Design of the air purification system with On/Off fan control to reduce harmful air in nail shop

[1*] Minwoo Cheon

Abstract

With the development of the beauty industry, the nail art industry is expanding, and through this, nail culture is becoming more popular. However, some products used in the nail art field may produce harmful substances, so great caution is required. In this paper, an air purification system was designed to reduce harmful air. The air purification system uses a harmful gas sensor to measure the level of pollution in the surrounding air and then turns the fan on/off to remove harmful gases and fine dust. Two types of filters and two fans can be driven and controlled respectively so that harmful gases are absorbed into the charcoal filter and fine dust is absorbed into the HEPA filter. In addition, filters, fans, and piping were appropriately placed to remove contaminated surrounding air as quickly as possible during nail procedures.

Keywords: *Nail shop, Harmful air, Fine particulate, Air purification, Reduction device*

I. Introduction

The beauty industry is developing worldwide, and the nail market, a related field to the beauty industry, is also being established. As a result, the demand for nail nails continues to increase, but it is also causing various environmental problems. Some nail products contain chemicals, which may harm the user's health due to hazardous substances, so caution is required.[1] In particular, chemicals are pointed out as one of the main causes of air pollution and disease in humans.[2][3]

However, nail work, which is mainly done in indoor environments, cannot avoid exposure to chemicals. Therefore, in order to study the health status of nail salon workers, we also investigated exposure to volatile organic compounds and their effects on health.[4] In addition, system improvement and related research were continuously conducted to improve the environment of nail workshops. [5][6] By evaluating the air concentration of volatile organic compounds generated during practical training at universities and analyzing correlations with business characteristics, fine dust and organic compounds were evaluated. Research on compounds, etc. is also continuously being conducted.[7][8] However, although ventilation devices are important for improving the environment of nail salons, it has been found that they are often not installed or not in operation.[9] It is expected that non-installation or non-operation of ventilation equipment is due to inconvenience in use.

Therefore, this paper proposes an air purification system to reduce harmful air in nail shops. The air purification system allows for on/off fan control, allowing harmful air to be sucked in immediately during nail work with a simple operation and reduced through a filter. In particular, filters, fans, and piping were designed to quickly remove contaminated air upon discharge.

II. Design of the air purification system

The appearance of the air purification system was designed using SolidWorks (SolidWorks 2016, Dassault systems, Canada). Figure 1 shows modeling of the air purification system. Fine dust and volatile organic compounds that may be generated during nail work are designed to be sucked in

[1*] *Professor, Dept. of Health Administration, Dongshin University (mwcheon@dsu.ac.kr)*

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through the suction part at the top. The suction part was designed in a semicircular shape to facilitate intake of surrounding air. In addition, LED lighting was installed to increase worker convenience when doing nail work. Harmful air sucked in from the top was connected to the filter section below through a semicircular pipe. At this time, in order to increase the suction strength, half of the suction pipe was closed and the harmful air was designed to flow in only one direction. The inhaled harmful air passes through a replaceable filter to filter out dust or volatile harmful gases and is then discharged to the outside. The filter part allows the use of a charcoal filter or a HEPA filter.[10]

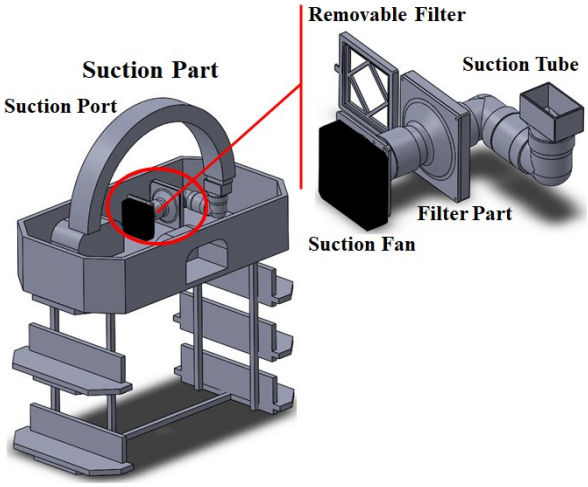

Figure 1. The modeling of the air purification system

It is designed so that a suction fan can be installed to allow harmful air to be sucked into the filter section. The suction fan is designed to use two fans to provide suction through the upper and lower intake ports. At this time, considering the size and thickness of the charcoal filter and HEPA filter, it was designed to be removable. The distance and close contact between the suction fan and the suction pipe are very important for the suction pressure of the suction part. Since most 3D printers have some errors, they were designed and manufactured to be slightly larger. In addition, a sponge was banded around the filter part to minimize the separation that may occur due to frequent attachment and detachment of the filter.

III. Fabrication of the air purification system

In this study, an air purification system was manufactured based on the designed 3D drawing. Figure 2 shows the manufactured air purification system. The air purification system is configured so that the fan can be driven after connecting an external power source. As suggested in the 3D design, the harmful air sucked in from the intake port was connected to the filter unit through the suction pipe. After removing harmful substances from the filter part, the air can be discharged to the outside. It is designed so that the filter can be replaced depending on the type of harmful substances. However, in the case of fine dust, it floats in the air but sinks to the floor due to its weight, so it can be separated and filtered. In other words, it is designed so that volatile organic chemicals can be sucked in through the suction port and fine dust can be sucked in through the bottom. The inhaled volatile organic chemicals were adsorbed in the removable charcoal filter shown in Figure 2. Additionally, fine dust that fell to the floor could be removed using a HEPA filter.

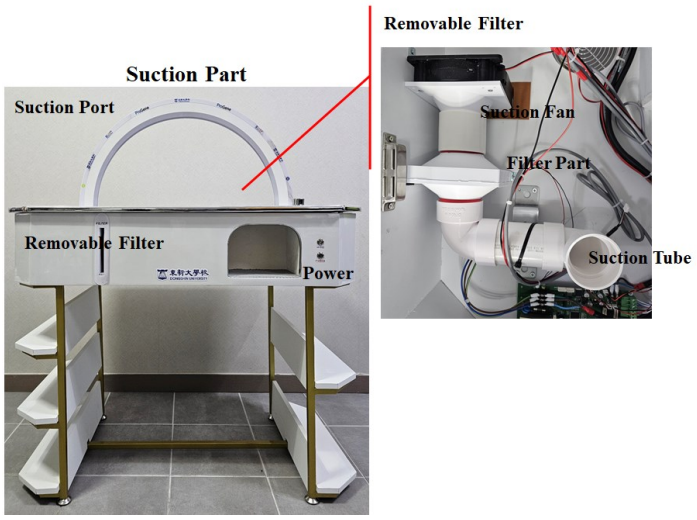

Figure 2. The fabrication of the air purification system

A main controller was used to vary the fan's acceleration depending on the degree of pollution of the surrounding air during nail work. Figure 3 shows the main controller circuit diagram. The main controller selected STM32F103VGT6, an Arm-based MCU, for fast processing and control of multiple sensor measurement values, external serial communication, LED control, and fan control. Using the main controller, the fan can be accelerated when the air around the nail work table deteriorates, and the fan can be slowed down when the surrounding air improves. An output pin for on/off control of the DC fan mounted in the filter unit is placed to control DC fan operation according to the situation to remove volatile organic chemicals and fine dust. STM32F103VGT6 is a 32-bit MCU, MB Flash, USB, CAN, 17 timers, 3 ADCs, 13 com. It has an interface. When manufacturing the PCB, an external oscillator was used to ensure stable operation of the main controller. Through this, the system operation clock can be input, and a pull-up resistor is applied to the reset pin to minimize errors due to external noise.

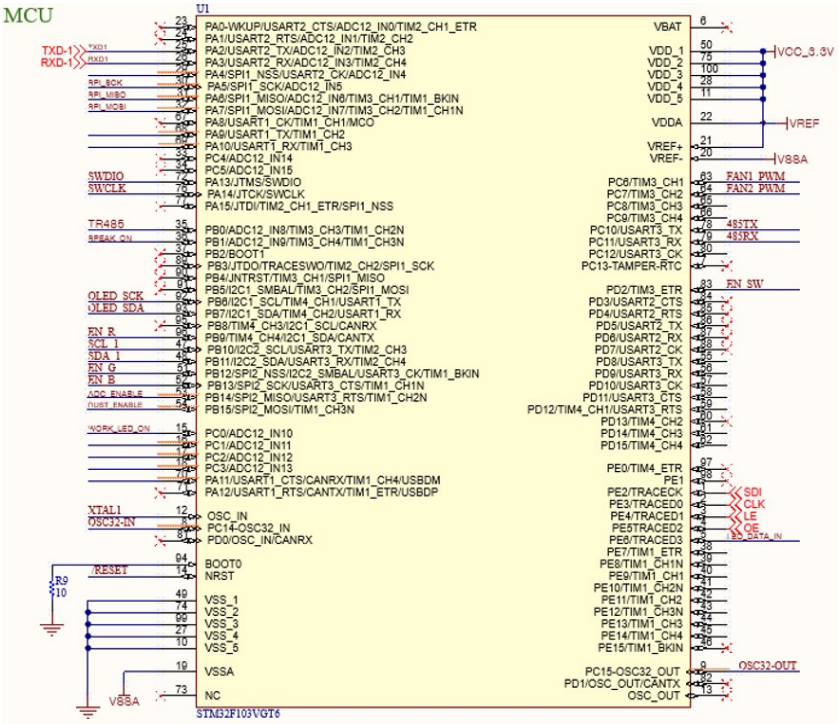

Figure 3. The circuit diagram of the main controller

The removal rate of inhalation of volatile chemicals and fine dust may vary depending on the performance of the fan. Therefore, a high-output fan was adopted and used, and a 12V SMPS (Switching Mod Power Supply) was installed externally to drive the fan. Figure 4 shows the fan driving circuit. The speed of the fan was controlled through On/Off control, and a transistor was placed for this purpose. It was designed to control the GND line of the DC fan by generating a HIGH/LOW signal at the gate pin of the main controller to turn the fan operation on/off. A pull-down resistor was placed on the gate signal pin side to prevent malfunction of the DC fan due to external noise. Two fans were used to control the charcoal filter section and the HEPA filter section respectively, and each fan could be controlled.

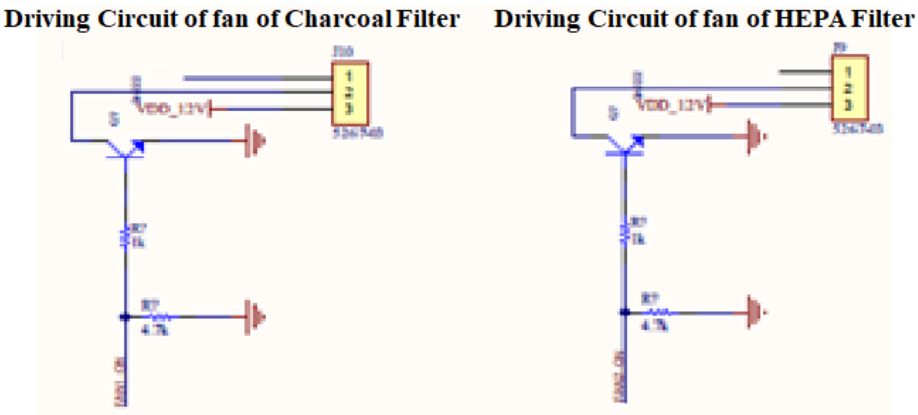

Figure 4. The driving circuit of the fan

The lighting device in the suction section at the top of the air purification system to increase operator convenience can be controlled manually using an on/off switch. In the case of LED used for curing nail gel, UV wavelengths are used, so to increase safety, a sensor is applied to detect the operation and it is configured to be controlled from the main controller. However, in the case of work lights, luminance is important, and the circuit is designed to be turned on/off even when the system is not turned on so that it can be used as general lighting even when not doing nail work. Figure 5 shows the work light LED driving circuit.

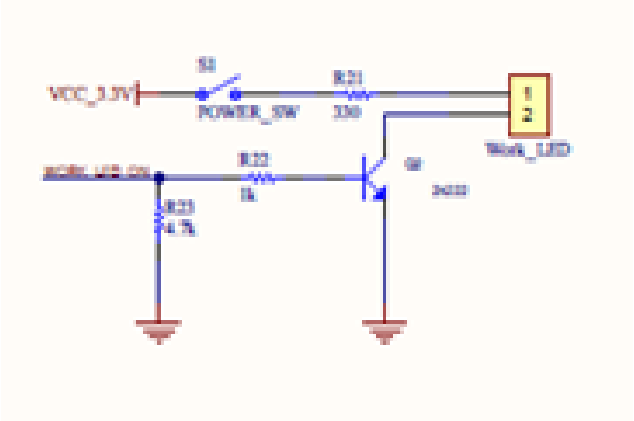

Figure 5. The driving circuit of the work light

IV. Counclusion

In this paper, we designed and manufactured an on/off control air purification system to remove volatile chemicals and fine dust that may be generated in nail shops.

Volatile chemicals were sucked in from the top of the table and removed through the charcoal filter. In addition, fine dust that may be generated when trimming nails using a grinder can be sucked into the bottom and removed through the HEPA filter unit. Each filter unit was designed to be operated by a high-performance fan, and the main control unit was designed and manufactured to ensure smooth on/off control. In addition, work lights were organized separately to improve the working environment of workers. The air purification system proposed in this paper is expected to be able to effectively remove polluted air around workers when introduced to actual work sites. To achieve this, it is deemed necessary to measure the amount of contaminants removed by applying this system to actual sites and allowing nail workers to use it. Therefore, we plan to study the roles and effects of charcoal filters and HEPA filters through additional research in the future.

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VI. References

[1] J. A. Cho, “A study on the working safety recognition and chemical hazard recognition,” Journal of the Society of Cosmetic Scientists of Korea. Vol. 13, pp.1028~1039, Mar., 2007.
[2] H. J. Shin, “Human health risk assessment of indoor air quality in small-sized multi-use facilities,”Master's Thesis. Seoul National University of Science and Technology. Seoul, 2016.
[3] M. Y. Kim and D. H. Moon. “Exposure Levels To Organic Compounds by Nail Art Technique.” Journal of the Korean Society of Cosmetology. Vo. 17, No. 2, pp. 218-224, 2011.
[4] N. H. Kim, K. W. Min, G. W. Cho, D. J. Seo, K. H. Im, W. S. Jeung, Y. G. Cho and J. S. Yang. (2021, Jan.), Health effects on Workers and actual exposure of VOCs in the nail shops. Journal of Korean Society of Occupational and Environmental Hygiene [Online]. Available: https://doi.org/10.15269/JKSOEH.2017.27.1.59
[5] C. H. Yun and S. H. Lee, “Study on the safety review and management system of Hazardous substances in nail products,” Journal of the Korea Convergence Society. Vol. 8, pp. 439-445, Nov., 2017.
[6] J. H. Yang and J. A. Cho, “A Consideration on the Influence of Harmful Chemicals Contained in Nail-Care Products on the Human Body,” Journal of the Korean Society of Cosmetology. Vol. 14, pp.535~542, Feb., 2008.
[7] Y. K. Park, I. J. Choi, H. Y. Choi, J. K. Ahn, S. J. Choi, S. J. Kim and H. S. Kim. (2019), Evaluation of Airborne Volatile Organic Compounds Concentrations During Nail Art Practicing for College Students. Journal of Korean Society of Occupational and Environmental Hygiene [Online]. Available: https://doi.org/10.15269/JKSOEH.2019.29.4.452
[8] B. R. Lee, S. Y. Kuag, W. H. Yang, S. I. Jun, J. S. Kim and K. Y. Lee. (2017), Characteristics of PM10, VOCs and Aldehydes Levels in Nail and Hair Shop. J Environ Health Sci. [Online]. Available: https://doi.org/10.5668/JEHS.2017.43.6.509
[9] G. Y. Lee, “Survey on indoor air quality in beauty salon and nail shop”. PRISM. Korean Society of Environmental Health, 2015
[10] M W. Cheon, Y. S. Kim, J. G. Cheon and M. S. Kim, “The 3D modeling design and fabrication of the filter part for application of the intelligent nail table”, 2023 DCS Proceedings, Vol. 1, No. 1, pp. 188-189, Nov., 2023

저자소개

천민우 (Minwoo Cheon)

2006 년 2 월 ~ 208 년 6 월 : ㈜바이오아테코 인공장기연구소 연구소장
2008 년 7 월 ~ 2010 년 2 월: ㈜에코레이 개발팀 개발팀장
2010 년 3 월 ~ 현재: 동신대학교 보건행정학과 정교수

관심분야 : ICT 융합, 사물인터넷통신, 무선통신, 재난안전 등