8	33.4	37.8	36.5	32.4

60	41.5	39.5	33.8	36.9	35.4	35.6	39.1	37.4	34.1
90	42.8	40.2	34.5	43.5	36.0	35.8	40.3	37.9	35.6
120	46.8	41.8	36.1	44.2	40.4	39.4	41.2	38.5	35.7
150	47.3	44.7	37.6	44.7	43.4	43.6	41.3	39.3	35.1
180	48.0	44.9	46.5	46.2	44.1	44.7	45.6	40.5	36.9
210	56.1	55.4	47.0	47.1	44.8	46.1	53.7	50.0	37.1
240	60.7	61.5	47.5	47.8	46.4	48.2	59.4	61.3	37.4
270	58.6	57.6	47.1	46.5	45.3	42.1	58.1	56.9	36.8
300	58.2	54.3	47.0	45.2	43.2	43.1	56.7	55.4	35.9
330	49.2	53.1	44.6	44.1	41.1	40.8	55.0	55.1	34.2
360	49.0	51.9	43.2	42.7	41.8	41.0	55.9	54.6	34.6
390	47.1	48.9	43.1	42.8	41.3	42.4	54.1	53.7	36.4
420	47.3	47.3	42.1	41.4	41.1	41.2	50.2	49.5	36.1
450	46.9	45.1	41.4	41.0	40.8	40.3	49.1	48.3	36.0
480	45.3	45.7	40.1	39.5	39.7	40.1	44.6	45.2	36.1

The ambient temperature varied from 31.4 ^{o}C to 37.4 ^{o}C, it increase gradually until minutes 240 then it decrease until 36.1^{o}C. The highest temperature is at minute 270, the reading is 61.3 ^{o}C at position 2, which is at the front panel. As expected the reading from position 1, 2, 7 and 8 has the highest temperature throughout the experiment. The other part of the car, point 3, 4, 5 and 6 give less increment in temperature reading.

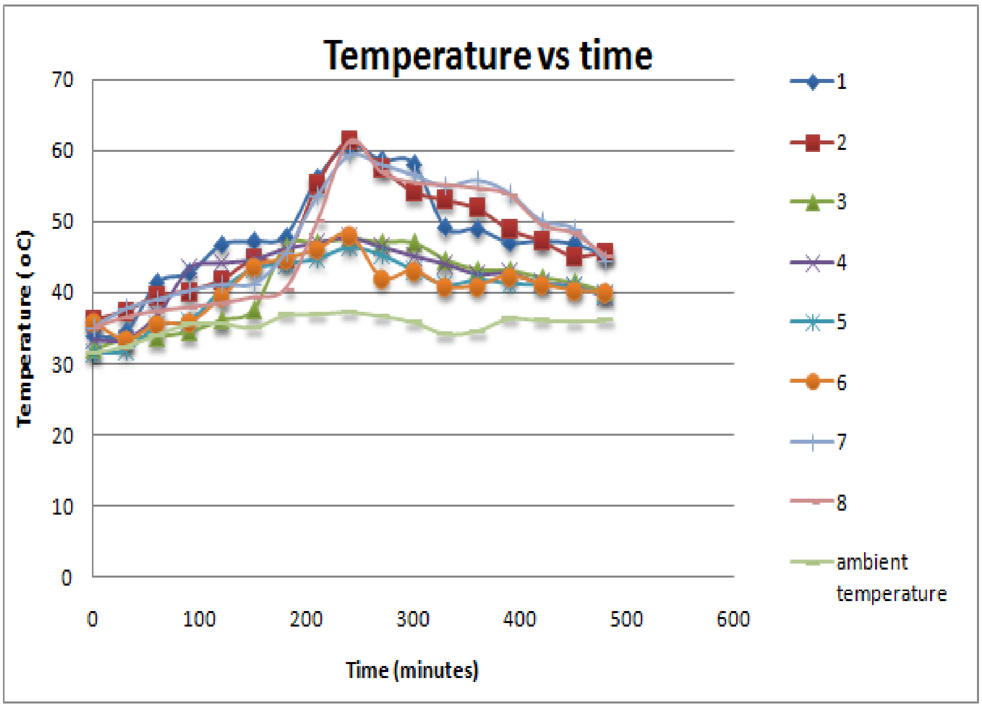


Figure 4.4: Temperature distributions for experiment 4

Figure 4.4 shows temperature distribution during experiment 2. Point 1, 2, 7 and 8 shows a higher gradient than point 3, 4, 5 and 6. Temperature increase as time increase and reach it maximum at 270 minutes after experiment started, then the temperature decrease gradually until minutes 480. The ambient temperature varies from 31.4 ^{o}C and 37.4 ^{o}C.

4.3 COMPARISON BETWEEN RESULTS

Table 4.5 shows the average reading takes inside the car cabin in each experiment. Experiment 1 and 2 is for fully closed car cabin without the use of heat extraction device. The 3rd and 4th experiment is run while heat extraction device is functioning. A heat management system connects to the heat extraction device that acts as a switch that will turn the blower on at 40 ^{o}C.

Table 4.5: Temperature average for each experiment

Experiments : / T(min)	**1 T(^{o}C)**	**2 T(^{o}C)**	**3 T(^{o}C)**	**4 T(^{o}C)**
0	32.9875	33.8625	33.7375	34.1
30	34.05	34.7375	35.2625	34.8
60	34.9	36.8625	35.75	37.4
90	37.8125	46.6	36.7875	38.875
120	43.525	46.625	42.7625	41.05
150	50.4125	51.5625	44.0875	42.7375
180	53.525	54.3375	47.4	45.0625
210	56.2125	58.85	50.3125	50.025
240	60.4875	61.8625	54.3625	54.1
270	63.175	64.1375	52.775	51.525
300	65.6125	64.3875	51.7375	50.3875
330	65.1375	61.3625	50.2875	47.875
360	61.7625	59.3875	49.675	47.5125
390	58.0625	55.8375	48.675	46.675
420	52.9375	52.9875	47.775	45.0125
450	51.15	50.4125	44.4	44.1125
480	49.4625	48.275	43.525	42.525

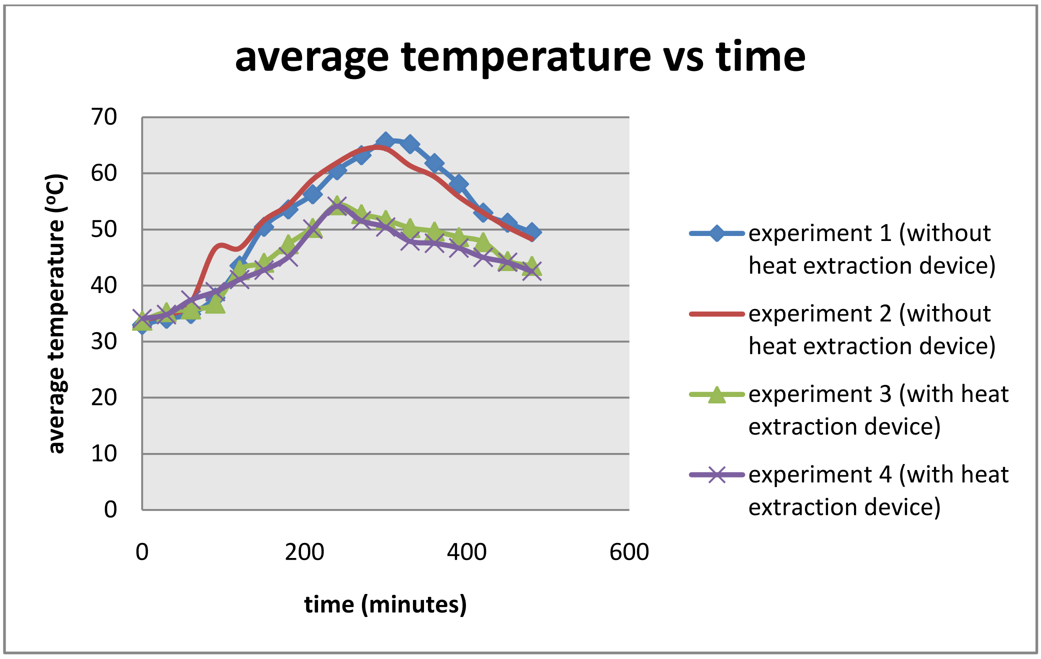


Figure 4.5: Comparison average temperatures between two different conditions

For experiment 1, the maximum average temperature taken is 65.61˚C. The heat built up for experiment 1 increase gradually until it reach maximum at minutes 300. Then the temperature starts to drops to 49.46 ˚C as the temperature of the environment decrease. The same thing happens in experiment 2 because the same term of experiment applies. The ambient temperature effects on the different temperature readings on both experiment. The maximum reading in experiment 2 is 64.39 ˚C that happens after 300 minutes experiments running. However the heat built up reduce more gradually in experiment 2 compare to experiment 1. The last temperature reading is 48.28 ˚C, 1.18 ˚C different from experiment 1.

With the availability of heat extraction device, the reading is reducing as expected. In experiment 3 and 4 the heat built up decrease after minutes 240. In comparison with equivalence heat built up in experiment, 1 and 2 the heat built up were rapidly building. For experiment 3 the maximum temperature read is 54.33 ˚C at minute 240. For experiment 4 the maximum reading is 54.10 ˚C at minute 240 of experiment time.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The result taken in the experiment is 65 ˚C is average highest temperature readings for experiment without heat extraction device. The highest average temperature readings for experiment with heat extraction device is 54.22 ˚C from the value the temperature different were 10.78 ˚C and it shows that the device does function in reducing cabin temperature.

The purpose of the project is to fabricate a heat extraction device. The fabrication required the product to be test by some experiment. The experiments were done to make sure that the heat extraction device can be produced the comfortable temperature range for the passenger to rest in. Reducing the cabin temperature while parked under direct sunlight also can bring much more benefit. Reducing heat can reduce the fuel consumption use to power the air conditioning system of the car. It can secure the safety of child passenger inside the cabin is such self-locked incident happen. Furthermore, the life span of the interior of the car can be elongate as it reduced from the exposure of extreme heat.

It is find out that there is a certain location, has the highest temperature reading, this location can be use to put a blower ducting system that will extract the heat there to a lower temperature region outside the car. With the help of the heat management system the usage of power of the device can be control automatically. After all the experiment and analysis that prove the efficiency of the device, the objective of the project achieved and all the scopes achieved.

5.2 RECCOMMENDATION

For future development and research, more detailed analysis of the heat extraction device and can be done a heat extraction experiment. Another power alternative for the device need be develops so it is power efficient and independent of the car power system.

Some other recommendations is to do a complete analysis of the rate of heat transfer for the heat extraction device, to make sure the result is more comprehensive a simulation by using a CFD software such as COSMOS and Fluent can be use. For the power system of the heat extraction device, it can use solar power as the car is exposed under direct sunlight. More optimum size of the ducting can be suggested for making the device function at it optimum condition.

REFERENCES

A. Alex Alexandrov, K. Vladimir, R.Marcelo, 2001, *Analysis of Flow Patterns and Heat Transfer In Generic Passenger Car Mini Environment*, Annual Conference of the CFD Society of Canada, 27 - 29 May

A. Aroussi, S. Aghil, *Characterisation of the Flow Field in a Passenger Car Model*, 2000, Optical Diagnostics *in Engineering,(p.p1-15)*

M. Jalal, Q. A. Haider, 2007, CFD Simulation for a Road Vehicle Cabin, Educational Technology Department, University of Technology, Baghdad, (p.p123-142)

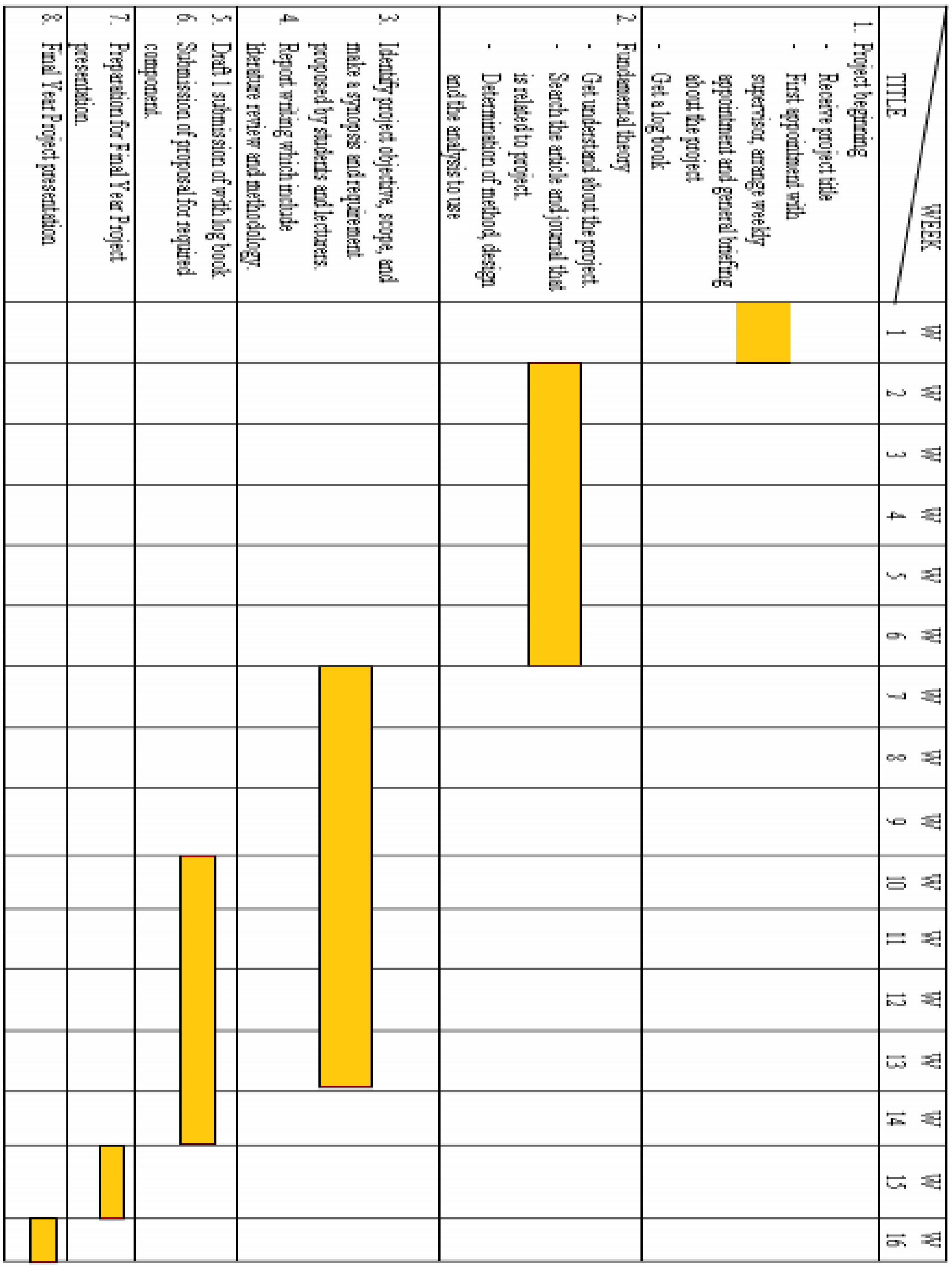
M.U. Khan, K. Kawaguchi, Temperature Mitigation of the Parked Automobile under a Blazing Sun, 1991, 41st Heat Transfer Symposium

K.D. Huang, S. C. Tzeng, W. P. Ma, M. F. Wu, (2005), Intelligent solar-powered Automobile Ventilation System, Applied Energy 80, (p.p141–154)

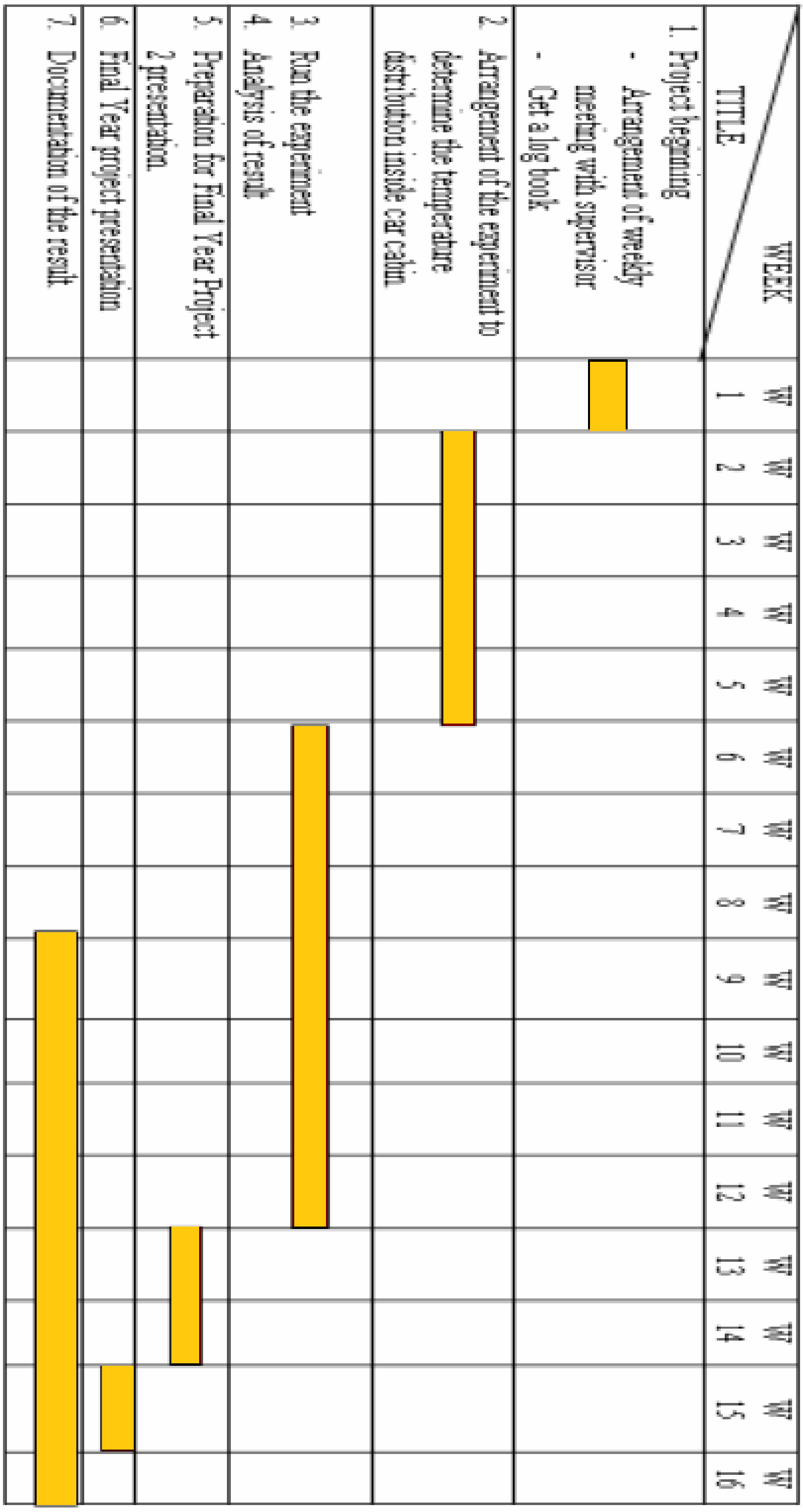
S. Burch, S. Ramadhyani, J. Pearson, *Analysis of Passenger Compartment Thermal Comfort in an Automobile Under Severe Winter Conditions*, 1991, ASHRAE Transactions, Vol. 97, Part 1

R.P. John, C. Lawrence, L. Jason, M. John, R. Mukesh, O. Kurt, K. Rupert, 2007, *Reduction in Vehicle Temperatures and Fuel Use from Cabin Ventilation, Solar Reflective Paint, and a New Solar-Reflective Glazing*,2007 SAE World Congress

APPENDICES



Appendix A1: Flow Chart for PSM 1



Appendix A2: Gantt chart for PSM 2