

## DESIGN AND DEVELOPMENT OF CHEMICAL SPRAY TROLLEY

Nur Daliela Wahida Zamry<sup>1</sup>, Norhanifah Abdul Rahman<sup>1</sup>, Matzaini Katon<sup>1</sup>, Nur Ain Abd Rahman<sup>1</sup>, Norhashidah Manap<sup>1</sup>, Hanipah Ghazali<sup>1</sup>

<sup>1</sup>School of Mechanical Engineering, College of Engineering, Universiti Teknologi MARA, Cawangan Terengganu, Kampus Bukit Besi, 23200 Bukit Besi, Dungun, Terengganu.

norhanifah@uitm.edu.my

### ABSTRACT

Backpack sprayers, also known as knapsack sprayers, are usually used by small farmers who need to carry them on their backs in unpredictable weather. Generally, small farmers used the traditional method of spraying crops with a backpack sprayer, which was time-consuming, costly, and caused human fatigue. Therefore, this paper aims to design a chemical spray trolley that is easy to handle using a mechanical engineering design process. The modeling for this product was developed using SolidWorks software. In order to accomplish the goals, research has been undertaken to brainstorm ideas and assess potential solutions for the design and fabrication of the product. At the end of the study, this chemical spray trolley is way more effective than a backpack sprayer and presents a valuable advantage for farmers.

**Keywords:** Design Process, Fabrication, SolidWorks, Chemical Spray Trolley

### 1.0 INTRODUCTION

Agriculture was one of the most important economic sectors. According to Sayyed et al. [1], agriculture stands as one of the largest industries globally, providing sustenance to nearly half of the country's population. Over the years it has evolved and the use of new techniques and equipment has replaced almost all traditional agricultural methods. Moreover, owing to insufficient resources for employing modern methods, some small-scale farmers continued to rely on age-old traditional farming practices. Generally, small farmers used the traditional method of spraying crops with a backpack sprayer, which was time-consuming, costly, and caused human fatigue. They have to carry heavy chemical sprays on their backs, which can lead to some back problems. With unpredictable weather, this traditional method has become a burden to the farmers as they have to manually pump multiple times before the dispersal of liquid chemicals. The user also easily gets exposed to potential liquid contamination which leads to human health risks and contributes to environmental pollution.

Considering the limitations faced by small-scale farmers, an easily maintainable agricultural sprayer was designed to overcome the issues. This multifunctional device was convenient because it can be used in different application stages in agriculture, depending on the needs of the process. Sprayers play an important role in pesticide spraying in agriculture nowadays. The sprayers depend on user preference and operational needs either motor-driven or hand-powered. Pesticide spraying was one of the main used among the farmers thus numerous potential pesticide sprayers have been studied by previous researchers. There is a study by Poratkar et al. [2] on pesticide sprayers as they suggested a low-cost mechanically operated multi-nozzle sprayer pump model that eliminates the necessity of carrying the pesticide tank on the back. This model is designed to be able to operate with a maximum rate in minimum time. Another study by Kumbhare et al. [3] as they developed an automatic pesticide-spraying machine as shown in Figure 1. In order to reduce and minimize the health risks of the users, this machine was remotely operated while ensuring a safe working

distance. This machine helped farmers to enhance operational efficiency, reduce costs, and increase production rate and profit.



Figure 1: Automatic Pesticides Spraying Machine

Gajbhiye et al. [4] developed the agricultural multi-nozzle spray pump trolley as shown in Figure 2. Carrying the heavy weight of a pesticide tank on the shoulders is a major pain point for farmers, and leads to back pain and fatigue. Thus, this study designed a lightweight trolley that can carry the pesticide tank with multiple nozzles that can cover the maximum spraying area at minimum time and maximum rate. Malonde et al. [5] also developed a multi-nozzle pesticide sprayer pump that can perform efficient tasks. The study focuses on a pesticide spraying machine that not only enhances productivity but also minimizes the effort farmers require. Oluwashola et al. [6] have fabricated a motorized spraying machine in order to overcome the major challenges for the farmer such as back fatigue while carrying the tank, one-handed with a single nozzle operation which slows down the spraying process. The same study was also done by Rakibuzzaman et al. [7], who successfully fabricated a spraying machine that can replace the manual backpack sprayers hence reducing the problems faced by farmers during the spraying process.



Figure 2: Agricultural Multi-Nozzle Spray Pump Trolley

Generally, the chemical spray trolley project contributes to the advancement of engineering knowledge. This is because the production of a chemical spray trolley requires a diverse array of designs and materials. Thus this paper aims to design and fabricate an improved chemical spray trolley using a mechanical engineering design process. The SolidWorks software was used to create the engineering analysis along with 3D and assembly drawings for this chemical spray trolley.

## 2.0 METHODOLOGY

The flowchart of the design and development of the chemical spray trolley is shown in Figure 3 below. This flowchart demonstrates the methodology used for this study. The procedure starts by identifying a problem that requires a solution. Successively, an analysis of the existing products related to the issue is conducted, facilitating a thorough understanding of the current situation. The next step involves creating concepts for solutions and evaluating their feasibility and effectiveness. The most favorable solution is then transformed into a physical prototype. This prototype is a preliminary development of the final product, functioning as an actual representation of the solution.

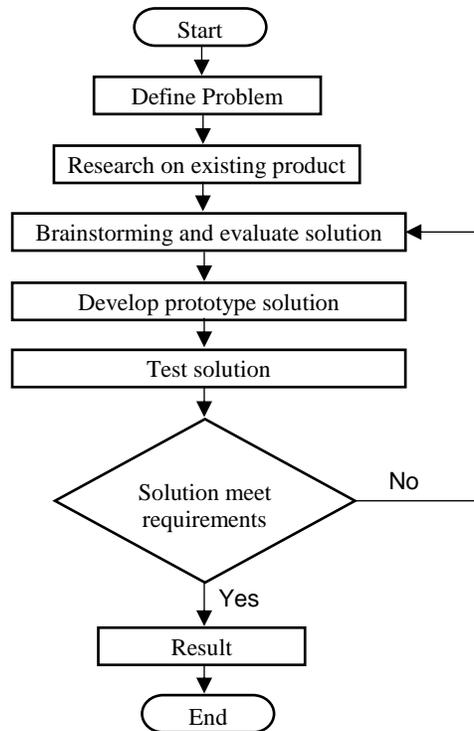


Figure 3: Flowchart of the Design and Development Chemical Spray Trolley

## 3.0 RESULTS AND DISCUSSION

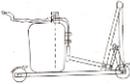
### 3.1 Concept Generation

Table 1 shows a detailed morphological chart for a chemical spray trolley. The morphological method is utilized for the concept generation process. The morphological method, which enables custom design, dissects an item (here, the product) into a recognizable sub-function. This technique helps designers assess all possible options for each sub-function, providing fresh insights to aid decision-making.

The process starts with identifying the sub-function available related to the product. Next, for each sub-function, the option solution is identified so that the sub-function can be fulfilled by using the option solution. After that, several combinations of options and solutions for each sub-function were made. For this study, three concepts were generated. Thus, the total combination of option solutions is made three times. Thus, the morphological method offers a systematic and thorough approach to creating feasible solutions. Table 1 shows six sub-functions identified; for each sub-function, at least three option solutions

are provided. The sub-function consists of the body, wheel, chain, the material of the tank, type of handle, and nozzle.

Table 1: Morphological Table of the Design and Development of Chemical Spray Trolley

Sub-Function	Option Solution 1	Option Solution 2	Option Solution 3	Option Solution 4
Body	 Body 1	 Body 2	 Body 3	
Wheel	 Big wheel	 Castor wheel		
Power Transmission	 Roller chain	 Belt		
Tank Material	 Plastic	 Stainless steel		
Handle	 One handle	 Double handle	 One handle adjustable	 Double handle adjustable
Nozzle	 Plastic	 Brass		

### 3.2 Concept Selection

The Pugh Method as shown in Table 2 is used to select the final concepts. The Pugh chart, a decision matrix, is a decision-making tool used in engineering and design. It helps evaluate and prioritize a list of options based on weighted criteria [8]. The steps used in making the Pugh chart are: (i) identify the critical criteria to compare for, (ii) set weightage for each criterion, (iii) select the datum product which will act as the reference product to be compared for each criterion, (iv) include the concept which needs to be compared for, (v) rate for each criterion for each concept by using +, 0 or – which represents better than, equally same or worst than (vi) last is to analyze the total score obtained for each concept.

Table 2 shows that 15 criteria were identified, and three concepts were compared. As for the result, concept 1 has emerged as the concept with the highest total score, which is 19, compared to concepts 2 and 3, which each gained 10 and 17, respectively.

Concept 1, as shown in Figure 4, is superior to the datum product in durability, safety, simplicity, reliability, strength, weight, mobility, environment, and mechanical parts. One of the characteristics of Concept 1 is that it has a big wheel, and an adjustable double-rod handle has been chosen as the best design. The body also is more stable when compared to other concepts. The big wheel is chosen because it has much better grip pads that can bite into the ground. This design also comes out with a chain because it is

durable and requires detailed maintenance. Then, for the material of the tank, stainless steel is chosen because it is durable for pesticide use, and the handle is adjustable with a double rod because the height of the handle can be adjusted according to their comfort. Lastly, brass is chosen for the nozzle because it is long-lasting.

Table 2: Pugh Chart for the Chemical Spray Trolley

Description		Concept 1	Concept 2	Concept 3
Criteria	Weightage			
Durability	3	+	+	+
Safety	2	+	0	+
Simplicity	1	+	0	+
Affordability	2	0	0	+
Reliability	2	+	0	0
Ergonomic (Human Factor)	2	0	0	0
Strength	3	+	+	+
Weight	2	+	+	+
Mobility	2	+	0	0
Ease of assembly	1	0	-	0
Reparability	1	0	0	+
Excitement	1	0	0	0
Aesthetic	1	0	0	0
Environment	1	+	0	0
Mechanical parts	3	+	+	+
+		19	11	17
-		0	1	0
0		7	10	7
<b>Net Score</b>		<b>19</b>	<b>10</b>	<b>17</b>

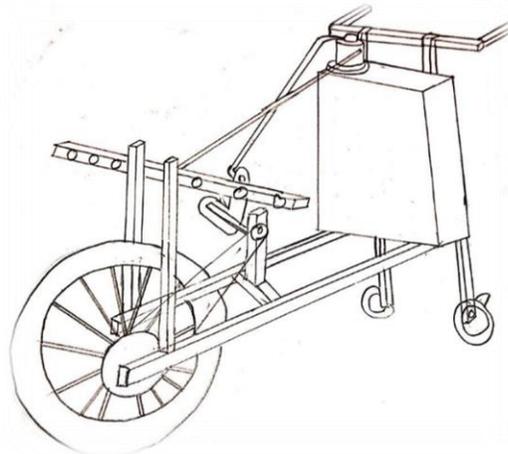


Figure 4: The Selected Concept for the Chemical Spray Trolley

### 3.3 Detail Design

Table 3 below shows the parts available in the chemical spray trolley and its functions. It consists of 10 parts which are; the nozzle, wheel, gear sprocket, crank, connecting rod, chain, handle, pump, tank, and screw. Figure 5 and Figure 6 show the assembly and disassembly drawings of the chemical spray trolley.

Table 3: List of Parts Available in the Chemical Spray Trolley

No.	Part	Function
1	Nozzle	To spray pesticide from the tank
2	Wheel	To move the trolley
3	Gear sprocket	To transmit rotary motion between two shafts
4	Crank	To convert circular motion into reciprocating motion
5	Connecting rod	To connect the crank and lever
6	Chain	To move the wheel
7	Handle	To control the trolley movement
8	Pump	To pump pesticide inside the tank
9	Tank	To provide storage of pesticide
10	Screw	To assemble all the parts

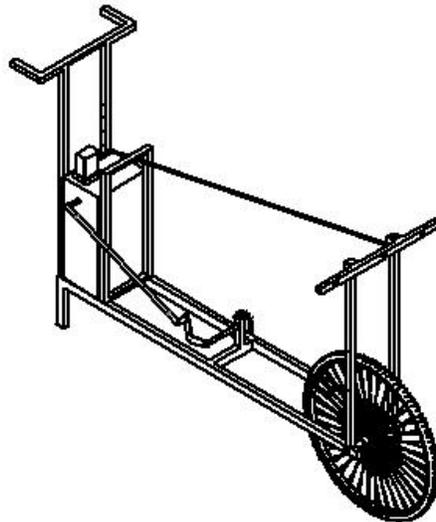


Figure 5: Assembly Drawing of the Chemical Spray Trolley

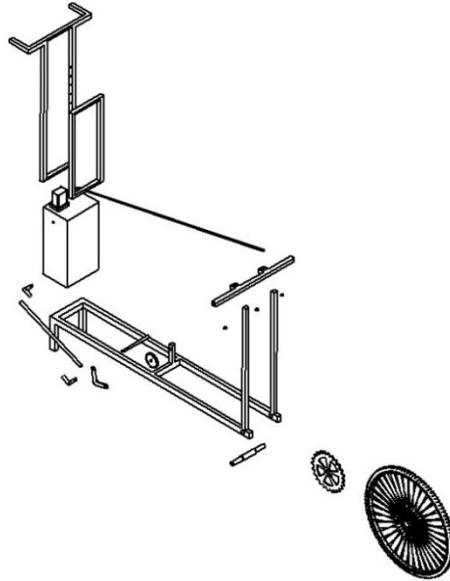


Figure 6: Disassembly Drawing of the Chemical Spray Trolley

### 3.4 Fabrication Process

For cost-effectiveness and optimal resource utilization, the chemical spray trolley was assembled in-house at UiTM Cawangan Terengganu Kampus Bukit Besi. Key components, including the frame chassis and spray nozzle, were fabricated in the workshop. Additional parts, such as pump mechanisms and pressure gauges, were procured from local hardware stores, ensuring compatibility and functionality.

Fabrication operations were executed by using three machines, as shown in Figure 7 below, which each machine offers specific capabilities:

- i. Gas Metal Arc Welding (GMAW) creates solid and long-lasting connections between metal parts.
- ii. Cutting Machine: The process of precision shaping metal was accomplished through a hand grinder.
- iii. Drilling Machine: This is used to create holes necessary for accommodating functional components.



Figure 7: Students Working on Welding and Cutting Metal Processes

This chemical spray trolley assembly focuses on three key components: (i) the frame, (ii) the sprayer unit, and (iii) the nozzle holder. The fabrication starts with the frame, where metal sections are precisely cut and then welded together. Wheels are subsequently attached to ensure smooth maneuverability.

The nozzle holder follows a similar workflow, with carefully cut metal sections drilled for bolt-and-nut assembly. This adjustable design allows for nozzle positioning. Finally, the sprayer unit takes a more straightforward approach, employing hose clips, T-joints, and elbows to connect its components efficiently. Throughout the assembly process, safety remains paramount, with established operational procedures guiding each step. Figure 8 below shows the finished product of the chemical spray trolley.



Figure 8: Final Product of Chemical Spray Trolley

### 3.5 Bill of Material and Costing

The chemical spray trolley is designed for affordability and accessibility, offering a cost-effective solution for farmers. It's assembled from six key components: a knapsack sprayer, two castor wheels, two sprinkle spray nozzles, hose clips, a hose, and a T connector. The combined cost of these parts totals RM 157.53, making it affordable to farmers.

To further enhance its affordability, the trolley features a modular design. Farmers who already own a knapsack sprayer can purchase only the trolley frame and associated parts, reducing the cost to an even more affordable RM 48.53. This flexibility allows farmers to tailor the purchase to their specific needs and budget.

Table 4: Bill of Material and Costing for Chemical Spray Trolley

Item No	Part Name	Description (part type/material/brand)	Source	Figure	Quantity	Price per unit, RM	Total Price, RM
1	Knapsack sprayer	Ogawa plastic	shopee		1	109.00	109.00
2	Castor wheel	Heavy duty rubber wheel	shopee		2	11.24	24.38
3	Sprinkle spray nozzle	Adjustable brass nozzle	shopee		2	1.62	3.25
4	Hose clip	Steel	MR DIY		1	2.90	2.90
5	Hose	Rubber	KJ Hardware Trading		2	5.00	10.0
6	T connector	brass	KJ Hardware Trading		1	8.00	8.00

#### 4.0 CONCLUSION

In conclusion, the chemical spray trolley was successfully designed and fabricated in UiTM Cawangan Terengganu Kampus Bukit Besi. Amongst the advantages of this machine is that it uses a large wheel for ease of movement on complex surfaces. The machine also includes safety features, such as the spray nozzle being located at the front and positioned down to the surface. This ensures that the chemical particles will not return to the farmers who move the chemical spray trolley. Thus, this improvement also helps reduce farmers' fatigue during chemical spray activities.

As for future works, the main frame can be improved by using lightweight aluminum to boost maneuverability, while a modular design featuring detachable components like the spray arm enhances adaptability and simplifies maintenance. These material upgrades empower the trolley to become a robust, adaptable, and eco-friendly workhorse for agriculture.

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