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Design, Analysis and Development of Automated Desk Sanitizing Machine

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***Abstract*: This project is one such effort attempted in conceiving, designing and developing a gadget with the objective of utilizing the same in classrooms to clean and sanitize the facility as a part of routine activities. Keeping all these developments in the current scenario it is indeed to develop an automated cleaning and sanitizing machine which helps the schools and colleges to clean the desks so that it helps to maintain the clean and hygiene environment. This project aims to provide cleaning and sanitization simultaneously in a lesser time so that the classrooms can be sanitized with safety and also in a quick succession in any type of classrooms in the institution premises. In this project the cleaning of the desks takes place and also a 5-litre capacity tank is maintained to store the sanitizer and later it will be pressurized using a pump and thereafter it is sprayed by means of nozzle on the desks. This movement of the nozzle takes place with the help of Screw rod on which the nozzle is mounted. Thereby the Cleaning and Sanitization process takes place simultaneously. Castor wheels are used in the project for movement of the equipment. For the movement of the screw rod, it has been used with a 500 RPM, 12V, DC motor. Mechanical limit switch is used for the purpose of Normally open and closed type. So finally, developing this project will be very helpful for all to fight against this pandemic and this ensures clean and safe environment for students.**

***Keywords*: DC motor, designing, desks, hygiene, nozzle, mechanical limit switch, screw rod.**

1. Introduction

In the present situation, maintaining cleanliness is a crucial part in everyday life and in fact it is true about the betterment of one's health. It is the way we keep our environment or the surrounding residue free, illnesses free for social and scholarly wellbeing. A few cleaning arrangements are accessible nowadays to keep our house, school or industries free from the dust or dirt.

Keeping in mind the importance of Cleaning & Sanitizing it was decided to develop a Machine operated dust cleaning & sanitizing machine in order to help many schools, organizations, industries and society.

Usually in household things people own a vacuum cleaner and this is one of the best and most important tools which helps to clean the surface areas. Using these vacuum cleaners has its own advantages and disadvantages.

As discussed, maintaining cleanliness is an important role for having a hygienic lifestyle and to be healthy. In prevailing this cleaning of our environment is very important and it has to be repeated daily to have a cleaned environment or the society. There might be errors by cleaning done by humans whereas these errors will be eliminated using the machines. This ensures the cleaning activity is done properly and more effectively

Focusing on schools and colleges, it is the place where the education is spread and also it is the place where the student learns how to socialize and later cultivate the same in their life. Cleaning and Sanitization in the school and college premises ensures or promotes the positivity environment for a student to focus on their educational responsibilities and also promotes a good attitude in students' life.

The dirt or germs in the school premises is very dangerous as it sometimes may tend to spread diseases. Hence the school or college premises or environment should be cleaned and sanitized in order to avoid the spread of these types of diseases.

A. Problem Statement

In the present pandemic situation due to COVID-19, It is intended to develop an automatic machine where it can undergo both cleaning and sanitizing operations simultaneously using advanced technologies without human intervention which serves in Schools and Colleges for its purpose.

B. Objective of Project Work

1. To study the process of Automatic sanitizing & Cleaning robots.
2. To design and fabricate automatic cleaning and sanitizing machine.
3. To develop a virtual model

2. Literature Review

S. J. Shanmugavel [1] et al in their work entitled "Automatic Table Cleaning Robot" have mainly focused on automation due to the families improper and long working hours. In their work they have developed an autonomous robot which is supposed to clean the table on its own i.e. automatically. This machine totally operates on the commands received to it. In recent days almost all the machines are automated and since they had planned to develop this product. The developed product can mop, suck and also it detects the obstacle on the table. They

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have used sensors for the machine in order to avoid the fall of the same from the table. Sensors and motors operated were controlled by means of a controller. Now this automated machine moves around the table and it sprays the water and cleans the surface and also it senses the obstacle presence on the table. Wipers are used in the wheels which also cleans the surface of the table.

Juhui Lee [2] et al in their work entitled "Design of Automatic Hand Sanitizer System Compatible with Various Containers" have undergone a project due to the demand of sanitization due to the outbreak in corona virus across the world. They looked into the limitations in the existing system, namely the compatibility issues between pumping devices and sanitizer containers from various manufacturers. Here their work has been designed in two stages i.e. explaining the instrument overview and also the controllers used in the system. They have used electricity to pump because it is an easy access to all devices. The results from their work have exhibited that the sanitizer container is compatible with all pumping devices. Sensors are used here to check for proximity between the sanitation pump and the hand. Their work extremely contributes to today's society with contactless disinfection in public places and also it prevents the spread of these viruses. This product they have developed is eco-friendly and also economical.

Raveena Ishalavath M [3] et al in their work entitled "Design and Development of an Automated Floor Cleaning Robot for Domestic Application" they focused on developing a device which is being controlled with the help of Bluetooth. These devices predict the presence of obstacles in the way for sanitization and avoid collision with them. They have used raspberry pi sensors as the main sensor in the device in order to control the device. They have also used servo motors which in turn are connected with an ultrasonic sensor which serves for the purpose of measuring the distance between the device and the obstacle. If they find any obstacle in their path the device actually stops and buzzer will start and this is enabled with the use of raspberry pie sensor. As per the requirement the mopping operation is taken place. The dc motor used here actuates the mopping brush attached. Controller feeds the signal to the motor. Whatever the operation is performed by the device is actually made visible through the use LCD attached in the device. The operating status is also indicated with the help of Buzzers whether it is about to start or stop or operation completed or any obstacle found.

Puput Wanarti Rusimamto [4] et al in their work entitled "Automatic Hand Sanitizer Container to Prevent the Spread of Corona Virus Disease" in concern with today's pandemic situation and to avoid the spread of coronavirus from workplace to home and to maintain hygienic atmosphere they have suggested to sanitize the workplace regularly. In this regard the available sanitizing machines are not in automated form hence human intervention is required which is a cause of spread of these viruses and thus they decided to develop an automated machine which serves for an automation to sanitize the workplace. They have used soap and water which automatically comes out. Suppose in case the liquid runs out from the container, a notification is sent to the smartphone indicating the same. They have used infrared radiation to sense the distance and it can sense the distance up to 50mm. The pump used here gets activated by the Arduino sensors. The ultrasonic sensor is connected to the blink server in order to send the data of measured distance over 35cm. The notifications can be shared to any smart phones or the pc that are IoT enabled devices, and they ensure that this device works with minimum errors and also, they can easily transfer the data in a smooth manner. Also, they have included a buzzer system to incorporate the correct working of the device in its operation.

3. Methodology

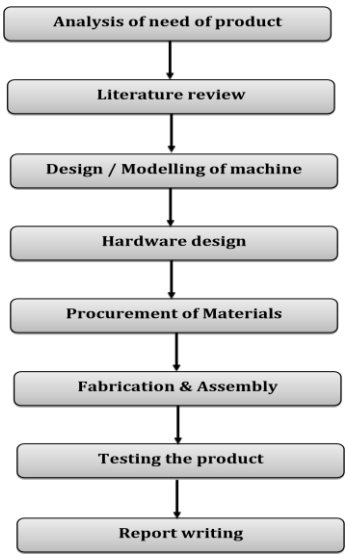


Fig. 1. Methodology

Table 1
Bill of materials

S. No.	Equipment	Quantity	Specification	Weight (Approx. in Kgs)
1	Screw Rod	1	12mm (h= 6 feet)	[0.8-1]
2	Spray Nozzle	2	Brass or PVC	0.1
3	Mopping Plate/Brush	2	PVC or Sunboard	0.3
4	Trolley Wheels	4	PVC	4*0.15
5	DC Motor	1	12v	0.3
6	Water Pump	1	12v	0.3
7	Tank	1	5L, PVC	0.5
8	Limit switches	2	Normally open & Normally closed	-

4. Design

A. CAD model of the product

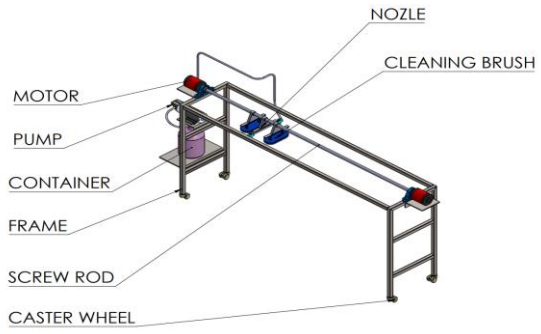


Fig. 2. Isometric view of the model

B. Design Calculation

It was decided to check the time taken for the cleaning and sanitizing process for each bench. First the assumed speed of the dc motor was 200 rpm and we carried out the calculations to check out the time taken to do the process and it was 5 min to complete the process. Later it was decided to check for next trials for best feasible time.

Trial 1: For considering the speed for 200 rpm

∴ The speed is 200 rpm

Converted to RPS we have, $\frac{200}{60}$ = 3.3 *RPS*

Pitch of the screw rod is 1.75
1.75 x 3.3 = 5.83 mm for 1 second on screw thread
Total distance is 1800 mm.

$\frac{1800}{5.83}$ = 308 *Seconds* = 5.1 *Min to complete the process*.

∴ The system takes 5.1 min to complete the process.

Trial 2: For considering the speed for 400 rpm

∴ The speed is 400 rpm
Converted to RPS we have, $\frac{400}{60}$ = 6.66 *RPS*

Pitch of the screw rod is 1.75
1.75 x 6.66 = 11.66 mm for 1 second on screw thread.

Total distance is 1800 mm

$\frac{1800}{11.66}$ = 154 *Seconds* = 2.5 *Min to complete the process*

∴ The system takes 2.5 min to complete the process

Trial 3: For considering the speed for 500 rpm
∴ The speed is 500 rpm
Converted to RPS we have, $\frac{500}{60}$ = 8.3 *RPS*

Pitch of the screw rod is 1.75

1.75 x 8.3 = 14 mm for 1 second on screw thread

Total distance is 1800 mm

$\frac{1800}{14}$ = 128 *Seconds* = 2 *Min to complete the process*

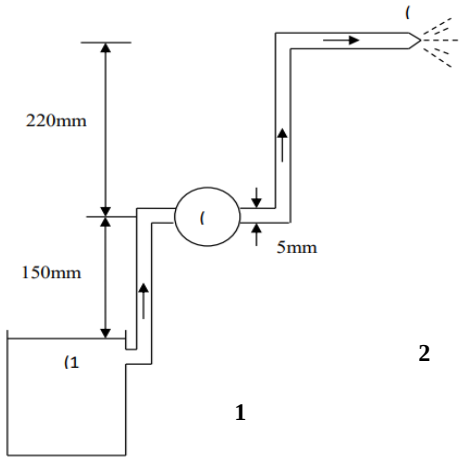
∴ The system takes 2 min to complete the process

Looking at the above trials and calculations the less time is consumed at 500 rpm of a dc motor as it takes 2 min to complete the process and it is proposed to go with a 500 rpm DC motor for serving the purpose of both cleaning and sanitizing works.

Suppose if 15 Desks / Benches available in a room it takes 2 x 15 = 30 Min to clean & sanitize the benches.

Time taken to cover the area/number of desks = 30 Min/15 Desk.

1) Pressure calculation at the nozzle outlet



(1) – tank, (2) – pump, (3) – nozzle

Fig. 3.

The pipe flow requires the applications of two principles, the law of conservation of mass (continuity equation) and the law of conservation of energy (Bernoulli's equation).

a) Conservation of mass

When a fluid flows at a constant rate in a pipe, the mass flow rate must be the same at all points along the length. Consider a liquid being pumped by a tank as shown in figure 3.

The mass flow rate at any section is $m = \rho A v_m$

ρ = density (kg/m^3)

A = cross sectional area (m^2)

v_m = mean velocity (m/s)

For the system shown in figure the mass flow rate at (1), (2) and (3) must be the same, so

$\rho_1 A_1 v_1 = \rho_2 A_2 v_2 = \rho_3 A_3 v_3$

Since it is liquid considered in the system, the density is equal. Hence,

$A_1 v_1 = A_2 v_2 = A_3 v_3 = Q$

b) Conservation of Energy

Bernoulli's equation is based on the conservation of energy. If no energy is added to the system as work or heat then the total energy of the fluid is conserved. Conservation of energy applies to flowing fluids, but as the fluid flows, energy may be converted from one form to another – pressure energy, potential energy, kinetic energy, thermal energy and mechanical work can be interconverted. The relationships between these different forms of energy can be found by Bernoulli's equation.

Bernoulli's equation is given by,

$$h_1 + z_1 + \frac{v1^2}{2g} = h_2 + z_2 + \frac{v2^2}{2g}$$

This is the head form of the equation in which each term is an energy head and z is the potential or gravitational head and v^2/2g is the kinetic or velocity head.

For liquids the density is same at both points so multiplying by ρg gives the pressure form. The total pressure is as follows,

$$P_t = p_1 + \rho g z_1 + \frac{\rho v1^2}{2} = p_2 + \rho g z_2 + \frac{\rho v2^2}{2}$$

Since the equations did not include internal energy, the balance is lost and extra term to be added to the right side of the equation to maintain the balance. This term is either the head loss to friction h_L or the pressure loss p_L.

$$h_1 + z_1 + \frac{v1^2}{2g} = h_2 + z_2 + \frac{v2^2}{2g} + h_L$$

The pressure form of the equation is,

$$p_1 + \rho g z_1 + \frac{\rho v1^2}{2} = p_2 + \rho g z_2 + \frac{\rho v2^2}{2} + p_L$$

For the system considered, the water is pumped from a tank with flow rate of 6LPM and the diameter of pipe taken as 5mm. The water from the pump is discharged through the nozzle of diameter 2mm. Since the point (1) is a free surface the pressure is atmospheric and at point (2) is 9 bars. Also, the surface area of point (1) is large (large tank), the velocity of surface is small and when squared becomes negligible. Assuming there is no energy loss, the pressure at point (3) is calculated as follows.

Area of pipe, $A_2 = \pi \times \frac{d^2}{4} = \pi \times \frac{0.005^2}{4} = 1.96 \times 10^{-5}\ m^2$

Flow rate, $Q = 6LPM = 0.0001 m^3/s$

Velocity in pipe, $v_2 = \frac{Q}{A2} = 51.02 m/s$

Area of nozzle, $A_3 = \pi \times \frac{d^2}{4} = \pi \times \frac{0.002^2}{4} = 0.314 \times 10^{-5}\ m^2$

Velocity in nozzle, $v_3 = \frac{Q}{A3} = 31.85 m/s$

Applying Bernoulli's equation between point (2) and (3),

$$p_2 + \rho g z_2 + \frac{\rho (v2)^2}{2} = p_3 + \rho g z_3 + \frac{\rho (v3)^2}{2} + p_L$$

As there is no energy loss, $p_L = 0$.

$P_2 = 9bar = 9x10^5\ N/m^2$

$z_2 = 150mm$

$v_2 = 51.02m/s$

$z_3 = 220mm$

$v_3 = 31.85m/s$

$$9x10^5 + 1000x9.81x0.15 + \frac{1000x51.02^2}{2} = p_3 + 1000x9.81x0.22 + \frac{1000x31.85^2}{2} + 0$$

$$\mathbf{p_3 = 16.94x10^5\ N/m^2 = 16.94bar}$$

$v_3 = 31.85m/s$

$$9x10^5 + 1000x9.81x0.15 + \frac{1000x51.02^2}{2} = p_3 + 1000x9.81x0.22 + \frac{1000x31.85^2}{2} + 0$$

$$\mathbf{p_3 = 16.94x10^5\ N/m^2 = 16.94bar}$$

C. Analysis of the Model

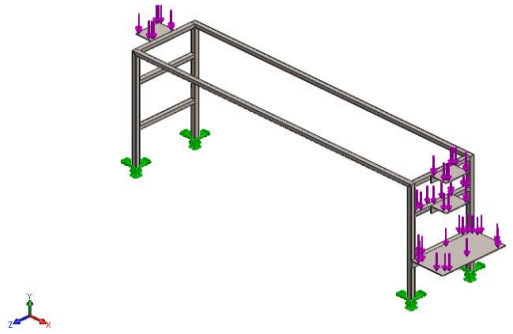
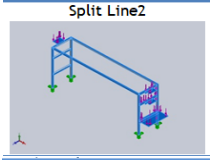


Fig. 4. Boundary conditions

Solid Bodies

Document Name and Reference	Treated As	Volumetric Properties
Split Line2 	Solid Body	Mass:18.4016 kg Volume:0.00238982 m^3 Density:7700 kg/m^3 Weight:180.336 N

Study name	Static 1
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	FFEPlus
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off

Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

D. Material properties

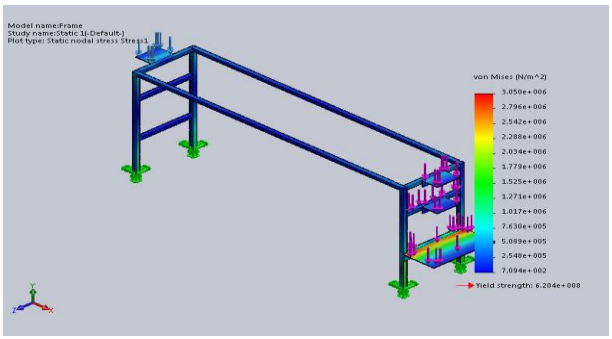


Fig. 5. Von-mises stress

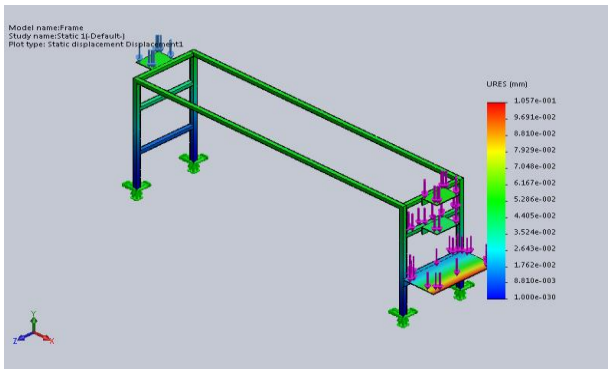


Fig. 6. Resultant displacement

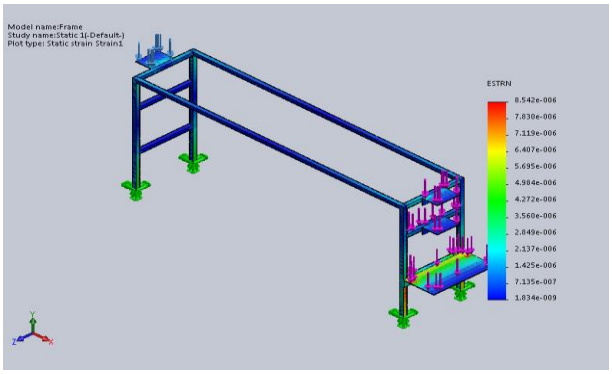
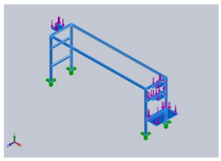


Fig. 7. Equivalent strain

Material Properties

Model Reference	Properties	
	Name:	Alloy Steel
	Model type:	Linear Elastic Isotropic
	Default failure criterion:	Unknown
	Yield strength:	6.20422e+008 N/m^2
	Tensile strength:	7.23826e+008 N/m^2
	Elastic modulus:	2.1e+011 N/m^2
	Poisson's ratio:	0.28
	Mass density:	7700 kg/m^3
	Shear modulus:	7.9e+010 N/m^2
	Thermal expansion coefficient:	1.3e-005 /Kelvin

E. Working of the Model

- The model consists of Mild steel frame, Castor wheels, Storage tank of 5L capacity, Screw rod of round 6 feet, Mopping plate, Spray nozzle, Brush, 12V – 500 RPM DC motor, Water pump.
- The Main frame is an adjustable frame. According to the height of desks it will be adjusted and fixed to serve for the purpose.
- A 5-litre capacity storage tank is maintained to store the sanitizer.
- A screw rod is held between the two main frames
- A storage tank is fitted with a water pump which pressurises the sanitizer from tank to nozzle and it is sprayed on the desks through nozzle. This helps in Sanitizing the desks.
- The system has a threefold architecture wherein the first layer is a brush which cleans the surface for dust on it, next is a nozzle system connected to the sanitizing tank sprays the sanitizer onto the desk as explained above and finally the brush wipes the sprayed sanitizer thereby completing the whole process.
- The screw rod gets activated with the help of a DC motor and it allows the movement of the nozzle from one end to another end.
- The entire system is supported with castor wheels which makes the machine portable from one place to another and also in serving operation it can be locked.
- Limit switches are used to control the motion of Nozzle as it reaches the start and end of the benches.

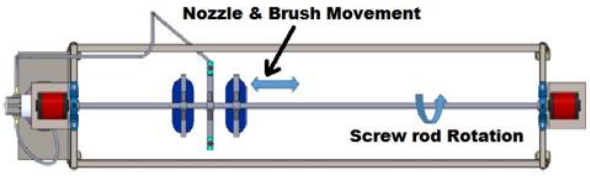


Fig. 8.

5. Conclusion

This paper presented an overview on the design, analysis and development of automated desk sanitizing machine.

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