Research, Design and Manufacture of Dust Filtration, Odor Removal, and Sterilization Equipment Suitable for Offices in Hanoi, Vietnam

N. H. Son[1], V. T. N. Uyen[2], N. C. Bao[2], N. T. Can[3], H. N. Tan[3]

[1]Department of Science and Technology, Hanoi University of Industry, Hanoi, Vietnam
[2]School of Mechanical and Automotive Engineering, Hanoi University of Industry, Hanoi, Vietnam
[3]Vietnam – Japan Center, Hanoi University of Industry, Hanoi, Vietnam

ABSTRACT

This article presents part of the research results on the design and manufacture of dust filtration, odor removal, and sterilization equipment (the Equipment) for offices in Hanoi, Vietnam. The Equipment integrates three functions: dust filtration (with two levels: coarse and fine), odor removal, and sterilization. This Equipment is designed based on the survey results of PM10 and PM2.5 dust concentrations at several locations in Hanoi. The Equipment is designed for offices with an area of 80 m², where the dust filtration module uses a two-layer filter, odor removal uses activated carbon filters, and sterilization uses ultraviolet (UV) light.

KEYWORDS: *Dust Filtration; Odor Removal; Sterilization.*

How to cite this paper: N. H. Son | V. T. N. Uyen | N. C. Bao | N. T. Can | H. N. Tan "Research, Design and Manufacture of Dust Filtration, Odor Removal, and Sterilization Equipment Suitable for Offices in Hanoi, Vietnam" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-8 | Issue-5, October 2024, pp.887-891, URL: www.ijtsrd.com/papers/ijtsrd69442.pdf

IJTSRD69442

I. INTRODUCTION

Air pollution is a cause of increased risks of stroke, neurological disorders, cardiovascular diseases, cancer, and a range of respiratory diseases such as asthma, pneumonia, and even lung cancer. Air pollution is currently a global concern as it is considered a leading factor causing serious impacts on the environment and public health.

Indoor air quality has a significant impact on the health and work efficiency of the community, especially in offices. When windows are closed to keep the room warm in winter or air conditioners are used to cool in summer, the level of indoor air pollution is often higher than outside.

Currently, dust filtration, odor removal, and sterilization equipment have been widely researched and produced in both industry and daily life. In Vietnam, there are many commercially available dust filtration devices [1], [2] from various origins such as China, South Korea, Japan, etc. However, each dust filtration device is usually suitable for different environmental conditions and locations. Therefore, researching and manufacturing integrated dust filtration, odor removal, and sterilization equipment suitable for specific conditions is necessary and highly practical.

II. SURVEY OF DUST CONCENTRATIONS IN SOME OFFICE AREAS IN HANOI

Each dust filtration device will have different dust filtration methods suitable for dust concentration and particle size. In reality, each specific area in Hanoi will have different dust concentrations depending on its location: near highways, industrial zones, or areas with many trees. Therefore, it is necessary to survey and evaluate dust concentrations in various areas of the city to develop appropriate models and technical factors for dust filtration equipment. Below are some images of measurements of total suspended particles with an aerodynamic diameter of less than or equal to 10 µm (PM10) at offices on Le Duc Tho, Duong Dinh Nghe, Pham Hung streets, and Nhon station (Fig 1).

Figure 1. Results of PM10 Dust Concentration Measurements at Several Points in Hanoi

The results show that the PM10 dust concentration is very high, significantly exceeding the permissible standards for office areas. The measuring device used is the handheld Airvom T dust concentration meter, manufacturer: OEM, origin: South Korea [3].

III. EQUIPMENT DESIGN

The equipment is designed based on the following technical specifications:

- Filters dust > 0.5 µm.
- Removes 99.5% of common viruses and bacteria in the output air.
- Airflow > 600 m³/h.
- Noise level < 70 dB.
- Power consumption < 200 W.
- Removes common odors.
- Suitable for rooms with an air volume of 240 m³.
- Equipment dimensions: 500×420×280 mm.

A. Selection of Exhaust Fan

To calculate the selection of the fan, we base it on the design parameters: Airflow (> 600 m³/h); Noise level (< 70 dB); Power consumption (< 200 W). With the requirement of circulating the air twice per hour for a workspace with a volume of 240 m³, the air volume pushed out in 1 hour is: 240×2 = 480 m³.

From there, we have the option to select the GF 120-2 fan (Figure 2) that meets the specified requirements [4]:

TABLE I Exhaust Fan Specifications (Fig 2)

No.	Fan name	Airflow (m³/h)	Noise Level (dB)	Power (W)	Duct Diameter (mm)	Pressure (Pa)
1	GF 120-2	633	65	90	150	112

Figure 2. Exhaust Fan

B. Design of Exhaust Fan Layout

* Option 1 (Fig. 3)

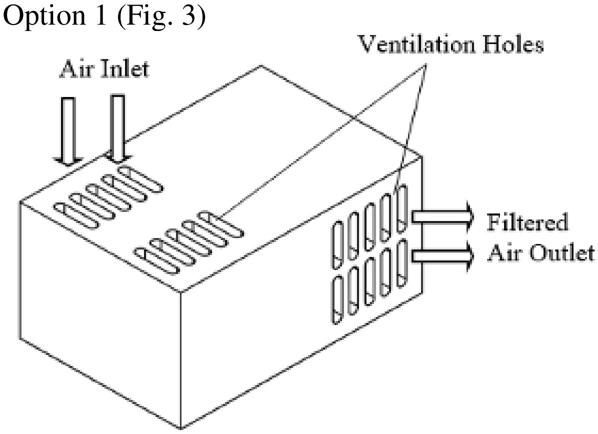

Figure 3. Exhaust Fan Layout Option 1

* Option 2 (Fig. 4)

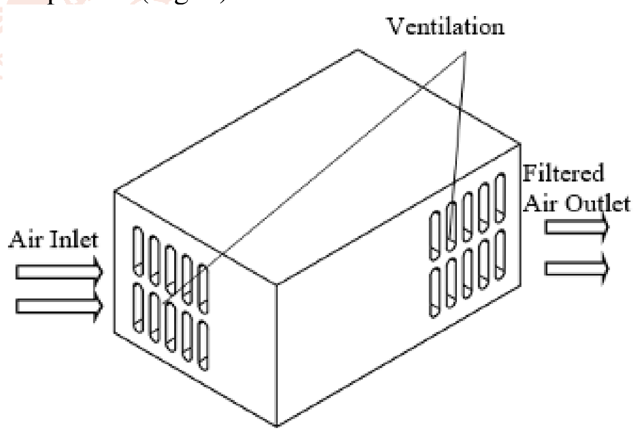

Figure 4. Exhaust Fan Layout Option 2

Based on the structural shape of the exhaust fan as shown (Figure 2) and the practical requirements when using the equipment, the author proposes two design options for the exhaust fan layout in the equipment as follows:

Through the images of the exhaust fan layout in the equipment for the two options, the author chooses Option 2 due to the following advantages:
- Easier to manufacture the casing
- Easier to arrange internal components
- Enhances the aesthetics of the equipment.

C. Design of the Number and Placement of Filters
To meet the requirement of filtering dust particles larger than 0.5 µm and removing odors, the equipment uses three filters. The filters are arranged sequentially from the air inlet, including a coarse filter, a fine filter, and an odor removal filter. The filters are placed in front of the fan.

* Coarse Filter: The coarse filter is the first layer that comes into contact with dust and dirt, capable of removing large dust particles larger than 10 µm and hazardous solid substances. Additionally, the coarse filter protects the subsequent filters (fine filter and odor filter), helping to extend their lifespan. The material of the coarse filter is usually synthetic fibers.

- With a fan duct diameter of 150 mm, the cross-sectional area of the fan duct is 17662.5 mm². The author will select a filter with a filtration area larger than the cross-sectional area of the fan duct. To optimize the filtration of air passing through the filter and for technical considerations, the author selects a filter with a cross-sectional area of 255x385 mm. Similarly, the other two filters, the fine filter and the odor filter, will also have a cross-sectional area of 255x385 mm (Fig 5).

Figure 5. Coarse Filter

* Fine Filter: High Efficiency Particulate Air (HEPA) filters are standard air filters that can filter particles larger than or equal to 0.3 micrometers (µm). The filtration efficiency is 99.97% according to U.S. standards or 99.95% according to European standards.

- Essentially, a HEPA filter is a mesh of randomly arranged fibers. The fibers, usually made of fiberglass or non-woven fabric, have diameters ranging from 0.5 to 2.0 micrometers. Important factors affecting filtration efficiency include fiber thickness and face velocity. The gaps between HEPA fibers are typically larger than 0.3 µm. Unlike thin-film filtration technology, where particles larger than the gaps in the filter are blocked, HEPA filters can block particles smaller than the gaps (Fig 6).

Figure 6. Fine Filter

* Odor Removal Filter: The odor removal filter is made from carbon cotton or fine granular activated carbon pressed into paper and fitted into a pre-cut frame to form a sheet.

- The operating principle of the activated carbon filter is that when the odorous air passes through this carbon sheet, it absorbs and removes the odor. Therefore, if the odor concentration is high, multiple layers are required to fully absorb the odor.

Figure 7. Odor Removal Filter

- The required dimensions of the equipment are 500x400x280 mm, and the estimated length of the fan is about 210 mm, so the total length for installing the filters in the equipment should not exceed 290 mm.

The author chooses to place the filters at equal distances to ensure the equipment's required dimensions and the effectiveness of the filters (Fig 7).

D. Selection and Arrangement of UV Light for Sterilization
Based on the design specifications, with the requirement to remove 99.5% of common viruses and bacteria, the authors choose LED lights for their long lifespan. The UV light model is UV GL14520, and the LED lights are arranged in front of the fan inlet to ensure that all air passing through is exposed to UV light (Fig 8).

Technical specifications of the light [5]:
- Power: 2.5W
- Voltage: 12V
- Current: 500mA
- Dimensions: 145x20x2 mm
- Wavelength: 265-285 nm
- Number of chips: 5 pcs

- Materials: aluminum/copper PCB and UVC LED diode

Figure 8. Đèn led UV GL14520

IV. 3D DESIGN AND CONSTRUCTION OF EQUIPMENT ASSEMBLY DRAWING

Any mechanical product must go through a rigorous design process to ensure quality and functionality. Mechanical products are designed in 3D using software tools that are considered powerful aids for engineers in the design and manufacturing process. These tools help design and develop products with greater accuracy and speed, facilitating assembly, inspection, and alignment to ensure all parts fit together perfectly in the final stage. Based on the above design analysis results, the authors designed the 3D model of the equipment as shown below (Fig 9).

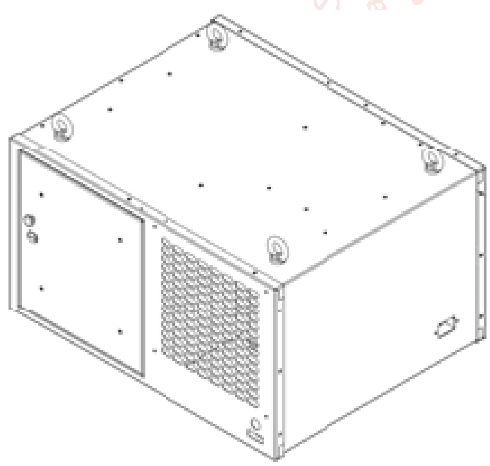

Figure 9. 3D Drawing of the Equipment

V. RESULTS OF MANUFACTURING AND TESTING THE EQUIPMENT

Based on the assembly drawings and detailed drawings of the equipment, the authors have manufactured the components according to technical requirements, assembled the equipment as required, and arranged the components as per the design. They connected the power and control systems for the equipment (the control system is not presented in this paper). The fully assembled equipment is described in Fig 10.

After assembly, the authors conducted trial runs and adjustments, then tested the equipment to evaluate its dust filtration, odor removal, and sterilization criteria in the field. The evaluation results showed that the equipment met the set requirements.

Figure 10. Equipment after Manufacturing

VI. CONCLUSION

In summary, the authors have presented the process of designing, manufacturing, assembling, and testing the dust filtration, odor removal, and sterilization equipment. This equipment is suitable for office environments with an area of about 80 m² in Hanoi, Vietnam. The equipment is designed and manufactured with the following basic specifications: filters dust > 0.5 μm; removes 99.5% of common viruses and bacteria; power consumption < 200W; removes common odors; equipment dimensions 500×420×280 mm. This equipment is suitable for working environments with high levels of air pollution (dust, odors, bacteria, mold). The equipment was tested and evaluated to meet the design requirements.

Acknowledgements: This work was supported by the Hanoi University of Industry, Vietnam under Grant No. 10-2022-RD/HD-DHCN.

VII. REFERENCES

[1] https://www.samsung.com/vn/air-care/air-purifier/ax3100-ax32bg3100gbsv/?cid=vn_pd_ppc_google-search-new_da-multiple_always-on_lt-da-smallha-awo2024-airpurifier-sem-Generic-Exact-Product-General-MaxClick-PDP_search-sem-ppc_none_none_lo&gclid=CjwKCAjw9p24BhB_EiwA8ID5BlVX7rlYYjT_H1OZi0evKvTkeiAj_djhObsUg5-5weRE8j6VOoNAixoC7PsQAvD_BwE

[2] https://www.lg.com/vn/cham-soc-khong-khi/may-loc-khong-khi/?ec_model_status_code=ACTIVE&sortCriteria=%40ec_spotlights_order_no+descending%

2C%40ec_salable_status+descending%2C%40ec_model_release_date+descending&utm_source=Google&utm_medium=cpc&utm_campaign=HQSEM_HA_VH_Google_Air-Purifier_Generic_Phrase_VI&utm_content=HQSEM_HA_VH_Google_Air-Purifier_Generic_Phrase_VI_Generic-Weather-H_k20230418417_pc_230705&gad_source=1&gclid=CjwKCAjw9p24BhB_EiwA8ID5BmfkO8HXWtRQDIaTTUtGYyqxUn2oxZd2thDXlS0FlCKt3ksR207RlhoCx9gQAvD_BwE

[3] https://tktech.vn/may-do-bui-min-va-bui-sieu-min-airvom-t/?srsltid=AfmBOorh2cLRZ2A1s8hc06KfuTPYEugQ64O5DRQR3D1aXMLZ47Cr-j31

[4] https://hungvuongcoltd.com/san-pham/quat-ly-tam-noi-ong-popula-gf1202-860.html

[5] https://vi.made-in-china.com/co_mrleds/product_LED-UV-Germicidal-Ultraviolet-Lamps-99-Disinfect-UVC-254-275nm-LED-Sterilizer-Lights-Bar_ysgugsggig.html

[6] Institute of Mechanical Research, Final Report on the Science and Technology Project: "Research, Design, and Manufacture of High-Capacity Dust Filtration for Rotary Kiln Cement Production Line, Capacity 2500 Tons of Clinker/Day," Publisher: Institute of Mechanical Research, 2010.

[7] Nguyen Sy Mao, "Environment and Emission Treatment Technology", Publisher: Science and Technology, 2008

[8] Boer K.W. (1990), "Survey of Semiconductor Physics", Van Nostrand. Reinhold, New York.

[9] Carraway E.R., Hoffman A.J., Hoffman M.R. (1994), "Photocatalytic oxidation of oganic acids on quantum-sized semiconductor collids", Environ. Sci. Technol. 28 (5), pp. 786-793.

[10] Kaneko M. and Okura I. (2002), "Photocatalysis science and technolory", Springer, Tokyo, pp. 51-68.

[11] Nguyen Duc Nghia (2007), "Nano Chemistry": Fundamental Technology and Source Materials, Natural Science and Technology Publishing House, Hanoi.

[12] Zhang H. and Banfield J.F. (1998), "Thermodynamic analysis of phasestability of nanocrystalline titania", J. Mater. Chem. 8, pp. 2073-2076.

[13] Kappos, A.D., et al., "Health effects of particles in ambient air", International journal of hygiene and environmental health, 2004. 207(4): p. 399-407.

[14] Beckerman, B.S., et al., "The association between chronic exposure to traffic-related air pollution and ischemic heart disease", Journal of Toxicology and Environmental Health, Part A, 2012. 75(7): p. 402-411.

[15] Silva, R.A., et al., "Global premature mortality due to anthropogenic outdoor air pollution and the contribution of past climate change", Environmental Research Letters, 2013. 8(3): p. 034005.

[16] TCVN 11858:2017, compiled by the National Technical Committee TCVN/TC142 on Air Cleaning Equipment and Other Gases, proposed by the Directorate for Standards, Metrology, and Quality, published by the Ministry of Science and Technology.

[17] Nguyen Dac Loc, Handbook of Manufacturing Technology, Volume 1, Science and Technology Publishing House, 2007.