A PUMP STORAGE PLANT WITH ZERO PUMPING EFFORT

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ABSTRACT

A pump storage plant is a special type of hydro-power plant where turbine serves the purpose of both generating & pumping. During generation phase turbine works like a turbine & during pumping phase works as pump. Pump storage plant is used as a subpart of a large generating station during the peak hours of load demand. But it has a special advantage that it can works with fix volume of water by re-cycling it. So it can be use to produce electricity for a small locality where slope/ elevation & geographical condition is favorable to set up a pump storage plant. But the main disadvantage is the pumping coz during the pumping it takes electricity from produced electricity so the net output is very low. To reduce the pumping cost an alternative idea has been introduced here. See-saw has some machining advantages & its reciprocation can be use to run reciprocating pump. So if a park is constructed with estimated numbers of see-saw it can reduce the pumping cost up to some extent.

Keywords: *See-saw, estimation of see-saw, optimum numbers & dimension.*

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INTRODUCTION

During pumping stage no electricity is produced the pumping is done only to circulate water from lower reservoir to higher reservoir. To reduce pumping cost see-saw pumps have been introduced. A see-saw is a lever pivoted at the middle & revolves w.r.t a fix point i.e fulcrum. Two weights are placed at the two ends of the lever & the see-saw revolves due to the moment of the weight. This revolution can convert into reciprocation to lift up water.

WORKING OF SEE-SAW PUMP

Fig-1

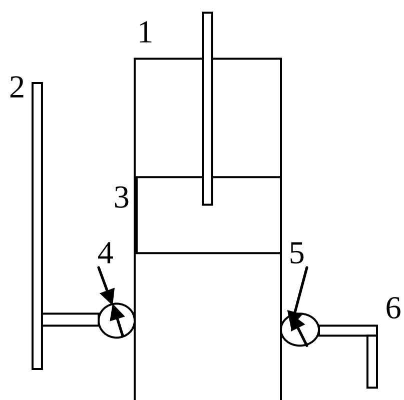


Fig-2

(1- Pump Cylinder, 2- Delivery pipe, 3- Plunger, 4 & 5- One-way Valves, 6- Suction Pipe)

$$Power\ required\ to\ drive\ the\ pump(KW) = \frac{\rho g A L N (h_s + h_d)}{6000}$$

Where, ρ= Density, g= Acceleration due to gravity, A= Cross-Sectional Area, L= Stroke Length, N= r.p.m, h_s= Suction Head & h_d= Delivery Head.

Specification of a See-Saw pump:-

Stroke length of plunger	220 mm-300 mm
Safe strokes	40 nos per minute
Discharge of pump with 30 nos/ minute	1500- 2000 lph
Total Weight of the pump	600 Kg
Total area required to operate the pump	9 sq.meter
Maximum Suction Head	80 meter
Delivery head	6 meter
Diameter of cylinder	120 mm

Now the required power to drive this pump according to above mentioned formula= 3.10 KW.

CALCULATION FOR PUMP STORAGE PLANT

Specification of a Pump Storage Plant:-

Upper reservoir height	80 meter
Upper reservoir surface area(A)	3000 sq.meter
Length of Panstoke	120 meter
Average water head in upper reservoir(h)	5 meter
Time required to empty reservoir(t)	20 hours=72000 sec
Diameter of panstok	0.8 m

Volume of water available in Upper reservoir =$A \times h \ m^3 = 3000 \times 5 = 15000 \, m^3$.

Time required to empty (t) = 72000 sec.

$Now, Q \times t = A \times h = 15000$

$Q = 0.20 \, m^3$/sec (Q= Discharge through panstoke)

$Velocity\ at\ the\ inlet\ of\ the\ panstoke(v) = \sqrt{2gh}$ = 9.89 m/s.

$Head\ loss\ due\ to\ friction\ in\ penstoke(h_f) = \frac{fLv^2}{2gd}$ $(Where, f = frictional\ factor)$

$$h_f = 17.9 \cong 18\, meter$$

$$Net\ head\ of\ plant(H) = 80 - 18 = 62\, meter$$

$Now, the\ generated\ power(P) = 9.8 \times Q \times H = 9.8 \times 0.20 \times 62 = 121.52\ KW$

The mean value of generated power is= 121.52 KW.

During the total duration of running the power output varies from maximum value to minimum value. Because this output depends on water head, water flowing velocity, discharge etc.

DATA SET OF PUMP STORAGE PLANT:-

With the help of the mean value (121.52 KW) of power generation I have prepared a data set of power generation & pumping losses.

Time (Hour)	Generating Data (KW)	Pumping Data (KW)
1	120	100
2	100	75
3	80	63
4	110	55
5	115	70
6	105	
7	85	
8	90	
9	117	
10	150	
11	180	
12	200	

Consider a Pump-Storage Plant runs for 17 hours of a day. Twelve hours for generating & five hours for pumping.

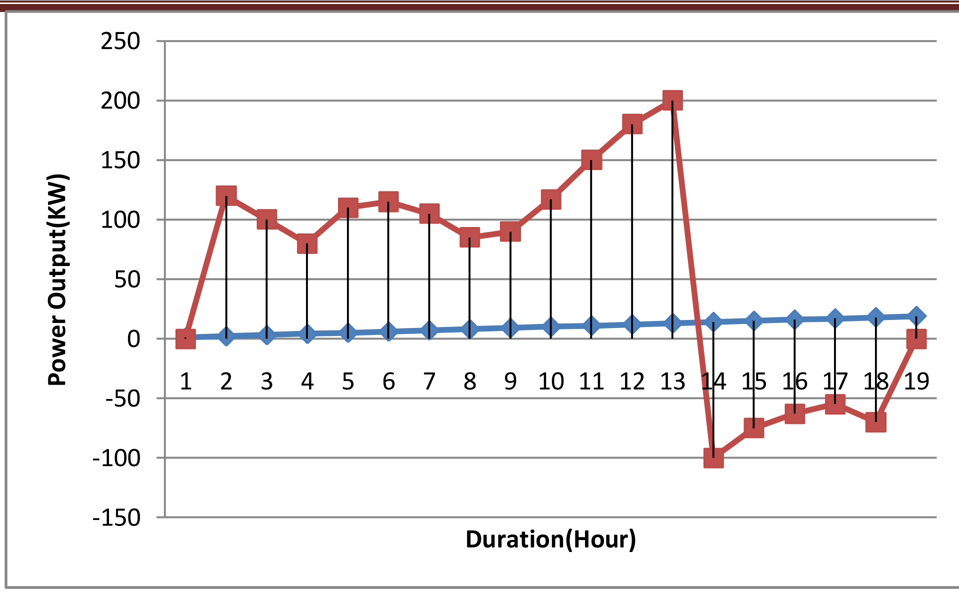


Fig-3

Upper area under the graph gives the total amount of generated power & lower area is representing the power used for pumping. Due this pumping effort the net generation of pump storage plant is less. To reduce the pumping losses the concept of see-saw pump has been introduced.

DESIGN OF A PARK WITH OPTIMUM NUMBER OF SEE-SAW

Consider that the pump will open for 4 hours/ day (2 hours in morning & 2 hours in evening). If a pump runs for 2 hours/ day then the power required for each pump$= 3.10 \times 2 = 6.20\ KWH$.

Mean value of pumping efforts$= \frac{100+75+63+55+70}{5} = 72.6\ KW$.

For 5 hours of pumping time total effort/ power =363 KWh.

Number of see-saw pump required$= \frac{363}{6.20} = 58.54 \cong 59$.

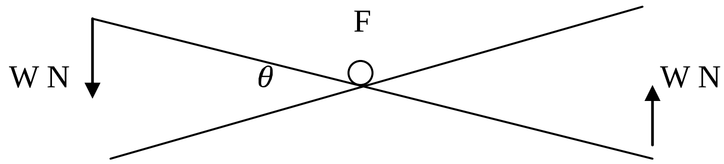
Standard formula for optimum numbers of see-saw$(\boldsymbol{n}) = \frac{\boldsymbol{QT}}{\boldsymbol{Pt}}$

Where, Q= Mean value of pumping power for a day (KW), T= Total duration of pumping for a plant (hour), P= Power required to run a see-saw pump (KW) & t= mean duration of running of each see-saw/day.

DIMENSION OF THE SEE-SAW LEVER

Consider, average weight of a child is $W\ N$.

If two boys of m kg sit at the two end of see-saw of length L then a couple of forces will form with respect to the fulcrum of the lever.



Torque$(\tau) = Weight \times Length = W \times L$

Again, torque $(\tau) = I\alpha$, $Where, I = Moment\ of\ Inertia\ \&\ \alpha = Angular\ acceleration.$

Consider, T= Time period of oscillation & maximum angular deflection= θ for each half revolution.

Angular speed $(\omega) = \frac{\theta}{T}$

For half revolution speed is clock-wise & for next half it is anti-clock-wise.

Linear Velocity $(V) = \omega \times \frac{L}{2} = \frac{\theta L}{2T}$

Linear acceleration (a)= Change in velocity within the time period T $= \frac{V-(-V)}{T} = \frac{2V}{T} = \frac{2}{T} \times \frac{\theta L}{2T} = \frac{\theta L}{T^2}$

Angular acceleration $(\alpha) = \frac{a}{L/2} = \frac{2a}{L} = \frac{2}{L} \times \frac{\theta L}{T^2} = \frac{2\theta}{T^2}$

Moment of inertia for these two mass $(I) = 2 \times m \times (\frac{L}{2})^2 = \frac{mL^2}{2}$

Now, $W \times L = I\alpha = \frac{mL^2}{2} \times \frac{2\theta}{T^2} = \frac{m\theta L^2}{T^2}$

Then, $mg = \frac{m\theta L}{T^2}\ or,\ g = \frac{\theta L}{T^2}\ \ or, \boldsymbol{L} = \frac{\boldsymbol{gT^2}}{\boldsymbol{\theta}}$

CONCLUSION

Pumping loss is the main cause of decreasing efficiency power output of pump-storage plant. Here one technique has been introduced which can eliminate or can reduce the pumping effort up to a certain extend. This technique is expensive because a park has to design for this. But every city has minimum two or three parks. Now if a new city is designed with a park based pump storage plant It can fulfill the electricity demand of that city with zero pumping cost. Here, I have already derived the formulas for optimum number of see-saw & dimension of see-saw.

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