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Development of Mechanical Ventilation Systems 'Smart Vehicle Ventilation' on Vehicles Using IoT

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Abstract: The present study aims to develop the mechanical ventilation system for vehicle based on IoT technology. The system is developed by using the ADDIE model which consist of five main elements. They are Analysis, Design, Development, Implementation and Evaluation. The main goal focuses on the development of this product which produces mechanical ventilation systems used in vehicles and controlled using IoT to get rid of heat which is trapped in vehicles when parked under sun radiation. This is due to the trapped temperature can exceed 48 ℃. In fact, the body temperature exceeding 40 ℃ can also provide the risk of suffering from heat stroke. Therefore, the main purpose of the researcher is to develop this product to prevent vehicle users from experiencing heat stroke. The results show that by using the ventilation systems, the process of heat removal in the vehicle can be increase up to maximum of 16.7% and minimum of 7.0%. Installation of this ventilation system is alternately a cost-effective, environmentally friendly and energy-efficient method for removing heat in vehicles. Based on expert reviews and suggestions, enhancement of this study is to use the correct CFM based on cabin size and product design appropriate to space in the vehicle.

Keywords: Mechanical Ventilation, IoT, ADDIE

1. Introduction

Ventilation moves the air from outside into a space and spreading the air inside the space. The general purpose of ventilation is to provide clean air to remove contaminated air and heat from any space (Wahab, Ismail, Abdullah, Rahmat, & Salam, 2018). An important thing in a space is to ensure maximum comfort is to have a clean air cycle (Wahab et al., 2018). The dirty air presence creates a sense of discomfort to humans and directly affects breathing difficulties and heat.

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During the daytime heat enters into a space through radiation or infiltration in the fractured wall, the sun's heat radiation will pass through the wall and warm up a space which does not provide a comfortable temperature to humans. The main cause of this implication is that the air cycle in a space is not perfect. This is due to air is filling every space available on this earth except for the vacuum room. The air quality of a space will be affected if it does not have a good air cycle. Indoor Air Quality (IAQ) is emphasizes on human health, productivity and human comfort in a space occupied or visited (Muhamad-darus, Zain-ahmed, & Talib, 2011). To obtain the perfect ventilation measurement is necessary through the guidelines set out in the IAQ. This is because the study is always on track so that the final decision will be at the optimum level.

There are three methods that can be used for building ventilation ie natural, mechanical and hybrid ventilation. Mechanical ventilation has been widely used over the past 50 years, but existing conventional systems need to be improved to cope with future technology needs (Rammer & Version, 2013). Mechanical fan that moves mechanical displacement are fans that are either mounted on windows, walls, or installed in airways to supply air or emit air.

Hybrid ventilation depends on the natural ventilation strength to provide the desired flow rate (Dieckmann, Roth, & Brodrick, 2006). It uses mechanical ventilation when the natural ventilation flow rate is too low. When natural ventilation is unable to accommodate the space, the exhaust fan is mounted to increase the ventilation rate. However, this hybrid ventilation should be used properly. Exhaust fans need to be installed so that it can remove air from inside directly to the outdoor environment through the walls or roof. The size and number of exhaust fans depends on the desired ventilation rate, and must be measured and tested before use.

There are more advantages of the natural ventilation system, compared to the mechanical ventilation system. Among them are natural ventilation to provide better economic ventilation rates (Flores-Velazquez, Montero, Baeza, & Lopez, 2014). This is due to environmental factors and wide openings. Natural ventilation also offers efficient use of energy. From the scope of technology, natural ventilation can be classified into a simple natural ventilation system and a high-tech natural ventilation system. The latest technology is controlled by computing system and it can be assist by a mechanical ventilation system through a hybrid system or a mix of mods. Natural high-tech ventilation also has the same limitations as the mechanical ventilation system.

Today, vehicles with comfort and safety are a necessity of the user as well as advanced developments in the automotive industry sector. To attract buyers, vehicle manufacturers need to highlight comfort, as well as affordable prices in producing a vehicle. Even vehicle users in the equatorial climate need to pay more attention to indoor air quality, as it is generally known that the climate has humid and hot throughout the year (Hamat, 2017).

Nowadays, it can be seen that the digital world is increasingly vibrant in the bustling of universal life and is a question mark if humans are ready to deal with it. In human life, the digital world paradigm is not just the development of the mass media, the widespread telecommunications network, or the cutting-edge smartphone model of sophistication. The Internet for everything or the Internet of Thing (IoT) is a smart network that connects everything on the internet platform to exchange information or communicate with other devices based on agreed protocols (Chen et al., 2014).

In the future, humans will see that electronic devices, goods, and data are connected in real time due to the technological revolution. IoT is also able to connect with anyone, everywhere, regardless of time, and place (Khan et al., 2012). Almost all IoT-based products have smart chip lifeblood that plays an important role in the technological era at the fingertips. If you look at the electronics market, dumping electronic and electrical devices like smart washers, which can be controlled by consumers only use smartphones remotely and do not require users to consume more time to operate them.

IoT technology is also not well-known in the global automotive world (Bajaj, Rao, & Agrawal, 2018). Only most luxurious vehicle manufacturers like Mercedez-Benz, Audi, BMW, and others have applied this technology in their car. For example if a BMW car users want to see the quantity of gasoline, users need to use the system app that BMW provides in their smartphones remotely without the need to go to the car. Hence, with the good response by various parties and industries, the researcher is of the opinion that this is the opportunity to combine the vehicle ventilation system and the IoT network to improve the aeration of the vehicle.

2. Problem Background

The automotive industry, which is gaining momentum in technology, has to focus on the comfort of consumers as opposed to global warming as the day progresses. Over the past few years Japan faces a wave of summer which can bring an increase in the risk of its people getting heat disease (Miyake, 2013). Heat stroke is very harmful to humans. Implications of heat stroke alone can increase body temperature of more than 40 ° C. Because of heat, the skin becomes dry and makes the nervous system abnormal like spasms, coma, and delirium (Bouchama & Knochel, 2002). Heat stroke occurs when humans are exposed to high environmental temperatures or heavy work (Leon & Helwig, 2012). If the heat stroke is not treated immediately, one is at risk of dying. In America, heat waves are more deadly than other natural disasters. Throughout 1979 to 1997 alone, 7,000 deaths were recorded in America as a result of further deterioration in the heat environment (Bouchama & Knochel, 2002).

Researchers feel that motor vehicle users have a heat stroke that can kill if they do not have good ventilation. It is a good thing when vehicles are able to provide comfort to passengers until they get out of the vehicle. But it is a problem when drivers leave their vehicles parked directly under the sun giving great potential for high heat traps (Basar, Musa, Faizal, & Razik, 2013). Night weather at night has a low impact on the user's vehicle but during the day it is the opposite. The heat generated by the sun's radiation entering the vehicle cabin is then trapped because it does not have good ventilation.

The human sense of taste is able to detect the heat and cold temperatures. Conditions that are harmful to humans are exposed to high temperatures and cause discomfort (Hamat, 2017). It happens when heat is trapped in the vehicle and the probability of contributing to the negative impacts to humans if exposed in a long term. Even humans can be at risk for heat stroke complications when exposed to high heat. With Malaysia having a warm and humid climate throughout the year, this hot condition makes Malaysians feel uncomfortable (Hamat, 2017).

The air temperature recorded in the passenger space can reach 48 ° C (Kamar et al., 2017). With that said, high cabin temperatures forces users to wait a while for the temperature to decrease. This way the user had to turn on the vehicle engine to use the air conditioning system and the direct smoke generated by the engine will pollute the surrounding air. The main factor of air pollution is due to the emission of vehicles especially in urban areas in Malaysia (Shuhaili, Ihsan, & Faris, 2013). As a result of this situation, air pollution containing toxic and harmful substances dispersed into the atmospheric space gives acordance to life on earth and destroys the environment (Jailani & Jaafar, 1999).

The philosophy of vehicle ventilation system as well as building ventilation systems is of no difference. Both have the same purpose of removing polluted air and getting rid of heat trapped in a space. Therefore, this ventilation system is also important to the vehicle for the comfort of drivers and passengers. A good ventilation system requires the use of mechanical type ventilation for better performance. The air and heat in the vehicle are sucked out into a motor-controlled environment (Hamat, 2017).

The researcher believes that the development of IOT-based mechanical ventilation systems on this vehicle can solve this problem. This system is controlled remotely by using smartphones and internet connections that can be accessed anywhere. This system can absolutely save consumers time and can reduce air pollution because it does not have to turn on the engine but uses the vehicle battery.

3. Problem Statement

As stated in the background of the problem, the researcher found that poor ventilation, in addition of the low IAQ value in the vehicle cab can pose a danger to drivers and passengers. Moreover, poor air quality will trap heat that can cause the driver or passenger to experience heat stroke. With the underdeveloped system, it can even contribute to the pollution of nature resulting from poor implications of environmental pollution.

Researchers are trying to find solutions to get rid of heat trapped inside the vehicle without switching on air conditioning systems but only using ventilation systems. In fact, in this study, the researcher uses the IoT approach to facilitate the user to remotely control the aeration system designed by the researcher. In addition, researchers found that the mechanical type of aeration system is powered by vehicle batteries. Thus this ventilation system does not require the main engine of the vehicle to operate and releases carbon monoxide. But there are some problems in which the researcher should take into account which is the most suitable position suitable to place ventilation fans to increase ventilation flow rates. Even researchers need to know how many fans are needed to shorten the time to get rid of heat trapped without users waiting in the long run. Next, the researcher needs to know the power supply needed to operate the fan and components related to IoT.

4. Methodology

The study was conducted with the aim of developing a system to get rid of trapped heat in the vehicle when parked under sun radiation with the help of IoT-based mechanical ventilation system in the vehicle in order to reduce air pollution generated by the main engine which activates the air conditioning system.The methodology used is as follows

4.1 Model

The design is a designed by the researcher to produce products in the study of developing mechanical ventilation systems in this IoT-based vehicle. The study should be aligned with the design method. In this study, the researcher refers to ADDIE model (Yaakob, 2017). The ADDIE model has elements such as Analysis, Design, Development, Implement and Evaluation as the basis for this model (Sega, 2006). The researcher uses the ADDIE model as it is easy to apply as a benchmark and a reference in product development.

4.2 Research Instrument

The research instrument is the device for obtaining relevant data based on the context of the study, but it has various alternatives to choose (Wilkinson & Birmingham, 2003). Therefore, the research instrument chosen by the researcher is using the expert confirmation form and questionnaire to evaluate the results based on the acceptance of Smart Vechicle Ventilation (SVV) results. A questionnaire was developed and then reviewed by a specialist, while an expert confirmation form was provided by the faculty.

4.3 Data Analysis

In this study, experiments will be carried out in four situations. The four conditions are temperature before and after ventilation, ambient temperature change with cabin temperature before ventilation, ambient temperature change with cabin temperature after ventilation, and duration of time taken for heat removal process. The four temperature conditions will be recorded and compared whether the product can eliminate heat as stated in the objective of the study.

5. Results and Discussion

The the results of the study and discussion are as following:

5.1 Results

To get a direct temperature reading, the researchers have used the temperature sensor attached to the circuit in the electronic box. The temperature reading is sent directly to the developer's Blynk application. Next, the researchers made the temperature comparison table before and after the ventilation to get rid of heat by time division. Researchers conducted this study randomly during the day. This is because the researcher wants the data to be adjusted to the current temperature at different hours as the temperature at each hour is different. Figure 1 shows the changes in cabin temperature before and after ventilation.

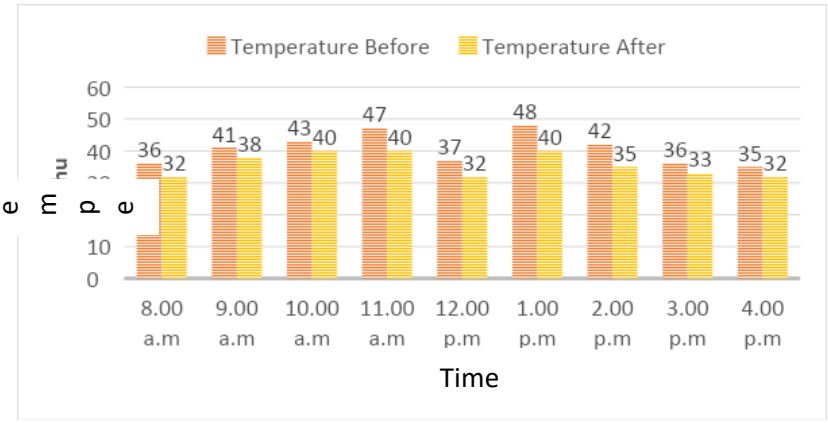

Figure 1: Changes in cabin temperature before and after ventilation

The difference in ambient temperature and cabin temperature before the heat removal process is also taken into account. This is because the ambient temperature also affects the temperature inside the cabin. The heat trapped in the product cabin is heat transfer from ambient temperature. Even the temperature in the cabin is higher than the ambient temperature. Figure 2 shows ambient temperature change with cabin temperature before ventilation.

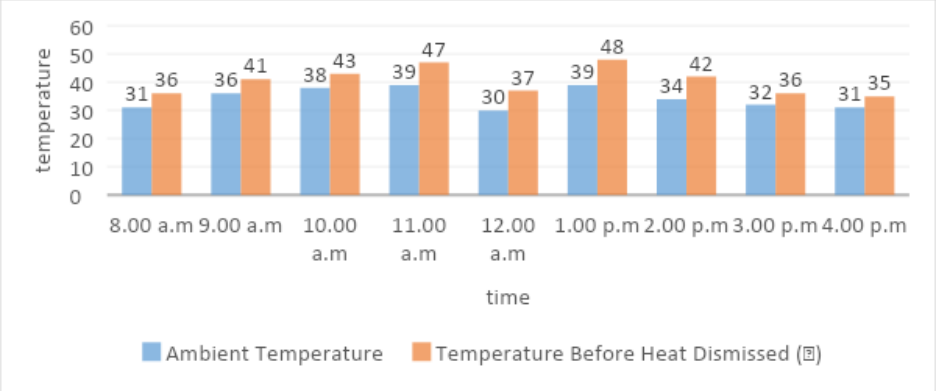

Figure 2: Ambient temperature change with cabin temperature before ventilation

Comparison of ambient temperature with cabin temperature after ventilation is also recorded. This is because the researcher wants to see the temperature reduction from heat removal and whether it is approaching ambient temperature or vice versa. Figure 3 shows ambient temperature change with cabin temperature after ventilation.

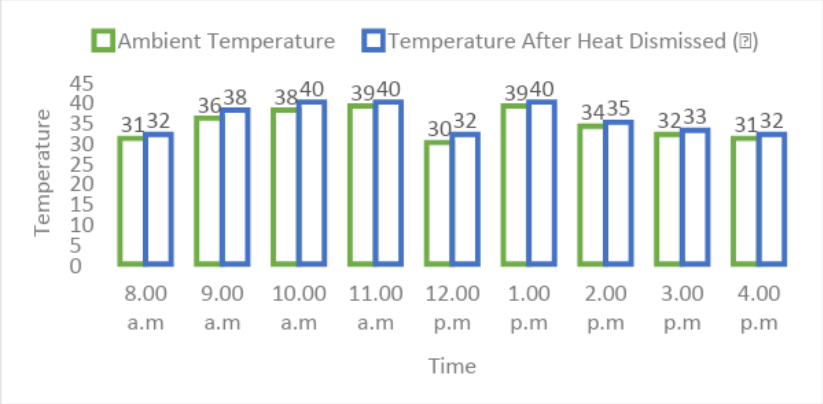

Figure 3: Ambient temperature change with cabin temperature after ventilation

In addition to the pre-and post-ventilation temperature recorded, the time required to reduce heat from high to low is also recorded. It aims to assess the efficiency of mechanical ventilation fans in producing high heat from inside the cabin of the product. Figure 4 shows time taken for the heat removal process.

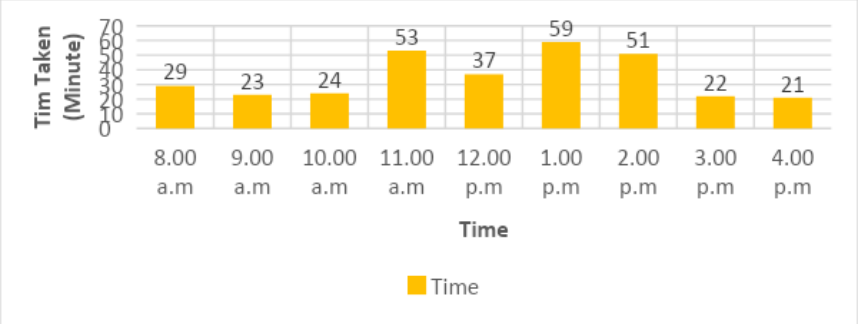

Figure 4: The time taken for the heat removal process

5.2 Discussions

The development of SVV study products is an effort to get rid of heat in vehicles sun-dried under sunlight. This product is built on the model of ADDIE which is free and suitable in terms of its systematic measures to produce user-friendly and quality products (Koksal, 2009). The product was also constructed and was evaluated by three experts comprising FPTV lecturers. This questionnaire was given to assess the design, development and functionality of the product.

During the development of this product, there are obstacles and challenges faced by researchers. Among the challenges faced by researchers is that while developing this product, time constraints become challenging as researchers need to develop this product together with six writings in this study. Because of the constraints, the researcher was unable to find more respondents to evaluate the product developed. Furthermore, other obstacles and challenges are difficult to find materials for the products in the areas nearby UTHM. This is because researchers need to find the material around Batu Pahat town. Although the city of Batu Pahat is great, it is still difficult to find it. Finally, the researcher found the material in a hardware shop near Bukit Pasir. Because the materials used in this product need to use the exact size as there are many experiments to conduct to select the appropriate material. In fact, it costly and tiring because this development needs to be done in detail. But the challenges and obstacles faced did not break the spirit of the researcher to improve and to achieve the objective.

The functionality of this product if viewed from respondents giving feedback is 100%. In addition, respondents agree that this product is easily controlled by the user and is safe to use. As a matter of fact, the three respondents stated that the product was developed to suit the vehicle.

From the results of the study, there is a difference in the temperature of the vehicle cabin between the use of ventilation fans and without ventilation. To answer the question of the third study, the researcher conducted two major analysis of this product. The two analysis are the change in cabin temperature before and after the ventilation, and the length of time taken for the heat removal process. The results of the analysis show that the product of this study succeeded in lowering the heat in the cabin. It even shows the effectiveness of this product until the temperature after ventilation approaches the ambient temperature. The purpose of this study is to prevent users from entering their vehicles in an uncomfortable situation and at risk of heat stroke. This SVV cannot provide cooler temperatures like air conditioning but it can provide a comfortable temperature to consumers when entering the vehicle. The largest percentage of heat can be eliminated is 1.00 p.m and 2.00 p.m each holding 16.7%. While the least percentage is at 10.00 a.m, only 7% of heat can be removed.

However, the hypotheses that can be used to investigate are, the greater the percentage of heat that can be eliminated, the longer the time taken to remove the cab. This can be seen where the greater the temperature difference the longer the time is taken to get rid of. Therefore, the heat removal process can also be affected by weather and wind speed during this study (Hamat, 2017). The ambient temperature was unable to be indicated by the researcher whether it was hot, cloudy, or windy.

6. Conclusion

Researchers have developed SVV products as a heat removal tool for vehicle cabin space when left in exposed parking space. Overall, this product was successfully developed using the ADDIE model. In the enhancement section for further research, some suggestions and opinions expressed by the appraisers in order to improve the quality and quality of the study so that researchers do not face difficulties and can improve the performance and efficiency of the removal. In fact, it can also shorten the length of time for SVV to get rid of heat so that users do not have to wait for long period of time. Additionally, for advanced product development and refining processes is a process that requires skills in a variety scope of work and ongoing. Due to the lack of skills and creativity, researchers faced some difficulties and obstacles when developing this product. In this regard, the researcher expects all the reviews and views provided by the lecturers in the specialist assessments to increase the SVV ventilation system to a higher and widespread level in the use of commercial vehicles.

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