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MANUFACTURING OF AGRO-BASED FERTILIZER SPRAYING CART

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Abstract:
The agricultural sector faces challenges to ensure efficient crop management and optimum utilization of resources. To address these problems this project is directed towards the manufacturing of agro-based cart. To improve precision, efficiency and sustainability in pesticide and fertilizer applications. The Cart is manually operated by eliminating the need for complex electronic systems and minimizing maintenance requirements. Equipped with adjustable nozzles and a reliable pumping mechanism, ensuring uniform spray coverage across the entire cultivation area with specified calculations. This innovation combines the practicality of manual operation with the efficiency of mechanized components to enhance fertilizer applications in farming.

Keywords: Crank and lever mechanism, Pascal's law, Cart, Spraying nozzle

Introduction

A manual mechanized sprayer represents a crucial advancement in agricultural technology, bridging the gap between manual and fully automated spraying system. The mechanized pump, powered either by a hand crank and lever mechanism, pressurizes the liquid, enabling uniform and controlled distribution through the nozzles. One notable advantage of manual mechanized sprayers is their versatility. Farmers can easily adjust the pressure, flow rate, and nozzle settings to accommodate different crops, growth stages, and environmental conditions.

This adaptability results in improved precision and reduced waste, as farmers can target specific areas with the right amount of pesticide or fertilizer. Furthermore, manual mechanized sprayers offer benefits in terms of economic and user-friendliness. In conclusion, manual mechanized sprayers play a pivotal role in modern agriculture by providing an effective and user-friendly solution for fertilizer applications.

Their ability to combine the advantages of manual control with mechanized precision makes them an indispensable tool for farmers seeking improved crop protection, increased yields, and reduced environmental impact. A manual mechanized sprayer is an agricultural tool designed to enhance the efficiency and precision of pesticide or fertilizer applications. Combining the advantages of manual operation with mechanized components such as pumps and nozzles, these sprayers enable farmers to cover larger areas while maintaining control over the spraying process.

Objectives

To design and manufacture an efficient and environmentally friendly agro-based fertilizer spraying cart that enhances crop productivity while minimizing environmental impact.

- The cart are used to optimize functionality and usability.
- The successful manufacturing of the agro-based sprayer offers a more viable solution than that of conventional manual spraying methods.

- This cart is low-cost, feasible vehicle helping farmers to increase the productivity of the crops by a uniform distribution of fertilizers in a systematic manner.
- Ensure the cart is easy to operate, maintain, and transport, making it accessible to a wide range of farmers, including those in remote or small-scale farming communities.
- Prioritize safety features to protect operators and adhere to regulatory standards for agricultural machinery.

Literature

Dr. Pankaj Gajbhiye et.al(2022) In this mechanized spraying system is designed to be cost-effective. It aims to provide increased efficiency without the high expenses associated with bulky and expensive electrical sprayers.[1]

Ashish Prakash Borhade et.al(2019) The proposed solution involves a trolley-operated system, which means the spray pump is mounted on a trolley or cart, reducing the physical burden on the farmer and making it easier to transport and operate.[2]

Charles Chikwendu Okpala et.al(2021) The study includes the design of a trolley that houses the water sprayer and allows for easy mobility, making it convenient for users to move the sprayer to different locations.[3]

R.Panchamoorthy et.al(2020) This mechanically operated wheel-driven sprayer is proposed as a portable, fuel-free device that can be easily moved and operated by the farmer. [4]

Sandeep Kumar et.al(2022) The wheel-driven sprayer utilizes a crank mechanism with a piston pump, driven by the rotation of the wheel. This design enables efficient spraying while being easy to use and maintain. [5]

Victor J. Rincon et.al(2021) In This Sprayer System results indicate that the flat-fan spray lance achieved a more uniform spray distribution in the plants compared to the other hand-held sprayers.[6]

Sagar S B et.al(2018) The spray pump is designed with multiple nozzles to increase the coverage area and improve spraying uniformity, ensuring better pest control and distribution of fertilizers. [7]

Dr. Anurag Singh Tomer et.al(2023) The primary objective of the study is to design a mobile water sprayer that can be fabricated using locally-sourced materials. The sprayer aims to automate the watering of plants, reducing manual handling and repetitive tasks. [8]

R.D. Mundhe et.al(2023) The design and manufacturing of a fertilizer spreader machine is a multifaceted process aimed at developing an efficient and effective agricultural tool for distributing fertilizers onto crops. [9]

Hemadri Chadalavada et.al(2020) Its design incorporates advanced technologies, including solar panels to harness renewable energy, reducing the dependency on fossil fuels and promoting environmentally friendly practices. [10]

Ashutosh Shimpi Ruchir Shinde et.al(2022)The flat-fan spray lance also resulted in significantly lower losses to the ground, reducing waste and potential environmental impacts. [11]

Ashish Prakash Borhade et.al(2018) The design incorporates a durable and lightweight frame, equipped with a tank for holding fertilizers and a spraying system for even distribution. [12]

Md Rakibuzzama n et.al(2023) The proposed design can help gardeners in terms of comfort during spraying, reducing energy used to pump tanks, and effectively utilizing spraying time. [13]

Ron Berenstein et.al(2018) An economic analysis estimates that up to 45% of pesticide reduction is possible when using the suggested spraying method. Actual savings depend on the spraying durations, target size, and distribution. [14]

R. B. Pawar et.al(2010) This design helps us to fulfil the energy demand of remotely located farmers for operating various farm equipment. [15]

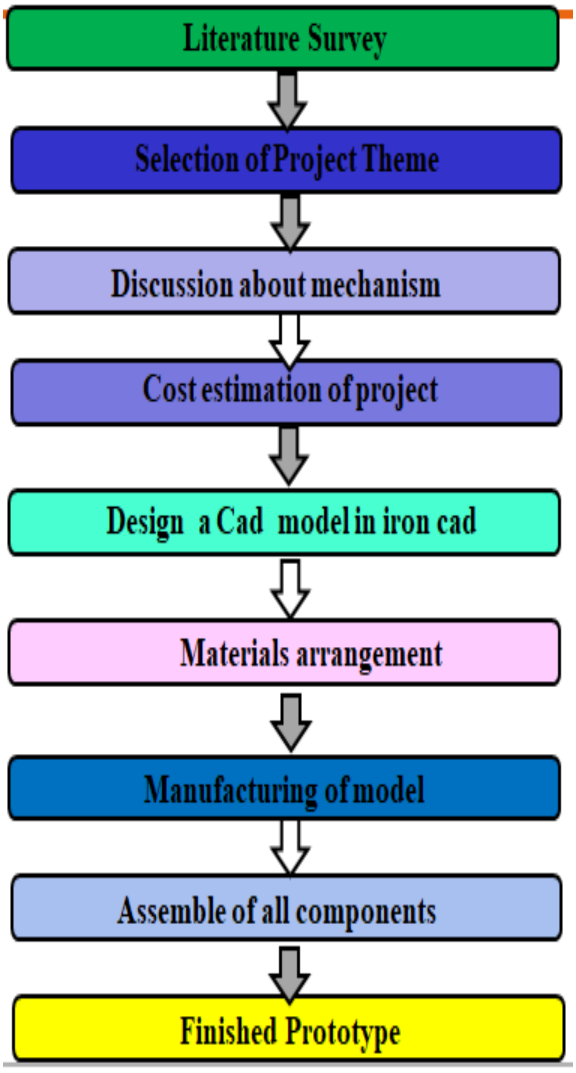
V. Pranavamoorthi et.al(2017) The argument for using existing conventional equipment is that farmers will face economic difficulties in case of chemical and electrical powered pumps and will also face health issues in case of hand operated pumps. One way to overcome the use of mechanical power. [16]

Julián SánchezHermosilla et.al(2023) The flat-fan spray lance obtains a more uniform spray distribution in the plant canopy and results in losses to the ground. [17]
Neha Dhankhar et.al(2021) This paper examines the impact of increasing fertilizers and pesticides on human health , highlighting the potential risks and benefits associated with their use. [18]

Methodology:

The motto of the project is to develop an efficient and versatile pesticide spraying system with less cost and works with less effort of human power.

- The cart is mainly worked by using crank and lever mechanism to pump the tank.
- Pascal's law is applied inside the tank and is used to distribute uniform pressure to the nozzles.
- The adjustable connecting rod is used to adjust the stroke length of the pumping action.
- The adjustable handle is used to adjust the height of the handle to hold for comfort
- The adjustable nozzle is used to minimize or maximize the fertilizer dispersed area.
- The adjustable lance setup is used to adjust the potential head of the nozzle for an efficient spraying system.



Materials Selected:

Wheel:

It is used to carry the whole assembly and transport the cart from one place to another by rotary motion it. It must be less in weight and high strength and minimum off-road conditions to bear. To maintain maximum ground clearance as like an agriculture vehicle (tractor).

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Fig-1: Tubeless Tyre's

Frame:

It is used to carry the Payloads and is uniformly distributed throughout the Structure. The frame is made of mild steel in the form of a Hollow square rod.

Fig-2: Cart Structure

Tank:

The tank caries as much fluid as it can be along with its self-weight as little as possible. We have taken a tank which is almost 16-liter capacity as reference. A tank material used is plastic fiber to bear low pressure of about 4-5 bar.

Fig-3: Spraying tank

Adjustable Connecting Rod:

The main function of the connecting rod converts rotary motion of crank to the reciprocating motion of the pump and extension rod. It must be less weight and high strength. It has a special feature of adjustable length to adjust the stroke length of the piston.

Fig-4: Adjustable Connecting Rod

Chain Drive:

In general maximum torque is transmitted through gear for this there is a long gap between the driving shaft and the driven shaft. To transfer we use a chain drive with some short of slip.

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Fig-5: Chain Drive

Sprockets:

It is generally to any wheel upon which radial projections engage a chain passing over it. The chain is made of steel which is used to transmit power from the gear sprocket to the pinion sprocket, and it has no slip. Here gear is bigger than pinion to get more gear ratio.

Fig-6: Sprockets

Crank:

The function of the crank is to transfer motion from the prime mover to the connecting rod for further operation. Here we use the circular disc having eccentricity at which the rotary motion of the crank is converted into a reciprocating motion through a connecting rod.

Fig-7: Crank

Nozzle:

It is a device that converts the pressure energy of fluid into kinetic energy, the sprayer nozzle is a precision device that facilitates the dispersion of liquid into a sprinkled mist and reduces the waste. It is used to distribute uniform coverage of the area by an adjustable screw System. The pressure is Uniformly Distributed to the nozzle through Pascal's law.

Fig-8: Adjustable Atomizer nozzle

Hose pipe:

It is used to transfer the fertilizer pump to the nozzle without any leakage and is mandatory of a flexible nature. And it is must be suitable for to pump Head.

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Fig-9: Flexible Hose pipe

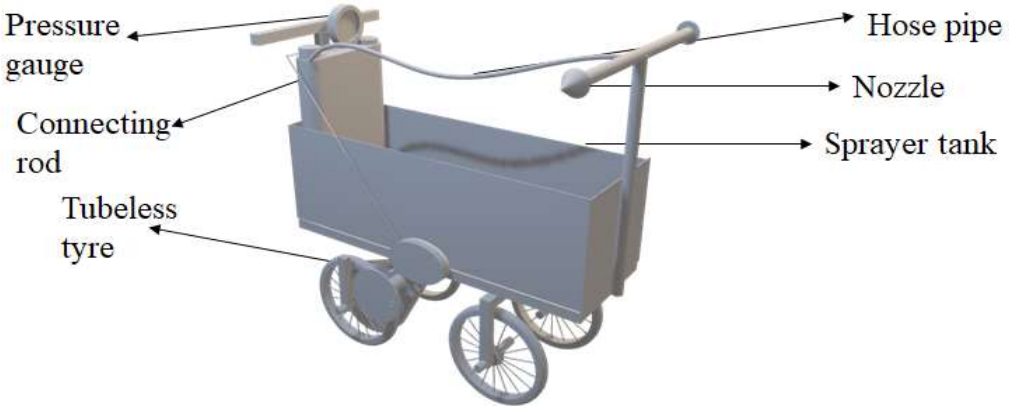

Fig-10: 3D Cad model of Cart

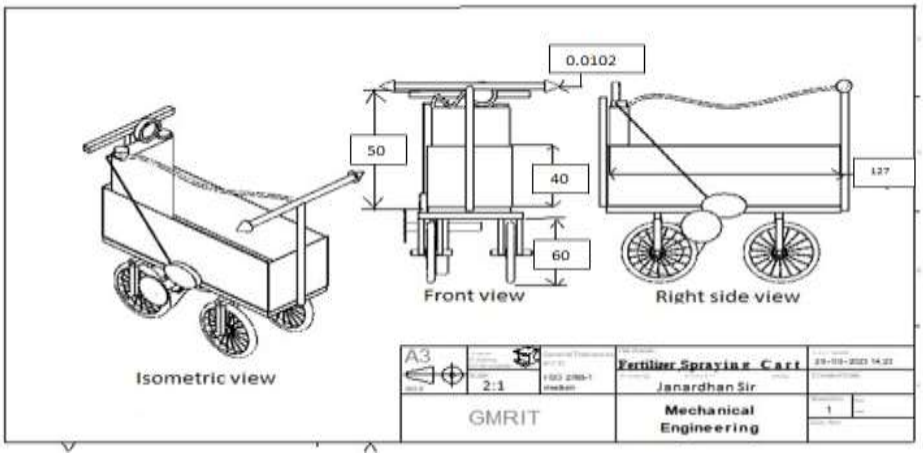

Fig-11: Layout diagrams of Cart

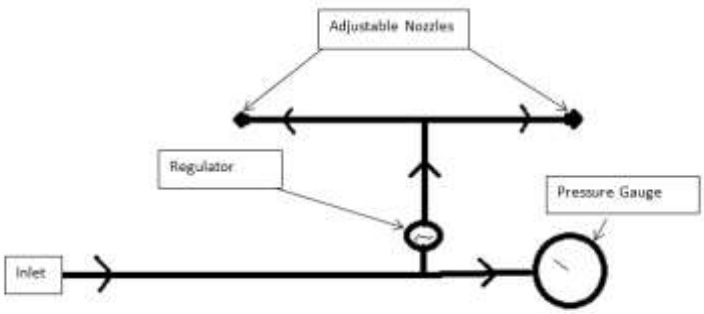

Fig-12: Layout diagram of hose pipe connection

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Cart Structural analysis

In this analysis the process begins with a 3D Cad Model of Frame is analyzed by Ansys workbench. Furtherly applying Boundary conditions and meshing to get a finite element is to be analyzed with material properties. And finally, apply a load on the frame upper surface of 9000N.

S.no	Mild steel Properties	Value
1	Young's modulus	$1.9\times1011N/m^2$
2	Poisson's ratio	0.3
3	Density	7850 KG/m^3

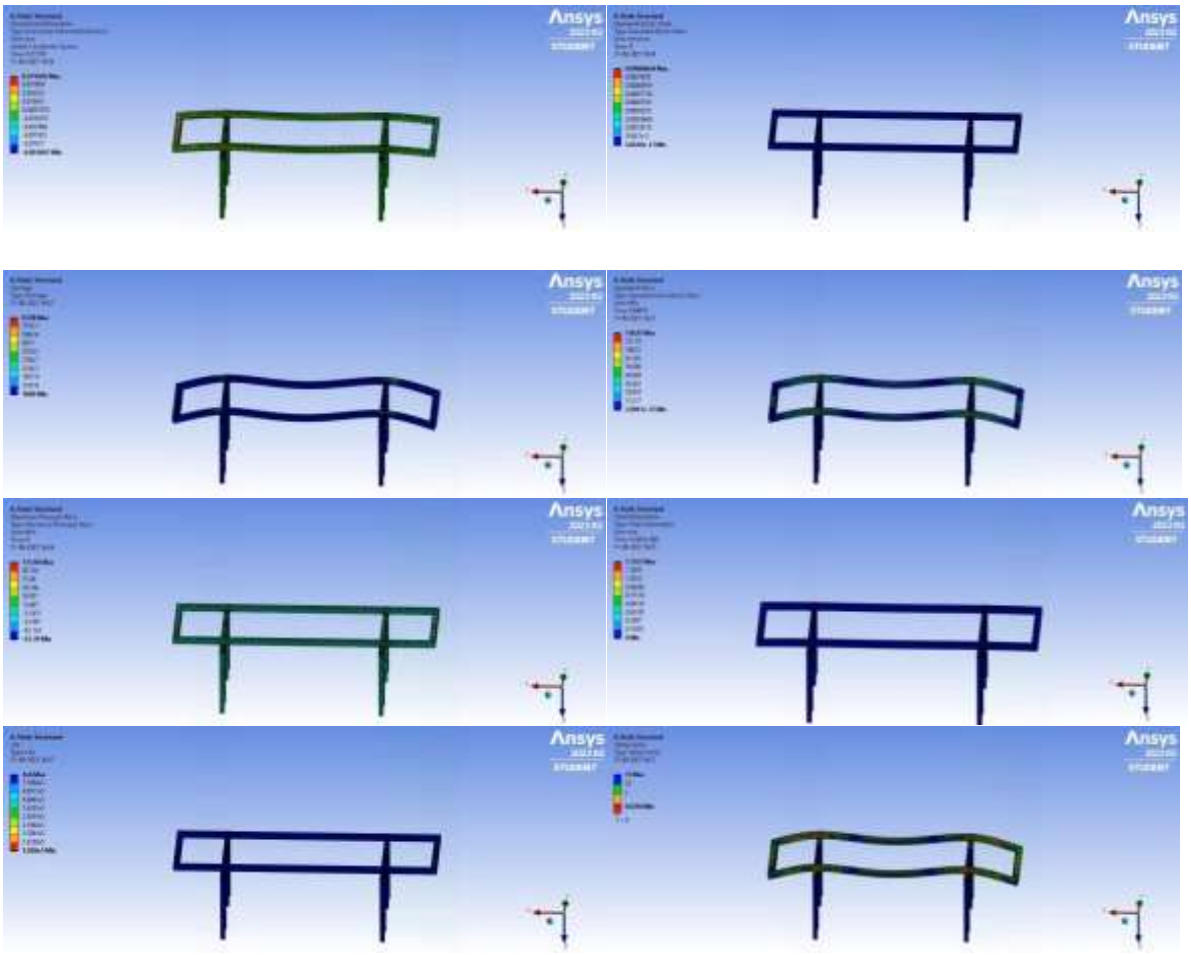

Fig-12: Analysis of stress, strain, damage, safe factor, deflection

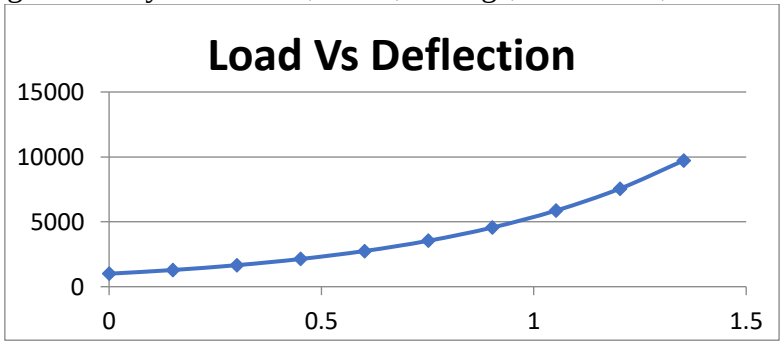

Fig-13: Load Vs Deflection

Design Parameters

- Wheel Diameter = 20 inches = 508 mm

- Ground clearance = 600mm
- No. of teeth in Driver sprocket = 44
- No. of teeth in Driven sprocket = 22
- Base- Hollow Square bar = 25mm *25mm *2 mm
- Support -Hollow Square bar = 20mm *20mm *1mm
- Tray volume = 1270mm *400mm *400mm
- Tray gauge thickness =0.8mm
- In-built pump rectangular tank capacity =16L
- 8/11 Hose Pipe length = 60 inches (1524 mm)

Calculations

Velocity Ratio (VR) $=\frac{\text{Number of teeth On Driver Sprocket}}{\text{Number of teeth On Driven Sprocket}}=\frac{44}{22}$ = 2:1

Distance Travelled by wheel in one revolution = Two times of crank revolution

Nozzle Discharge:

S No.	Stroke Length(cm)	Pressure Generated after Second Stroke(PSI)	Time taken to fill 100ml of Fertilizer (Min)	Discharge (Q) ml/min
1	11	24	0.070	1428.57
2	9	21	0.098	1020.40
3	7	16	0.152	657.89
4	5	13	0.325	307.69
Average Pressure:		18.5 PSI	**Average experimental Discharge:**	853.63ml/min

Theoretical Discharge Calculation:

Q=28.9× $D^2 \times \sqrt{P}$

Where,

Q=Discharge in GPM (gallon per minute)

D=Diameter of nozzle in inch

P= Pressure develop in the tank in PSI

Q= 28.9× $0.04^2 \times \sqrt{18.5}$

Q=28.9× 0.0016 ×4.301

Q=0.1988 GPM

Or

=0.1988× $3.785 = 0.75278 LPM$=752.78 millilitre per minute

Power required to run the Vehicle in terms of calories per minute:

C= ρ×g×Q×H

C – Useful power, Watt

ρ – Density of the pumped medium, kg/m^3

g – Gravity acceleration, m/s^2

Q – Flow rate, m^3/s

H – Total head, m

C = ρ×g×Q×H

Q= 853.63×1.667× 10^{-8}=0.0000142272 m^3/s

C=1000× 9.81 × 0.0000142272 × 0.6

= 0.08374Watt

=0.08374× 14.3307

=1.2Cal/min

Cost Estimation

S.no	Components	Quantity	Cost
1	Tubeless wheels	4	400
2	Base frame	1	300
3	G.I Sheet 250*60 gauge #20	2	1000
4	Sprayer (16L)	1	1250
5	Support frame	1	500
6	Pressure Gauge	1	500
7	Regulator	2	50
8	Hose pipe	1	400
		Total cost:	4400

Working procedure:

- When an external force is applied to a cart handle makes the forward motion of a cart, it initiates a chain reaction of mechanical movements.
- The wheel's rotation, synchronized with the sprocket, drives a crank via a chain drive.
- This rotary motion is then converted into reciprocating motion by a slider crank mechanism connected to a driven sprocket.
- By connecting with an adjustable connecting rod used to adjust the stroke of the piston pump.
- The reciprocating motion, in turn, powers a piston, creating pressure as it moves upward (during expansion) draws pesticide into the pump, and pushes it downward (during compression) towards the delivery valve.
- This tends to develop inbuilt pressure inside a tank.
- The pressurized pesticide is then directed through the piston rod to the delivery valve, which is connected to a hose pipe leading to adjustable nozzles. Due to Pascal's law the pressure is equally distributed to each nozzle.
- The height and the angle of spraying can be adjusted according to the requirement.
- Thereby efficient way of spraying through the manual mechanized sprayer.

Fig-13: Final Prototype

Conclusion

In conclusion, the described mechanism represents an efficient and versatile pesticide spraying system. The Cart eliminates the conventional sprayer methods causing throat and eye infections that may lead to eyesight loss and death. The Short-term health issue impacts farmer's efficiency and leads to early death. The pesticide sprayer is heavy weight creating backbone problems for farmers. This agro-based fertilizer spraying cart will increase yield thereby improving his income from crops. By making it has a reliable tool for farmers in various agricultural settings. Moreover, the design is considered economic, making the sprayer easy to handle and reducing physical strain on farmers during spraying operations. Thus, the structural analysis of the cart is done for is it essential to run on the ground is suitable. Incorporate digital technologies for data collection and analysis, allowing farmers to optimize fertilizer application based on real-time data, thus maximizing efficiency and minimizing waste.

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