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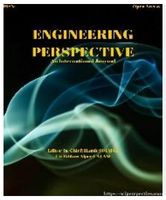

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Research Paper

Industrial Type UV-C Supported Portable Air Cleaning Unit

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ABSTRACT

In this study, it was made a portable air purification unit with UV-C supported. UV-C supported air purification nit was designed and produced that cleans and disinfects the air in closed communal living spaces such as hospital sh opping malls, restaurants, industrial shops and offices. In the air cleaning unit; suitable components have been selected in the design and supplied. Assembly was performed in a wooden cabinet in a way that would work with UV sup port. The air is sent back to the environment by ozonizing the air with the ozone generator by passing through the U V-C fluorescent inside the PVC. As a general practice, the air-cleaning unit should be designed in accordance with IS O standards. It is seen that the designed and manufactured air cleaning unit has an impact volume of approximately 6 0 m^3. Room class, total air change and maximum and minimum air flow were determined. The most important advant ages of the system are its portability, light weight and silent operation. It can be also said that with its deodorizing fe ature, it eliminates the bad odor in the environment and givesit to the outside by means of the fan.

Keywords: Air Cleaning Unit, UV-C, Communal Living spaces, Virus

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1. Introduction

As it is known, Covid and similar epidemics pose a risk to people. So, technology and different devices are used in order to save the human healthy at this point. It has been mentioned that these tools are thought to be used and the cost of these materials are another important issue. The dissemination of good living conditions and the development of air technologies to control the passage of these nuisances and improvements for these technologies should be performed throughout the day. With the current application of the technology, air solidification and disinfection are applied. At this situation, personal protection measures should be widely observed. For this purpose, a prototype was built for simple air purification, which could be implemented in this current study. It is suitable product for a general usage and airtight product. The system is light, quiet and easy to use for handheld [1-5]. It can be used in restaurants, business offices, shopping malls, industrial shops, etc. The air will be sucked through the pipeline using fan and purified with UV-C fluorescent. UVC light is ultraviolet light with a wavelength of 200-280 nm (nanometers). UV-C lights kill microbes at these wavelengths by disrupting the structures in their DNA. The inactivation energy is found by multiplying the intensity of the light and the irradiation time and dividing it by the irradiated area. Since UV light is of vital importance in the disinfection process, a quality UV ray was preferred while supplying it. UV light inactivates bacteria and viruses smaller than a certain micron size [2-7].

Improving the air quality of the environment mostly consists of three items such as dilution ventilation, reducing the causes of environmental pollution and reducing the causes of ambient pollution and ambient air purification. The fact that this triple technique has a hierarchy, the air quality of the environment is a reality in practice in ambient air quality applications. This apparent difficulty is that control of the source is often not possible. On the other hand, ventilation presents increasing challenges in terms of building's energy use and lack of fresh air in most parts of the world. This is why air purification is receiving rising attention as an environment's air strategies. While air purification has a long and extensive history, research on air purification technologies is extremely short. Air filtration has historically been used for a wide variety of special purposes, including dust control in industrial areas, infection in hospitals, and radioactive aerosols. Early building air filtration devices were mostly used to remove fans, air-conditioning inventory, and debris larger than the air stream to avoid contamination of ambient surfaces [1-10].

In this study, it was aimed to design and produce industrial type UV-C supported portable air cleaning unit. For this reason, room class was specified according to ISO standards. And then total air change and maximum and minimum air flow were determined. The produced device was successfully controlled and tested.

2. Material and Method

Within the scope of this present study, a design and prototype was carried out for a practical and portable, effective air purification and disinfection unit that will allow widespread usage. In the air cleaning unit. Suitable components were selected for design and assembly was made in a wooden cabinet in a way to work with UV support. Figure 1 depicts the designed and produced industrial type UV-C supported portable air cleaning unit. At first, the device consists of three parts: suction of the air, using UV ray in order to destroy bacterium and producing ozone with ozone generator.

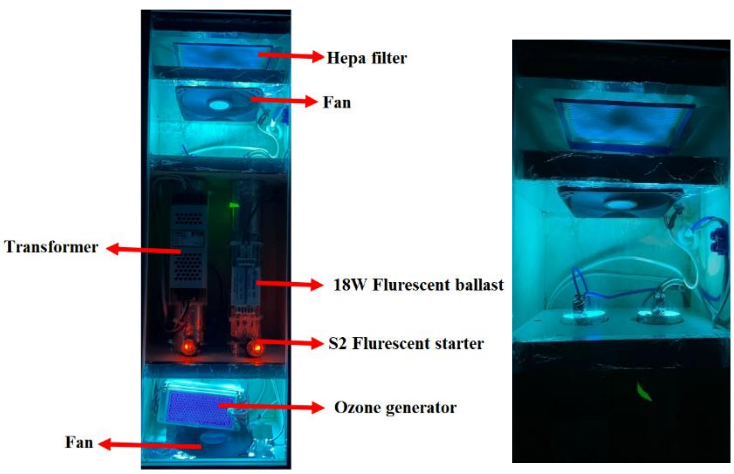

Figure 1. Designed and produced industrial type UV-C supported portable air cleaning unit

The properties of the used fan are also critical in view of consumed energy and control of the fan speed. The technical properties of the used fan are seen in Table 1. Quiet operation and minimalization are important for using this device while designing. In the present study, 2 fans were used to provide suction. With the help of these fans, the air flow will pass around the UV-C fluorescents inside the plastic pipe and will be exposed to different light lengths and the germs and bacteria in the air will be inactive. The air sucked through the plastic with the help of the fan comes to the ozone generator section and cleans the bacteria by the generator that produces ozone gas. This device has a period of use according to every environment. In excess and in poorly ventilated areas, it may adversely affect human health.

Wood was chosen as the case material. The thickness of the wood used was 8mm. Before assembly, the wooden case was cut according to the prototype dimensions and then fixed to each other with the help of glue and screws. Aluminum foil is used for a better image and reflecting heat. Ozone generators are produced with advanced technology which are used to produce ozone gas.

Table 1. The technical properties of fan [11]

Dimensions [mmxmmxmm]	120x120x25
Speed [rpm]	1000
Construction	Sleeve bearing
Voltage [Volt]	12
Connector type	3pin + 4 Pin Molex

Oxygen (O_2) in the air is divided into parts thanks to Silent Corona Discharge [9-13]. The split individual oxygen atoms (O) attach to the oxygen molecules, causing Ozone Gas (O_3) to emerge. In areas where ozone gas is used; viruses, bacteria, germs and similar dirt are cleaned. The ozone generator, which is a powerful disinfection device, sticks to the dirty things and odor molecules in the air and on the surfaces and removes them. Thus, the ozone generator helps in cleaning 99.9% of the places where it is used.

Ozone generators, apart from the high disinfection they add; It helps to clean the air where it affects. Due to the clean air, the life expectancy will also increase where the ozone generator is used. It also affects the sleep time in the cleaned area with the ozone generator, thus allowing us to sleep more. It also allows to wake up fresher, stronger, more energetic for each day. In addition, it will help persons who have trouble breathing while sleeping. When they sleep in a clean room with an ozone generator, there is a more regular breathing and exhalation.

Ozone generators transforms the air into ozone gas. These generators help disinfect every aspect of our lives and increase life expectancy for the better.

Ozone consists of three oxygen atoms. Chemical reactions are also denoted by O_3. It is a gas with a sharp and characteristic odor. Ozone wraps around earth and protects the earth from the sun. The color of this gas is also pale blue at room temperatures [3-6, 13-16].

3. Results and Discussion

3.1. Determination of Room Class

The international quality of the system to be established in the hygiene rooms must meet the standards.

Determination of the class room is critical for purification and ventilation the air. ISO 14644-1 has specified a method to calculate which room class the air cleaning unit to be designed will be effective. The classification is based on the following method [16].

$$Cn = 10^{N} . \left(\frac{0.1}{D} \right)^{2.08} \tag{1}$$

Here Cn, D and N show the maximum permissible concentration of transported particles in air, the assumed particle density in terms of μm and the ISO classification number which should not exceed 9 respectively.

Hygiene rooms are classified according to how clean the air is according to the particulate matter and size per air volume. Table 2 shows the selected airborne particulate cleanliness classes.

Table 2. Selected airborne particulate cleanliness classes [14, 15-17]

ISO14644-1:1999 Classification number	$0.1\mu m$	$0.2\mu m$	$0.3\mu m$	$0.5\mu m$	$1.0\mu m$	$5.0\mu m$
	Maximum concentration limits (Particles/m^3)					
ISO Class 1	10	2				
ISO Class 2	100	24	10	4		
ISO Class 3	1000	237	102	35	8	
ISO Class 4	10000	2370	1020	352	83	
ISO Class 5	100000	23700	10200	3520	832	29
ISO Class 6	1000000	237000	102000	35200	8320	293
ISO Class 7				352000	83200	2930
ISO Class 8				3520000	832000	29300
ISO Class 9				35200000	8320000	293000

As a result of the process, it has been seen that the produced air cleaning device is in accordance with the ISO 8 standard. Used ozone generator is seen in Figure 2. The properties of ozone generator are seen in Table 3. Oxygen (O_2) in the air we breathe is divided into parts thanks to Silent Corona Discharge. The split individual oxygen atoms attach to the oxygen molecules, resulting in Ozone Gas (O_3). Ozone is produced through high voltage discharge. The high voltage, thereby generating a large number of small barrier discharges between the electrodes, creates a very high electrical field.

When stimulated with UV light, the virus is prevented from reproducing itself by the differences in the chemistry of the RNA/DNA molecules. 12 V power supply was used in order to support electric energy. Output current is 8A. On the other hand, 18W fluorescent ballast was utilized to make the lighting elements work.

Figure 2. Ozone generator

Table 3. The properties of ozone generator [18]

Model	Ozonator
Output ozone [g/h]	20
Dimensions [mmxmmxmm]	145x57x83
Weight [kg]	0.414

Hepa filter helps to improve air quality. Dust, particles, microorganisms, etc. in the external environment. It is used to keep unnecessary microorganisms very well. Used hepa filter keeps bacteria larger than 0.3 microns and it kills [14-18].

3.2.Total Air Change Number

Designed system should be in accordance with the ISO 8 standards framework. The maximum effect volume of the designed device was determined as 60 m3. According to ISO 8 standards, the number of cycles is determined as a minimum of 10 and a maximum of 25. Since these data are known, the total air exchange capacity of the device in an hour can be calculated [5, 14-21].

$$\text{Maximum number of cycles x Volume}(m^3) = \text{Total air exchange } (m^3/h) \quad (2)$$

So, total air exchange was determined as below.

$$25 \times 60 = 1500\, m^3/h$$

3.3. Average Air Flow and Flow Mode

The air flow of used fan is 55 CFM. So, it can be defined as 0.0259 m3/sn. Area of flow can be computed according to produced device.

Flow rate can be determined using continuity equation as below [22].

$$Q = A.V \quad (3)$$

$$A = \frac{\pi.D^2}{4} \quad (4)$$

$$V = 0.711\, m/sn$$

Flow area was computed and then the flow rate was determined using Eq. 4.

Hydraulic diameter should be determined in order to obtain Reynold number that specifies the flow regime. The area where air flow occurs is not cylindrical like pipe in this study. So, hydraulic diameter was found as following [22].

$$D_H = \frac{4ab}{2(a+b)} \quad (5)$$

$$D_H = 0.19\, m$$

Reynold number was determine as below [22].

$$Re = \frac{\rho.V.D}{\mu} \quad (6)$$

$$Re = 9110.94$$

It was realized that turbulent flow was seen in device.

4.Conclusions

With the increasing importance of clean room technologies, studies on this study has attracted attention. In this work, a portable air cleaning unit for indoor environments was designed and made. The designed and produced air cleaning device was controlled and tested successfully. It was seen that some points should be paid attention considering the researches and examples. If it is to be designed for hospitals, the clean room class must be determined. The filters used in the device should be selected in accordance with the required standards. The fan system used in the device must be selected in such a way as to provide the one hour total air exchange capacity required by the environment. Filters must be of safe change type. The UV light system can be used more than once at the required points. Apart from these criteria, device design can be designed by adding different configurations by calculating manufacturability and appropriate cost. In this study, the project implementation made in order to provide cost-effective and easy-to-use. It has been designed taking into account the criteria mentioned above, as well as criteria such as easy mobility, versatile air distribution system.

Nomenclature

ISO : International Organization for Standardization
DIN : Deutsches Institut für Normung FS : Federal Standard 209E For Cleanroom
SWKI : Guideline 99-3 Heating, ventilation and air-conditioning systems in hospitals
ASHRAE : American Society of Heating Refrigerating and Air Conditioning Engineers
DEHS :Filter System Integrity Test EC:ElectronicallyCommutated
CADR : Clean Air Delivery Rate

Conflict of Interest Statement

The authors must declare that there is no conflict of interest in the study.

CRediT Author Statement

Yiğitcan Tokcan: Project administration, Data curation, Formal analysis, Methodology, Funding acquisition, Conceptualization, Investigation, Resources**,** Data curation, **İzzet Demir:** Conceptualization, Funding acquisition, Roles/Writing–original draft, Resources **Ahmet Uyumaz:** Supervision, Writing-review&editing, Conceptualization, Methodology, Investigation, Supervision, Visualization, Software

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