Microhydro Design

Saturday, January 30, 2016 9:07 AM

Important to always include tailrace to reduce environmental impact due to erosion.

Story - 3" pipe from US does not fit 3" pipe in Mexico

Weir
- Back pressure
- control flow.

GATE
- Need to be able to turn off. for example for maintenance.

channel
Can be made of pipe, or concrete open channel
+ easier to build and fix
- debris addition
- crack in concrete

Settling Pool
large area for particles to fall out

Take off use water for other uses and reduce power generation
* Fire
* Ag

Microhydro Systems are very efficient 50-90%

Holding tank
gain head to drop water

Turbine generates electromagnetic or kinetic Energy
- Generates electricity by spinning wires w/magnets in USA - Always (almost)
- mechanical energy → run a mill

El Limon Microhydro example
100 families have their homes powered by Microhydro.

Channel to a self cleaning filter which is still cleaned once a week.

Everyone works 1hr/month on the system

powerhouse Tail Race goes to agriculture

Everyone works 1hr/month

Penstock goes to powerhouse. Tail Race goes to agriculture.

About 80 meters of head

Types of Systems

vary in size a lot

Pelton wheels — 4 inch diameter → greater than 10ft.

Can change the number of nozzels spraying on the wheel. Their efficiency is around 85%.

The water leaving the generator still has energy so the tail race needs to protect the environment from unnecessary erosion.

Location

· Important · balance between efficiency and cost. There is loss due to friction in pipes and electricity transmission versus the cost of pipes & transmission lines

Environmental Impacts

Can design system so there are negative impacts.

- Avoid black pipes or bury pipes
  - + protect pipe
  - − hard to find the leak
  - use stand pipes to monitor pressure

Small N. Calif. systems.

Intakes

→ need low sediment if no settling or will "sand blast" pelton wheel generator.

Pipes above ground

- + easy to fix leak
- − easy to break
- − ugly

generator.

Pipes above ground
- + easy to ~~fixx~~ fix leak
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- − ugly

Calculations

Max Power is a function of flow rate (Q) & head (H)

$$P = \frac{Q H e}{K}$$

Q: Kinetic
H: potential
e: efficiency of turbine
K: conversion factor for (flow)(height) = Power units

conversion factors are on sheet

IDEA: Have student feel the power of water by changing flow and head.

The higher your head then the smaller the pipe you can use Because your pipe must accomodate Q = the flow.

$$P_{max} = \frac{Q_{max} H_{max} e}{K}$$

Q_{max}: Max take (GPM)
P_{max}: Power (KW)
H_{max}: Max accessible height w/out lost (ft)
e: $e = 1$ (100% efficiency impossible)

Each of these (Q & H & e) are lower in real life.

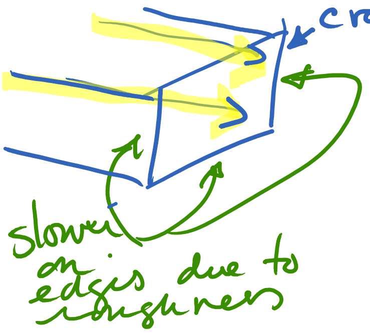
CALCULATIONS AFTER FIELD WORK

Flow rate is the same along the stream as long there are no tributaries or diversions.

- This is a reasonable assumption.

- Demo of two people walking at
  1) same speed
  2) behind slower
  3) infront slower

This demo shows that water has to go @ the same few rate as a group. Imagine once everything is moving (not turning off & on). So lengthwise water flows at same rate.



But in a cross-section the velocity of the water varies due to edge effects water flows slower on edges – the rougher the edge – the slower the water flows.

Assumptions / Given

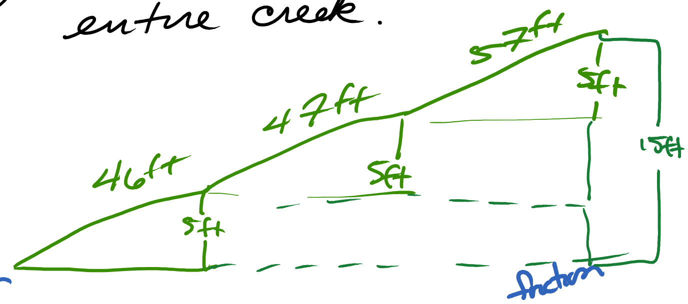
This estimate is the flow for the entire creek.

$Q_{max} = 1000 \frac{\text{gallons}}{\text{min}}$ (GPM)

$H_{max} = 15$ feet (ft)

Run = 150 ft

$e_{turbine} = 0.88$



manufacturer says 88% efficiency – we still need to compute losses due to pipes.

Assume 10% take – meaning we would only take 10% of the flow due to environmental constraints

$$P_{max_{10\%}} = \frac{(Q_{max})(10\%)(H_{max})}{K} = \frac{(100\ \text{GPM})(15\text{ft})}{5310\ \frac{(\text{Gal})(\text{ft})}{(\text{min})(\text{KW})}} = 0.282\ \text{KW}$$

$P_{max_{10\%}} = 282\ \text{W}$

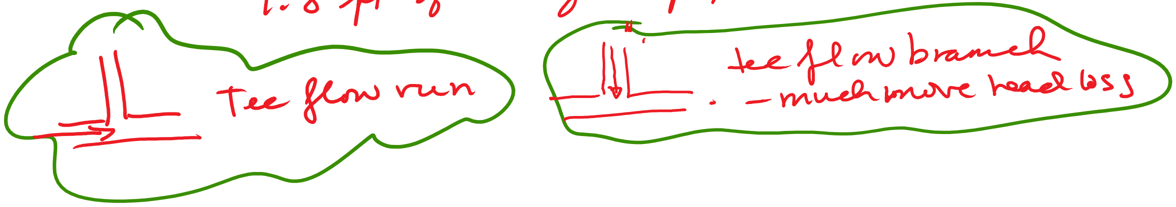
$P_{net_{10\%}}$? we know $Q_{net} = Q_{max}(10\%) = 100$ GPM

To find H_{net} we need to figure out the friction losses using tables.

Table 1 tells how much head is loss due to size of pipe

Table 2 tells how much head is lost due to a fitting

e.g. 45° elbow given 1 inch pipe is equivalent to 1.8 ft of straight pipe e.g. 45° elbow given 1 inch pipe is equivalent to 1.8 ft of straight pipe



Back to our imaginary system assume 3" pipe

Qty	fitting	Equivalent length	total
2	90°	7.9	15.8
1	45°	4.0	4.0
2	Gate valve @ top & bottom	6.2	6.0
0	T branches	0.0	0.0
15	adapters	6.5	97.5
150	pipe	1.0	150
			286 ft

We started w/ 150ft but we have equivalent friction loss of 286ft

PFHL (Pressure foot head loss) for 3" pipe is $\frac{2.3\,ft_{head}}{100\,ft_{pipe}}$

Head loss $= H_{Loss} = \text{Equivalent length} * PFHL$

$$= 286(ft)_{pipe} * \frac{2.3\,ft_{head}}{100\,ft_{pipe}}$$

$$= 6.58\,ft$$

$$H_{net} = H_{max} - H_{Loss} = 15ft - 6.58ft = 8.42ft$$

$$P_{net} = \frac{Q_{net} H_{net} e}{K} = \frac{(100\,GPM)(8.43\,ft)(0.88)}{5310\ \frac{(gal \cdot ft)}{(min)(kW)}}$$

$$= 0.139\,kW$$

Can calculate loss from $P_{max_{100\%}}$ vs $P_{net_{0\%}}$

$= 0.139\ kW$

$= 139\ W.$

Loss from $P_{max_{100\%}}$ vs $P_{net_{0\%}}$

Comments

- Note that flow is 24hrs vs solar panels.
- can do this calculation month by month for flow variation and demand variation
- often batteries can not store over the seasonality of change in flow.

Resource

Be sure to check out interative spread sheet so you can do calculations assuming different configurations. Also, at the bottom of the interative spread sheet there is a graph which shows the impact of pipe size on different flows.

Design

Students can be invited to design a system given flow & financial constraints.