Current Applied Science and Technology e-ISSN: 2586-9396

Curr. Appl. Sci. Technol. ….., Vol… (No…), e0267312

Research article

The Study and Design of the Filter Bag Efficiency Control Set Using Arduino

Ataphon Praeyat[1], Thitiwut Mongkolpak[1], Pitchayathida Salalai[1], Akekachai Pannawan[2], Chaowanan Jamroen[2] and Niphon Chinchusak[1]*

[1]Division of Mechanical and Automotive Engineering Technology, Faculty of Engineering and Technology, King Mongkut's University of Technology North Bangkok, Rayong Campus, Rayong, 21120, Thailand
[2]Division of Instrumentation and Automation Engineering Technology, Faculty of Engineering and Technology, King Mongkut's University of Technology North Bangkok, Rayong Campus, Rayong, 21120, Thailand

Received: 22 April 2025, Revised: 19 October 2025, Accepted: 22 December 2025, Published:18 February 2026

Abstract

The objectives of this research were to study and design a filter bag efficiency control set using Arduino that could function as a real-time alert system. The device consisted of dust measurement sensors located at two different spots and a NodeMCU control board. The lab was simulated using a transparent acrylic box, and two experiments were conducted. There were two methods used in Experiment 1, and the results of the second method with an installed filter bag and operating blower showed to be more efficient than the first one as it could reduce the amount of dust down to 12 μg/m³. In Experiment 2, talcum powder was utilized as the dust. The amount of dust passing through the blower into the bag varied in accordance with that inside the box. When the filter bag was full (at 1710 s [= 1,000 μg/m³]), the amount of dust increased during the ongoing experiment due to the lower efficiency of the bag. When the amount of dust surpassed the standard amount of 120 μg/m³ (at 2520 s), a red warning light appeared, indicating that the filter bag had to be immediately replaced with a new one.

Keywords: design; filter bag; efficiency; control set; Arduino

1. Introduction

The current problem of dust is one of the major environmental crises worldwide. Dust is defined as small particles of solids in the air, which are divided into different sizes, e.g., PM10 and PM2.5, with the numbers referring to the diameters of the dust measured in microns. In particular, PM2.5 particles, which are so small that they can penetrate into the respiratory system and bloodstream of humans, can result in severe health

*Corresponding author: E-mail: niphon.c@eat.kmutnb.ac.th
https://doi.org/10.55003/cast.2026.267312

problems. The causes of dust mainly arise from human activities, e.g., fossil fuel combustion from transportation and industrial plants, forest fires, agricultural material burning, and construction. The impact of dust does not only damage human health in terms of respiratory illnesses, asthma, heart disease, and lung cancer but also includes a wide range of effects on the environment such as reduced visibility and less sunlight reaching the ground, which affects photosynthesis and the balance of the global climate. Undoubtedly, dust is therefore a problem that requires urgent solutions at the global, continental, national, and local levels, such as promoting public transportation in order to reduce the use of personal vehicles, banning open burning, creating more green spaces to absorb dust, building awareness for cooperation to reduce dust-generating activities, identifying solutions, and relying on pollution reduction technology in industrial plants.

Currently, the number of industrial plants in Thailand is growing, resulting in higher amounts of dust, air pollution, and environmental impact. Several industrial plants with an awareness of the problems and harm caused by dust, implemented the ISO 14000 (International Organization for Standardization, 2015), an international standard for environmental management. Even so, there are still a large number of plants without efficient environmental management. These plants generate significant dust from their own manufacturing processes, e.g., rubber band plants, Thai herbal medicine plants, cassava starch plants, plants making corrugated carton boxes with cassava-based liquid glue, etc. In general, filter bags are available in these plants in order to prevent dust from spreading inside the operations areas; however, most employees in those areas do not recognize when filter bags are full, or their filtration efficiency is low because there is no alert system.

Thus, there have been numerous studies and research conducted in order to investigate more efficient dust management methods, and more electronic systems, communication systems, digital platforms, and computer programs are being applied. For example, the filtering process was tested on both a PC-based platform and an embedded system in a study by Çelebi (2020). The first goal of this study was to compare the results of the filtering process obtained in MATLAB and Arduino environments. The second purpose involved trying the filtering process in real-time on the Arduino platform with the produced filter coefficients. The influence of heterogeneous dust concentrations as a common filter non-uniformity is investigated on filter performance, i.e., pressure drop increase as a measure for filter cycle cleaning frequency, being a precursor for filter life-time, dust emissions, and operating costs (Koch & Krammer, 2016). A dust source was simulated to maintain dust concentrations in the air as required in the control room using Arduino (Hofstetter et al., 2022).

The Internet of Things (IoT) is used for dust detection and alert (Deecharoenchitpong & Tortrakul, 2019). It is also applied to an indoor air purifier (Kousalya, 2022), with the use of a low-cost ventilator design using Arduino. In this research, a portable ventilator was designed using an AMBU (Artificial Manual Breathing Unit) Bag. By employing sensors, the breathing count, pressure, and volume of air passed to the patient from the ventilator were measured and the readings could be displayed using both an Android app and a LCD display. When the pressure exceeded the threshold level, the assistant near the patients was alerted by a buzzer, and a doctor received a message notification via Telegram (Hridhya, 2021).

An air purifier was designed and developed with three auto-driving speed levels under a remote controller for dust and pathogen filtration. The device functioned with two modes as follows: 1) In Auto mode, which detected dust at the level of PM2.5, the values obtained were compared with the standard safety level (≤ 25 μg/m³), and when the values were over 25 μg/m³, the blower and the UV light started operating and then stopped when the dust amounts were below 10 μg/m³. 2) In Manual mode, the air filter began running immediately after the switch was turned on. In this research, dust was created by lighting incense sticks (Deephang et al., 2022).

Research on the contamination accumulation characteristics of insulators is the basis of pollution flashover prevention work (Lv et al., 2019). Also, equipment to reduce air pollution from angle grinders was designed and improved using the theory of inventive problem solving, Eco design concepts (Arom, 2023), and a cyclone dust collector (Peiymjaisawang, 2020). Filter bag separation efficiency in furniture wooden boards was tested using pulse-jet filtration (Dembinski et al., 2022). A dust remover was developed based on knowledge about electrostatics and electronics (Homnan & Phukhang, 2012).

A PM2.5 monitoring and alert device with results received via the LINE application was also developed. This device used a microcontroller to regulate the interpretation from the sensor that measured the amount of PM2.5, temperature, and humidity. Alerts were displayed as flashing green, yellow, and red lights on the screen (Pongphab & Santakij, 2021). The impacts of temperature and humidity on concentrations of PM2.5 and PM10 (Zender-Swiercz et al, 2024) were also studied. The research team (Yueroh at al., 2024) examined the relationship between the amounts of air pollution in the forms of PM10 and PM2.5 and the medical treatment of respiratory diseases.

Simultaneously, a MiniVol Portable Air Sampler operating at 5 L/min was designed and used at three sampling stations. Elemental analysis was performed on a microwave plasma atomic emission spectrometer (MP-AES). In total, 14 inorganic elements (Zn, Fe, Cd, V, Ca, Ni, Cu, As, Co, Pb, K, Mn, Mg, and Na) were quantified in the PM10 mass. The indoor and outdoor concentrations of PM10 ranged from 3.81 to 19.07 µg/m3 and from 17.86 to 51.35 µg/m3, respectively (Rojano et al., 2023).

Recently, a predictive model was created using Rapid Miner Studio, along with a dust warning system and a model to predict the amount of PM2.5 that could send alerts via the LINE application when the amount of dust was over the standard limit. Artificial neural networks were also used to predict amounts of dust beforehand (Sawangcharoen et al., 2024).

Based on these previous findings, the researcher searched for and studied the methods that could provide a warning or alert when filter bags were full or their filtration efficiency was low, with instant reports that could be applied to industrial filter bags in plants. Thus, the simulation of a filter bag efficiency control set using Arduino was implemented in this research. The equipment used was simple, inexpensive, easily installed, and easy to use. Furthermore, the device could reduce the levels of dust that affect employee health and could promote predictive maintenance as well.

2. Materials and Methods

2.1 The development and design of the dust measurement equipment

The structure in this simulation was designed in a vertical rectangular shape, as if it were an operating area that requires control and measurement of dust amounts.

2.1.1 Dust filter installation structure

The materials used for designing and constructing the structure were angle bars and six transparent acrylic sheets (60 x 80 x 3 mm), which were used to close all four sides as well as the top and bottom forming a box that simulated a room that could be viewed clearly during the experiment. These are common and inexpensive materials with a high level of durability. Then, the first sensor was installed on the top of a 15 x 32 cm filter bag for 5-micron particles to measure the amounts of dust. The lowest part of the structure was installed with the second sensor at the blower. This spot was located outside the box in order to suck the simulated dust into the filter bag (Figure 1).

2.1.2 Dust source

Most of the dust in plants is PM2.5, referring to particles/particulate matter smaller than 2.5 microns. Some types of dust might be larger than this, e.g., PM10 (≤ 10 microns). The size of dust depends on the type of industry and manufacturing process. Thus, talcum powder, with its 5-micron particles (Figure 1), was used as the simulated dust source to imitate the dust that is commonly found in plants (Xi'An LIB Environmental Simulation Industry, 2023). Its typical profile lies within the range of Thailand's air quality standard control for PM10, i.e., a 24-h average concentration of ≤120 μg/m³ (Pollution Control Department, 2023). The dust measurement system relied on a gravimetric reference standard (Suwanthada, 2017).

2.1.3 Sensor

A PM2.5 PM-G7 (PMS7003) sensor was installed at two locations (Figures 1 and 2). This model provides precise measurements of particles in the air and can detect PM1.0-PM2.5 and PM10. Using laser technology, the sensor facilitates detection of the smallest particles of 0.3 μm. The precision of measurement is basically calculated in μg/m³. The response time is less than 10 s. As for the calibration frequency of the PM2.5 sensor, it depends on its usage. If it is used for legal reports, the measurement must be done once a year. However, in the case of measurement for monitoring the results, it should be done more often, e.g., every 3 months, every 6 months, or as suggested by the manufacturer (Tido Technology, 2024).

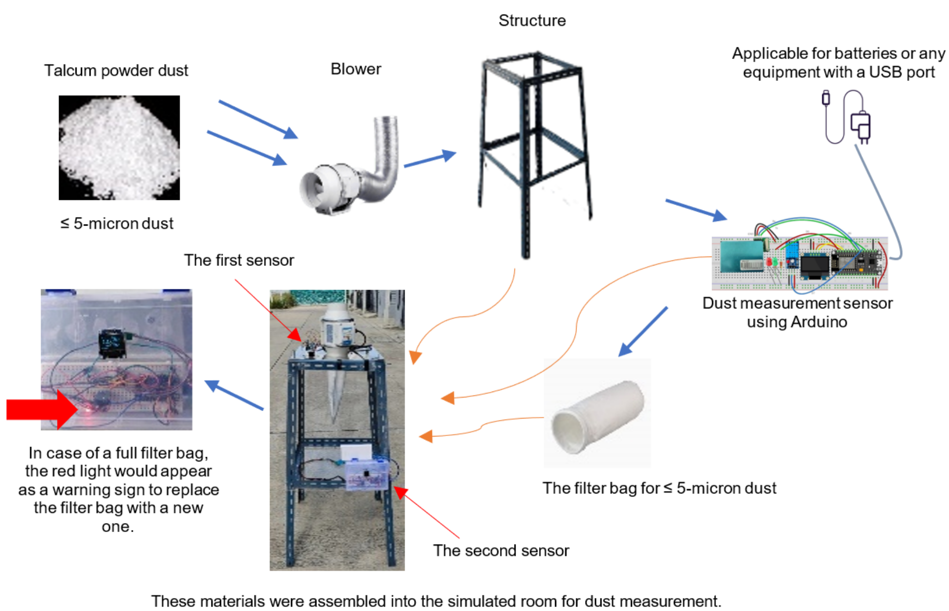
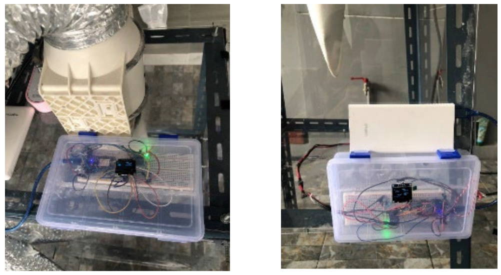


Figure 1. Structure of the dust measurement equipment and efficiency control in the filter bag using Arduino



The first sensor The second sensor

Figure 2. The two locations where the sensors were installed.

2.1.4 Dust measurement equipment

There were two sets of dust measurement equipment using Arduino, starting from creating the particulate matter station through three steps as follows.

1. Registration for Blynk IoT
2. Creating a template and setting the DataStream on the Blynk website
3. Coding

Step 1: Registration for Blynk IoT

First, the program was uploaded to the NodeMCU board, which was connected to the computer through USB. The board was set to "NodeMCU 1.0 (ESP-12E Module)" by activating Arduino IDE. To describe, the researcher clicked Tools > Board "NodeMCU 1.0 (ESP-12E Module)" > ESP8266 > NodeMCU 1.0 (ESP-12E Module) (Figure 3).

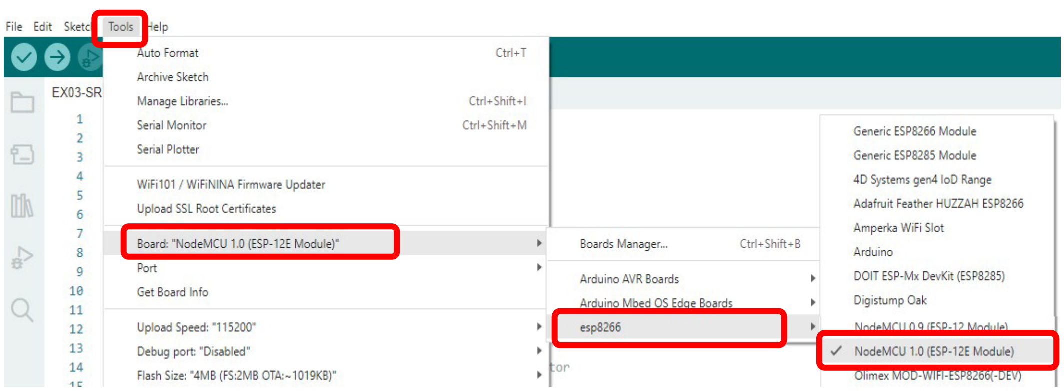


Figure 3. Uploading the program to the NodeMCU board

Following this, the researcher implemented the use of Blynk, an application for the Internet of Things (IoT), with the NodeMCU board. The interesting features of this application include easy coding with no need to write an app on your own, real-time use, and simple connections between various devices and the internet, i.e., Arduino, Esp8266, Esp32, NodeMCU, and Raspberry Pi. Above all, Blynk can be used free of charge and supports both IOS and Android (Figure 4).

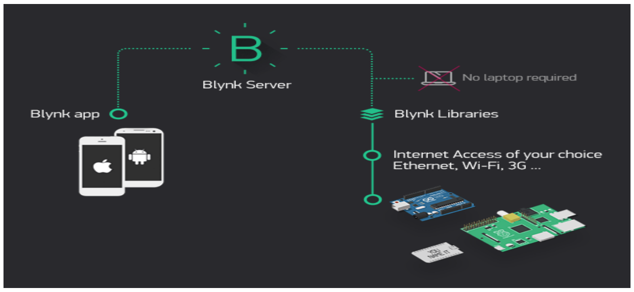


Figure 4. Blynk server connection structure
Source: https://docs.makerplayground.io/intro/iot/blynk

Step 2: Creating a template and setting the DataStream on the Blynk website as follows.

1. The researcher went to https://blynk.cloud/dashboard/login and logged into the "Dashboard" (Figure 5).

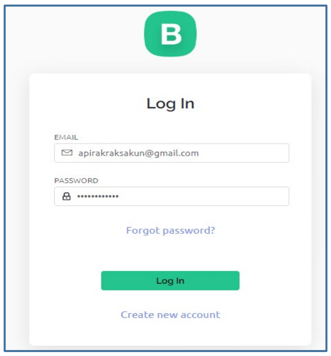


Figure 5. Login page to enter the "Dashboard"

2. On the "Developer Zone" page, the researcher clicked "My Template" and "New Template" (Figure 6).

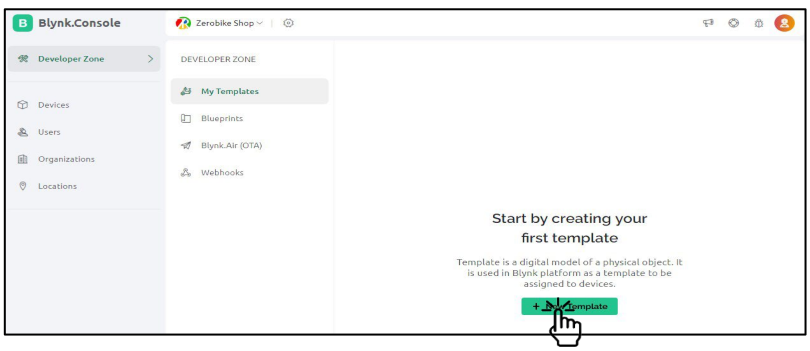


Figure 6. "Start by creating your first template"

3. Then, clicked “Done” (Figure 7).

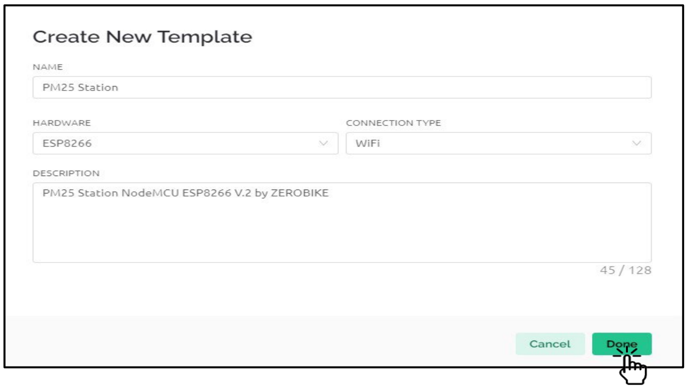


Figure 7. After the data selection, clicked “Done”.

4. The “Template” page appeared as shown in Figure 8, and the data could then be edited.

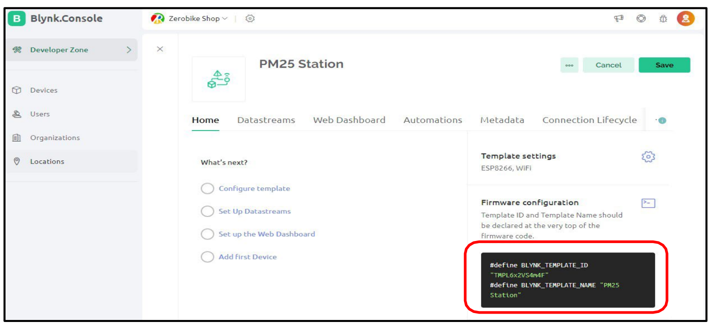


Figure 8. The “Template” page, on which data could be edited

5. On this page, clicked “Datastreams,” “New Datastream,” and “Virtual Pin” (Figure 9).

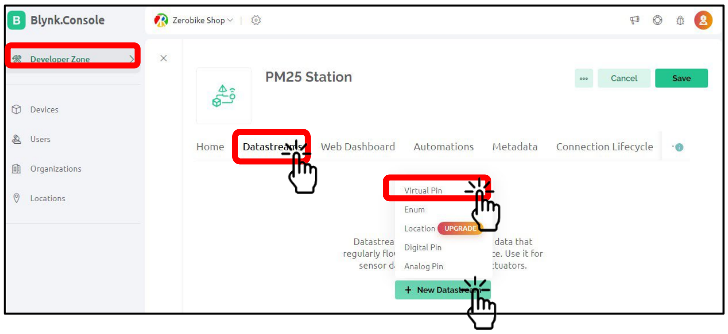


Figure 9. The “Template” page

6. On the “Virtual Pin Datastream” page, filled in the blanks, and clicked “Create” (Figure 10).

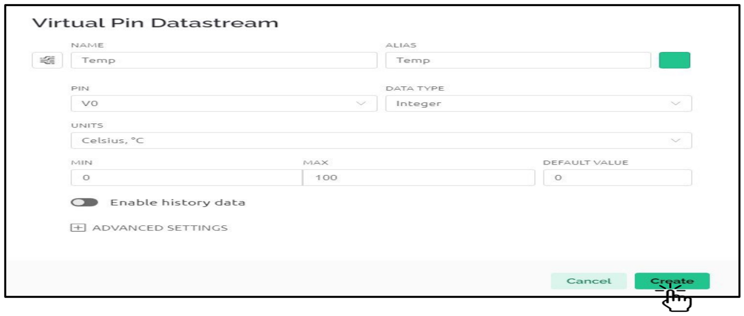


Figure 10. On the “Virtual Pin Datastream” page, filled in the blanks and clicked “Create”.

7. The “Datastream” with the name “Temp” was created (Figure 11).

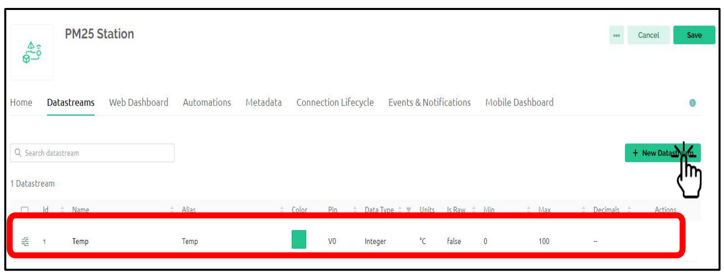


Figure 11. “Datastream” with the name “Temp”

8. Clicked “New Datastream” again to create the “Virtual Pin Datastreams” with the names “Humidity” and “PM 2.5,” set as V1 and V2 (Figure 12).

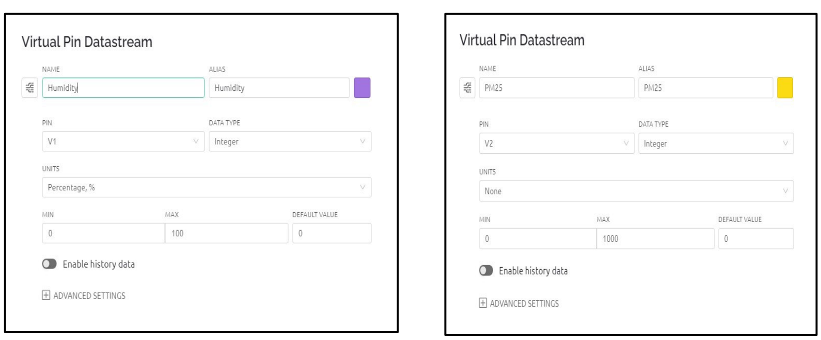


Figure 12. “Virtual Pin Datastreams” named “Humidity” and “PM 2.5,” set as V1 and V2

9. Checked “Datastreams” (Figure 13) and clicked “Save” to finish creating the Datastreams. Temperature and humidity were included in the settings because they affect

dust measurement in plants. Rising/higher temperatures increase the kinematics of particles in the air, resulting in increased floating and spread of dust. High humidity facilitates the formation of dust into clusters and might also result in absorption of moisture, which may result in increased weight.

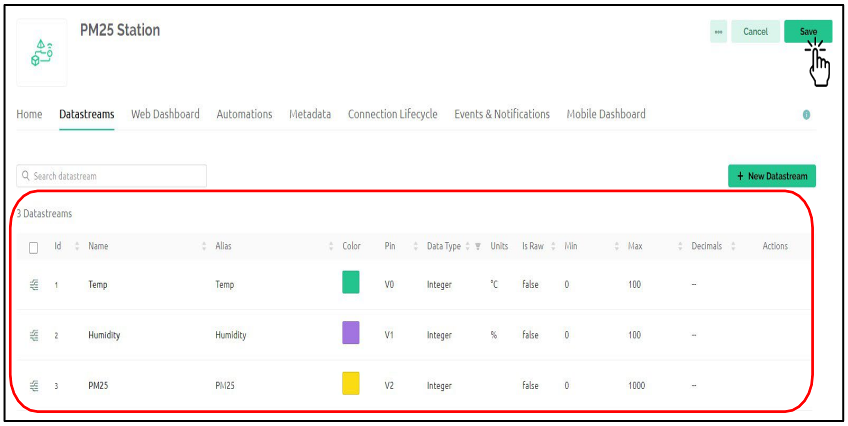


Figure 13. Finished DataStreams

Step 3: Coding

1. Blynk was installed by first opening Arduino IDE. Then, the researcher clicked "Tools" and "Manage Libraries," or opened them by clicking on the icons (Figure 14).

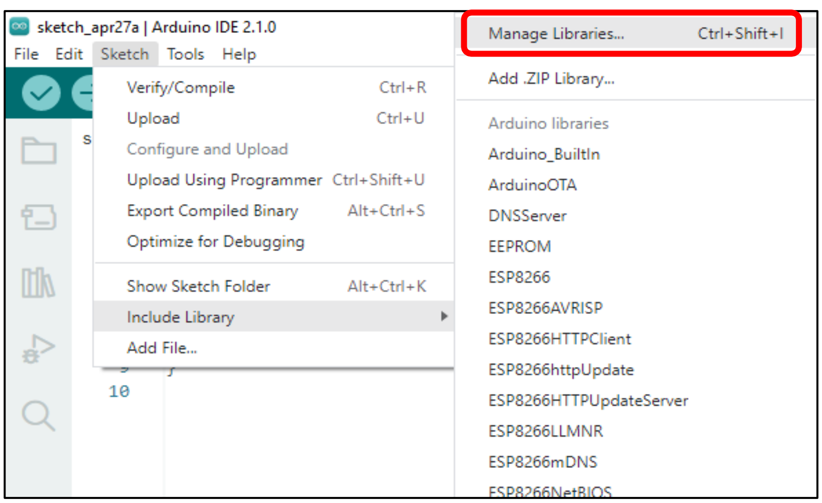


Figure 14. Library installation for Blynk by opening Arduino IDE and clicking "Tools" and "Manage Libraries," or by clicking on the icons

2. Typed the word "Blynk" in "Filter your search" to search for and install the "Library." Then, "Library Blynk" appeared (Figure 15).

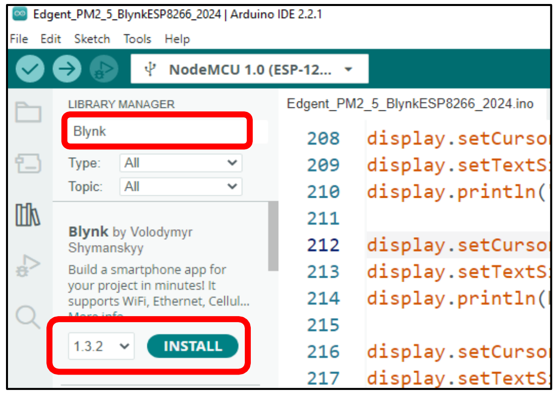


Figure 15. Searching for and installing the “Library”

3. Selected the latest version (“1.3.2” in Figure 16) and clicked “INSTALL ALL.”

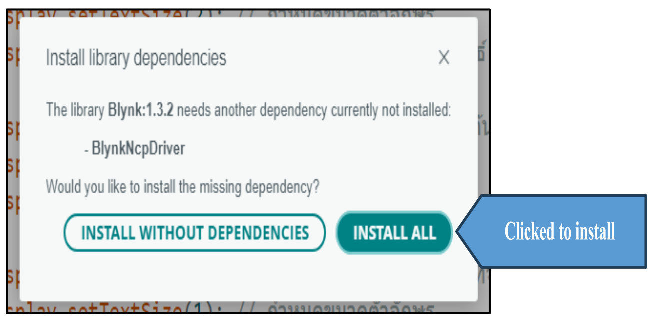


Figure 16. The latest version (1.3.2) selected for installation

4. Installed the “Library for 0.96” OLED display (Figure 17).

Figure 17. “Library” installation for 0.96 OLED display

5. Typed “adafruit ssd1306” in the blank “Filter your search” to search for and install the “Library,” and “Library Adafruit SSD1306” appeared. Then, selected the latest version (2.5.9 as seen in Figure 18) and clicked “INSTALL.”

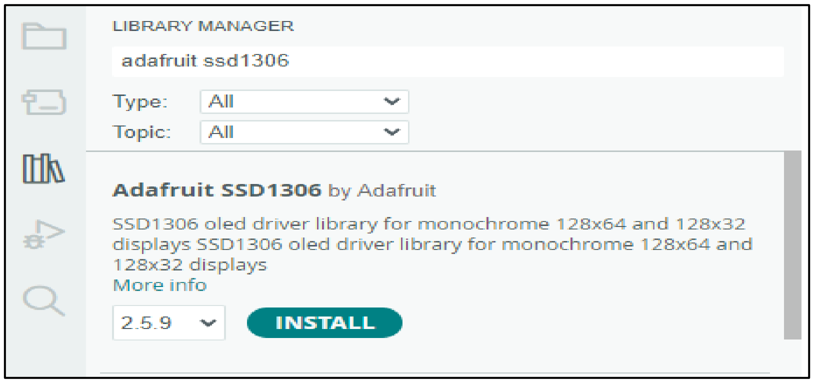


Figure 18. Searching for and installing the “Library”

6. Clicked “INSTALL ALL” for “Adafruit GFX Library” installation (Figure 19) and waited until the installation was finished.

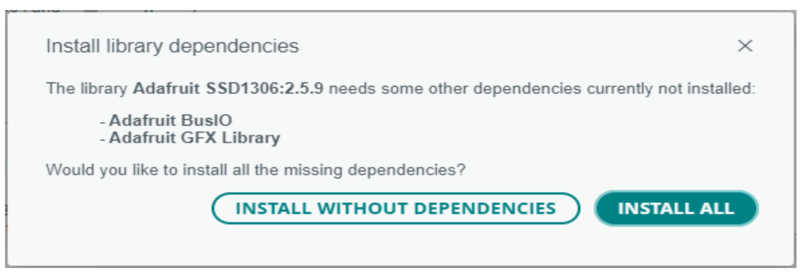


Figure 19. “Adafruit GFX Library” installation

7. Copied the files from “Zerobike Shop” to “Document” and “Arduino” (Figure 20).

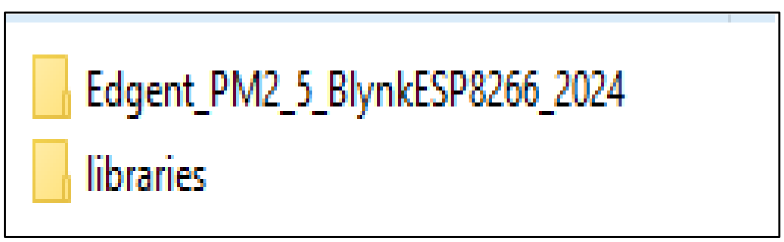


Figure 20. The files copied from “Zerobike Shop” to “Document” and “Arduino”

8. Opened “Sketch” in the folder “Edgent_PM2_5_Blynk ESP8266_2024” and edited the “Blynk Template” in accordance with the created “FIRMWARE configuration” in Step 2 regarding “BLYNK_TEMPLATE_ID” and “BLYNK_DEVICE_NAME” (Figure 21) (Copied and replaced).

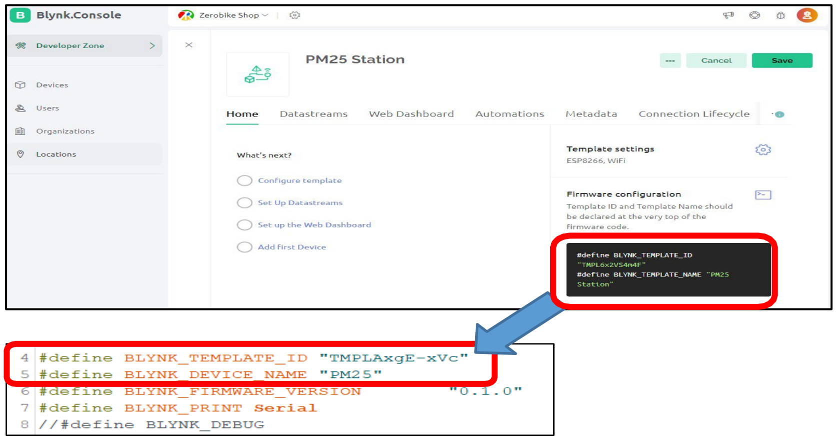


Figure 21. The opened “Sketch” in the folder “Edgent_PM2_5_BlynkESP8266_2024”

9. Assembled the circuit of the filter bag efficiency control set (Figure 22).

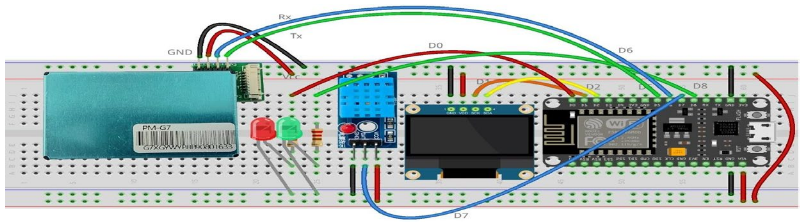


Figure 22. Assembled filter bag efficiency control set circuit.

10. The correct boards and ports were selected. Then, clicked “Upload” (Figure 23) to finish the installation of the dust measurement equipment for the filter bags using Arduino.

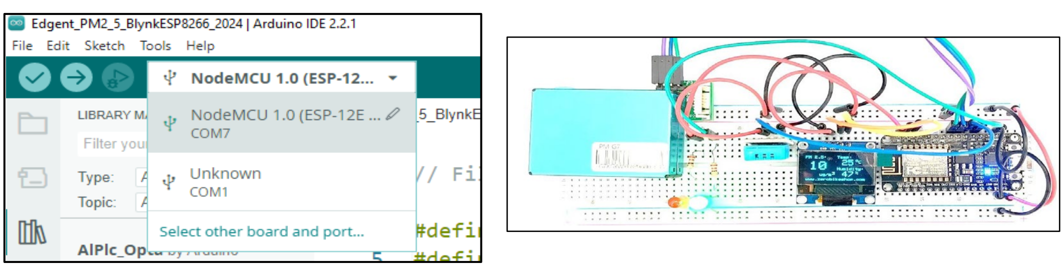


Figure 23. Dust measurement equipment of the filter bags using Arduino

2.2 Testing the simulation by dust measurement

For the testing of the dust measurement in filter bags with instant reports, Arduino was used to facilitate the dust measurement. There were two experiments as follows.

2.2.1 Experiment 1

The amounts of dust around the entrance of the blower (external area) and inside the acrylic box (similar to the air inside a room) were measured. There were two cases as below.

Case 1: No filter bag, with the blower turned on (Figure 24-A).

Case 2: With a filter bag and the blower turned on (Figure 24-B).

The second sensor was installed for dust measurement to compare the amounts of both spots, and to analyze the results (Figure 24).

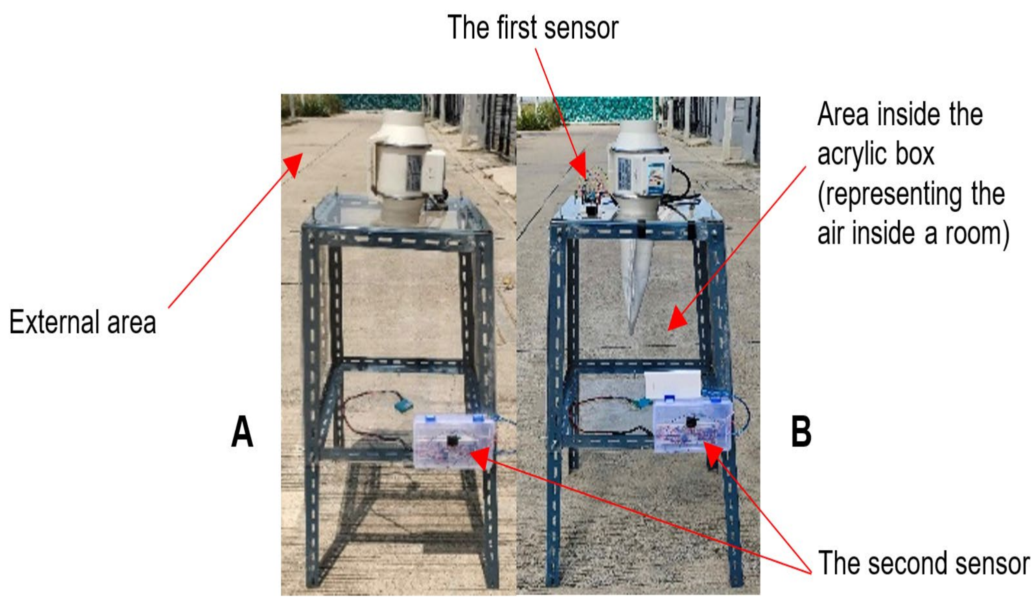


Figure 24. Equipment in Experiment 1

2.2.2 Experiment 2

The experiment of dust measurement was conducted using talcum powder to simulate dust in a plant in order to identify the amounts of dust passing through the blower into the filter bag (Sensor 1), and to quantify the amounts of dust inside the acrylic box (as if it were an operations area at a plant, with dust occurring while working and with the filter bag in the room (Sensor 2). The values obtained from the sensors at both spots were compared, followed by an analysis of the results (Figure 25).

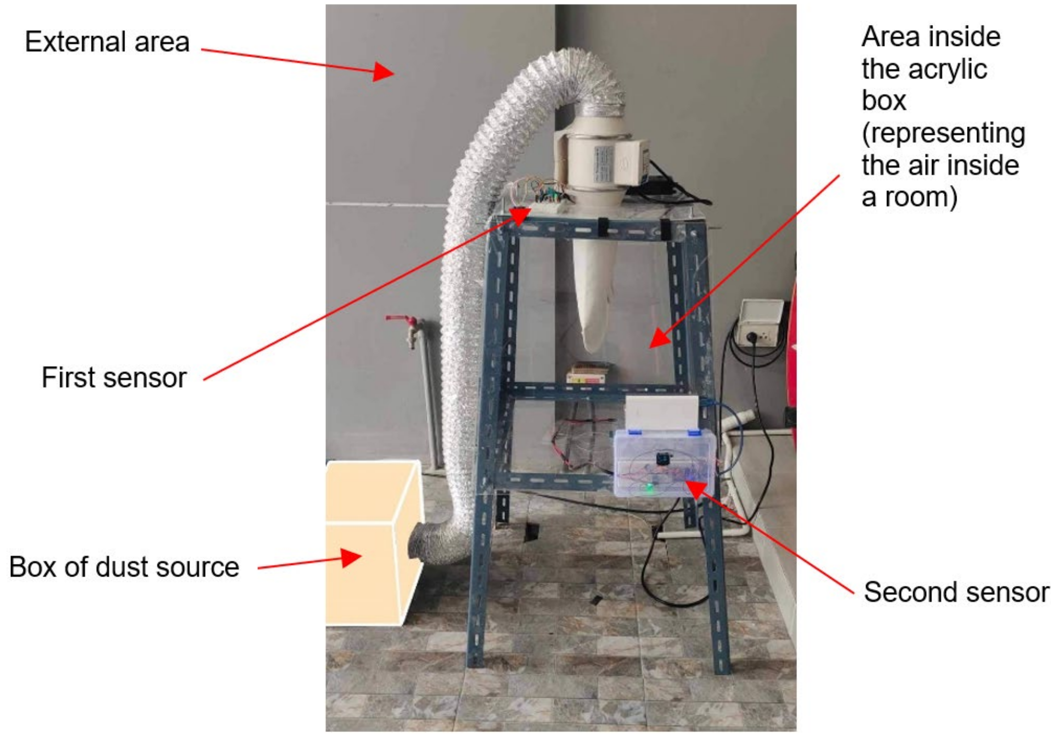


Figure 25. Equipment in Experiment 2

3. Results and Discussion

3.1 Data of Experiment 1

Case 1: No filter bag. The blower was turned on, and the experiment was conducted. The data was collected four times, and the average amounts of dust inside the box and from the external area were 50 and 60 μg/m³, respectively. The amount of dust inside the box tended to be similar to that found in the external area at each point in the experiment (Table 1).

Table 1. Amounts of dust found in Case 1 (No filter bag, with the blower turned on)

No.	Area Inside the Acrylic Box (μg/m³)	External Area (μg/m³)
1	39	60
2	55	61
3	58	61
4	48	58
Avg.	50	60

Figure 26 shows the graphs indicating the average amounts of dust inside the box and in the external area in the case with no filter bag. It was found that the amounts obtained were not significantly different. If this area were a real workspace, it would be unsafe without the use of filter bags, and dust in the area could be harmful and affect employee health.

Case 2: A filter bag was installed (each time), and the blower was turned on. The experiment was conducted, and the data was collected four times. The average amounts of dust inside the box and in the external area were 12 and 62 µg/m³, respectively. The amount of dust inside the box tended to be obviously reduced when compared with that in the external area at each point of the data collection in the experiment (Table 2).

Figure 27 presents the graphs showing the average amounts of dust inside the box and in the external area in the case with installed filter bags. It was found that the amounts obtained were obviously different. If this area were a real workspace, the filter bags inside could reduce the amounts of dust as well as the impacts on employee health.

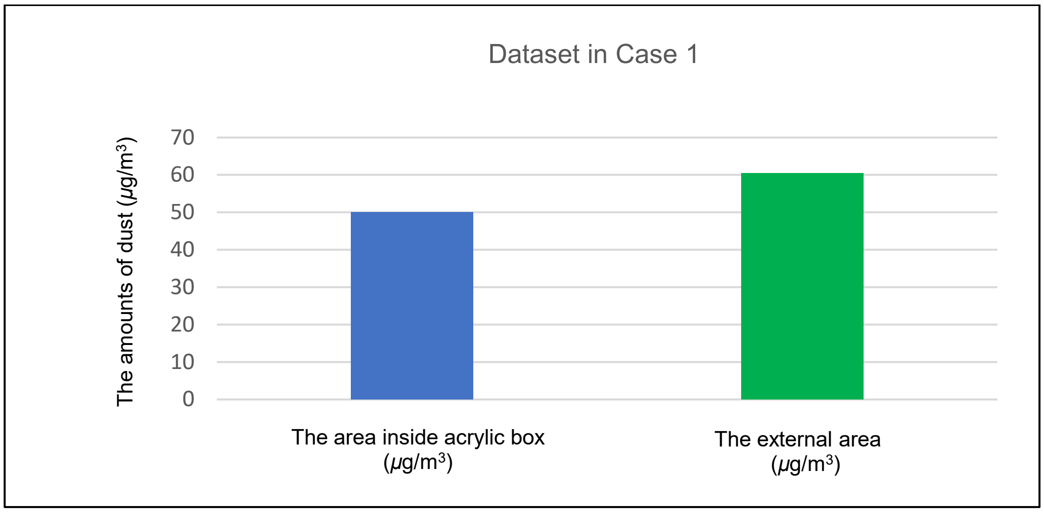


Figure 26. Average amounts of dust inside the box and in the external area in the case with no filter bag

Table 2. Amounts of dust in Case 2 (with filter bags and the blower turned on)

No.	Area Inside the Acrylic Box (µg/m³)	External Area (µg/m³)
1	21	60
2	10	65
3	9	63
4	7	60
Avg.	12	62

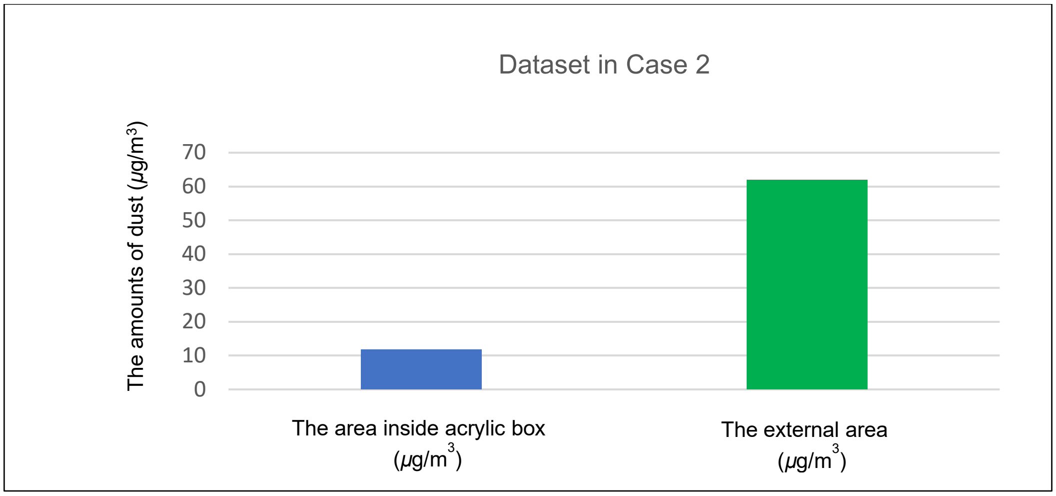


Figure 27. Average amounts of dust inside the box and in the external area in the case with installed filter bags

3.2 Data of Experiment 2

The amounts of dust were measured during the simulation. In this research, dust was simulated using talcum powder to imitate the real dust found in plants in order to evaluate the amount of dust collected through the blower into the filter bag, and the amount of dust inside the acrylic box was also calculated. The sensors were installed at two locations (Figure 25). The results were reported every 45 s until the amount of dust inside the bag reached 1,000 μg/m³ and when the amount of dust in the controlled area went over the standard amount of 120 μg/m³, the red light appeared as a warning sign, which indicated that the experiment was finished. The experiment was repeated from the start to the end one more time, with the results reported in Table 3.

As can be seen in Table 3, the values obtained from the results of the two experiments were identical. The detected amounts of dust in the filter bag, compared with those inside the acrylic box, are shown. Clearly, the amounts of dust passing through the blower into the filter bag varied when compared with those inside the box. Furthermore, when the filter bag was full (at 1710 s = 1,000 μg/m³), dust continued to enter the bag during the ongoing experiment. Therefore, the amount of dust inside the box increased due to the lower efficiency of the bag, and when the amount of dust in the controlled area surpassed the standard amount of 120 μg/m³ (at 2520 s), the red warning light appeared. If this area were a real workspace inside a plant, the red light would remind employees of the need for filter bag replacement. In a case where they continued using the same bag, it could affect employee health due to the poor efficiency of the filter bag.

Figure 28 displays the graphs showing the amount of dust inside the filter bag compared with that inside the acrylic box. Obviously, the amount of dust passing through the blower into the filter bag (the blue line graph) at the initial phase of the experiment (at 45 to 1710 s) continued to increase while that inside the acrylic box (the orange line graph) decreased, respectively. Moreover, when the filter bag was full at the amount of 1,000 μg/m³, the amount remained stable, but as the experiment was continued, dust kept entering the box until the amount of dust inside the box (the orange line graph) increased due to the lower efficiency of the filter bag (at 1710 to 2745 s).

Table 3. Amounts of dust in Experiment 2

Time (s)	Amounts of Dust Inside the Filter Bags (µg/m³)		Amounts of Dust Inside the Box (µg/m³)	
	Test#1	Test#2	Test#1	Test#2
45	89	86	83	82
90	92	90	80	80
135	97	97	79	79
180	112	112	78	78
225	120	120	77	77
270	132	132	69	69
315	165	165	66	66
360	183	183	57	57
405	191	191	43	43
450	201	201	36	36
495	213	213	34	34
540	221	221	33	33
585	229	229	28	28
630	241	241	28	28
675	269	269	28	28
720	312	312	27	27
765	336	336	27	27
810	441	441	22	22
855	537	537	22	22
900	586	586	22	22
945	588	588	22	22
990	613	613	21	21
1035	618	618	21	21
1080	644	644	19	19
1125	768	768	16	16
1170	786	786	15	15
1215	810	810	13	13
1260	822	822	12	12
1305	850	850	12	12
1350	912	912	12	12
1395	913	913	12	12
1440	913	913	10	10
1485	945	945	10	10
1530	960	960	9	9
1575	978	978	9	9
1620	988	988	9	9

Table 3. Amounts of dust in Experiment 2 (continued)

Time (s)	Amounts of Dust Inside the Filter Bags (µg/m³)		Amounts of Dust Inside the Box (µg/m³)	
	Test#1	Test#2	Test#1	Test#2
1665	991	991	9	9
1710	1000	1000	7	7
1755	1000	1000	7	7
1800	1000	1000	6	6
1845	1000	1000	18	18
1890	1000	1000	31	31
1935	1000	1000	43	43
1980	1000	1000	66	66
2025	1000	1000	71	71
2070	1000	1000	88	88
2115	1000	1000	91	91
2160	1000	1000	97	97
2205	1000	1000	98	98
2250	1000	1000	105	105
2295	1000	1000	106	106
2340	1000	1000	109	109
2385	1000	1000	109	109
2430	1000	1000	114	114
2475	1000	1000	115	115
2520	1000	1000	123	123
2565	1000	1000	129	129
2610	1000	1000	129	129
2655	1000	1000	132	132
2700	1000	1000	161	161
2745	1000	1000	175	175

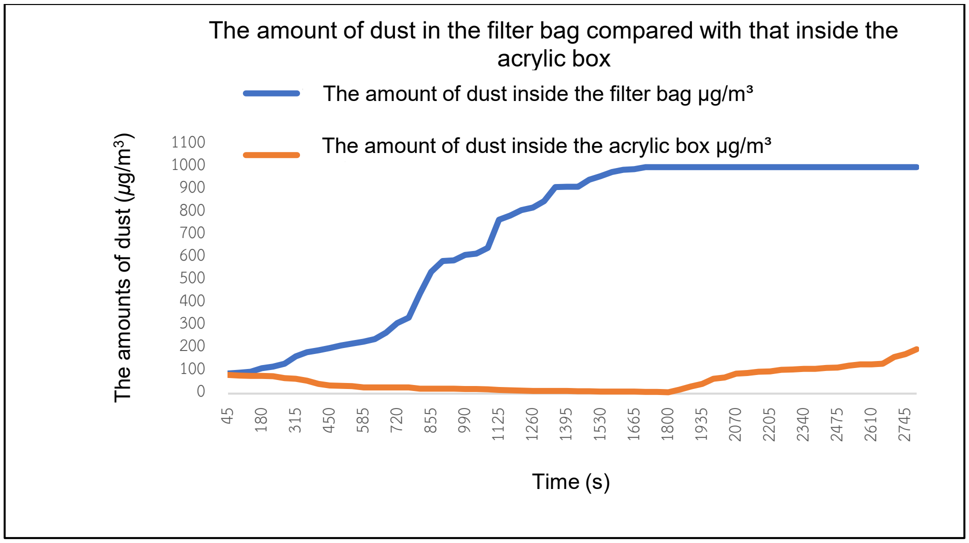


Figure 28. Amounts of dust inside the filter bag and inside the acrylic box

As can be seen in Figure 29, the red line indicates the standard amount of dust that is controlled inside general plants that should not be over 120 μg/m³ (the safe standard amounts should range from 6 to 120 μg/m³). Obviously, the effective and high-level efficiency of the filter bag led to lower amounts of dust or safe/controllable amounts. To clarify, the blue line graph must remain between the green and the red lines. In contrast, the full filter bag or its lower efficiency resulted in higher amounts of dust inside the acrylic box. To illustrate, from 2520 s onward, as indicated by the blue line graph, the amount of dust in the box tended to rise above the red line. This instantly implied that the level was unsafe and that the filter bag must be replaced with a new one. At this point, the red warning light from the filter bag efficiency control box would immediately appear.

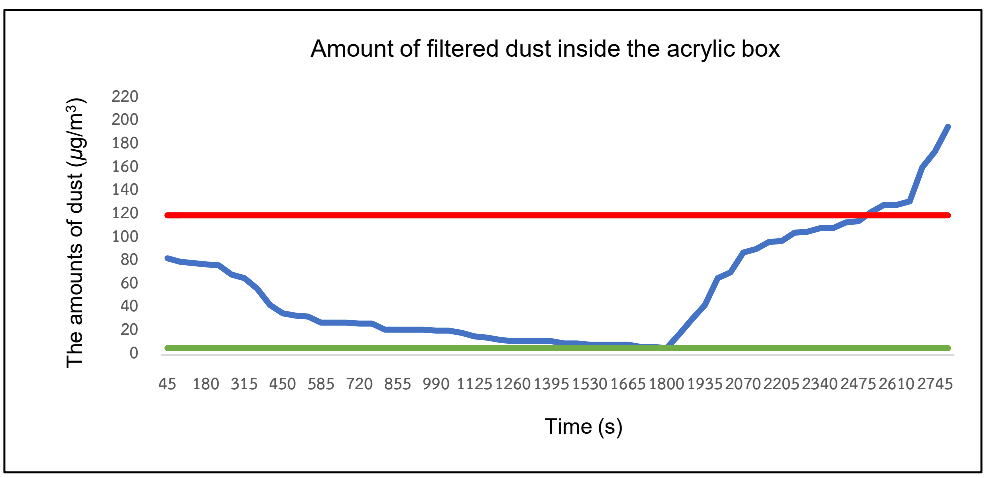


Figure 29. Amount of dust when the filter bag was full and operating with lower efficiency.

4. Conclusions

Based on the simulation of the filter bag efficiency control set using Arduino with the dust sensor at two locations, it was found that the design used in Experiment 1 (Method 2), with filter bags and the blower turned on, was more effective. The amounts of dust found inside the acrylic box and the external area were significantly different, i.e., 12 and 62 μg/m³, respectively. If this area were a real workspace, the filter bags inside could reduce the amount of dust as well as the impacts on employee health. As for Experiment 2, in which talcum powder was used as dust, the amount of dust passing through the blower into the filter bag varied with that inside the acrylic box. Moreover, when the filter bag was full at 1710 s [= 1,000 μg/m³], the amount of dust inside the box increased due to the lower efficiency of the bag during the ongoing experiment. Additionally, when the amount of dust in the controlled area exceeded the standard amount of 120 μg/m³ (at 2520 s), the red light appeared as a reminder that it was the time to replace the filter bag with a new one immediately. Currently, a large number of workplaces and plants contain dust during their operations without any warning systems of full filter bags at all. As a result, environmental impact on workspace occurs, along with short-term and long-term effects on employee health. Thus, installation of filter bag efficiency control sets using Arduino can alleviate these problems and can be applied to the installation of dust measurement and control sets for filter bags in general industrial plants. Moreover, this will also promote predictive maintenance at the same time.

5. Acknowledgements

This research was supported by the Faculty of Engineering and Technology, King Mongkut's University of Technology North Bangkok, Rayong Campus, Rayong, Thailand.

6. Authors' Contributions

Ataphon Praeyat and Niphon Chinchusak designed research;
Ataphon Praeyat, Thitiwut Mongkolpak, Pitchayathida Salalai and Niphon Chinchusak performed research;
Ataphon Praeyat, Akekachai Pannawan and Niphon Chinchusak contributed new reagents/analytic tools;
Ataphon Praeyat, Thitiwut Mongkolpak, Pitchayathida Salalai and Niphon Chinchusak analyzed data;
Akekachai Pannawan and Chaowanan Jamroen coordinated research; and
Ataphon Praeyat and Niphon Chinchusak wrote the paper

7. Conflicts of Interest

The authors declare no conflict interest.

References

Arom, P. (2023). *Design of dust collector for angle grinder via cyclone system*. [Master of Engineering Thesis, Thammasat University]. Thammasat University https://ethesisarchive.library.tu.ac.th/thesis/2023/TU_2023_6410037029_17184_29412.pdf

Çelebi, M. (2020). Digital filter design based on ARDUINO and its applications. In *2020 medical technologies congress (TIPTEKNO)* (pp. 1-4). IEEE. https://doi.org/10.1109/TIPTEKNO50054.2020.9299311

Deecharoenchitpong, J., & Tortrakul, P. (2019). The development of dust detection and warning system prototypes by Internet of Things. *Journal of Thonburi University (Sciences and Technology), 3*(1), 34- 43.

Deephang, A., Addoddorn, D., & Aekkuerkul, T. (2022). The design and construction of automatic 3 speed level mobile air filter controlled by microcontroller. *Udon Thani Rajabhat University Journal of Sciences and Technology*, *10*(3), 63-79.

Dembinski, C., Potok, Z., Kucerka, M., Kiminiak, R., Ockajova, A., & Rogozinski, T. (2022). The dust separation efficiency of filter bags used in the wood-based panels furniture factory. *Materials*, *15*(9), Article 3232. https://doi.org/10.3390/ma15093232

Hofstetter, D., Fabian, E., Dominguez, D., & Lorenzoni, A. G. (2022). Automatically controlled dust generation system using Arduino. *Sensors*, *22*(12), Article 4574. https://doi.org/10.3390/s22124574

Homnan, W., & Phukhang. (2012). *Dust collector*. [Bachelor Thesis, Faculty of Electrical and Computer Engineering, Naresuan University]. Naresuan University https://nuir.lib.nu.ac.th/dspace/bitstream/123456789/3104/1/WeeraphanHomnan.pdf

Hridhya, A. P. (2021). Low cost ventilator design using Arduino. *International Advanced Research Journal in Science, Engineering and Technology*, *8*(2), 221-226.

International Organization for Standardization. (2015). *ISO 14000 family: Environmental management*. ISO. https://www.iso.org/standards/popular/iso-14000-family

Koch, M., & Krammer, G. (2016). Filter performance with non-uniformly distributed concentration of dust-evidence from experiments and models. *Powder Technology*, *292*, 149-157.

Kousalya, C. G., Boppana, U. M., Kondapalli, R., Ahammed, T., Gallardo, C. G. S., Balaji, P., & Afroj, M. (2022). Design of IoT based indoor air purifier. In *2022 Third international conference on intelligent computing instrumentation and control technologies (ICICICT)* (pp. 1534-1539). IEEE.

Lv, Y., Zhao, W., Yan, W., & Liu, Y. (2019). Optimization of the contamination particle deposition model based on humidity and surface energy. *Applied Thermal Engineering*, *157*, Article 113734. https://doi.org/10.1016/j.applthermaleng.2019.113734

Peiymjaisawang, R. (2020). Cyclone: Dust sorting tool in the industrial sector. *Thai Environment*, *24*(4), 1-9.

Pollution Control Department. (2023). *Air quality index of Thailand Law in 2023*. Ministry of Natural Resources and Environment. https://www.pcd.go.th/laws/29909

Pongphab, D., & Santakij, P. (2021). Dust PM 2.5 monitoring and alert system via LINE application. *UTK Research Journal, 15*(2), 45-57.

Rojano, R., Vengoechea, A. M., & Arregocés, H. A. (2023). Indoor/outdoor relationship of particulate matter (PM10) and its chemical composition in a coastal region of Colombia. *Case Studies in Chemical Environmental Engineering*, *8*, Article 100397. https://doi.org/10.1016/j.cscee.2023.100397

Sawangcharoen, K., Teekasap, S., Nareenoi, P., & Todaeng, P. (2024). Creation of a dust warning system and a model for predicting the amount of small dust particles PM 2.5 using artificial neural networks for local development. *Journal of BSRU-Research and Development Institute, 9*(2), 73-96.

Suwanthada, P. (2017). Importance of flow rate to atmospheric dust measurements. In *2017 Academic conference on flow metrology day "we go together."* National Institute of Metrology (Thailand). https://shorturl.asia/f4reS

Tido Technology. (2024, May 10). *PMS7003 Laser dust sensor PM2.5 G7. Air Dust Sensor.* https://www.tido.tech/index.php/product/pms7003-laser-dust-sensor-pm2-5-g7/#

Xi'An LIB Environmental Simulation Industry. (2023). *Talcum powder for IP 5X dust testing*. https://th.libtestchamber.com/info/talcum-powder-for-ip-5x-dust-testing-87587375.html

Yueroh, N., Supapvanich, C., Pongkaset, A., Darama, M., & Bilheem, S. (2024). Respirable dust levels and hospital visits for respiratory diseases of people living in Hat Yai Municipality, Songkhla Province. *The Southern College Network Journal of Nursing and Public Health, 11*(1), 1-13.

Zender-Swiercz, E., Galiszewska, B., Telejko, M., & Starzomska, M. (2024). The effect oftemperature and humidity of air on the concentration of particulate matter-PM2.5 and PM10. *Atmospheric Research*, *312*, Article 107733. https://doi.org/10.1016/j.atmosres.2024.107733