STUDY OF AIR TEMPERATURE PROPAGATION OF PARKED CAR

Musthaq Ahmad; Jamshid Ali Turi

ma_5099@yahoo.com; Jamshidturi@gmail.com

Department of Engineering Tenaga Nasional Universiti Malaysia Kajang Campus
Faculty of Industrial Management, University Malaysia Pahang

Abstract:

Thermal comfort is only one factor that affects the driving experience. Several infants/children death reported across the globe after left in the parked car and high temperature create heat stroke. The aim of the paper is to determine the temperature variation inside the car cabin under direct sunlight in Malaysia also to reduce the temperature variation inside the car cabin by installation of exhaust fans. Experimental study has conducted to record outdoor and indoor car cabin temperature and compare the variation difference also install exhaust fans to reduce from the cabin. Findings shows outdoor and indoor 15-20 ^{0}C temperature difference found in the peak solar day time and by installation of four fans slightly reduce the indoor temperature. Study concluded that car parked under direct sunlight indoor car cabin temperature is higher 15-20 C and by installation of fans or windows slightly lower close may reduce the inside temperature.

Key Words: Parked Car, Temperature variation, Indoor and outdoor car cabin

1.0 Introduction

Worldwide private car is one the most important transportation for each individual compares to public transport (Hitge & Vanderschuren, 2015 #1). The rapid development and economic growth worldwide and especially in the developing nations have seen high demand for private transportation in the recent decades. According to (Lee, 2017 #2) quoted Malaysia Automotive Association, (2017) 13.28 million vehicles are privately registered in east and west Malaysia. The statistic shows total numbers of vehicles units 28.2 million were registered at June 2017 compare to 2015 1.88 million vehicles were increased on the road. The numbers of privately owned vehicles has abruptly increased and national car projects (Proton, perdua etc) also have played a role in motor vehicle growth by limiting the options available to the government

(Shariff, 2012 #3). Increasing number of private transportation create many problems such as environmental pollutions, traffic congestion badly affect human physical and mental health and parking problem in big cities. Study of (Saidur, 2009 #4) found that outdoor car parking under the direct sunlight increase the car cabin temperature up to 60C^{o}.According to (Al-Kayiem, 2010 #6) vehicle parked under direct sunlight, temperature inside the vehicle cabin raise up to 80C^{o}. The hot temperature inside the car absolutely makes the driver feel uncomfortable in the first 10 minutes (Mezrhab, 2006 #7). Stanford University School of Medicine has found that even on a relatively cool day, the temperature inside a parked car can quickly spike to the life threatening levels. More recently reported that since 1998 at least 468 infants died alone in the US due to thermal heat in a parked car, and a lot of drivers report thermal comfort inside the car (Saidur, 2009 #4). Australian study for forensic reveled that temperature level of the parked vehicle normally 20C^{o} higher than outside temperature in sunny days. Moreover children or pets left in a parked car for period of the 30 minutes suffers heat stress and possible death caused. Another report published by National Highway Traffic Safety Administration, (2004) stated that a car windows act like a greenhouse, trapping sunlight and heat and approximately twenty five children a year die as a result of being left or becoming trapped in hot vehicles. Vehicles parked under the direct sunlight become an oven and outside temperature does not have to be hot in order for a car to become hot an oven like death trap. Heat stroke in an adult person can occurred when temperature reached above 50C and children body temperature can reach faster than adults. Globally, children death main cause of left in the park vehicle have been reported frequently more recently 2 years baby girls found died in the parked vehicle in Malaysia. Heat loss or gain mainly occurs in a car cabin by three primary mechanisms: According to (Gilles, 2012 #8) heat in a cabin develops 15% from the road, 20% from engine and catalytic converter and 65% from sunlight. The aim of the paper is to determine the temperature variation inside the car cabin under direct sunlight in Malaysia also to reduce the temperature variation inside the car cabin.

2.1 Thermal Comfort

Thermal comfort is only one factor that affects the driving experience (Parsons, 2014 #9) countries like Malaysia gradually variation of temperature impact on parked car ventilation system caused thermal comfort. First time in 1920s heating system in the car was produced, and

1939 first cooling system (air condition) was introduced. Thermal comfort has link with driving performance. Thermal comfort decrease driving vigilance and increase driving errors classed as moving violations (WYON, 1996 #10). American Society of Heating Refrigerating and Air Conditioning Engineers, (1992) define thermal comfort the state of mind which expresses satisfaction with the thermal environment. (Parsons, 2014 #9) defined thermal comfort is influenced by a combination of physical, physiological and psychological factors. Moreover thermal influencing factors depends solar radiation, color variation inside and outside vehicle cabin, cabin size, clothing material wearing passenger.

2.2 Contributing Factors

This is important to know those factors affect thermal comfort of the vehicle cabin. There is many factors can potentially affect the climate of vehicle cabin. Some factors include interior upholstery, the interior and exterior colors and overall size of the vehicle, the clothing of the passengers, thermal insulation, and the passenger capacity of the vehicle cabin. The last factor points to a rather unique characteristic of vehicle cabins: Their relatively small size means that each individual person in the cabin can affect the thermal environment. This is because every individual radiates a certain amount of heat; if a car is filled to capacity with occupants; the cabin temperature is likely to be higher than if a single person occupied the vehicle. Lastly the location and external temperature of parked area effect on generation of heat inside the cabin.

2.3 Solar Radiation

Solar radiation is one of the most substantial factors to affect the climate inside a motor vehicle. Solar energy reaches the surface of the earth in the form of an electromagnetic wave after passing through the Earth's atmosphere. Solar radiation at ground level varies significantly with location, atmospheric conditions time of day, time of year, humidity, and natural environment. One may think of radiation in terms of reflectance and absorbance. For instance, every exterior surface of an automobile, including the roof and doors, reflects and absorbs certain portions of solar energy. A portion of the absorbed energy acts, in turn, to increase the air temperature within the vehicle cabin. It must also be remembered that the solar energy that is transmitted into the cabin also will be absorbed and reflected by whatever is inside, including upholstery, dashboard materials, and occupants. In every case, the temperature of whatever is absorbing

solar energy will increase. In general, solar radiation energy is reflected, absorbed, or transmitted on the glass depending on the optical properties.

2.4 Climate Control

Climate Control refers to the systems in a vehicle that allow customers to adjust air temperature, humidity, and direction. Although we usually think of climate control as just a comfort feature, the defroster is a safety feature. Air conditioning also improves the air quality, which may benefit people with certain health problems, by dehumidifying and cleaning the air as it cools it. All the components of the Climate Control system work together as a complete system. Understanding the relationship between these components will help accurately verify and diagnose complaints. For example, when a customer selects Defrost, the system opens the fresh air intake door, activates the heater core and refrigerant loop, directs air over the evaporator and the heater core, and blows this warm, dry air through the defroster ducts on the dashboard. If any one of these components isn't working properly, the customer will have concerns about poor defroster performance. Similarly, a customer may have concerns with poor air conditioner performance if the Sun load sensor has failed and the ATC is no longer accounting for the heating caused by sunlight on the vehicle.

2.5 Car Interior Become an Oven

There is no safe time to be in a parked car with windows rolled up especially in sunny days (Baser, 2013). In addition to he stated that people don't realize how hot it could be inside the car cabin. several studies conducted to know inside parked car temperature recorded and shows that external temperature 90F and internal temperature of increase just after 10minutes of car parking under direct sun light which was 110F and after 20 minutes when external temperature was constant internal temperature was recorded 120F but study stated that increasing of interior temperature of the cabin depends on the location, environment and solar radiation. Normally human body temperature between 98F and 100F degrees but once body temperature gets above a certain level, 105F and 106F, the temperature regulating mechanisms and the hypothalamus in the brain, all these things go haywire. Damage can be very rapid to brain and other organs in the body. In the result serious death can be caused. San Francisco State University, (2007) conduct study to know the interior temperature on different interval of times and their effects following figure shows interior car temperature with respect to external temperature. For the first ten

minutes when outside temperature was 90F and interior temperature rise to 109F. When outside temperature for an hour was same and so internal temperature was recorded for 30minutes and for 1 hour.

Below given figures shows the result of rapidly increasing temperature inside the cabin. Study concluded that under direct sunlight interior temperature of the cabin is 43 degree higher than outside temperature after an hour.

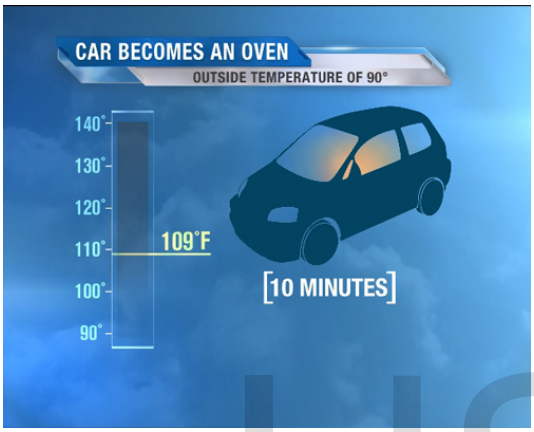

Figure 1: after 10 minutes

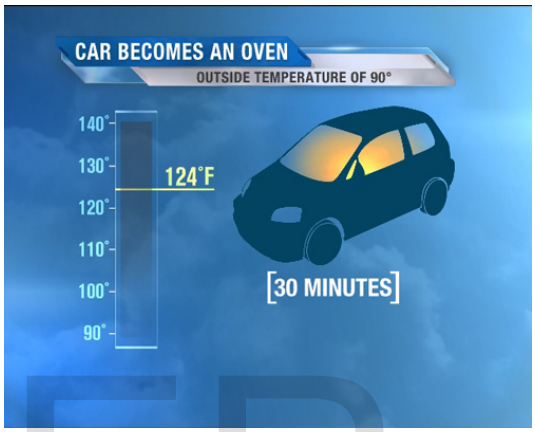

Figure 2: after 30minutes

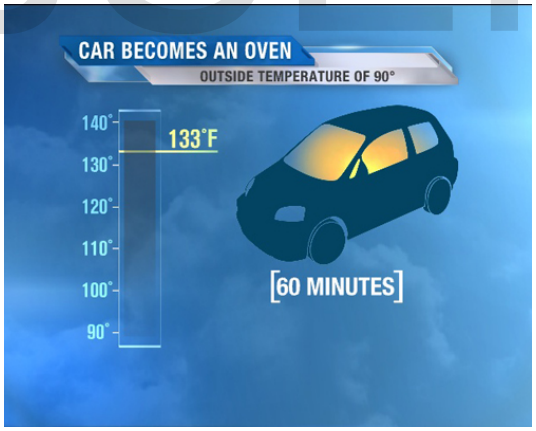

Figure 3: after an hour

Study conducted at university of Georgia, (2010) and developed a temperature , time table in closed parked car during hot weather which may help all those who parked their car and left behind something important in the car need to car because study stated that after an hour car cabin become like an oven. Study recorded temperature of closed car parked under direct

sunlight with variation of external temperature at different time interval. In hot weather in an open parking lot, the inside temperature of a car can rise by 7 degrees Fahrenheit in five minutes, 13 degrees in 10 minutes, 29 degrees in 30 minutes and 47 degrees in an hour.

This means interior temperatures can reach levels deadly to small children in less time than some parents might think.

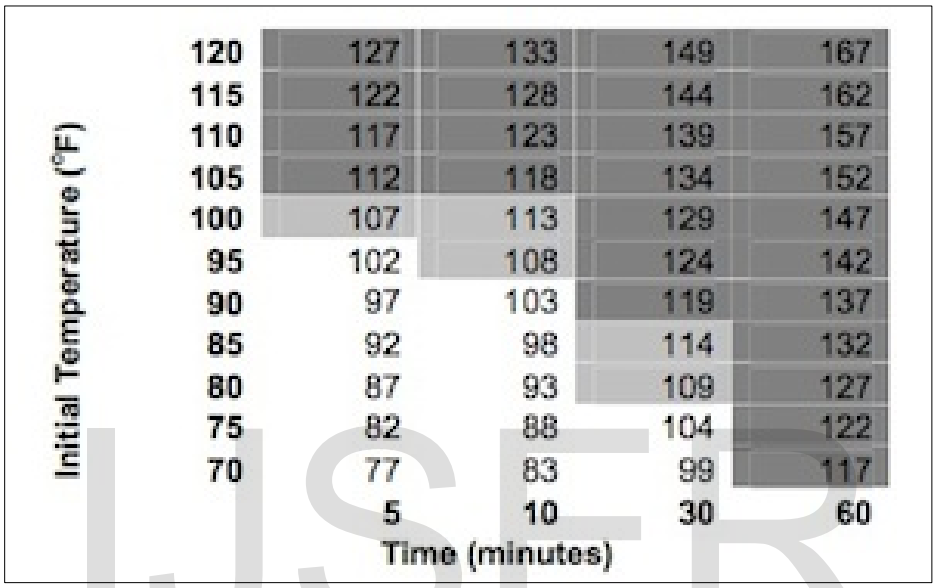

Figure 4: times, temperature table

3.1 Experimental Setup

Perodoa Kancil 800cc Malaysia made car parked under the direct sunlight ensured direct sunlight from all direction through windscreen and on rear windows. The tests were performed on 7 continuous days with possibly minimum cloudy weather from 4th September 2017 to 9th September 2017 and the weather was dried and hot. The time interval selected for the tests is from 09:00 AM to 04:00 PM, as the sun load within this period is at the highest. To measure exterior and interior temperature Pros-Kit- NT312 digital temperature humidity with probe device, LCD display, measuring temperature range from -10 degree to +55degrees centigrade was used. The experiment was carried out in three stages,

1. Firstly all windows closed under direct sunlight, normal
2. Secondly, two 12 volt fans installed, one in the front for exhaust and one in the back,

3. Thirdly, addition of 12 volts four fans, two in front for exhaust and two in the back for intake

4.0 Results and Analysis

4.1 Windows Close

The test vehicle was parked 15minutes earlier because need to set up experimental equipment's inside the car. Ensured that all doors and windows are closed, measuring senor was setup inside the car and digital meter was set outside to record the data with interval of times.

Outdoor and indoor temperature was recorded from 4th September to 8th September for same condition on interval one hour from morning 9am to 4pm evening. Table 1 shows outdoor temperature gradually increasing from 9am in the morning to 4pm in the evening, the highest outdoor temperature during this period was recorded at 02pm after noon which is 39.8 centigrade.

Table 1: Outdoor temperatures

Days	9am	10am	11am	12pm	13pm	14pm	15pm	16pm
4th	28	31	33	35	40	41	38	37
5th	29	30	32	34	41	37	37	35
6th	28	29	34	36	39	38	38	36
7th	28	30	33	34	39	39	36	37
8th	29	31	32	36	40	40	37	36
Average	28.4C°	30.2 C°	32.8 C°	35 C°	36.2 C°	39.8 C°	39 C°	37.2 C°

Table 2 shows the inside car cabin temperature variation at different intervals. Indoor temperature gradually increases with day time interval and is higher than the outdoor temperature. The peak average temperature was measured at 2pm about 54.2C° when outdoor temperature was 39.8 C°. These findings justify the pervious result stated temperature difference of indoor (car cabin temperature) and outdoor is about 20 C°.

Table 2: indoor parked car temperatures

Days	9am	10am	11am	12pm	13pm	14pm	15pm	16am
4th	29	32	36	44	54	53	51	44
5th	30	31	35	43	56	49	50	47
6th	29	31	37	45	53	52	48	45
7th	30	31	36	46	53	53	49	47
8th	30	32	35	47	55	49	47	45
Average	29.6C°	31.4 C°	35.8 C°	45 C°	51.2 C°	54.2 C°	49 C°	45.6 C°

4.2 Installation of two Fans (1 exhaust and 1 intake)

The purpose of fan installation is to reduce the temperature impact inside the parked car cabin. Two 12 volts mini fans were installed, one for exhaust and other one for intake air, directly run with car battery. Test was run under the same circumstance and same procedure was followed to record the data. Drafted result is shown in Table 3, indicating that at 1pm indoor maximum temperature was 52C° where outside temperature was 39C° .

Table 3: Two fans installed

Time	Outdoor temperature	Indoor temperature
09am	29	30
10am	31	32
11am	32	35
12pm	34	46
13pm	39	52
14pm	40	50
15pm	38	49
16pm	37	45

4.3 Installation of Four Fans (2 exhaust and 2 intake)

In the second stage, numbers of fans increased to reduce the indoor temperature, two fans were installed for exhaust and two for intake purpose. These fans were run with car battery directly, car was parked under the direct sunlight and procedure was repeated as before. The recorded data

is drafted in Table 4. Study found that after installation of four fans slightly variation of temperature inside the cabin happened as compared to previous stages. In this case maximum temperature at 01pm was recorded 42C when outdoor temperature was 40C. Installation of four fans enhances the condition of indoor car cabin to exhaust hot air from the cabin.

Table 4: Four fans installed

Time	Outdoor temperature	Indoor temperature
09am	30	30
10am	31	32
11am	33	34
12pm	36	37
13pm	40	42
14pm	37	40
15pm	36	38.8
16pm	37	38

4.6 Comparing of Manipulated Conditions

The results shown in table 5 installation of fans enhance the parked car interior temperature under direct sunlight up to certain degree to reduce the heat/temperature in the parked car. Improvement has been come after installing two and four fans. Windows up verses 2 fans and four fans shows enhancement in reducing car cabin temperature up to certain limits. At 1pm high temperature for close windows was recorded which was 52C^{o} but after running two and four fans the temperature was enhanced at 42C^{o}.

Table 5: comparing of all stages

Hours	Windows closed	2 fans	4 fans	Avg. outdoor temp
9am	29.6	30	30	29
10am	31.4	32	32	30.6
11am	35.8	35	34	32.6
12pm	45	46	37	35
13pm	52	51	42	38.4

14pm	54.2	50	40	38.9
15pm	49	49	38.8	37.6
16pm	45.6	45	38	35.1

5.0 Conclusion and Recommendations

The study was carried out into three stages and obtained result was compared. The indoor car cabin temperature was found 15-20C^0 higher than outdoor temperature. The indoor temperature was slightly reduce by installing two fans and four fans which shows the heat affect slightly reduce. The fans are directly connected with battery and function to exhaust the indoor temperature. As a conclusion, the portable car cooling system was developed for this study and reduces the interior heating temperature of the car up to certain limits as compared to normally windows up condition. Internal temperature of the car also depends on the location of car parked and outdoor temperature, in Malaysia most of the year temperature is approximately 35-40C, so the interior temperature also control for maximum of 60C^o. Following recommendation has been made based on obtained results from the experiments. This recommends using portable fan for the exhaust system in the car cabin to exhaust air from the cabin and also recommend for the future to study for vehicle color variation as well use the automatic temperature controlled fans in the cabin to reduce the parked car temperature.

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