Homemade Pressure Washer System (DIY)

Syamsul Azrin[1]*,Taranjit Singh[2], Syafiq Ikhwan[2], Sathesh Kumaar[2]

[1]Vehicle Control and Robotics Engineering (VECARE), Department of Mechanical Engineering, Centre for Diploma Studies, Universiti Tun Hussien Onn Malaysia, Pagoh Education Hub, 84600 Pagoh, Johor, MALAYSIA

[2]Department of Mechanical Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600 Pagoh, Johor, MALAYSIA

Abstract : The pressure washer system is a mechanical device that is used to remove dirt and unwanted things from surfaces and object. However, there are few problems when it comes to cleaning process, firstly the effectiveness of an existing water supply to produce a water jet to clean dirty surface most of underground pipe source flows at existing water pressure quiet low and pressure washer system are required to cope this problem. However, the price of a pressure washer system differs according to its specification and design. Hence better the quality of the product, higher the cost price but high cost cannot be afforded by B40 society to use for effective cleaning process. Hence the main objective of this project is to increase the pressure of existing water supply without using any pump or electricity and at the same time it is environmentally friendly. Not only that, this homemade pressure washer system aims to introduce a cost-saving method for B40 society. This project consisting of simple fabrication process whereby only PVC pipe and fittings, valve, nozzle and storage bottle is utilized to construct the final product. It is easy to assemble and requires minimum machining process. As a result, the project is able to increase the existing water supply by 52 % which is able to generate 200 kPa of output water pressure. Not only that, this project able to generate a maximum output velocity of water at 20.37 m/s compared to existing water supply that is measured at 0.61 m/s.

Keywords: Energy-saving Method, Low-cost Method, Pressure Washer System

1. Introduction

There are varieties of version of Pressure Washer System in current market that now can be runs by either electricity or gasoline (motor) for small application and heavy industries usage. In the growth of current market, the global pressure washer market size is expected to grow up to 4.2 % by the year 2026 due to the high demand from the growing construction and agriculture industries for various

commercial applications [1]. Due to this, the price per unit is expected to be higher from year to year. This will cause a burden for a certain society, especially for B40 society.

This project is focusing on creating a new design of pressure washer system to provide an average-cost, simple and reliable engineering product. First, the goal of this project is to investigate the mechanism of a pressure washer system on water analysis, specifically how the mechanism can increase the pressure and velocity of water from a normal standardized pressure and the principals involved in this engineering product. The material selection is solely based on easy-to-find material as this project are focusing on Do-It-Yourself concept (DIY) as it is much cost-saving method.

Indeed, this Homemade Pressure Washer System will provide the cheaper and affordable cost of maintenance and operation, a cheaper and stronger materials, and environmental-friendly as it does not involve usage of fuel or electricity to operate, instead just using a natural flow of water itself from the water sources like underground water supply sources. Therefore, this pressure washer system that helps to save the environment by conserving the electricity and to introduce a cost-saving method with low maintenance to have a pressure washer instead of buying high technology pressure washer system that requires high-cost maintenance such engine services.

2. Materials and Methods

In this project, the development of the machine has been divided into several stages. Starting with project planning and generating the idea for the project. The preliminary or model design of the Homemade Pressure Washer system has few design stages before moving to the actual representation and final design of the project. At an early design stage, several sketches of product are conducted by using the pipeline circuit diagram. The design that have been produced by manual sketches and then the best design is being chosen for the next stage. The next stage is model design whereby the sketches are detailed into SolidWorks feature with specified dimension. A few modifications of project design is altered until the final design of homemade pressure washer system is achieved. The next step is moving to component selection and analysis such as type of PVC pipes, fittings, type of valve and nozzle was analyse in order to build the components. Then next stage was the fabrication process that covers measuring and cutting of raw material into a designed size and shapes, for permanent assembly and finishing process of the component before a complete assembly process. The next stage is moving towards test run process whereby mass flow rate, water pressure and velocity of water is done by making comparison with product with existing water supply to record the result and data analysis. If test run is successful, then project can proceed to thesis and final report compilation, if unsuccessful the model design of project will be revised and modified again. **Figure 1** shows the flow chart of developing homemade pressure washer system.
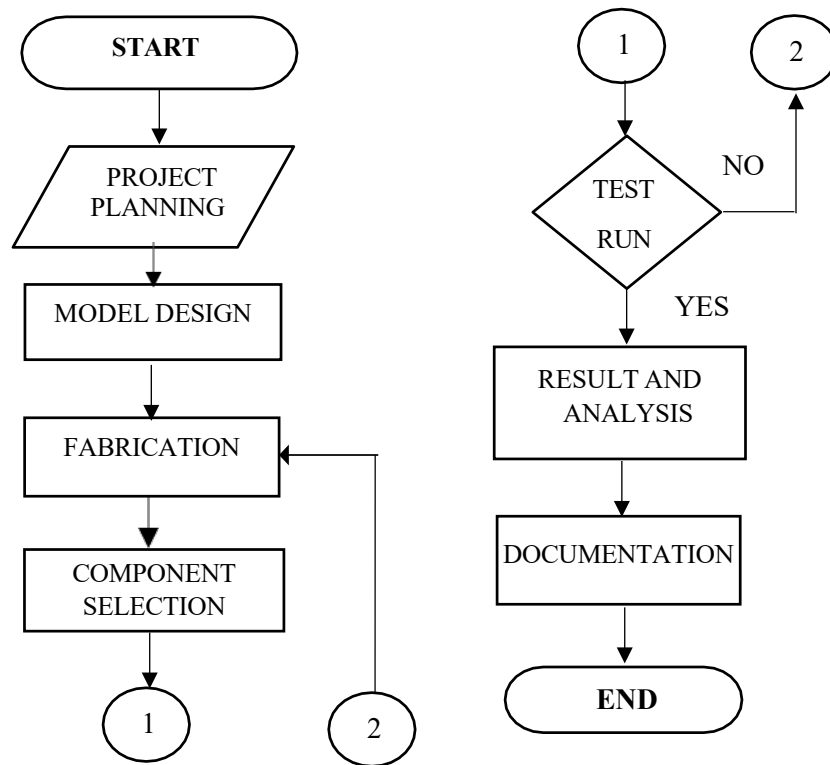
**Figure 1: Flow chart developing homemade pressure washer system**

3. Design Concept

The preliminary design of the Homemade Pressure Washer system has few design stages before moving to the actual representation and final design of the project. Each of the design is improved and modified in order to achieve the research objective of the project that is to increase pressure and velocity of existing water supply.

3.1 Design analysis and fabrication of product

Figure 2 shows the main components of pressure washer system. The components parts consist PCV pipes, 900 angle PVC elbow joint, PVC tee joint, PVC adaptor, 1.5 L storage bottle, brass ball valve and brass hole nozzle. **Figure 3 (a)** shows the final design of homemade pressure washer. In this final modification, the brass ball valve is added at the output section of homemade pressure washer system from the previous prototype model. This is to temporarily to halt water flowing through output section of the project. This to allow water to fill up bottle at maximum capacity and hence increasing the water pressure at output section. Furthermore, pressure measuring system (Pressure Gauge meter) is added into the project for data analysis at input and output section (**Figure 3 (b)**). Air filling pin is also added at top of storage bottle to measure the water pressure inside the 2 bottles (**Figure 3 (c)**). **Figure 3 (d)** is the final product and modification of Homemade Pressure Washer System with main components show in figure below.

The fabrication process of this project involves 3 main process which is measuring, cutting and assembly process. The measuring process is done by using a measuring tape onto the specified dimension from the model design and marked for next fabrication process. Next fabrication is cutting process. The cutting process is completed onto the 15mm PVC pipes for the Homemade Pressure Washer System with specified dimensions by using a hacksaw blade and PVC plastic cutter. The next fabrication stage is assembly process whereby PVC pipe and fittings is joined with other components such as valve, storage bottle and nozzle. PVC glue and proxy (steel) is used as medium of joining process between components to strongly adhere the project together.
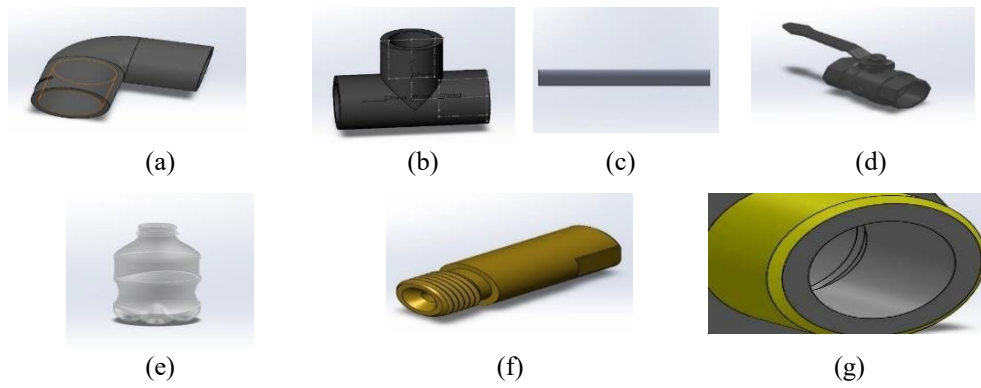
Figure 2: Main components of pressure washer system (a) 90° PVC elbow, (b) 15mm PVC tee joint, (c) 15mm PVC pipe, (d) brass ball valve, (e) 1.5 L storage bottle, (f) brass hole nozzle, and (g) PVC adapter

Figure 3: Final design homemade pressure washer
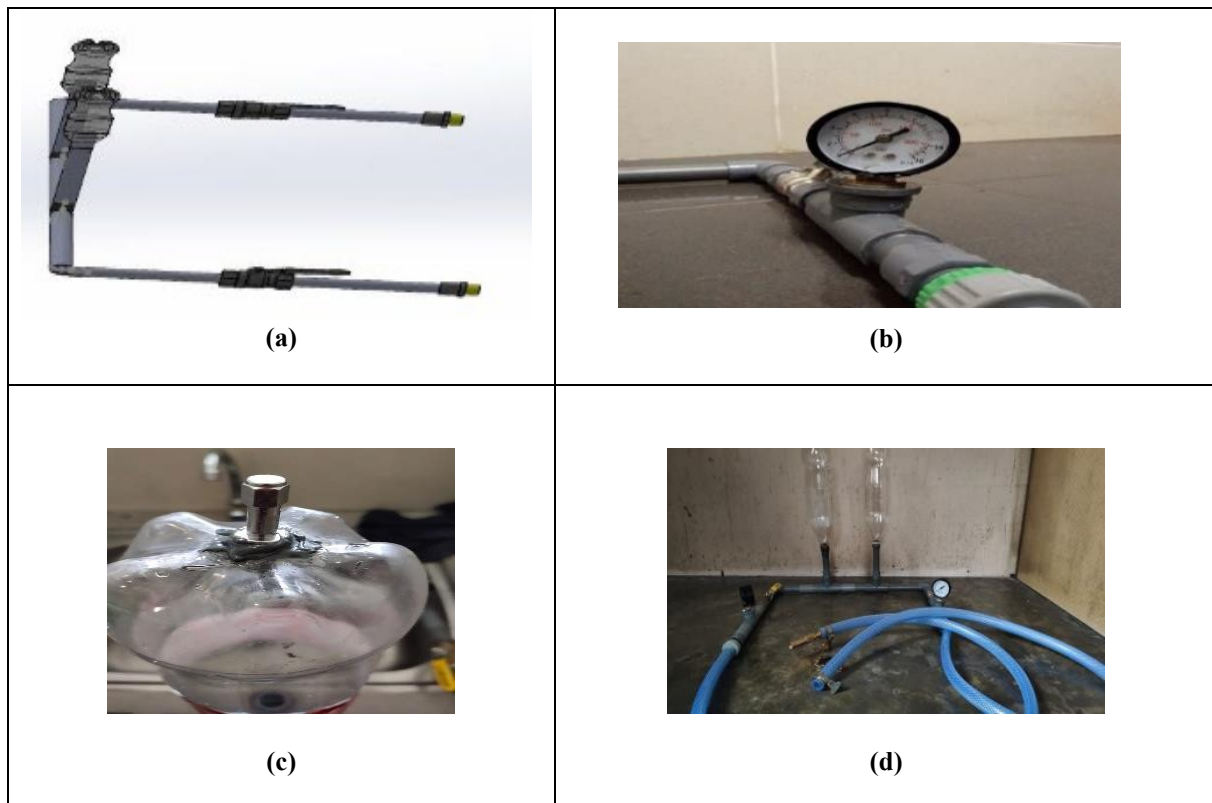
Figure 3: Design and final product (a) Final design homemade pressure washer, (b) Pressure meter gauge at input and output section, (c) Air filling pin at top, (d) Final Product of storage bottle

3.2 Project cost analysis

The objective in this project to introduce a cost-saving method with low maintenance to have a pressure washer instead of buying high technology pressure washer system that requires high-cost maintenance such engine services. **Table 1** shows the cost of materials used to develop this product. Approximately RM 47.15 total cost was used to realize the product. Besides that, the total cost analysis

for low-cost pressure washer system includes comparison among other pressure washer brand present in market is shown in **Table 2**.

Table 1: Project cost analysis

Materials/ Parts	Quantity	Cost
1. Hose clamps	4	RM 2.30
2. JL seal tape (PVC Tape)	1	RM 0.75
3. PVC TEE Brass Threaded (1/2 inch)	2	RM 2.70
4. PVC Socket (1/2 inch)	3	RM 1.40
5. PVC 90º elbow (1/2 inch)	2	RM 1.10
6. Brass Ball Valve (1/2 inch)	2	RM 10.50
7. PVC Pipe 1 meter (15mm)	3	RM 2.10
8. PVC Adhesive Glue	1	RM 2.50
9.PVC Netting Hose (15mm) 1.50 meter	2	RM 5.20
10. Tap adapter (1/2 inch)	2	RM 1.10
11. Brass Hole Nozzle	2	RM 12.50
12. Proxy adhesive (steel)	1	RM 5.00
Total Cost	25	RM 47.15

Table 2: Price Comparison between pressure washer brands [2][3]

Product	Pros	Cons	Price
K2- Karcher Pressure Washer	- It is compact - It is lightweight - Generate good pressure to clean dirt	- Not capable cleaning heavy dirts - Not portable	RM 319.00
Bosch Cleaner AQUATAK 125	- Capable of cleaning heavy dirts - Dual pump system to generate high pressure - Takes less space and portable	- It is very expensive - Heater system need to be replaced or maintained	RM 590.00
Daewoo High Pressure Washer	- It is low cost - Good built quality - Changeable nozzle diameter	- Small storage tank - The nozzle head can damage easily if not locked	RM 189.00

From the **Table 2** there are three main pressure washer brand that is chosen which are popular in market. The price ranges from RM 189.00 to RM 590.00 excluding the maintenance cost. Therefore, the low- cost introduction method for this Homemade Pressure Washer System is achieved which is considered portable, lightweight and cheap. This project also environmentally friendly as it does not consumed electricity compared to normal pressure washer brands. The total project cost is only RM 47.15 which is lower than other brand of pressure washer system in market. This allow project to be affordable by B40 society and able to compete in market. There are several factors that is need to be considered in order to produce a low-cost project such as types of piping material, type of valve, and types of nozzle.

4. Results and Discussion

The homemade pressure washer was tested to obtain the results for its targeted objectives. The test was carried out to determined water pressure analysis, mass flow rate analysis, velocity of water.

4.1 Water pressure analysis

Table 3: Water pressure analysis for product

Area of Measurement	Average Water pressure (bar)	Actual Water pressure (kPa)
Input section (tap water)	0.93 bar	93 kPa
Storage tank	1.62 bar	162 kPa
Output section of the project	2 bar	200 kPa

The water pressure analysis of the homemade pressure washer system is conducted in three different area of section which is at input section of pipe, water pressure at storage tank and output section of pipe. The result is shown in **Table 3**. The output section of homemade pressure washer has highest reading which is 200 kPa meanwhile the input section (tap water) has lowest water pressure value measured at 93 kPa. This proves that homemade pressure washer is capable of increasing the water pressure of exiting water supply. The water pressure at the input and output section is measured by using a meter gauge meanwhile for water pressure in storage tank is measured by using a air-tyre filling pin.

The increment of water pressure is between storage bottle and input section of Homemade Pressure Washer System is calculated by using this equation [4]:

$$Increasing\ input\ pressure\ percentage = \frac{(storage\ tank\ pressure\ -\ input\ water\ pressure)}{input\ water\ pressure} \times 100\%$$

$$= \frac{(162\ kPa\ -\ 93\ kPa)}{93 kPa} \times 100\% = 74.19\%$$

$$Increasing\ output\ pressure\ percentage = \frac{(output\ water\ pressure\ -\ storage\ tank\ pressure)}{storage\ tank\ pressure} \times 100\%$$

$$= \frac{(200\ kPa\ -\ 162\ kPa)}{162 kPa} \times 100\% = 23.46\%$$

The increase of water pressure at storage tank relative to input water pressure is 74.19 %. The increment of pressure at output section of homemade pressure washer system increases by 23.46 %. This is proven that the objective is achieved in order to increase the pressure washer of homemade pressure washer system.

4.2 Mass flow rate analysis

The mass flow rate of water is measured at three sections which at the tap water, tap water connected with pipe hose and brass hole nozzle and output section of homemade pressure washer system. Firstly, the mass of bucket is measured using a weight scale. A marker is used to measure the desired level for water to fill up the bucket. The tap is turned on and stopwatch is started simultaneously until it reaches marked level. The mass flow rate is given by formula as shown in **Eq. 1** [5]. The mass of empty bucket is 1.50 kg while mass of bucket fill with water at marked level is 12 kg.

Table 4: Water pressure analysis for product

Area of measurement	Average Time taken to reach marked level (s)	Mass flow rate (kg/s)
Tap water	34.96 s	0.30 kg/s
Tap water connected with piping hose and brass hole nozzle	31.29 s	0.34 kg/s
Homemade Pressure Washer (Output section)	26.47 s	0.40 kg/s

The **Table 4** shows an increasing trend of mass flow rate at three different areas. The output section of homemade pressure washer has highest reading which is 0.40 kg/s meanwhile the input section (tap water) has lowest water pressure value measured at 0.30 kg/s. The mass flow rate is calculated by using this equation:

$$mass\ flow\ rate\ = \frac{(mass\ of\ bucket\ in\ fluid\ -\ mass\ of\ empty\ bucket)}{time\ taken\ to\ reach\ marked\ level} \quad \textbf{Eq. 1}$$

The increment of mass flow rate analysis is done by comparing the tap water connected with piping hose and brass hole nozzle and output section of homemade pressure washer system to the mass flow rate of tap water. From the result, the increment of mass flow rate by using homemade pressure washer system was 33.3% compared to mass flow rate produce by existing water supply (tap water). Furthermore, the mass flow rate at output section is 17.6% higher compared to flow rate using a tap water connected with brass hole nozzle via pipe hose. This provides concrete evidence that mass flow rate can affect the water pressure. The homemade pressure washer registers a higher mass flow rate data proves strengthens the research objective of this project.

4.3 Water velocity analysis

Table 5: Water pressure analysis for product

Area of measurement	Velocity of fluid(water) (m/s)
Tap water	0.61 m/s
Piping system	2.26 m/s
Brass hole nozzle	20.37 m/s

Table 5 shows the analytical comparison of water velocity measured at three different areas. It shows an increasing trend of water velocity three different areas. The output section of brass hole nozzle homemade pressure washer has highest velocity which is which is 20.37 m/s meanwhile the input section (tap water) has lowest water velocity which is measured at 0.61 m/s. Furthermore, by using piping system the 15mm PVC pipe the velocity of tap water can be increased by 1.65 m/s and brass hole nozzle by 19.76 m/s higher than tap water. This basically proves that this project is not only able to increase water pressure but also the output velocity of an existing water supply.The velocity of water at different area of measurement is calculated by using the volume flow rate formula [6]. However, to find the velocity of water at area of measurement, the mass flow rate formula needed to be applied [7] to find the volume flow rate of the desired area of measurement. The velocity analysis for the project is conducted at three section area which is tap water, tap water connected with brass hole nozzle and throughout piping system of homemade pressure washer system. The volume flow rate can be calculated by using the mass flow rate formula given by:

$$Mass\ flow\ rate = \rho \times Q$$

$$Volume\ flow\ rate = Velocity \times Area$$

The average velocity of water at tap water of a water supply is determined by applyingthe volume flow rate formula [3]. The mass flow rate at tap water is 0.30 kg/s based on **Table 4** result. The internal area of tap water is 0.000491 m^2.

$$Mass\ flow\ rate = \rho \times Q$$

$$0.30\frac{kg}{s} = \frac{1000kg}{m^3} \times Q$$

$$Q = 0.0003 m^3/s$$

$$Volume\ flow\ rate = Velocity\ \times Area\ of\ measurement$$

$$velocity = \frac{volume\ flow\ rate}{area\ of\ measurement}$$

$$velocity = \frac{0.0003 m^3/s}{0.000491 m^2}$$

$$= 0.61\ m/s$$

5. Conclusion and Recommendation

The research objective in this project has been achieved where this project is able to increase the pressure and velocity of existing water supply successfully. Furthermore, the project cost is reasonable and cost-saving method for B40 society. This project is simple yet functional for domestic use. This project is able to compete with other pressure washer brand in market since it best at cost-saving area that attracts customer. This pressure analysis for the pressure washer provides a concrete and solid evidence to achieve the research objective. From the result, the project is able to increase the existing pressure of water supply from 93kPa to 200kPa at the output. This helps to remove the stain from surface of object. The velocity of pressure washer is also increased to 20.37 m/s from existing water supply which is 0.61m/s. This project is able to perform removal of dirt surface up to cleaning black stain on toilet but is unable to remove ink stain on floor. This shows that our project has high limitation even it has its high potential of removing stain from an object surface. The homemade pressure is able to clean dirty surface of a material effectively till certain extent. Improvement and modifications should be done continuously to produce a quality, long lasting and powerful pressure washer system. The first recommendation is that use a larger diameter of pipe system to increase the flow rate and output water volume generating a higher pressure and velocity. Not only that, bigger storage tank or increasing storage bottle quantity can be utilized to store larger water capacity to improve pressure system. Furthermore, a smaller diameter nozzle can be utilized to produce a larger water pressure in cleaning process.

Acknowledgement

References

[1] "Pressure washer market size: Industry research report, 2019-2025," Pressure Washer Market Size | Industry Research Report, 2019-2025. [Online]. Available: https://www.grandviewresearch.com/industry- analysis/pressure-washer-market. [Accessed: 03-Jan-2022].

[2] A. Groove, "Guidelines For The Proper Selection Of A Pressure Washer", Pwma.org, 2022. [Online]. Available: https://www.pwma.org/docs/Guidelines-For-The-Proper-Selection-Of-A-Pressure-Washer.pdf. [Accessed: 09- Jun- 2022].

[3] J. Orkiszewski, "Predicting Two-Phase Pressure Drops in Vertical Pipe", Journal of Petroleum Technology, vol. 19, no. 06, pp. 829-838, 1967. Available: https://onepetro.org/JPT/article/19/06/829/163016/Predicting-Two-Phase-Pressure-Drops-in-Vertical. [Accessed 17 June 2022].

[4] M. Nicholson, K. Aziz and G. Gregory, "Intermittent two-phase flow in horizontal pipes: Predictive models", The Canadian Journal of Chemical Engineering, vol. 56, no. 6, pp. 653-663, 1978. Available: https://onlinelibrary.wiley.com/doi/abs/10.1002/cjce.5450560601. [Accessed 17 June 2022].

[5]   M. Saleta, D. Tobia and S. Gil, "Experimental study of Bernoulli's equation with losses", American Journal of Physics, vol. 73, no. 7, pp. 598-602, 2005. Available: https://aip.scitation.org/doi/epdf/10.1063/1.5050357. [Accessed 17 June 2022]

[6]   H. Badeer and C. Synolakis, "The Bernoulli-Poiseuille equation", The Physics Teacher, vol. 27, no. 8, pp. 598-601, 1989. Available: 10.1119/1.2342887 [Accessed 11 July 2022].

[7]   C. Waltham, S. Bendall and A. Kotlicki, "Bernoulli levitation", American Journal of Physics, vol. 71, no. 2, pp. 176-179, 2003. Available: 10.1119/1.1524162 [Accessed 11 July 2022].