Proceedings: ***International Invention, Innovative & Creative (InIIC) Conference, Series 1/2021***
eISBN: 978-967-18412-5-9 (Publication Date: 30 June 2021) *MNNF Publisher*

Unaware Threat of Cabin Vehicle Safety: A Review

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ABSTRACT

Modern vehicle design is completed with the additional support of a passive and active safety system. The main reason is to ensure the driver and the vehicle occupant is prevented from potential hazard while driving on the road. However, there is still an unaware potential hazard in the vehicle cabin, which caused the sudden death. It is due to poisonous gasses such as carbon monoxide (CO), carbon dioxide (CO_2), and many more. The high concentration of these gasses may affect the driving performance and health of the other vehicle occupant. Therefore, this paper aims to review hazardous gasses as the most significant threat to vehicle safety. The initial part of this paper discusses relevant information such as gas composition in the vehicle cabin after inhalation, the symptoms, and the effects of high concentration gasses. It shows that different levels of CO concentration within a certain period have a different effect on human life. The second part of this paper discusses the existing research on vehicle gasses detection systems. Later, based on the reviewed approaches, suggestions are made to improve the integration of power windows with the CO gasses detection system and other electronic components without changing the power window motor's original shape.

Key Words: *Vehicle safety, CO sensor, power window*

1. INTRODUCTION

Nowadays, when information technology is high, cars are a prevalent means of transportation. Every car has an air conditioning system embedded in it, and the exhaust engine of almost every car produces Carbon Monoxide (CO) gas which may enter into car cabins through AC vents. The air conditioner sucked exhaust engine discharges CO fumes. Car air conditioner gathers the poisonous and odorless CO gas when the engine is idle. There are few cases involving the poisoning of carbon monoxide, which causes death in the car. But a recent case in Penang, three adults were found dead after taking a break and sleeping in the car, which is believed to be CO poisonous (Mohamad, 2020). Therefore, this study aims to identify the potential hazard due to gasses concentration level in the vehicle cabin and how the technology could be beneficial to avoid sudden death in the cabin due to CO poisonous.

2. LITERATURE REVIEW

2.1 Gas Composition in the Vehicle Cabin

A vehicle cabin is a compartment that is created as a space for driving and carrying passengers. The volume of the vehicle cabin depended on the design of each car manufacturer. Nowadays, we saw various types of vehicles with different sizes of cabins, including two-seaters, four-seaters, and seven-seaters. However, a wide driving space provided a well driving experience to the driver. Besides that, a good riding experience also can influence by the air quality inside the vehicle. Vehicle these days come with Heating Ventilation and Air-Conditioning (HVAC) systems. The role of the HVAC system is to provide a comfortable ambiance inside the cabin by controlling the high low of a temperature. In a typical environment of daily life, there have multi types of gases contained in the air. The common gases that we can found inside the vehicle cabin are carbon monoxide (CO), hydrocarbon (HC), volatile organic compounds (VOC), oxide of

nitrogen (NOx), particulate matters (PMs), semi-volatile organic compounds (SVOCs), and oxygen (O_2). These gases enter the vehicle cabin through the Heating Ventilation Air-Conditioning (HVAC) system (Zulauf et al., 2019). When the car windows are in close condition, uncirculated air causes the air quality inside the cabin to decrease rapidly. These gases are produced by so many machines such as vehicle engines. Not only by humans but also by burning fossil fuel and biomass such as forest and bushfire.

2.2 The Risks of High Concentration of Gases

After we did a lot of research and study from related articles and books, we found that the air inside the vehicle also contained various toxic gases. These gases can enter the vehicle cabin through the vehicle HVAC system, windows, and other small gaps on the vehicle body. These poisonous gases threaten the lives of passengers every second because humans cannot detect these gases through their naked eyes or even smell. However, the density of the toxic gases only can be detected with the help of a gas detector. This device is a type of safety system used to detect multi types of harmful gases in surroundings. Normally, the detected toxic gases will be displayed through the digital display screen. As reported by the United States Consumer Product Safety Commission in September 2020, a number of 400 people die in the United States each year due to unintentional carbon monoxide poisoning, not fire-related. Among them, cases related to vehicles accounted for the majority.

In Malaysia, there have also been many car-related carbon monoxide poisoning incidents. Among them, cases happened in Kota Kinabalu, Kg Jaya Baru, where two teenagers died because of sleeping in the car while the car engine is still running and believed the main reason would be poison by carbon monoxide (Muslim, 2018). Besides that, another case of CO poisoning happened in Seberang Jaya, Malaysia. Three college students were found dead when they sleep in a car at a gas station while their twins' friends were unconscious then sent to the hospital for emergency treatment (Mohamad, 2020). The symptoms for various level of CO concentration is summarized as shown in Table 1.

Table 1: Symptoms and Effects of Different CO Concentration Level

Concentration (ppm)	Symptoms and Effects
0	Fresh air
9	Maximum indoor air quality level
10-34	Possible health effects with long-term exposure
35	Headache and dizziness within 6-8 hours of constant exposure
100	Slight headache after 2-3 hours
200	Slight headache within 2-3 hours; loss of judgment
400	Severe headache within 1-2 hours
800	Dizziness, nausea, and convulsions with 45 min Continued exposure: Death within 2-3 hours
1600	Headache, increased heart rate, dizziness, and nausea within 20 min Continued exposure: Death in less than 2 hours
3200	Headache, dizziness, and nausea in 5-10 min Continued exposure: Death within 1 hour
6400	Headache and dizziness in 1-2 min Continued exposure: Death in less than 20 minutes
12800	Unconsciousness after 2–3 breaths Continued exposure: Death in less than 3 minutes

In other words, human breath and metabolism inside a closed cabin cause the concentration of carbon dioxide to increase rapidly. Recommended of an allowable level of CO_2 inside vehicle cabin as suggested by American Society of Heating and Air-Conditioning Engineers (ASHRAE) standard 62-2001 is about 1200 ppm to 1300 ppm. However, exceed 3000 ppm will cause nausea and decision-making obstacles. From Occupational Safety and Health Administration OSHA, a standard concentration of oxygen (O_2) for humans was between 19.5% and 23.5% per cabin capacity. If the O_2 drops to 16% or below, the body cells fail to receive the oxygen needed to function correctly.

2.3 Vehicle Gas Detection System

Che Soh et al. (2018) have proposed a gas leakage detector to warn the driver of high CO concentration levels. The system was built based on four major components: NEMOTO semiconductor (NAP-11A) as a CO sensor, microcontroller on-board system, logic detector, and alarm system. Once the recorded CO concentration level reaches its maximum, the logic detector circuit will receive a signal to activate the alarm system with a red LED indicator through its programmed microcontroller.

Another proposed gasses detection system is proposed by Ramya (2012). It was a project installed with two types of gas sensors, which are CO and O_2 sensors. The sensors' signals will be sent to an

ADC0808 data acquisition component before received by the AT89C51 microcontroller. The function of the AD converter is to convert Analog to Digital input when it receives the input from the sensors and then sent to the microcontroller. The detected concentration of gases will display through an LCD screen. A high concentration of carbon monoxide and low oxygen level will activate the alarm system to alert the driver and the ventilation provided. Simultaneously, the system will alert users by sending a text message through their phones. So that people will able to know the critical situation inside the cabin.

Using Arduino mega as the main controller, an additional sensor is applied in the other study where the ultrasonic sensor installed in the embedded system detects (Batra & Batra, 2018). The main function of the ultrasonic sensor is to detect any occupant presence in the car cabin. If there is a passenger in the cabin while the CO gas level concentration is high, the system will generate a warning notification through the LCD and alert with the alarm. Then, the microcontroller will receive a preset sequence number that functions as input to operate the power window after the warning text message is sent by GSM kit to the occupant's cell phone. The power windows will be closed automatically when the CO reaches below a predefined threshold value.

Table 2: Comparison of Previous CO Detection System

Authors	Highlights
Che Soh et al. (2010)	• The detection system does not operate the automatic power window • The alarm awakens not all people
Ramya & Palaniappan (2014)	• The system required both gasses reading to reach the predefined value. Otherwise, the system will not trigger the alarm system. • The system is dependent on a human decision after receiving the text message. It may be a risk if we consider technical issues such as low or no coverage for line providers in a certain area.
Batra & Batra (2018)	• The position of the motion sensor should be properly identified inside the vehicle cabin. Otherwise, the sensor cannot detect any occupant who blocks by the front seat.
Sathish et al. (2018)	• The system required some modification and additional attachment of mechanical components, which needed more space.

Rather than measuring the CO concentration, another study proposed applying an O_2 sensor in their research (Sathish et al., 2018). The sensor will be the main signal to the control unit attached with the motor to modify the rack and pinion arrangement design. Low concentration O_2 level will activate the microcontroller to operate the motor, so the rack and pinion movement will allow the opening and closing of vehicle windows. All the reviewed detection system consists of their advantages. However, there is still space for improvement for future system development. Therefore, this study is highlighting the disadvantages of an existing system as listed in Table 2.

3. RECOMMENDATION & CONCLUSION

Based on the identification of some disadvantages points as listed in Table 2, an improvement design is necessary where the CO safety detection system should be designed with several consideration, such as an automatic ventilation system based on CO concentration as the input with alarm system and investigation of the maximum and minimum opening for the windows. Then the application of Arduino Uno as a control unit could be applied due to a cost-effective project. Lastly, it should focus on modifying the power windows wiring system rather than additional mechanical components in the power windows system. With these proposed recommendations for a future gas detection system, the system will satisfy the user and potentially be commercialized.

The rate of sudden death cases in the vehicle can be reduced with technology assistance. However, it requires continuous support from society to enhance the awareness related to this hazard.

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