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Design and Fabrication of Mechanical Sprayer used in agricultural applications

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Abstarct: In present days agriculture sector is using mechanization to carry out various works. Mechanical sprayer is also a part of them for spraying pesticides and water. Existing sprayer is manually operated which takes more time to spray and physical strain to operator, hence it is made automatic in this project. The model is developed by using slider crank mechanism which converts rotational motion to reciprocating motion. Design and modelling is done by using CATIA software. Discharge rate is calculated and cost analysis is done.

Keywords: Mechanical Sprayer; Slider crank mechanism; CATIA; Discharge rate

1.INTRODUCTION

India is an agricultural country with small, marginal, and wealthy farmers. Because of its versatility, cost, and design, small scale farmers are interested in manually lever driven knapsack sprayers [1]. As pests and insects have become more prevalent in recent years, They've been sprouting up everywhere in the vegetation and they've also developed resistance to the environment. Farmers all over the world are now required to apply pesticides and insecticides on a regular basis in order to protect the environment to keep their crops from rotting and being eaten by insects parasite protection is critical in all agricultural activities, and it necessitates ongoing monitoring and management [2]. When action is required, it is taken quickly. Various equipment, insecticides, and labour are frequently required for this purpose. Agriculture is extremely important to the Indian economy. Around 65 percent of the state's population is reliant on it [3].

Despite the fact that it currently accounts for around a sixth of India's GDP, it employs 56 percent of the country's workforce. In 1960-61, the percentage of marginal and small farmers was roughly 81 percent, while the share of land operated was 44 percent. In terms of the current situation, more than 75% of farmers are tiny and marginal landholders. Cotton is the only crop that employs nearly 80% of the Indian labour. As a result, any improvement in the situation is welcome [3-4]. Productivity-related tasks serve to improve the status and economics of Indian farmers. The existing backpack sprayer has several limitations and consumes a lot of energy to function. The proportion land allocation for agricultural makes up the majority [5] .

2.LITERATURE REVIEW

2.1 "Development of Multi nozzle Pesticides Sprayer Pump" was completed by Sandeep H.Poratkar and Dhanraj R. Rout.

India is a land of farmers, with small, marginal, medium, and wealthy farmers. Farmers on a small scale. Because of its adaptability, cost, and design, the manually lever driven knapsack sprayer has piqued our curiosity. But this sprayer has some drawbacks, such as the inability to sustain adequate pressure, which causes back pain. However, this equipment might lead to incorrect chemical application and inadequate pest management. As a result of dribbling or drift during application, insecticides are lost. This problem not only raises production costs, but it also pollutes the environment and causes an imbalance in the market system of natural echoes A model is proposed in this study.

2.2 Rajashekhar goud Angadi, Rohit L G, Satish Changond, Santosh Kagale "Cam Operated Agrochemical Pesticide Sprayer"

Agriculture is the backbone of India. Agriculture sector is required to enhance and increase the productivity of the field crop by use of a cam operated agrochemical pesticide sprayer. This project deals with design of COAP, in turn improve the spraying methods, increase the crop productivity, and reduce the farmers effort with skill implementation in agriculture sector. The sprayer tank kept at rear basket of bicycle and placed for four nozzles to the pipe diameter of 10mm.The spaying method is purely mechanical based in which rear wheel of bicycle sprocket connected with chain to cam. As bicycle start moving forward kinetic energyconverted into rotating energy, then pump press on pressure tank to create a suction pressure to discharge the flow rate of water through nozzle.

2.3 Mishra, Ashutosh & Bhagat, Neetu & Singh, Padam. (2019). Development of SolarOperated Sprayer for Small Scale Farmers.

The cost of fuel and the effect of emission of gases from the burnt fuel into the atmosphere, this necessitated the use of the abundant solar energy from the sun as a source of power to drive a sprayer The Photovoltaic (PV) panel of 6 V, 5 W capacity configured to trap and convert the sun's energy into the useful power was used to perform the work of spraying. Solar PV Panel was used for operating the sprayer and for charging a battery. The motor was used to regulate spraying liquid from the sprayer tank (5 lit.) and spray it through spinning disc nozzle. The SPV operated sprayer was provided with 6volt, 4.5amp lead acid battery which was used as alternative power source during cloudy atmosphere (in rainy season).

2.4 "The design and development of a multipurpose pesticide spraying equipment" wascompleted by the writers of Shailesh Malonde.

Spraying pesticides is a must on Crops are grown in a specific way. The current concept is concerned with the design and manufacture of a pesticide sprayer which will be beneficial and inexpensive to farmers will aid in the increase of crop productivity The creators as a result, the cost of the sprayer has decreased as compared to the previous year. It can be

operated on a modest scale using the existing sprayer. The flow rate is 2.5 times what it would be if it were done manually a sprayer that is operated the amount of area sprayed everyhour has grown by a factor of 2.6 times the time it would take to do it manually.

3.OBJECTIVES

- The final goal of this paper is to help the farmer to be able to pull the mechanism mounted on the trolley to operate the pesticide sprayer pump and spray the pests instead of carrying the full pesticide sprayer pump on his shoulders. The farmer feels more at ease, calm, and less tired as a result of this.
- The second goal is to lower the amount of work required by humans due to the constant pumping action used to generate pressure inside the pesticide sprayer, so providing a comfortable atmosphere for the user and lowering the fatigue burden on the user body.
- As previously said, the farmer must continue to pump with one hand while spraying pesticides on the crops. The other hand is used to cultivate crops. This is a tedious and time-consuming job in the long run.

4.METHODOLOGY

4.1 Crop selection:

The crop selected is capsicum annum. It is one of the most important commercial crops in India. The crop parameters are listed below. It is taken from the reference [6].

S.no	Name of the plant	Distance between plants (Horizontal)	Height of crop
1.	Capsicum annum	40 to 50 cm	47 to 69 cm

4.2 Development of wheel sprayer

The components of developed wheel sprayer are main frame, sprayer tank, wheel, driving and driven sprockets, boom assembly, nozzle, chain, piston pump, hose, shaft, plummer block bearing and connecting rod.

4.2.1 Main Frame

The main frame is to carry whole assembly on it. The frame is made of steel bars of mild steel. The height of the frame handle is designed as per the ergonomic considerations. Frame is made of mild steel bars which can be easily welded

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[8]. Main frame attached with wheel is shown in below fig.1. The length of the main frame is selected as per design and values is 840 mm.

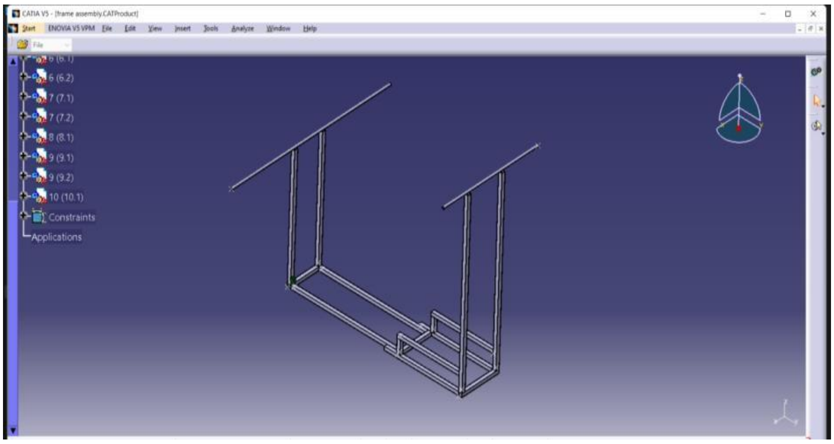

Fig.1: Catia model of Main frame

4.2.2 Selection of Components with their material specifications

Table no.1

Sr. No	Name of component	Dimensions	Material used
1.	Frame	Length=840 mm	Mild steel
2.	Tank	420 x 360 x 180 mm	Plastic
3.	Bicycle wheel	Rim diameter 320mm Wheel diameter 400mm	Plastic Rubber
4.	Driving sprocket	24 teeth Diameter 100mm	Alloy steel
5.	Driven sprocket	18 teeth Diameter 60 mm	Alloy steel
6.	Boom	Length 460mm	Mild steel
7.	Nozzle	Diameter 50mm Nozzle hole diameter 1 mm	plastic
8.	Piston pump	Diameter 50mm Stroke 60mm	Brass
9	Connecting rod	Length 260mm	Mild steel
10.	Hose pipe	Length 1000 mm	Plasticized PVC
11.	Shaft	Length 440 mm	Mild steel
12.	Bearing	Bearing no. UC204	Cast iron
13.	Chain	Length 928 mm	Alloy steel

4.3 Design Calculations

Motion transmission allows a transfer of mechanical energy from one object to another without changing the nature of movement. The motion transmission of the driving and driven sprockets is rotational to rotational. Gear ratio is calculated by dividing the number of teethon the driving sprocket to the number of teeth on the driven sprocket [7].

4.3.1 Calculation of Gear ratio

$$\text{Gear ratio(i)} = \frac{no.of\ teeth\ on\ driving\ sprocket}{no.of\ teeth\ on\ driven\ sprocket}$$

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$$i=\frac{T_1}{T_2}\ (T_1>T_2)$$

Where,

T_1=No of teeth of driving sprocket=24 teeth

T_2=No of teeth of driven sprocket =18 teeth

$$i=\frac{24}{18}$$

$$i = 1.33$$

4.3.2 Determine the range of chain pitch [7]

Center distance, x= (30 to 50)p

x- centre to centre distance between two sprockets = 330mmp- pitch of chain

Therefore, $p_{max}=\frac{330}{30}=11mm$

$p_{min}=\frac{330}{50}=6.6mm$

Available pitches are 9.52 mm, 12.7 mm, 15.875 mm Choose the maximum value and then standardize the valueSo, the selected pitch value, p =12.7 mm

4.3.3 Calculation of no.of links

Now, no.of links $=\frac{2c}{p}+\frac{(T_1+T_2)}{2}+\left[\frac{(T_2-T_1)^2}{4\pi}\right]\times\left(\frac{p}{x}\right)$

$$=\frac{2\times330}{12.7}+\frac{(24+18)}{2}+\left[\frac{(24-18)^2}{4\pi}\right]\times\left(\frac{12.7}{330}\right)$$

= 73.07

Therefore, no.of links, m ≈ 73

4.3.4 Calculation of length of chain [7]Length of chain = m×p

= 73×12.7

Therefore, length of chain = 927.99 mm

4.4 Total force required

Total force required for motion is given by formula

Force, $F=\mu\times W$ Where, μ= coefficient of friction=0.45 for mud W= total load on the complete assembly

Weight of the frame and the complete sprayer assembly is weighed using digital electronic balance (0-500 kg). Total load is determined by multiplying total weight of the complete assembly with acceleration due to gravity [7].

F=0.45 × 21.088 × 9.8

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F=93 N

Therefore, Force required for motion(F)=93 N

4.5 Working Principle

4.5.1 Slider crank mechanism

With the help of a connecting rod, the rotating motion generated by the crank from the chain drive is translated into reciprocating action of the piston in the created wheel sprayer. Compression is used to generate the desired pressure, and the spray solution is ejected from the nozzle. The reciprocating pump is connected to one of the turning wheels by the crank as shown in the fig.2. The wheels are fixed on the main axle, while the cranked axle drives the piston rod in and outof the cylinder, forcing air into the tank. The spray tank is mounted on the frame and containsspray solution as shown in the fig.3. The sprayer final result is that the operator's push force is transformed to pressure energy and the fluid is sprayed. An air pump in this piece of equipment compresses air into the tank and pressurises the spray mixture. As the liquid is sprayed, the pressure gradually reduces. The spray solution flows out of the tank due to the amount of pressure created. The spray solution was sprayed on the plant surface via the nozzle [8].

4.5.2 Working of wheel sprayer

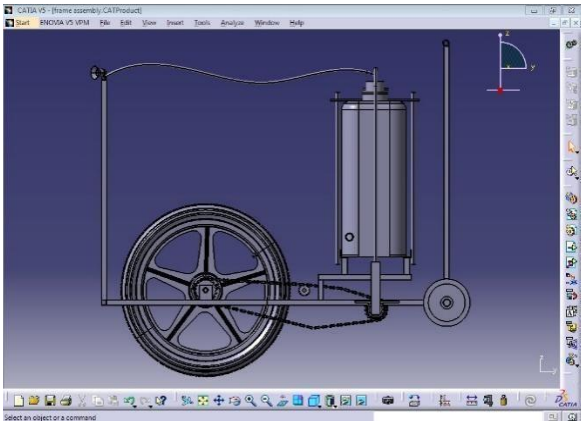

Fig.2: Side View

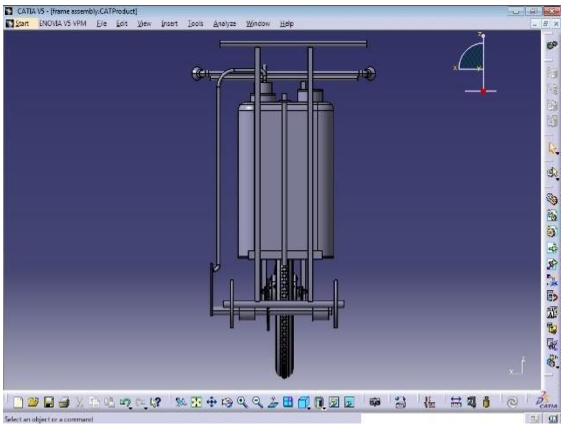

Fig.3: Front View

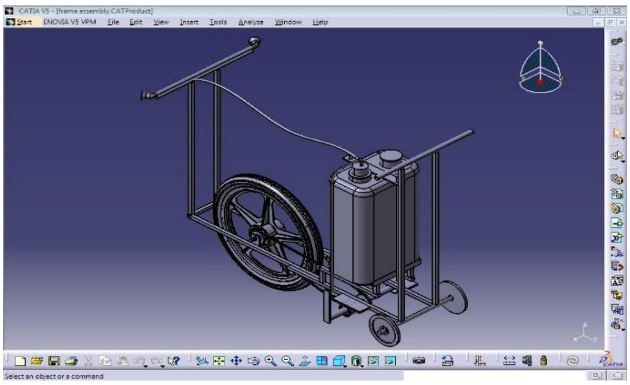

Fig.4: Isometric View

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The evolved wheel sprayer's handle is pushed forward by the operator. It is shown in fig.3 The gear sprocket attached on the wheel revolves at the same speed as the wheel. The motion of the driving sprocket is transferred to the driven sprocket via the chain drive. On either side of the same shaft, the driving sprocket and connecting rod are placed. With the help of the crank and connecting rod mechanism, the rotating motion of the shaft is turned into the reciprocating motion of the pump as shown in fig.4. The piston pump's reciprocating motion creates the required pressure for spraying the spray solution via the nozzles. Because the wheel, sprockets, and chain are all bicycle-style, the pump only sprays when the created wheel sprayer is moved forward by the operator. The piston pump reciprocates when the wheel sprayer travels forward, causing the spray solution to discharge through the boom assembly and droplets to be sprayed on the plant surface by the spray nozzles [9].

5.RESULTS AND DISCUSSIONS

This chapter deals with the discharge calculated and cost analysis of the mechanical sprayer[3].

$$Q = \frac{ALN}{60}$$

$$Q = \frac{\pi \times 0.06^2 \times 0.05 \times 21}{60 \times 4}$$

$Q = 4.948 \times 10^{-5} m^3/sec$

Multiply with 60,000 to convert into lit/min$Q = 4.948 \times 10^{-5} \times 60{,}000$

Q=2.968 lit/min

Since there are two nozzles used at the boom assembly.

$$\text{Discharge per nozzle} = \frac{Total\ discharge\ rate}{no.of\ nozzles}$$

$$= \frac{2.968}{2}$$

Discharge per nozzle = 1.484 lit/min

So, the total discharge obtained at each nozzle is 1.418 lit/min.

The working of mechanical sprayer is shown in the fig.5 and fig.6 shows the total assembly of mechanical sprayer.

Fig.5: Nozzle assembly

Fig.6: Total assembly

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5.1 Cost Estimation :

Table no. 2

SL NO.	Descriptionof items	Materials used	Quantity	Rate per unit	Total cost
1	Main Frame	Mild steelbars	10	50	500
2	Shaft	Mild steelhollow rod	1	50	50
3	Knapsack sprayer Tank	Plastic	1	1100	1100
4	Wheel Rim	plastic	1	300	300
5	Tyre	Rubber	1	500	200
6	Driving Sprocket	Alloy Steel	1	300	300
6	Driven Sprocket	Alloy Steel	1	150	150
7	Nozzles	Plastic	2	30	60
8	Hose	Plasticized PVC	1 m	100	100
9	Chain	Alloy Steel	1.3 m	400	400
10	Bolts and Nuts	Mild steel	4	100	100
11	Bearings	Cast iron	2	150	300
11	Other expenses	-	-	400	400

Total cost(rupees) = 3960/-

The analysis of rates and the cost estimation is done in order to evaluate the economic feasibility of the developed wheel sprayer. The estimated total cost for the fabrication of wheel operated sprayer is found out to be Rs. 3960 /- as shown in table no.2 . The total cost included the cost of fabrication of all components of the wheel sprayer [4].

6. CONCLUSIONS

1. The suggested model has removed the problem of back pain, since there is no need to carrythe (pesticides tank) on the back.
2. As suggested model has two nozzles which will cover maximum area of spraying in minimum time and at maximum rate.
3. Proper adjustment facility in the current model with respect to crops helps to avoid excessive use of pesticides which results into less pollution.
4. Muscular problems are removed because there is no need to operate the lever.

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