SANITAS: JURNAL TEKNOLOGI DAN SENI KESEHATAN
ISSN : 1978-8843 (*PRINT*) / 2615-8647 (*ONLINE*) **Vol. 11 (2), 2020 : 213 - 221**

OPTIMIZATION OF ULTRAVIOLET STERILIZATION CABINET BY IMPROVING LIGHT REFLECTION USING ALUMINIUM FOIL

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Submitted: 28th September 2020; Accepted: 14th December 2020

https://doi.org/10.36525/sanitas.2020.20

ABSTRACT

UV light radiation is the most important thing to sterilize medical devices. Over years studies continue to develop technology for sterilization using UV lights. This study aimed to develop an affordable UV cabinet sterilizer design by optimizing UV light using aluminum foil. The main contribution of this study is that the device can optimize the UV light intensity to whole over the cabinet. For instance, the device was only used two UV lamps as resources. Furthermore, the UV lights reflecting on the aluminum foil surface. To validate the results, the intensity of UV light was measured using a UV analyzer. The intensity was measured at 5 different points inside the device. This study has shown the measurement of UV light intensity at 5 different points were almost similar. The highest intensity was on center point 860$\mu W/cm^2$, on the front area 632 $\mu W/cm^2$ and 606$\mu W/cm^2$. On the rear area, the intensities are 630 $\mu W/cm^2$ and 670$\mu W/cm^2$. This study improved the UV light intensity by using an aluminium surface to reflect the lights. This study has proven that UV radiation can be maximized by using the aluminum foil as the light reflector.

Keywords: *UV Sterilizer, UV radiation, Aluminum Surface*

INTRODUCTION

Sterilization is an important part of maintaining medical devices, it is a process to prevent the spread of viruses and diseases from medical devices that have been used. Technologies to sterilization and disinfection of medical devices are continued to develop a decade. Various methods are developing not only on technologies but also on the process used. Generally, sterilization processes on medical devices are divided into two processes, high-temperature process and low-temperature process (1).

Low-temperature processes are usually used for medical devices that unable to withstand high-temperature. Radiation heat transfer technology using UV radiation is an example of this process. Over years UV light was developed to sterilize medical devices(2). Many studies have developed tools for sterilization using UV lamps. The author in (3) and (4) registered patent an ornamental design of a portable UV sterilizer, similarly author (5) also registered patent an ornamental design.

Research performed by Card et al found that UV radiation not linear on differential geometry and object's distance to the source (6). Author (7) provided a hand dryer but the UV radiation decrease as the farther the distance from the UV light source. It is important to ensure optimum UV radiation to disinfect things. Despite the numerous work carried out on the same study, no previous investigation has thoroughly investigated how to optimize the UV light radiation in a sterilizer cabinet.

Hence this work is to develop an affordable UV cabinet sterilizer design by optimizing UV light using aluminum foil. Aluminum is considered to be the most important mirror metals. The aluminum has a high reflectance in all useful regions, the ultraviolet, visible, and infrared (8). The contribution of this study is to develop an affordable new design of UV sterilizer cabinet by optimizing the UV radiation

METHODS

Experimental Setup

This study is used UV lamps to sterilize the objects. The relay module was used as the automatic switch for the lamp. The buzzer was used to give notice by making a sound when the process is complete. The Arduino Uno microcontroller was used to control all the works of the device. LCD I2C 16x2 was used to display the time and the menu. The aluminum foil was used as a light reflector.

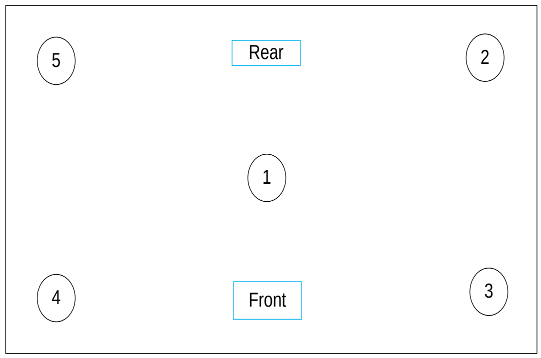

Fig. 1. Five Points to Measure The Intensity

In this study, the aluminum foil was affixed to all sides in the box. Then, the intensity of UV light was measured using a UV analyzer. By placing the analyzer on the tray in the box for 1 minute. The distance between the UV lamps and the tray is 18.5 cm. The intensity was measured at 5 different points as shown in Fig. 1

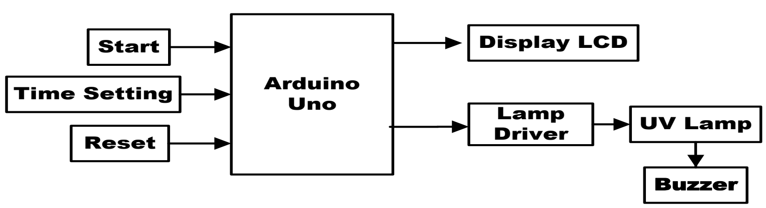

Fig. 2. The Diagram Block of UV Sterilizer Cabinet

The Flowchart

The Arduino program was built based on the flowchart as shown in Fig.3. After the initialization of the LCD, the time can be set with the up button and the down button. Then, the time will be displayed on LCD I2C. UV lamps will turn on when the time has been set and the start button is pressed. After that, the program starts to count down the time until the process is complete. Lastly, the UV lamps will turn off and the buzzer will active.

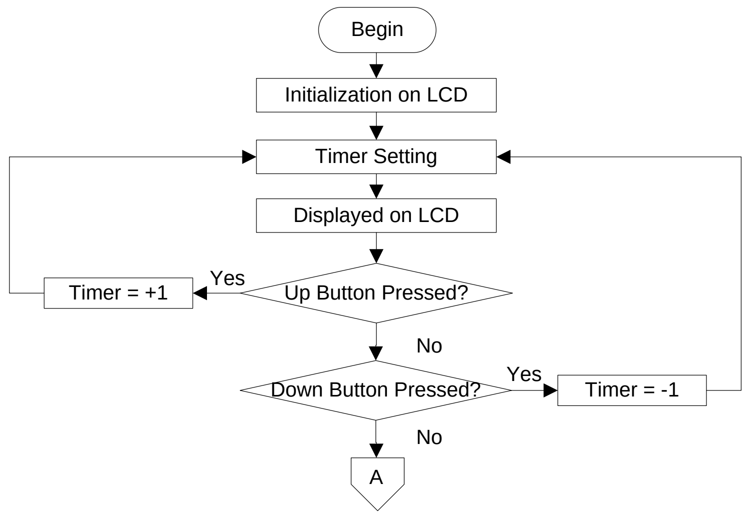

Fig. 3. The Flowchart of UV Sterilizer Cabinet

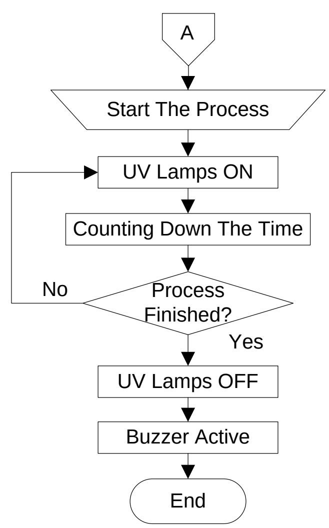

Fig. 4. The Flowchart of UV Sterilizer Cabinet (Continued)

RESULTS AND DISCUSSION

The Program of UV Sterilizer Cabinet

In this study, the program was built to set the duration of the sterilization process. The duration (hour, minute, second) was set manually. The hours, minutes, and seconds can be set with the buttons.

```
IF the step is SetHOUR THEN
  IF up button is pressed THEN Add 1 to SetHOUR
  ENDIF
  IF down button is pressed THEN Remove 1 to SetHOUR
  ENDIF
  IF reset button is pressed THEN Reset the SetHOUR
  ENDIF
  IF select button is pressed THEN Set the minute
  ENDIF
  Print SetHOUR
ENDIF

IF the step is SetMINUTE THEN
  IF up button is pressed THEN Add 1 to SetMINUTE
  ENDIF
  IF down button is pressed THEN Remove 1 to SetMINUTE
  ENDIF
  IF reset button is pressed THEN Reset the SetMINUTE
  ENDIF
  IF select button is pressed THEN Set the second
ENDIF
  Print SetHOUR:SetMINUTE
ENDIF

IF the step is SetSECOND THEN
  IF up button is pressed THEN Add 1 to SetSECOND
  ENDIF
  IF down button is pressed THEN Remove 1 to SetSECOND
  ENDIF
  IF reset button is pressed THEN Reset SetSECOND
  ENDIF
  IF select button is pressed THEN Start the process
  ENDIF
  Print SetHOUR:SetMINUTE:SetSECOND
ENDIF

IF the process is starting THEN
  Turn on the UV lamp
  Count down SetHOUR:SetMINUTE:SetSECOND
  Print Count down
  IF SetHOUR:SetMINUTE:SetSECOND<=0 THEN
    Turn off the UV lamp
    Turn on Buzzer
  ENDIF
ENDIF
```

The UV Sterilizer Cabinet Design

The design of "UZeBeAr" UV sterilization cabinet that was shown in Fig. 4 used acrylic boards with thickness 3 mm and a size of 40 cm x 21 cm x 30 cm. The design was completed with the buttons to set menu and time. The aluminum foil was affixed to the inside of the box as shown in Fig. 5

Fig. 5. "UZeBeAr" UV Sterilizer Cabinet

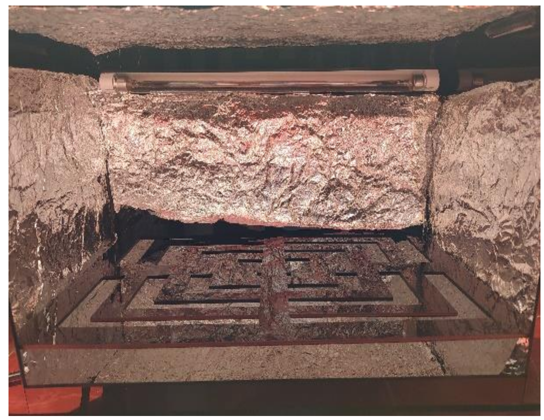

Fig. 6. Aluminum Foil Inside The Box

. The illustration of the difference between UV light exposure without aluminum foil and UV light exposure with aluminum foil as shown in Fig. 6 and Fig. 7, respectively

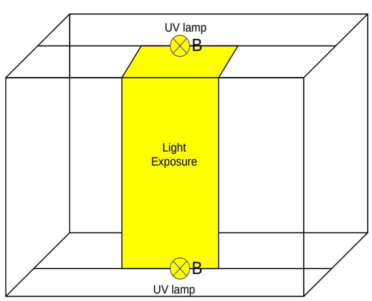

Fig. 7. Light Exposure without Aluminum Foil

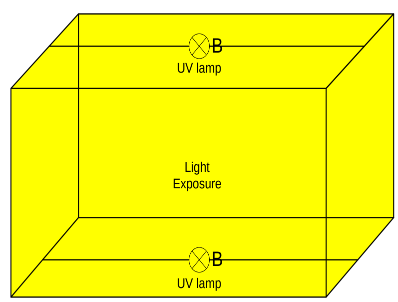

Fig. 8. Light Exposure with Aluminum Foil

The Measurement of UV Light Intensity

The intensity was measured by a UV analyzer placed on the tray in the box. There are five different points in the work zone. The different points are intended as an analysis of the highest UV light intensity. The result of the measurement is shown in table I

Table 1. The Result of UV Light Intensity Measurement Using UV Analyzer

Point Area	Average of UV Light Intensity
1	860 $\mu W/cm^2$
2	630 $\mu W/cm^2$
3	632 $\mu W/cm^2$
4	606 $\mu W/cm^2$
5	670 $\mu W/cm^2$

The data on table 1 shows the highest UV light intensity is 860 $\mu W/cm^2$ which is the 1st point area as the center point of the device. On the other hand, UV light intensity on another point area shows similar results.

Discussion

In this study, the purpose of using aluminum foil is to improve the UV light radiation. UV light radiation is one of the crucial factors to reach the level of sterility expected from the UV sterilizer cabinet (9)(10)(11).

Based on the illustration in Fig. 6, UV light radiation only comes from the above and the below where UV lamps are located. Therefore, UV light only exposes the top and the bottom of the contamination material. However, based on the illustration in Fig. 7, UV light radiation comes from all directions because it is reflected by aluminum foil which is affixed to the inside of the box. Hence, UV light can expose all sides of the contamination material. After measuring the intensity of UV light, the data shows the highest intensity is 860$\mu W/cm^2$. That is on the 1st point which is the center of the work zone. And because of the reflection of UV radiation, the intensity can be maximized on the front area and the rear is. The data shows on the front area, the intensities are 632 $\mu W/cm^2$ and 606$\mu W/cm^2$. On the rear area, the intensities are 630 $\mu W/cm^2$ and 670$\mu W/cm^2$. Compared to another study built a 148 mm × 66 mm UV sterilizer optimizing the radiation using heatsink at the lamp (12) the highest intensity of the UV radiation was 70.1 W/m^2 but also increased the temperature of the object.

Although this study gave significant improvement on UV sterilizer design, however, there is some limitation of this work. Obviously, UV light intensity can be reflected but will also decrease as the farther the distance from the UV light source.

Conclusion

This study aimed to optimize the UV sterilizer cabinet by optimizing UV light using aluminum foil. This study proved that UV radiation can be maximized by using the aluminum foil as the light reflector. This study has shown the measurement of UV light intensity at 5 different points were similar, the highest intensity was $860\mu W/cm^2$. In summary, the study addressed the problem of reduced UV radiation in a sterilizer cabinet. Future studies should focus on a new way to optimizing the exposure of the UV lights and overcome the problem of reduced UV intensity due to the distance from it’s sourced. Further research needs to improve how to amplify UV radiation.

REFERNCES

1. Wallace CA. New developments in disinfection and sterilization. Am J Infect Control [Internet]. 2016;44(5):e23–7. Available from: http://dx.doi.org/10.1016/j.ajic.2016.02.022
2. Arts SRP, Commerce KB, Science SBCJ, Khambht C, Gujarat A. UV Light for Sterilization. Res Rev Int J Multidiscip. 2017;3085(11):19–20.
3. Wei Wen C. Portable UV sterilizer for baby bottle and nipple. USA; Patent Number US D707,363 S, 2015.
4. Yellen I, Kutz S, Alexander Esquer M. Handheld UV Disinfectant Unit. 2019.
5. Yi Ou Yan C. UV STERILIZER. 2019.
6. Card KJ, Crozier D, Dhawan A, Dinh M, Dolson E, Farrokhian N, et al. UV Sterilization of Personal Protective Equipment with Idle Laboratory Biosafety Cabinets During the Covid-19 Pandemic. medRxiv [Internet].

2020;2020.03.25.20043489. Available from: https://www.medrxiv.org/content/10.1101/2020.03.25.20043489v1%0Ainternal-pdf://0.0.23.4/2020.03.25.html

7. Tunggal TP, Apriandi AW, Poetro JE, T.Helmy E, Waseel F. Prototype of Hand Dryer with Ultraviolet Light Using ATMega8 [Internet]. Vol. 1, Journal of Robotics and Control (JRC). 2019 Dec [cited 2020 Aug 22]. Available from: http://journal.umy.ac.id/index.php/jrc
8. Hass G. Filmed Surfaces for Reflecting Optics*. J Opt Soc Am. 1955;45(11):945.
9. E. G-S, M. H-R, E. A-F, M. L-L, E. G-P, M. A-C, et al. Impact of ultraviolet air sterilizer in intensive care unit room, and clinical outcomes of patients. Crit Care. 2016;
10. Elisanti AD, Ardianto ET, Ida NC, Hendriatno E. Effectiveness Of Uv And Alcohol 70% Exposure To Total Bacteria Of Folding Money Circulating During The Pandemic Covid-19. J Ris Kefarmasian Indones. 2020;2(2):113–21.
11. Stibich M, Stachowiak J, Tanner B, Berkheiser M, Moore L, Raad I, et al. Evaluation of a Pulsed-Xenon Ultraviolet Room Disinfection Device for Impact on Hospital Operations and Microbial Reduction. Infect Control Hosp Epidemiol. 2011;32(3):286–8.
12. Pirc M, Caserman S, Ferk P, Topič M. Compact UV LED Lamp with Low Heat Emissions for Biological Research Applications. Electronics [Internet]. 2019 Mar 21 [cited 2020 Aug 22];8(3):343. Available from: https://www.mdpi.com/2079-9292/8/3/343

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