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Design and Fabrication of Solar Agricultural Spray Pump

Manoj Kumar Sharma[1], Pratik Mhamunkar[2]
[1, 2] M.E Thermal engineering, Pillai College of engineering, New panvel, Navi Mumbai, Maharashtra, India.

Abstract: The consumption of energy is directly proportional to the progress of mankind. The most important source of energy is fossil fuel, which is nonrenewable source of energy. Also use of fossil fuels causes urban air pollution, global warming & acid rain. This finiteness of fossil fuels strongly suggests making use of non-conventional, renewable & eco-friendly resources. Even though India is on fifth rank all over the world and on second rank in Asia for power generation from solar, still today lot of rural areas suffering from power cut. Thus main purpose is that on individual level use of renewable energy should be increased by installing such small solar sprayer to tackle with the agricultural problems up to certain extent. This paper is about fabrication of solar spray pump model which will generate 100w. As we were making model, so we made our body from mild steel. Also we tested that with help of 17 watt motor it can self- start without use of any external helping mechanism. Thus fabrication of small scale model is done on the basis of design calculations and some assumptions
Keywords: Solar energy, renewable energy, agriculture, solar panel, solar sprayer

I. INTRODUCTION

A hand sprayer is used to spray fluids such as pesticides, herbicides and fertilizers to agricultural crops. Usually tank is carried by the operator on his back or using automotive systems consuming nonrenewable fossil fuels such as petrol or diesel. To begin with, we came up with this topic through extensive searching on search engines as well as other sources of mass media and literature review. Agriculture is still a major occupation field for India. Spraying pesticide is the most important practice requires a lot of human efforts thus getting this work automatically with very less effort with no fuel consumption and using renewable form of energy i.e. solar is very vital. Combination of solar energy and mechanical systems to overcome the conventional problems is proposed in this paper. Solar panel is used to harness sun’s radiation for generation of electrical energy which is used to operate the sprayer.

II. PROBLEM STATEMENT

In conventional type pesticide sprayer, the heavy tank containing pesticide is carried by the farmer on his back and requires a lot of human efforts for spraying. For spraying out the pesticide farmer needs to hold the nozzle in the desired direction. Another type sprayer is fuel operated and requires expensive fuel i.e. Diesel or petrol. Thus the load on back of the farmer increases causes health issues.

III. CONSTRUCTION

The main components of Solar Agricultural spray pump are as follows -

A. Solar panel

Solar panels, also called photo voltaic or PV modules as it directly converts sunlight into electricity. We have used 40 watts mono crystalline (1kg) solar panel.

B. Frame

The main application of frame is to carry all components on it & strong enough to bear all the operating loads. The frame is made of mild steel L type angle.

C. Sprocket

It is a disc having tooth on its periphery to mesh with chain. Sprocket is made of mild steel. It is used for transfer rotary motion from one shaft to another.

D. Crank

The function of crank is to transfer motion from motor to the connecting rod.

E. Connecting Rod

The main application of connecting rod is to convert rotary motion into reciprocating/linear motion. Here we convert rotary motion into reciprocating using crank and connecting rod mechanism.

F. Pump

It consist of piston and cylinder arrangement, it has a lever to operate the motion of piston in reciprocating direction.

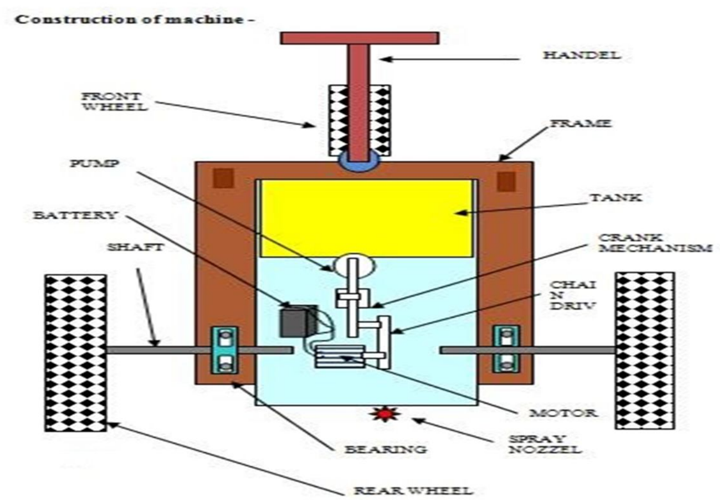

Fig 01 Construction of solar agricultural sprayer

IV. WORKING

Here we convert rotary motion into reciprocating using crank and connecting rod mechanism. Rotary motion is created by solar panel charged battery. The rotation of wheel is reducing by chain drive because we need more torque to operate pump to pressurize pesticide tank. So we use small sprocket on wheel shaft and big sprocket on crankshaft. The reciprocating motion of connecting rod is given to reciprocating pump. The pump sucks air from atmosphere and fills it in tank by non-return valve mechanism. The pressure inside tank pushes liquid out through nozzle.

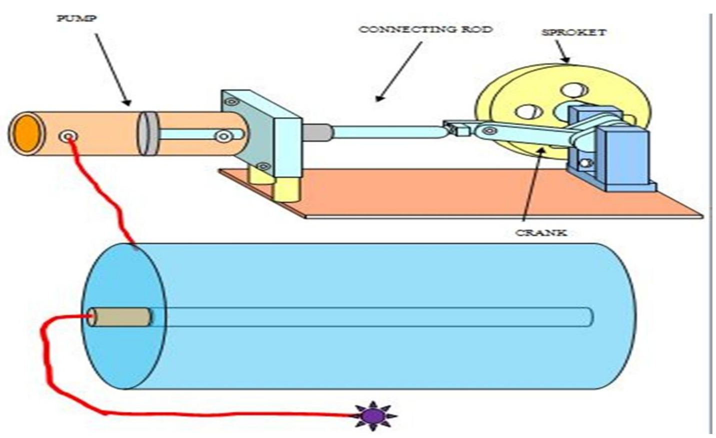

Fig 02 Working of solar agricultural sprayer

Design of solar agricultural sprayer
Pump capacity
Pump Capacity= (Boom requirement)*(1.2)
Boom requirement=Nozzle flow rate (gpm)

1.2=factor to provide agitation and offset pump wear (20% greater capacity).

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$$gpm = \frac{gpa \times mph \times w}{5940}$$

gpm = gallons per minute, the nozzle flow rate.
GPA = gallons per acre, a decision made based on label recommendations, field conditions, Spray equipment and water supply.
Mph = the ground speed you select, miles per hour.
Boom requirement (gpm) = (gpa *mph*w)/5940, gpm = (15.87*3.1*47.2)/5940

Pump Capacity= (Boom requirement)*(1.2)

Pump capacity (Q) = 0.39*1.2

=0.468 gpm

=1.78 lit/min

=1780 cm^3/min

Q= ALN/60

A=area of the piston, L=length of the stroke & N-speed of the piston

Diameter of wheel=622mm

V=5km/hr.

W=v/r= (5000*1000)/ (60*311)

268 rad/min

N=W/ (2* π)

=268(2* π)

=42.5 rpm

Q= (π/4 * D*D*L*N)/60

1780= (π/4 *D*D*D*2.5*42.5)/60

D=10.85CM

Therefore,

L=27.14CM

Design of motor

Power of Shaft = P = 17 watt

Power transmitted by shaft,

$$P = \frac{2\,\pi\,N\,T}{60}$$

Where, N→ Rpm of motor shaft = 24

T →Torque transmitted

2π x 24

17 = ---------------------- x 10^3

60

<u>T= 6.76 x 10^3 N-mm</u>

No. of teeth (Gear) , N1 = 12

No. of teeth (sprocket) N2 = 36

Ratio = R = 1: 3

Torque on sprocket = 3 × T

= 3 × 6.76

= 20.280 x 10^3 N-mm

Diameter Of sprocket,

Periphery = π × diameter of sprocket

36 × 6.25 = π × D

D = 36 × 6.25

π

<u>D = 72 mm</u>

Torque transmitted,

T = Force × radius

20.280 x 10^3 = F × 36

F = 563.33N

F = 563.33 N

9.81

<u>F = 58 Kg</u>

So selection of motor is safe

Torque transmitted by shaft,

T = π/16 x τ x d^3

Select permissible shear stress (τ) from design data book.

τ = 70 N/mm^2

Therefore, 20.28 x 10^3 = π /16 x d^3 x 70

D = 12 mm.

We select diameter. Of shaft = 12 mm.

Taking FOS = 1.6

Actual diameter of shaft = 12 x 1.6 = 19.2 mm = 20 mm

For shaft diameter 20 mm we select standard bearing from design data book is P204

Design of sprocket

We know,

TRANSMISSION RATIO = Z2 / Z1 = 36/12 = 3

For this transmission ratio number of teeth on pinion sprocket is in the range of 21 to 10, so we select number of teeth on pinion sprocket as 12 teeth.
So, z1 = 12 teeth
Selection of pitch of sprocket
The pitch is decided on the basis of rpm of sprocket.
Rpm of pinion sprocket is variable in normal condition it is = 24 rpm
For this rpm value we select pitch of sprocket as 6.35mm from table.
P = 6.35mm
Calculation of minimum center distance between sprockets
The transmission ratio = z2 / z1 = 36/12 = 3 which is less than 5
So from table,
Minimum center distance = c' + (80 to 150 mm)

Where $c' = \frac{dc1 + dc2}{2}$

$c' = \frac{80 + 25}{2}$

c' = 52.5 mm

Minimum center distance = 52.5 + (100 to 200 mm)
Minimum center distance = 220 mm
Calculation of values of constants k1 k2 k3 k4 k5 k6
Load factor k1 = 1.25 (load with mild shock)
Factor for distance regulation k2 = 1.25 (fixed center distance)
Factor for center distance of sprocket k3 =0.8
Factor for position of sprocket k4 = 1
Lubrication factor k5 = 1.5 (periodic)
Rating factor k6 = 1.0 (single shift)
Calculation of value of factor of safety
For pitch = 6.35 & speed of rotation of small sprocket = 24 rpm
factor of safety = 8.55

calculation of value of allowable bearing stress

for pitch = 6.35 & speed of rotation of small sprocket = 24 rpm

allowable bearing stress = 2.87 kg / cm^2

$= 2.87 * 981 / 100 = 28 \text{ n} / mm^2$

calculation of coefficient of sag k

for horizontal position coefficient of sag k = 6

calculation of maximum tension on chain

as we know maximum torque on shaft = T_{max} = T2 = 20280 N-mm

Where,

T1 = Tension in tight side

T2 = Tension in slack side

O1, O2 = center distance between two shaft

From fig.

$$\sin \propto = \frac{R1 - R2}{150}$$

$$\sin \propto = \frac{40 - 12}{150}$$

$\sin \propto = 0.18$

$\propto = 10.36$

TO FIND θ

$\theta = (180 - 2*\propto) X 3.14/180$

$\theta = (180 - 2*10.36) X 3.14/180$

$\theta = 2.7$ rad

We know that,

$T1/T2 = e^{\mu\theta}$

$T1/T2 = e^{0.35 \times 2.7}$

T1 = 2.57T2

We have,

T = (T1 – T2) X R

20280 = (2.57 T2 – T2) X 40

T2 = 323 N

T1 = 2.57 X 323

T1 = 830 N

So tension in tight side = 830 N

We know,

Stress = force / area

Stress induced =830/ (3.14 * 3^2 / 4)

Stress induced = 117 N /mm^2

As induced stress is less than allowable stress = 320N /mm^2 design of sprocket is safe.

Design of link

M = 40 x 580 = 23200 N mm

Now using the relation

Fb = M / Z

Fb = 23200/ 106

Fb = 217.5 N / mm^2

Design of angle -

Here the angle is subjected to bending failure

Max bending moment = W x L

W = applied load assume 30 kg = 30 x 9.81 = 300 N

L = length of frame = 650 mm

M = 300 x 650 = 195000 N mm

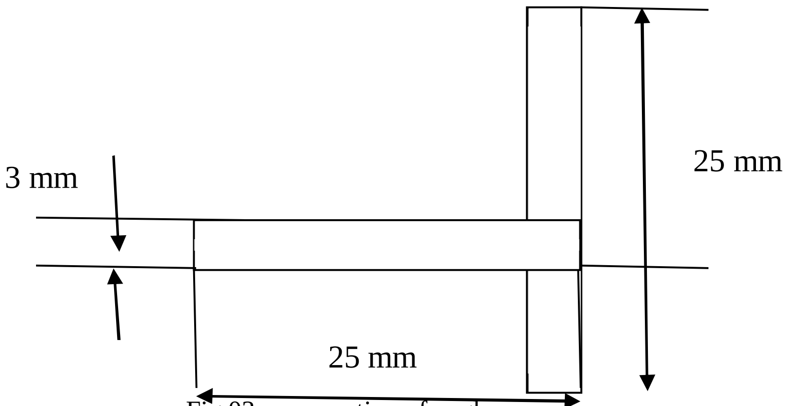

Fig 03 cross section of angle

Section modulus of l section

$Z = (B^3 - b^3)/6$

$Z = (25^3 – 22^3) / 6$

Z = 829.5

$Z = 829.5\ mm^3$

Induced stress in frame

Fb induced = M / z

Fb induced = 195000 /829.5 = 235 N $/mm^2$

Fb allowable = 320 N $/mm^2$ from material hand book.

As induced stress is less than allowable stress the design is safe.

V. CONCLUSION

The huge demand of extracting energy is never ending, and generating power from non-conventional energy source like solar, is met by this project. The design and fabrication of this project was successfully handled and every dimension was calculated by referring to published research on this topic. The ideal output was 20v supply from solar panel. Thus the aim of producing economical sprayer was met successfully. This success in achieving our aim would prove beneficial in implementing this project on practical basis.

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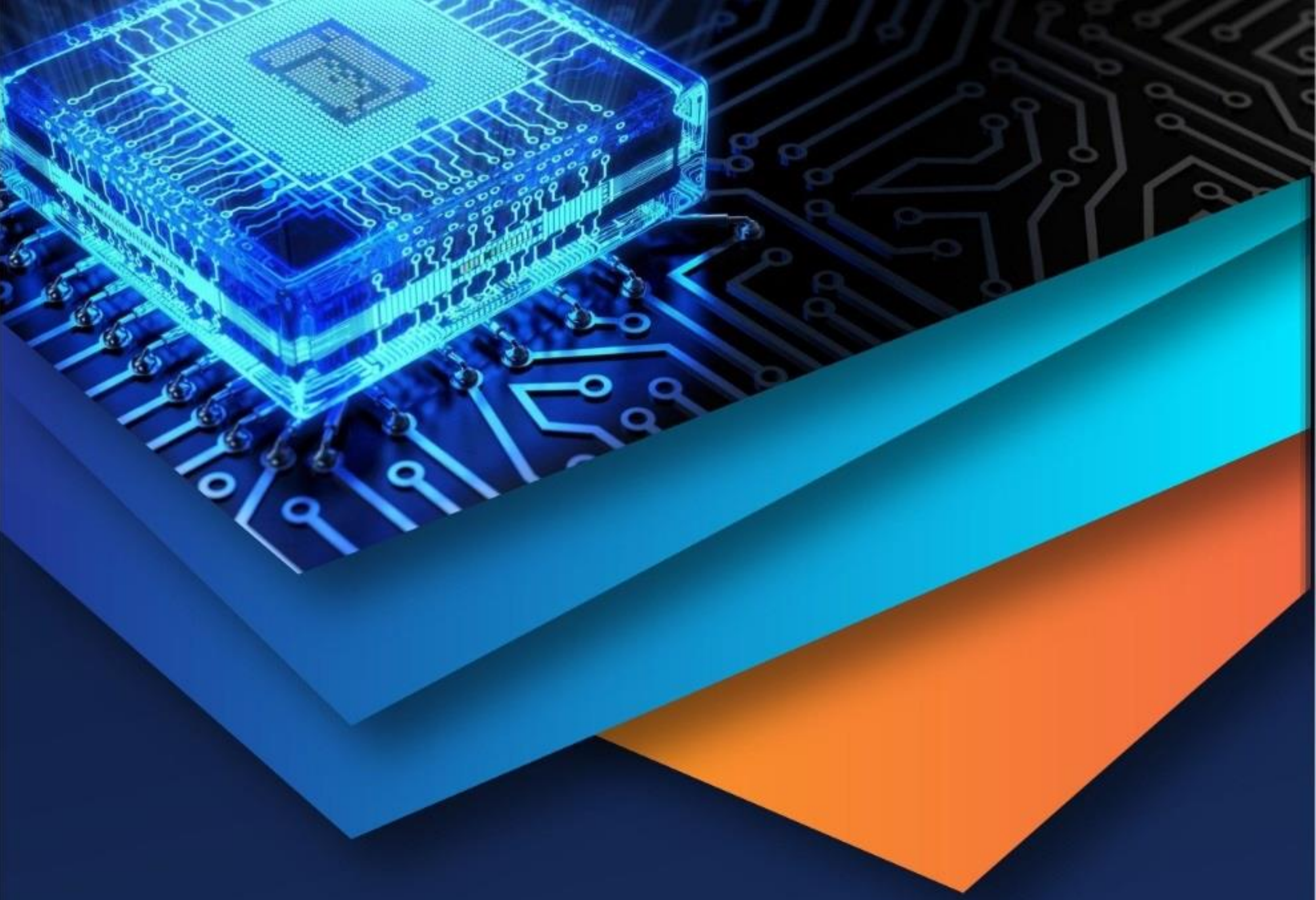

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