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Twin Spray Sanitation Machine

Tham Sook Chan, Mazlina Mohd Tahir, Mahmood Ali, Azhar Rostani ^{a*}

^aDepartment of Mechanical Engineering, Port Dickson Polytechnic, 71050, Port Dickson, Negeri Sembilan, Malaysia.

Abstract

The whole world has now been hit by the Coronavirus (Covid-19). However, with the availability of undiscovered vaccines, it can be avoided from spreading through self-sanitation and environmental processes. Through an interview with the Senior Fire Officer at the Teluk Kemang Fire and Rescue Station, the task of carrying a spray barrel with a volume of 18 litres is a heavy and tiring load. From this problem, the Twin Spray Sanitation Machine's product innovation objectives are triggered, namely, producing a larger tank capacity, saving time in spraying and applying the ergonomic concept. Through attractive design using the "Design Thinking" methodology based on "explore, empathize, define, ideate, prototype & test" and "PDCA Cycle", sanitation machine with influential storage tank was equipped with push trolley. Through tests conducted on Port Dickson Polytechnic's campus building, it is proven that there is no issue in sanitation activities with time savings of 50% per 1000 square feet with minimal firefighters. In short, this machine can facilitate its users in sanitation activities indoors and outdoors. Hopefully, it can be widely used once modified to materials using natural fibers and electric power supply motor, making it more user friendly

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Key-word: Sanitation, Sanitation Machine, Covid-19 Outbreak, Design Thinking

1. Introduction

The whole world today has had difficulty coping with the sudden spread of Coronavirus (Covid-19). Various innovations related to this pandemic have been done by researchers to deal with this adverse situation. The outbreak can be prevented from spreading by using hand sanitizer and sanitation processes on the affected area as long as no vaccine has been found. Therefore, a more efficient sanitation spraying process around affected areas should be done quickly and comprehensively by obeying to the Standard Operating Procedure (SOP) provisions from the Ministry of Health Malaysia (MoH). The MoH organized diverse disinfection activities to be conducted by the Ministry of Housing and Local Government, local authorities, and the DBKL (Kuala Lumpur City Council) at mainly in high-risk areas recently (Bernama, 2020e). According to Adrija Roy et. al (2020) in order to curb the dispersed of the disease there is an immense role of disinfection, though the virus survives on environmental surfaces for varied period of time, it gets easily trigger off by chemical disinfectants. At another hand, as mentioned by Public health expert, Dr Ahmad Zaid Fattah Azman, who is also a lecturer at the Faculty of Medicine and Health Sciences Universiti Putra Malaysia (UPM), said the same process can be done a second time if there are recurring cases at the location (Berita Harian, 08 April 2020). So, the correct and effective use of disinfectants, are extremely important, due to, the germs or virus will die immediately when sprayed with right amount of chlorine or antiseptic liquid. It is really depending on what material is used in sanitation work.

The previous product in sanitation work, Sanitary Spray Barrels, as shown in Figure 1 (either manually or motorized) used in conventional sanitation methods has various weaknesses and shortcomings after several tests. As a result, the idea arose to create a Twin Spray Sanitation Machine (TSSM) that can overcome previous products' weaknesses.

* Tham Sook Chan. Tel.: +60125613570; Fax: 066622026
E-mail address: sookchan@polipd.edu.my

Generally, Sanitary Spray Barrels are uncomfortable and can cause pain to the body, especially on the shoulders and do not meet the ergonomic features. The heavy load of 18 litres had to be borne by an individual or front liner member. In addition, according to the Director General of the Fire and Rescue Department, Datuk Mohammad Hamdan Wahid, wearing personal protective clothing (PPE) during hot weather to clean and disinfect inside the affected area inside a building is one of the challenges faced by firefighters and rescuers while handling the task (Berita Harian, 16 May 2020). Therefore, to overcome the issues, this product has various innovative characteristics that have been improved, such as a larger tank capacity of 50 litres to reduce the refilling sanitary fluid into the tank more often. The special feature of this product is the addition of two nozzles units to the sprayer so that it can operate with two people at once. Finally, the idea arose to innovate a spray barrel from the way of carrying the spraying barrel on a shoulder to the concept of pushing a sanitation tank on a trolley. The concept of pushing this specially designed tank can prevent its users from carrying heavy spray barrels. It can even reduce the risk of frontline users being exposed to the hazard of toxic sanitary chemicals (Sodium hypochlorite - a bleach) where such chemicals can affect their health for a long period of use.

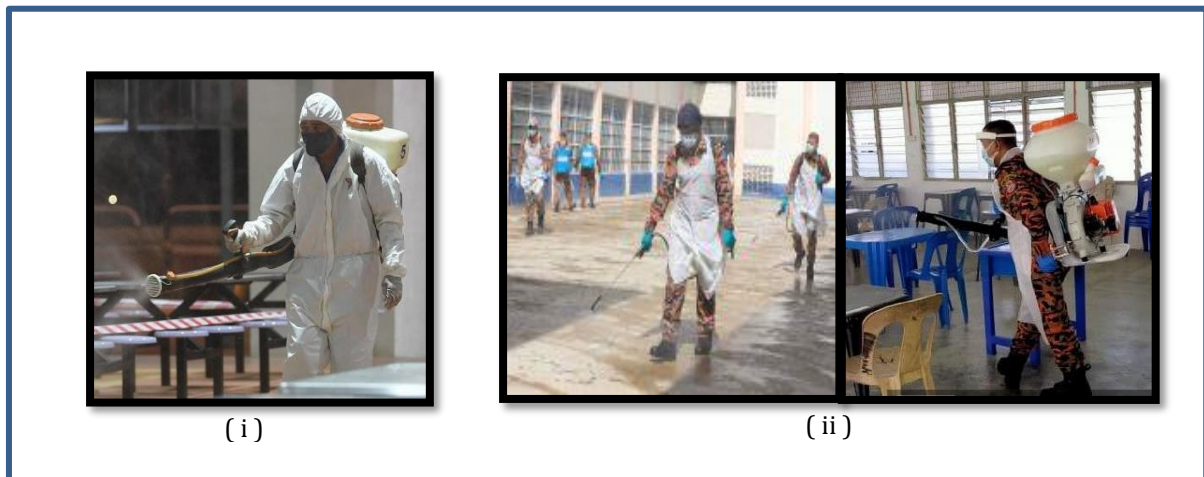


Figure 1 Sanitary equipment commonly used in sanitation work (i) Manual Spray Sanitation Barrel, (ii) Motorize Spray Sanitation Barrel (Berita Harian on 22 April and 10 September 2020)

2. Problem Statement

Through an interview with Tuan Sabarudin Ahmad, Senior Fire Officer II from the Teluk Kemang Fire and Rescue Station, the problems identified through the use of conventional sanitation methods using existing spray barrel as shown in Figure 2, are:

- i. The firefighters and rescuers involved have to carry a manual or motor sprayer barrel with a volume of 18 litres while performing the task, and it is a heavy and tiring load. In addition, the manual use of sanitary spray barrels makes it difficult for the users because they need to pump the sanitary fluid first before they can do the sanitary spray. This repetitive work can cause fatigue in the limb joints and prolonged back pain.
- ii. Mixture liquid containing Sodium Hypochlorite (a type of bleach), can overflow when fully filled in a barrel or when the limbs bend while on duty. This causes exposure to the body and is dangerous in terms of limb health, even wearing PPE with Tyvek clothing as in Figure 1.
- iii. The use of a small capacity tank with a volume of only 18 litres for a spray area of more than one acre is ineffective. Consumers need to refill the sanitary mix more often. The productivity of sanitation work is not guaranteed because they have to consider the waiting time to refill the mixing liquid.



Figure 2 Existing Spray Barrel Sanitation Equipment and used at the Fire and Rescue Station in Teluk Kemang, Port Dickson.

3. Objective

From the interview results of frontliner members, the product objectives to address the problem statement that has been found are as follows:

- i. Produce a machine with a large capacity to carry sanitary fluid, to facilitate the work of filling the sanitary liquid mixture with more quantity.
- ii. Save time in the process of spraying sanitary fluids to all places in any building and the surrounding area, so that residents in the polytechnic are more confident to attend work or students are more motivated to study.
- iii. Assist the fire department in finding other alternatives for this sanitation business through innovation, from carrying a spray barrel to the concept of pushing the sanitation tank on the trolley.

4. Methodology

4.1 Design Thinking Methodology

In the initial stage, various methods are implemented in finding information for this product. Therefore, the "Design Thinking" methodology, is the most effective method and very helpful in finding problem statements and objectives. In the "Design Thinking" methodology, there are six phases that can help to expedite producing a product, namely 'explore', 'empathize', 'define', 'ideate', 'prototype' and 'test'. In the initial process of 'explore', an individual need to research a place to find various problems and know how to solve them in advance. In the second phase, 'empathize' is to find information through how an interview of a user or individual is involved. For example, doing more in-depth sanitation work is known through interviews with firefighters or frontliner members involved. The use of existing products used is also studied to see its shortcomings in finding space for improvement. The third and fourth phases of 'define' and 'ideate' are to do various types of mind maps, collect the main problems and solve them. The fifth phase of the 'prototype' is to build a model to see the initial effectiveness and know the shortcomings that can be overcome before the actual product is made. In turn, they can save costs in purchasing components for the product. The sixth or final phase of 'test' is trying the product made and presenting to consumers and non-consumers to get feedback results. It can help reduce weaknesses in the product. Fabrication and installation are implemented according to the scale that has been set to be tested. The final stage is to apply this machine at the target location to see its functionality and effectiveness. Design thinking is a good approach to solve real world problem where researcher have the opportunity to address the real engineering problem, Zuraidah Ahmad et. al (2020).

4.2 Methodology Selection of Main Components

- i. Tank with a capacity of 50 litres.

It has a larger tank than a standard tank with a capacity of 18 litres, as shown in Figure 3. The use of sanitary liquid storage tank material that is resistant to the chemical reaction of High-Density Polyethylene (HDPE) was chosen due to its nature to withstand the level of corrosion caused by sanitary liquids. Table 1 describes High-Density Polyethylene (HDPE) properties, making it an ideal material for storing chemicals.



Figure 3 Sanitation storage tank

Table 1 Thermophysical Properties of High Density Polyethylene (HDPE) (*International Journal of Research in Engineering and Technology. Bangalore, India: IJRET/Sun Publications. 04 (12)*)

Density	940 kg/m ³
Melting Point	130.8 °C.
Temperature of crystallization	111.9 °C.
Latent heat of fusion	178.6 kJ/kg.
Thermal conductivity	0.44 W/m.°C. at °C.
Specific Heat Capacity	1330 to 2400 J/kg-K
Specific heat (solid)	1.9 kJ/kg. °C.
Crystallinity	60%

With reference to the comparison in Figure 4, High Density Polyethylene (HDPE) is the most suitable plastic for alcohol base and other liquids in the sanitation process. Therefore, sanitary storage tanks are recommended to use this type of material.

	ETFE	FEP/TFE / PFA	FLPE	FLPP	HDPE	LDPE	PC	PETG	PP	PVC	TPE***	
Acids, dilute or weak	E	E	E	E	E	E	E	G	E	E	G	E
Acids,** strong / concentrated	E	E	G	G	G	G	G	N	G	G	F	G
Alcohols, aliphatic	E	E	E	E	E	E	G	G	E	G	E	G
Aldehydes	E	E	G	G	G	G	G	G	G	G	G	G
Bases/Alkali	E	E	F	E	E	E	N	N	E	E	F	F
Esters	G	E	G	G	G	G	N	G	G	N	N	F
Hydrocarbons, aliphatic	E	E	E	G	G	F	G	G	G	G	E	F
Hydrocarbons, aromatic	G	E	E	N	N	N	N	N	N	N	N	N
Hydrocarbons, halogenated	G	E	G	F	N	N	N	N	N	N	F	N
Ketones, aromatic	G	E	G	G	N	N	N	N	N	N	F	N
Oxidizing Agents, strong	E	E	F	F	F	F	F	F	F	G	N	N

E 30 Days of constant exposure causes no damage. Plastic may tolerate for years.

G Little or no damage after 30 days of constant exposure to the reagent.

F Some effect after 7 days to the reagent. The effect may be crazing, cracking, loss of strength or discoloration.

N Not recommended. Immediate damage may occur. Depending on the plastic, the effect may be severe crazing, cracking, loss of strength, discoloration deformation, dissolution or permeation loss.

*not for tubing chemical resistance (except pvc)

**except for oxidizing acids (see Oxidizing Agents, strong)

*** TPE gaskets

Figure 4 The chart shows the resistance of plastics to chemicals (<https://www.calpaclab.com/chemical-compatibility-charts/>)

ii. Twin sprayers.

Twin sprays have the advantage of speeding up and saving time on the sanitation process. Therefore, it can shorten the time of sanitation activities. 'Stainless steel' 420 was chosen as the material for twin sprayers because prolonged use of sanitary liquids will tend to result in corrosion. The Figure 5 shows the durability levels of stainless steel used for twin sprayers for corrosion resistance and chemical resistance. Therefore, grade 420 stainless steel is very suitable for sanitary use because it is stainless and resistant to chemicals.

TYPE OF STAINLESS	STAINLESS GRADE	FEATURES/ BENEFITS	USEFUL FOR
Austenitic	304	A general purpose grade. It is commonly used because it offers reasonable corrosion resistance, and is reasonably priced.	A variety of applications, including interior, and non-coastal exterior, or coastal exterior applications which are hidden from sight (as may tea-stain).
	316	Sometimes referred to as the 'marine grade' because of its excellent corrosion resistance (better than 304).	Boat and marine applications, and exterior use near the coast (within 5km).
	Bumax	A 316 grade with extra Molybdenum added. Usually made to high strength classes 80 and 100 and has excellent corrosion resistance.	Where high strength and excellent corrosion resistance is required.
	310	Used for high-temperature applications.	Furnaces and locations of extreme heat.
Martensitic	410	A Martensitic grade that can be hardened by heat treatment.	Self Drilling (into metal) screws in non-coastal and less corrosive environments (e.g. interior use).
	420	A nickel-free grade with high carbon. It is stronger than 410.	Spring Pins in less corrosive environments.
	Hardtec	A Martensitic alloy like 410 so can be hardened with heat treatment, but has Molybdenum added and so offers much better corrosion resistance (similar to 304 grade).	Self Drilling (into metal) screws.

Figure 5 Durability levels of various types stainless steel for corrosion resistance and chemical resistance (<https://removeandreplace.com/2016/11/07/stainless-steel-grades-and-types/>)

iii. How to bring a trolley concept

The use of trolley can help reduce the risk of joint disease, back pain and ergonomic problems. In addition, it makes it easier for consumers to use this product to carry heavy liquids with a volume of 50 litres.

iv. Water Pump

The use of water pumps is also a key aspect in helping sanitation activities be done more effectively and does not take too long. Its function is to help drain fluid throughout the system automatically after turning on.

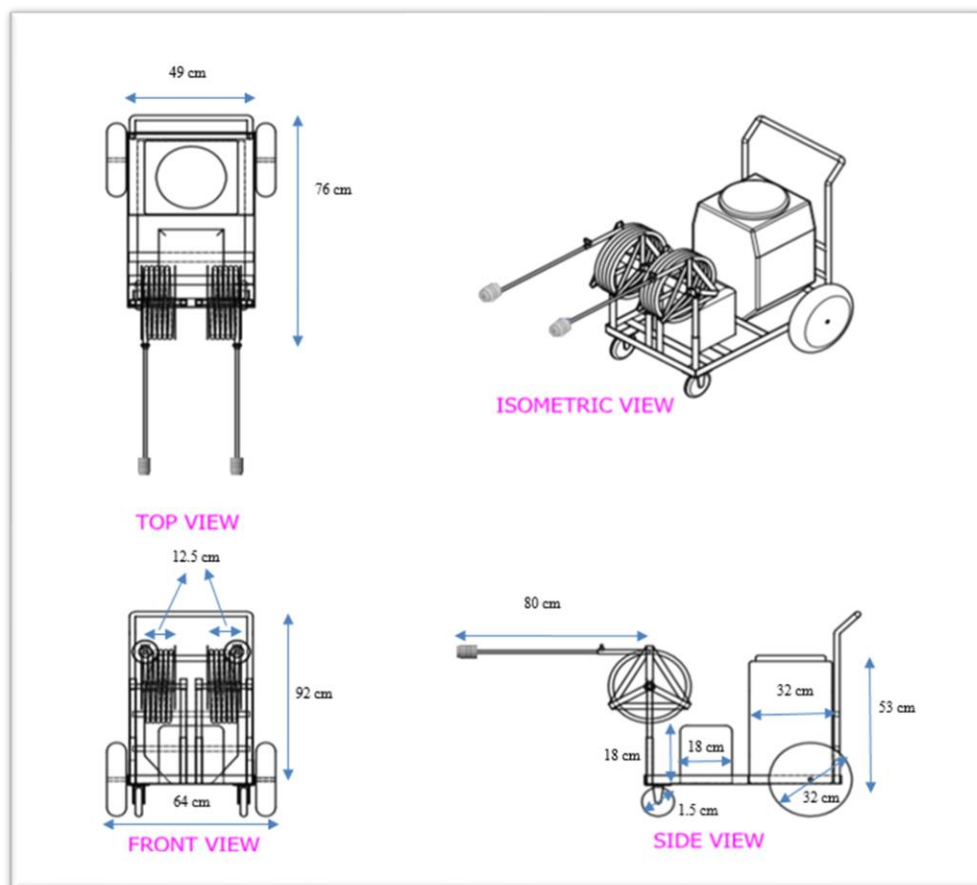
Briefly, this machine's main components' specifications are described, as shown in the Table 2. The maintenance of this product is divided into two main parts, which are; water pump and 50-litres capacity tank. The water pump needs to be maintained every three times to prevent it from becoming clogged by making a lubrication maintenance process on the pump. The tank with a capacity of 50 litres needs to be maintained after use by cleaning the tank to prevent the tank from becoming muddy and cause it to clog.

Table 2 Machine's main components' specifications

Main component	Specification
Water pump	The water pump is powered by 1.2 horsepower, and uses 2T petrol and engine oil as fuel
High pressure water hose (10 bar - 50 bar)	Length in 15m and 8.5 mm in diameter
Sanitation storage tank	50 litres capacity tank
Twin sprayer	420 stainless steel, anti-rust and chemical resistant

5. Results

Twin Spray Sanitation Machine (TSSM) has a high impact on the sanitation services sector and the local community as shown in Figure 6 and Figure 7. Therefore, this product applies various technologies to help and meet the characteristics of ergonomic factors of human work so that the discomfort and long-term effects of joint pain do not extend to individuals who use this product. This machine can provide time savings of 50% per 1000 square feet in the sanitation process. Further, it can increase productivity with a liquid filling tank of 50 litres without frequent filling of sanitary mixtures. In addition, reducing the number of users can reduce the risk of consumers being exposed to the hazard of toxic sanitary chemicals (Sodium hypochlorite - a type of bleach). Thus, increasing the satisfaction of consumers who do sanitation work and the confidence of polytechnics in performing activities at work can be maximized. The impact of this innovation product has been compared to an 18 Litres sanitary spray barrel and has been summarized as in Table 3.

**Figure 6** Isometric drawings Twin Spray Sanitation Machine (TSSM)

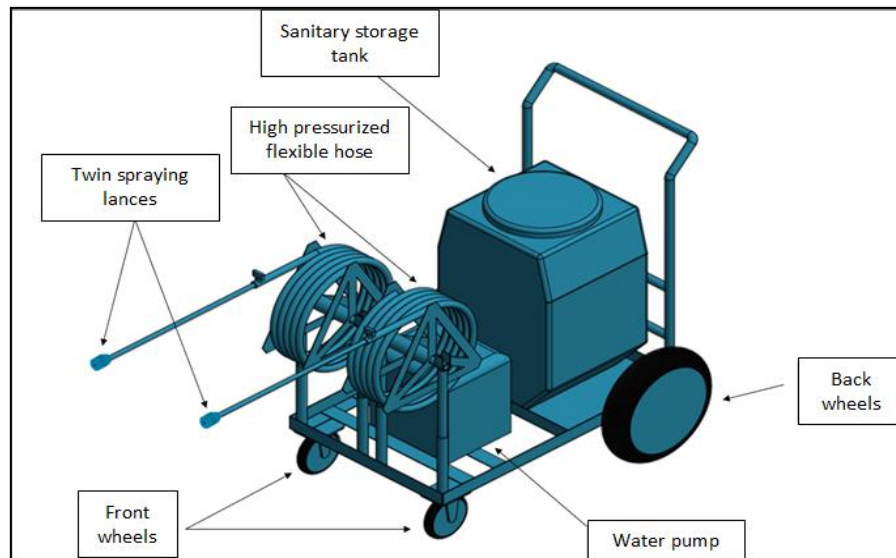


Figure 7 Three-dimensional overall drawings for the Twin Spray Sanitation Machine (TSSM)

Table 3 Summarization and comparison TSSM with 18 L manual spray barrel

No.	Comparison Criteria	50L Twin Spray Sanitation Machine	18L Manual Spray Barrel
1	Number of sprayers that can be used at one time	Two (2)	One (1)
2	Machine ratio: users at a time	1: 2	1:1
3.	The use of spray time for an area of 1000 square feet based on the number of sprayers available	15 minutes	30 minutes
4.	Operating mechanism	Semi-automatic (users can continue spraying after the flow of sanitary fluid is pumped by the water pump)	Manual (users need to pump first before spraying)
5.	Sanitation tank capacity	Almost 3 times more than a manual spray barrel	-

This product has led to the innovation of various features that are quite specific, namely from the use of sanitary barrel that is always used to those that are easier to carry and can be used by two users simultaneously at the same time. The components and materials used are easy to find and more user friendly. Phases trigger this product's production in the Design Thinking approach and the PDCA cycle. Therefore, the unit cost of the innovation project is estimated at RM750 per unit.

6. Conclusion

After making the analysis, there are some weaknesses in the innovation of this machine. Petrol engine can be modified to electric power supply motor to reduce noise and smoke pollution. In addition, the front and rear wheels can also be improved with a large size and can move themselves partially and fully automatically to smooth the process of sanitation work. Material such as natural fiber can be replaced to save production costs and reduce machine weight for certain part of this product. A system of calculation of the total volume of sanitation that has been carried out and added a gauge or measure of the percentage rate of chemical and water mixture with IoT concept could be applied.

Overall, this innovation of the Twin Spray Sanitation Machine (TSSM) can help prevent the spread of Covid-19 pandemic infection to employees and students at the Port Dickson Polytechnic (PPD). This can also help the PPD management to practice a high level of cleanliness to enable the teaching and learning activities of students and staff to be carried out comprehensively. Therefore, this product can reduce the rate of operating costs that need to be borne by the management in the process of sanitation of the area inside and outside the polytechnic campus. It is hoped that this product can be widely used in premises that require sanitation services other than at Port Dickson Polytechnic. This innovative product has great potential to be replicated in all Fire and Rescue Stations in Negeri Sembilan through collaborative efforts, and can also be recommended to Local Authorities and other parties related to building and environmental sanitation activities.

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