UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE PROTOTYPE DESIGN OF VEHICLE CARBON MONOXIDE DETECTOR (VECOD) WITH A LOW-COST SENSOR USING ARDUINO UNO AS A PLATFORM

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in fulfillment of the requirements for the degree of
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2022

DECLARATION

I declare that this choose an item entitled “Vehicle Carbon Monoxide Detector (VeCOD)” is the result of my own research except as cited in the references. The choose an item has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : Muhammad Firdaus Bin Yusdianto

Date : 25/01/2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical And Manufacturing Engineering Technology (Air Conditioning And Refrigeration System) with Honours.

Signature : 

Supervisor Name : Ts. Azwan Bin Aziz

Date : 25/01/2022

DEDICATION

I would like to dedicate the success of this research to my parents, Yusdianto Bin Mohd Yunus and Saadiah Binti Abdul Hamid. This dedication is then made to my siblings, who helped me complete this report by providing advice, financial support, and encouragement. Then, I'd want to express my heartfelt gratitude to Ts. Azwan Bin Aziz, my supervisor, and my friends for their help in completing this Final Year Project.

ABSTRACT

Carbon monoxide (CO) is a toxic, colorless, and odorless gas that is difficult to detect. Carbon monoxide is produced in large quantities by automobile exhaust emissions. Carbon monoxide can get into the vehicle through holes in the exhaust system. Inhaling an excessive amount of carbon monoxide for an extended period has a direct influence on human health and can result in lethal carbon monoxide poisoning. To ensure that the level of carbon monoxide in the vehicle is safe, the air quality must be monitored. Drivers who must endure long drives and must rest in their automobiles will be particularly affected. When the car's air conditioner (AC) is turned on during hot weather, the engine is simultaneously turned on, generating CO leakage into the vehicle. Many people perished as a result of carbon monoxide poisoning in cars. As a result, incorporating a low-cost "Vehicle Carbon Monoxide Detector (VeCOD)" into a carbon monoxide monitoring system minimizes similar incidents. Using an MQ-7 CO gas sensor, this research intends to construct a CO gas warning system for detecting CO in cars. To make the system more realistic, an Arduino Uno is utilized as a microcontroller to control the entire system. In addition, the LCDs the CO concentration within the car in ppm units and warns of leaks at the exhaust-to-engine connection, using an alert system consisting of an LED and a buzzer. CO concentration is divided into two levels in this project based on the output voltage of the sensor. This system would automatically warn the driver or user if a leak connection between the exhaust connection and the engine is detected, or if a dangerous level of CO in the car cabin is detected, by activating signals via LCD, LED, and buzzer to alert the driver or user to avoid carbon monoxide poisoning.

ABSTRAK

Karbon monoksida (CO) adalah gas beracun, tidak berwarna dan tidak berbau yang sukar dikesan. Karbon monoksida dihasilkan dalam jumlah besar oleh pelepasan ekzos kenderaan. Karbon monoksida dapat masuk ke dalam kenderaan melalui lubang pada sistem ekzos. Menghirup sejumlah besar karbon monoksida untuk jangka masa yang panjang mempunyai pengaruh langsung terhadap kesihatan manusia dan dapat mengakibatkan keracunan karbon monoksida yang mematikan. Untuk memastikan tahap karbon monoksida di dalam kenderaan selamat, kualiti udara mesti dipantau. Pemandu yang mesti menempuh perjalanan panjang dan mesti berehat di dalam kenderaan mereka akan sangat terjejas. Apabila penghawa dingin kereta (AC) dihidupkan semasa cuaca panas, mesin dihidupkan secara serentak, menyebabkan kebocoran CO ke dalam kenderaan. Banyak orang mati akibat keracunan karbon monoksida di dalam kereta. Akibatnya, memasukkan "Vehicle Carbon Monoxide Detector (VeCOD)" kos rendah ke dalam sistem pemantauan karbon monoksida meminimumkan kejadian serupa. Dengan menggunakan sensor gas MQ-7 CO, penyelidikan ini bermaksud membina sistem amaran gas CO untuk mengesan CO di dalam kereta. Untuk menjadikan sistem lebih realistik, Arduino Uno digunakan sebagai mikrokontroler untuk mengawal keseluruhan sistem. Selain itu, LCD memaparkan kepekatan CO di dalam kereta dalam unit ppm dan memberi amaran akan kebocoran pada sambungan ekzos ke mesin, menggunakan sistem amaran yang terdiri dari LED dan buzzer. Kepekatan CO dibahagikan kepada dua tahap dalam projek ini berdasarkan voltan output sensor. Sistem ini secara automatik akan memberi amaran kepada pemandu atau pengguna jika hubungan bocor antara sambungan ekzos dan mesin dikesan, atau jika tahap bahaya CO di kabin kereta dikesan, dengan mengaktifkan isyarat melalui LCD, LED, dan buzzer untuk mengingatkan pemandu atau pengguna untuk mengelakkan keracunan karbon monoksida.

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LIST OF SYMBOLS AND ABBREVIATIONS

CO	-	Carbon Monoxide
COHb	-	Carboxyhemoglobin
O_2	-	Oxygen
SnO_2	-	Tin oxide
Hb	-	Hemoglobin
US	-	United States
VeCOD	-	Vehicle Cabon Monoxide Detector
IDE	-	Integrated Development Environment
PEL	-	Permissible Exposure Limit
ppm	-	Parts per million
OSHA	-	Occupational Safety and Health Association
DOSH	-	Department of Occupational Safety and Health
NIOSH	-	National Institute for Occupational Safety and Health
MOS	-	Metal-Oxide-Semiconductor
MEMS	-	Micro-Electro-Mechanical Systems
GPS	-	Global Positioning System
CPS	-	Cyber-Physical System
GMS	-	Google Mobile Services
MQ-7	-	Carbon Monoxide Sensor
LED	-	Light Emitting Diode
LCD	-	Liquid Crystal Display

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CHAPTER 1

INTRODUCTION

1.1 Background of the study

One of the pollutants that pollute the air is carbon monoxide (CO). Carbon monoxide is commonly found on highways because it is formed when incomplete combustion occurs, such as in a car engine. Carbon monoxide can also be created through the high-heat-pressure combustion of fuels such as natural gas, firewood, solar, coal, and gasoline. Malaysia is seeing an increase in the number of vehicles on the road. As a result, gas pollution rises. Toxic and unhealthy gases will be produced by the exhaust of vehicles such as cars, buses, and others. Poor ventilation systems or leakage problems in the car's air ducts can give way to toxic gases entering the spacecraft slowly. A more dangerous situation can be created when dozens of vehicles stop waiting for a green light on the road.

Staying or sleeping in a vehicle with the engine running, driving a vehicle with exhaust damage, or driving a vehicle with holes in the car body are the most common causes of carbon monoxide poisoning. Carbon monoxide can enter the car through cracks in the exhaust system, windows, or doors. Inhaling carbon monoxide gas over some time and being in an enclosed place can cause serious health problems as well as will be deaths against the driver and also passengers inside the vehicle due to carbon monoxide poisoning. Carbon monoxide affects people by replacing oxygen with carboxyhemoglobin in the blood, reducing the amount of oxygen available to the body. According to death and fatality rates

attributable to CO poisoning in the United States (US) from 1999 to 2010, as shown in Figure 1.1, there has been a significant increase in concern each year.

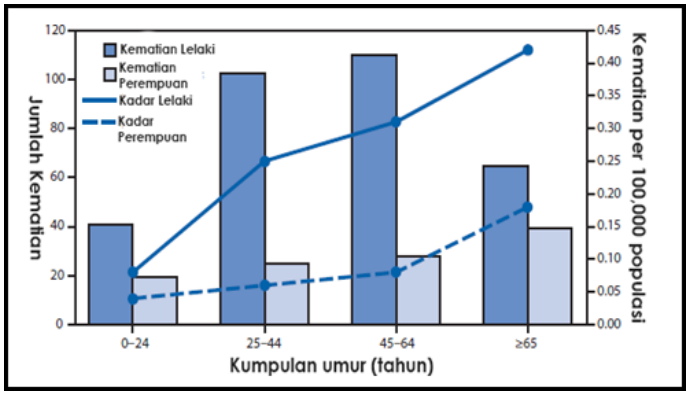

Figure 1.1Average Annual Number of Deaths and Mortality Rates Due to CO Poisoning in the United States (1999-2010). (Source: Centers for Disease Control and Prevention (CDC), 2014)

CO is one of the hardest gases to detect with the human senses. A project called "Vehicle Carbon Monoxide Detector (VeCOD)" is being proposed to solve the problem of excessive CO inhalation in vehicles by generating alarm signals when CO concentrations in vehicles exceed harmful levels. The Arduino Uno acts as the project's main component, controlling all VeCOD inputs and outputs for CO detection in vehicles. The MQ-7 sensor is used in the project, and it has a detection range of up to 2000 parts per million, making it suitable for use in a CO detection system. The CO content in the automobile is displayed on the LCD, showing whether it would be high or low. When the CO concentration in the vehicle exceeds the predetermined limit, the LED and buzzer outputs will be triggered, notifying the people in the car to avoid carbon monoxide poisoning in the vehicle.

1.2 Problem Statement

The case of a sudden death while sleeping in a car has worried the Malaysian community and the authorities. Especially for car drivers and passengers who normally stop at a certain place (e.g., on the side of the road) to rest, but are unfortunately poisoned by carbon monoxide during sleep. Exhaust gas leaks have contaminated car passenger space, especially for poorly maintained cars. Previous reports showed sudden deaths due to gas poisoning during sleep due to inhaled carbon monoxide gas in the density range of more than 800 ppm. The latest case took place in Seberang Jaya, Penang, where four friends were unconscious in a Honda Odyssey multi-purpose vehicle (MPV) due to inhalation of carbon monoxide (CO), and it was found that three students died while the other survived the incident. In another case, two teenage boys died in a Perodua Myvi car in Kampung Jaya Baru believed to be carbon monoxide poisoning.

The average case that happened was that they slept in the car without stopping the engine or shutting off the air conditioning system. The fact about carbon monoxide (CO) gas is that it is a colorless, tasteless, and toxic gas that is difficult to detect, making it even more harmful. The absence of additional devices to detect the presence of carbon monoxide gas is a major problem, and its application is seen as insignificant. Therefore, this paper proposes a prototype of an automated carbon monoxide detector using Arduino that can benefit car drivers and passengers. A project entitled "Vehicle Carbon Monoxide Detector (VeCOD)" should be developed through study and design to detect carbon monoxide gas. It can directly assist drivers in detecting carbon monoxide gas leaks.

1.3 Objectives

1.3.1 General Objective

To design the prototype of a carbon monoxide detection system with a low cost for average car owners.

1.3.2 Specific Objectives

i. To analysis the level of carbon monoxide on the vehicles.

ii. To develop a carbon monoxide detection system to prevent carbon monoxide poisoning in vehicles.

1.4 Scope of Project

This device is specially made to be installed for road users who use motor vehicles such as cars, buses, lorries, and so on. Then, this research is a first step in developing low-cost carbon monoxide detection equipment that will be available to all consumers to avoid deaths caused by carbon monoxide gas in vehicles. The hardware and software of the project can be separated into two categories. Both hardware and software are used to execute this project. In the circuit design, components such as an Arduino microcontroller, a CO gas sensor, a buzzer, an LCD, and an LED are used. The Arduino microcontroller's work is used to monitor the entire detection system's operation. The CO sensor detects the presence of CO, and when CO is detected, the buzzer will sound. LED indicators are used to show the state of the device to the user. After CO is measured, the sensor reading will be shown on the LCD panel. The Arduino integrated development environment (IDE) is used to program the system in the software phase, which is simple to read and understand.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Carbon monoxide (CO) is a colorless, odorless, tasteless, invisible, and poisonous gas that can be fatal when inhaled into the human body (Masek et al., 2019). The incomplete combustion of fossil fuels produces this toxic gas. These fuels (coal, gasoline, kerosene, natural gas, oil, propane, and wood) are used by many people all over the world (Vacanti et al., 2011). CO is described as the "silent killer" because it leaves no visible signs of its existence (Long & Flaherty, 2017). In many places, especially vehicles, carbon monoxide poisoning has become the most common type of lethal air poisoning. As the number of vehicles on the road rises, so does the degree of pollution from carbon monoxide fumes (Chamberlain, 2016).

2.2 Carbon Monoxide (CO)

CO is a product of incomplete hydrocarbon combustion, which occurs most commonly in vehicle engines. According to a study, motor vehicles emit over 70% carbon monoxide (Farhan et al., 2003). In 2011, mobile vehicles accounted for 60% of carbon monoxide emissions in the United States (US EPA, 2014). Carbon monoxide exposure is assumed to be higher in urban areas with heavy traffic congestion (Farhan et al., 2003). According to the regulations set by the United States Department of Labor (USA Department of Labor, n.d.), the Occupational Safety and Health Association (OSHA) permitted exposure limit (PEL) is 55 mg/m3 for eight hours.

According to the Department of Occupational Safety and Health (DOSH) Malaysia, the maximum CO concentration allowed indoors is less than 10 ppm TWA (Industry Code of Practice on Indoor Air Quality, 2010). CO is a colorless, odorless, and tasteless gas, yet highly toxic. CO is difficult to detect due to its properties (Prockop et al., 2007). CO poisoning is the most common cause of death in several countries (Omaye, 2002). CO poisoning is difficult to diagnose due to the lack of clear clinical symptoms (Prockop et al., 2007).

CO is dangerous to humans because when inhaled, CO will combine with hemoglobin in the red blood cells to form carboxyhemoglobin (COHb). This will reduce the level of oxygen (O_2) delivered throughout the body. The affinity of hemoglobin towards CO is 210 times higher than that of O_2 (Prockop et. al., 2007). The brain and heart can be severely affected after exposure to CO with COHb surpassing 20% (Prockop et al., 2007). Among the symptoms of CO poisoning are headaches, dizziness, vomiting, nausea, and fatigue. These symptoms are similar to viral flu symptoms, causing misunderstandings for the victim (Khandelwal et al., 2007). At a CO concentration of 1600 ppm, CO poisoning can be fatal to the victim in less than 2 hours (Goldstein, 2008).

2.3 Effect of Carbon Monoxide on the Human Body

Every aerobic form of life is killed by carbon monoxide (CO). Through the lungs, it was simply absorbed into the bloodstream (U.S. Environmental Protection Agency, 2000). Because CO has a 240-fold higher affinity for hemoglobin than oxygen, oxygen cannot bind to hemoglobin. Carboxyhemoglobin lowers the blood's ability to carry oxygen and interferes with oxygen delivery to tissues. Continuous oxygen supply can cause tissue hypoxia by interfering with cellular respiration (Q. Liu et al., 2012). Increased blood levels of

carboxyhemoglobin (COHb) reduced the quantity of oxygen transferred across the body by the hemoglobin in red blood cells.

Carbon monoxide is a toxic gas with harmful effects on the human body. CO combines with hemoglobin (Hb) in the blood during inhalation to generate carboxyhemoglobin (COHb). This reduces the amount of oxygen available to the human heart and brain. Carbon monoxide is absorbed faster by red blood cells than oxygen. As a result, higher CO inhalation can harm one's health by cutting off oxygen delivery to the body's organs. As a result, high levels of carbon monoxide can be lethal. Table 2.1 shows the health effects of long-term exposure to various carbon monoxide concentrations in parts per million (ppm) (Flachsbart, 2007).

Table 2.1 Concentration of carbon monoxide and signs after inhalation (Flashsbart, 2007)

Concentration	**Effects and Symptoms**
0 ppm	Fresh air
9 ppm	Maximum indoor air quality level
10-34 ppm	Possible health effects with long-term exposure
35 ppm	Headache and dizziness within 6-8 hours of constant exposure
100 ppm	Slight headache after 2-3 hours
200 ppm	Slight headache within 2-3 hours ; loss of judgment
400 ppm	Serious headache within 1-2 hours
800 ppm	Dizziness, nausea and convulsions with 45 min Continued exposure: Death within 2-3 hours
1,600 ppm	Headache, increased heart rate, dizziness, and nausea within 20 min Continued exposure: Death in less than 2 hours
3,200 ppm	Headache, dizziness and nausea in 5-10 min Continued exposure: Death within 1 hour