DESIGN AND FABRICATION OF HIGH DISCHARGE TREADLE PUMP

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ABSTRACT: **A treadle pump is a human powered low-cost pump designed to lift shallow water sources for irrigation. A treadle is a lever device pressed by the foot to drive a machine, in this case a pump.The treadle pump can do most of the work of a motorized pump, but costs considerably less to purchase. Because it needs no fossil fuel (it is driven by the operator's body weight and leg muscles), it can also cost less to operate than a motorized pump. Because leg muscles tire less than arm muscles, it can also be used by the farmers for longer. The treadle pump can greatly increase the income that farmers generate from their land, both by extending the traditional growing season and by expanding the types of crops that can be cultivated. In our project we change the actual design to some changes to achieve the more efficient discharge using a pulley, rope, pump , treadles are used. This is a developed design of the project to very useful for the irrigation at the same time for the day to day applinces.**

I . INTRODUCTION

The treadle is a very simple design that is used to produce rotary or reciprocating motion in a machine, which dates back to Thomas Saint's original sewing machine design he had patented in 1790 and earlier. This basic component can be used in many simple machines, including grinders and pumps. A Treadle pump is defined as a foot operated single acting double cylinder piston pump for low lift irrigation. Pumping is activated by stepping up and down on the treadles to drive the attached pistons, creating suction in the cylinder that draws groundwater to the surface. This water can be sourced from a river or well and is used for irrigating farmers' fields or to store water in a container for later use.Treadle pumps have been used in many countries worldwide such as Ghana, Zambia, Swaziland, Kenya, Bangladesh, Nepal, India, Cambodia and Myanma, as well as many others. Presently, 84 manufacturers now produce treadle pumps and 1.4 million have been sold to small plot Bangladeshi farmers since 1985 .Design and their origins, maximum volumetric input, features and cost.

II.ENGINEERING PRINCIPLE

A.HYDRAULICS

A 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 centrifugal pumps it is common to refer to the NPSHa, which is the net positive suction head available. 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 and NPSHa decreases as the difference increases.

B.STATICS

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.The Swiss Concrete Pedal Pump (SCPP), developed by W-3-W

Association Switzerland, is prime example of a class I lever (Figure 3). Tests conducted at the Lucerne School of Engineering and Architecture (HTA) showed a very impressive 65% energy efficiency and a maximum discharge volumetric flow rate of 80 L/min (with an average human input of 60 – 65 W and a suction lift of 3 m).

Fig.1.An example of a class I lever in the Bangladesh treadle pump

Mechanical advantage has a direct impact on the stroke length of the piston: an MA greater than 1 means a decrease in stroke length while an MA less than 1 results in an increase in stroke length. Taking advantage of MA's greater than 1 allows more force to be applied to the piston, hence greater pumping pressures can be achieved, but this is at the expense of volumetric flow because of the reduced piston stroke length .

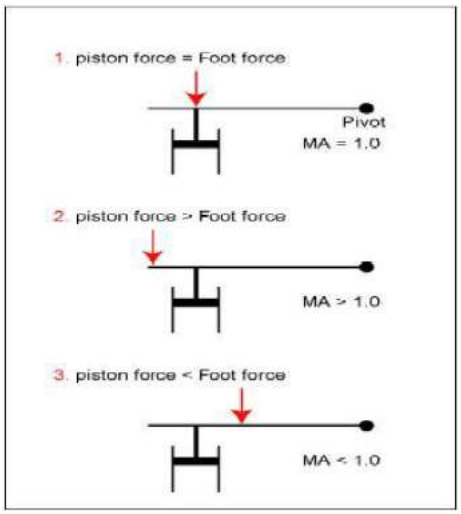


Fig.2.Using mechanical advantage

III.BASIC COMPONENTS

- Pump cylinder
- Pump manifold
- Piston
- Pulley wheel and rocking bar
- Non return valves
- Frame
- Treadles

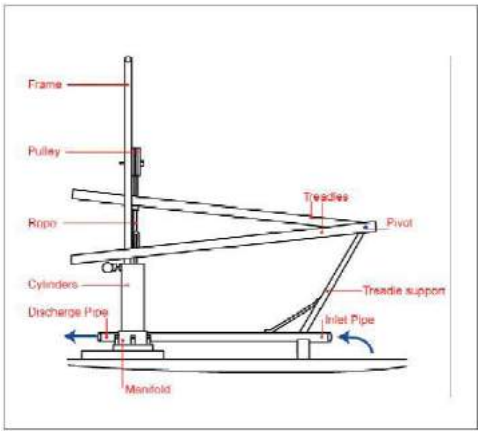


Fig.3.Basic components of a treadle pump

A.PUMP CYLINDERS

Treadle pumps make use of two cylinders (one per treadle), with an average cylinder diameter of 100 mm and a normal range of diameters between 75 mm (for high heads) and 150 mm (for low heads) . A cylinder of diameter 100 mm is capable for pumping water to heads of between 3 and 8 m . Materials used include curved steel sheet, bamboo, PVC pipe and concrete . The material used varies widely based on availability of the materials, availability of skilled workers, type of pump (suction vs. pressure – bamboo is considered unsuitable for pressure pump applications) and cost.

Fig.4.Pump cylinder

B.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 most likely a steel box, but can be made of concrete as well, as in the Swiss design. It can also be made from, in a pump with PVC cylinders, pipe fittings or straight pipe.

C.PISTON ASSEMBLY

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; 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. Piston rods are generally made of round steel bar, as it is a very robust material and is usually available. The pistons themselves can be made of wood, plastic, or steel as well, with leather or rubber cups or rings to form the seal with the cylinders. The piston cups or rings must themselves also be robust; they must sustain of continual friction against the cylinder wall.

D.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. Various types of non-return valves are used, including rubber flaps, swinging gates and poppet valves.

E.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 generally made from wood, bamboo or steel. Steel is the stiffest and most expensive of these materials; however, the mechanical advantage can be greatest when using steel treadles. There is a practical upper limit to this 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.

Fig.5. Treadle

F.PULLEY WHEEL OR ROCKING BAR

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 normally used. It is usually made of wood soaked in oil to preserve it and to lubricate the movement. The alternative to the rope and pulley method is the rocking bar. This arrangement is harder to balance but may be easier to construct in some cases.

Fig.6.Rope and Pulle

IV. 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

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 cylinders are used instead of one. They are positioned side by side and a chain or rope, which passes over a pulley or a rocker bar, 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 has gained wide acceptance among farmers and seems to be preferable to any mechanism that requires only one foot or arms and hands. This pump has become 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. But since its advent another form of treadle pump has been developed which is commonly known as the pressure pump. This operates on exactly the same principle as the suction pump but the delivery end has been modified so that water can be fed into a pipe rather than an open channel. Instead of water flowing over the top of the cylinders into a channel, the upward movement of the pistons pushes water through a second valve into a delivery pipe.

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. Hence the name pressure pump. These are not the ideal names, because they imply that the two pumps are different, when in reality they both work on the same suction principle. However, these are the names that have been generally accepted and so in accordance with common use they are used throughout this manual.

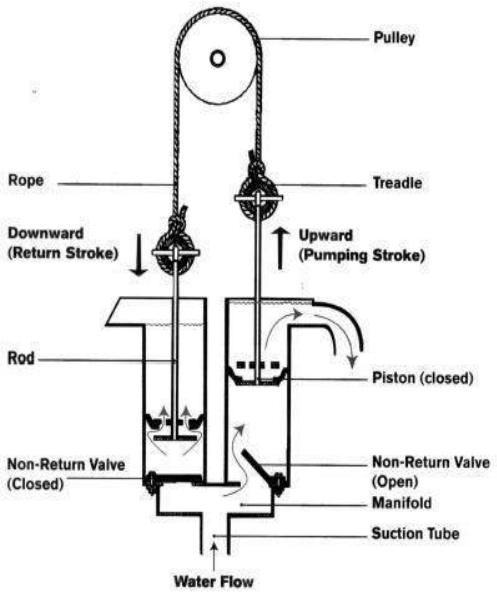


Fig.7.Working Layout

A.BASIC HYDRAULICS

Many professionals without an engineering background often do not have a good understanding of basic hydraulics and pumping. This section is designed to clarify some of the important issues such as pressure, head and discharge and what is meant by such terms as suction lift and delivery head.

B.PRESSURE AND HEAD

Pressure is defined as a force acting uniformly over an area. It is normally measured in kilo-Newtons per square metre (kN/m^2). In some European countries, kilograms force per square centimetre (kgf/cm^2) is still used. Another common unit is the bar. One bar is the equivalent of atmospheric pressure and is equal to 1 kgf/cm^2. Many non-engineering professionals find kilo-Newtons confusing and much prefer to work in kilograms force (kgf), as it can be easily related to the common understanding of kilograms as a measure of weight.

This is the unit of measurement used throughout the manual. Pressure is often referred to as a head of water. To understand this, imagine a long vertical tube, in which the pressure is to be measured, connected to a pipe. Water will rise up the tube, because of the water pressure in the pipe. The height to which it will rise is a measure of the pressure. This is called the head and is another way in which pressure is expressed. It has the advantage of allowing changes in land topography that can affect pumping pressure to be taken easily into account when working out pressure requirements. It must, however, be linked to the fluid in the pipe, as different fluids would rise to different heights because of their different densities. So the correct term to use is head of water. The relationship between pressure and head is a simple one:

Head of water (m) = 0.1 × pressure (kN/m^2)
or = 10 × pressure (kgf/cm^2)
or = 10 × pressure (bar)

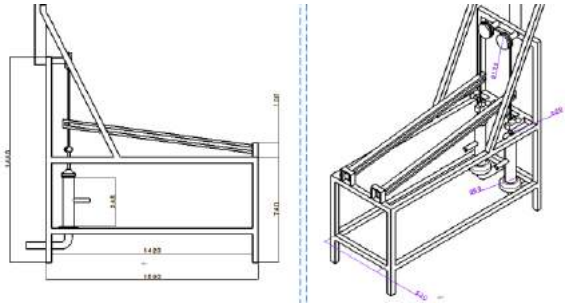
As an example, a pressure of 3 bar or (3 kgf/cm2) would result in water rising to a height of 30 m in the tube. (For more explanation of pressure and other aspects of hydraulics, see Kay, 1998.) Atmospheric pressure, which is important for pumping water, is equal to 10 m head of water. The reasons for its importance are discussed in the next section.

C.SUCTION LIFT

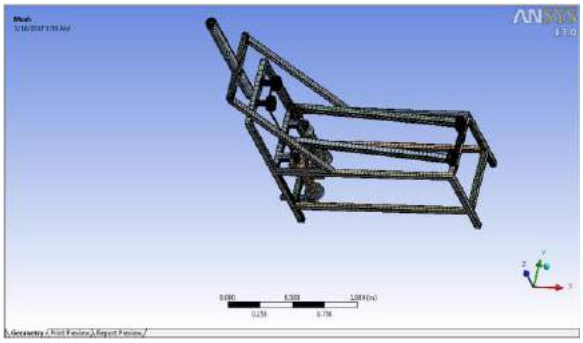
For operating convenience, pumps are usually located above the water source and a short length of pipe is used to draw water into the pump. This is called the suction pipe. The difference in height between the water surface and the pump is called the suction lift. The idea of suction lift and its limitations is one that is not well understood, so a word of explanation is perhaps appropriate here. Pumps do not actually suck water, as is often imagined. A pump takes water from the source in much the same way as you would suck up water through a drinking straw.

V.MODELLING AND ANALYSIS

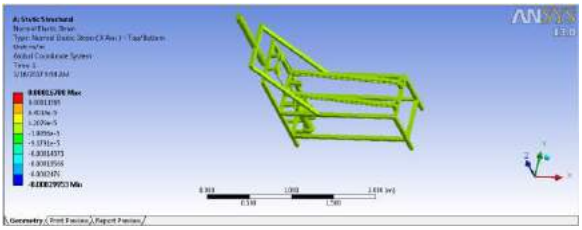
A.DRAFTING IMAGE



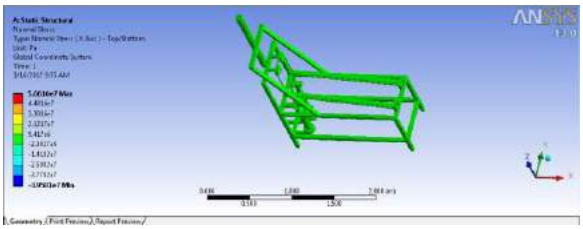
B.MESH



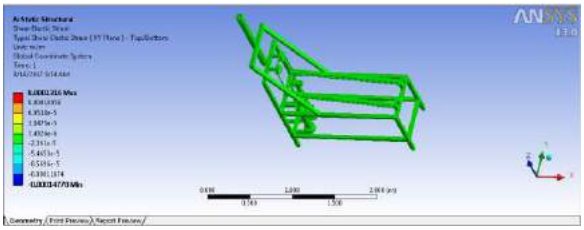
C.NORMAL STRAIN



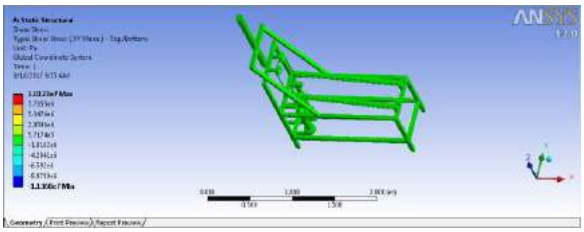
D.NORMAL STRESS



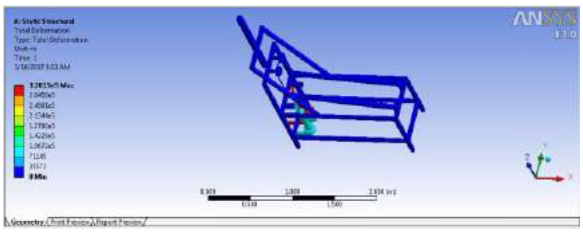
E.SHEAR STRAIN



F.SHEAR STRESS



G.TOTAL DEFORMATION



VI. FABRICATION PART

WELDING

Here for the permanent joint we are using arc welding.

Fig.8.FABRICATION OF TREADLE PUMP

VII. ADVANTAGES

- More efficiency
- Easy to use
- Good exercise for health
- Less cost
- No consumption of fuel
- No need of skilled person
- Eco-friendly

VIII. CONCLUSION

Treadle pumps are most commonly used by farmers on small plots of land, typically about the size of an small land. They are also used in poor countries and small villages such as villages in Africa, small farmers in Asia, and anywhere else where money is an issue. Compared to bucket. irrigation, the treadle pump can greatly increase the income that farmers generate from their land by increasing the number of growing seasons, by expanding the types of crops that can be cultivated, and improving on the quality of grown crops.

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