

# Design and Fabrication of Pedal Powered Household Reciprocating Pump

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**ABSTRACT:** Many mechanisms have been invented for pumping water from lower grounds to higher grounds. Rotary pumps and reciprocating pumps are the basic types of water pumps; both these types have their own advantages and disadvantages. Among these, electric powered rotary pumps are commonly used because of its ease of operation, but electricity is a major problem in many rural places. Also, in urban areas water pumps are used in pumping water from lower grounds to the overhead tanks, here also electric rotor pump are used. Therefore in this work, a pedal powered reciprocating water pump with scotch yoke mechanism is designed and fabricated, which can be used to pump water from lower grounds i.e. wells or sump to higher grounds i.e. cultivating lands or overhead tanks respectively. This mechanism is operated mechanically by pedalling; therefore it's economical and healthy.

**KEYWORDS:** Reciprocating Pump, Scotch Yoke Mechanism, Pedal Powered

## I. INTRODUCTION

For being such a seemingly ordinary vehicle, the wheelbarrow has a surprisingly exciting history. This is especially true in the East, where it became a universal means of transportation for both passengers and goods, even over long distances. The Chinese wheelbarrow - which was driven by human labor, beasts of burden and wind power - was of a different design than its European counterpart. By placing a large wheel in the middle of the vehicle instead of a smaller wheel in front, one could easily carry three to six times as much weight than if using a European wheelbarrow. The one-wheeled vehicle appeared around the time the extensive Ancient Chinese road infrastructure began to disintegrate. Instead of holding on to carts, wagons and wide paved roads, the Chinese turned their focus to a much more easily maintainable network of narrow paths designed for wheelbarrows. The Europeans, faced with similar problems at the time, did not adapt and subsequently lost the option of smooth land transportation for almost one thousand years.

If we boost the research on pedal powered technology - trying to make up for seven decades of lost opportunities - and steer it in the right direction, pedals and cranks could make an important contribution to running a post-carbon society that maintains many of the comforts of a modern life. The possibilities of pedal power largely exceed the use of the bicycle.

Peddalling a modern stationary bicycle to produce electricity might be a great work-out, but in many cases, it is not sustainable. While humans are rather inefficient engines converting food into work, this is not the problem we want to address here; people have to move in order to stay healthy, so we might as well use that energy to operate machinery. The trouble is that the present approach to pedal power results in highly inefficient machines.

Ever since the arrival of fossil fuels and electricity, human powered tools and machines have been viewed as an obsolete technology. This makes it easy to forget that there has been a great deal of progress in their design, largely improving their productivity. The most efficient mechanism to harvest human energy appeared in the late 19th century: pedalling. Stationary pedal powered machines went through a boom at the turn of the 20th century, but the arrival of cheap electricity and fossil fuels abruptly stopped all further development.

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## II. RELATED WORK

James A Cripe *et al*[1], investigated the effect of pump and system interaction for reliable operation. Pump cannot be isolated. Gowrishankar.k *et al.*,[2] designed and fabricated a reciprocating pump which operates on less human effort through oscillatory motion. G.Jaganraj *et al.*,[3] designed and fabricated a double acting reciprocating pump using scotch yoke mechanism in order to improve the volumetric efficiency of the pump. R.Praveen Kumar *et al.*[4], designed and fabricated a dual side water pumping system using scotch yoke mechanism in order to pump water at high pressure for various heads. Mogaji P B[5] designed and fabricated an improved pedal powered water pumping system using chain drive mechanism, in order to reduce the effort of water pumping. Aakash M bodh *et al.*[6], studied and analysed a pneumatic system for improvements of reciprocating efficiency. Sermaraj M[7] reviewed the advantage and disadvantage of reciprocating water pumps with rotary water pumps, further designed and fabricated an improved simple reciprocating water pump. A Nasir *et al.*,[8] designed and fabricated a manually operated hand pump and analysed its performance by analytical methods. Therefore in the present work a pedal powered reciprocating water pump using scotch yoke mechanism has been designed and fabricated for pumping water from sump to overhead tanks, this same mechanism can also be used for agriculture purpose also.

## III. DESIGNING AND DISCUSSION OF RESULTS

### 3.1 MECHANISM

Scotch yoke is one of the rotary to linear conversion mechanism. It consists of two main parts mainly i) a rotating scotch and ii) a sliding yoke. Sliding yoke is driven by a pin that is eccentrically placed on to the rolling scotch. Figure 3.1, 3.2 and 3.3 shows orthographic views of Scotch yoke mechanism. In this mechanism the number of links and joints are less hence reliability of the mechanism is more. There is no link in the mechanism that works against its self –weight found that scotch yoke transmission was optimal in low torque and low speed applications. The main disadvantage of scotch yoke was that it was rolling and sliding friction acts directly on to the shaft of motor. In such cases low speed operation would reduce the effect of these forces in the shaft found that the back and forward motion of scotch yoke is synchronously equal and so it was obvious that this mechanism could drive two syringes and synchronously at the same time with equal force found that scotch yoke mechanism behaves well even in vertical transmission. The disadvantage of scotch yoke was that its transmission efficiency depended on the eccentrically placed pin and due to sliding contact the pin may wear out easily. To avoid this rubber bush can be provided at the contact point.

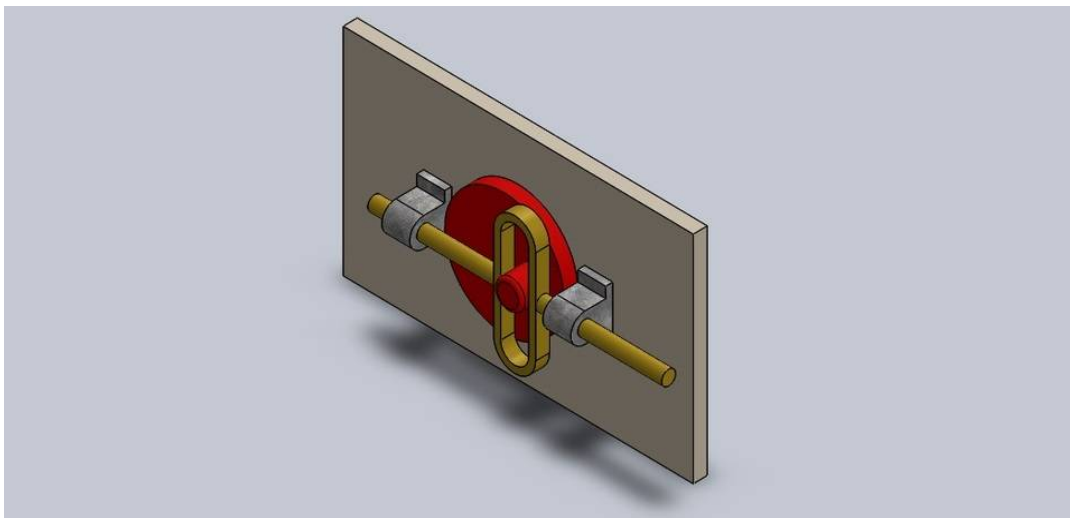


Fig3.1 ISO view of scotch yoke mechanism

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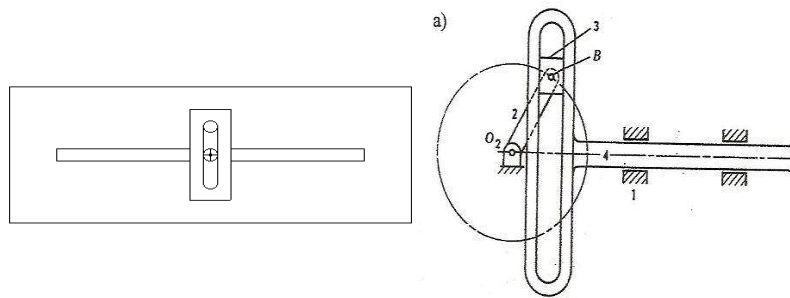


Fig3.2 top view and front view of scotch yoke mechanism



Fig3.3 scotch yoke mechanism

Thus the overall performance is to provide high power forward cutting stroke with a low power and higher speed Quick Return in preparation for the next lift.

### 3.2 STAND SETUP PARTS

Material – mild steel 1”sq pipe

Stands are introduced to immobilize the apparatus. Various components used are fixed to this arrangement. The chassis of the bicycle is used as the stand setup parts. The stand described here is designed to support most bicycles. Figure 3.4 shows the stand up set up.



Fig3.4 Stand up setup

1. The stand assembly is divided into two parts: the rectangular base frame and two triangular upright supports. Measure and cut the five pieces of 3/4" (20mm) angle specified for the base frame. Mitre the corners at 45 degrees so they fit together tightly and form square corners.
2. Weld the rectangle together. Do not weld the centre frame member to the rectangle yet.
3. Measure and cut as specified the 5 pieces for each upright support.

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4. Carefully assemble the upright support pieces for welding, being sure to leave a 1/8" (3.2mm) gap in the base of each support. This gap will mate with the centre frame member of the base frame, allowing the upright supports to slide to accommodate different rear axle widths. Note that the two upright supports are not identical. They are mirror reflections of one another. Weld each upright support assembly together into a secure structure.

5. Place the upright supports onto the base frame, and position the centre frame member so that it mates with the gap in the side supports. Mark its position, and weld it in place.

### 1. PEDAL ARRANGEMENT

A pair of pedals is attached to the stand setup in which the power will be generated manually. A typical Bicycle arrangement is used.

#### PEDAL

A bicycle shoe crank bottom bracket bicycle pedal is the part of a that the rider pushes with their foot to propel the bicycle. It provides the connection between the cyclist's foot or and the allowing the leg to turn the spindle and propel the bicycle's wheels.

Pedals were initially attached to cranks connecting directly to the driven (usually front) wheel. The safety bicycle, as it is known today, came into being when the pedals were attached to a crank driving a sprocket roller chain. that transmitted power to the driven wheel by means of a

Pedals usually consist of a spindle bearings that threads into the end of the crank and a body, on which the foot rests or is attached, that is free to rotate on with respect to the spindle.

### 2. FLYWHEEL

Material – Cast iron

Diameter- 0.168m



Fig3.5 Flywheel

A flywheel is an inertial energy-storage device. It absorbs mechanical energy and serves as a reservoir, storing energy during the period when the supply of energy is more than the requirement and releases it during the period when the requirement of energy is more than the supply.

The main function of a fly wheel is to smoothen out variations in the speed of a shaft caused by torque fluctuations. If the source of the driving torque or load torque is fluctuating in nature, then a flywheel is usually called for. Many machines have load patterns that cause the torque time function to vary over the cycle. Internal combustion engines with one or two cylinders are a typical example. Piston compressors, punch presses, rock crushers etc. are the other systems that have fly wheel. Flywheel absorbs mechanical energy by increasing its angular velocity and delivers the stored energy by decreasing its velocity

### 3. PUSHROD

Material - Mild steel

Dimension- 0.26m



Fig3.6 Pushrod

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Pushrod is a rod which is used to transmit the reciprocating motion from yoke of the scotch yoke mechanism to the piston of the pump. The desirable properties of the pushrod are

- ✓ It should withstand the impact forces during operation
  - ✓ It should have smooth surface finish to offer minimum resistance during sliding motion
  - ✓ It should have good fatigue resistance
  - ✓ Should be non corrosive
4. RECIPROCATING PUMP



Fig3.7 Reciprocating pump

### CONSTRUCTION:

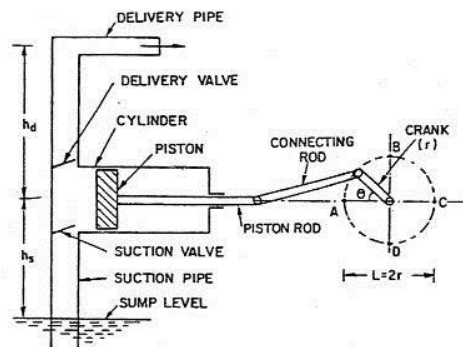


Fig3.8 Construction of reciprocating pump

The Main Parts of Reciprocating Pump are:

1. CYLINDER

It is made of steel alloy. The piston reciprocates inside the cylinder. The movement of piston is obtained by a connecting rod which connects piston and rotating crank.

2. SUCTION PIPE

It connects the source of water and cylinder, the water is sucked.

3. DELIVERY PIPE

Water sucked by pump is discharged into delivery pipe.

4. SUCTION VALVE

It adjusts the flow from the suction pipe into delivery pipe. Brass valve is used here.

5. DELIVERY VALVE

It admits the flow from the cylinder in to delivery pipe.

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The working of the reciprocating pump is very simple and just like an I.C engine. First of all the piston has the function of providing the suction force, so that the liquid can be lift up or can be sucked in with great force. After that comes the compression part which will impart the required pressure energy to the fluids. In this part of the phase the piston have to do a great work so that the liquid can be compressed properly and its pressure can increased to the desired level. The inlet and the outlet valve open at a certain pressure which is set by manufacturer. If the piston is of single acting type which means it can suck from one side and transmit to the same side only. But we can have the double reciprocating pump too which have the function of the giving suction and discharge simultaneously in each stroke.

Note: It is to be noted that the reciprocating pump is a positive displacements pump which means that the fluid can only move in one direction and can never reverse back. So due to this the pump is always started with outlet valve open otherwise the pressure will keep on building and this will lead to rupturing of the pipeline or even the pump itself. But if relief valve is fitted then this pressure will come down.

Pump specifications

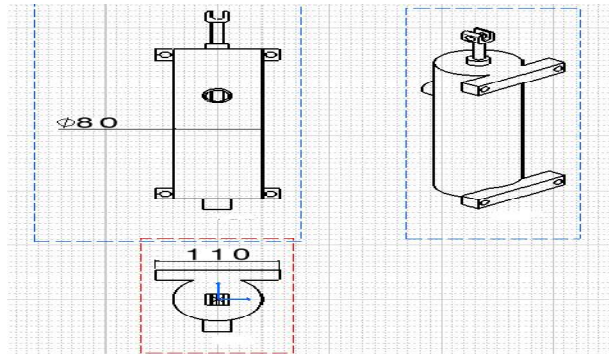


Fig3.9 Pump dimensions

- Outer dia. =80 mm
- Inner dia. = 60mm
- Stroke length = 180 mm
- Overall length of pump= 230 mm
- Inlet and outlet dia. = 20 mm
- In 1 stroke there will be 200ml suction capacity.

(Above all are pump specification i.e. these size specification pump available in market)

Full working model is shown in figure3.10



Fig 3.10 Working model

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After completion of testing the working model for different speeds the following discharge were obtained by the model for a head of 20feet.

Table-3.1 – discharge vs speed

Sr No	Speed rpm	Discharge in lpm
1	40	7.8
2	60	12
3	80	15.6
4	100	20
5	120	24
6	140	27.6
7	160	31.8

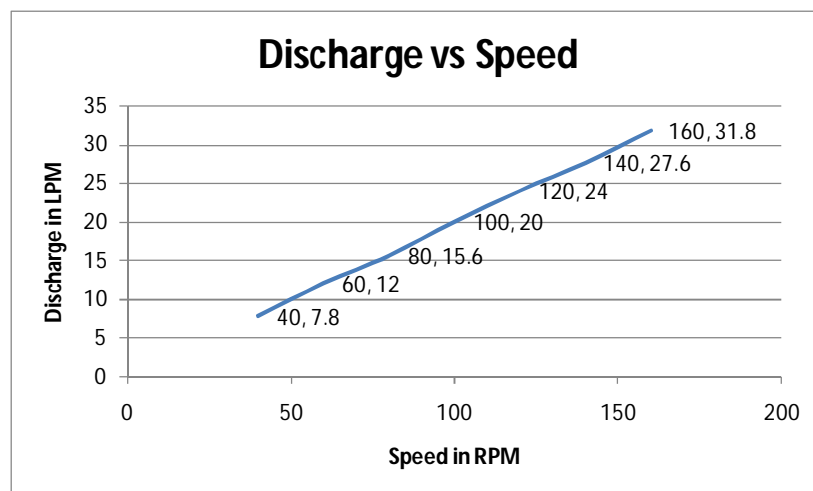


Fig-3.11 Discharge vs speed graph

Figure3.11 shows that as speed of the pedal increases, the discharge also increases linearly.

#### IV. CONCLUSION

This work is focused on modelling, design and control of pedal operated water pumping, with emphasis on lightweight, portable appliances. An innovative method of minimizing manual stress and thus reliably stabilizing the pumping was also presented. It is very useful for the small scale works

Thus a low cost and simple design pedal operated pump is fabricated. This simple design of conventional design which can enhance today's household needs and daily day to day purposes .By using this method we can do any operation as per our requirement without the use of electricity. So we can save the electrical power.

#### V. CONCLUSION

Electricity is a major problem in many of the rural areas. In urban regions people spends lot of their money on fitness and health. Therefore in our present work, we have designed and fabricated a pedal powered reciprocating water pump

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with scotch yoke mechanism which can pump water from lower ground to upper ground with less human effort. This mechanism can be used for agriculture purpose as well as for household water pumping to overhead tanks.

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