UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ANALYSIS OF CAR HYDRONIC COOLING SYSTEM WITH POSSIBILITY OF USING SOLAR POWER

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Refrigeration and Air Conditioning System) (Hons.)

by

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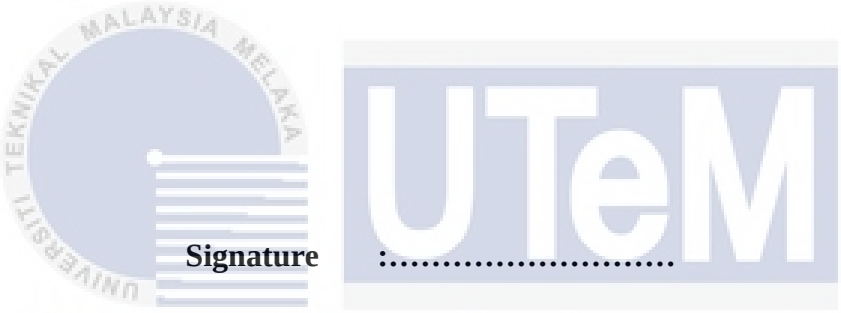

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Refrigeration and Air-Conditioning System) (Hons.). The member of the supervisory is as follow:

…….

(Encik Muhammad Nur Bin Othman)

ABSTRACT

Nowadays, the car is the main transport used to go to one place to another place. When the car is parked under direct the sun, the heat will be accumulated and trapped inside the car when all car windows closed. Under these conditions, the temperature inside the car is getting hotter. This causes the driver and passenger in the car will feel uncomfortable. The heat is trapped inside the car absorb the material that made from rubber. These compounds are called voltaic organic compound. Based on this problem, I conducted a study in which to reduce the temperature of the heat trapped inside the car. The research that I did about car hydronic cooling system. The purpose of this experiment was to calculate the amount of temperature trapped in the car while the car is parked in the sun and analyze a suitable medium that use in a mini chiller during to decrease temperature trapped inside the car. Based on experiments, the average temperature trapped inside the car before the installation of the hydronic cooling system is 45.23° C. After installing and running the cooling system with suitable amount of mixture water, ice and salt the total average of temperature reduced is 9.7 °C.

ABSTRAK

Pada zaman kini kereta merupakan pengangkutan utama yang digunakan untuk pergi ke sesuatu tempat. Apabila kereta di letakkan di bawah sinaran matahari, haba akan terkumpul dan terperangkap di dalam kereta apabila semua tingkap kereta di tutup. Berdasarkan keadaan ini, suhu yang berada di dalam kereta semakin panas. Hal ini menyebabkan pemandu dan penumpang yang masuk di dalam kereta akan berasa tidak selesa. Haba yang terperangkap di dalam kereta akan menyerap pada bahan yang diperbuat dari getah di dalam kereta. Sebatian ini dikenali sebagai voltan sebatian organic. Berdasarkan masalah yang sedemikian, saya telah menjalankan kajian di mana untuk mengurangkan suhu haba yang panas terperangkap di dalam kereta. Kajian yang saya lakukan adalah tentang sistem penyejukan hidronik bagi kereta. tujuan eksperimen ini dijalankan adalah untuk mengira jumlah suhu yang terperangkap di dalam kereta semasa kereta diletakkan di bawah matahari dan medium yang sesuai digunakan di dalam bekas penyejukan semasa sistem dijalankan bagi menyingkir suhu yang terperangkap. Berdasarkan ekperimen yang di jalankan, purata suhu yang terperangkap di dalam kereta sebelum pemasangan system penyejuk hidronik adalah 45.23 °C. Setelah pemasangan sistem penyejukkan hidronik kereta dijalankan purata dan nilai suhu yang dapat di kurangkan adalah 9.7 °C.

DEDICATIONS

For my beloved parents, I would like to thank the infinite for giving encouragement and support to me in making this final semester project. Besides that, they are also quite patient and responsible to teach me to realize my dream. Finally, thanks for friends who help me in making this final semester project directly and indirectly. The guidance that they give to me, I will recalled all the time.

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First of all grateful to divine grace and blessings for my final year semester project was complete the project successfully during the due date. Thank you to my parents for their support, encouragement and motivation to during this final year project. Do not forget to say thanks you to my supervisor Mr. Muhammad Nur bin Othman for giving guidelines when carrying out this project and makes final year report project. Thanks to my friend who helped me during the making of this project. Besides that, also thanks to those who have helped me directly and indirectly in making the final project of the semester. Thank you.

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LIST ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

Indoor Air Quality	**IAQ**
Direct Current	**DC**
Volatile organic compound	**VOC**
Heating, Ventilating, and Air Conditioning	**HVAC**
Coefficient of Performance	**COP**
Air Mass Zero	**AM0**

CHAPTER 1

INTRODUCTION

In this chapter the most important subtitle topics involve are background, parameters, problem statement, objective, work scope and organization of thesis.

1.0 BACKGROUND.

The background of this project describe the subtopic such as air conditioning system, hydronic radiant cooling system and solar power. Air conditioning system, hydronic radiant cooling system and solar power are presented and in details.

1.1 AIR CONDITIONING SYSTEM.

Air conditioning is the process of altering the properties of air to more comfortable condition. The aim of the distributing the conditioned air to an occupied space of building or vehicle to improve of thermal comfort and Indoor Air Quality (IAQ). Indoor Air Quality (IAQ) relates to the health and comfort for the occupants. However, conventional air-conditioning is does not fit for the economic due to the high energy intensive. Besides that, for this analysis thermal comfort is important for the occupant when they enter the car at parking because they feel hot in the cabin. The hydronic cooling system includes a

packaged outdoor combination hot and cool unit residential and commercial installations comprise control valve. This is for directing water through alternately an evaporator for cooling the liquid during the cooling mode of the system for heating the liquid. A hydronic heating and cooling system having heating and cooling modes adapted be connected to a terminal system comprising a chiller tank provided with a water reservoir in the bottom portion. A refrigeration system operative during the cooling mode and including a compressor, a condenser and an evaporator in operative relationship to the water in chiller tank and evaporator being located in chiller tank above reservoir. Also presented are fundamental heat transfer equations that govern the radiant cooling panel means temperature as a function of coolant temperature and space temperatures. These study are illustrated where the radiant panel are integrated with a dedicated outdoor air system capable of maintaining the space dew-point temperatures. The design of the hydronic cooling system might be affecting the total load of the conditioned surrounding and resulting in condensation of the cooling surface. The preventation of condensation process is to improve the dew point temperature control inside the conditioned space by using the parallel ventilation system to maintain indoor air quality. According these research, the radiant cooling system is complicated due to the thermal load, structure and hydronic system and impact to the thermal comfort.

1.1.1 HYDRONIC RADIANT COOLING SYSTEM.

In hydronic cooling systems the heat carrier is either pure water or water mixed with some kind of brine often glycol. Hydronic systems are also called water based or radiant systems. The hydronic system, using water as exchange fluid and it provides perfect cooling with high efficiency. There is not much difference in balancing a heating and a cooling system. Besides that, comfort cooling system is to ensure that a correctly calculated amount of water is distributed to induction units, chilled beams, and chilled panels in the system. The part of hydronic system is used water as a transport medium, and pump to flow the

water through the copper tube inside the car panel. Hydronic system does not required a compressor but need a circulation of pump.

1.1.2 SOLAR POWER.

Solar power is the conversion of sunlight into electricity using the photovoltaics (PV). Photovoltaics convert light into an electric current using the photovoltaic effect. Besides that, photovoltaics were initially solely used as a source of electricity for small and medium-sized applications. The purpose of a photovoltaic power system is produces direct current (DC) power which fluctuates with the sunlight's intensity. From this project, it is renewable environment friendly and has a free flow of electricity, thus it is better preference of energy.

1.2 PARAMETERS.

1.2.1 TEMPERATURE.

Heat is trapped in the car due to Greenhouse effect represent of the exchanges of the energy between the source (sun), the Earth’s atmosphere and the ultimate sink outer space. Also, a phenomenon of increasing the earth temperature by trapping the heat within the atmosphere. When sunlight reaches the surface of the earth, some of heat will absorbed which will warm the ground. When the car under the sun the compartment of car so hot and the temperature will increase.

1.3 PROBLEM STATEMENT.

Sometimes people parked their car under direct of sunlight with closed windows. The heat emitted in the car cabin car is trapped and causes a significant increase of temperature due to the greenhouse effect. Besides that, when the temperature is high that may cause damage the interior cabin of the car and make the people feel discomfort. When the dashboard is hot, it release some chemical Volatile organic compound (VOC). That chemical have high vapor pressure at ordinary room temperature may affect the human health. To overcome these problem is by implementing the hydronic cooling system. Conventional air conditioning system is required. Therefore, a literature solution with energy saving is essential that is hydronic radiant cooling system.

1.4 OBJECTIVES.

1. To overcome the heat trapped inside the car.
2. To investigate the possibility of using solar power by implementing hydronic cooling system.

1.4.1 SPECIFIC OBJECTIVE.

1. To measure the temperature and calculating the heat inside and outdoor the car.
2. To determine the required size of PV for supplying necessary power to run the pump.

1.5 WORK SCOPE.

The scope of work of this project is an open environment area to park a car. The temperature of car cabin is measure before and after the implementation of the Hydronic Cooling System (HRC). Apart from that, the system is implement the real car instead a prototype and the scope include the designing and installing the cooper tube inside the car and operating the mini chiller.

1.6 ORGANIZATION OF THE THESIS.

In the chapter 1 explain the introduction of project which includes the background, problem statement, objective, parameters and work scope of this project. Besides that, in chapter 2 is explain about the review theories, experimental work and finding some pass research that related to the current project. Apart from that, in chapter 3 methodology and strategy to the objective and explain briefly. The working procedure, materials and apparatus will explain in this chapter.

CHAPTER 2

LITERATURE REVIEW

Hydronic radiant cooling systems is a system that provides thermal comfort. This system does not like a conventional cooling system because this system not rely use of vapor compression to generate the cooling system. In this chapter will discuss the hydronic cooling system and the effect of heat trapped in the car. Besides that, the theories and finding from the previous studies are reviewed and the knowledge that associated with current study.

2.1 GENERAL CONVENTIONAL AIR-CONDITIONING SYSTEM.

Heating, Ventilating, and Air Conditioning (HVAC) equipment perform heating and cooling for residential, commercial. Besides that, to achieve the aim important to increase in Heating, ventilation and air conditioning (HVAC) system is achieve by consume more than 40% of energy use. In this cases, also have significant impact on indoor air quality, thermal comfort, and quality life for the occupant's, reported by (Fisk 2000, Clements-Croome 2006, EIA 2012).To dilute the interior airborne contaminants in HVAC system, also be responsible for providing fresh outdoor air such as odors from occupants, volatile organic compounds (VOC's) emitted from interior furnishings, chemicals used for cleaning and others based on Self-Study Programme 208, Fundamental of Air Conditioning in Motor Vehicle Next, to make a comfortable indoor environment round when maintained must do the properly designed system. Apart from

that, the goals of HVAC systems is for maintaining better thermal comfort and indoor air quality. From the study of air conditioning, to cool an air conditioner and dehumidifies the air is passes over a cold coil surface.

For the heat exchanger, the indoor coil is an air to liquid with rows of tubes that pass the liquid through the coil. After that, to increase the heat transfer characteristics between the air passing over the coil and liquid the finned surfaces connected to these tubes and overall the surface area of the cold and passing through the coil. The system selected is depends on the type of the liquid used. Direct expansion (DX) equipment and chilled water (CW) also uses the liquid as the refrigerant medium.

When temperature is required to a chilled water system means it near to the freezing point of water. Then, glycols and salts are added as a freeze protection for the water. The liquid is delivered to the cooling coil at a cold temperature regardless the liquid as a medium, (http://www.fsec.ucf.edu/en/consumer/buildings/commercial/hvac.htm, cited on 23/4/2016).In this case, the air passing over through the indoor cooling coil using the direct expansion equipment and heats the cold liquid refrigerant. The refrigerant was transform from a cold liquid to a warm gas and the boiling is causes by heating process. Next, the cooling coil to the compressor was pumped warm gas through a copper tube suction line to the compressor where the warm gas is compressed. This process is increases the pressure of the refrigerant vapor and also increases the temperature of the vapor.

Moreover, heat is rejected when the compressor pumps the vapor through another heat exchanger such as outdoor condenser and the hot gas is condensed to a warm high pressure liquid. This medium is pumped through a smaller copper tube of liquid line to a filter and the high pressure liquid is reduced to a cold and low pressure liquid using an expansion device The process repeats and the cold liquid enters the indoor of cooling coil Schematic Diagram of HVAC System is shown in Figure 1.

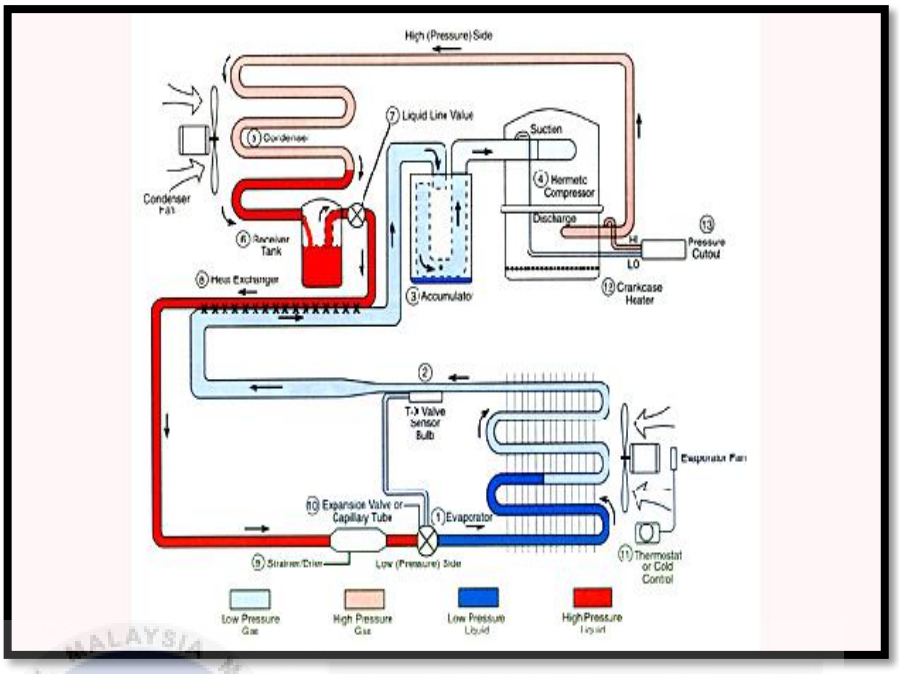


Figure 1 Schematic Diagram Of HVAC System.

2.2 AIR CONDITIONING SYSTEM IN VEHICLES (CAR).

Based on the book entitled A Guide to Vehicle Air Conditioning published by Glasnevin, et.al (2013), to deliver passenger and driver comfort air conditioning and climate control both inside vehicle provide ways of controlling the air temperature. The vehicles use the waste heat from the engine to warm up the cabin air during the winter months. However, air conditioning is often needed during the summer, to reduce the temperature of the cabin for a comfortable level. It also responsible to dehumidify and demist the vehicle.

During this study, whereas climate control can provide both hot and cold air the air conditioning just cools and dries the air. It allowing to choose a specific temperature usually between 15° and 26°. The fuel consumption can increase use 20% of air conditioning and climate control units' cars and vans because they take power from the engine and add to the weight of the vehicle. Besides that, the heated cabin air exchanged

with ambient temperature when in the strong sunlight particular. In addition, the intake point of the air outlet to the air temperature usually rise route a If the fan speed is higher more comfort will get. From this, it also expose the occupants to other nuisances such as noise, exhaust gases and pollen when opening a window or sliding roof

Scientific studies conducted by the WHO (World Health Organization) have shown that effects of an unfavorable vehicle interior temperature on human is ones of ability to concentrate and reactions are impaired when under stress. Moreover, when the sunlight is too hot it can increase the temperature in the interior car more than 15 OC above the ambient temperature in the head area.

A system which keeps the air temperature at a level comfortable to humans which is air conditioner. The air was created in order to reduce or eliminate completely as well as purifying and dehumidifying such stress. To produce the air outlets a temperature which possible much lower than high of outside air temperatures. The average of temperature is influence of air conditioning and ambient temperature increase (Daehui Lee, et al. 2 0 1 5,). Then, the refrigeration system operates in high compression ratio and condensing pressure air for efficient condensation in tropical region. Based on the Fundamental of Air Conditioner in the Motor Vehicle Self-Study Programme 208, the compressor provide cold of gaseous refrigerant at a low pressure. In this study, the refrigerant is compressed in the compressor and refrigerant is pumped into the circuit on the high-pressure side causing it to heat up.

Next, compressor compressed liquid refrigerant continues to flow up to a narrowing. The evaporator causing its pressure to drop low-pressure side once the refrigerant reaches the narrowing injected. Then, the injected liquid refrigerant expands and evaporates inside the evaporator. The purpose of the evaporation heat required is to extract warm fresh air which cools down when it passes through the evaporator fins and temperature inside the vehicle reduced pleasant level.

After that, the refrigerant flows to the condenser. When the heat is extracted to the compressed, the hot gas in the condenser flows by the air through headwind and fresh air blower. Refrigerant condenses and becomes a liquid when it reaches its melting point

pressure dependent. Diagram of Air Conditioning System in Vehicles (Car) is shown in Figure2.

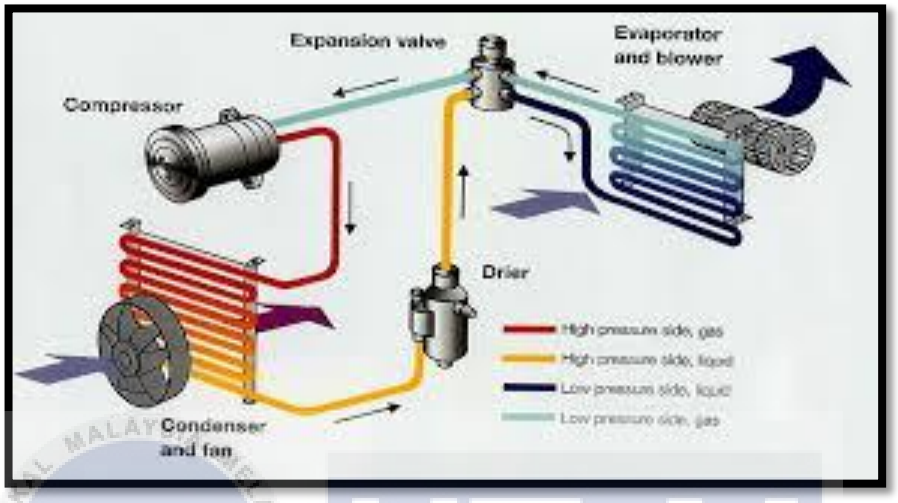


Figure 2 Diagram of Air Conditioning System in Vehicles (Car).

2.3 HYDRONIC RADIANT COOLING SYSTEM.

Hydronic radiant cooling system is the system that cools indoor by removing the sensible heat using the method of surface temperature control. Radiant cooling systems have been proven provided the improved thermal comfort of indoor environment to be potentially more energy efficient (Dong Xie at El. 2016). Besides that, chilled water is supplied at a higher temperature to radiant cooling systems than conventional air conditioning systems. To control independently indoor temperature and humidity, ceiling radiant cooling panel (CRCP) system is available and it achieves specialty advantages for the perception of human thermal comfort.

An efficient way to deliver cold to a zone is considered with smaller temperature gradient inside the room and avoid local thermal discomfort compared the conventional air-conditioning system .For conventional Heating, Ventilation and Air Conditioning

(HVAC) system, the task of cooling a building is achieving by convection . It only, supply air directly cooled by cooling coil to keep dehumidification control and air-supply at dew point. Nowadays, energy consumption and heat transfer of hydronic radiant cooling system have been growing interests for characterizing. Apart from that, from an experiment research on CRCP system was carried out to obtain actual cooling performance under different working conditions and influencing parameters Heat transfer performance and water condensation phenomenon of radiant cooling panel was conducted to analyze heat transfer performance conducted by Yin et El (2016). Based on Jeong (2016), radiant cooling system of the energy consumptions compared to conventional HVAC system could save on average 30% .To indicate that CRCP system consumed 42% less energy than HVAC system with outdoor air for free cooling in spring and fall. For the conventional HVAC system, radiant cooled ceiling systems could be below than 20%.

The heat transfer coefficients between radiant surfaces and room were influenced by surfaces temperature internal gains and air movements in an enclosure. Moreover, to reduce energy consumption has many features such as first reduction is attributed to transporting heat by circulating water as compared to circulating air (Raftery et al. 2011). The heat exchange the temperature of the cooling water can be only a few degrees different from the room air temperature. Heat pump is use to allows the difference of temperature with the highest coefficient of performance (COP) values (Gayeski 2010). Next, system that allows use of alternative low-energy cooling sources such as, solar, evaporative processes, or ground heat exchange (Babiak et al. 2007). However, according to the research, the radiant cooling system is complicated due to the thermal load, structure and hydronic system give the impact to the thermal comfort.

2.4 THERMAL COMFORT.

Human thermal comfort is an important parameter in this project. Based on the ISO 7730 standard as being that condition of mind which expresses satisfaction with the thermal environment. The vital parameters that influences a person's thermal comfort level is temperature. When a room is too hot, the person will feel not comfortable. Besides that, the human cold sensors begin to send impulses to the brain and the thermal comfort level decreases if the skin temperature falls below 34°C (Roberto Lambert, 2015). Indoor environmental quality of thermal comfort and the assessment is do not depend solelyon physical parameters.

An integrated various physical phenomena that interact with the space in the human body's physiological responses to the environment are dynamic such as light, noise, vibration, temperature and humidity (Roberto Lambert, 2015). The international standards commonly used in the area of thermal comfort, to evaluate the thermal environments are ISO 7730-2005 (ASHRAE 55-2013 and EN 15251-2007) Indoor temperatures of thermal comfort in those situation was reached with up to 30◦C and relative humidity of 70%. Thus, 40% of an annual energy savings may be achieved considering the range of comfort temperatures is about 15oC until 30◦C and using personalized conditioning (Ricardo Forgiarini Rupp, 2015). Apart from that, thermal comfort is that state of mind that is satisfied with the thermal environment; thus the condition of minimal stimulation of the skin's heat sensors and of the heat-sensing portion of the brain.

Thermal comfort are not absolute to the environmental conditions conducive but rather vary with the individual's metabolism. The body's ability to adjust a wider or narrower range of ambient. The human body requires a fairly narrow range of environmental conditions compared with the full scope of those found in nature for comfort and efficiency. Human beings are essentially constant-temperature animals with a normal internal body temperature of about 98.6°F (37.0°C). Moreover, the body as a result of metabolic activity and its production can be controlled, to some extent, by

controlling metabolism. However, to maintain thermal equilibrium the body must reject heat at the proper rate in order given a set metabolic rate. If the body loses more heat to a cold environment than it produces decreases heat loses by constricting the outer blood vessels reducing blood flow to the outer surface of the skin and effect risk of hyperthermia. (Human Comfort and Health Requirements 2014).

2.4.1 EFFECT OF HEAT TRAPPED IN THE CAR.

Based on the Department of the Environment (2016), greenhouse effect is a phenomenon that warms the earth surface which the sun energy reaches the earth's atmosphere. Sun energy absorbed and re-radiated of some reflected back to space by greenhouse gases. On the other hand, heat radiates from earth towards space and absorbed rest of sun energy by the ocean and heating earth. Greenhouse gases cause some of this heat trapped in the atmosphere and Earth warm enough to sustain life. When the amount of greenhouse gases released to the atmosphere, then the temperature of Earth's rise and trapping extra heat. The total radiant energy represent 44% energy emitted.

Furthermore, the heat absorbed and does not turn on the interior surface that energy comes as a light. Air inside the car does not leave while continuing to accumulate more heat. More heat will come when heat leaving the car and the sun goes down (Articles of car solariums and green effect 14/5/2016). Based on UCSB Science Line (14/5/2016) conducted that the temperature emitted energy at every object in the car. Radiation heat of the spectrum emitted to the human being is 100 0 F. the heat inside the car will absorbed by the water vapor and CO2 air. From this situation never leave the pets or child inside the car even the temperature outside is 70 o F it can exceed easily to 1000 C in the interior of car that could dangerous for the pet and child healthy.

On the other hand, the windows of a car are relatively transparent to the sun's shortwave radiation and are warmed little at the atmosphere. Energy does not strike the heat at the and easily reach the temperatures in the range of 180 to over 200 degrees F at a dark dashboard or seat. Air trapped inside the car is very efficient to the vehicle and the heat adjacent air on dashboard, steering wheel and child seat by conduction and convection off long-wave radiation From the National Oceanic & Atmospheric Administration National Weather Service published by National Milwaukee and Sullivan (2013) shows the temperature rise to 123°F just for one hour park the car under the sun. This can effect a quickly death trap for a child. Diagram of sun heat for one hour park the car and vehicles in the sun can be death traps is shown in Figure 3 and 4.

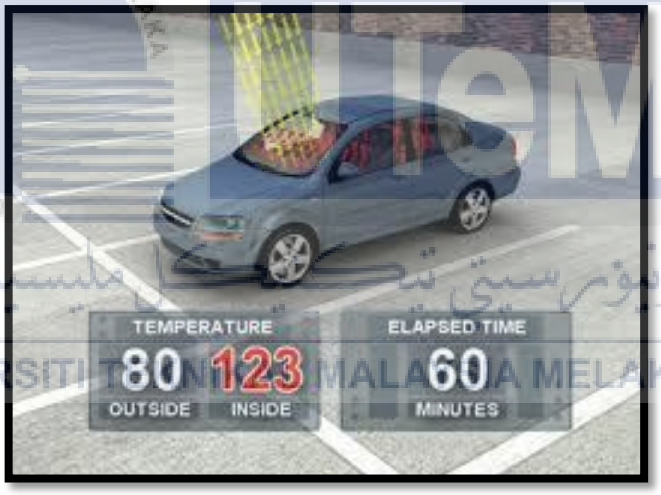


Figure 3 Diagram of Sun Heat for One Hour Park the Car.

Figure 4 Diagram of Vehicles in the Sun Can Be Death Traps.

Apart from that, since 1998, five hundred children have died due to hyperthermia. Hyperthermia is occurs when the body absorbs more heat than it can dissipate an acute condition even on a mild day. This can occur even on a mild day. In this study, shown that the temperature inside a parked car can increase dramatically to a dangerous level for children, and adults. Children and pets get quickly effect more than adults because their bodies warm. When the heat trap inside the car that can get more heat symptom. The heat symptoms are sunburn, heat cramps, heat exhaustion and heat stroke. Next, the most serious symptom is heat exhaustion and heat stroke which can lead fainting and vomiting. Heat stroke is the rapid and strong pulse that effect the mental function, (Sullivan Smith 2013).

Based on the experiment from the Journal of the Louisiana State Medical Society (1995) conducted by Louisiana State Medical Society, shown that the comparison between degree of heat exposure in dark colored vehicles temperature rise inside an enclosed and the temperature of vehicle with light colored which window partly open. Besides that, a person left alone in a sun- exposed car is unable to remove himself from an enclosed vehicle at risk for a life- threatening even a relatively short period of time. Table method of experiment Louisiana State Medical Society (1995) is shown in table 1.

Method that use in this experiment are shown in table below:

Table 1 Method of Experiment Louisiana State Medical Society (1995).

Specimen	Labcraft 227-876 thermometer
Reading of car exposed to the sun	2:30 pm until 4:00 pm every 10 minutes
Place	Downtown New Orleans
Date	27 July 1995
Outside ambient temperature	93^{o}F
Relative humidity	53%
Condition of cloudy	Partly cloudy

From this, the first car was a dark blue sedan with the widows closed and the second car was light gray minivan with both of the front windows open with 1.5 inches. For the first car, the thermometer was direct sunlight but was shaded from direct sun light in second car. Both of the vehicles were cloth and the thermometer was placed upon the front of car seat to be likely the match position of the occupants. Table and diagram result of the experiment Louisiana State Medical Society (1995) was shown in the table 2 and figure 6.

Result of the experiment was shown in the table 2 and figure 6.

Table 2 The Result of the Experiment.

Time	Result
10 minutes	Temperature for the dark colored enclosed sedan than for the light color minivan
20 minutes	Exceed 125 ^{o}F
40 minutes	The dark enclosed sedan with the maximum stabilized temperature 140 ^{O}F and light colored minivan is 138 ^{O}F.

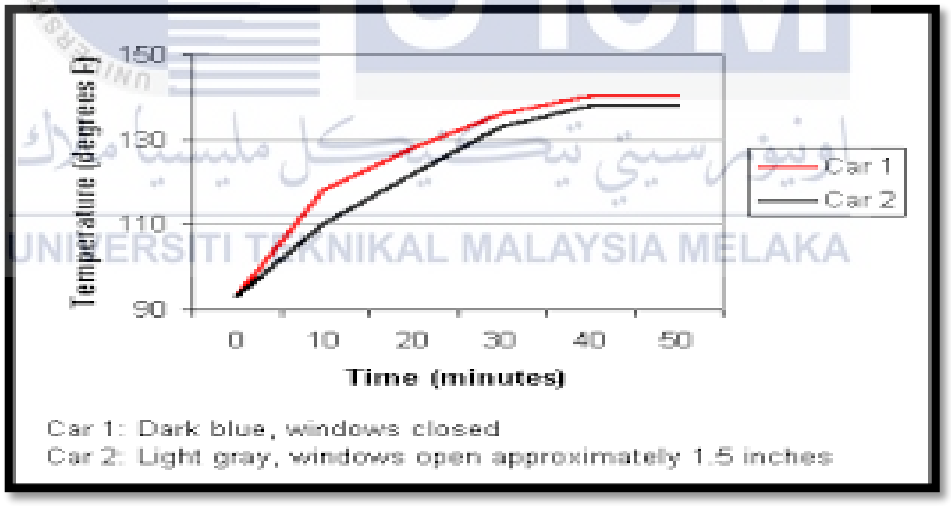


Figure 6 Diagram Result of Experiment Louisiana State Medical Society. (1995).

The light colored vehicle with partially open the window temperature much higher than previous report. The dark temperature reading maximum stabilized and temperature rise which enclosed sedan is the same from the previous study.

2.4.2 HUMAN THERMOREGULATION.

Thermoregulation is the different of surrounding temperature to keep ability of an organism of body temperature within certain boundaries. The surrounding temperature simply adopts its own body temperature of thermo conforming organism. Thus it's avoiding need for internal thermoregulation. Human thermoregulation is focuses of aging on human temperature regulation and aging in thermoneutral conditions during hypo- and hyperthermic challengers. The effect of chronological age from concurrent factors such as fitness level, body composition and chronic disease. In this study, the first effect baseline body core temperature is age related and temperature cycle of the circadian phasing rhythms. Besides that, core temperature of baseline (Tc) decrease with age advancing and has highest variability in older population, W. Larry Kenny and Thayne A. Munce (2003). Age and circadian temperature cycle is the most strong and consistent indicators of circadian synchrony with reflecting activity of the rhythm's strong oscillator.

Furthermore, the same state that refer to the process of internal body environment is called homeostasis. Homeostasis is the most important of body temperature regulation that controlled by the thermoregulatory center in the hypothalamus. Thermo receptors is from two sets of receives input which is receptors in the hypothalamus. Hypothalamus is the blood as it passes through the brain (the core temperature) monitor the temperature by itself and the external temperature is monitor the receptors in the skin especially on the trunk. Both sets of information are needed so that the body can make appropriate adjustments.

Then, several different effectors sends impulses to adjust body temperature is called thermoregulatory center. The main function of brain is to give the instruction to muscle, organs, glands and nervous system when the body 2temperature is too low or too high. Apart from that, hyper thermic environment is exposed to a healthy person which can cause physiological responses that are critical for the thermoregulations. When the temperature is decrease it can cause hypothermia such as cardiac, arrest, stroke and death. The most critical responses is when the skin blood flow increase. The others effect of the thermoregulation being too hot is effect of the smooth muscles in the arterioles of skin. It will cause the vasodilation where the core of the muscle surface carry the heat and convection and radiation are lost. That will cause the turn red.

2.5 HEAT TRANSFER AND THERMAL CONDUCTIVITY.

In this project, heat transfer is the most important that have to measured. The heat was trapped inside the car and it will removed by the chilled water regarding the heat exchanger process. Heat transfer can be define as an energy transferred by the temperature difference and the pressure. Heat flows from the high region to the lower temperature regions. Moreover, the heat will not transfer from the colder to a hotter body without some external energy sources describe from The Second Law of Thermodynamics. The heat transfer are usually referred to different types of modes which is conduction, convection and radiation, Chris long and Naser Sayma (2009).

Conduction :

The process temperature gradient exists in a medium of solid or liquid that occur at the molecular level and heat transferred by the conduction along the temperature gradient.

Convection :

The process of energy transferred between a solid surface and the adjacent of gas that in motion of a fluid.

Radiation :

The process that the energy emitted by a matter in the forum of electromagnetic waves or photo as a result of change.

Thermal conductivity known as the material properties ability to conduct heat and appears in Fourier Law for heat conduction. Besides that, thermal conductivity is used to measure the heat loss of the materials.

$$k = q\frac{L}{\Delta T}$$

Where:

L= thickness of the specimen

T= temperature (K)

q= Heat flow ($\frac{w}{m^2}$)

2.5.1 THERMAL CONDUCTIVITY OF A MATERIAL AND FOURIER'S LAW.

The amount of energy required to increase the temperature of the liquid is the thermal conductivity materials. Thermal conductivity rates is depend on the types of materials. The different materials has different thermal conductivity rate based on the molecular structure, Hewitt (2006). Table of thermal conductivity of material shown in table 3.

Table 3 Thermal Conductivity of a Material.

Material	Thermal Conductivity W/(m·K)	CTE (10^{-6}/K) @ 20 °C
Alumina	18	6.9
Aluminum Nitride	170	4.7
AuSn solder	57	16
Copper	400	17
Aluminium	237	24
Tungsten	160	4.3
Silver	419	18
Gold	318	14
GaN	130-225	3.1
Sapphire	40	8.4
Silicon	150	2.6
Diamond	900-1900	1.18

Fourier's Law is material proportional to the negative gradient are in the temperature.

$$\boldsymbol{k = kA\frac{dT}{s}}$$

Where:

q = heat transferred per unit time (W$\frac{Btu}{hr}$)

A=heat transfer area (m^2, ft^2)

k = thermal conductivity of the material (W/mK)

dT = temperature difference across the material (K or ^{o}C, ^{o} F)

s = material thickness (m, ft)

2.6 PHOTOVOLTAIC CELL.

Photovoltaic cells convert light directly to electricity and most common source of light on earth is the sun. At a temperature of 6000 K, the photosphere emits radiation closely approaching of a thermodynamic "black body" or perfect radiator, with a spectral distribution governed by Planck's radiation law, Bryce Sydney Richards and Martin Green (2006). Besides that, the radiant power per unit area perpendicular to the direction of the sun outside the earth's atmosphere is essentially constant. It also known as the solar constant or air-mass zero (AM0) radiation, which has the value of 1.367 kW/m. At least 30% of sunlight is attenuated by while passing through the earth's atmosphere due to scattering of light by molecules, aerosols and dust particles. Photovoltaic cell as absorption by gases such as oxygen, ozone, water vapor and carbon dioxide.

Moreover, photovoltaic cells utilize the photovoltaic effect to convert sunlight directly into electric current and voltage. The type of photovoltaic cell depending on the efficiency of the conversion process ranges from a few percent up to nearly 37%. In addition, they are sold with warranties of up to 30 years and generate many times their embodied energy during their operation lifetime. Photovoltaic cells, also called solar cells which are the first application for powering spacecraft and have been used for many years to power a wide range of products, Bryce Sydney Richards (2006). The conversion efficiency of these metal-semiconductor devices was well below 1% due to the large dark currents.

Apart from that, a semiconductor is device offered better properties in this regard. In 1941, Russell Ohl of Bell Telephone Laboratories formed the first p-n junction in a silicon crystal. P-n junction photovoltaic cell in 1954, which had an efficiency of about 4.5. Photovoltaic cells can be assume as a large-area, illuminated semiconductor diode. They use semiconducting materials to absorb light and to generate free charge carriers within the material. It also use because a junction in the semiconductor separates the negative and positive charge carriers and producing a unidirectional electrical current through the two contacts. Voltage of two connection are different.

The front surface reflection must first be reduced to allow efficient absorption at least 30% of photons as a polished silicon wafer reflects. An antireflection coating made of using transparent dielectric materials and roughening the front surface. Photovoltaic cell has a high energy photons which absorbed strongly near the front of surface. Energy of photon decrease towards the infrared and these penetrate deeper into device are more weakly photon absorbed. The direct band gap semiconductors are known in some materials that absorption involves just the photon and the created carrier pair, Martin Green (2006). The process in indirect band gap semiconductors also requires one or more phonons quanta of crystal atomic vibration) to take part. Example of indirect band gap semiconductors, such as silicon (Si). Silicon is exhibit weaker absorption due to the required presence of particle for carrier generation. Then, gallium arsenide (GaAs) also example for a direct band gap semiconductor.

Furthermore, the device allow physical connection of the photovoltaic cell to an electrical load and the photo generated current to flow. To minimize the fraction of the front surface area that is shaded the front contact is normally in the form of a fine metallic grid. That, preventing light from passing through into the semiconductor. The rear side of the device is typically covered with the second metal contact. An electrons flow out of the cell into the circuit with the light-generated current flows in normally regarded as the reverse direction in diode. Based on theory, the n-type contact and back into the cell through the p-type contact though the voltage across the cell is in the forward bias direction as positive at the p-type. The resultant current negative for a range of positive voltages. In this quadrant, the cell can generate power. The solar cell of an electrical loads should connected to keep the operating point close to the optimum knee point during normal operation. Diagram of Mechanisms of Photovoltaic Cell and Stage of Photovoltaic Cell is shown in Figure 7 and 8.

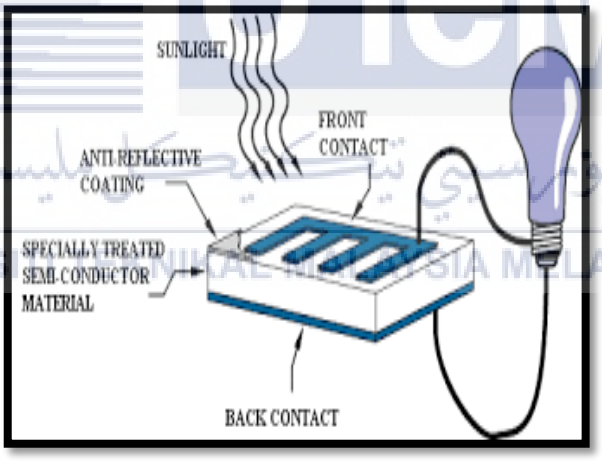


Figure 7 Diagram of Mechanisms of Photovoltaic Cell.

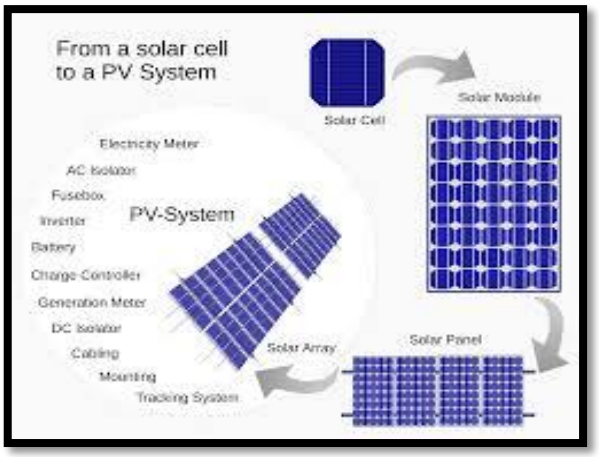


Figure 8 Diagram of Stage of Photovoltaic Cell.

2.7 PEAK SUN HOUR.

Based on Inutec Solar Center International (2016) states peak sun hours refers to the sun were shining at its maximum value for a certain number of hours which a particular location would receive solar insolation. The average daily solar insolation is 1 kW/m2 is the number of peak sun hours since the peak solar radiation is numerically identical. Example a location that receives 7.7 kWh/m2 per day can received 7.7 hours of sun per day at 1 kW/m2.Besides that, PV modules are often rated at an input rating of 1kW/m2 because it able to calculate the peak sun hours being useful. The Insolation Peak Sun hours is (kWh/m2per day) (hours per day at 1kW/m2).Apart from that, the time when the sun is highest in the sky, compared to the rest of the day solar radiation occurs at solar noon is maximum .In the morning and evening sunlight does not deliver much energy to the earth's surface because at low angles more atmosphere filters the sunlight. Due to the sun's higher position in the sky, an hour of sunshine packs more energy in midsummer, than the same hour of sunshine in the winter, Jeff Huffman and Brier, Washington (2007).

In the other hand, peak sun hour is the sun's location over a 1 hour period straddling solar noon in the summertime perpendicular to the amount of solar energy striking a one square meter area, Jeff Huffman and Brier, Washington (2007). Power is

standardized one square meter surface the amount of at 1,000 watts (1 kilowatt). The various amounts of solar irradiation over the course of a day equivalent to 1 solar-noon midsummer hour (1,000 watts per square meter for 1 hour). Furthermore, the average of summertime Seattle conditions equivalents 4.8 peak sun hour from sunup to sundown and wintertime average about 2.5 sun hours per day. The daily average works out to about 3.76 peak sun-hours over the course of a year. A solar irradiation information is variety of cities in the United States for every month. The amount of solar power received per square meter of area is a solar irradiation levels. This varies across different parts of the world and also over different times of the day based on A Guide to Solar Power Genera Aon in the United Arab Emirates. Diagram of Solar Insolation and Peak Sun Hours shown in Figure 9 and 10.

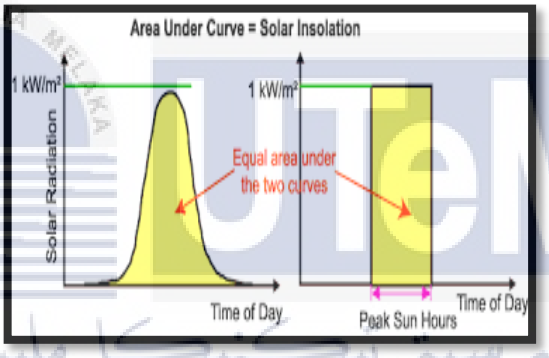


Figure 9 Diagram Of Solar Insolation.

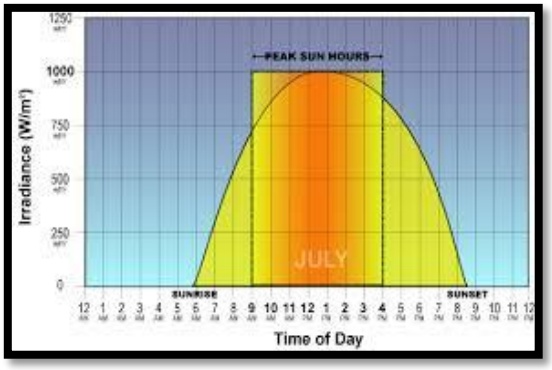


Figure 10 Diagram Of Peak Sun Hours.

CHAPTER 3

METHODOLOGY

This chapter provides description and explanation about the methodology for the project which include three stages. It start from design to know the suitable dimension for my project. Next stages is fabrication which mention that material used in this project. Last stages is do the experimental work to measure the temperature indoor and outdoor of the car.

3.1 DESIGN AND PREPARATION OF THE SYSTEM.

The strategy that starts to fabricate the system is materials and equipment selections.

3.3.1 MATERIALS AND EQUIPMENT.

1. Copper Tube.

The main transportation of chilled water is flow through the copper tube that was attached in the ceiling of the car.

Figure 10 Picture of Copper Tube.

2. Aluminium Sheet.

Aluminium sheet used to increase the cooling capacity and to increase the heat transfer rate. It contact the surface of copper tube. The area of aluminium sheet to cover copper tube as the area of cooper tube required.

Figure 11 Picture of Aluminium Sheet.

3. Rubber Tube.

The function of rubber tube is to connect the piping network of the chiller through to the rubber tube.

Figure 12 Picture of Rubber Tube.

4. Thermocouple.

Thermocouple used to measure temperature of interior the car before and after implementation of hydronic cooling system.

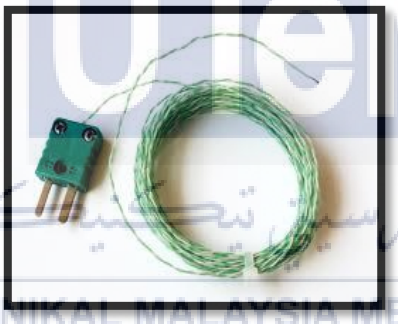


Figure 13 Picture of Thermocouple.

5. Pump.

Pump is used to transmit water from the chiller the flow through the piping network and circulate through the system to complete the cycle.

6. Cooling Element.

Cooling element that used in this experiment are water, ice and salt. This materials is put in mini chiller to cool the car. Salt is the medium that used to anti- freezing substance for chilled water.

Figure 14 Picture of Ice, Water And Salts.

7. Multimeter.

Multimeter used to check the voltage and current of the system.

Figure 15 Picture of Multimeter.

8. Battery

Battery used to give the source of energy and easy to open and close electrical circuit.

Figure 16 Picture of Battery.

9. Photovoltaic Cells.

Generation of the electrical energy is gained by solar energy and convert it to the electrical energy using the photovoltaic cells.

Figure 17 Picture of Photovoltaic Cells.

10. Electrical Wire.

Electrical wire used to connect the wiring of the pump to the photovoltaic cells.

Figure 18 Picture of Electrical Wire.

11. Daihatsu Charade Car.

The installation the hydronic radiant cooling system using Daihatsu Charade car.

Figure 19 Picture of Charade Car.

12. Polystyrene Ice Box.

A water container as the mini chiller to be used to store the water for cooling system. The water will placed in the back compartment.

Figure 20 Picture of Polystyrene Ice Box.

13) Solar Controller

Solar Controller used to charge the batteries and the required to control the load.

Figure 21 Picture of Solar Controller.

14) Switch

Switch used to make easy to open and close the electrical circuit, turning the flow electricity on or off.

Figure 22 Picture of Switch.

3.1.2 PREPARATION TO INSTALL THE HYDRONIC COOLING SYSTEM INSIDE THE CAR.

In this study, to reach the main objective Daihatsu Charade car has been used as a prototype for this experiment. This experiment will run in the car to know the temperature inside the car when the heat trapped. Besides that, the data will be collected and recorded to see the different of temperature inside the car during the different variable parameter in this experiment. Apart from that, installation process divide into three main parts which is mini chiller, copper piping system, wiring system photovoltaic cells connect to the pump. The main materials should be assembled. In this section, details of the description will be explained.

3.1.3 MINI CHILLER.

In this experiment, mini chiller as medium storage for cold water and supply the cold water throughout the system using pump. Salts, ice and water is the mixture of the cold water. In this experiment polystyrene ice box will use as a mini chiller. Firstly, mini chiller will connect to the piping network through the inlet and outlet holes in the front side and the backside of the polystyrene ice box. The next steps is, rubber tube will insert into the hole with have been made. After that, pump is connected to the to the rubber tube with the front side. Next, connect both sides of the rubber tubes to the copper piping network. Pump is used to deliver the cold water and flow cold water to the whole piping system network. Before that, fill the water inside the mini chiller and poured the ice cube. Then salts will add into the mixture to lower the temperature of water. The chilled water will flow through the piping system and occur the heat exchange process will allowed. When the heat absorbing inside the car, the warm water will be allow to circulate water and release some heat energy. The process is repeated. Picture of Mini Chiller

using Solid work and Picture of Isometric Views of Mini Chiller as shown in figure 23 and 24.

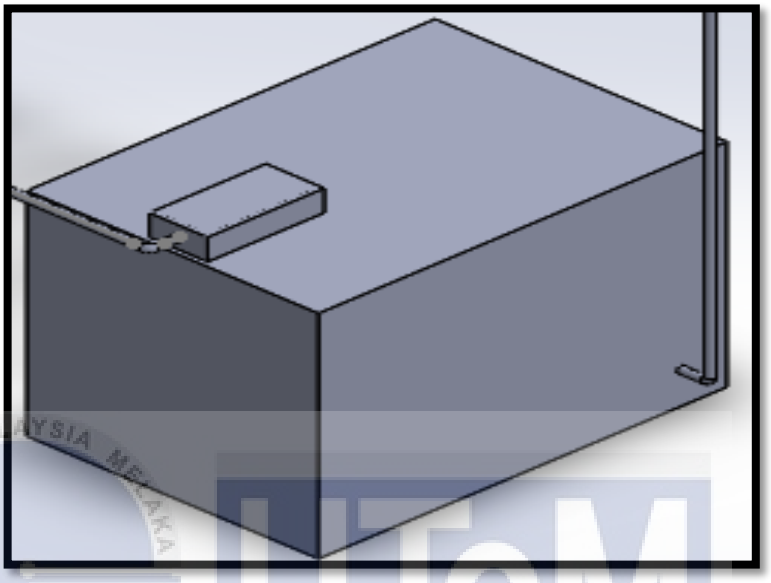


Figure 23 Picture of Mini Chiller Using Solid Work.

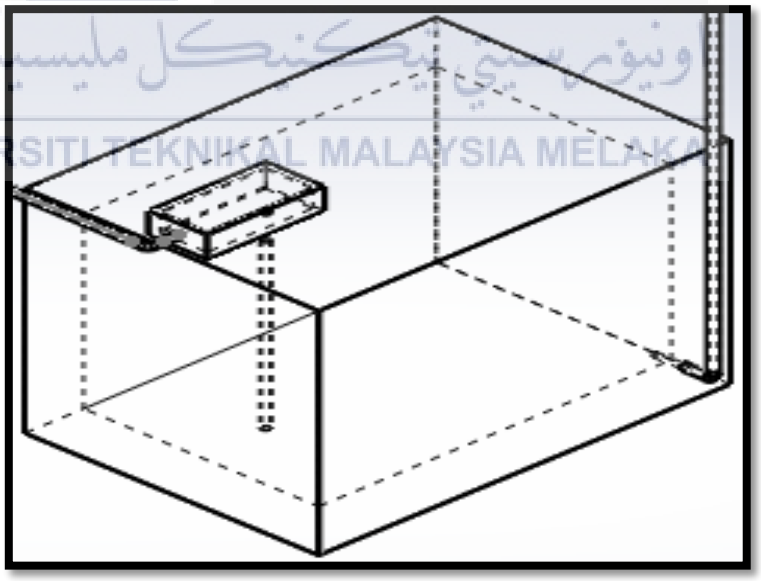


Figure 24 Picture of Isometric Views of Mini Chiller.

Figure 25 Picture of Mini Chiller and the Pump Connection to the Solar Panel.

3.1.4 DESIGN OF THE ELECTRICAL CIRCUIT FOR PHOTOVOLTAIC CELLS.

In this study, the amount of the heat trapped in the car will be calculate and the pump will used to flow the chilled water and eliminate the heat inside the car. Photovoltaic used in this system to run the pump and the amount of the photovoltaic cells will be calculated. The electrical of the photovoltaic cells to run the pump as shown below. Picture of electrical circuit for pump and photovoltaic cells as shown in figure 23.

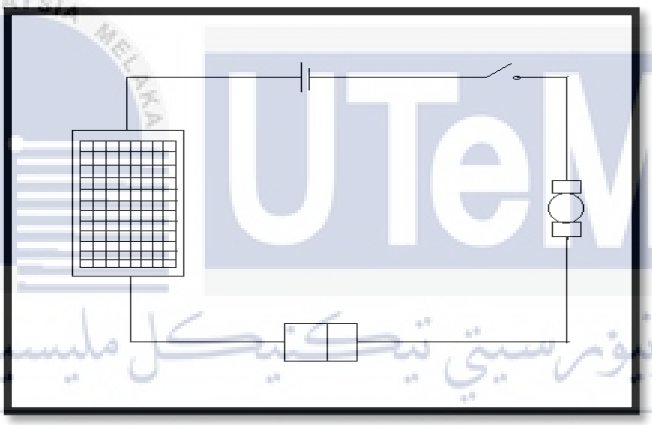


Figure 26 Picture of Electrical Circuit for Pump and Photovoltaic Cells.

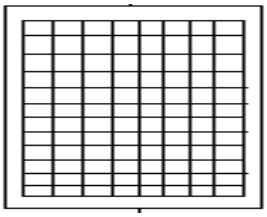
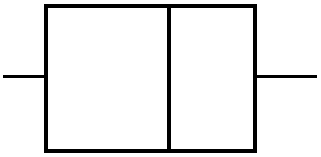
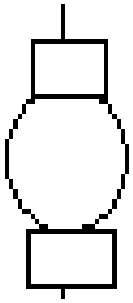
SYMBOL	NAME
	Solar Panel
	Diode
	Capacitor
	Switch
	Pump

Figure 27 Picture of Electrical Circuit for Pump and Photovoltaic Cells Symbols.

3.1.5 CHILLED CEILING PREPARATION.

Chilled ceiling panel is place on the ceiling of the car to provide the cooling inside the car. The chilled water will circulated through the copper piping network and the heat inside the car will absorbed. The temperature inside the car measure will measure and recorded using the K-type thermocouple. On the other hand, copper tube are bend using the hand tube bender to make the serpentine pattern. Next, to increase of the total surface area and increasing the heat transfer rate system is an Aluminium sheet attached with the cooper tube. Total of the aluminium surface area is depending on the copper piping network. Picture of isometric, top view and front view of Cooper Tube Installation on Upper Side of Car as shown in figure 27, 28, and 29.

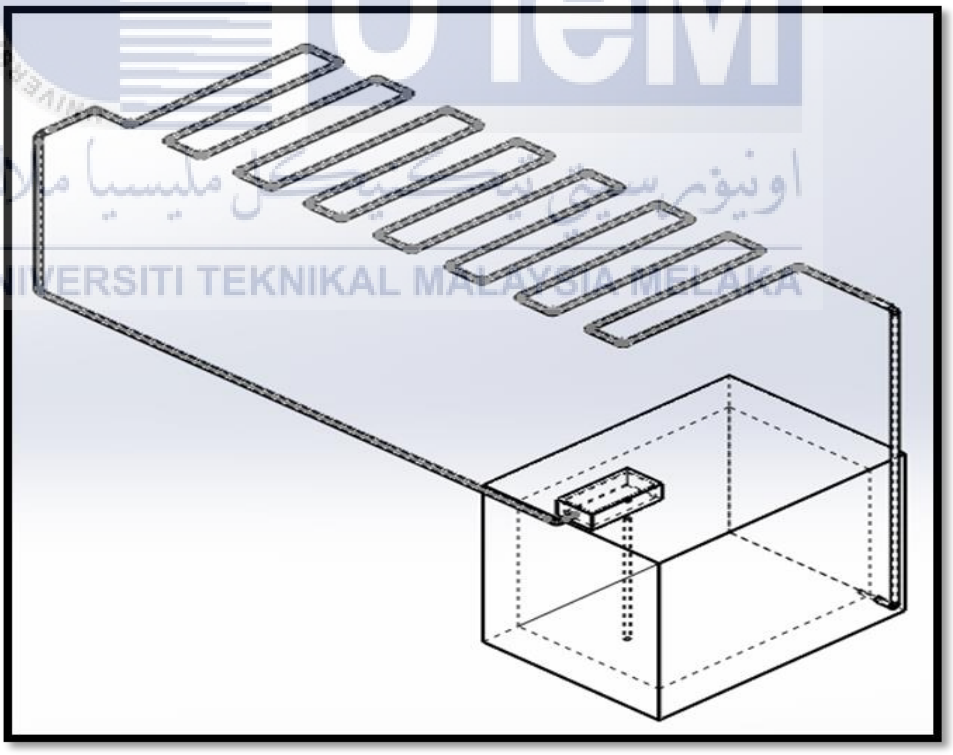


Figure 28 Picture of Isometric Cooper Tube Installation on Upper Side of Car.

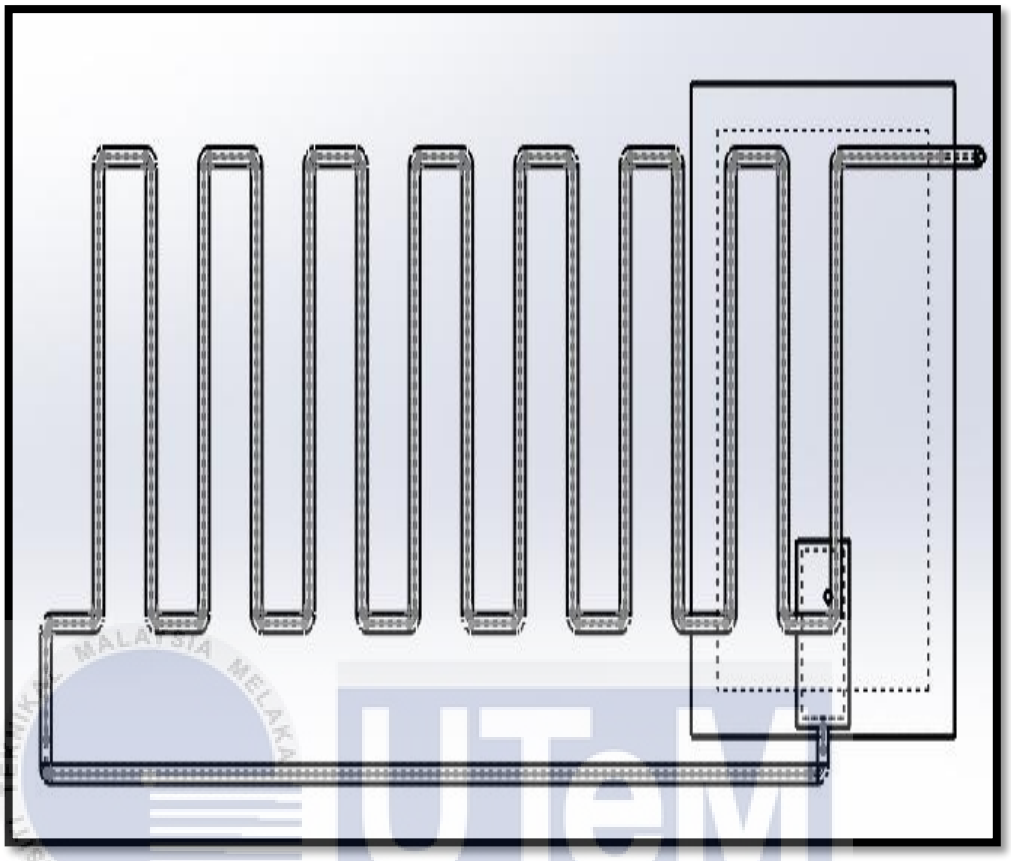


Figure 29 Picture of Top View Cooper Tube Installation on Upper Side of Car.

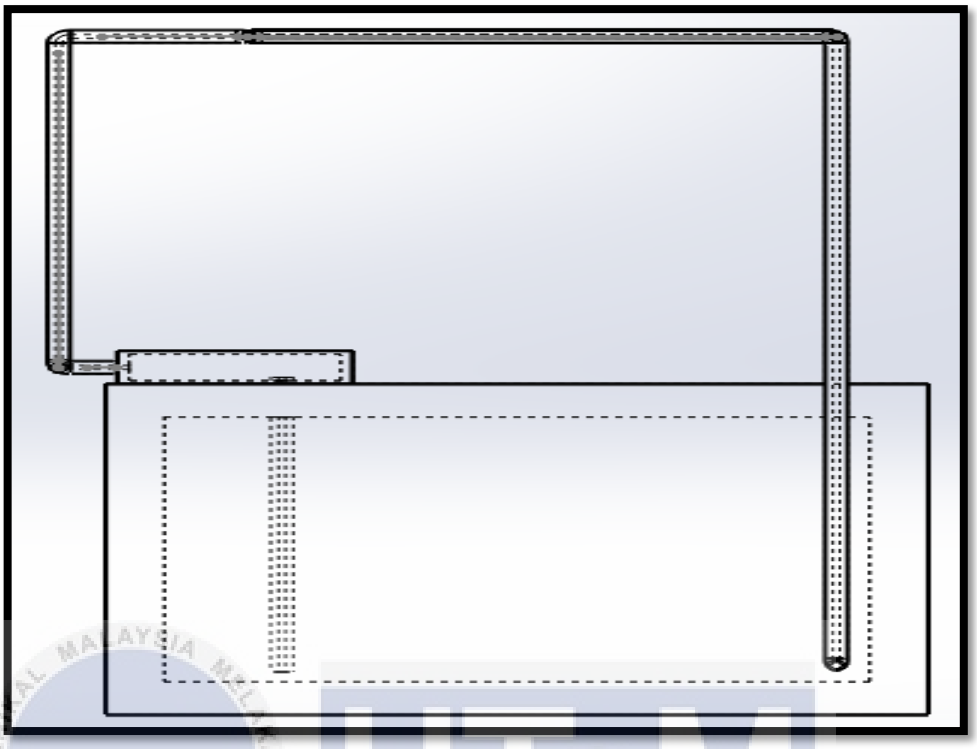


Figure 30 Picture of Front View Cooper Tube Installation on Upper Side of Car.

Figure 31 Picture of Serpentine Pattern of Copper Tube Installed at the Ceiling of Car

Figure 32 Picture of Serpentine Pattern of Copper Tube Installed at the Ceiling of Car with Connection the Hydronic Cooling System

Figure 33 Picture of Serpentine Pattern of Copper Tube

3.2 CALCULATION OF HEAT.

Data from experimental work 1 is required and taken to calculate the heat radiation inside the car. The calculation of heat radiation is the most important calculation before calculate the amount of photovoltaic cells. Photovoltaic cells is used to run the pump in the system and to eliminate some of heat, to decrease the interior temperature of car.

3.2.1 HEAT RADIATION

On this calculation, all of the data in Case 1 is used to calculate the heat radiation. The average data of temperature used start from 11.00 am to 3.00 pm because this time sunlight more hot compared to other time. The ambient temperature is 36 º C.

$$Q = \varepsilon\sigma A\Delta T$$

Where:

Q = Amount of heat or total energy radiated.

ε = Emissivity ($0 \leq \varepsilon \leq 1$)

A = Area of windows ($2.74m^2$)

σ = Stefan-Boltzmann Constant ($5.67x10^{-8}Wm^{-2}k^{-4}$)

ΔT = Temperature different of an enclosed space

Consider ε as a black body.

Table 3.2.1 Heat Radiation

Time	Temperature		$Q = \varepsilon\sigma A\Delta T$	Q (kW)
	˚C	K		
11.00 am	40.02	313.02	$1 \times 5.67 \times 10^{-8} \frac{W}{m^2K^4} \times 2.74\, m^2(313.02^4 - 309.00^4)K^4$	0.075
12.00 am	43.39	316.39	$1 \times 5.67 \times 10^{-8} \frac{W}{m^2K^4} \times 2.74\ \ m^2(316.39^4 - 309.00^4)K^4$	0.140
1.00 pm	44.49	317.49	$1 \times 5.67 \times 10^{-8} \frac{W}{m^2K^4} \times 2.74\, m^2(317.49^4 - 309.00^4)K^4$	0.162
2.00 pm	45.23	318.23	$1 \times 5.67 \times 10^{-8} \frac{W}{m^2K^4} \times 2.74\ \ m^2(318.23^4 - 309.00^4)K^4$	0.176

3.2.2 PHOTOVOLTAIC CELLS SIZING

After making a heat radiation calculation, the photovoltaic cells sizing calculation also needed. The proper calculation is needed to know the optimum electrical power that used to run the pump. Photovoltaic cells has three types which is Moncrystalline, Polycrystalline, and Film. For this project, Polycrystalline is one to be chosen.

Irradiance

Irradiance is terms of measurement to determine the power density of sunlight or the total power from a radiant source falling on a unit area which is W/m^2. The irradiance by the Earth for the solar is constant from the top of atmosphere. After determine the solar irradiance, the performance and capacity of polycrystalline photovoltaic can be measured. The performance of the polycrystalline photovoltaic cells is 80%.

$$\text{Irradiance, } s = \frac{E}{4\pi R^2}$$

Where:

E = Sun total power (3.9×10^{26} W)

R = Average earth sun distance (1.5×10^{11} m)

Calculation of photovoltaic cells size

$$PV\ size = \frac{Power\ of\ load}{Irridiance\ x\ performance\ of\ percentage}$$

The calculation of irradiance is as follows;

$$\text{Irradiance, S} = \frac{E}{4\pi R^2}$$

$$\text{S} = \frac{3.9\ x\ 10^{26}\ W}{4\pi(1.5\ x\ 10^{11}\ m)^2}$$

$$\text{S} = 1379.34\ \frac{W}{m^2}$$

Calculation of photovoltaic cells size as follows:

$$PV\ size = \frac{Power\ of\ load}{Irridiance\ x\ performance\ of\ percentage}$$

Power of Load DC pump:

Voltage	Current	Power
12V	**0.98 A**	**11.76 watt**

$$PV\ size = \frac{11.76\ watt}{1379.34\ \frac{W}{m^2}\ x\ 80\%.}$$

=0.0106 m²

3.3 EXPERIMENTAL WORK.

The purpose of this experiment is to achieve the current objectives of this project. The most important parameter output on this project are temperature. This experimental work conduct two strategy to achieve the current objective which during experiment procedure and the experimental work.

3.3.1 EXPERIMENT PROCEDURE.

The most important parameter output in this project are temperature. The first stage is measure the interior car temperature when car placed under the sun and the higher temperature of heat energy are recorded to identify the different value of heat energy before and after installed the system. Second stage is measure a water temperature which can absorb the amount of heat energy trapped inside the car using the different medium. Last stage is measure the temperature of interior car with multiple situation which is during the window fully open and window fully close after installed copper tubing network. The result of the temperature are recorded.

a) EXPERIMENTAL WORK 1.

The first way of this experiment is measure the heat temperature which trapped in interior part of car. This process is carried out for a 5 days from 9am until 4pm. The temperature is measured by using a thermocouple. The car parked under direct sunlight with thermocouple is placed inside the car then the temperature reading was collected. To get an accurate and precision reading, temperature measured twice which are T1

and T2. From the data collected, the highest temperature during 5 days is determined and recorded. Besides that, to determine the precise and accurate data of this experiment the data temperature were collected at every one hour. Based on the data temperature analyzed the highest temperature that are recorded for 7 days without using the system.

CASE 1.

Case 1 is the temperature of the interior car will measured with all windows, doors and any open parts fully closed. The data are recorded and collected every one hour start from 9.00 am to 4.00 pm. From the data the highest temperature are recorded. The highest average temperature is 44.06 ^{o}C.

CASE 2.

Case 2 is the temperature of the interior car will measured with all windows, doors and any open parts fully opened. The data are recorded and collected every one hour start from 9.00 am to 4.00 pm. From the data the highest temperature are recorded. The highest average temperature is 41.23^{o}C.

b) EXPERIMENTAL WORK 2.

The second experimental work is to determine the water temperature that can absorb the heat energy of interior car. Water temperature is the variable parameter. To get the cold temperatures of water that two cases have been observed which is the water mix with ice and mixture of water and ice fill with salt .From this process the

temperature of water between two cases was measured and water temperature suitable and precise used for cooling system of interior car to absorb the heat energy trapped was also determined. Based on the data the suitable water temperature between two cases was analyzed.

CASE 1.

The temperature of water mix with ice is recorded. Besides that, the amount of water and ice that suitable used for cooling system of this project was measured. The data will be collected and recorded at least 15 minutes. Temperature of water is depends on the amount of water and ice. This experiment the suitable amount of water and ice was used is 3 liter water and 18 kg ice.

CASE 2.

The temperature of water mix of ice added with salts is recorded. The amount of salts that added in the mixture of water and ice was recorded, then the temperature of this mixture recorded. The data will recorded at least 15 minutes to see the freeze of ice and the temperature of this mixture .After that, the accurate temperature of this mixture determined and the suitable value used for cooling system of this project was choose. The amount of water and ice constant which are 3 liter water and 18 kg ice and the amount of salts is 2.7 kg. From the two cases, make a comparison of water temperature between two cases and the suitable temperature depends on cases was choose.

c) EXPERIMENTAL WORK 3.

The third experiment is to determine the temperature of interior car. This experiment will conducted to identify the highest temperature reading of the sunlight trapped in car. From the previous experiment needs accurate and precise temperature. In this study, suitable mixture temperature that use in cars cooling system effect on experimental 3 was identified. The data will be taken from a different cases will be used as a preliminary result which be used to compared the measured temperature after the implementation of hydronic cooling system.

CASE 1.

Case 1 is the temperature of the interior car will be measured with all windows, doors and any open parts fully closed. The data recorded and collected at least for six times and the average of temperature is calculated. Picture of Windows car fully closed as shown in figure 33.

Figure 34 Picture of Windows Car Fully Closed.

CASE 2.

Case 2 is the temperature of the interior car will measured with all windows, doors any open parts fully opened to determine the difference temperature. The data recorded and collected at least for six times and the average of temperature is calculated. Picture of windows car fully opened as shown in figure 34.

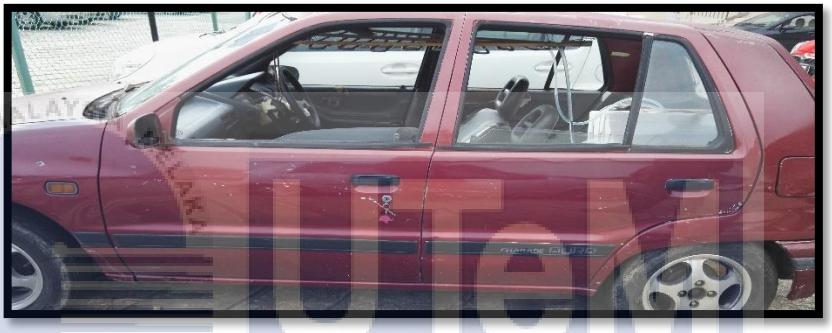
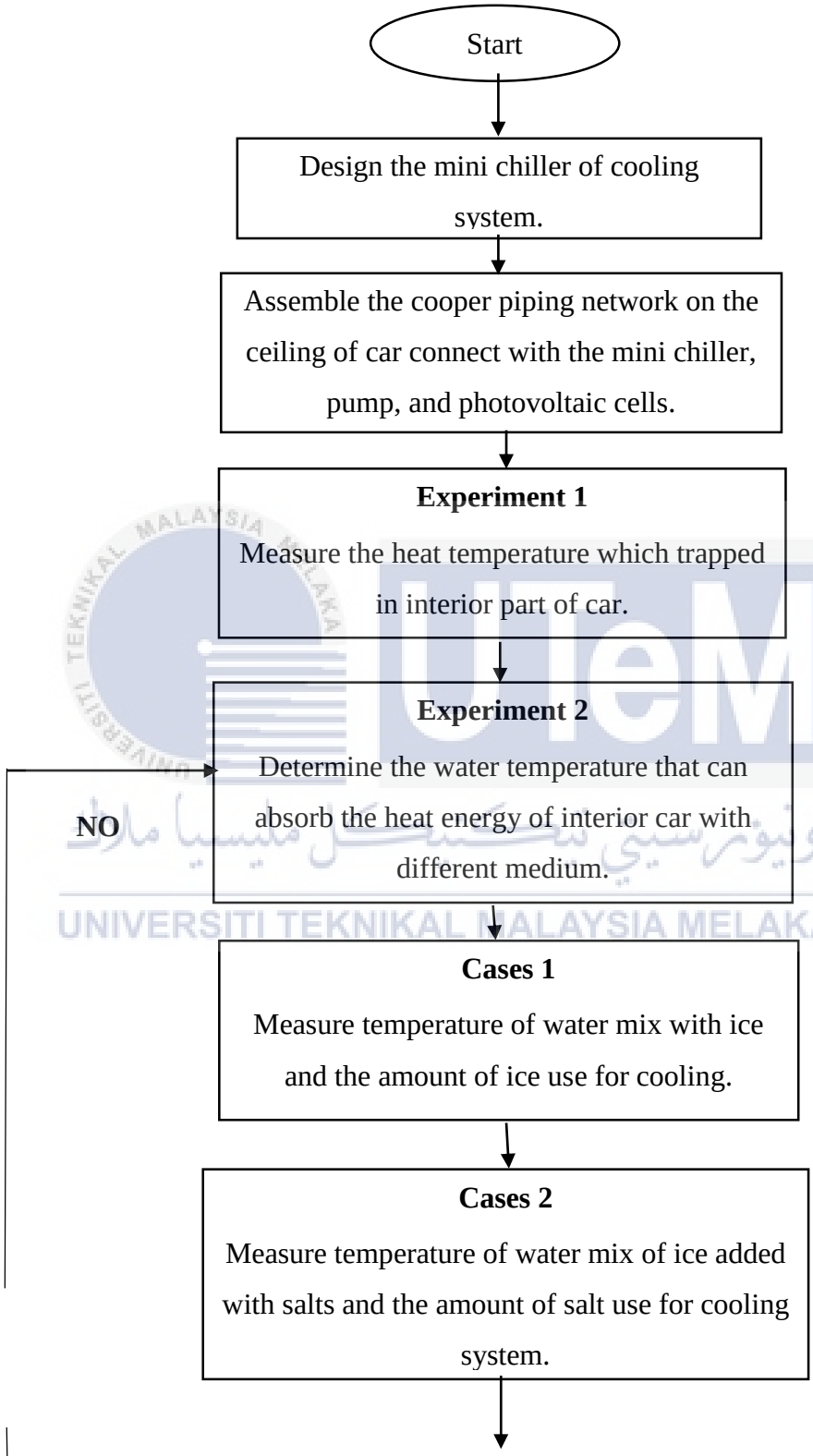
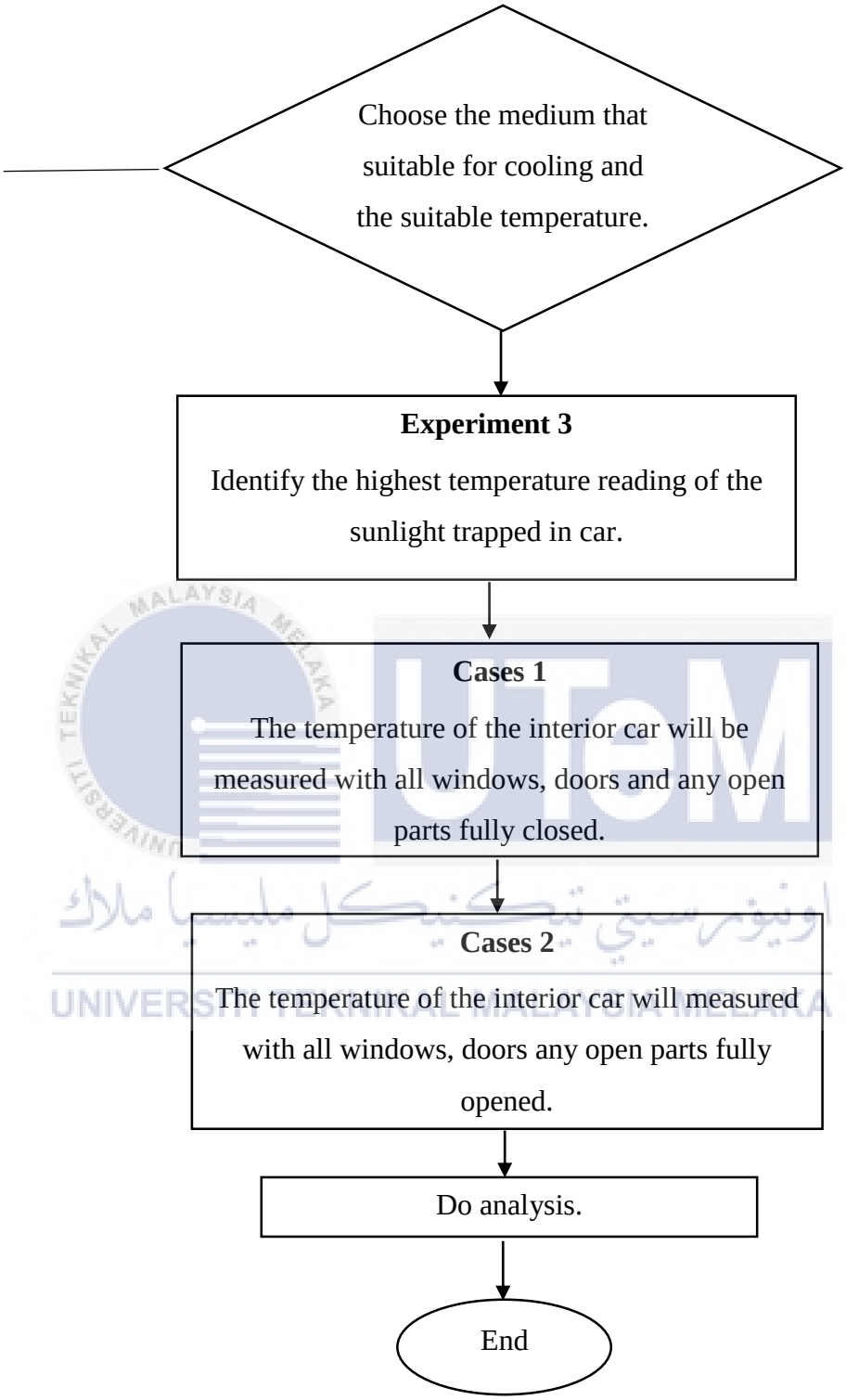


Figure 35 Picture of Windows Car Fully Opened.

3.3.2 FLOW CHART FOR THIS SYSTEM.





CHAPTER 4

RESULT AND DISCUSSION

This chapter provides result from Experimental Work 1 to Experimental Work 3.with difference cases The result from all experimental work are present in table.

4.1 RESULT FROM EXPERIMENTAL WORK 1 (CASE 1)

This part is presented about the result of the interior part of car temperature with all windows, doors and any open parts fully closed. The process is started by measuring the temperature of the interior part of car. Besides that, the data is taken for 5 days from 9 am to 4 pm. The car parked under direct sunlight with thermocouple is placed inside the car then the temperature reading was collected. To get an accurate and precision reading, temperature measured twice which are T1 and T2.From the data collected, the highest temperature during 5 days is determined and recorded. The result of the temperature was shown in table 4.1 to 4.5 shown at the appendix. A Table below shows the average temperature of car interior from day 1 to day 5 start from 9.00 am to 4.00 pm.

Table 4.6 Average temperature of car interior from Day 1 to Day 5

TIME	Day 1 (ºC)	Day 2 (ºC)	Day 3 (ºC)	Day 4 (ºC)	Day 5 (ºC)	AVERAGE (ºC)
9.00 am	29.75	27.4	29.35	28.55	30.25	29.06
10.00 am	32.95	30	31.7	32.95	35.5	32.62
11.00 am	39.4	40.15	39.1	40.15	41.3	40.02
12.00 pm	41	44.35	44.95	43.3	43.35	43.39
1.00 pm	44.06	39.35	47.25	45.45	46.35	44.49
2.00 pm	42.5	42.85	45.8	46.65	48.35	45.23
3.00 pm	43.05	34.45	44.4	46.9	51.1	43.98
4.00 pm	44.95	30.85	40.85	42.2	47.05	41.18

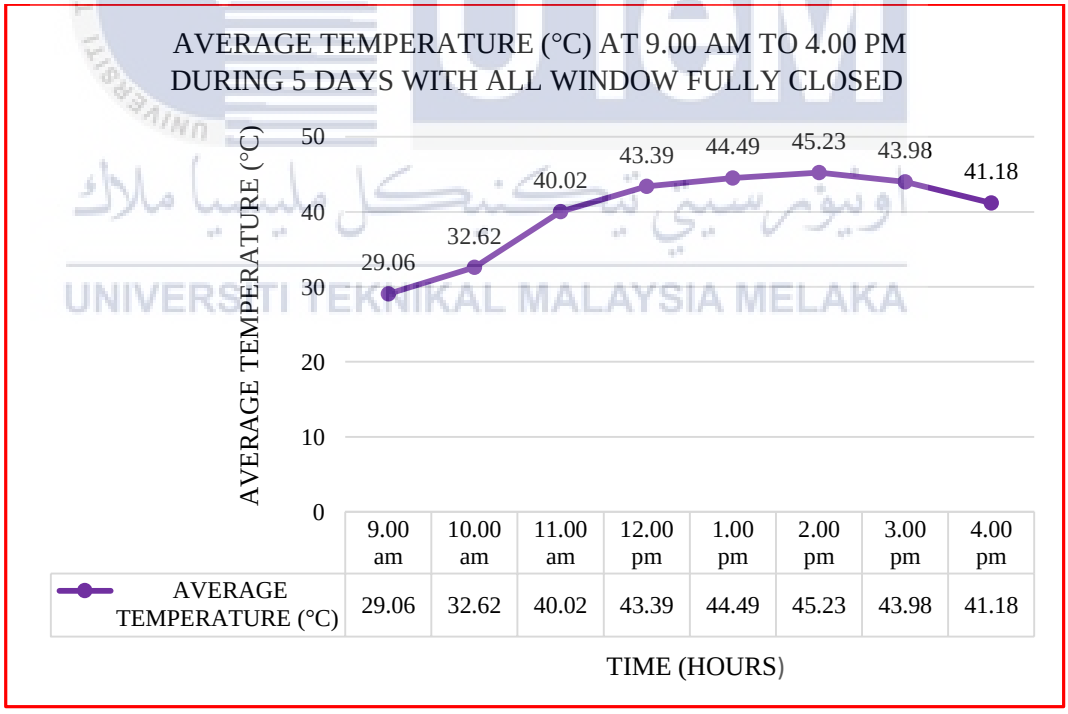


Figure 36 Average Temperature at 9.00 am to 4.00 pm during 5 Days with all Window Fully Closed

Table above shows the average temperature that taken for 5 days from 9.00 am to 4.00 pm. At 9am the average temperature was 29.06 ^{0}C. The average of temperature that trapped inside the car increase until 2.00 pm. At 2.00 pm, the average temperature was 45.23. This happen because at that time solar intensity increase and the amount of heat trapped inside the car also increase. Furthermore the average of heat trapped inside the car decrease start from 2.00 pm until 4.00 pm.

4.2 RESULT FROM EXPERIMENTAL WORK 1 (CASE 2)

This part is presented about the result of the interior part of car temperature with all windows, doors and any open parts fully opened. The process is started by measuring the temperature of the interior part of car. Besides that, the data is taken for 5 days from 9 am to 4 pm. The car parked under direct sunlight with thermocouple is placed inside the car then the temperature reading was collected. To get an accurate and precision reading, temperature measured twice which are T1 and T2.From the data collected, the highest temperature during 5 days is determined and recorded. The result of the temperature was shown in table 4.7 to 4.11 shown at the appendix B. Table below shows the average temperature of car interior from day 1 to day 5 start from 9.00 am to 4.00 pm.

Table 4.12 Average temperature of car interior from Day 1 to Day 5

TIME	Day 1 (ºC)	Day 2 (ºC)	Day 3 (ºC)	Day 4 (ºC)	Day 5 (ºC)	AVERAGE (ºC)
9.00 am	28.2	24.85	24.70	24.70	26.8	25.85
10.00 am	30.6	28.85	32.25	33.40	32.05	31.43
11.00 am	34.65	38.75	44.25	42.30	36.4	39.27
12.00 pm	34.15	40.45	45.05	43.05	39.15	40.37
1.00 pm	33.15	45.05	42.15	41.70	44.1	41.23
2.00 pm	32.0	44.85	37.70	42.70	45.5	40.55
3.00 pm	31.5	41.10	37.85	38.80	39.65	37.15
4.00 pm	30.65	40.35	30.75	35.35	37.65	34.95

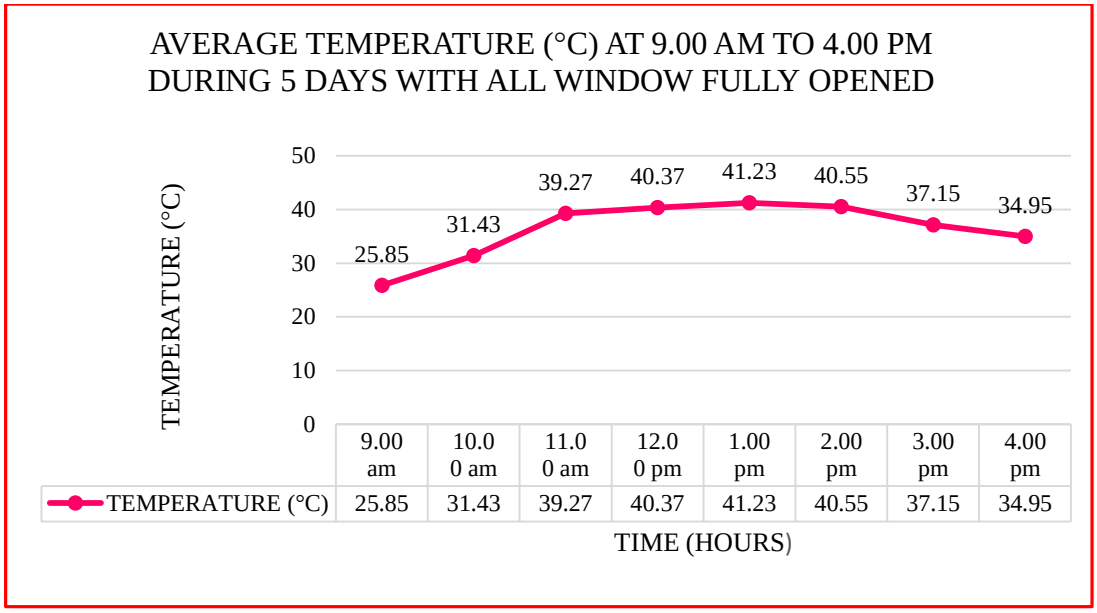


Figure 37 Average Temperature at 9.00 am to 4.00 pm during 5 Days with all Window Fully Opened

Table above shows the average temperature that taken for 5 days from 9.00 am to 4.00 pm. At 9am the average temperature was 25.85 ^{0}C. The average of temperature that trapped inside the car increase until 2.00 pm. At 2.00 pm, the average temperature was 40.55. This happen because at that time solar intensity increase and the amount of heat trapped inside the car also increase. Furthermore the average of heat trapped inside the car decrease start from 2.00 pm until 4.00 pm.

4.2.1 Result from experimental work 1 (Case 1)

Table 4.13 Average temperature of car interior when fully closed

Days	Temperature ºC
1	42.50
2	42.85
3	45.80
4	46.65
5	48.35
AVERAGE	**45.23**

The table 4.2 shows an average of temperature reading that trapped interior of car when doors, windows and any open part was closed. Temperature that trapped interior of car increased by 45.23. This situation occurs due the heat interior of the car cannot be released at the surrounding. The result shows that the amount of intensity of solar are increased.

4.2.2 Result from experimental work 1 (Case 2)

Table 4.14 Average temperature of car interior when fully opened

Days	Temperature ºC
1	33.15
2	45.05
3	42.15
4	41.70
5	44.10
AVERAGE	**41.23**

The table 4.2 shows an average of temperature reading that trapped interior of car when doors, mirrors and any open part was fully opened. Temperature that trapped interior of car increased by 41.23. This situation occurs due the heat interior of the car released at the surrounding. The result shows that the amount of intensity of solar are decreased.

4.3 RESULT FOR PEAK SUN HOURS

This section shows the results of peak sun hours trapped in a car during the day based on the result from experimental 1 case 1.

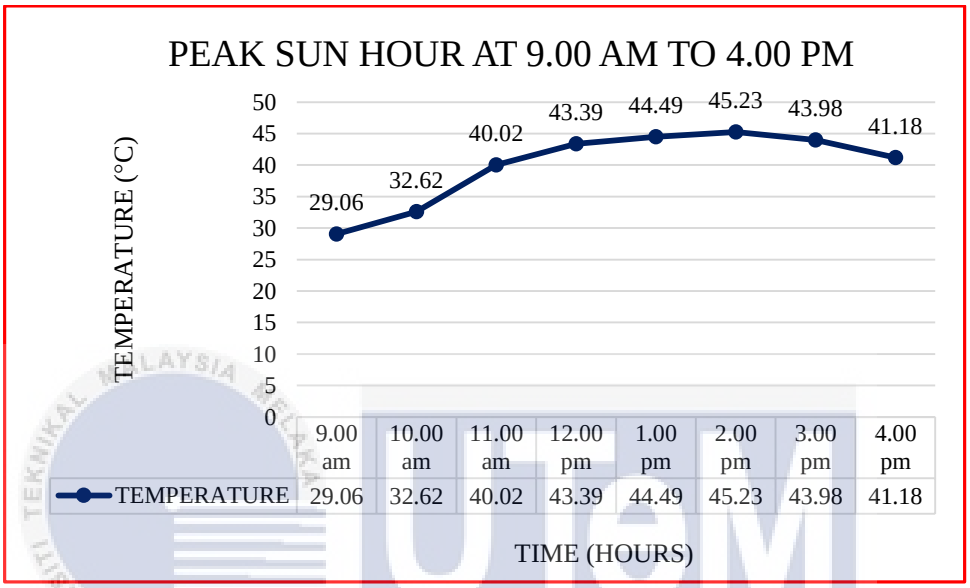


Figure 38 Temperature of Interior Car at 9.00 am to 4.00 pm

The figure shows the result of temperature trapped inside the interior of car versus the time of solar intensity when all window are closed. As we can see at 9.00 am the temperature that trapped in the interior of car is 29.06 ˚C. The temperature was rising up at 10.00 am which increment as much as 3.56 ˚C.

Besides that, the highest increment of concentration solar intensity is 7.4 ˚C which temperature is 40.02 ˚C at 11.00 am. This happen because the total of solar intensity at the surrounding is very hot so the temperature that trapped inside the car also increased. At 12.00 pm to 1.00 pm, the temperature was 43.39 °C and 44.49 °C which increment the concentration of solar intensity is 1.1°C.

Apart from that, 2.00 pm to 3.00 the temperature in the interior of car was slightly decreased because the total intensity at the surrounding is not to hot due the sunset. At 4.00 pm the temperature also decreased as much as 41.18 °C. This also happen because the effect of the total heat that absorb at the material and compartment inside the car when

the car fully closed. From the overall result, we can see that the peak sun hour in interior of car is at 2.00 pm.

4.4 RESULT FROM EXPERIMENTAL WORK 2 (CASE 1)

This part is presented about the result of the interior part of car temperature with all windows, doors and any open parts fully closed with run the cooling system using pump. The mixtures that used for cooling inside the mini chiller is water and ice. The quantity of water and ice have been in. apart from that, this experiment will conducted at 12 pm to 2 pm because this time the highest average heat temperature trapped in the interior of car. This mixtures used to reduce the temperature of heat trapped in the interior of car. Besides that, the data is taken for every 15 minutes. The car parked under direct sunlight with the system running inside the car then the temperature reading was collected. The result of the temperature was shown in table 4.14.

Table 4.14 Temperature Interior of Car after Implement the Cooling System with added Ice

WATER (LITRE)	ICE (KG)	TEMPERATURE INSIDE MINI CHILLER (^{O}C)	TEMPERATURE INTERIOR OF CAR (^{O}C)	TIME (MINUTES)
3	**0**	**0**	**40.8**	**0**
3	**6**	**0.8**	**35.4**	**15**
3	**12**	**-0.3**	**31.9**	**30**
3	**18**	**-0.6**	**28.7**	**45**

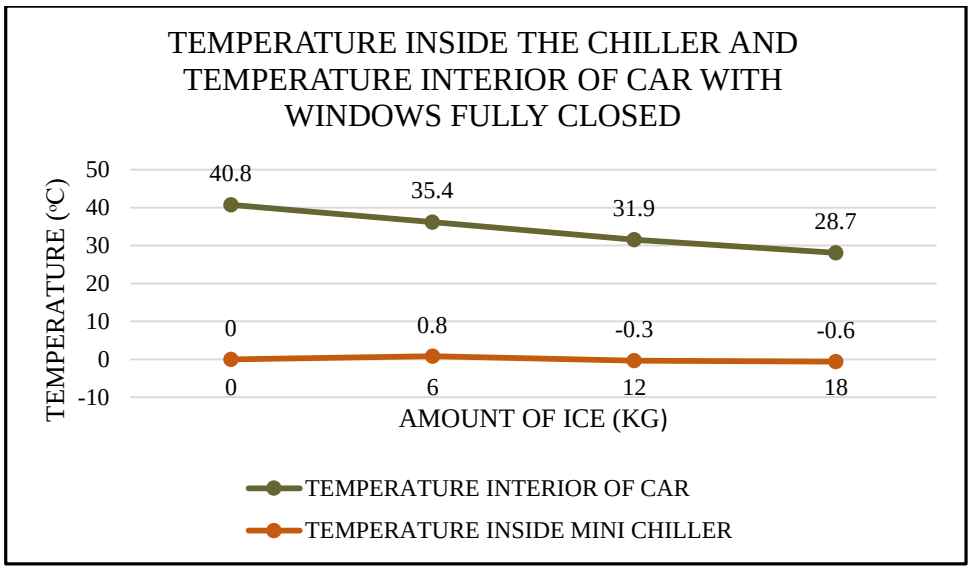


Figure 39 Temperature inside Mini Chiller and Temperature Interior of Car with All Window Fully Closed with added Ice

The figure shows the result of temperature inside the mini chiller versus the temperature interior of car when all the widow fully closed. When all windows fully closed so the heat that trapped in the car does not flow out. In this experiment the amount of water used to mix with ice is constant with 3 litre. The amount of ice that used is already set to get the lowest temperature that trapped in the car when the system in the mini chiller was running.

Besides that, in this time the temperature at surrounding is 36.1 As we can see from this graph the temperature inside the mini chiller is 0.8 ℃ when the 6 kg of ice was mix in the water.so when the system is running about 15 minutes the temperature that interior of car was 40.8 °C. The temperature interior of slightly decreased 28.7 ℃ when amount of ice that used in mini chiller is 18 kg and temperature in mini chiller is – 0.6.

From this experiment, we can see that ice is the mixture that suitable used to decreased the temperature when the system is running in the all of widow was fully closed. Mixture of ice and water can absorb the amount of heat that trapped in the car that parked in the direct of sun. The overall result shows, the amount of 18 kg ice is suitable used in cooling system inside the mini chiller.

4.5 RESULT FROM EXPERIMENTAL WORK 2 (CASE 2)

This part is presented about the result of the interior part of car temperature with all windows, doors and any open parts fully opened with run the cooling system using pump. The mixtures that used for cooling inside the mini chiller is water and ice. The quantity of water and ice have been in. Apart from that, this experiment will conducted at 12 pm to 2 pm because this time the highest average heat temperature trapped in the interior of car. This mixtures used to reduce the temperature of heat trapped in the interior of car. Besides that, the data is taken for every 15 minutes. The car parked under direct sunlight with the system running inside the car then the temperature reading was collected. The result of the temperature was shown in table 4.15.

Table 4.15 Temperature Interior of Car after Implement the Cooling System with added Ice

WATER (LITRE)	ICE (KG)	TEMPERATURE INSIDE MINI CHILLER (^{O}C)	TEMPERATURE INTERIOR OF CAR (^{O}C)	TIME (MINUTES)
3	0	0	37.8	0
3	6	0.8	31.2	15
3	12	-0.3	28.7	30
3	18	-0.6	26.3	45

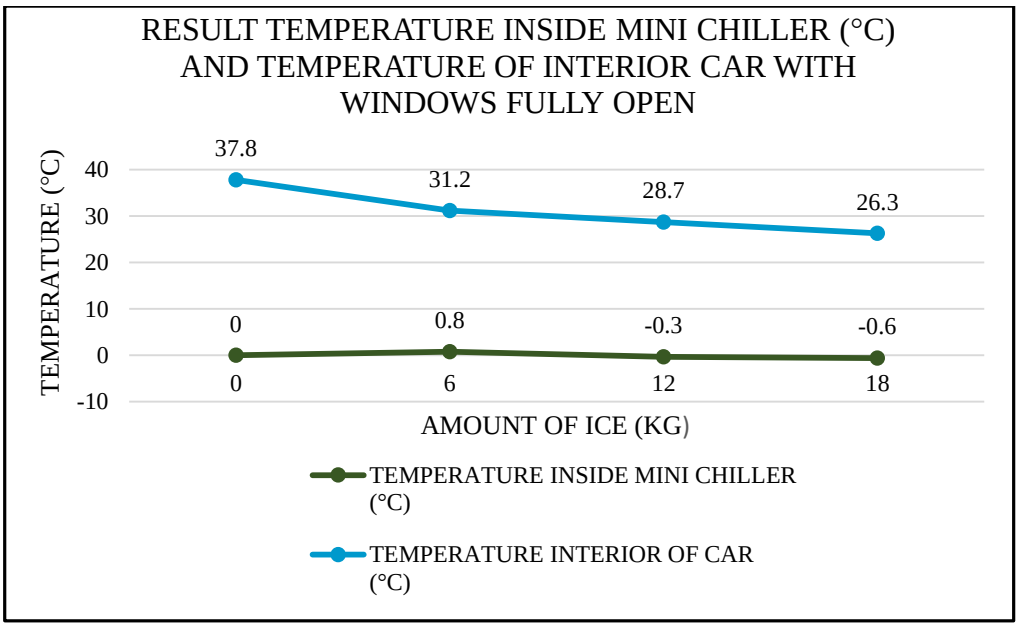


Figure 40 Temperature inside Mini Chiller and Temperature Interior of Car with All Window Fully Opened with added Ice

The figure shows the result of temperature inside the mini chiller and the temperature interior of car versus amount of ice (kg) when all the widow fully opened. When all windows fully opened so the heat that trapped in the car can flow out. In this experiment the amount of water used to mix with ice is constant with 3 litre. The amount of ice that used is already set to get the lowest temperature that trapped in the car when the system in the mini chiller was running.

Besides that, in this time the temperature at surrounding is 36.1 As we can see from this graph the temperature inside the mini chiller is 0.8 ℃ when the 6 kg of ice was mix in the water.so when the system is running about 15 minutes the temperature that interior of car was 31.2 ℃. The temperature interior of slightly decreased 26.3 ℃ when amount of ice that used in mini chiller is 18 kg and temperature in mini chiller is – 0.6.

In this experiment, we can see that the result of temperature interior of car more decreased when the all window fully opened proportionate the result in the case 1 when the all window fully closed with the cooling system in mini chiller was running. So, from this case with all window was opened and the cooling system was running the heat that

trapped in the car slightly decreased because the heat can flow out. The temperature interior of car more cool through the car was parked under direct of sun.

4.6 RESULT FROM EXPERIMENTAL WORK 3 (CASE 1)

This part is presented about the result of the interior part of car temperature with all windows, doors and any open parts fully closed with run the cooling system using pump. The mixtures that used for cooling inside the mini chiller is water, ice and salts. For this experiment the quantity of water and ice are constant but quantity of salt is manipulated. Apart from that, this experiment will conducted at 12 pm to 2 pm because this time the highest average heat temperature trapped in the interior of car. This mixtures used to reduce the temperature of heat trapped in the interior of car to get the lowest temperature. Besides that, the data is taken for every 15 minutes. The car parked under direct sunlight with the system running inside the car then the temperature reading was collected. The result of the temperature was shown in table 4.16.

Table 4.16 Temperature Interior of Car after Implement the Cooling System with added Salts

WATER (LITRE)	ICE (KG)	SALTS (KG)	TEMPERATURE INSIDE MINI CHILLER (^{O}C)	TEMPERATURE INTERIOR OF CAR (^{O}C)	TIME (MINUTES)
3	0	0	0	37.8	0
3	18	0.9	-14.4	27.6	15
3	18	1.8	-18.3	24.4	30
3	18	2.7	-20.4	22.9	45

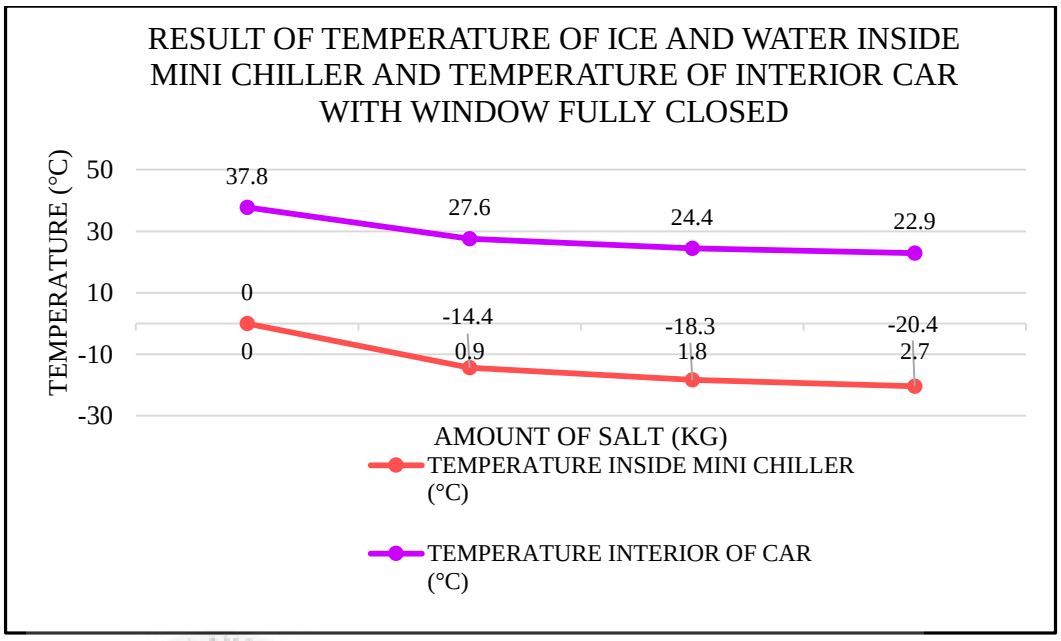


Figure 40 Temperature inside Mini Chiller and Temperature Interior of Car with All Window Fully Closed with added Salts

The figure shows the result of temperature inside the mini chiller and the temperature interior of car versus amount of salt when all the window fully closed. In this experiment the amount of water used to mix with ice and salts is constant with 3 litre. The amount of ice that used are constant 18 kg. As we can see the result from experimental work 1 using the 18 kg ice slightly decrease the temperature in the interior of car when the system in the mini chiller was running.

Besides that, in this time the temperature at surrounding is 36.5 As we can see from this graph the temperature inside the mini chiller is -14.4 °C when mixture of ice and water was mix the amount of salt which 0.9 kg. When the system is running about 15 minutes the temperature that interior of car was 27.6 °C. The temperature interior of slightly decreased 22.9 °C when amount of salt that mix with water and ice in mini chiller is 2.7 kg and temperature in mini chiller is -20.4 °C.

From this experiment, we can see that salt is the good mixture that suitable used to get less of temperature when the system is running in the all of widow was fully closed. Mixture of ice and water with salt can absorb the amount of heat that trapped in the car

that parked in the direct of sun. The overall result shows, the amount of 2.7 kg of salt can get the interior of car more cool and also can freeze an ice when the system running under direct of sun.

4.7 RESULT FROM EXPERIMENTAL WORK 3 (CASE 2)

This part is presented about the result of the interior part of car temperature with all windows, doors and any open parts fully opened with run the cooling system using pump. The mixtures that used for cooling inside the mini chiller is water, ice and salts. For this experiment the quantity of water and ice are constant but quantity of salt is manipulated. Apart from that, this experiment will conducted at 12 pm to 2 pm because this time the highest average heat temperature trapped in the interior of car. This mixtures used to reduce the temperature of heat trapped in the interior of car to get the lowest temperature. Besides that, the data is taken for every 15 minutes. The car parked under direct sunlight with the system running inside the car then the temperature reading was collected. The result of the temperature was shown in table 4.17.

Table 4.17 Temperature Interior of Car after Implement the Cooling System with added Salts

WATER (LITRE)	ICE (KG)	SALTS (KG)	TEMPERATURE INSIDE MINI CHILLER (^{O}C)	TEMPERATURE INTERIOR OF CAR (^{O}C)	TIME (MINUTES)
3	0	0	0	37.6	0
3	18	0.9	-14.4	24.3	15
3	18	1.8	-18.3	22.1	30
3	18	2.7	-20.4	21.1	45

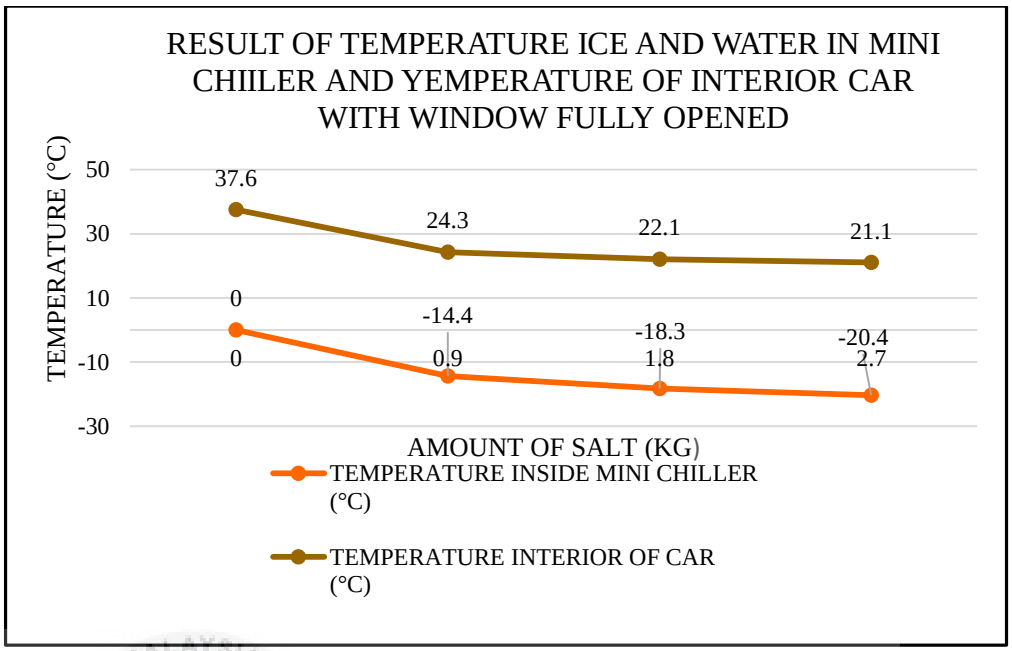


Figure 41 Temperature inside Mini Chiller and Temperature Interior of Car with All Window Fully Opened with added Salts

The figure shows the result of temperature inside the mini chiller and the temperature interior of car versus amount of salt when all the window fully opened. When all window fully opened the heat that trapped interior of car flow out and temperature interior of car more cool. In this experiment the amount of water used to mix with ice and salts is constant with 3 liter. The amount of ice that used are constant 18 kg. As we can see the result from experimental work 1 using the 18 kg ice slightly decrease the temperature in the interior of car when the system in the mini chiller was running.

Besides that, in this time the temperature at surrounding is 36.5 As we can see from this graph the temperature inside the mini chiller is -14.4 °C when mixture of ice and water was mix the amount of salt which 0.9 kg. When the system is running about 15 minutes the temperature that interior of car was 24.3 °C. The temperature interior of slightly decreased 21.1 when amount of salt that mix with water and ice in mini chiller is 2.7 kg and temperature in mini chiller is -20.4 °C with all window are opened.

From this experiment, we can see that salt is the good mixture that suitable used to get more decreased of temperature when the system is running in the all of window was

fully opened. Mixture of ice and water with salt can absorb the amount of heat that trapped in the car that parked in the direct of sun. The overall result shows, the temperature inside interior of car cool during the cooling system running when all window are fully open because no heat that trapped inside the car and heat was eliminated.

4.8 RESULT OF EXPERIMENTAL WORK 3 DURING TEST AMOUNT OF SALT MIXTURE WITH ICE AND WATER

The experiment will focused to decrease the temperature that trapped inside interior of car with all windows fully closed. Based on the experiment that have done, the result shown mixture of water, ice and salt are suitable to use in this cases to get the lower temperature when the car was parked under direct sun during the system of mini chiller was running. The temperature of mixture water, ice and salt in mini chiller with different amount of salt is 0, -14.4, -18.3 and -20.4 °C .The temperature that suitable used in mini chiller is -20.4 ° C. During run the system, the temperature inside interior of car is 22.9 °C. Besides that, the amount of water, ice and salt that suitable use is 3 liter of water, 18 kg of ice and 2.7 kg of salt. That mixture are chosen to get the lower temperature trapped inside interior of car when the car was parked under direct sun with all windows fully closed when the system of cooling was running. The result was taken using the thermocouple that was every 15 minutes.

4.9 RESULT OF SURROUNDING TEMPERATURE AND CAR INTERIOR TEMPERATURE

Table below shown the surrounding temperature and car interior temperature when using the suitable amount mixture of ice, water and salt inside the mini chiller when the system was running every 15 minutes.

Table 4.18 Surrounding Temperature and Car Interior Temperature

TIME (MINUTES)	SURROUNDING TEMPERATURE (°C)	CAR INTERIOR TEMPERATURE(°C)
0	38.9	42.8
15	37.4	22.9
30	35.1	30.5
45	36.7	37.1

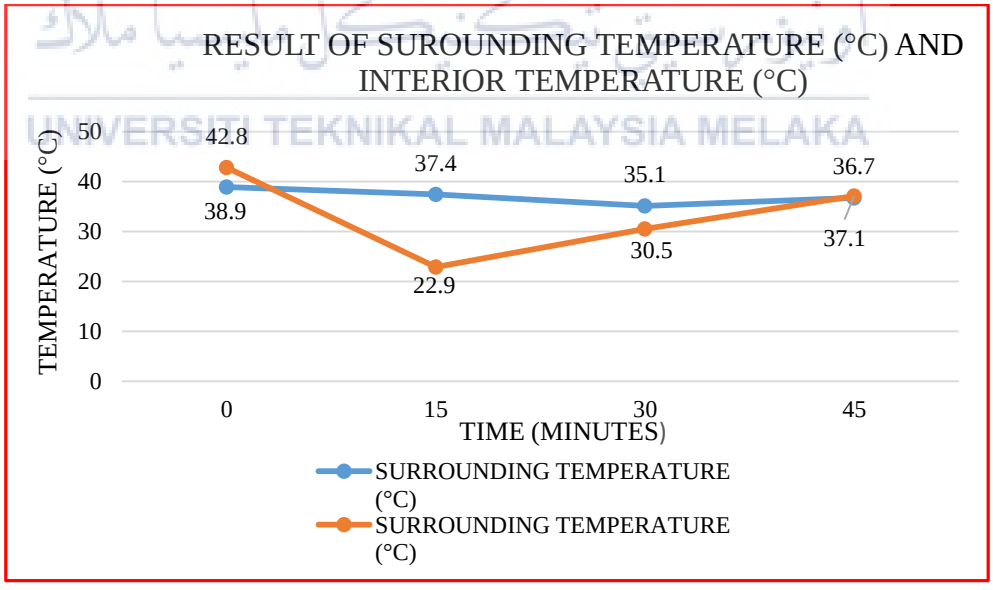


Figure 42 Surrounding Temperature and Car Interior Temperature

Figure shows that temperature between the surrounding and the interior of car after implement the hydronic cooling system. From the graph, as we can see at the beginning the temperature of interior of car is 42.8 °C when the temperature of surrounding is 38.9 °C. After the system was running during 15 minutes the temperature inside interior of car was significantly drop 22.9 °C. The difference of temperature drop from 42.8° C to 22.9 °C is 19.9 °C.

Furthermore the temperature inside interior of car was increased during the next 15 minutes which is 30.5 °C and 37.1 °C. This happen because the mixture of water inside the mini chiller was transfer from the interior of car so it was effect mixture of water in mini chiller. The temperature in the car was reduce due the heat transfer inside the mini chiller.

Based on this result, the average of the temperature was drop inside interior of car during the hydronic cooling system running is 9.7 °C. The temperature inside interior of car was evident when the mixture of salt, ice and water in the mini chiller was used.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

This chapter provides summary of project, achievement of project objective and future development. To achieve the objective three experimental work have been carried out and the best result was choose.

5.1 SUMMARY OF PROJECT

The project is about designing, installing and implementing hydronic car cooling system during car was parked under direct the sun. Three experiments were carried out according to a specific case. Experiment was conducted to get a results of temperature drop 22.9 °C when heat trapped inside interior of car under direct sun. In addition, this experiment carried out by two different cases, which are when all the windows fully opened and all the windows fully closed.

First experiment carried out taking the reading temperature trapped inside interior car when all the windows are fully closed and all windows fully opened. This experiment carried out for 5 days to get the highest average temperature of heat trapped inside interior car when the car parked under direct sun. Temperature readings of heat trapped inside interior of car were taken from 9.00 am to 4.00 pm.

The second experiment was conducted to identify the amount of water and ice is suitable for cooling systems in mini chiller. The temperature of the water and ice that is

suitable for drop -20.4 °C the heat trapped inside interior of car recorded. The best results amount of water and ice that can drop the temperature inside interior of car during the system was running are recorded.

The third experiment carried out by setting the amount of ice and water that can be used based on the results from the second experiment. A mixture of ice and water mix with the different amounts of salt used in mini chiller. The most significant total quantity of salt that reduce interior car temperatures during the hydronic cooling system will run in select. After that, based on the best results, the cooling system will be conducted and the results recorded by taking the temperature during all the windows closed and all the windows opened.

Moreover, temperature interior of car during the cooling system running is carried out every 15 minutes and temperature of mini chiller recorded. Result of comparison the surrounding temperature and car interior temperature was recorded to know the total average the temperature drop.

5.2 ACHIEVEMENT OF PROJECT OBJECTIVE

Based on the experimental work result the objective of this project was achieved. The conclusion was stated from the achievement of objective below:

1) The first objective had been achieve which overcome the heat trapped inside the car. To measure the temperature and calculating the heat inside and outdoor the car. The temperature of heat that trapped inside interior of car before and after implementing the hydronic cooling system had been prove during the experiment. Beside that the result of surrounding temperature and interior of car temperature also verify during the experiment.

2) The second objective also had been achieve to investigate the possibility of using solar power by implementing hydronic cooling system. This objective is to determine the required size of PV for supplying necessary power to run the pump. Although, this experiment use the 16. 8 volt of DC photovoltaic cell to run the 12 of DC pump. The 12 volt of battery is used to support the photovoltaic cell because the weather not necessarily sun. This photovoltaic can run the pump and pump push the mixture of water in the mini chiller then circulate in the copper tube.

5.3 FUTURE DEVELOPMENT

Due the limitation of cost during this project few idea have been removed. Moreover, for improvement in this study for further few recommendation to improve hydronic car cooling system. The recommendation as below:

1) Installed the blower in this system and run the blower using the photovoltaic cell. When the system have the blower, the heat that trapped in the car during the system running is quick to released heat and the drop of temperature is more significant. Besides that, it save the cost when the blower was running using the photovoltaic.

2) Design and installed the cooper tube at the wall of car interior. When the cooper tube was design and install at the wall of car interior, when running the hydronic system , the temperature inside the interior of car was cooler because much cooper tube that can circulate water in the part wall interior of car .

3) Increase the pressure of water pump. In this project, the water pump used is submersible water pump capable to create can push the water as high as 6 meter. So, a higher pressure of water pump can circulate the flow of water smoothly and the heat transfer can occur efficient.

APPENDICES

A. CAR TEMPERATURE WITH ALL WINDOWS, DOORS AND ANY OPEN PARTS FULLY CLOSED.

RESULT FROM EXPERIMENTAL WORK 1(CASE 1)

Table 4.1 Temperature of car interior start from 9.00 am until 4.00 pm on Day 1

Time	Temperature 1(°c)	Temperature 2 (°c)	Average (°c)
9.00 am	28.2	31.3	29.75
10.00 am	31.2	34.7	32.95
11.00 am	33.2	45.6	39.4
12.00 pm	34.2	47.8	41.00
1.00 pm	35.9	52.2	44.06
2.00 pm	35.8	49.2	42.50
3.00 pm	36.0	50.1	43.05
4.00 pm	36.1	53.8	44.95

Table 4.2 Temperature of car interior start from 9.00 am until 4.00 pm on Day 2

Time	Temperature 1(°c)	Temperature 2 (°c)	Average (°c)
9.00 am	26	28.8	27.4
10.00 am	29.2	30.8	30
11.00 am	33.1	47.2	40.15
12.00 pm	36.9	51.8	44.35
1.00 pm	37.5	41.2	39.35
2.00 pm	36.6	49.1	42.85
3.00 pm	34.2	34.7	34.45
4.00 pm	30.9	30.8	30.85

Table 4.3 Temperature of car interior start from 9.00 am until 4.00 pm on Day 3

Time	Temperature 1(°c)	Temperature 2 (°c)	Average (°c)
9.00 am	28.2	30.5	29.35
10.00 am	30.3	33.1	31.7
11.00 am	32.6	45.6	39.1
12.00 pm	37.4	52.5	44.95
1.00 pm	39.2	55.3	47.25
2.00 pm	38.5	53.1	45.8
3.00 pm	40.1	48.7	44.4
4.00 pm	37.2	44.5	40.85

Table 4.4 Temperature of car interior start from 9.00 am until 4.00 pm on Day 4

Time	Temperature 1(°c)	Temperature 2 (°c)	Average (°c)
9.00 am	27.3	29.8	28.55
10.00 am	31.6	34.3	32.95
11.00 am	33.8	46.5	40.15
12.00 pm	35.4	51.2	43.3
1.00 pm	37.5	53.4	45.45
2.00 pm	38.1	55.2	46.65
3.00 pm	39.7	54.1	46.9
4.00 pm	36.3	48.1	42.2

Table 4.5 Temperature of car interior start from 9.00 am until 4.00 pm in Day 5

Time	Temperature 1(°c)	Temperature 2 (°c)	Average (°c)
9.00 am	29.2	31.3	30.25
10.00 am	32.3	37.8	35.5
11.00 am	34.7	47.9	41.3
12.00 pm	35.2	51.3	43.25
1.00 pm	39.4	53.3	46.35
2.00 pm	41.3	55.4	48.35
3.00 pm	44.7	57.5	51.1
4.00 pm	40.2	53.9	47.05

B. CAR TEMPERATURE WITH ALL WINDOWS, DOORS AND ANY OPEN PARTS FULLY OPENED.

RESULT FROM EXPERIMENTAL WORK 1(CASE 2)

Table 4.7 Temperature of car interior start from 9.00 am until 4.00 pm on Day 1

Time	Temperature 1(°c)	Temperature 2 (°c)	Average (°c)
9.00 am	26.8	29.6	28.2
10.00 am	28.0	33.2	30.6
11.00 am	29.0	40.3	34.65
12.00 pm	29.6	38.7	34.15
1.00 pm	29.8	36.5	33.15
2.00 pm	29.7	34.3	32.0
3.00 pm	29.3	33.7	31.5
4.00 pm	28.9	32.4	30.65

Table 4.8 Temperature of car interior start from 9.00 am until 4.00 pm on Day 2

Time	Temperature 1(°c)	Temperature 2 (°c)	Average (°c)
9.00 am	24.9	24.8	24.85
10.00 am	28.9	28.8	28.85
11.00 am	32.3	45.2	38.75
12.00 pm	36.4	44.5	40.45
1.00 pm	39.1	51.0	45.05
2.00 pm	39.9	49.8	44.85
3.00 pm	39.3	42.9	41.10
4.00 pm	37.9	42.8	40.35

Table 4.9 Temperature of car interior start from 9.00 am until 4.00 pm on Day3

Time	Temperature 1(°c)	Temperature 2 (°c)	Average (°c)
9.00 am	26.6	25.8	24.70
10.00 am	33.0	31.5	32.25
11.00 am	40.8	47.7	44.25
12.00 pm	41.2	48.9	45.05
1.00 pm	40.3	44.0	42.15
2.00 pm	37.2	38.2	37.70
3.00 pm	36.8	38.9	37.85
4.00 pm	30.3	31.2	30.75

Table 4.10.Temperature of car interior start from 9.00 am until 4.00 pm on Day 4

Time	Temperature 1(°c)	Temperature 2 (°c)	Average (°c)
9.00 am	24.6	24.8	24.70
10.00 am	32.3	34.5	33.40
11.00 am	38.9	45.7	42.30
12.00 pm	39.2	46.9	43.05
1.00 pm	41.3	42.1	41.70
2.00 pm	42.2	43.2	42.70
3.00 pm	37.8	39.8	38.80
4.00 pm	33.3	37.4	35.35

Table 4.11 Temperature of car interior start from 9.00 am until 4.00 pm on Day 5

Time	Temperature 1(°c)	Temperature 2 (°c)	Average (°c)
9.00 am	26.7	26.9	26.8
10.00 am	31.6	32.5	32.05
11.00 am	33.9	38.9	36.4
12.00 pm	37.6	40.7	39.15
1.00 pm	43.5	44.7	44.1
2.00 pm	44.1	46.9	45.5
3.00 pm	40.8	38.5	39.65
4.00 pm	38.6	36.7	37.65

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