Design and Fabrication of Treadle Pump

[1]Devaraj, [2]Pradeep S, [3]Suresh, [4]Yashvant, [5]Pavan D
[1, 2, 3, 4] School of Mechanical Engineering
[5]Assistant Professor, School of Mechanical Engineering
[1, 2, 3, 4, 5] REVA University, Bengaluru, Karnataka, India

Abstract: The implementation of an easily produced treadle pump could change the lives of millions of poor families in rural areas of developing countries. Ideally, a treadle pump design would be manufactured locally in the major cities of developing countries and then shipped to rural farms. These irrigation pumps are stepped on like a Stairmaster machine to generate a pumping action, which drives the pistons to lift water from a well, river, or other water sources. It was desired to limit the parts of the treadle pump produced like, the pump, cylinders, pistons, and the platform to which they mount. This project deals with lifting the water from 8 feet and to provide cost effective and efficient Treadle pump for poor agriculturist and it also deals with study of less cost pump, produce cost effective design and then implement it practically, our aim is to make a working practical model and also study by conducting experiment.

Index Terms **- Treadle pump, Cylinder.**

I. INTRODUCTION

Irrigation water pumps can play a vital role for increasing food grain production in India. Capital intensive technology like deep tube wells, shallow tube wells are beyond the Irrigation plays a vital role as a leading input because the productivity of other inputs such as improved seed and fertilizers largely depend on the availability of ensured water supply in the fields. With the supply of irrigation water, most of the agricultural lands can be brought under cultivation of high yielding crops. The productivity of the land now producing food under natural condition can be increased considerably by the application of supplemental irrigation.

The socioeconomic condition of India farmer does not permit large scale irrigation investment. Hence, introduction of small scale irrigation like pedal purchasing capacity of the poor farmers, while they can afford labor intensive technologies such as pedal pump, hand pumps, rower pumps, treadle pumps etc. due to their lower cost. In the context of India, where labours are abundant and most of the farmers are poor, the pedal pump seems to be an appropriate irrigation technology. Such kind of irrigation technologies are operated and maintained by farmers themselves from their own capital for producing crop in the small fragmented lands.

The treadle pump comprises a cylinder fitted with a piston and some means of pushing the piston up and down (Figure 1). A pipe connects the pump to the water source and at the end of this pipe is a no return valve that allows water to enter the pipe and stops it from flowing back into the source. The piston and the cylinder must have a very close fit, so that when the piston is raised, it creates a vacuum in the cylinder and water is sucked into the pump. When the piston is pushed down, the water is pushed through a small valve in the piston to fill up the space above it. When the piston is raised again, it lifts this water until it pours out over the rim of the cylinder and into an irrigation channel or tank. At the same time, more water is drawn into the space below the piston. The downward stroke of the piston once again pushes water through the small valve into the space above the piston and the process is repeated.

II. LITERATURE REVIEW

A minor revolution is taking place in the field of manual irrigation in Bangladesh. Low-cost bamboo and PVC tube wells introduced in the late 1970s have brought irrigation within the reach of millions of small and marginal farmers. This study assesses the impact of one kind of manually operated tube wall in northern Bangladesh. The treadle pumps a human powered. Twin cylinder pump head with a bamboo or PVC tube well was introduced by RDRS in 1979. Since then over 185,000 pumps have been sold, making it one of the most successful irrigation pumps ever made in Bangladesh. The growing popularity of the treadle pump has attracted attention in developing countries throughout the world. [1]

Over the past decade, a small but significant revolution has been taking place in small-scale irrigation in the developing world with the introduction of the treadle pump. This simple, human-powered device can be manufactured and maintained at low cost in rural workshops in developing countries. The principle is based on suction lift using a cylinder and piston to draw water from a source below ground level, for example a river or shallow groundwater. Originally developed for hand pumps for domestic water pumping, it has been skillfully adapted for use in irrigation, where much greater volumes of water are needed, by changing the driving power from arms and hands to feet and legs. These have much more powerful muscles and so are capable of lifting much more water. Two pistons are used, each connected to a treadle. The operator stands on the treadles, pressing the pistons up and down in a rhythmic motion. Two pumps have developed from this idea. The first was a suction pump to lift water from a shallow source and discharge it over a spout into a canal for gravity irrigation. This was developed in Bangladesh where farmers needed to lift large quantities of water through shallow lifts of 1-2 m. The second development was the pressure pump. This works on exactly the same principle as the suction pump but the delivery end was modified so that water could be fed into a pipe under pressure for sprinklers or hoses. It is also better at lifting water from deeper sources than the suction pump. This development came from the needs of African farmers who often have to lift water from deeper sources, in excess of 4 m, and irrigate undulating land with sprinklers or hosepipes. [2]

III. WORKING PRINCIPLE

Vacuum is created when the piston moves up in the cylinder and atmospheric pressure is then used to propel the water into the cylinder. Both temperature and pressure have an effect on the atmospheric pressure and the suction lift that can be obtained. In the treadle pump case, since the pump is located above the water source, the difference in elevation between the water and the pump is taken as positive.

The force applied by the person on the treadle is based on the lever principle. Operators of the pump can move their position on the treadles to gain a mechanical advantage while maintaining a comfortable applied force and steady cadence. There are three types of levers: in the class I lever, the applied force and the load are on either side of the fulcrum.

IV. COMPONENTS OF TREADLE PUMP

1. CYLINDERS

Treadle pumps make use of two cylinders (one per treadle), with cylinder diameter of 80 mm and is made up of cast steel.

2. PUMP MANIFOLD

The manifold connects the inlet and outlet pipes to the cylinders, as well as housing the non-return valves (two in a suction pump and three in a pressure pump). Due to the nature of the outlet of a suction pump, there is no need for the outlet side. It is necessary that the design of the manifold take into consideration the removal of the non-return valves for maintenance. The manifold is a steel box.

3. PISTON ASSEMBLY

Figure 1: Cylinder pump

Figure 2: Cylinders connected to treadles

The pistons travel up and down within the cylinder, and it is important that they remain vertical in the cylinder as the treadles are moved up and down (Figure 1) this is done to maintain a good seal between the piston and the walls of the cylinder. The piston rod is thus connected to the treadle via a hinged joint (Figure 2). Piston rods are made of steel bar, as it is a very robust material and is usually available. Also the pistons are made of steel as well, with rubber rings to form the seal with the cylinders. The piston rings must themselves also be robust; they must sustain of continual friction against the cylinder wall.

Head=8 feet
Stroke length, L=200 mm
Diameter of cylinder, d=80 mm
Area of piston, $A = 5.026 \times 10^{-3}\ m^2$
Theoretical discharge, Q_{the} = 25 liters/min

4. NON-RETURN VALVES

It has been mentioned previously that suction pumps have two non-return valves and pressure pumps have three. The valves allow water to flow in one direction only, by opening and closing due to the positive and negative pressures developed during pumping. It is possible for another valve to be fitted at the entrance to the inlet pipe, which would avoid the need to re-prime the pump every time it is used, as well as preventing large pieces of dirt from getting sucked into the pump system.

5. TREADLES

Treadles need to be strong enough to take the forces applied by the operator, and stiff enough to transfer the applied forces to the pistons without undergoing significant bending. Depending on the lever class being used, the treadles can be hinged at one end or in the middle, with the opposite end being supported by a rope and pulley or rocking bar. The range of movement is dictated by the stroke length of the pistons and by the comfortable working step of the operator. Treadles are made out of steel. There is a practical upper limit of advantage, as the pump may overturn if the operator stands at the extreme end of the treadles and there isn't enough weight in the frame.

6. PULLEY WHEEL AND ROPE

The rope and pulley wheel enable the reciprocal movement of the treadles. The wheel has a central axle mounted to a frame; a simple axle, such as a 16 mm diameter bolt is used. A polymer rope is used to tie up the treadles along the pulleys.(Figure 3)

Figure 3: Pivot and Rope

V. WORKING PROCEDURE

A treadle pump comprises a cylinder fitted with a piston and some means of pushing the piston up and down. A pipe connects the pump to the water source and at the end of this pipe is a non-return valve that allows water to enter the pipe and stops it from flowing back into the source. The piston and the cylinder must have a very close fit, so that when the piston is raised, it creates a vacuum in the cylinder and water is sucked into the pump. When the piston is pushed down, the water is pushed through a small valve in the piston to fill up the space above it. When the piston is raised again, it lifts this water until it pours out over the rim of the cylinder and into an irrigation channel or tank. At the same time, more water is drawn into the space below the piston. The downward stroke of the piston once again pushes water through the small valve into the space above the piston and the process is repeated. The most important innovation has been to change the driving.

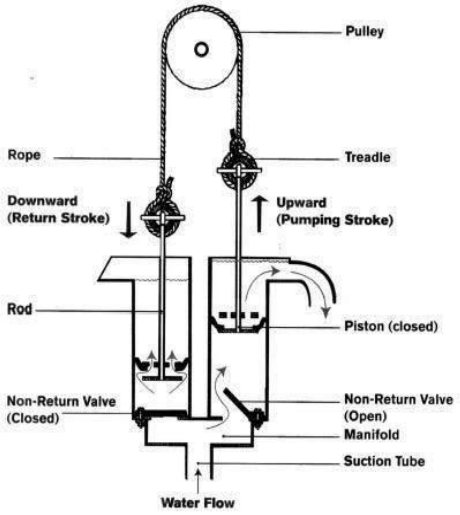

Figure 4: Schematic representation of working procedure of the cylinder pump

Power given form legs, these have much more powerful muscles and so are capable of lifting much more water. Two cylinders are used instead of one. They are positioned side by side and rope, which passes over a pulley, connects the two pistons so that when one piston is being pushed down, the other one is coming up. Each piston is connected to a treadle. This rhythmic method of driving the pump will gain wide acceptance among farmers. This pump is known as the suction pump and it is used to draw water up from a well or river and discharge it into a canal for irrigation. This valve closes on the downward stroke to stop the flow from reversing. In this way it is possible to maintain a pressure in the delivery pipe that can be used to drive sprinklers or drippers or deliver water to a header tank.

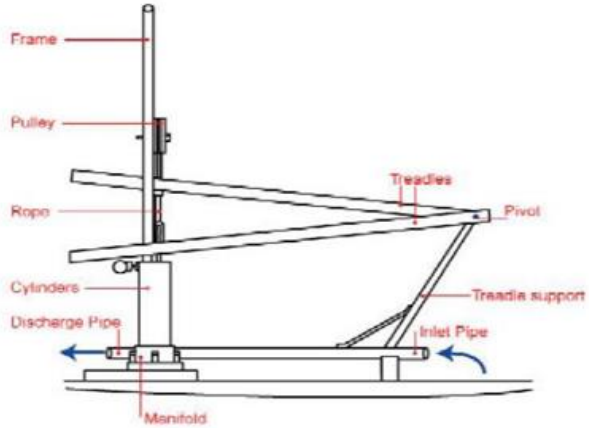

Figure 5: Schematic representation of working principle of treadle pump

VI. CAD MODELS

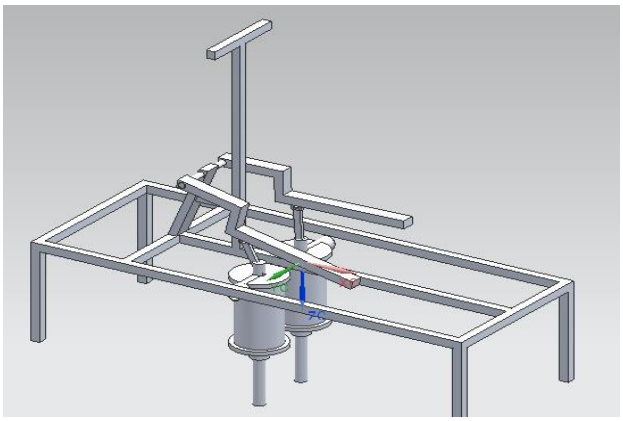

Figure 6: 3D CAD Model of assembly of Treadle Pump

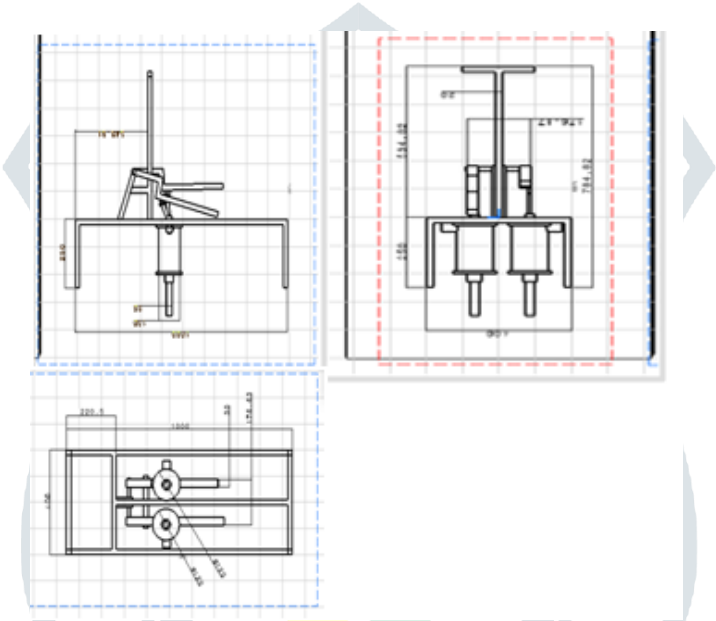

Figure 7: 2D Top, front and side views of assembly of Treadle Pump

VII. TEST RESULTS

A Tests result shows the discharge flow rate of treadle pump is 10 liter/min with an average human input of 60 W of power to lift the water from a height of 8 feet.

VIII. CONCLUSION

A treadle pump is designed and fabricated as per the requirements and it is tested for the purpose of serving. In treadle pump the water discharge rate can be varied by varying the speed of peddling. Since the mechanism is so simple and versatile the fabrication process of the unit is very simple and also can be handled easily and smoothly by any operator.

REFERENCES

[1] Bolton.W, 1997. Pneumatic and hydraulic systems. Butterworth-Heinemann, Jordan Hill, Oxford

[2] Jon Naugle , et all. 1978, Approve TEC Kenya and Joseph Zirebwa, Institute of Agricultural Engineering, Zimbabwe, the four authors of the country

[3] Antonio Esposito, 1980 Fluid power with application. Prentice hall, India private limited.

[4] Catalogue of Jana tics pneumatic product Jana tics Private Limited Coimbatore.

[5] Design data book –compiled by faculty of mechanical engineering P.S.G. College of technology, Coimbatore.

[6] Festo Didactic KG, 1998 Fundamentals of control technology, Esslingen.