

RESEARCH ON THE DEVELOPMENT OF AN AIR PURIFICATION DEVICE WITH UV-C TYPE LAMPS

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ABSTRACT: The purpose of this research is to develop an air purifier with UV-C lamps. For this, several concepts were developed, regarding the components, their positions and the design of the product. An analysis of the competition and one of the concepts was also performed, the best ones being chosen for the product. Finally, a simulation of the purification process was performed using the NetLogo program and a few advantages and disadvantages were highlighted. Based on the information obtained, some conclusions were drawn regarding the product and future research directions.

KEY WORDS: purification, UV-C lamps, concept.

1. Introduction

In recent years, there have been more and more respiratory infections, which can be caused by viruses, dust, pollen, animal hair or dust mites. Thus, purifiers can reduce these causes of a certain infection in the human body. They have different filtering options, which help to remove fine dust, germs, pollen and other particles from the air that are not visible to the naked eye.

UV-C radiation is a disinfectant known for air, surfaces, objects and water, which can help reduce the risk of infection, and has been used extensively for over 40 years [1]. All bacteria and viruses tested so far respond to UV-C disinfection [3].

The aim of this research is to develop concepts of air purifiers with UV-C lamps that ensure the capture and destruction of pollutants and the release of purified air in a room.

2. The current stage

To develop a particular product, we need to identify the needs of its users and what are the conceptual solutions that meet these needs. An analysis of the market to be launched is also needed.




Needs are certain conditions which, if not satisfied, both the existence and the progress of man and society are not possible [2].




This air purifier will allow you to breathe clean air, eliminate all types of viruses and bacteria from the room and facilitate the protection of the health of the respiratory tract.

3. Competitors analysis

In order to identify the necessary specifications for the product to be developed and to carry out an analysis of the competitors, we extracted information about similar products existing on the market. Examples of products with similar specifications are shown in Table 1.

Table 1. Similar competing products

Nr. crt.	Name	Picture	Specifications
1	Dyson Purifier Cool™ TP07 [4]		<p>Captures dust, allergens and bacteria; 360 ° watertight filtration system; Automatically detects and captures pollutants; Dimensions: 22 x 20.4 x 105.4 cm (L x W x H); Maximum airflow settings: 290 l/s. Weight: 4.65 kg; Price: 3000 LEI.</p>
2	Philips 4000i Series Air Purifier [5]		<p>Removes nano particles up to 3 nm in size: viruses, mites, allergens; Automatic mode and 4 manual speed levels; It purifies the air, from a room of 20 m², in 5 minutes; The colored ring provides real-time feedback on indoor air quality: Red - low quality Purple - medium quality Blue - good quality Price: 3250.99 LEI.</p>
3	San: 90W active air [6]		<p>Targeted disinfection of the air through the active circulation of air in the room and the conduction of air next to a UV lamp. Fully enclosed case in matt anodized aluminum profile with integrated wiring and electronic ballast. 1 integrated UV lamp with long life, high disinfection performance and low energy consumption. Degree of continuous air disinfection in the room: 80% approximately 550 m³ room volume Approximately 88% of the room volume is 75 m³ Air circulation speed 36 m³/h Housing L x W x H 1000 x 105 x 105 mm Weight about 6 kg Lifetime UV lamp 10,000 h Number of UV lamps 1 Max. 40 ° C IP class 54 protection class Price: 1067 EURO approximately 5335 LEI</p>

Nr. crt.	Name	Picture	Specifications
4	UV-C AIR GUARD 50W Ultraviolet Disinfection Lamp with Mobile Frame Mount [7]		<p>AIR GUARD 50W device lamp, with mobile frame mounting, for air disinfection and purification. The device can be used for disinfection and purification of an air volume of 30 m³/h. Time of efficient operation of biocidal tubes until reduction of UV-C light by 15%: 9,000 hours; Disinfected air flow: 30 m³/h; Equipped with filter; Power supply: 220V / 50Hz, grounded socket; Power cord length: 3 m (or according to customer requirements); Frame support leg diameter: 41 cm; The frame is provided with four rollers, of which an antistatic roller and with brake; Price: 2481 LEI</p>
5	Professional air purifier and sterilizer AlecoAir S1000 WALL [8]		<p>S1000 Wall is a device designed to sterilize the air through UV-C technology, without risk to people in the room. UV-C lamps are located inside the unit. The air is sucked out of the room and passed through the filters of the device to capture microparticles and then passed through a UV-C tunnel to sterilize it. Dimensions: 1000 × 380 × 160; Air flow: 1000 m³/h; Noise level: ≤ 55dB; UV-C energy released: ≥10000 μw/cm²; Recommended for spaces up to 100 sqm - 120 sqm; Power: 250 W; Price: 5599.99 LEI</p>
6	UV radiation disinfectant, MidasAnAir 3040T [9]		<p>Device for disinfecting air with concentrated flow of UV radiation Supply voltage: 230V Power consumption: 45W Disinfected air flow: 90mc / h Noise level: 22dB Lifespan of UV-C generators: 7000 hours UV-C wavelength: 253.7nm Weight: ~ 5.5 Kg Dimensions: 71.5 x 23.5 x 12 cm Metallic case Operating mode: remote control, programmable Installation: horizontal wall mounting Applications Medical industry: Hospitals, Medical offices, Dental offices; Pharmaceutical industry: Laboratories, Drug factories; Food industry: Food processing and packaging factories; Cosmetics and Spa: Beauty salon, SPA; Public spaces: Schools and kindergartens, waiting rooms, commercial offices; Price: 2397.85 LEI</p>

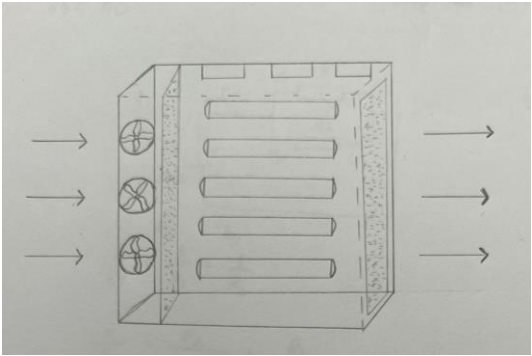
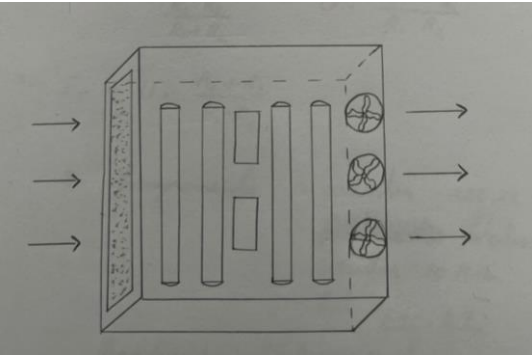
Following this analysis, there is a shortage of UV-C lamp purifiers in homes, with most manufacturers allocating these products to industrial premises. Thus began the development of such a product for relatively small spaces.

4. Concepts

In order to choose a concept, several design variants were analyzed, both in terms of the components used and their location, and in terms of product design. Subsequently, depending on the results obtained, two proposed concepts were chosen for the placement of the components and four design concepts that we are going to use to make the product and to select the optimal variant.


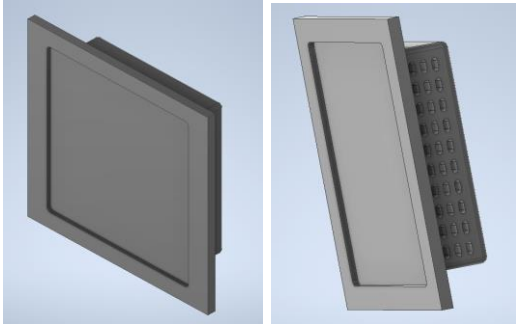
The concepts related to the components used and their location are presented in Table 2, and those related to the design of the product can be found in Table 3.

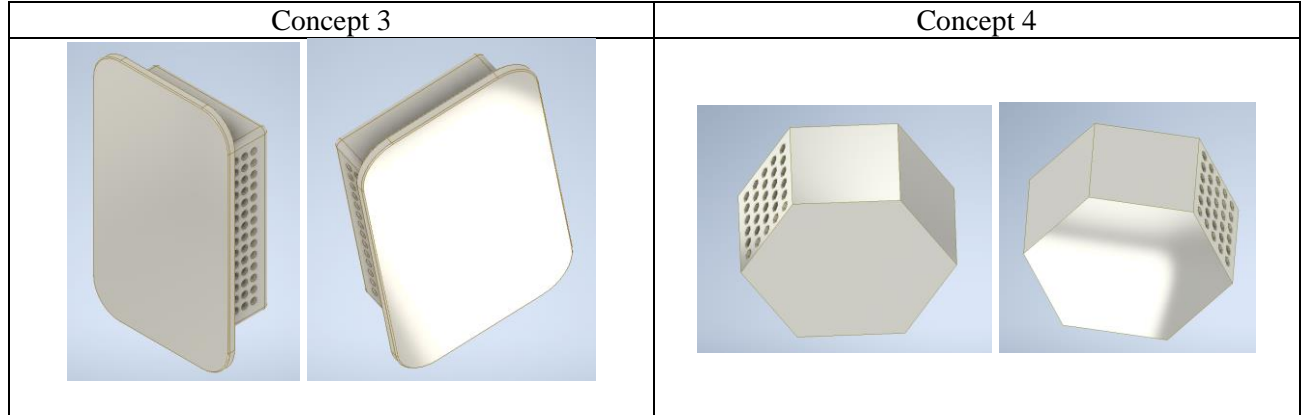
Table 2. Interior concepts

Concept 1	Concept 2
	

Both concepts use UV-C lamps with a power of 25 W, several starters equivalent to half the number of lamps because one starters is used for the operation of two lamps. It is also observed the use of three fans and an air filter, for concept 2, respectively two filters for concept 1. For the development of the product was chosen concept 2, this being the optimal one because with the help of fans that have a higher power absorption, the air is much more circulated and purified to the greatest extent possible.

Table 3. Product design concepts

Concept 1	Concept 2
	



For the developed product, 4 concepts related to the product design were developed: clock, picture, mirror and hexagonal object, but all contain a space for the purification system. Following an analysis of the customers, it was found that the object that can be customized for each buyer is the one related to the picture frame. It was chosen to be studied and carried out in future research.

5. Purification simulation program

In order to be able to exemplify the phenomenon of air purification with the help of UV-C type lamps, we made it with the help of a multi-agent program, namely NetLogo.

A box was considered to be the place inside which the lamps are found and the process and circular elements that signify the dust particles take place. The red ones are the particles that contain dust or other bacteria and the blue ones are the purified particles that are obtained from the process. An image of the program interface is shown in Figure 1.

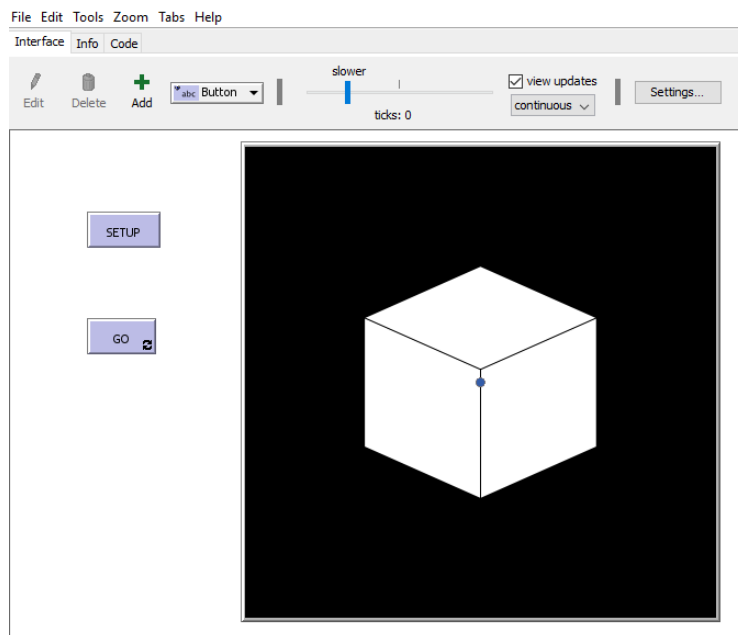


Fig. 1 Program interface

The following code has been created for its operation:

```

to setup
clear-all
reset-ticks
create-turtles 1
[set shape "box"
set size 18
set color white]
create-turtles 35
[set shape "circle"
set size 0.6]
end

to go
move-turtles
Tickle
end

to move-turtles
ask turtles [
if shape = "box"
[setxy 0 0]
if shape = "circle"
[setxy random-xcor 0
fd 1]
if shape = "circle"
[setxy random-xcor 0
fd 1]
if (pxcor < 0)
[red color set]
If (pxcor > 0)
[set color blue]
fd]]
end

```

The operation of this system consists in the penetration of a number of particles with dust and bacteria in the box where the UV-C type lamps are found and the exit of purified particles from it. An example of the program is shown in Figure 2.

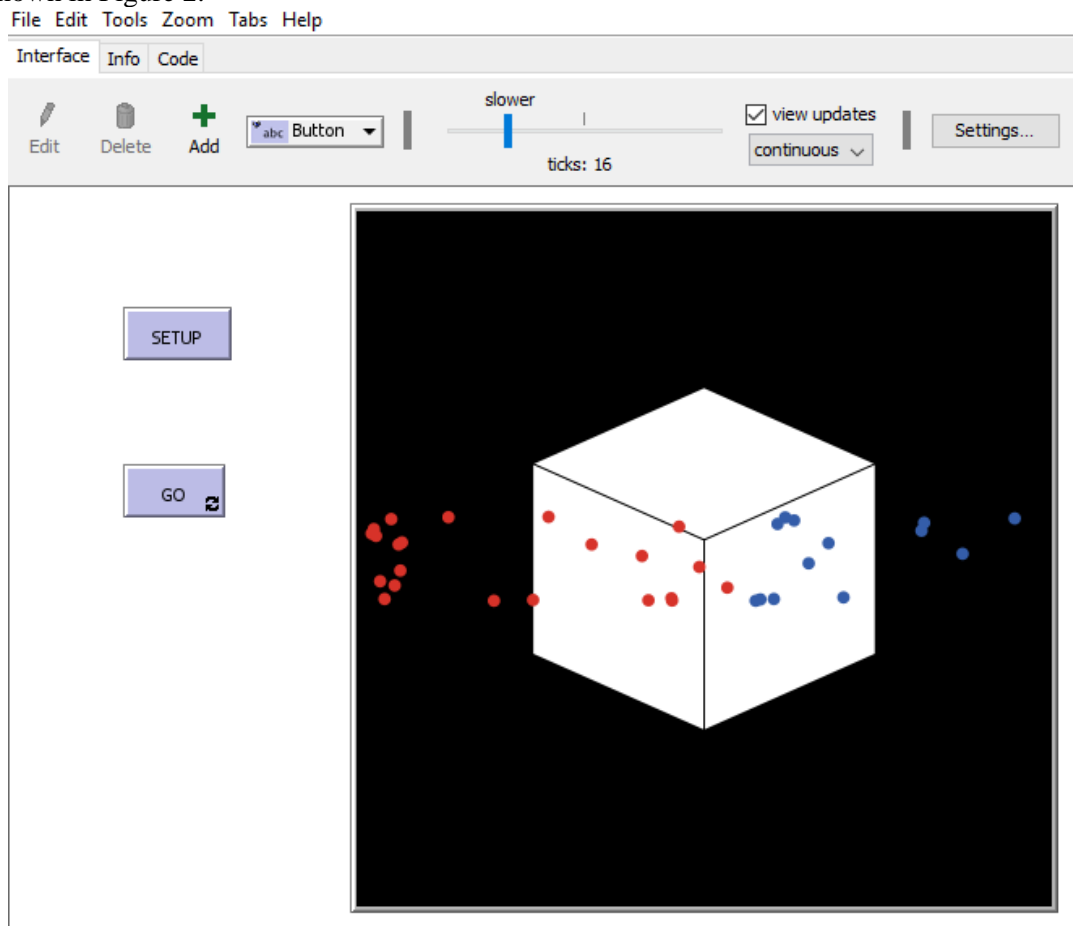


Fig. 2 Exemplify the program

6. Advantages and disadvantages

In order to develop a product that is as useful as possible, a number of advantages and disadvantages have been considered in the use of the product. Benefits include:

- Visual-protected UV-C radiation source, which allows continuous operation, even if there are people in the room;
- Low energy consumption and minimal maintenance costs;
- The product does not use chemicals in the disinfection process;
- Eliminate unpleasant organic odors, including tobacco odor;
- 99% of the room air is disinfected.

Also, in terms of disadvantages, only one was found so far, namely a high selling price of the product.

7. Conclusions

In conclusion, following the development of the concepts, both those that refer to the components used and their location, as well as those related to the design of the product, the best ones were chosen, which can lead to a functional product. In future research, it is intended to create a functional prototype that reflects as much as possible the final product.

Thus, the air purifier with UV-C lamps to be developed is intended to provide air disinfection as quickly and efficiently as possible, which is environmentally friendly and does not endanger human health.

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