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Design and Construction of a Battery Powered Jet Spray Cylinder for Micro-Irrigation Scheme

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Abstract:- The jet spray cylinder is an important device which helps to provide more yield for same plant and also enables continuous and maximum crop production throughout the year be it winter or summer by supplying the right amount of water needed by plants for optimum performance. The jet spray cylinder can also be adapted for other applications such as pest control, weed control etc. This device is more convenient to operate and maintain since the function of the lever bar is replaced by a battery powered pump. The device gave a uniform continuous flow and also a higher efficiency as it was able to discharge 2 liters in 10(ten) seconds and thus discharging the whole volume of the cylinder (16 liters) in one minute twenty seconds.

I. INTRODUCTION

Irrigation involves the deliberate and controlled application of water for agricultural purposes, using man-made systems to address water needs not met by natural rainfall. Crop irrigation plays a vital role worldwide, ensuring sufficient food production for the ever-growing global population. The primary objective of irrigation is to provide each plant with the precise amount of water it requires. Various irrigation methods are employed globally, such as center pivot, drip, flood, furrow, gravity, rotation, sprinkler, sub-irrigation, traveling gun, supplemental, and surface irrigation.

Jet spray cylinder pressurized irrigation, whether in the form of sprinkler or drip systems, plays a crucial role in enhancing liquid efficiency and significantly contributing to improved food production. Sprinkler irrigation, which falls under the pressurized irrigation category, involves the application of liquid to the soil surface using mechanical and hydraulic devices that mimic natural rainfall. This widely used irrigation method helps replenish nutrients consumed by crops and ensures the soil is adequately softened for agricultural activities. The ultimate goal of any irrigation system is to provide each plant with precisely the right amount of water it needs for optimal growth and productivity. Whether it's through sprinklers or drip systems, the controlled application of water supports sustainable agriculture and efficient resource utilization. Various designs of jet spray cylinder for micro irrigation scheme have inadequate design consideration with designers not really taking into account the headache faced by the operators of this piece of equipment in moving the rocker bar up and down continuously to create a pressure difference throughout the period of spraying. Designers also more often don't adapt the equipment for other purposes like weed control pest control etc., thus bringing the need for this project work. The aim of this project is to design a device which will be used in micro irrigation scheme to supply water to the root of the plant in the form of localized irrigation. Also specific objective are outlined below;

- To construct a jet spray cylinder that makes localized surface irrigation easier .Installation and maintenance cost are reduced in comparison to an underground irrigation system.
- To construct a device that will improve agricultural productivity by ensuring more yields for same plant and reduced time for products to grow to maturity.
- To reduce the stress of moving the rocker bar up and down continuously in order to create a pressure difference between the inside of the cylinder and the outside which will otherwise cause tiredness to the individual.

The study involves an x-ray of various jet spray cylinder devices used for micro irrigation. It also covers conceptual design and detailed design of the device in question. It covers the detailed drawing, construction, costing and testing device.

II. LITERATURE REVIEW

➢ *Review of Micro-Irrigation*

Drip irrigation, also referred to as trickle irrigation, is an efficient method of watering plants. By allowing water to drip slowly onto the soil surface or directly onto the root zone, this technique conserves water and fertilizer. The system operates through a network of valves, pipes, tubing, and emitters (R. Goyal, 2005) to deliver water directly to the base of each plant through narrow tubes.

➢ *History*

The practice of primitive drip irrigation dates back to ancient times. In the first-century BCE, "Fan Sheng-Chih Shu" in China documented the use of buried, unglazed clay pots filled with water as a method of irrigation (Bainbridge, A. David, 2001). Modern drip irrigation, as we know it today, traces its origins to Germany in 1860 when researchers started pioneering subsurface irrigation. They experimented with clay pipes to develop innovative combination irrigation and drainage systems.

In the 1920s, research on drip irrigation expanded further to include the application of perforated pipe systems. Subsequently, in Australia, Hannis Thill played a significant role in the development of using plastic materials to hold and distribute water in drip irrigation systems. His contributions helped advance the efficiency and effectiveness of modern drip irrigation techniques.

In 1973, the breakthrough in drip irrigation came from Israel, where Simcha Blass and his son Yeshayahu Massada Limited introduced the concept of using plastic emitters. Instead of relying on tiny holes that could easily become blocked by particles, they devised a system that released water through larger and longer passageways, utilizing the velocity of water to slow it down within the plastic emitter. The initial experimentation for this innovative method was conducted by Blass in 1959, and later he collaborated with Kibbutz Hatzerim to establish an irrigation company named Netafim. Together, they successfully developed and patented the first practical surface drip irrigation emitter in 1974 (Massada, Limited, Israel). This groundbreaking development significantly improved the efficiency and reliability of modern drip irrigation systems

In the early 1960s, Richard Chapin from Chapin Watermatics in the United States developed the first drip tape, known as Dew Hose, marking a significant advancement in drip irrigation technology. Since the invention of the impact sprinkler in the 1930s, modern drip irrigation has emerged as one of the most valuable innovations in agriculture. Offering a practical alternative to surface irrigation, it has revolutionized farming practices worldwide. In addition to traditional dripping emitters, micro-spray heads are also utilized in drip irrigation. These devices spray water in a small area, making them suitable for tree and vine crops with wider root zones. Subsurface drip irrigation (SDI) is another variant, involving the use of dripperline or drip tape buried permanently or temporarily at or below the plant roots. This method is gaining popularity for row crop irrigation, particularly in regions with limited water supplies or where recycled water is used for irrigation. SDI helps optimize water distribution and enhance crop yields in such challenging conditions

Drip irrigation for horticulture requires a careful study of factors like land topography, soil, water, crop, and agro-climatic conditions. The components used in drip irrigation, listed in order from the water source, are: pump or pressurized water source, water filter(s) like sand separator, optional fertigation systems (Venturi injector) and chemigation equipment, backwash controller (backflow prevention device), and pressure control valve (pressure regulator). Additional components include the main line, hand-operated, electronic, or hydraulic control valves and safety valves, smaller diameter polytube (laterals), poly fittings and accessories, and emitting devices like emitters or drippers, micro spray heads, inline drippers, or inline rip tube. Pump and valves can be manually or automatically operated with a controller. Large drip irrigation systems commonly use filters to prevent clogging of the small emitter flow path caused by waterborne particles. Recently, new technologies have emerged that help minimize clogging. In residential systems, some installations skip additional filters as potable water is already filtered at the water treatment plant. However, nearly all drip irrigation equipment manufacturers strongly advise the use of filters and may not honor warranties if they are not employed. To enhance filtration efficiency, it is strongly recommended to include last line filters just before the final delivery pipe. This precaution accounts for fine particle settlement and the accidental introduction of particles into the intermediate lines, ensuring optimal system performance and reducing the risk of clogs

Drip and subsurface drip irrigation are predominantly utilized when using recycled municipal wastewater due to regulations that prohibit spraying untreated water through the air that does not meet potable water standards. These irrigation methods allow for a controlled application of water directly to the root zone of plants, minimizing the risk of waterborne contaminants. In traditional surface irrigation methods, timed-release fertilizers may not be as effective when used with drip systems. To address this, liquid fertilizers are often mixed with the irrigation water in drip systems. This approach ensures that plants receive the necessary nutrients directly and efficiently through the irrigation process, promoting optimal growth and maximizing the effectiveness of the fertilization process.

Drip irrigation, when properly designed, installed, and managed, offers various water conservation benefits compared to other irrigation methods like flood or overhead sprinklers. By delivering water directly to the plant roots, evaporation and deep drainage are minimized, contributing to water conservation (M. Burt and W. Sturt, 2007). Furthermore, drip irrigation can prevent the spread of diseases that may occur through water contact with the foliage, improving plant health and reducing the need for chemical treatments. In regions with severe water limitations, drip irrigation may not result in actual water savings but can lead to increased production while using the same amount of water as before (M. Burt and W. Sturt, 2007. In extremely arid regions or on sandy soils, the preferred approach is to apply irrigation water as slowly as possible to maximize absorption and minimize runoff or deep percolation. Pulsed irrigation is occasionally used to deliver water in smaller quantities over time, further reducing the risk of runoff or deep percolation. However, pulsed systems can be costly and require extensive maintenance.

Indeed, the latest efforts by emitter manufacturers are concentrated on developing innovative technologies that allow irrigation water to be delivered at ultra-low flow rates, often less than 1.0 liter per hour. This advancement in slow and even water delivery significantly enhances water use efficiency without the need for costly and complex pulsed delivery equipment. An emitting pipe is a specific type of drip irrigation tubing that comes with emitters pre-installed at the factory. These emitters are set at predetermined distances and flow rates per hour, tailored to suit the specific needs of various crops. Emitters, also known as drippers, play a crucial role in transferring water from the pipe or tube to the targeted irrigation area. They are available in a range of flow rates, typically from 0.16 to 4.0 U.S. gallons per hour (0.6 to 16L/h). Some emitters vary their flow rates with changes in pressure, while others are designed to be pressure-compensating, maintaining a consistent flow regardless of pressure fluctuations. This ensures uniform water distribution across the entire irrigation system, irrespective of the varying water pressures at different points

As advancements were made in materials and solutions for issues like clogging, drip irrigation started to gain popularity for residential and small commercial applications. The system's relative simplicity made it accessible even to homeowners and non-professionals, enabling them to install and use it effectively. With these improvements, drip irrigation became an attractive and efficient option for providing water directly to plants' root zones, conserving water and promoting healthier growth. As a result, more and more individuals and small-scale businesses embraced drip irrigation as a practical and cost-effective means of watering their gardens, landscapes, and agricultural plots.

➢ *Benefits of Micro-Irrigation*

Micro-irrigation stands as the epitome of water efficiency for trees, crops, gardens, and landscapes. Unlike overhead irrigation methods like rotors and pop-up spray heads, which operate at around 50-70 percent efficiency, a well-designed drip irrigation system can achieve nearly 100 percent efficiency. Embracing drip irrigation offers a multitude of advantages:

- *Tailored Precision: It allows precise delivery of the required amount of water to individual plant*
- *Minimal Evaporative Losses: When used with mulching, evaporative losses are significantly reduced.*
- *Ideal for Windy Conditions: Drip irrigation performs exceptionally well in windy environments.*
- *Water Conservation: Less water is utilized as it is targeted only to the plants in need.*
- *Weed Control: Fewer weeds thrive since the spaces between plants remain unirrigated.*
- *Reduced Foliar Diseases: Incidences of foliar diseases are lowered.*
- *Pollution Prevention: Runoff pollution is reduced or eliminated.*
- *Enhanced Plant Health: Fertilizers and chemicals are delivered precisely where they are required, benefiting plant health.*
- *Steady Soil Moisture: Fluctuations in soil moisture are minimized, promoting healthier plants.*
- *Flexible Adaptation: The system adapts easily to accommodate plant growth or changes in the landscape.*
- *Versatility in Soil and Terrain: Drip irrigation is well-suited for various soil types and terrains.*
- *Exemption from Watering Restrictions: Its exceptional efficiency often exempts it from watering restrictions.*
- *Efficient Coverage for Large Areas: Large areas can be watered simultaneously due to its low flow rate.*
- *Cost-Effective: Installation and maintenance costs are typically lower compared to underground sprinkler systems*

➢ *Disadvantages of Micro-Irrigation*

Despite the numerous advantages of drip irrigation, some contractors exhibit reluctance to adopt this method due to certain perceived drawbacks. The most common concern cited is the challenge of assessing its functionality since there is no visible spray pattern, as seen in overhead irrigation. Micro-irrigation is typically concealed under a layer of mulch, making it less apparent. Additionally, other disadvantages include:

- *Vulnerable to Landscaping Activities: Drip irrigation systems are susceptible to damage during other landscaping tasks*
- *Prone to Rodent Damage: Rodents may cause chewing damage to the system components.*
- *Susceptible to Vandalism: Particularly in non-mulched areas, the system can be subject to vandalism.*
- *Tripping Hazard: For children and pets, the exposed tubing can present a tripping hazard, though this can be mitigated by anchoring the tubing and covering it with mulch.*
- *Emitters Clogging: Emitters can become clogged, leading to the interruption of water flow to certain parts of the landscape. However, advancements in system filtration and self-cleaning emitters have addressed many of these issues.*
- *Limited Root Growth: Drip irrigation may restrict plant root growth to the area directly wetted by the system*

Despite these concerns, it's worth noting that many of these disadvantages can be overcome or minimized through proper installation, maintenance, and incorporating newer technologies designed to address these issues effectively.

➢ *Lever Operated Knapsack Sprayer*

The traditional knapsack sprayer design has seen little change since its inception in the late 1800s (Matthews 1969). Nevertheless, its popularity remains steadfast due to its adaptability for various pesticides, making it a valuable tool for small-scale farmers in developing nations seeking to boost agricultural productivity under challenging conditions. Recent advancements in plastics and metals have resulted in lighter and more efficient sprayers, easing their use, especially in regions with hot climates and rugged terrain. As a result of a diverse range of brands and ergonomic designs available in the market, farmers and pesticide applicators can now choose a knapsack sprayer that best suits their physical stature and strength, enhancing ease of use and overall efficiency.

➢ *Description of Lever Operated Knapsack Sprayer*

The manually operated knapsack sprayer, as shown in Figure 1, comprises a tank with a capacity of 10 to 20 liters, designed to be carried on the back using two adjustable shoulder straps. To power the sprayer, there's an operating lever positioned either over the shoulder or under the arm, which operates a piston or diaphragm pump. The under arm lever can be adjusted for use with the right or left arm, while the over the shoulder lever can be operated with either arm. To enhance comfort and efficiency, some models include a waist strap, which not only provides support and firmly holds the tank in place but also ensures that the operator's pumping energy is effectively transferred from the lever to the pump. The pump is commonly located on the inside of the tank to protect it from potential damage. However, in certain designs, the pump is placed on the outside of the tank, facilitating easier maintenance when needed.

The operation of a knapsack sprayer requires continuous pumping, and the choice between a piston or diaphragm pump depends on the type of application intended. When applying insecticides and fungicides, piston pumps are typically favored because they can achieve pressures of 2.0 bar or higher (FAO, 1994) with relative ease. In the case of a piston pump, the liquid is drawn from the tank into the pump chamber through a valve during the upward movement of the piston. On the reverse stroke of the lever, the spray solution passes through a second valve and enters an air or pressure chamber. Many sprayers incorporate this air chamber as part of the piston system

The air chamber serves as a critical component in the structure of a knapsack sprayer. It plays a vital role in the operation by trapping air in a part of the pressure chamber and compressing it as liquid is forced into the chamber. Consequently, as pressure builds up in the air chamber, the liquid is directed through a dip tube, hose, trigger valve, and finally, through a lance to the nozzle (FAO, 1994; Matthews, 2000). The size of the pressure chamber can vary across different types of knapsack sprayers, typically ranging from 160 to 1300 ml (Matthews, 2000). It is essential for the air chamber to be as large as possible and should be at least ten times the pump capacity (FAO, 1994; Matthews, 2000). Despite the pumping action of the applicator causing some fluctuations in pressure, the situation worsens significantly if the pressure chamber's capacity is inadequate (Matthews, 2000). Therefore, a properly sized and adequately large air chamber is crucial for maintaining stable and consistent pressure during spraying operations.

When the pump displacement and pressure cylinder capacity are small in a knapsack sprayer, operating the sprayer becomes more laborious, particularly when aiming for higher pressures (Matthews, 1969). In contrast to piston pumps, diaphragm pumps utilize a flexible elastomer diaphragm, typically located at the base of the tank, instead of a sealed piston. However, due to the limited up and down movement of the diaphragm, these types of sprayers are generally less efficient. Diaphragm pump knapsack sprayers require more force on the lever compared to piston pumps, and achieving the desired volume per hour output at various pressures and with different nozzles demands a higher mean number of strokes per minute (Matthews, 1969). As a result, diaphragm pump knapsack sprayers are better suited for low-pressure applications. They may be less effective for tasks requiring higher pressures, where piston pumps offer better performance.

➢ *Pump*

A pump can be described as a device designed to impart energy to a fluid system, either by increasing its pressure energy, kinetic energy, or both, through the conversion of mechanical energy. On the other hand, a turbine operates in the opposite manner, as the fluid flow occurs from the high-pressure side to the low-pressure side, creating an accelerated flow. In contrast, a pump causes the fluid flow to move from the low-pressure side towards the higher pressure side, leading to a decelerated flow. This fundamental distinction between a turbine(has accelerated flow) and a pump(has decelerated flow), from a hydrodynamic perspective, highlights the different roles these devices play in fluid systems (R.K. Rajput, 2005).

- *Pump Classification*

A basic system of pump classification does the follow,

- ✓ *Defines the principle by which energy is added to the fluid:*
- ✓ *Identifies the means by which this principle is implemented*
- ✓ *And delineates specific geometries commonly employed*

- *Pumps can be Grouped as,*
- ✓ *Dynamic pumps*
- ✓ *displacement pumps*

- *Classification of Dynamic Pumps*

In dynamic pumps, energy is consistently added to elevate the fluid velocities within the machine to levels higher than those observed at the discharge point. Consequently, when the velocity is subsequently reduced within or beyond the pump, it results in a corresponding increase in pressure. These pumps typically have a notable gap between the rotating part, such as the impeller, and the stationary part. Dynamic pumps can be further categorized into various types of centrifugal pumps and other specialized effect pumps, as detailed in Fig 1.

- *Classification of Displacement Pumps*

These pumps operate by intermittently adding energy through the application of force to one or more movable boundaries, creating enclosed fluid-containing volumes. This process directly increases the pressure until it reaches the necessary value to propel the fluid through valves or ports into the discharge line. Typically, there is a narrow gap between the moving and stationary parts. Displacement pumps can be broadly categorized into reciprocating and rotary types, based on the movement of the pressure-generating components. Each of these primary classifications can be further divided into specific types that hold significant commercial significance, as depicted in Fig 2.

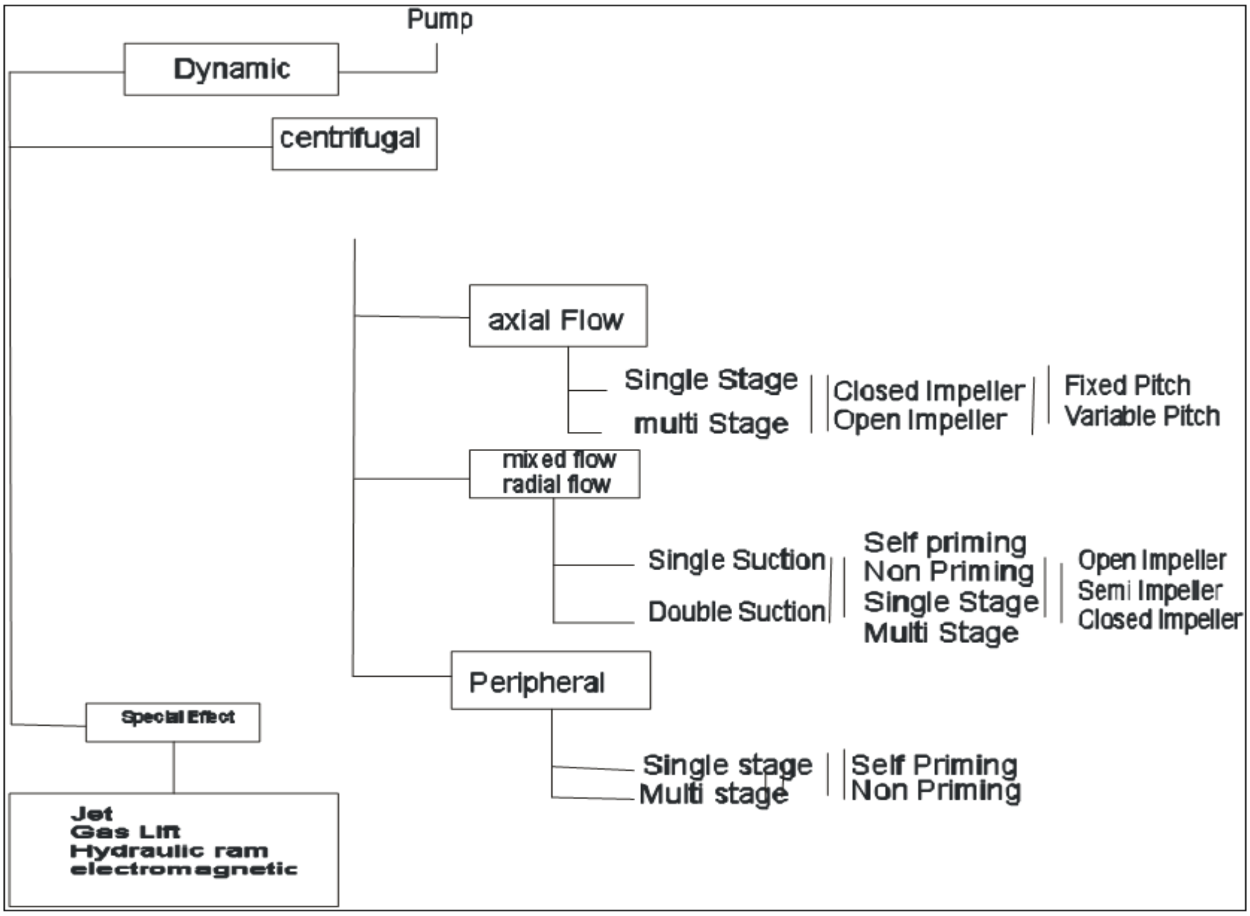

Fig 1 Classification of Dynamic Pumps

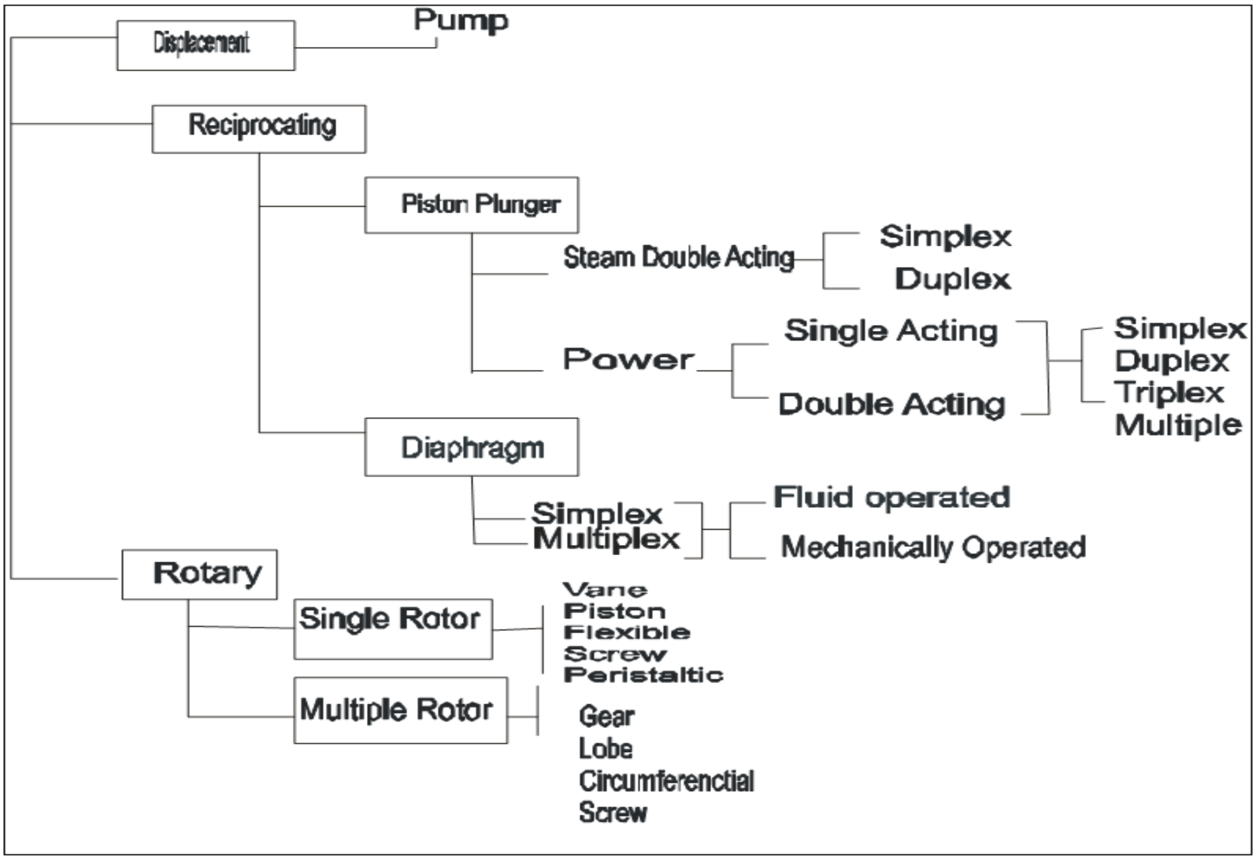

Fig 2 Classification of Displacement Pumps

➢ *Pressure Head of a Liquid*

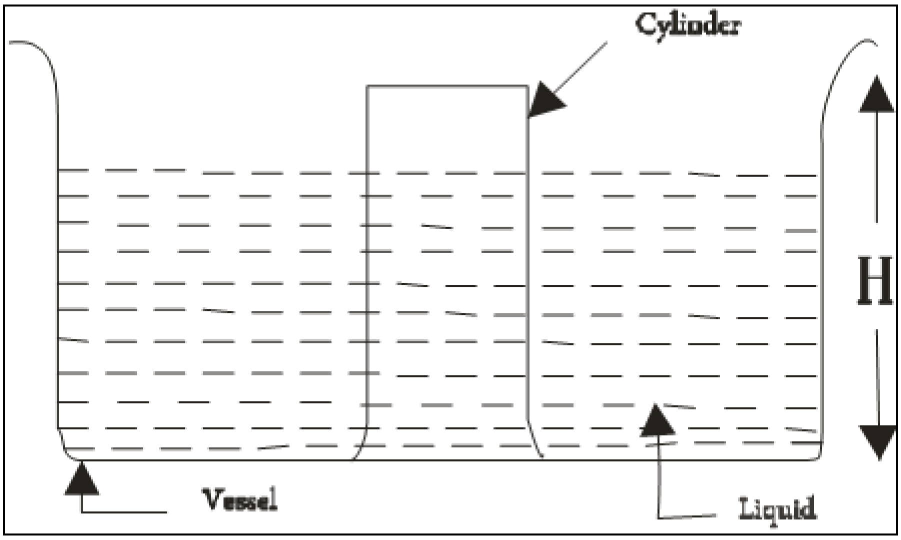

Fig 3 A liquid is subjected to pressure due to its own weight, this pressure increase as the depth of the liquid increases. Consider a vessel containing liquid.

The liquid will exert pressure on all sides and bottom of the vessel now the Cylinder is made to stand in the liquid, as shown in the figure.

Let, h = Height of liquid in the cylinder,

A = Area of the cylinder base,
W = Specific weight of the liquid,
And, P = Intensity of pressure.
Now, Total pressure on the base of the cylinder = Weight of liquid in the cylinder.

i.e. p.A = wAh
p = $\frac{wAh}{A}$ **= wh**
i.e., p = wh
p = ɭgh

➢ *Bernoulli's Equation*

Bernoulli's equation state as follow:

" In an ideal incompressible fluid when the flow is steady and continuous, the sum of pressure energy , kinetic energy and potential (or datum) energy is constant along a stream line "**R.K RAJPUT(2000)"**

Mathematically,

$\frac{p}{w} + \frac{v^2}{2g} + z = \text{constant}$

In others words, $\frac{p_1}{w} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{w} + \frac{v_2^2}{2g} + z_2$

Where, $\frac{p}{w}$ = pressure energy,

$\frac{v^2}{2g}$ = kinetic energy, and

Z = Datum (or elevation) energy.

➢ *Rate of Flow or Discharge*

Rate of flow (or discharge) is defined as the quantity of a liquid flowing per second through a section of pipe or a channel. It is generally denoted by Q. let us consider a liquid flowing through a pipe.

Let, A = Area of cross-section of the pipe, and

V = Average velocity of the liquid

∴ Discharge, Q = Area × Averagevelocity i.e., Q = A.V.

If area is in m^2 and velocity is in m/s, then the discharge

Q = $m^2 \times m/s = m^3/s$ =cumecs

➢ *Rate of Flow or Discharge*

The continuity equation is based on the principle of conservation of mass. It state as follows "if no fluid is added or removed from the pipe in any length then the mass passing across different sections shall same" consider two cross – section of a pipe as shown.

A1 = Area of the pipe at section 1-1

V1 = Velocity of the fluid at the section 1-1

P1 = Density of the fluid at the section 1-1

And 2, V2, P2 are corresponding values at section 2-2

The total quantity of fluid passing through section1-1 = p1A1V1

And the total quantity of fluid passing through section 2-2 = P2A2V2

From the law of Conservation of matter (theorem of continuity), we

P1A1V1 = P2A2V2

A1V1 = A2V2

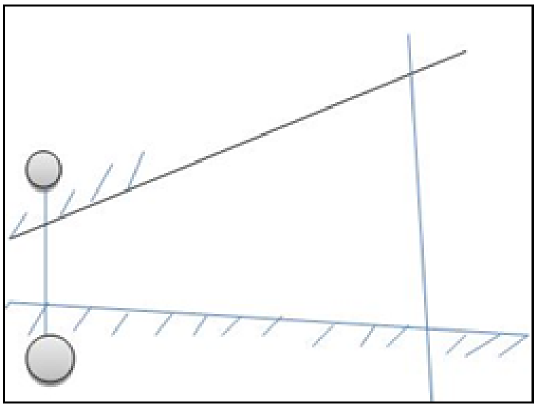

Fig 4 The Law of Conservation of Matter (Theorem of Continuity)

$$\text{WHP} = \frac{Q \times H}{3600}$$

Net positive suction Head (NPSH)

$$\text{NPSH} = \frac{V^2}{2g} + \frac{p}{sw} + \frac{pv}{sw}$$

Fluid velocity

$$V = \sqrt{2g\left(\text{NPSH} - \frac{P}{SW} + \frac{PV}{SW}\right)}$$

Where;

WHP = Water horsepower

Q= from note or discharge

NPHS = Net positive suction head

V = velocity of the fluid or liquid

P = inlet pressure

PV = Vapour pressure of liquid or fluid

SW = Specific water weight of liquid or fluid

G = Acceleration due to gravity

➢ *Stresses in a thin Cylindrical Shell due to Internal Pressure*

The analysis of stresses induced in a thin cylindrical shell are made on the following assumption (**J.K Gupter, R.S Kurmi, 2005).**

- The effect curvature of the cylinder wall is neglected
- The tensile stresses are uniformly distributed over the suction of the walls.
- The effect of the restraining action of the head at the end of the pressure vessel is neglected

➢ *When a thin Cylindrical shell is Subjected to Internal Pressure it is Likely to fail in the following ways*

- It may fail across the longitude section i.e (circumferentially) splitting the cylinder into two cylinder into two trough.
- It may fail across the transverse section (i.e longitudinally) splitting the cylinder into thin cylindrical shells. Thus the wall of a cylindrical shell subjected to an internal pressure has to withstand tensile stresses of the following two type circumferential or hoop stress Longitudinal stress. (J.K Gupta, R.S Khurmi2005)

Circumferential or Hoop stress

$$\sigma t_1 = \frac{P \times d}{2t} = > t = \frac{P \times d}{2\sigma t_1}$$

Longitudinal stress

$$\sigma t_2 = \frac{P \times d}{4t} = > t = \frac{P \times d}{4\sigma t_2}$$

Where :

P = Intensity of pressure

d:= Internal diameter of the cylindrical shell.

L: Length of the cylindrical shell

t: Thickness of the cylinders

σt_1 = circumferential stress for the material of the cylinder

σt_2 = longitudinal stress for the material of the cylinder

III. CONCEPTUAL AND DETAIL DESIGN

The conceptual design is the initial stage of the design process, primarily utilizing drawings or solid models as the primary tools and outcomes. During this phase, the conceptual design provides a comprehensive description of the proposed system through integrated ideas and concepts, outlining its intended functionality, behavior, and appearance in a manner that is easily understandable by the end-users. We studied various jet spray cylinder devices in the market and found out, most of them were manually operated with the aid of level arm. Thus in an attempt to reduce the stress of moving the rocker bar before pressure is induced in the cylinder we conceived different ideas out of which we selected one to achieve our aim.

➢ *Evaluation Criteria*

The evaluation of each of our three conceptual designs and the selection of a particular design concept was on the following factor:

- *Functions rather than mechanical drawings.*
- *Cost in relation to function*
- *User friendliness*
- *Compatibility*
- *Safety*

➢ *Design Concept 1: The Conventional Chemical Jet Spray*

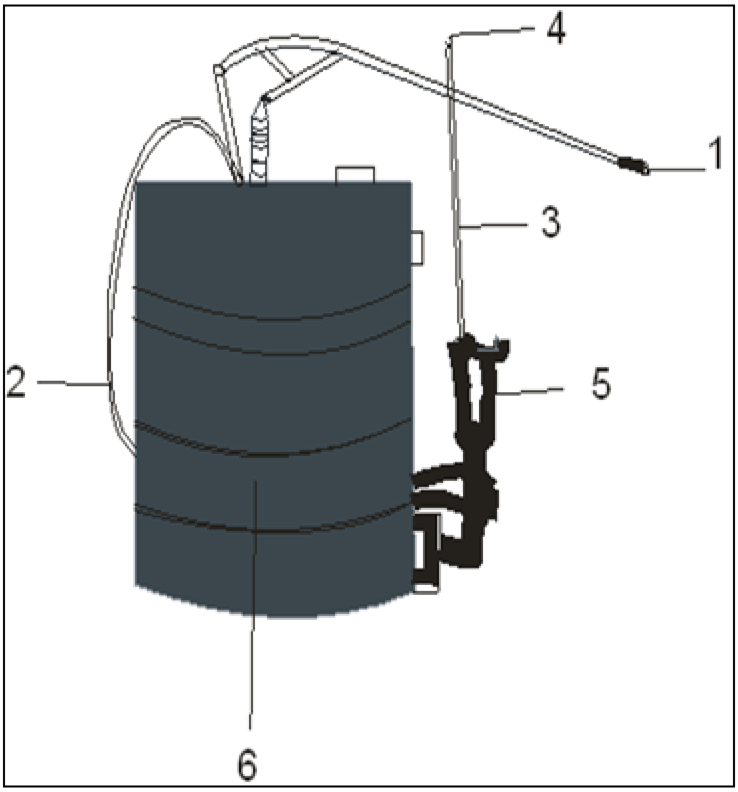

Fig 5 First Conceptual Design (Chemical Jet Spray)

➢ *Component Parts of Cylinder*

- *Lever Arm*
- *Carriage*
- *Capillary Tube*
- *Nozzle*
- *Trigger*
- *Liquid Reservoir*

This arrangement is shown in figure 2 above. It consist of a liquid reservoir, a pneumatic pump that is lever arm activated, and a hose and a spray nozzle. Many of them belong to the back pack category that is they are carried in the back with the help of straps around the waist and shoulder. They are manually operated with the up and down stroking of a lever arm. They operate under the simple pneumatci (bicycle pump) principle where a volume of air, in this case liquid is sucked into a pressurised chamber through an opened one way valve by the application of a lever arm and discharged through a spray nozzle.A spray nozzle is a precision device that facilitates dispersion of liquid into a spray. They are used for three purposes:

- *To distribute a liquid over an area,*
- *To increase liquid surface area*
- *To create impact force on a solid surface*

➢ *Advantages*

- *Simple to use and Maintain.*
- *Light Weight*
- *Low Cost of Production and Maintenance.*

➢ *Dissadvantages*

The manually operated conventional back pack jet spray has the following dissadvantages

- *They lack the ability of a continous flow as they are itermitently activated by the up and down stroke of the lever arm.*
- *They can easily lose presure with time as the liquid volume decreases*
- *It is cubersome as the human operator could easily feel fatigue in the hands*
- *Low pressure is most likely achieved from the pump power that are mostly inserted in them*

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- *Design Concept 2: Electric or Fuel Powered Chemical/Fertilizer Jet Spray*

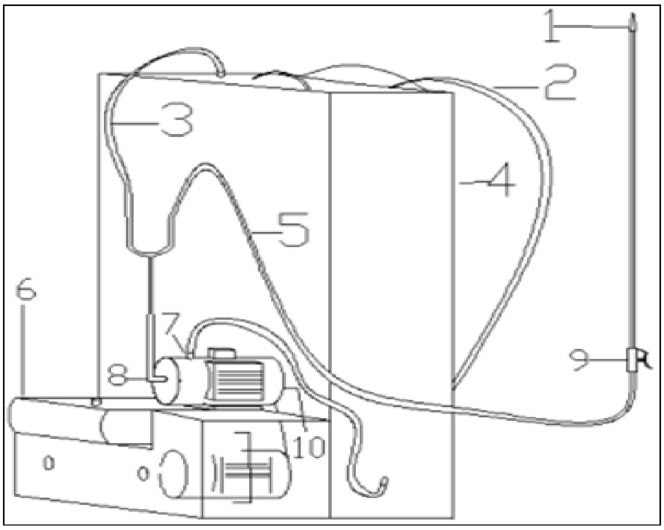

Fig 6 Design Concept 2: Electric or Fuel Powered Chemical/Fertilizer Jet Spray

Table 1 Components Part of Jet Spray

1	Jet Nozzle
2	Carriage Strapp
3	Return Hydraulic Hose
4	Liquid Reservoir
5	Discharge Hydraulic Hose
6	Fuel Tank
7	Suction Hose
8	Discharge Hose
9	Trigger
10	Hydraulic Pump
11	Prime Mover

This arrangement is shown in figure 3. This concept is a dual powered jet spray that is capabable of being electrically and fuel powered. It is aimed at being able to discharge liquid based fertilizer and pesticides. It consist of the following components; comparted fluid reservoir, hydraulic hose and nozzle,

- *Adavantages*

The advantages of this concept which are meant to mitigate and optimise the disadavantages of the conventional jet spray concept are as follows;

- *It will have a double chamber capable of holding two different liquids*
- *It will have the ability to execute a continous discharge spray due to its motorised pump*
- *It can be operated with convenience without pain to the human hand*
- *It will have the abilit to spray larger area in lesss time*

- *Disadvantages*

- *It has relatively high weight.*
- *cost of production and operation is relatively high.*
- *maintenance is difficult and its cost is also high.*
- *more complex.*
- *often noisy*

- *Design Concept 3: Battery Powered Chemical/Fertilizer Jet Spray*

This concept is a battery powered jet spray that will be capable of spraying pesticides and fertilizer with both been liquid based.It will consist of a cylinder compartment, two nozzles, belt for its carriage, battery, pump, hydraulic hose etc.The mechanism of operation is quit simple as the pump which is powered by the battery sucks in liquid through the inlet, discharges it through the outlet in which the hose, trigger, and nozzle compartment are coupled.

- *Advantages*

- ✓ *It will have the ability to execute a continous flow*
- ✓ *It can be operated with convenience without pain to the human hand*
- ✓ *It will have the ability to spray large area in less time*
- ✓ *Simple to use and maintain*

- *Disadvantages*

- ✓ *Its weight is a little higher than the manual type.*
- ✓ *Dependency on power source.*

- *Criteria for Design Selection*

In selecting our design out of these three concepts, we applied the evaluation of the entire concepts discussed above. Comparing the three concepts above,it was found that the third proposed concept has far more better advantage to the first two and thus this design work was purely based on the third concept.The lever operated pump is replaced by a battery driven one.Avoiding manual pumping is less tiresome for the operator despite the extra weight of the unit.Flow can be expected less “pulsed” and fluctuating in pressure.

- *Material Specification*

Spec 1: *Material for the body is stainless steel*
BASIS for good appearance and light weight
JUSTIFICATION for ease in carrying

Spec 2: *Water pump*
BASIS to give a continous flow
JUSTIFICATION source from practical course on fluid mechanics

Spec 3: *Switch component*
BASIS to control the flow of the liquid
JUSTIFICATION as in existing model

Spec 4: *JET tube*
BASIS for the passage of fluid
JUSTIFICATION as in most existing model

Spec 5: *Strainer plate*
BASIS to filter out all unwanted debris

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Spec 6: *Nozzle*
BASIS to control the direction of fluid flow
JUSTIFICATION source from existing model

Spec 7: *Back belt*
BASIS to allow for easy carriage
JUSTIFICATION source from existing model

➢ *Detailed Design*

- *Volume of Cylinder:*

V= $\pi r^2 h$
Where:
r=radius=120mm=0.2m
h=height of cylinder=360mm=0.36m
∏=3.142
V=3.142x120²x360=16288128mm³
=16litres

- *Area of the Cylinder*

A= 2∏r(r+h)
A= 2x3.142x120(120+360)
=361958.4mm²

- *Pressure in the Cylinder*

P= ℓgh
Where
ℓ= desity=1000kg/m³(density of water)
g= acceleration due to gravity=9.81m/s²
p= 1000x9.81x0.36
= 3531.6N/m²

- *Stresses in the Cylinder Wall*

Circumferential or hoop stress $=\frac{pxd}{2t}$

Where:

P = pressure in the cylinder=3531.6
d = diameter of cylinder base=0.24m
t = thickness of cylinder wal=0.004mml
= (3531.6x0.24)/(2x0.004)=105948N/m²
Longitudnal stress = $\frac{pxd}{2t}$
= (3531.6x0.24)/(4x0.004)
= 52974N/m²

The circumferential stress is twice the longitudnal stress.

Therefore this design will be based on the circumferential stress since it is the maximum stress on the cylinder.

- *Rate of Flow or Discharge (Q)*

Q = AV
Where V = flow velocity of fluid = ?
A = area of cylinder=361958.4mm²=0.3619584m²
Let V = Q/A
Where Q = 134litres/hour
Recall 1litre = 1000m^3
1 hour=3600seconds
Q=134000/3600m³/s
Q=37.22m³/s
V = 37.22/0.361
= 103.11m/s

- *Nozzle Design*

To determine the discharge flow rate from a specific nozzle, the Bernoulli's principle can be applied. According to Bernoulli's law, the energy of a liquid flow remains constant along all sections of the flow, neglecting friction and turbulence losses. This assumption is reasonable for the purpose of calculating the discharge flow rate between two sections that are relatively close to each other. By applying Bernoulli's principle, the flow rate through the nozzle can be estimated accurately

The energy "E" of the given liquid flow crossing a given pipe section is compose of a given three parts namely;

P Pressure energy of the liquid particle per volume unit

$\frac{1}{2}\rho v^2$ Kinetic energy of liquid particle per volume unit
$\rho g z$ potential energy of liquid particle per volume unit
Where ρ = density of liquid, g = gravitational acceleration, z = height respect to one plane of reference, v = liquid velocity
The Bernoulli law can be written as follow
P $+\frac{1}{2}\rho v^2 + \rho g z$ = E
Kinetic energy = 0.5 x1000 x 103.11^2
= 5315836.1 Joules
Potential energy = 1000 x 9.81 x 0
= 0 Joules
Hence, E = 3531.6 + 5315836.1 + 0
= 5319367.65 Joules

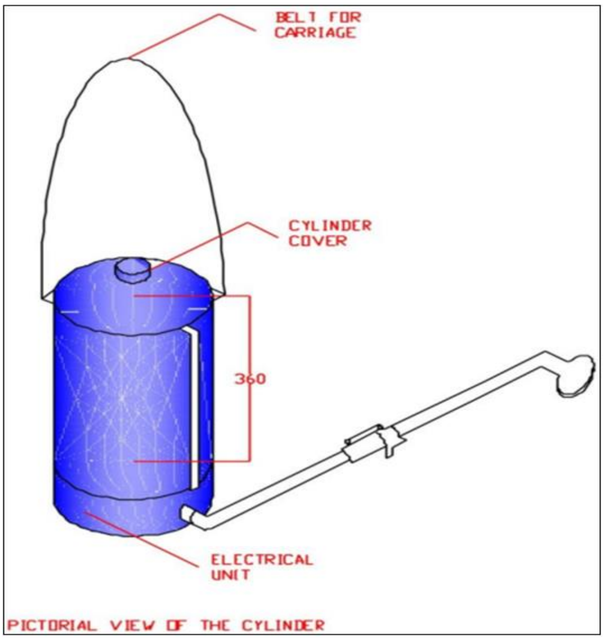

Fig 7 Pictorial View of the Cylinder

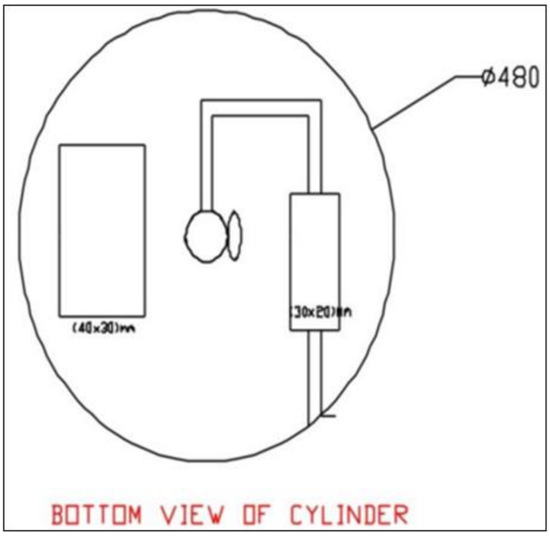

Fig 8 Bottom View of Cylinder

- Battery, Trigger, Capillary Tube, Nozzle

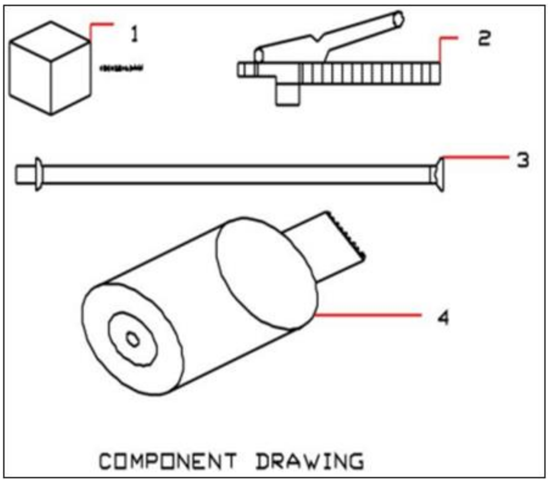

Fig 9 Component Drawing

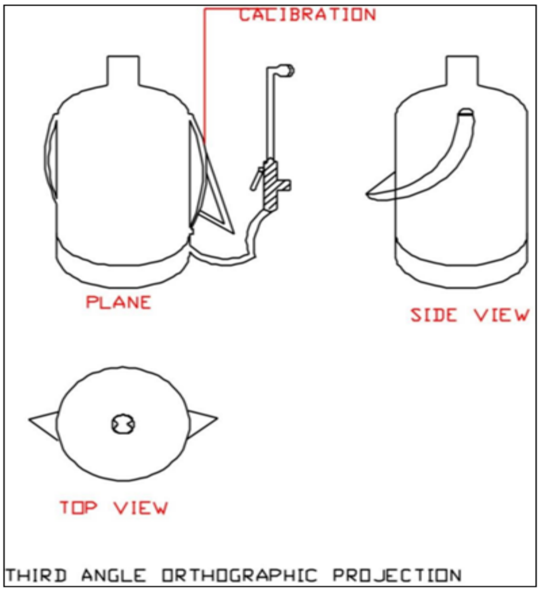

Fig 10 Third Angle Orthografic Projection

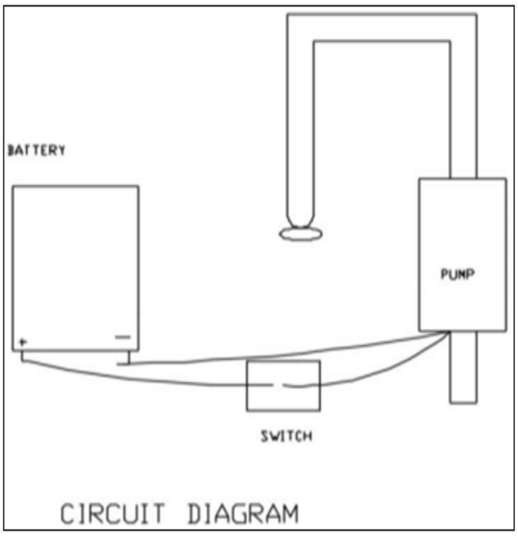

Fig 11 Circuit Diagram

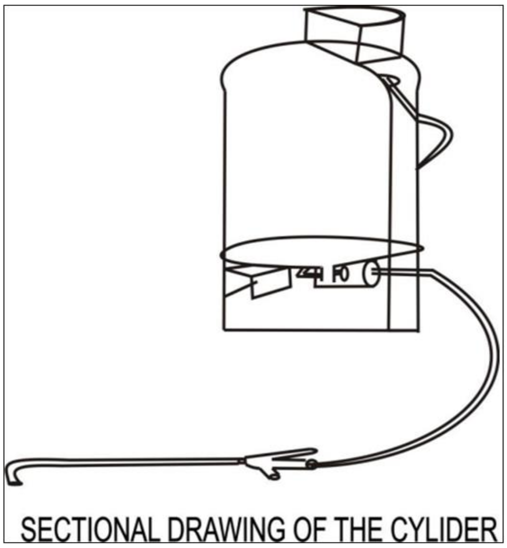

Fig 12 Sectional Drawing of the Cylinder

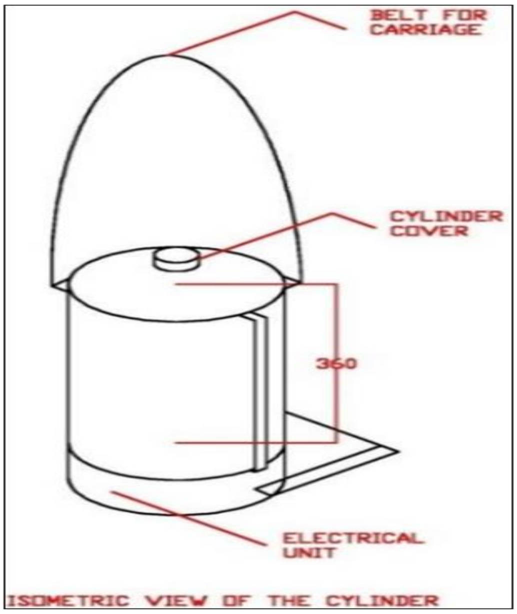

Fig 13 Isometric View of Cylinder

IV. CONSTRUCTION OF PARTS AND ASSEMBLY

The construction process of a design plays an important role in engineering because it change the form of material into the final product. The development of modern manufacturing is dependent on research in materials and product which requires a variety of manufacturing processes for these materials. In this project of ours the various processes used in manufacturing the jet spray cylinder are:

- *Material selection and purchase*
- *Marking out*
- *Folding*
- *Welding*
- *Drilling*
- *Grinding*
- *Assembling*

➢ *Material Selection and Purchase*

For a particular design to be efficient, it is important that the designer clearly understand the material which are available in order to bring forth the desired result (performance), by knowing the properties these materials are made of, choice depend on factors such as intensity and type of stresses to which the components are subjected, whether it is to be flexible or rigid or it is to experience high temperature or corrosion action.

The designer's selection, however will affect the strength, appearance weight and very importantly cost of the product and in fully competitive environment may go along way to make the difference between success and failure when the product is fully marketed.

➢ *Marking Out*

The marking out operation consists of outlining measured lines on the surface of a sheet metal using a scriber, measuring tape, steel chalk and centre punch where necessary. Thereafter, the angle grinding machine is used to cut out the scribed path to suit the design.

➢ *Folding Operation*

The cylinder was folded with the aid of a pipe folding machine

➢ *Welding*

Welding is the process of permanently joining two metals together through the application of heat. The type of welding used to join the folded cylinder and its parts is shielded metal arc welding.

➢ *Drilling*

For any design operation to be complete, drilling operation is one basic necessity. This process involves the creation of holes of desired diameter on the surface of the work piece with the aid of a drill bit using either a pistol drilling machine, a pillar drilling machine or a table drilling machine.

➢ *We carried out the drill operation as follow;*

- *First of all, we marked the work with a scriber or a steel chalk and then centre punch at the centre of the hole to be drilled.*
- *It is then held firmly with a clamp or vice*
- *We fit the drill bit into the chuck.*
- *The hand drill is then lower ensuring that point of the drill is in exact alignment with the previously marked centre of the hole.*
- *The motor is now started and the rotating drill is gradually pressed into work to produce the desired hole.*
- *The pressure was frequently received during the drill operation otherwise the cutting edges of the drill will be strained and the drill is damaged.*
- *In order to avoid the spoiling of cutting edges of the drill, a coolant was constantly used during the drilling operation.*

➢ *Grinding*

The welded joints, sharp edges, drilled hole were given a smooth finish by grinding off excess metal from these locations, grinding is the process of removing metal by the use of grinding disc. The work to be grinded is pressed against the grinding wheel which rotates at a comparatively high speed and surplus metal is removed by abrasion. It produces extremely smooth finish due to the small cutting edges on the wheel.

➢ *Assembly*

This stage is one of the most critical aspects of this design this process was carried out in several stages which is clearly stated below

Constructing of the cylinder using a 4mm thick stainless-steel plate,

After fabrication of the cylinder, the jet spray is assembled in the following order; Fitting of the battery and electric pump into its positions

With the aid of a 2.5mm diameter hose, the electric pump is connected to the outer pipe from the cylinder to the inlet side of the pump.

Electrically, the pump is connected to the DC source (battery) and a switch to control power supply.

The capillary tube is connected to the cylinder through the drilled hole and to the pump.The capillary tube is fitted with a nozzle that is replaceable and adjustable with various type of spraying pattern.

V. TESTING, TEST RESULT

➢ *Testing*

The cylinder was tested to determine its performance characteristic which is vital in determining its ability to carry out certain duties like spraying water around a plant uniformly and a controlled rate. To achieve this, we first

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coupled the various part of the jet spray and connected the electrical part. Thereafter, we introduced water through the opening on top of the cylinder and filled it up to its maximum capacity of 16 liters. The pressure within the cylinder was found to be 3.5Kpa. In our test the flow was measured with the aid of stop watch, i.e. determining the time taking to discharge certain volume of water.

- *Test Results*

In our test, two (2) liters of water was discharged in ten (10) seconds while sixteen (16) liters was discharged in 1 minute 20 seconds. The result got from our test show that our device performed a little below expectation due to problems encountered during construction process and battery capacity used for the test. And as such, we had a flow rate of 12 liters per minute.

VI. DISCUSSION

- *Problems*

The task of constructing the jet spray cylinder was not easy right from material selection to assembly. We had to embark on an intensive search to get the particular pump to suit our purpose. Our original idea was to use a hand pump to induce pressure in the cylinder which will cause the liquid to flow out of the cylinder at a controlled rate through the nozzle. Many consultations were made, and it down us that such a set up would not be able to produce the required uniform continuous flow rate. At the end we had to settle for a dc (direct current) pump, the task of getting the right battery to power the pump was also difficult and thus we decided to use two six volt batteries.

VII. CONCLUSION AND RECOMMENDATION

- *Conclusion*

The jet spray cylinder for micro irrigation scheme was designed, constructed, tested and worked as conceived.

- *Recommendation*

Based on the features of this jet spray cylinder for micro irrigation scheme, we propose that subsequent research should be done to improve the technicality of the device like designing a control switch for switching on and off of the device and also an improved nozzle design should be carried out to obtain a well evenly distributed flow. Further investigations could also be done on the battery used to power the pump.

If taking seriously by the government, it could serve as a boost to the economy of the country. This could reduce the poverty rate in the country which is caused by overreliance on imported products rather. A project of this kind can provide job opportunity for upcoming entrepreneurs.

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