DESIGN AND ANALYSIS OF LOW-COST INDOOR AIR QUALITY MONITORING DEVICE

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (Air Conditioning and Refrigeration System) WITH HONOURS

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A thesis submitted
in fulfillment of the requirements for the degree of
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2022

DECLARATION

I declare that this Choose an item. entitled “Design and Analysis Of Low-Cost Indoor Air Quality Monitoring Device” 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 : *Shazni*

Name : NurShazni Sahira Binti Mohmad Sariff

Date : 17 January 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 Engineering Technology (Air Conditioning and Refrigeration System) with Honours.

Signature : ....

Supervisor Name : Ts Dr Mohamad Haidir Bin Maslan

Date : 17 January 2022

DEDICATION

This project report is dedicated to my beloved family who has been a constant source of inspiration for me. Thank you to my supervisor, Ts Dr Mohamad Haidir Bin Maslan, as well as all of my lecturers for their assistance and encouragement in this project. They have given me the motivation and discipline to approach any challenge with zeal and determination. Last but not least, I'd like to thank all of my friends who have helped me. This project would not have been possible without their support.

ABSTRACT

Succeeding to the current issue of air quality, this low-cost monitoring device is developed to see whether the air quality in the FTKMP laboratory and campus area are in a good condition or not. Measuring the air quality is the main factor in spreading awareness about the need of ensuring a healthy life for future generations. This device can save cost, easy to access and to analyze the air quality in the FTKMP laboratory and campus area in real-time from the IoT platform that use the Blynk application. This project is to design and develop air quality monitoring device using Arduino Nano as a microcontroller paired with the ESP8266 wifi module which can help to display data in online while the gas sensors, temperature and humidity sensor detect the hazy day which can display the live data on the internet of things (IoT) using the Blynk application. The parameter that measured are the volume of carbon monoxide (CO) and carbon dioxide (CO_2), the temperature and the relative humidity. Other than that, this device can record for 24 hours of histories also it is easy to access and easy to maintain. The CO_2 sensor have calibrated by using the TSI Quest EVM-7 and this device has proved that it can reduce cost on components while can monitored the air quality in the FTKMP laboratory and campus area.

ABSTRAK

Berkenaan dengan isu kualiti udara semasa, alat pemantauan kos rendah ini dibangunkan untuk melihat sama ada kualiti udara di makmal dan kawasan kampus FTKMP berada dalam keadaan baik ataupun tidak. Mengukur kualiti udara adalah faktor utama dalam menyebarkan kesedaran tentang keperluan memastikan kehidupan sihat untuk generasi akan datang. Alat ini boleh menjimatkan kos, mudah diakses dan menganalisis kualiti udara di makmal FTKMP dan kawasan kampus dalam masa nyata daripada platform IoT yang menggunakan aplikasi Blynk. Projek ini adalah untuk mereka bentuk dan membangunkan alat pemantauan kualiti udara menggunakan Arduino Nano sebagai mikropengawal dipasangkan dengan modul wifi ESP8266 yang boleh membantu untuk memaparkan data dalam talian manakala sensor gas, sensor suhu dan kelembapan mengesan hari berjerebu yang boleh memaparkan data secara langsung yang menggunakan medium *internet of things* (IoT) iaitu aplikasi Blynk. Parameter yang diukur ialah isipadu karbon monoksida (CO) dan karbon dioksida (CO_2), suhu dan kelembapan relatif. Selain itu, peranti ini boleh merakam data sejarah selama 24 jam juga ia mudah diakses dan mudah diselenggara. Penderia CO_2 telah ditentukur dengan menggunakan TSI Quest EVM-7 dan alat ini telah membuktikan bahawa ia boleh mengurangkan kos komponen di samping boleh memantau kualiti udara di makmal FTKMP dan kawasan kampus.

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In the Name of Allah, the Most Gracious, the Most Merciful

Alhamdulillah, I would like to take this opportunity to impress my deepest gratitude to Allah because of His willingness to give strength and will for me to finish and implement this project report which were implemented successfully. Besides that, I wish to present million thanks to my parents because have sacrificed and give fully support and impetus by education and implementation this project in Universiti Teknikal Malaysia Melaka (UTEM).

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One more time thanks a lot to my fellow friends for their help to implement this project, sacrificing of time, give outburst idea until completed this project without knowing the meaning of despair. Indeed, each cooperation and assistance from certain parties whether directly or not is huge a blessing for me. Infinite thanks to all who are involved directly especially in Universiti Teknikal Malaysia Melaka (UTEM).

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LIST OF SYMBOLS AND ABBREVIATIONS

IAQ	-	Indoor Air Quality
CO	-	Carbon monoxide
CO_2	-	Carbon dioxide
NO_2	-	Nitrogen dioxide
SO_2	-	Sulphur dioxide
$PM_{2.5}$	-	Fine particulate matter
PM_{10}	-	Coarse particulate matter
IEQ	-	Indoor Environmental Quality
WHO	-	World Health Organization
US	-	United States
EU	-	European Union
API	-	Air Pollutant Index
IPU	-	Indeks Pencemaran Udara
BC	-	Black carbon
VOC	-	Voltile organic
DOSH	-	Department of Occuppational Safety and Health
ETS	-	Environmental tobacco smoke
SBS	-	Sick building syndrome
BRI	-	Building related illness
PAH	-	Polyaromatic hydrocarbon
IARC	-	International Agency for Research on Cancer
APIMS	-	Air Pollutant Index of Malaysia
WAQI	-	World Air Quality Index
USEPA	-	United States Environmental Protection
Hb	-	Haemoglobin
COHb	-	Carboxyhemoglobin
IoT	-	Internet of Things

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CHAPTER 1

INTRODUCTION

1.1 Background

This final year project entails the design and analysis of a low-cost indoor air quality (IAQ) monitoring device. This is a power kit attachment to monitor the boundaries of healthy and harmful indoor air quality in laboratories and campus area in terms of temperature, relative humidity, CO, CO2, PM2.5, and PM10.

This chapter considers the context of the issue statement and offers the goals to be reached as well as the scope of the research project, which clearly outlines the study's constraints. The report's foundation can be used to represent the dissolution in this chapter as well. Furthermore, the course overview and how this project functions are illustrated. Air pollution is the most serious challenge that all countries face, whether developed or developing. Health concerns have become increasingly prevalent, particularly in developing nations' metropolitan centres, where industrialisation and a rise in the number of automobiles has resulted in the production of huge amounts of gaseous pollutants. Pollution causes minor allergic reactions such as irritation of the throat, eyes, and nose, as well as more significant issues such as bronchitis, heart disease, pneumonia, lung illness, and exacerbated asthma. Indoor air quality (IAQ) has been combined with mental health and diseases which are not easily seen in the short term but can constitute major long-term concerns.

Environmental or government entities with regulated pollutant measurement devices are currently monitoring air pollution at static monitoring sites. As people become more aware of the importance of indoor air quality, a slew of indoor environmental quality (IEQ) issues have arisen. indoor lighting quality (ILQ), Indoor air quality (IAQ), thermal comfort (temperature and relative humidity) and acoustic comfort are all included in the term IEQ. These factors, together with the ventilation and air-conditioning systems, have an impact on the health, comfort, and performance of the occupants. Increased ventilation reduces air pollutants and, as a result, pollutant sources, it is one of the most popular ways for enhancing interior air quality. Filters and the replacement of outdated equipment are two other options. Chemical and physical monitoring, on the other hand, are necessary to identify the sources of poor air quality and assess the effectiveness of air quality improvement strategies.

In response to this significant challenge, this project was established to assess air quality for people and all living creatures on the earth. One of the most essential aspects of our life to understand is how safe we are now, as well as how the climate and weather have changed in order to keep a healthy level of pollution in the air. The understanding of air quality reactions will be aided by this monitoring equipment.

1.2 Problem Statement

This device is to monitor the air quality in the laboratory and the campus area whether in a good condition or not. So, while this device has a basic design with three primary sensors: the MQ9 for detecting flammable and carbon monoxide gases, the MQ135 for detecting hazardous and carbon monoxide gases, and the DHT11 for temperature and humidity reading. Before utilising the Arduino IDE software to run the system, the Arduino must be programmed. The Arduino Nano that used with ESP8266 module is a good choice for this project since it responds rapidly and has great stability and long-life qualities. It is suited for mobile measurement and intelligible data collection that is affordable, user-friendly, low-cost, and requires the least amount of power.

1.3 Research Objective

The primary objective of this research is to track the healthy and hazardous limits of indoor air quality for human thermal comfort in Malaysia. This project employs CO and CO_2 sensors, as well as a temperature sensor and a humidity sensor to monitor air quality in terms of dust particles and surrounding temperature, as well as a humidity sensor to monitor air quality in terms of surrounding humidity. The following are the specific objectives:

a) To develop of low-cost indoor air quality monitoring device that easy to access, easy to maintain and portable.

b) To analyze the air quality in the FTKMP laboratory and campus area in real-time from the IoT platform that use the Blynk application.

1.4 Scope of Research

The scope of this project will be focused on the design and analysis of a low-cost monitoring device to monitor the limits of healthy and harmful indoor air quality. The scope of this research are as follows:

- Using Arduino Nano as the microcontroller.
- Using modified of three IAQ standards which are from DOSH, OSHA and ASHRAE.

- The IAQ parameters measured are temperature, relative humidity, volume of CO and CO_2.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Emissions monitoring is now done using either expensive fixed-site facilities or portable devices. It is important to recognize the scope of their actions in terms of air quality. A protection and health improvement industrial air quality surveillance system were also developed in order to identify dangerous gases and their impacts. An air quality control system is proposed in this project. Arduino was used to build the system. The air emissions observation system was developed for real-time monitoring and analysis. The proposed method gives reliable assessments of air quality. In its most basic form, the air pollutant index (API) is a metric for calculating the quantity of pollution in the atmosphere. The higher the API, the greater the hazard to human health from air pollution.

Indoor Air Quality (IAQ) is concerned with air quality in buildings and structures, as well as in the environment, with a focus on occupant health and comfort. Controlling and reducing common contaminants at home can assist to minimize your risk of indoor health issues. Following exposure to indoor air pollution, health consequences may occur immediately or years later.

It has been estimated that low air quality in New Zealand causes 1,175 premature deaths and costs more than $4 billion annually. Both our cardiovascular and respiratory systems can be harmed by poor air quality. Various forms of contaminants affect our wellbeing differently. So far, most air quality research has focused on the open air, although we spend roughly 80% of our time indoors. As a result, we must have a better understanding of the pollutants to which individuals are exposed indoors. Furthermore, new literature shows that indoor pollutant exposure is much higher than indoor exposure.

The Air Pollutant Index (API) or IPU (Indeks Pencemaran Udara) in Malay is used for characterising and documenting air quality, which may be assessed using a variety of sets of air pollution data. The Malaysian air quality index is the same as the Air Pollution Index. The API system employs six major air pollutants that may have an impact on human health in situations of poor health. On September 22, 2015, Palangkaraya in Indonesia recorded the highest API value ever for Southeast Asian hazel, which was 1,986.

Indoor environmental quality (IEQ) can also be referred to as indoor air quality (IAQ), ventilation requirements and health consequences assessed through the Hazard Index and cancer risk have been studied through indoor or outdoor accumulation of CO2 and particulate matter (PM) in a naturally ventilated classroom (Schibuola & Tambani, 2020). The occupancy of a region depends on a number of device parameters. Adequate indoor quality (IEQ) is determined by four basic components: thermal comfort, air quality (IAQ), sound and eye comfort (reddy Kotha, 2014).

2.2 Particulate Matter

Indoor air contributes essentially to personal exposure to pollutants (Morawskaet al., 2017). A broad variety of pollutants, including particulates (PM), black carbon (BC), voltile organic

(VOC), and others, are used indoor indoor air contaminants in addition to formaldehyde (Li et al., 2020). The quantity of both dangerous particles and liquids roaming in the air. The entire complex mix includes both natural and artificial particles such as powder, pollen, coal dust, smoke and water vapour but they are considerably different in scale, design and origin (Li et al., 2020). Particles in the air, for instance if coal is burnt and wind brings dust, may either be emitted directly. It can also be made indirectly by converting the previously emitted gaseous pollutants into the environment into so-called particles (Li et al., 2020). PM can be divided into two major groups known as the ground fraction and fine fraction based on its size. It includes the larger particles with the finer fraction, which is between 2.5 and 10 µm in size (PM_{10}-$PM_{2.5}$). Whereas the smaller fraction up to 2.5µm ($PM_{2.5}$) is found for the fine fraction.

2.3 Coarse Fraction (PM_{10})

PM10 is categorized as coarse fractions particulate matter. The inhaled particles typically measure about 10µm in diameter and are less. The general matter of airborne PM10 particles is sea salt and other combustion processes, including cars and mechanical activities. The mechanical decomposition of larger solid particles creates coarse particles. The rough part may include highway dust, agriculture operations, exposed soil or mining, and non-fuel released materials for fossil fuels (Man, 2019). According to the World Health Organisation, the minimum air quality guidelines for PM10 are 20µg/m3 per year and 50µg/m3 per 24 hours (WHO). Anyone with chronic heart or lung conditions will also be at risk as they improve the side-effects, including wheezing, chest strain, and respiratory difficulties. The person's eyes and throat could be caused by long-term PM10 toxicity.

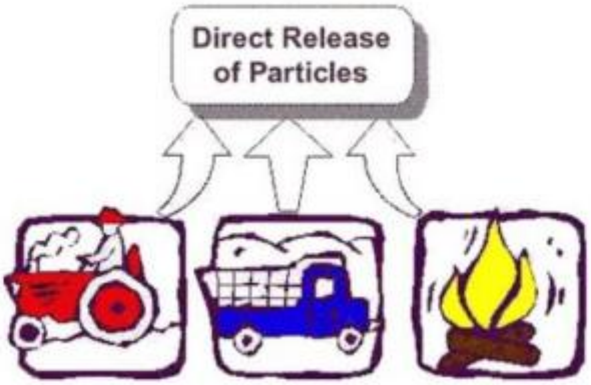

Figure 2.1 Coarse fraction particulate matter exposer

2.4 Fine Coarse($PM_{2.5}$)

PM2.5 is divided into fine particles and consists mostly of gases. PM2.5 is smaller than 2.5µm in diameter. PM2.5 can be divided into two, both indoor and outdoor outlets. PM2.5, which originates in traffic and manufacturing operations from an external source and which is distributed to indoor areas by airflow and open windows. However, heating, smoking and cleaning may also lead to the indoor source (Li et al., 2020). According to the World Health Organization, the minimum Air quality requirements are 10µg/m3 per year and 50µg/m3 per 24 hour, respectively (WHO).

2.5 Effects of Indoor Air Quality

Indoor Air Quality (IAQ) refers to the air quality inside and outside of buildings and facilities as it pertains to the health and comfort of those who reside there. Understanding and tracking common indoor contaminants can assist you in lowering your risk of developing indoor health concerns. Indoor air pollution can have immediate or long-term health implications.