



DESIGN AND FABRICATION OF ELLIPTICAL TRAMMEL USING PERFORMANCE ANALYSIS OF RECIPROCATING PUMP

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Abstract--- *The elliptical trammel mechanism is used in many ways across the world for many works on machines. This trammel mechanism is special since it is less space consuming and can be used in various aspects since its working principle only depends on mechanical conditions. Thus in this project we are going to show the design and fabrications along with the working of a reciprocating pump using the elliptical trammel mechanism. With this the discharge of the reciprocating pump is also calculated to show that the elliptical trammel mechanism used is no way lesser than using a motor to the reciprocating pump. This project is to show that the elliptical trammel mechanism can be used for any application which is regarding to rotary and linear motions. This will guide us thorough a way to show that the mechanism can be used in other ways to help and to bring a lot of simple works to happen without spending other energy sources which are produced by other means. This elliptical trammel mechanism can be operated my man power and can be used for various other an working operation of a elliptical trammel.*

1. INTRODUCTION

A trammel of Archimedes is a mechanism that generates the shape of an ellipse. It consists of two shuttles which are restricted ("trammed") to perpendicular channels or rails, and a rod which is attached to the shuttles by pivots at fixed positions along the rod. As the shuttles move back and forth, each along its channel, the end of the rod moves in an elliptical path. The semi axes a and b of the ellipse are the distances between the end of the rod and the two pivots. An elliptical trammel of an Archimedes intended to draw, cut, or machine ellipses, e.g. in wood or other sheet materials. An elliptical trammel has the appropriate instrument (pencil, knife, router, etc.) attached to the rod. Usually the distances a and b are adjustable, so that the size and shape of the ellipse can be varied. The history of such ellipsographs is not certain, but they are believed to date back to Proclus and perhaps even to the time of Archimedes. As we have seen in our review papers, lot of experts have tried their views and working principles as needed for them in their own experiments. One of them has done a tool changing apparatus, one has given a nice journal

comparison. The elliptical trammel mechanism has various applications as it can be made in various gestures. The triangle trammel has a perfect structure of a hexagon a universal component. This structure is strong and has a unique value as it is made by the pi value signatures. In our project we are going to show an single application of using a normal elliptical trammel to run a reciprocating pump and calculate its discharge using formulae. In this way we will be able to find the use of elliptical trammel in every way. Since if this mechanism can be used up to this small scale apparatus, then it is surly a great gesture in major value graded mechanisms.

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2. EXPERIMENTAL PROCEDURE

2.1 Trammel

Our trammel will be made by cast iron itself. Since it's a simple apparatus, it can be done easily by arc welding itself. Poly propylene will be strong and efficient for our need as a piston. Connecting rod can be of cast iron or stainless steel. The pump will be bought from any designated company. A temporary tank will be provided for its usage. Since it is used in water oriented application, the setup will be painted for safety.

2.2 Sprocket

A sprocket or is a profile wheel with teeth ,or even sprockets that mesh with a chain, track or other perforated or indented material. The name 'sprocket' applies generally to any wheel upon which radial engage a chain passing over it. It is distinguished from a gear in that's sprockets are never meshed together directly, and differs from a pulley in that sprockets have teeth and pulleys are smooth. Sprockets are used in bicycles, motorcycles, cars, tracked vehicles, and other machinery either to transmit rotary motion between two shafts where gears are unsuitable or to impart linear motion to a track, tape etc. Perhaps the most common form of sprocket may be found in the bicycle, in which the pedal shaft carries a large sprocket-wheel, which drives a chain, which, in turn, drives a small sprocket on the axle of the rear wheel. Early automobiles were also largely driven by sprocket and chain mechanism, a practice largely copied from a motorcycles.

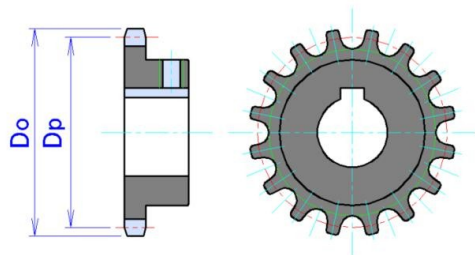


Fig 2.1 Sprocket

Sprockets are of various designs, a maximum of efficiency being claimed for each by its originator. Sprockets typically do not have a flange. Some sprockets used with timing belts have flanges to keep the timing belt centered. Sprockets and chains are also used for power transmission from one shaft to another where slippage is not admissible, sprocket chains being used instead of belts or ropes and sprocket-wheels instead of pulleys.

2.3 Chain

A chain is a series of connected links which are typically made of metal. chain may consist of two or more links. Those designed for lifting, such as when used with a hoist; for pulling; or for securing, such as with a bicycle lock, have links that are torus shaped, which make the chain flexible in two dimensions (The fixed third dimension being a chain's length.).

Those designed for transferring power in machines have links designed to mesh with the teeth of the sprockets of the machine, and are flexible in only one dimension. They are known as roller chains, though there are also non-roller chains such as block chain.

Two distinct chains can be connected using a quick link which resembles a carbines with a screw close rather than a latch A chain transmitted to a power in sprockets arrangement of elliptical trammel , the trammel with uses of high level of power transmission of chain then various of flexible of two chain arrangement of a rotates of cycling motion of a chain.

2.4 Power transfer:

Chain drive transfers power from the pedals to the drive-wheel of a bicycle,. that is driven by an external power source. Likely power transmitted using chain drive from external electrical motor.

3. DESIGN

3.1 Trammel

The trammel apparatus is simple. It can be made by welding angle and flat cast iron rods. The connecting rod rotates in an elliptical shape. That's why this setup is known as an elliptical trammel apparatus. In our need, we have only rotary setup. To connect this sloter mechanism is used. By using this mechanism, the connecting rod is slotted to give a trapezoidal structure. This trapezoidal structure is connected by chain drive and sprockets. This chain is driven by belt to connect with motor. This motor is used to operate the trammel mechanism. Now the trammel is ready.

With this a reciprocating pump is to be connected to the trammel and the discharge is to be calculated. Both the pistons move around inside the slots provided for them in the mechanisms. Connect the piston rod of the pump to the piston of the trammel. Now that the structure is at risk of not running on continuous way. Hence the rod is fixed using a bolt into the piston of the trammel from the other side of the pump

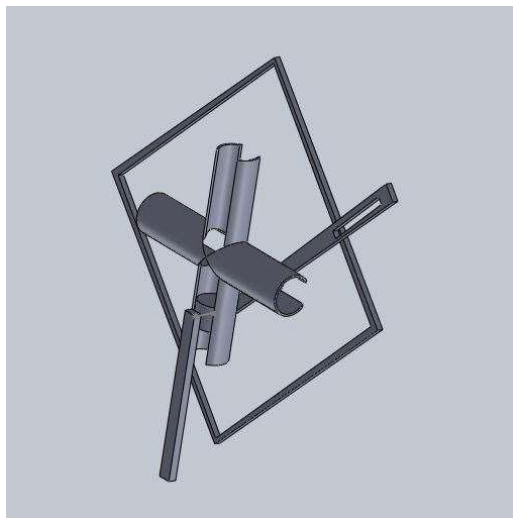


Fig. 3.1 Front Right Angle View of the Trammel

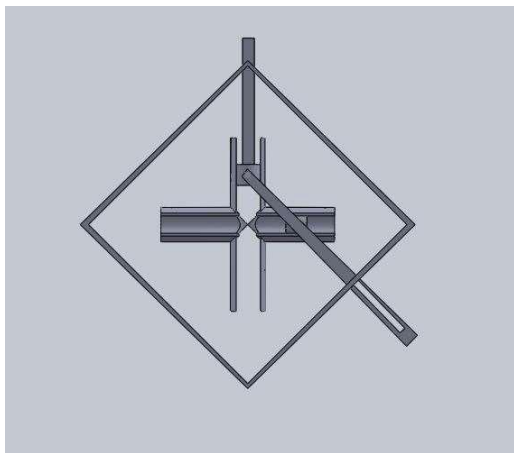


Fig. 3.2 Rear View of the Trammel

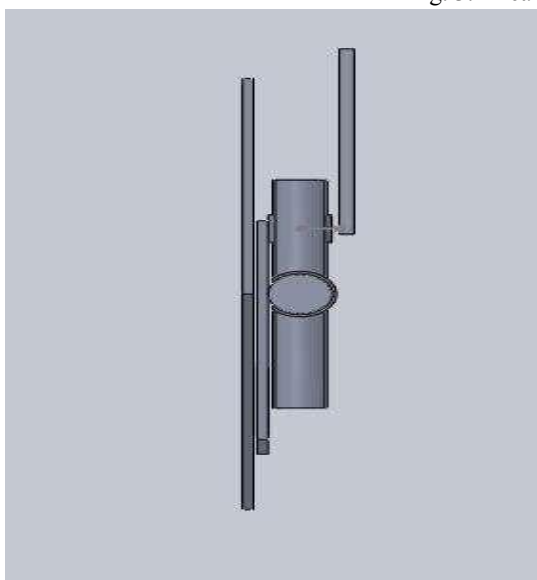


Fig. 3.3 Side View of the Trammel

3.2 Reciprocating pump

The above design doesn't consist of the design or fitting of the reciprocating pump needed the most in our project. This setup will be connected to the piston connected to the top corner of the connecting rod which connects both the pistons of the trammel mechanism. This shows an exact outcome of the pump without altering the setup of the trammel. The pump will be connected at the bottom of the apparatus since it will be easy to give connection to the tank and the outlet and so on. This will be done according to the need during the fabrication process. The frame should be made a little long during the fabrication due to the wait balancing concepts.

4. CALCULATION

4.1 Trammel calculation

- Since the length of pump's connecting rod is 390mm , We have took the stroke as 390mm
- The connecting rod of the trammel is taken as 780mm because to the correct formation of the elliptical angle.

Dimension

- Stroke length = 390 mm
- Piston = 125 mm
- Connecting rod = 780 mm
- Vertical length = 650mm
- Horizontal length = 1000mm

4.2 Chain

$$C = \frac{p}{8} [2L - (N+n) + \frac{2L - (N+n)^2}{8(N+n)}]$$

P=0.25 (Pitch of chain)

N=20 (No.of.teeth large sprocket)

n=20 (No.of.teeth small sprocket)

$$\begin{aligned} &= \frac{0.25}{8} [2(96) - (20+20) + \frac{2(96) - (20+20)^2}{8(20+20)}] \\ &= \frac{0.25}{8} [192 - 40 + \frac{36864 - 20.2642}{8}] \\ &= \frac{0.25}{8} [152 + 192] \\ &= \frac{0.25}{8} [344] \\ &= 10.75 \text{ inches} \end{aligned}$$

4.3 Sprocket

20 Tooth Sprocket REV-41-1340
Chain clearance 1.830 in 46.50 mm
Outside diameter 1.728 in 43.90 mm

4.4 Actual Discharge

The actual discharge of the reciprocating pump using elliptical trammel mechanism can be found by using theoretical methods. There are formulae that we learnt in our previous semesters. In fluid mechanics lab, we had an exercise to calculate the efficiency of an reciprocating pump. Here we are going to use those formulae to find the actual discharge and so on for this reciprocating pump. The actual discharge of a reciprocating pump.

Actual Discharge $Q = (\text{Area } A \times \text{Height of water raise } Y) / \text{Time taken } t$

Here we have used a cylindrical tank. In this apparatus we are going to reverse some things. Since in our apparatus, we don't have a collecting tank, we will use the inlet tank for calculations. The amount of water drained from this tank is equal to the amount of water discharged. Hence we will do calculations as per this tank. The time taken will be calculated practically using an stop watch. Area of tank $A = \pi \times \text{Radius}^2$

Area $A = 0.1962 \text{ m}^2$
Height of water drained $= 0.25 \text{ m}$
Time taken $t = 1.13 \text{ s}$

Therefore,

Actual discharge $Q = 0.04340 \text{ m}^3/\text{s}$
6.2 Efficiency

Same as above, the efficiency of the reciprocating pump can be found using theoretical formulae. We

Efficiency $= \text{Input power} / \text{Output power}$
Input power $= 0.15 \text{ KW}$ for 1HP motor.
Output Power $= (\text{Density of water} \times \text{Gravity} \times \text{Discharge} \times \text{Height}) / 1000 \text{ KW}$
Density of water $= 1000 \text{ kg/m}^3$
Gravity $= 9.81 \text{ m/s}^2$
Discharge $= 0.04340 \text{ m}^3/\text{s}$
Height $= 0.25 \text{ m}$

Therefore calculating the output power,

Output power $= 0.1064 \text{ KW}$

Thus calculating efficiency of the pump

Efficiency $= 14.09\%$

Thus the calculations are made and the efficiency of the pump is found out along with the discharge values.

4.5 Design

A general design of the whole apparatus told above is made in Solid works software. These gestures may not resemble with the original one made or designed. The design is made in a 3D platform. The design at various views is shown in the pictures below. the design is made temporary since the real making may differ with the design made as it necessary during the making process. The on field problems faced on the design will be altered as per the need during the fabrication process.

5. FABRICATION

5.1 Introduction

The trammel is made by the design as we have discussed in our previous chapters. The trammel is completely made by cast iron material. The pump is connected to the bottom of the design, so that it won't interfere with other stuff during the fabrication of the model working. The fabrication is made tough by the arc welding. This requires exact sizes and fixes of all the necessary parts. Most likely the sprockets and chain assembly is really a challenging part of the fabrication. It has its own properties. The poly propylene needs a lot of lubrication to work properly inside the slotted apparatus done. The pump is fixed with the temporary tank at the bottom of the apparatus. This provides an easy setting for the water connection and so on. This is setup is given an setting to connect to the belt drive which can be connected to the motor later on so that the apparatus will be made up to the working conditions.

5.2 Trammel

The trammel is made simply and easily as shown in the design on the previous chapter. The trammel is made in 10" inch slot. The slider is made of poly propylene, which has enough properties to withhold in our work. Both the sliders are connected to each other by a connecting rod which is made up of stainless steel. This setup was made easy on the other hand to work perfectly to bear the stresses made by both the motor and the reciprocating pump. The cast iron is choose an to be of 5mm thickness to give enough strength. The cast iron steel is made up by the rectangular wall rod. So that the work is made simple by the product itself to made it easy for the fabrication to be made simple.

5.3 Reciprocating Pump

The reciprocating pump is bought from the market with a significant size enough to hold the water and use it according to the project. The pump as told has been fixed below the trammel and is connected to one of the sliders parallel to the pump itself.

5.4 Fixes

Lot of other fixes are done during the fabrication process. These fixes are done in general using screw and bolt mechanisms. The bolts are used twice to provide axial multi variant support to the screw so that it could hold the sprockets on position to itself. These sprockets catch hold of the chain to be connected to the connecting rod of the trammel setup. One of the sprockets is connected to the belt drive using a belt drive setup attached to it in parallel. This can be used to connect any type of motor to this setup. In basic a 1 HP motor is more than enough to run this setup in ease and do the work in more than enough and sufficient way.



Fig. 5.1 Fabrication trammel

6. RESULT AND DISCUSSION

6.1 RESULTS

As per our previous chapter, our reciprocating pump using elliptical trammel gives us a good efficiency and a faster discharge as we expected for a reciprocating pump. This fabrication process is a huge success as for our design and make. Our results are given below in a simplified way.

Discharge = 0.04340 m³/s

Efficiency = 14.09%

As seen above 0.043m³/s is a valid amount of water discharge. It is about 2litres per second. Hence this values which show an efficiency of almost 15 % is worth enough for this reciprocating pump apparatus.

6.2 Discussion

Now that we have seen the results of this reciprocating pump using elliptical trammel mechanism is a huge success, we can try to use more than one pump in this apparatus. If we are going to use more than one pump, say we have connected one more on the top, just like the bottom, the discharge ratio will double, since one half of the trammel energy is being wasted now. Since one half is totally wasted now, at least we should have to use the other half of it so efficiently as possible. By using another reciprocating pump on the other side of the slider mechanism on the perpendicular direction of this apparatus can give us an epic raise in discharge values and so on, in the same energy spend on this 1HP motor provided.

7. CONCLUSION

Now that we have seen the results provided efficiently, we conclude by saying, a trammel mechanism can be used on various types of applications, from the least one like this to a most tedious work like some sudden changing stuff or things from one direction to other something in lathe or CNC or anything. This mechanism is widely used now a only in CNC as tool changing apparatus. But we conclude by saying that every now and there, there is an opportunity to use this elliptical trammel mechanism in any one of the application needed as per the need. Not only by this, an elliptical trammel can be used for various other non electrical orient jobs. To bring out water from a well or something like that, this setting will provide an easy use for the people of region who don't have enough supplies for electric supply and so on. An elliptical trammel can be used in various aspects that people don't even think of. So we can make a lot of other day to day applications by means of this mechanism.

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