Design Of A Detection Device For Dangerous Gas In Electric Cigarette Users Using Arduino Nano

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ABSTRACT

The use of electronic cigarettes (vapes) is expected to be a healthier alternative to tobacco cigarettes. However, various studies have shown that electronic cigarettes also contain hazardous substances such as Benzene and Carbon Monoxide which damage lung health. Previous studies have studied methods for detecting hazardous gases in the lungs, but most of them use expensive devices and complex methods such as SPME–GC/MS which are not easily accessible to the public. This study aims to develop a portable, easy-to-use, and affordable, non-invasive and real-time hazardous gas detection device, especially for Carbon Monoxide and Benzene. This device uses an Arduino microcontroller board and MQ-7 and MQ-135 gas sensors to measure gas levels from users' breath. The results showed that 30 participants exceeded the safe limit of Benzene of 0.5 ppm and 17 participants exceeded the safe limit of Carbon Monoxide of 6 ppm, indicating the potential risk to lung health of electronic cigarette users. These findings can increase public awareness of the dangers of electronic cigarettes and encourage reduction or cessation of their use.

Keywords: Gas level detection, Lungs, Electronic cigarettes, Arduino**.**

INTRODUCTION

Since their emergence in 2003, e-cigarettes have become popular as an alternative to conventional cigarettes, despite containing similar harmful substances. In Indonesia, their use increased from 7.2% in 2013 to 9.1% in 2018, with the same dangerous health risks.[1]. In the research[2]shows that e-cigarettes contain hazardous substances such as Nitrosamine, Diethylene Glycol, PBDEs (Polybrominated Diphenyl Ethers), Nicotine, Propylene Glycol, and Benzene, which are risky for lung health and can cause cancer. The variability in the composition of substances produced by e-cigarettes, as well as the possibility of being adjusted according to personal preferences, is the attraction of e-cigarettes for young people, raising concerns about the safety of this product. E-cigarettes have negative impacts, especially in increasing the levels of Carbon Monoxide and Benzene in the lungs of users, which have the potential to interfere with lung function. Therefore, it is necessary to develop a simple detection device that can help e-cigarette users monitor the levels of hazardous gases in their lungs in real-time, in an easy and instant way. This study developed a portable device based on Arduino Nano and MQ-7 and MQ-135 sensors to detect Carbon Monoxide and Benzene non-invasively and in real-time in the lungs of e-cigarette users. This device measures the levels of inhaled hazardous gases and displays gas concentration information on the LCD screen. The results are expected to help e-cigarette users reduce or stop their e-cigarette consumption.

LITERATURE REVIEW

Arduino Nano

The Arduino Nano is a compact, power-efficient, and easy-to-use microcontroller board based on the ATmega328P microcontroller. Although smaller than the Arduino Uno, the Arduino Nano has similar features. It is designed for projects with limited space, such as wearable electronics, robotics, or embedded systems. The Arduino Nano can be programmed with the Arduino IDE software, just like other Arduino boards, making development easy.[3].

Arduino IDE

To use Arduino as a process unit, a program with a command line that matches the desired design is required. This program must be developed with Arduino IDE software. Arduino IDE is software used to create programs that are then entered into the microcontroller. When writing lines of code or coding processes, the C language is used as the main language when writing lines of code in this program, where the C language is one of the most famous computer languages among programmers.[4].

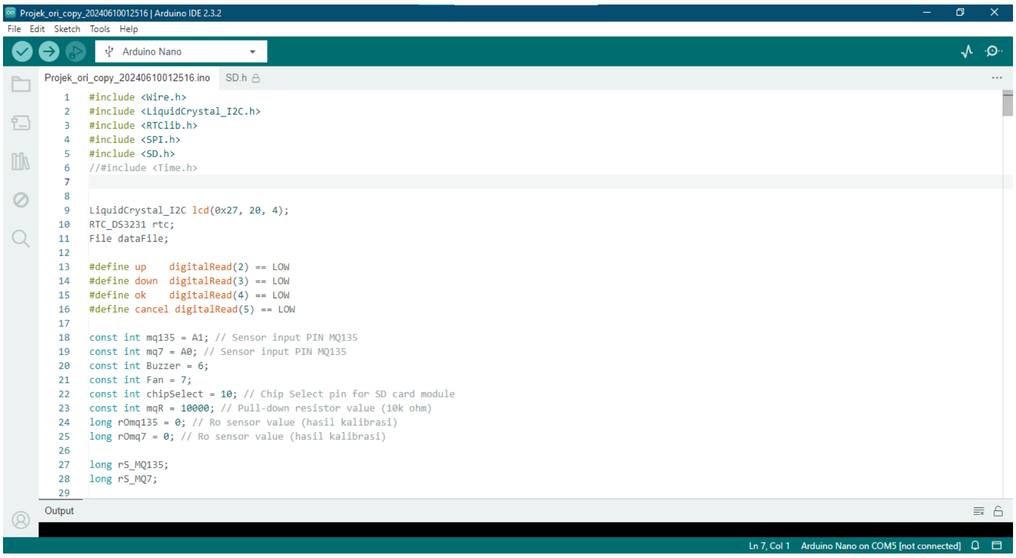

Figure1. Arduino IDE view.

Gas Sensor

Gas sensors monitor pollutant components in the air, such as Carbon Monoxide, Hydrocarbons, Nitrous Oxides, and others. Gas sensors are basically composed of sensor elements, sensor bases and sensor caps, where the sensor element consists of chemicals that are sensitive to certain gases and heating materials that aim to heat the elements on the sensor and act as triggers. Of course, sensor sensitivity is what distinguishes each gas sensor from other gas sensors on the market. Gas sensors operate on the principle that the greater the concentration of gas, the lower the resistance. There are several types of gas sensors used and available on the market, including the MQ-135 and MQ-7 types used in this study.[5].

LCD Screen

LCD (Liquid Crystal Display) is a form of electronic display that uses CMOS logic technology to transmit light from behind the screen, known as backlight, or reflect light from the front, known as frontlight. LCD displays data in the form of characters, letters, numbers, or images. The LCD module contains a microcontroller IC, which operates as a character display controller with memory and registers[4].

METHODS

Hardware Design

This study uses MQ-135 semiconductor sensors for Carbon Monoxide detectors and MQ-7 as Benzene detectors where both sensors have good sensitivity for each gas from 10-10,000 ppm. The installation of both sensors is arranged in such a way as to minimize detection from outside air.

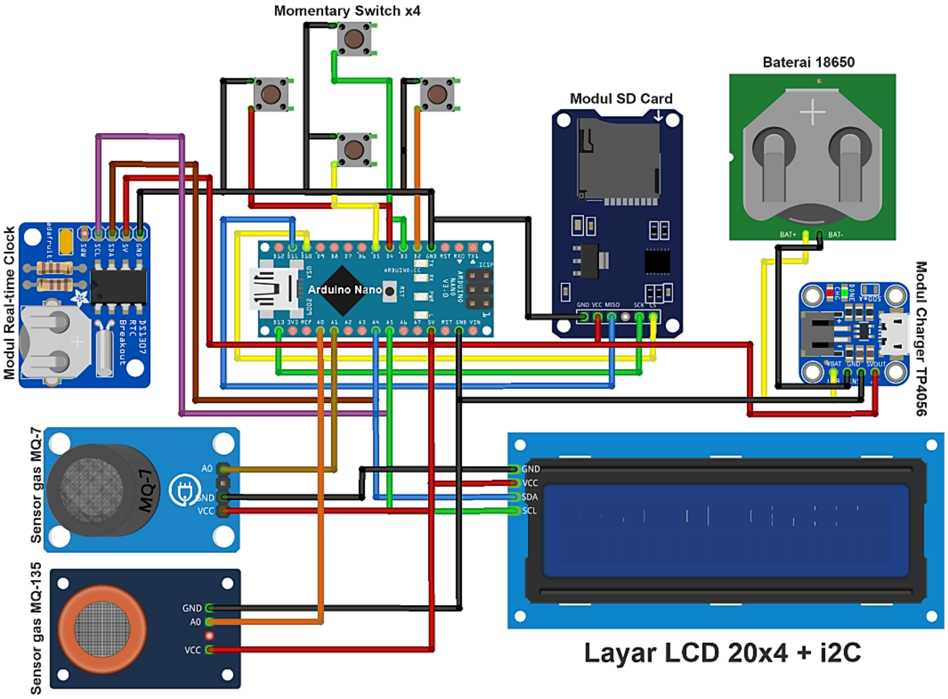

Figure2. Design the detection device using a wiring diagram.

Software Design

The design of the research device is described using graphical depictions with geometric symbols called Flowcharts.[6].

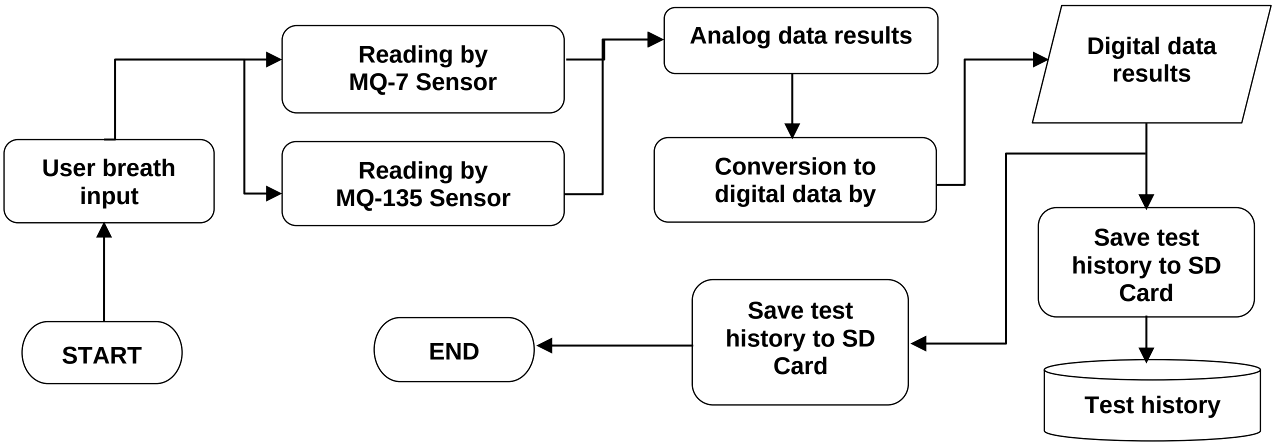

Figure3. Flow diagram of detection device.

The process of detecting hazardous gas content in the breath of e-cigarette users begins with measurements through reading the MQ-7 and MQ-13 sensors that measure the amount of Carbon Monoxide (CO) and Benzene (C6H6) contained in the user's breath. The output from the sensor is in the form of analog data which is then converted into digital data by Arduino Nano. This data is then stored in the SD Card module to record the history of previous tests. The saved test history can be viewed again for research or comparison. The results of measuring hazardous gas levels are also displayed on the LCD screen so that users can see the results of measuring hazardous gas levels in their breath directly.

RESULTS AND DISCUSSION

The finished result of the detection device manufacturing process can be seen in Figure 4 below.

Figure4. The detection device looks both inside and out.

Participant

Based on the results of observations and surveys conducted, 30 participants were taken as test samples. Participants consisted of 13 women and 17 men with an age range between 20 and 28 years. All participants were also active users of e-cigarettes (vapers) who had been using e-cigarette products for more than a year.

Testing Phase

Based on medical research, there are several non-invasive methods to measure the levels of harmful gases in the lungs, one of which is by taking a breath sample which is then detected using a gas sensor. In this testing phase, participants are required to follow certain procedures to ensure the desired results, including:

1. Participants took a long, deep breath through their nose with the aim of taking the deepest breath in their lungs.

2. Then the participants held their breath for 15 seconds.

3. Next, the participant exhales slowly and consistently through the tube provided on the device until the participant has exhaled all of his/her breath.

4. The gas sensor will continuously capture the levels of Benzene and Carbon Monoxide in the body in ppm units which are then displayed on the LCD.

Test Results

At this stage, the device has undergone direct testing of breath samples from participants consisting of men and women with the background of all participants being active e-cigarette users or commonly called vapers. Testing is carried out in the morning, afternoon and evening and is carried out in a closed room. This non-invasive test uses a 16 mm pneumatic plastic pipe to take breath samples, with a gas sensor designed to always measure the level of gas around it. Therefore, after three calibrations, the tolerance limit is set at 0.5 ppm for Benzene and 14 ppm for Carbon Monoxide in order to ensure accurate test results.

Figure5. Breath sample acquisition process.

The results of breath sample testing to detect Benzene and Carbon Monoxide gas content in e-cigarette users are presented in the table below.

Table1. Results of participant breath sample testing.

Participant to	Gender	Benzene (ppm)	Carbon Monoxide (ppm)	Age
1	man	1.5	7.4	23
2	Woman	0.7	5.8	24
3	Woman	0.9	5.6	20
4	man	1.9	7.7	25
5	man	0.5	7.6	22
6	man	1.2	5.0	27
7	Woman	1.7	6.8	23

8	man	1.1	6.3	24
9	Woman	1.4	5.3	27
10	man	1.8	5.0	21
11	man	1.4	7.3	20
12	Woman	1.2	5.8	22
13	man	1.6	6.8	28
14	man	0.7	6.5	25
15	Woman	1.4	5.2	28
16	Woman	0.7	5.6	21
17	Woman	1.5	6.6	22
18	man	0.7	5.9	21
19	Woman	0.7	7.2	22
20	Woman	1.3	7.1	21
21	Woman	1.4	7.5	21
22	man	1.8	6.8	24
23	man	1.3	7.9	20
24	man	1.4	5.8	25
25	man	1.3	5.4	23
26	man	1.9	7.1	23
27	Woman	1.4	6.7	20
28	man	0.7	6.9	20
29	Woman	0.6	7.0	26
30	Woman	1.5	5.8	20

The results of breath sample testing showed that almost all participants who actively used e-cigarettes had carbon monoxide levels that exceeded the safe limit of 6 ppm.[7]and Benzene levels which also exceed the safe limit, namely 0.5 ppm[8]. The results of this test also showed that the average level of Carbon Monoxide in male participants was 6.5 ppm, while the Benzene level was 1.3 ppm. Meanwhile, female participants had an average level of both gases lower than male participants with a Benzene level of 1.09 ppm and a Carbon Monoxide level of 6.2 ppm.

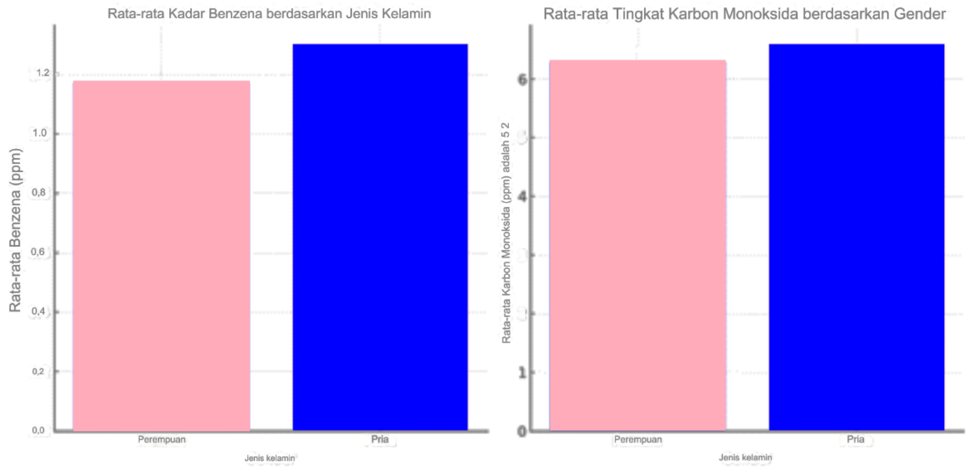

Figure6. Average levels of each gas by gender.

The distribution of Benzene and Carbon Monoxide levels was also further analyzed, showing the range of Benzene and Carbon Monoxide levels in participants. Explanations and graphs of the distribution of Benzene and Carbon Monoxide levels can be seen in Figure 7 below.

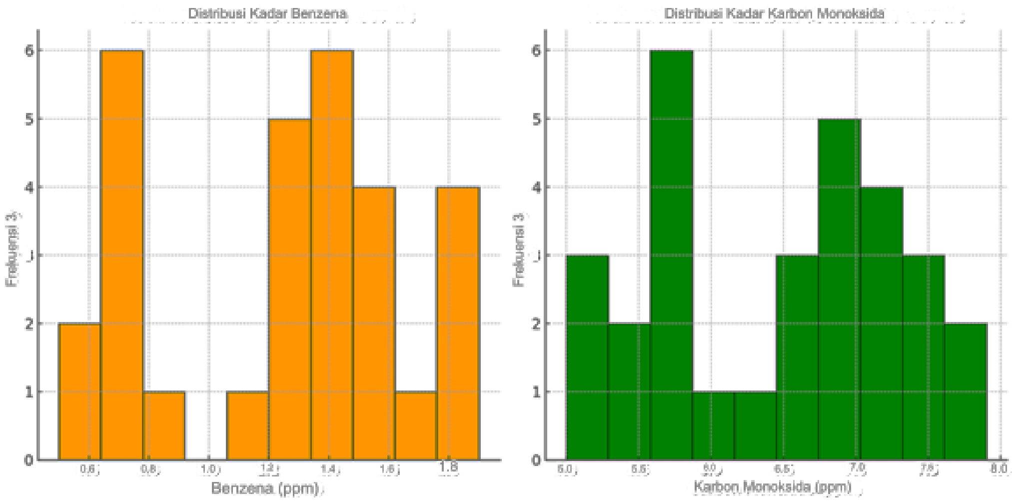

Figure7. Distribution graph of levels of each gas in participants.

The graph above shows the concentration of each gas level where the X-axis shows the concentration of the measured gas level, while the Y-axis shows the frequency of participants whose levels of each measured gas are within the X-axis range. Benzene levels in the left graph, were observed to range from about 0.5 ppm to 1.9 ppm. The most frequently found Benzene concentration ranges were in the range of 0.7 and 1.4 ppm, where each level was found in 6 participants.

Then the Carbon Monoxide levels shown in the right graph, it was observed that the Carbon Monoxide levels found in each participant were in the range of 5.0 and 8.0 ppm, where the most frequently found levels were at 7.0 ppm with 6 participants.

CONCLUSION

The data generated from testing breath samples on e-cigarette users showed that the detection device designed for this study was able to detect levels of Carbon Monoxide and Benzene in the lungs with high sensitivity with both Benzene and Carbon Monoxide gas levels showing a high concentration range among participants. In addition, this study also shows that e-cigarettes and conventional cigarettes are equally dangerous to health in the long term, with the potential to trigger various serious diseases and even death.

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