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DESIGN OF SOLAR STEAM IRRIGATION PUMP

Vishal Dhimmar[1], Pragnesh Chaudhari[2],Vipul Patel[3]
Assistant Professor, Mechanical Dept., S.N.PI.T&r.C., Umrakh, Umrakh, Gujarat, India [1]
Assistant Professor, Mechanical Dept., S.N.PI.T&r.C., Umrakh, Umrakh, Gujarat, India [2]
Assistant Professor, Mechanical Dept., S.N.PI.T&r.C., Umrakh, Umrakh, Gujarat, India [3]

***Abstract**: This study attempts to solve the problem of small farm irrigation associated scenario in rural living. Most worlds are using conventional energy as the energy source to fulfill their general requirement. As the day passing the nonconventional energy is coming necessary to use because of rising economic rates of conventional energy. Solar energy is the most common nonconventional energy source. The solar energy is most easy source of energy can directly use to general requirements. Solar irrigation pump are this type of device which use solar energy for water pumping. Water pumping is an energy intensive activity and consumes a large amount diesel and electricity. Solar energy, which is abundantly available, can be used for pumping water via solar parabolic reflector. Smallholder farmers in low income countries can benefit from affordable irrigation pump systems as they enable cultivation of high value crops during dry season. This generates extra income and contributes to an improvement in quality of life.*

Keywords: **Non renewable energy, Solar Energy, Steam Irrigation pump.**

I. INTRODUCTION

The Solar collector collects energy coming from sun. Boiler located at focal point of collector absorbs solar energy which heats up water and turns it into steam. Steam conveyed to buffer vessel of steam engine via insulated hose. Pressure in buffer allowed to build up until 1 - 1.5 bar (120 – 130^{o}C). When the desired pressure is reached, operator manually turns the flywheel counter clockwise, opening the inlet valve allowing steam to enter the working chamber. The pump has a reciprocating positive displacement action that lifts water through the relative movements of a piston and a foot valve. The down stroke closes the foot valve and the piston moves through the water displacing a column of water equal to the volume of the stroke; the upstroke displaces the water above the piston while opens the foot valve drawing water into the pump cylinder. The original piston design was a hollow steel cylinder with a diameter fractionally below that of the pump casing cylinder. The idea was that it would be frictionless and resistant to wearing by abrasive soils. However it soon had to be replaced, because the sandy soils would not allow the piston to move freely. There are now two types of pistons installed according to the amount of sand encountered in the initial well development. The pump has a reciprocating positive displacement action that lifts water through the relative movements of a piston and a foot valve. The down stroke closes the foot valve and the piston moves through the water displacing a column of water equal to the volume of the stroke; the upstroke displaces the water above the

piston while opens the foot valve drawing water into the pump cylinder. The feeder pump is an important system component with two main purposes (i) return the condensate to the boiler; (ii) allow manual topping up of the boiler. For practical construction and operational reasons it has an oversized capacity and a minimum of 'dead space' so each stroke pumps mainly air. This water pump needs to be designed more carefully to avoid air leaks. The performance of the feeder pump is critical to the effective operation of system. During the monitoring there were frequent problems with the seals and valves, which meant that the boiler sometimes had to be refilled several times in a day. This led to gaps and discontinuities in the data collection.

II.DESIGN

A. SUCTION PIPE

In small farm the requirement of water for the irrigation is less pump discharge 1000 ltr /hr.

Discharge, $Q = 1000 \text{ lit/hr}$

$= 0.2778 \text{ lit/sec}$

$= 277777.78 \text{ mm}^3\text{/sec}$

Suction head is 15 m so Length of pipe,

$L = 15.54 \text{ m}$

$= 15540 \text{ mm}$

As per market survey the diameter for the discharge is,

Diameter of pipe $D = 38.1 \text{ mm}$

Area of pipe $A_p = \frac{\pi}{4} D^2$

$= \frac{\pi}{4} 38.1^2$

$= 1140.09 \text{ mm}^2$

Velocity of water $V_w = \frac{\text{Discharge}}{\text{Area}}$

$= \frac{277777.78}{1140.09}$

$= 243.65 \text{ mm/sec}$

Suction pressure $= 1 \text{ atmosoheric pressure} - \text{suction head}$

$= 1 \text{ bar} - \rho_w g L$

$= 0.1 - (10^{-6} \times 9.81 \times 10^3 \times \times 15540)$

$= -152.35 \frac{N}{mm}.\text{sec}^2$

B. VARIOUS LOSSES IN PIPE

Entrance loss h_i	**1.51** mm
Exit loss h_e	**3.03** mm
Friction loss due to suction head h_f	**223.62** mm
Total loss	**228.16** mm
Total head H	**15311.84**mm

C. PRESSURE VESSEL

It is a device which is used to receive solar energy from the parabolic collector is used to generate steam from water which is further used to run steam engine. It is generally made from the aluminum and steel. To increase efficiency of this receiver it is painted with prime black color.

Assumptions

To increase quantity of steam and to achieve pressure approximately 1.5 bar the dimension of pressure vessel as given below,

Radius of vessel $r = 150\ mm$

Length of vessel $L_v = 300\ mm$

$$Volume\ of\ vessel\ V_v = \pi r^2 h$$
$$= \pi \times 150^2 \times 300$$
$$= 21205750.41\ mm^3$$

D. **PISTON FOR SINGLE CYLINDER DOUBLE ACTING STEAM ENGINE**

Assumption

When the steam acts on piston due to the loss in pressure we assume that final pressure on the piston will be,

Steam pressure $P = 0.05\ N/mm^2$

As per working pressure on piston the,

Stroke length $L_s = 50$ mm

Clearance $L_c = 2.5$ mm

Total length $L = 55$ mm

Bore diameter $d = 53$ mm

Speed of piston $N_p = 100$ rpm

Stroke volume $V_s = \frac{\pi}{4} d^2 L_s$
$$= \frac{\pi}{4} \times 53^2 \times 50$$
$$= 110309.17\ mm^3$$

Clearance volume $V_c = \frac{\pi}{4} d^2 L_c$
$$= \frac{\pi}{4} \times 53^2 \times 2.5$$
$$= 5515.46\ mm^3$$

Total clearance volume $V_c' = 2 \times V_c$
$$= 2 \times 5515.46$$
$$= 11030.92\ mm^3$$

Total volume $V_t = V_s + V_c'$
$$= 110309.17 + 11030.92$$
$$= 121340.09\ mm^3$$

Compression ratio $r_c = \frac{V_s + V_c'}{V_c'}$
$$= \frac{110309.17 + 11030.92}{11030.92}$$
$$= \frac{121340.09}{11030.92}$$

$= 10.99$

Piston Force $F_p = \text{Pressure} \times \text{Area}$

$= p \times \frac{\pi}{4} d^2$

$= 0.05 \times \frac{\pi}{4} 53^2$

$= 110.31$ N

Piston Torque $T_p = F_p \times \frac{d}{2}$

$= 110.31 \times \frac{53}{2}$

$= 2923.19$ N mm

Piston Power $P_p = \frac{2\pi N T_p}{60}$

$= \frac{2 \times \pi \times 100 \times 2923.19}{60}$

$=30.611$W

E. **BUFFER CHAMBER**

Assumption

To give the continuous pressure rise steam to piston cylinder assembly dimension of buffer chamber must be less the dimension of pressure vessel

Length of chamber $L_b = 150\ mm$

Height of chamber $H_b = 140\ mm$

Width of chamber $W_b = 80\ mm$

Volume of chamber $V_b = L_b \times H_b \times W_b$

$= 168 \times 10^4\ mm^3$

F. **FLY WHEEL**

Assumption

To get constant discharge the flow of steam is to be constant, if there is fluctuation in steam generation to give constant energy supply we assume following criteria,

Speed of flywheel $N_f = 60\ RPM$

Density of flywheel $\rho_f = 7.85 \times 10^{-6} \frac{kg}{mm^3}$ $(For\ ms\ material)$

Mean diameter of flywheel $R = 240\ mm$

Thickness of rim $t = 20\ mm$

Usually $\frac{b}{t} = 2$ is taken.

Area of flywheel $A_f = b \times t$

$= 40 \times 20$

$= 800\ mm^3$

Volume of flywheel $V_f = 2\pi R \times A_f$

$= 2\pi \times 240 \times 800$

$= 1206371.58\ mm^3$

Mass of flywheel $M = Volume \times \rho_f$

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$$= 1026371.58 \times 7.85 \times 10^{-6}$$
$$= 9.47\ kg$$
$$\cong 10\ kg$$

Energy stored in flywheel $= \Delta E$

$$= M\omega^2 R^2 C_s$$
$$= 10 \times (6.28)^2 \times (240)^2 \times 0.04$$

= 908660.74 kg mm^2/sec^2

We know that relation between maximum fluctuation of energy and kinetic energy / total energy is given as below,

ΔE = E x 2Cs

The value of Cs for pumping is given in appendix.

908660.74 = E x 2 X0.04

$$E = \frac{908660.74}{2\ X\ 0.04}$$

= 113582.63 kg mm^2/sec^2

III.CONCLUSION

Research and development into this type of renewable energy technology is particularly important in the present day. Solar energy can easily transmit to kinetic energy by means of solar steam irrigation pump. Solar steam irrigation pump is very useful to small scale farmer and it is feasible to develop with minimum cost. It is beneficial to small scale farmer in following manners.

•Improve food security during the dry season.
• Create extra income.
• Reduce labour and fossil fuel inputs.
• Adapt better to potential climate change effects.

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