

## VIRTUAL MODEL OF A ROBOTIC VACUUM CLEANER

**Abstract:** This paper presents the 3D virtual model of the robotic vacuum cleaner in terms of vacuum cleaner elements. The paper is focused on the design of the subassemblies specific to the vacuum cleaner and presents the features added by attaching new modules to a robotic vacuum cleaner. Also the paper develops aspects concerning HEPA [High-efficiency Particulate Air] filters how important they are in people's modules and aspects regarding acoustic sensors illustrating how the robotic vacuum cleaner moves in the room for cleaning and also how it avoids obstacles which are in front of it.

**Keywords:** robotic vacuum cleaner, components, acoustic sensors, assembly, movement, cleaning movement.

### INTRODUCTION

Vacuums are indispensable in people's households: they make our lives easier, they help saving time and by using them people can clean more efficiently. Robotic vacuums are important in houses because they deliver confidence and they create some spare time which is very important in nowadays because people spend more time in the office and less time in their houses.

People were reticent at first about robotic vacuum cleaner, but a solution that will be presented in this paper will accomplish all their needs in cleaning the floor and also cleaning the air which has dust particles. It is very important that the floor and the air in the house to be clean when children or a pet lives in the house because they are the most sensitive to bacteria. The children up to a certain age spend most of their time on the floor. In this case, a robotic vacuum cleaner is a must because it can be used to clean frequently. Also, it is important to be durable, to accomplish well its purpose because people's expectations are higher when they pay a lot of money on a new gadget like a new robotic vacuum cleaner, but the unique house cleaning instrument can make the difference between sneezing because of the pepper in food or due to dust.

The product must be designed judiciously, efficiently, easy to use and repair, simple, safe and it needs to offer strong advantages in the target market. A recipe for success of this product is to combine necessary functions that are completed by two devices at the same time and these needs to be done well by using components which their basic characteristics are: performance, durability, quality and aesthetics.

The virtual modeling of the robotic vacuum cleaner illustrates a conceptual solution for a domestic cleaning robot that vacuum cleans, and also two modules which will do the wet cleaning of the floors and the other can perform the function of air purifier. The critical functions of this robotic vacuum cleaner are:

- removing dust from the floor;
- cleaning the floor with water;
- removing dirt water and leave as dry as possible;
- cleaning the air in the room.

With the constraints imposed by these requirements, at the design and modeling of shape, in order to get satisfactory solutions, it depends on material and components used, so that the product designed will be functional and it will have an attractive shape. The virtual model 3D has been created using Solid Works application.

### 2. ROBOTIC VACUUM CLEANER DETAILS

The robotic vacuum cleaners aim to achieve vacuum cleaning with minimal human interaction. The cleaners operate with the same suction system as regular vacuum cleaners but in order to avoid the human interaction a self-navigation system is required. With a press of a button or a pre-scheduling feature the cleaning robot starts operating through the room.

The continuous improvement of the robotic vacuum cleaners determined significant progress concerning the cleaning performance, energy efficiency, reliability and quality.



**Fig. 1** First robotic vacuum cleaner [1]

The most important developments on this type of vacuum machine are its clearance dimension and simple construction, in the same time it needs to accomplish all of the requirements that it has been created. One of the older robotic vacuum cleaners used in earlier of 1997 Electrolux Trilobite (fig. 1). Nowadays the difference between the first robotic vacuum cleaner and a new one is not that significant but the performance in accomplishing the cleaning job and energy efficiency have been improved. Therefore, it requires that the

product is easy to use, easy to handle, manipulate, providing maximum comfort and requiring a minimum expenditure for maintenance and operation.

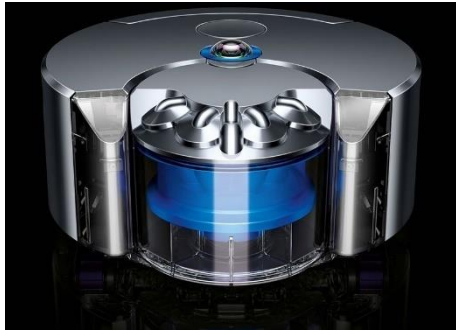


Fig. 2 Dyson 360 Eye's vacuum cleaner [2]

Latest technology in this field is Dyson robotic vacuum cleaner (fig. 2) which improvements are its major for mapping the movements that it has to do. It has a 360 eye's that make the device to not run hazardously. In its namesake, a 360-degree camera is nestled in the top of the device (fig. 3), which is constantly monitoring and triangulating its position relative to the room. This is paired with a methodical (and obsessive) cleaning method that aims to cover the entire floor in the most efficient way possible. The vacuum rolls out of the dock and starts to clean immediately. Once it is interrupted, it starts to plot the most concise way of cleaning around the obstacle, trying not double-back on itself if possible. Importantly, the robot never gave up or got lost in pillars of dining chairs [3].



Fig. 3 Top camera used for scanning the room [3]

All of these robots are powered by rechargeable batteries whose capacity determines the cleaning time. If the desired cleaning area is not finished within the battery time they return to their base station to recharge and afterwards the robot continues the cleaning where it stopped.

The design of these robotic vacuum cleaners is one of the simplest as their usual form represents a circle, with the diameter smaller than 40 centimeters. The front wheel allows the robot to rotate around its center and the side wheels only have the purpose of pushing forward the machine.

The cleaning robots compete in a wide range of diverse features like design, ease of use, experience in use, reliability and quality. The main constraint that must be regarded in the development of a cleaning robot is the size since without a minimal size it will not maintain its mobility. While sustaining the small size, the robot must

deliver a proper cleaning result with minimal human intervention.

Figure 4 shows how the vacuum cleaner can accomplish his job, by having an input energy and a material that must be removed to accomplish the mission. The process is not so complicated but it has some energy lost in moment of energy storage and also in moment of substitution the energy in motion (fig. 5).

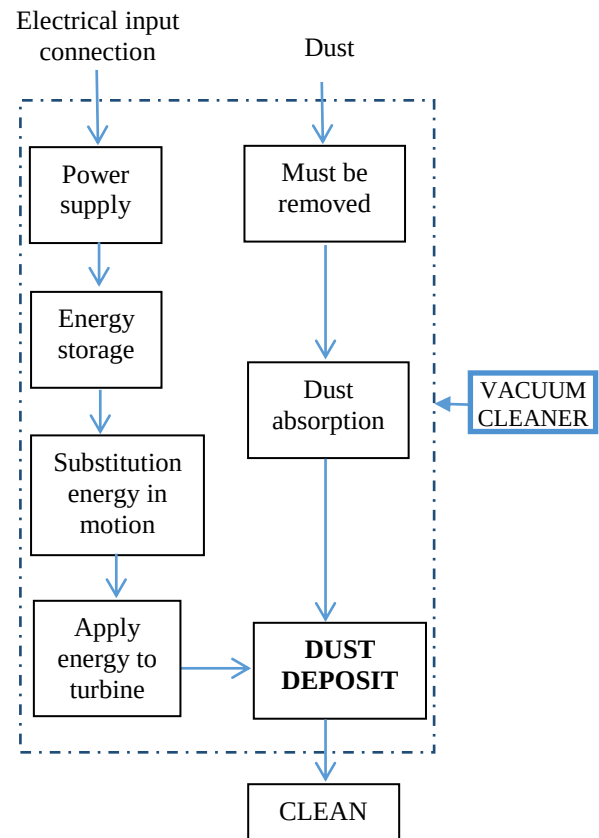


Fig. 4 Structural functions of a vacuum cleaner

### 3. WHY THERE IS THE NEED TO CLEAN THE FLOOR AND AIR?

The principal reasons for floor cleaning are:

- To prevent injuries, due to tripping or slipping. Injuries due to slips and trips on level floors are a major cause of accidental injury. Bad practice in floor cleaning is a cause of accidents.
- To beautify the floor;
- To remove stains dirt, litter and obstructions;
- To remove grit and sand which scratch and wear down the surface;
- To remove allergens, in particular, dust;
- To prevent wear to the surface;
- To make the environment sanitary;
- To maintain an optimum traction;

The treatment that needs to be done for cleaning the floor is very different in this case as there is an attached module that can clean the floor by wetting, or people can choose not to use that module and the cleaning will be dry.

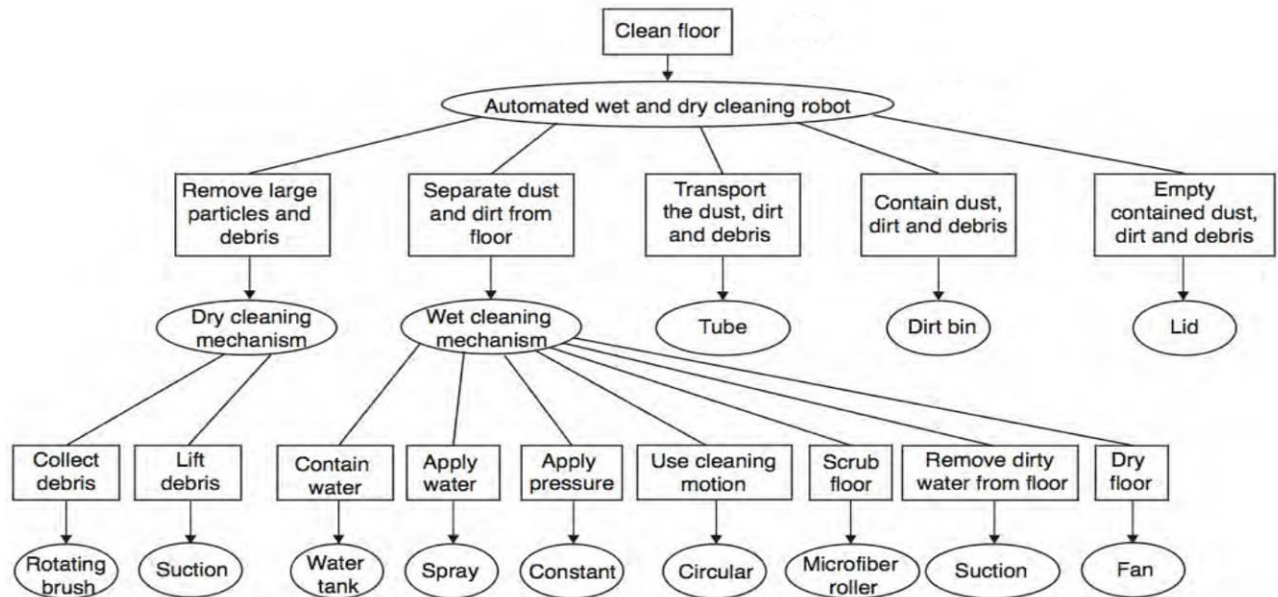


Fig. 5 Process of cleaning the floor using a robotic vacuum cleaner [4]

Breathing polluted air can make people's eyes and nose to feel like they burn. It can irritate residents' throat and make breathing difficult. In fact, pollutants like tiny airborne particles and ground-level ozone can trigger respiratory problems, especially for people with asthma. Today, nearly 30 million adults and children in the United States have been diagnosed with asthma. Asthma sufferers can be severely affected by air pollution. Air pollution can also aggravate health problems for the elderly and others with heart or respiratory diseases [5]. That is one of the reason why there is a need to improve something in houses, the solution is not all efficient, but it is a way to start having a clean air, so the machine that can improve air quality is an air purifier. In this case, there is also attached a module that can clean the air from people's room.

#### 4. CASE STUDY

The robotic vacuum cleaner that should fulfil the next tasks: remove dust from the floor, clean the floor with clean water, remove the water and leave the floor as dry as possible and clean the air from the room. To accomplish all of these requirements in small dimensions, this machine will have the possibility to attach new modules on the back (fig. 6). That will also simplify the product, the cleaning performance would not be decreased and the energy efficiency will be improved by using or not the modules.

This prototype of robotic vacuum cleaner needs to meet the following characteristics:

- the product is adapted at the market needs;
- the product is unique and in the same time it has an outstanding quality;
- the product is realized using the new process of fabrication;
- the product is evaluated to perform all the proposed requirements.

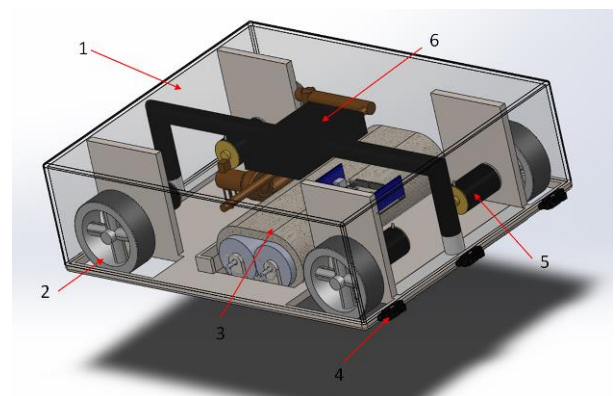


Fig. 6 The main module of projected robotic vacuum cleaner

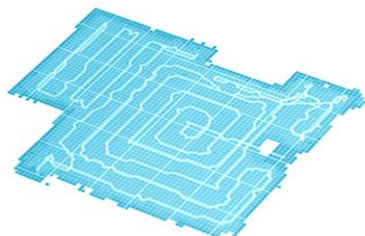
The main components of the robotic vacuum cleaner are listed below:

- 1-main cassette to protect all the components inside;
- 2-wheels to sustain the vacuum cleaner and also to provide traction on the floor;
- 3-brush area, in this case, a brush on two dumps because that can help the robot cleaner to improve the efficiency of cleaning;
- 4-the acoustic sensors to help the cleaner to avoid existent obstacle in the room and also to make his movement well planned;
- 5-one of the electric engine that provides traction for the vacuum cleaner and also for the front wheels to make a rotation;
- 6-the dustbin contains the dry dirt which was taken from the floor.

All of these components are part of the main module (fig. 6) that can accomplish the most important function of a robotic vacuum cleaner: to remove the dry dirt from the floor. To make it an exceptional device from the other robots existent on the market, this one uses a

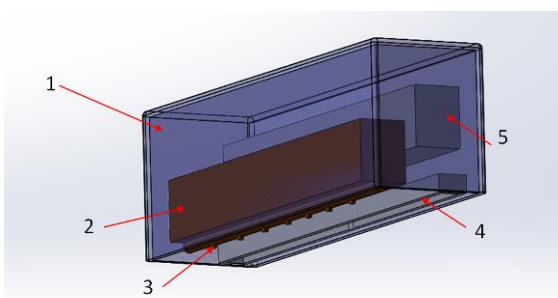
different type of brush, not with one dump but with two. That will make the difference between it and the others from the market by cleaning the floor with a single pass of the cleaner.

Also, by using the acoustic sensors and a logical system calculation for room obstacles the robotic vacuum cleaner can make a map for the room, and then it starts the cleaning (fig 7).



**Fig. 7** Map trajectory for a room using acoustic sensors

The second module is made for making the wet cleaning: it consists of a case with two water tanks: one part for clean water and one for the dirty water, a drip system which has the function of leaving drops of water on the floor and a vacuum mouth for absorbing the water for leaving the floor dry and clean behind (fig. 8).



**Fig. 8** The second module of robot

The components of second module are listed below:

- 1-the main case which have two valves for water adding and removing;
- 2 and 4 – tanks for clean and dirty water;
- 3- a pipe system for clean water;
- 5- vacuum mouth system for absorbing the dirt water from the floor.

The last module of robotic vacuum cleaner will be used for cleaning the air from the room (fig.9). This will have the same principle like an air purifier, can be used any time of day, the noise is quieter than an used laptop's. This module is composed of two ventilators and one HEPA filter that can be changed after several uses. This filter is produced from a fibre that allows it to stay in a case full of water. Using this material will allow it to trap the entire dust particles which exist in air from the room.

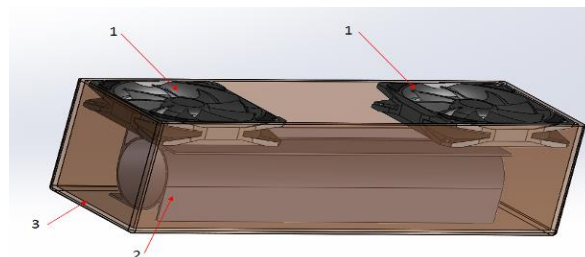
The disadvantages of using this module it is given by the power of suction because the used fans are too small for a room bigger than 20m<sup>2</sup>. To be efficient this module need to be used in small rooms.

The components of third module are listed below:

- 1-ventilators their size is 120mm, with high airflow;

2-HEPA filter that can be change when we see that it's full of dust or after;

3-the case, where there is needed water halfway of HEPA filter in it.



**Fig. 9** Third module of robot

## 5. CONCLUSIONS

Building a modular robotic vacuum cleaner is highly recommended because of many advantages these structures have. The solution of accomplishing all of requirements ensures a minimal number of parts and several variants in which the product can be presented. The module that is presented in this paper can be changed with others that can give other functions to this vacuum cleaner. Why should there be this type of gadget in people's houses? The answer is that the time is shorter and people do not have enough time to finish their job in necessary time, so this device can give as time to spend how people want.

It is important for design engineers to see how people want their machine to look like, to simplify it, to be precise as possible and to create a familiar shape that can do more things with less effort.

The market of robotic vacuum cleaners is in constant development and it begins to increase its presence as saving the energy will make the classical vacuum disappear.

## REFERENCES

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