The Fabrication Of A Mobile Water Sprayer For Car Washing And Agricultural Businesses

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***Abstract*—Over the years, vehicles that ply the highways and other roads of Nigeria are exposed to high level of dust, grease, muds, and other oily substances which leads to not just dirt but also accidents and road crashes, as they cover the windshields and driving mirrors of vehicles. The drudgery associated with manual washing and hand spraying of water during the washing process often lead to dirty and improperly washed vehicles on the roads. However, this can be addressed by the use of mobile water sprayers which in most developing countries like Nigeria are largely unavailable or expensive. Design, prototyping, fabrication, calibration, assembling and testing of the device were undertaken to achieve the objectives of the study. The fabricated model was subjected to real-time tests on five vehicle surfaces and the results obtained were carefully compared with that of an already existing model, MWS – 20. It was observed that after plotting the graph of volumetric flow rate against the generated pressure irrespective of the surface, the volume of water fluctuated in an unpredictable manner but still gave readings which were close and correlated slightly with the estimated readings. The results obtained from the study showed that the fabricated model is quite useful for water spraying in car washing and agricultural businesses.**

Keywords—car washing, fabrication, mobile water sprayer, nozzle, pump, agriculture

1. Introduction

Cleaning or washing of houses and vehicles largely depends on surfaces and materials of the object. The level of exposure and absorption of dirt helps one to understand the nature and volume of pressure to apply and localize in the site of dirt (Porter et al., 2013). This forms a basis for assessing the nature, degree and probable solution to the dirtiness. Air quality being an abstract term which is often represented with indicators such as dust levels, is measured for different sizes of particles, but the threshold defining these categories for cleaning purposes tends to differ (Khot et al. 2012).

A mechanical means of a high-pressure sprayer designed into a pump device known as the water sprayer can be used to deliver water in washing, but may also be expressed in gallons or liters per minute, and variability of velocity is achieved through a hose nozzle (Naik, Singh, and Swain 2015; NASDA, 2014; ASABE, 2007).

Musculo-Skeletal Disorders (MSD) are cumulative degenerative disorders that result from repetitive work activities and work conditions over a long period of time, which leads to body pains, impairments and subsequent decrease in production output (Godwin and Okpala, 2013). These disorders result from the poor ergonomics employed in manual (hand) washing of vehicles resulting in continuous bending, manual gripping of rough surfaces and stretching of hands to channel water over large car surfaces. It is therefore necessary to replace the manual procedures with more convenient and efficient means of water delivery which would reduce or completely eliminate the problems associated with MSDs, in order to enhance efficiency and production output.

Before the fabrication of the MWS, painstaking efforts were made to achieve a reliable design. Commenting on the need for the design, Okpala et al (2021), explained that “the design of the MWS is of great importance as it gives a lead into the development of relatively convenient, portable, affordable and readily available mobile water sprayer for the washing of vehicles.”

Customarily, sprayers are considered for simply agricultural purposes of liquid fertilizer dispersal (Kiran et al., 2018; Kumbhare, 2016; Choudhary, 2015). They are considered to have failed in operation if they fail to deliver a given volume expressed in litres during a period of time (Teejet, 2016). Here, the greater the velocity at which the water is pumped, the greater the flow rate.

Controversy would exist about the desirability of measuring the flow rate using the cross-sectional area and velocity or a simple volume to time ratio. Regardless of the specific parameters used in the measurement of this, the goal is simply to deliver appropriate amounts of water at a required velocity over a given period of time to reduce drudgery and the repetitive tasks associated with manual car washing and/or house cleaning.

2. Components and Types Mobile Water Sprayer

2.1Components of MWS

The major components of the Mobile Water Sprayer (MWS) are the pump, trolley, water tank, hose, trigger gun, O-ring and the nozzle. The pump is a mechanical device that is used to pick water up from low-pressure level to high-pressure level (Pranavamoorthi, Vasanthi, and Pappa 2017). It changes the energy flow from mechanical to the fluid and can be used in process operations which need a high hydraulic force (Naik, Singh, and Swain 2015). The energy sources of pumps mainly include wind power, manual operation, electricity and engines. The trolley used in this project is a platform trolley with handles at one end, wheels at the base, with a ledge to set objects on, flat against the floor when the truck is upright (Sanjay et al., 2015).

The objects to be moved are made to rest on the ledge. The whole assembly of a water sprayer is mounted on the trolley, and the length of the trolley is 100cm with width 50cm. The water tank is simply serving as the water storage. Also, it is important to take note of the design and construction material choice for the tank (Pranavamoorthi, Vasanthi, D. and Pappa 2017).

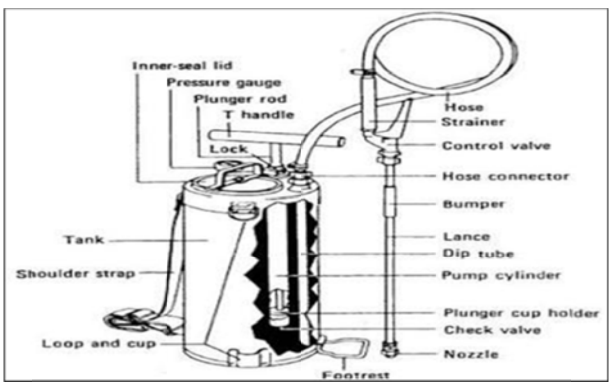

Figure 1: Components of a water sprayer

As shown in figure 1, a flexible hollow tube designed to carry fluids from one location to another is known as the hose, which is sometimes called pipe or tube. There are several types of hose which depends on the type of fluid to be delivered and they include water hose, hot water and steam hose, beverage and food hose, air hose, ventilation hose, material handling hose, oil transmission hose, and chemical hose amongst others.

The trigger gun is a valve that closes when the trigger is released, it is a fairly simple mechanism designed around a trigger operated switch. It saves water and fuel by switching off the motor once the trigger is released. The trigger gun is connected between the hose and the nozzle with its major function being to start or stop the flow. A water sprayer O-ring is a small round gasket that's used to give a water tight seal between hose, nozzle and wand connections. O-rings wear out overtime and eventually have to be replaced.

The nozzle is a cylindrical or round spout at the end of a pipe, hose, or tube used to control a jet of gas or liquid (Pranavamoorthi, Vasanthi, and Pappa 2017).

The first generation of water spraying pumps to be developed were the electric-powered piston types with reciprocating mechanisms having rubber seals in a cylinder and very much similar to the piston in an engine. Its disadvantages being in proper maintenance and low revolutions per minute causing limited water pressure capabilities.

This therefore necessitated an improvement for industries such as car wash, agriculture, house cleaning, ship cleaning and water blasting which needed the water sprayers. Ceramic pumps were developed to eliminate the disadvantages of the already existing model. Not only could the new ceramic pumps meet ever-increasing performance goals, they required far less maintenance. With superior system sealing methods and an oil bath, they operated more smoothly, working longer and more efficiently.

2.2Types of MWS

As depicted in figure 2, there are mainly four types of water sprayers: cold water sprayer, hot water sprayer, electric water sprayer, and the gas-powered water sprayer, although some authors have reported on backpack sprayer (Gangwar and Dixit, 2017), knapsack sprayer (Sanjay et al., 2015), flat fan, solid stream, full cone, hollow cone hand driven sprayers, fuel operated sprayers (Rao, Mathapati, and Amarapur 2013) amongst others which are named after the spray nozzles (Langefeld and Swanson, 2015; Swanson, Agasty and Langefeld, 2012).

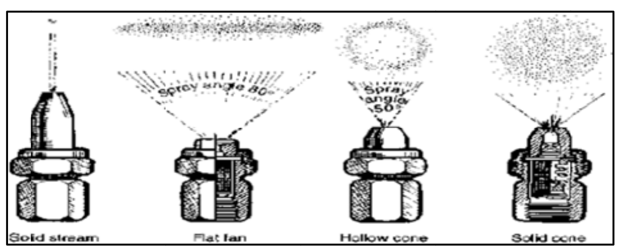

Figure 2: Images of the types of water sprayers based on spray nozzles

2.3Risks Involved and Safety Precautions

The mobile water sprayer (MWS) is a powerful machine capable of cleaning large area as quickly and efficiently. However, the risks associated with water sprayers can be catastrophic and including death. OSHA reported over 800 instances of water sprayer related injuries. Electric shock can occur if the water sprayer is not properly used and if the safety instructions are not duly followed.

Using small gasoline powered engines to drive pumps can cause carbon monoxide poisoning and this type of water sprayer should not be operated inside buildings or other partially enclosed spaces unless the gasoline engines can be placed outdoors and away from air intakes. To ensure safety of the operator and those around while using the water sprayer, the following precautions should be taken seriously:

a)Never point a water sprayer at yourself or others

b) Never use a gasoline powered sprayer in an enclosed space

c) Wear rubber sole shoes that provide some insulation when using the water sprayer.

d) Never allow children to operate a water sprayer, keep children at a safe distance while using it.

3.**Industrial Benefits of the Water Sprayer**

The Water Sprayer has become vital in the car wash industry for easier and faster removal of dirt in car surfaces and in cleaning of houses. It is important to note that this innovation was particularly revolutionary in the industry as it provided efficient and more effective way of getting objects and surfaces cleaned in the shortest period of time.

Commercial Farming (Agriculture) - the water sprayer device has found its importance in the agricultural sector as large-scale farmers make use of it in the required velocity to deliver water and fertilizer to the farms. This system has replaced the bucket method and can easily be linked to the water source for irrigation purpose, especially when there is a steady source of energy for pump generation.

Horticulture and Beautification of the environment has boomed since the development of water sprayer. This means that water can easily be delivered in a large scale at particular sizes and droplets which are key in horticulture. The fountains are common forms of the water sprayers or pumps which are available in many hotels and residential areas.

Finally, when cars and houses are cleaned using the water sprayers, it reduces the risk of musculoskeletal disorders, pains, injuries associated with task repetitiveness and manual tool handling. This in turn improves the general health and well-being of individuals.

Project Master Schedule

The project master schedule is an essential tool for the project planning and execution. This is a report that shows the date of commencement and completion of the project.

Table 1 shows the blue print created for the Design and Fabrication of a Mobile Water Sprayer with its normal completion date on the 30th of May 2021.

Table 1: Project master schedule of the MWS

S/N	Task	Start	Due	Assigned To	Remark
	PROJECT INITIAL STAGE				
1.	**Research** • Data collection • Knowledge of parts	Jan 7, 2021	Jan 10, 2019	All members of the group	The systematic project analysis was done and a blue print was drawn with set milestones.
	PROJECT PLANNING STAGE				
2.	**Design of Machine Elements** • Engineering drawings and CAD • Calculations • Aesthetics • Project Time management • Activity Sequence	Jan 11, 2021	Jan 16, 2021	Drawings and aesthetics: Ekweoba Ifeanyi. Calculations: All members of the group	The drawings, calculations, calibrations, analysis were carried out to determine the MWS operational capacity, strength, durability, power rating, environmental friendliness, ergonomics, efficiency and aesthetics. It gives the details of how assembly and operation.
3.	**Material Selection** • Bill of materials • Analysis of parts • Cost management	Feb 20, 2021	Feb 27, 2021	All group members	Quantitative & qualitative analysis of materials needed for the project while considering costs.

	PROJECT IMPLEMENTATION STAGE				
4.	**Fabrication of Parts** • Measuring and marking out • Cutting • Welding • Filing • Bending • Drilling	Mar 2, 2021	Apr 10 ,20210	All group members	Fabrication was carried out to specifications based on the design drawn. Wastage was avoided and assistance called in for physical works.
5.	**Assembling** • Screwing • Welding • Hinging	Apr 12, 2021	Apr 20, 2021	All group members	MWS parts to be it purchased or fabricated are brought together to form one unit. Care is taken to avoid geometrical and dimensional alterations from design.
	PROJECT CLOSING STAGE				
6.	**Finishing** • Polishing • Painting • Brushing • Filing	May 1, 2021	May 14, 2021	All group members	Finishing touches are done to achieve project surface smoothness and eliminate discrepancies from machine parts.
7.	**Testing** • Result Discussions • Risk Analysis	May 30, 2021	June 7, 2021	All group members	Further calibrations and operational testing for quality, stability and functionality undertaken.

4. Caliberation

During calibration, the system combined the speed and power of system 824 real time analyzer, with sophisticated user-friendly audit software that is completely under computer control. This did not in any way sacrifice the accuracy and stability of the mobile water sprayer as it was achieved in few minutes.

The following procedure was used to calibrate the device:

1. Turn on power supply of 12V DC to the device.
2. Wait for at least 5 seconds to allow the device to boot completely.
3. Press the system start button to send outputs with different pressures and flow rates, the display powers and also monitors the response button for command.
4. Allow at least 3 seconds for the reading to stabilize. The visual display switches on the corresponding indicator base on the state of the system.
5. Record the digital output obtained, this is the zero or reference point, at the maximum flow rate
6. Clear reading after the examination section.
7. Repeat steps 2 to 6 with different pressures with the maximum flow rate as target for each.

The resulting output of the response from the calibration as read by the micro-controller was then analyzed and used to develop a working algorithm and set thresholds that represent certain pressures applied.

5. Fabrication and Assembling

The physical components with its casing were then designed using Solid Works CAD with different dimensions until the best fit was achieved. Ergonomics issues were seriously considered during the fabrication of the equipment and the trolley. According to Okpala and Ihueze (2017), lack of ergonomics consideration by manufacturing companies lead "to decrease in productivity, income and efficiency, low product quality, increased medical claims, musculoskeletal disorders, as well as disabilities."

The components were later fabricated and assembled to follow the Circuit diagram generated from the design using Proteus, by soldering the physical components on a Vero board. The 40-pin socket was soldered in place first to the position of best fit so as to hold the IC in position. The other components where then soldered to the board and where there was not enough space to connect certain components using the soldering lead on the board, these components were connected in proper order with the use of jumper wires.

The metal casing comprised of the galvanized metal as its cover was cut into suitable shape and the Vero board with the complete circuitry was then placed inside the casing and then connected with the battery.

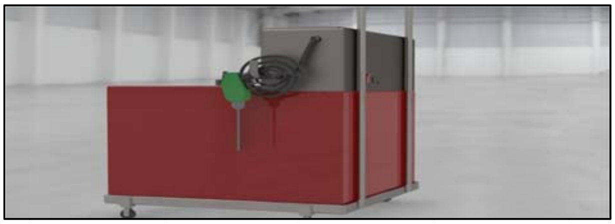

Figure 3: Side view of the assembled Mobile Water Sprayer

Testing The Mobile Water Sprayer was subjected to real time situations after calibration where 5 vehicles/Surfaces (Subject A, B, C, D and E) were tested using the device after they had been confirmed to be dirty or dusty. The subjects were obtained at the discretion of the owners for the purpose of the study. The potential subjects were well sprayed and those with high level of dirt were marked. Consent was obtained from subjects whose owners accepted the compensation of having their surfaces cleaned and repaired in case of any damage.

In testing the device, the following procedures were followed:

The vehicles/surfaces for purpose of the study were recorded alphabetically with Subjects A, B and C as cars, while Subjects D and E as home surfaces. They took turns to be washed using the device such that about 20 minutes was elapsed from the start to finish of each subject. Readings from the device was taken at the end of the tests for both pressures and flow rates as cleanliness was achieved without drudgery.

The following details of the subjects were collected:

a) Applied pressures,

b) Volumetric flow rate of water, and

c) Cleanliness level.

Calibration

Results of calibrating the mobile water sprayer are shown in Figure 4. The graph of pressure against volume was plotted, the red lines representing results for the fabricated model while the results gotten from already available water sprayer appear in blue lines.

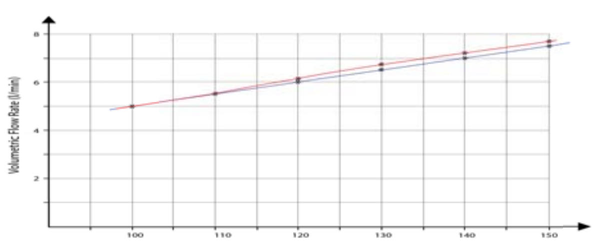

Figure 4: Calibration Result

Testing

The detailed results obtained from testing the mobile water sprayer on five cars, marked as subjects. Subjects A, B, C, D and E as shown in graphical forms are illustrated in figures 4, 5, 6, 7, and 8 respectively. Subject A was compared to an already existing model, the results of the fabricated model (MWS-20) are shown in red lines, while that of an existing model are depicted in blue.

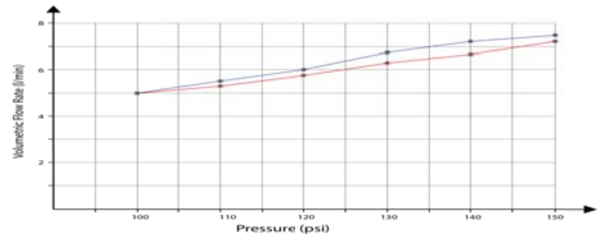

Figure 5: Subject A result

The results obtained from Subjects B to E are shown in figures 6 to 9.

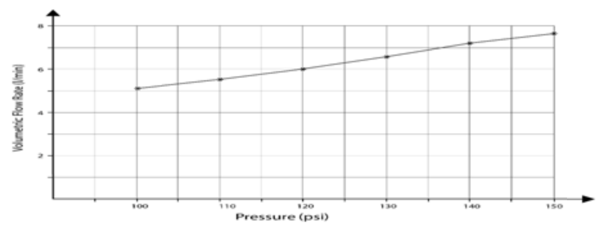

Figure 6: Subject B result

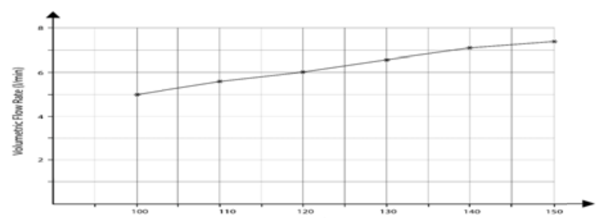

Figure 7: Subject C result

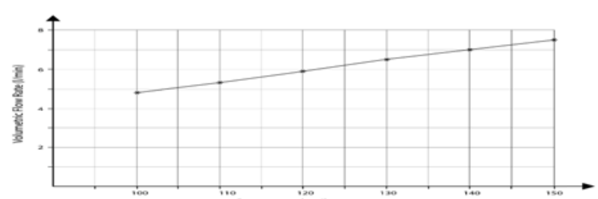

Figure 8: Subject D result

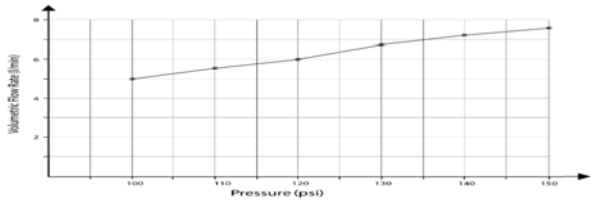

Figure 9: Subject E Result

6. Discussion of Results

During the calibration process, the fabricated model of the mobile water sprayer was subjected to calibration tests using the observed volumetric flow rate for each pressure generated. Based on the calibration results as shown in table 4.1, volumetric flow rates measured in liters per minute were channeled at pressure values of 100-150psi. The graph produced from the proposed fabricated model was compared to the MWS – 20 which in an already existing model. Here where a pressure gauge with quick-attach fittings that can snap in place of the nozzle fitting was used to run periodic calibration.

This gave a similar result for the highest flow rates for each pressure value produced although the fabricated model was at 6l/min which gives more room for repetitions of all pressures as depicted in table 2. The mobile water sprayer operates in pressures of 100-150psi while the MWS – 20 functions at 100-180psi. Flow rates below the given values would mean that the device does not give room for equal spray pressure through the spray gun which are either uneven or restricted in the line and may be viewed as unacceptable for effective application in commercial washing.

Table 2: Calibration results for the Water Sprayer

Pressure (Psi)	100	110	120	130	140	150	160	170	180
Flow Rate (l/min)	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0

This data act as a basis to provide the function within the program that responds to volumetric flow rates of generated pressures and delivered as results on digital displays.

Each of the subjects was subjected to cleaning tests using the fabricated model. The applied pressures and volumetric flow rates achieved were evaluated, plotted on a graph and compared. It was observed that after plotting the graph irrespective of the subject, the volumetric flow rate of the device fluctuated in an unpredictable manner but still gave readings which were close to and correlated with the estimated recordings (from already existing models) as seen in figures 5 to 9.

However, since the readings obtained were close in range with the estimated values, the variations observed were then used to reorganize the analyzed information given as feedback on the fabricated device. The team therefore decided to represent readings from the device in ranges so as to cover the points of minimum and maximum variations in values observed from the graph which were in agreement to the study reported by Kiran et al (2008) and Naik, Singh, and Swain (2015).

Figure 10: The Fabricated Mobile Water Sprayer

7. Conclusion

Volumetric and pressure results obtained in this study confirm and support the fact that the Mobile Water Sprayer serves various functions of liquid delivery and is very essential in the removal of loose paint, mold, grime, dust, mud and dirt from surfaces and objects such as buildings and vehicles. However, even with the ease of using the device, there should be little or no wind disturbance for few minutes as the device is being used on vehicles for improved water concentration and direction.

Due to the instability of the generated pressure; programme delay and water spraying, the observed graphical pattern was not exactly predictable using mathematical models but with sufficient time between the pressure intervals, the readings correlated with the expected values. For this reason, the displays were designed to show the digital readings for both quantities; the first corresponded to the pressure values whereas the second represented the volume of water released through the spray gun.

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