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A New Approach to Design Sanitizing Machine by using Automated Guided System

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Abstract

Demand for sanitizers has increased since the coronavirus broke out and spread over the world Sanitization machines are operated by a driver manually. Sanitization machines are totally human-dependent in order to work. But after the COVID-19 sanitization has also become challenging for the person who is operating the machine in contaminated areas. So, this paper suggests the design of a sanitization machine that will be Automatic & self-operated by combining a sanitization machine & an Automated Guided System. So that machine can self-navigate its movement and sanitize its surrounding. Automated Guided System (AGS) is one kind of system in which a machine or a vehicle follows the given pre-defined paths and route. This sanitization can be done in the contaminated areas where humans are not safe to go and also in all types of indoor public gathering places by using this machine.

Keywords: Sanitization, Automatic Guided System, Covid-19, Hands free sanitization.

INTRODUCTION

Demand for sanitizers has increased since the coronavirus broke out and spread over the world. Hand sanitizers are commonly applied by squirting the sanitizer liquid when one presses a pump with one's hand [1]. As a result, a large number of people come into touch with the pump handle, increasing the possibility of viral transmission. On the market, several hand sanitizers are automatically pumped. However, because hand sanitizer containers and pump devices are designed to work only with other goods from the same manufacturer, consumers must also replace the liquid container if they replace the hand sanitizer [1,2]. Hand sanitizers with alcohol gel are often applied by squirting the sanitizer liquid while pressing a pump with one's hand. As a result, a lot of people come into touch with the pump handle, increasing the risk of viral transmission. Many people avoid cleaning their hands because pressing the pump handle is inconvenient. Furthermore, because everyone presses the pump handle differently, it's impossible to forecast how much will be used and manage refills and replacements. As a result, people are using fewer hand sanitizers, which doesn't help prevent the infection from spreading.

On the market, several hand sanitizers are automatically pumped. However, because sanitizer containers and pump devices are only designed to work with other products from the same manufacturer, consumers must also purchase a new liquid container if they replace their hand sanitizer. It is not cost-effective, and it has a negative environmental impact by increasing waste emissions. Furthermore, some users may believe that purchasing a hand sanitizer-containing device-compatible hand sanitizer is inconvenient, so they pour other hand sanitizers into previously used containers and reuse them.[2]

Two major contributions to the art of sterilization came in the 1860's, when the French chemist and microbiologist Louis Pasteur wrote extensively on how germs cause disease and the English physician, Joseph Lister, developed a technique that used carbolic acid as a spray to disinfect instruments. Time to Time Sanitization Machine are upgrading as per the demand, in order to make the process of sanitization easy and human friendly. But, after COVID-19 sanitization has become challenging for the person who is sanitizing in contaminated areas. Sanitization on a regular basis has become our need, in order to live in healthy and non – contaminated atmosphere.

In this work effort has been taken to develop an automated guided system which can self-navigate the sanitization machine.

REVIEW OF LITERATURE

Automated Guided System plays a vital role in all research areas. Many recent studies have focused on the problem of sanitization process. In this work sanitizing machine & Automated guided system combined together to make it robotic sanitizing machine. The sanitization machines are operated by a driver manually. But after the **COVID-19** sanitization has also become challenging for the person who is operating the machine in contaminated areas. So, to fulfill this loophole; new design of sanitization machine which will be Automatic & self-operated is proposed.

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino & IR Sensors is also cost efficient & helps for automation. Arduino is a brain of prototype to navigate the machine by itself. Person operating sanitizing machine in hazardous & contaminated areas are risky. After prototype implementation, it meets the use of sanitization in public gathering places and in dangerous & contaminated working areas where humans are not safe to go**.**

TECHNICAL ASPECTS OF SANITIZING MACHINE

Sanitization machine will move on tracks automatically or can be controlled by the transmitter and will sanitize its surrounding.

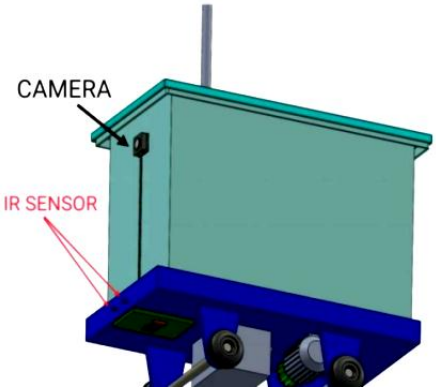

Fig.-1: CAD Model of Sanitizing Machine

Machine has two types of movement they are -:

i. Fully Automatic- In this, machine will move on tracks and these tracks will be made of colored tapping on the floor. As with the help of infrared sensors machine will able to follow the colored tapping by sensing it. And, these infrared sensors will avoid any type of collisions on the track. Its machines sense any type of collisions. So, it will suddenly stop and remained stopped until the path is not clear. To move Arduino which is used as motor controller will guide the movement of the machine. In this manner machine will self-navigate its movement and sanitize its surrounding without any human guidance and can be used in indoor public gathering places.

ii. Semi-Automatic Movement- In this, machine can be operated by human. As receiver is installed and connected to the Arduino board. A person can control its movement and sanitize to any particular region. The Camera is also installed at the front of the machine. So, the live movement of the machine can be tracked on mobile screen of a person who is controlling the machine. Live camera vision will help the operator to control it more preciously. With the help of this movement a person sitting in some safe environment can sanitize a contaminated room or infected area more preciously. Without physically present with the machine.

A- Various components required for Sanitizing Machine

The Various components are required in Sanitizing Machine which is modified by automatic guided system.

a. **Arduino** - Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a motor, turning on an LED, publishing something online. In proposed system, Arduino is a main motor controller and it is a brain of system. It will guide the machine movement by detecting the paths with the help of infrared sensors.

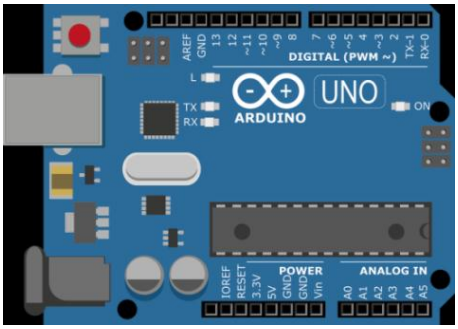

Fig. -2: Arduino

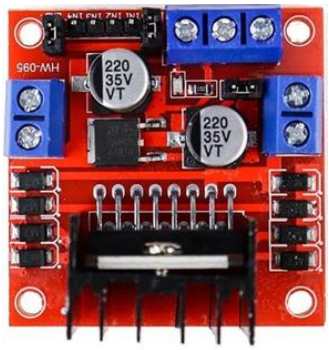

Fig.-3: Motor Driver Shield

b. **Motor Driver Shield** -The Motor Shield shown in fig.3, is a driver module for motors that allows to use Arduino to control the working speed and direction of DC gear motor.

c. **Drive Wheel** - A drive wheel is a wheel of a motor vehicle that transmits force, transforming torque into tractive force from the tires to the road, causing the vehicle to move. There are total four wheels in our prototype. Two wheels at front & another two at rear.

d. **DC Gear Motor** (12V) – A gear motor is an all-in-one combination of a motor and gearbox. The addition of a gear head to a motor reduces the speed while increasing the torque output.

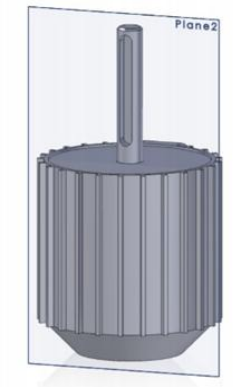

Fig.-4: DC Gear Motor

Fig.-5: Infrared Sensor

e. **Servomotor** – The servomotor (or servo motor) is a simple electric motor, controlled with the help of servomechanism. In proposed prototype it is connected to the front wheels for the steering maximum. It is also known as Servomotor Electronic Steering Mechanism for giving machine left and right movement.

f. **Infrared Sensor**- It is an electronic device that measures and detects infrared radiation in itssurroundingenvironment.Activeinfraredsensorsbothemitanddetectinfraredradiation.In proposed prototype Infrared sensors are used for debating colored tapping on the floor or predefined paths. Also, avoid collisions on the path.

g. **Acrylic Sheets** - are thermoplastics, often purchased in sheets as a lightweight or shatter-resistant alternative to glass. Acrylic is known by many names, with generic names including acrylic, acrylic glass, and Plexiglas. In our prototype carrier bed or chassis is made – up of Acrylic sheets which will carry our above assembly of liquid tank.

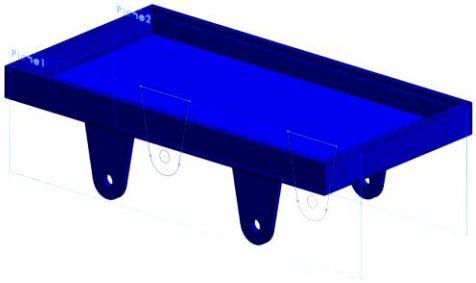

Fig.-6: Carrier Bed or Chassis

h. **Lithium-ion Battery** – A lithium-ion battery or Li-ion battery is a type of rechargeable battery. Battery is the main & only source of energy for our prototype.

i. **Liquid Tank** - In machine prototype liquid tank is placed over the carrier bed and it will carry the sanitization liquid.

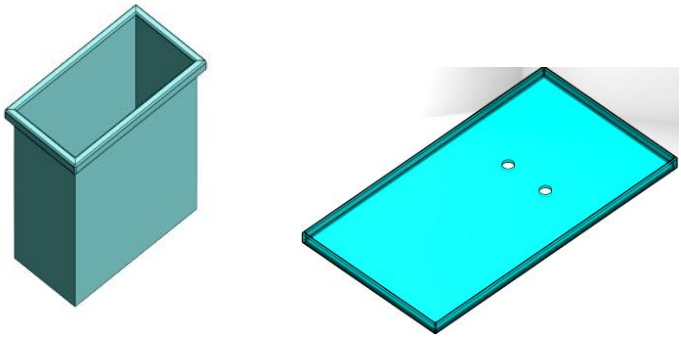

Fig.-7: liquid tank and its cover

j. **Pipes -** A pipe is a tubular section or hollow cylinder, usually but not necessarily of circular cross-section, used mainly to convey substances which can flow - liquids. Pipes are used to transfer the sanitizing liquid from liquid tank to the nozzle spray.

Fig.-8: Pipe

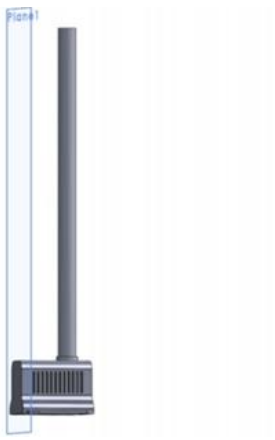

Fig.-9: Diaphragm Pump

k. **Diaphragm Pump -**A diaphragm pump is a positive displacement pump that uses a combination of the reciprocating action of a rubber, thermoplastic or Teflon diaphragm and suitable valves on either side of the diaphragm to pump a fluid. In prototype, it is used for pumping liquid form the tank to the nozzle. Diaphragm pump are most suitable pump for spraying because of their law cavitation's.

l. **Gear and Shaft**– Gears are mechanical components that transmit rotation and power from one shaft to another, if each shaft possesses appropriately shaped projections (teeth) equally spaced around its circumference such that as it rotates, the successive tooth goes into the space between the teeth of the other shaft.

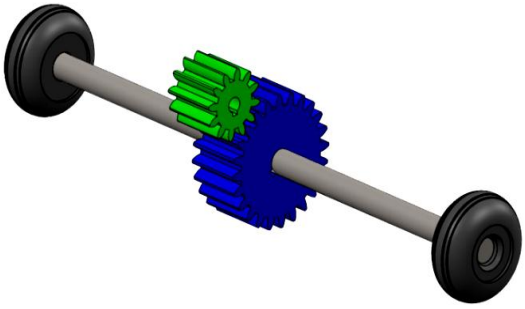

Fig.-10: Gear and Shaft

Fig.-11: Nozzle (T-shaped)

m. **Nozzle**- is a precision device that facilitates dispersion of liquid into a spray. Nozzles are connected at both the end of T-shape pipes at the top of the machine. It is used for spraying.

n. **Camera** - Camera visions are used in the front of our prototype to capture the live movement of the machine when it is controlled by the transmitter.

o. **Transmitter and Receiver –** A device for sending electromagnetic waves; the part of a broadcasting apparatus that generates and modulates the radiofrequency current and conveys it to the antenna. It is used for controlling the movement of the machine whenever it is required. Receiver is connected to the Arduino, which will receive signals from the Transmitter and transfer signal to the Arduino.

DESIGN CALCULATIONS OF SANITIZING MACHINE

The calculations of the machine for the requirement of DC gear motor, Battery pack and Shaft design. Following assumption are taken into consideration while design the sanitizing machine.

Weight of the machine = 15 kilogram

Length of the machine = 40 cm = 0.4 meter

Width of the machine = 28 cm = 0.28 meter

Height of the machine = 30 cm = 0.30 meter

Speed of the machine = 1 meter/second = 3.6 kilometer/hour

Wheel radius = 0.03 meter (2 inches)

Rolling resistance (R_R) = 0.01

Drag coefficient (C_d) = 0.88

Air density (ρ) = 1.22 kg/m^3

Now, total distance covered by machine is calculated by;

$Linear\ Distance\ Covered = 2\pi r\ = 0.1884\ m$

Therefore, $Revolution\ per\ minute\ (RPM) = \frac{Total\ distance\ covered\ per\ hour}{linear\ distance\ travelled} = 318.47$

A- Calculations for Power Input

To calculate total input power required to run the sanitizer machine Rolling force, Drag force and Gradient force are taken into consideration. These different types of the forces are calculated.

i. Rolling force

$Rolling\ force = mg \times R_R = 15 \times 9.8 \times 0.01 = 1.47\ N$

By using the Rolling force the Rolling power is calculated.

Therefore, $Rolling\ power = 1.47 \times (velocity) =$ **1.47 Watts**

ii. Drag force

$$Drag\ Force = \frac{\rho \times A_f \times V^2 \times C_d}{2}$$

Where, A_f is frontal area, C_d is drag coefficient and V is the velocity of machine.

Therefore, $Drag\ Force = 0.06468$ N

The Drag Power can be calculated by following equation,

Drag Power = Drag force x velocity = $0.06468\ Watts$

iii. Gradient Force

$Gradient\ Force = mg \times sin\emptyset = 15 \times 9.8 \times sin20° = 50.276$ N

And, $Gradient\ Power = Gradient\ Force \times Velocity =$ **50.276 Watts**

Total Power:

Total power can be calculated by following equation,

$\sum$ Power $= Rolling\ Power + Drag\ Power + Gradient\ Power$

$\sum \text{Power}_{\text{Input}} = 51.811$ Watts (Approximately 52 Watts)

B- Calculation for Torque

The torque can be calculated by

$$Torque = \frac{9.5488\ Power\ (N)}{Speed\ (RPM)} = 1.55\ N - meter\ or\ 15.5\ kgf - cm$$

C- Battery Calculations

The total Power of prototype is 52 Watt and RPM is approximately 400 as calculated.

Supply Voltage of battery = 12 Volt.

$$watt.\frac{hour}{kilometer} = \frac{52}{3.6} = 14.44\ W - hr/km$$

Now converting it in "Ampere-hour/kilometer"

$$\rightarrow \frac{14.44\frac{W-Ahr}{km}}{12V} = 1.203\ A.\frac{hr}{km}$$

So, Vehicle requires battery of capacity 1.203 amp-hr/km. It is assumed battery is 80% efficient.

And here lithium polymer battery pack is used.

Efficiency factor of lithium polymer battery is 1.2 and Lithium polymer factor is 1.04

Therefore, Battery consumption for 1 kilometer is $1.501344\ ampere - hour$

Or $1501\ mili\ ampere - hour$

D- Shaft Design

For the shaft stainless steel material is used, which has allowable shear stress,

$\tau = 45\ MPa = 45\ n/mm^2$, having composition of 8% nickel and 18% chromium.

The length of Shaft (L) is considered as *0.28 m,*

The Pitch Circle Diameter of gear which will be mounted on shaft, *D is 0.04 m*, is consider by keeping ground clearance.

Pressure angle of gear is taken 20 degree,

Torque transmitted by shaft,

$$T = P\,x\frac{60}{2\pi N} = \frac{52x60}{2\pi \times 400} = 1.241Nm$$

Therefore, Tangential Force of the Gear,

$$F(t) = \frac{2T}{D} = 2 \times \frac{1.241}{0.04} = 31.035\ N$$

Normal Load acting on the tooth of the gear,

$$W = \frac{F(t)}{COS\ 20} = \frac{31.035}{0.9397} = 33.02\ N$$

As gear is mounted at the middle of the shaft, therefore maximum bending moment (M) at the centre, $\frac{WL}{4} = 2.31\ Nm$

Now, Equivalent Twisting Moment, T (e) $=\sqrt{M^2 + T^2} = 2.623\ N.mm$,

And, the diameter of the shaft (d) can be calculated by another formula of Equivalent Twisting

Moment; $T(e) = \frac{\pi}{16}$ x ζ x d^3

By putting the value, the diameter of the shaft (d) is 6.67mm; approximately 7 mm.

So, steel shaft of diameter 7 mm which is suitable for prototype.

CAD MODEL OF SANITIZING MACHINE

The CAD model is prepared by using Solid Works 2016. Fig. 12 shows the various views of sanitizing machine and Fig. 13 shows exploded view of machine.

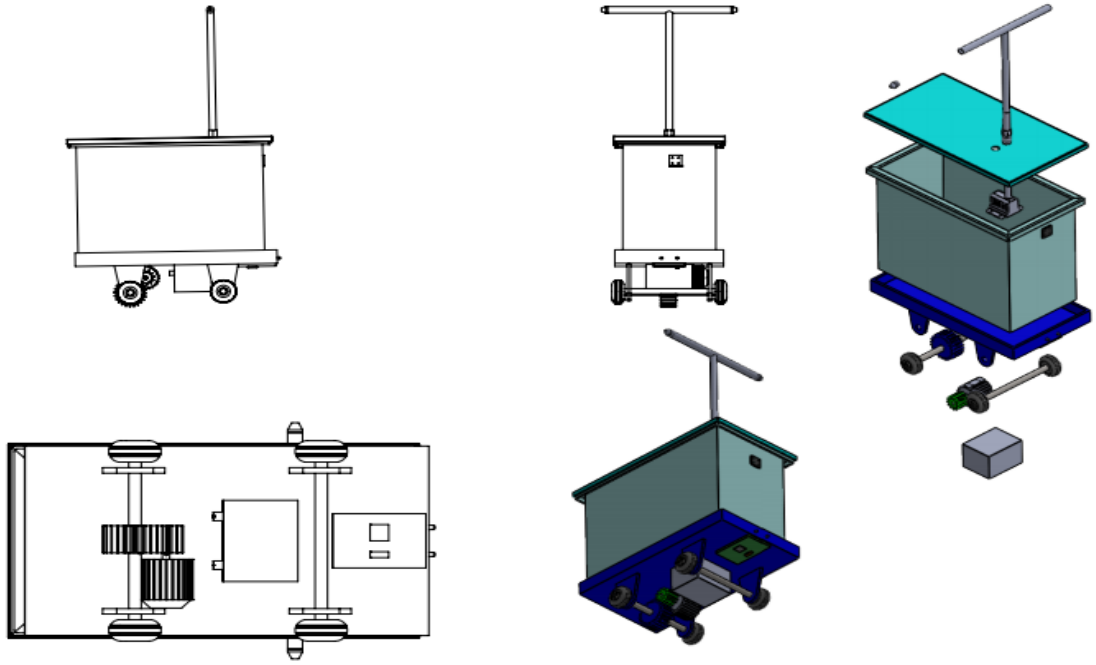

Fig.-12: Views of the Prototype

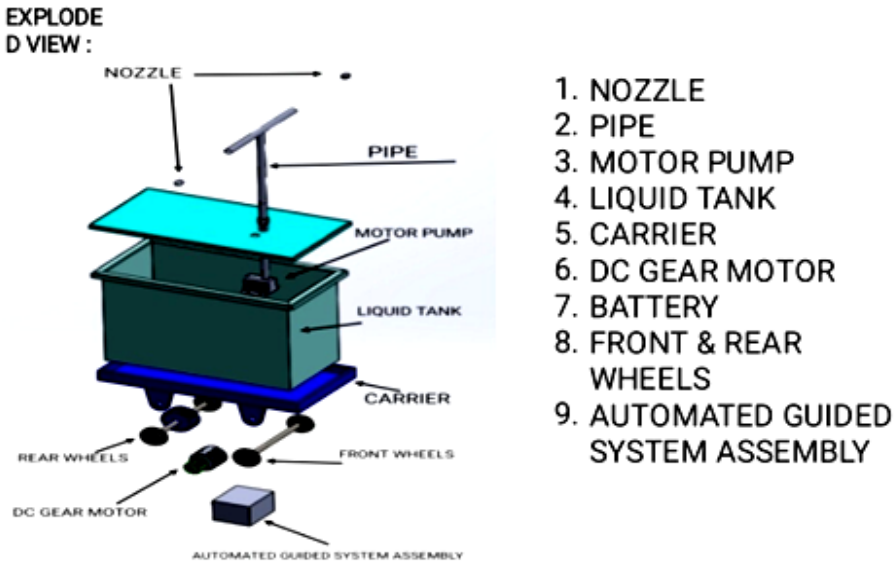

Fig.-13: Components of the Prototype

CONCLUSION

After the prototype implementation, this machine can be used in all type of public gathering places like; Malls, Library, Schools, Collages, Hospital's and etc. This machine will work without any human dependency and can work 24×7. Sanitizing will become much easier and efficient with the help of this machine. After the COVID-19 sanitization has become our need in order to live in a safe and infection free environment. With the help of this machine sanitization will become much easier and can be done in all type of indoor public working areas like; Industrial fields, warehouses, medical fields and etc. Basically, all types of indoor public gathering places, where huge crowed gathering on regular basis including stations and airports as well. With the help of the machine, spreading of COVID-19 can be stopped.

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