53:071 Hydraulics and Hydrology Project #1

Pelton Turbine

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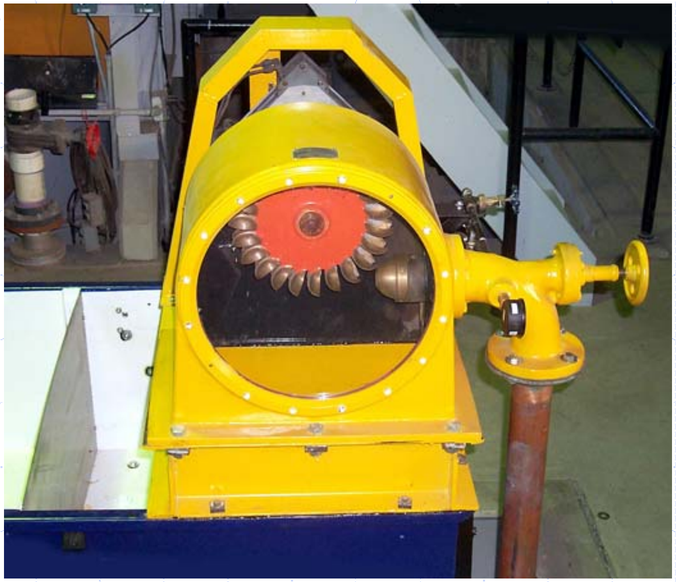
Problem Statement

- A children's museum in Colorado has purchased a small Pelton turbine for its new display on renewable energy.



Problem Statement

- The museum wishes to operate the turbine (with available flows) and sell the power on the open market.
- You have been hired as a consultant to the museum.

Project Objective

- To determine energy (kWh) that can be generated from the laboratory-scale Pelton turbine, and the revenue it can generate ($/year) for the museum.

Site Information

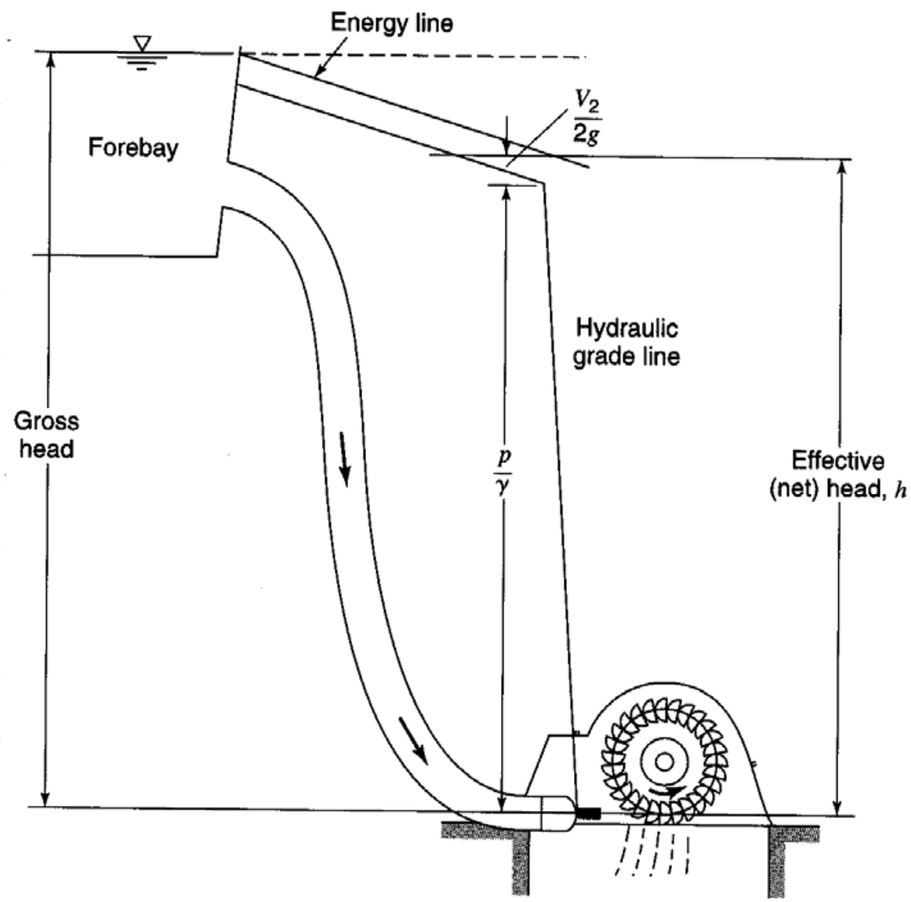


Figure 13.2.4 Definition sketch for impulse-turbine installation (from Linsley et al. (1992)).

- The effective head for operations at the site is ~XX ft
- Variations in the forebay elevation are assumed to be minor

Operational Information

- The museum will operate the turbine 7 days a week (9 am to 4 pm).
- The museum has secured water rights to operate the turbine at the following flow rates:
  - Q: 0.XX cfs in the winter (Nov-Mar)
  - Q: 0.0X cfs in the summer (Apr-Oct)

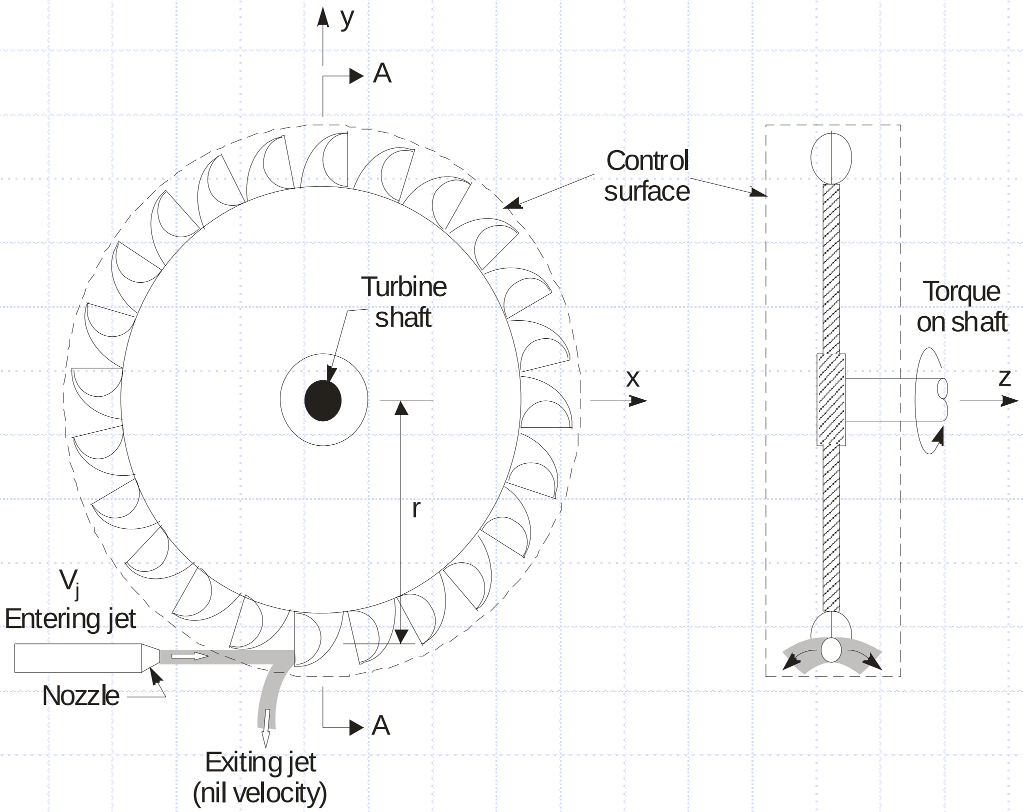
Laboratory Component

- Determine the energy conversion efficiency of the laboratory-scale Pelton turbine for the proposed operating conditions ($H_{available}$, Q)

Engineering Analysis Components

- Compute the energy produced (kWh/yr) if operated as planned.
- Estimate the revenue that can be generated if the energy is sold on the open market ($/year).

Principle

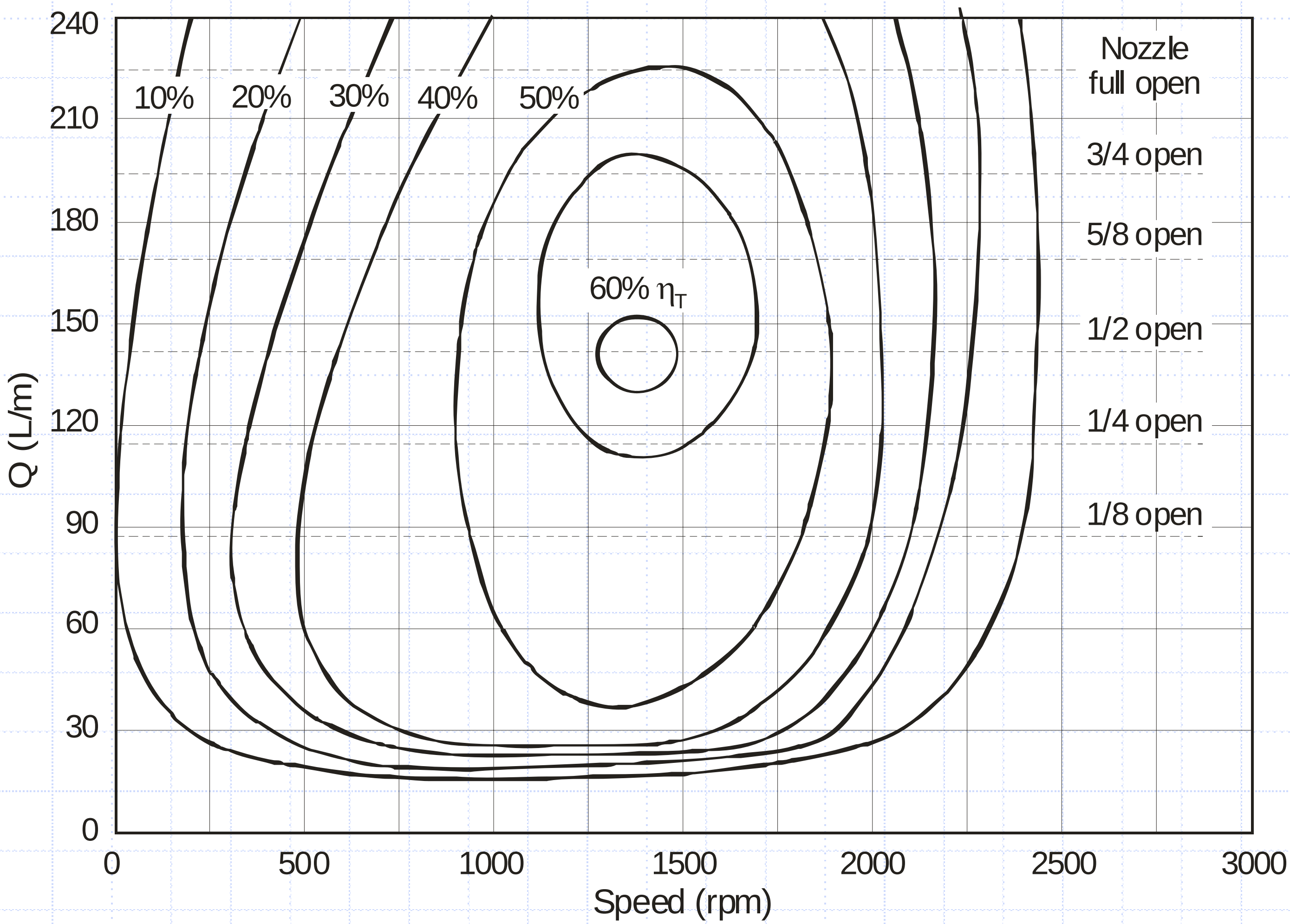


$$P_{available} = QH_{available}$$

$$P = \omega T = 2\pi NT$$

$$\eta = \frac{P}{P_{available}}$$

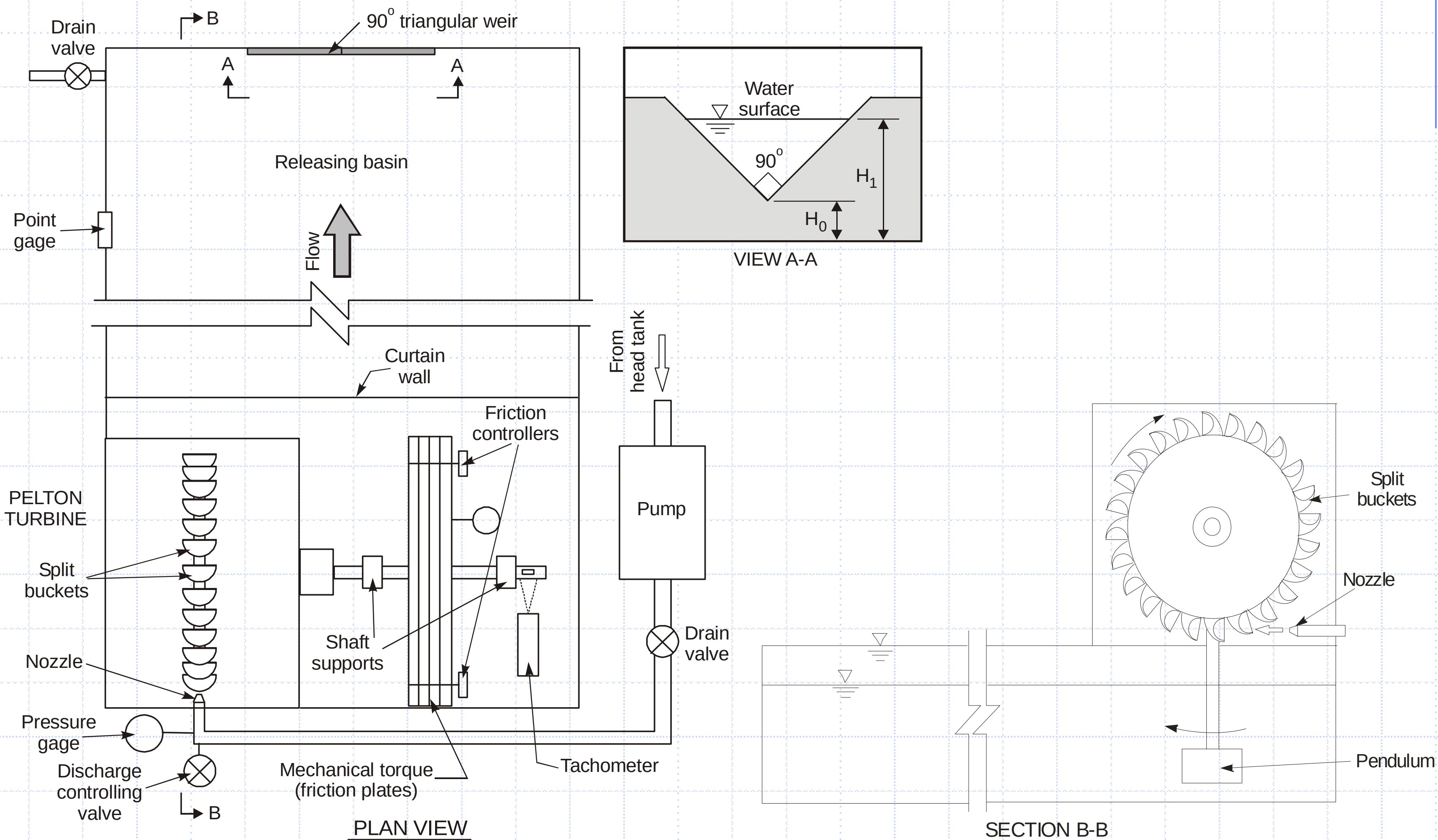
Principle


240
210
180
150
120
90
60
30
0
Q (L/m)
0
500
1000
1500
2000
2500
3000
Speed (rpm)
10%
20%
30%
40%
50%
60% η_T
Nozzle
full open
3/4 open
5/8 open
1/2 open
1/4 open
1/8 open

Laboratory Objective

- To determine energy conversion efficiency (η) for the laboratory-scale Pelton turbine for the two operational discharges (Q)

Laboratory Apparatus



Laboratory Procedures

1. Open the discharge controlling valve and record the pressure on the pressure gage.
2. Measure the head on the weir (H_1) and record the reference point (H_0).
3. Loosen the torque brake and adjust the torque gage to zero with tachometer reading of 1800 rpm.
4. Measure the rotational speed under the runaway condition.
5. Tighten the friction hand-wheels and record the torque and rotational speed.
6. Repeat Step 5 until the shaft is fully stopped.
7. Repeat Step 1 to 6 for a higher discharge with a runaway speed of 2000 rpm.

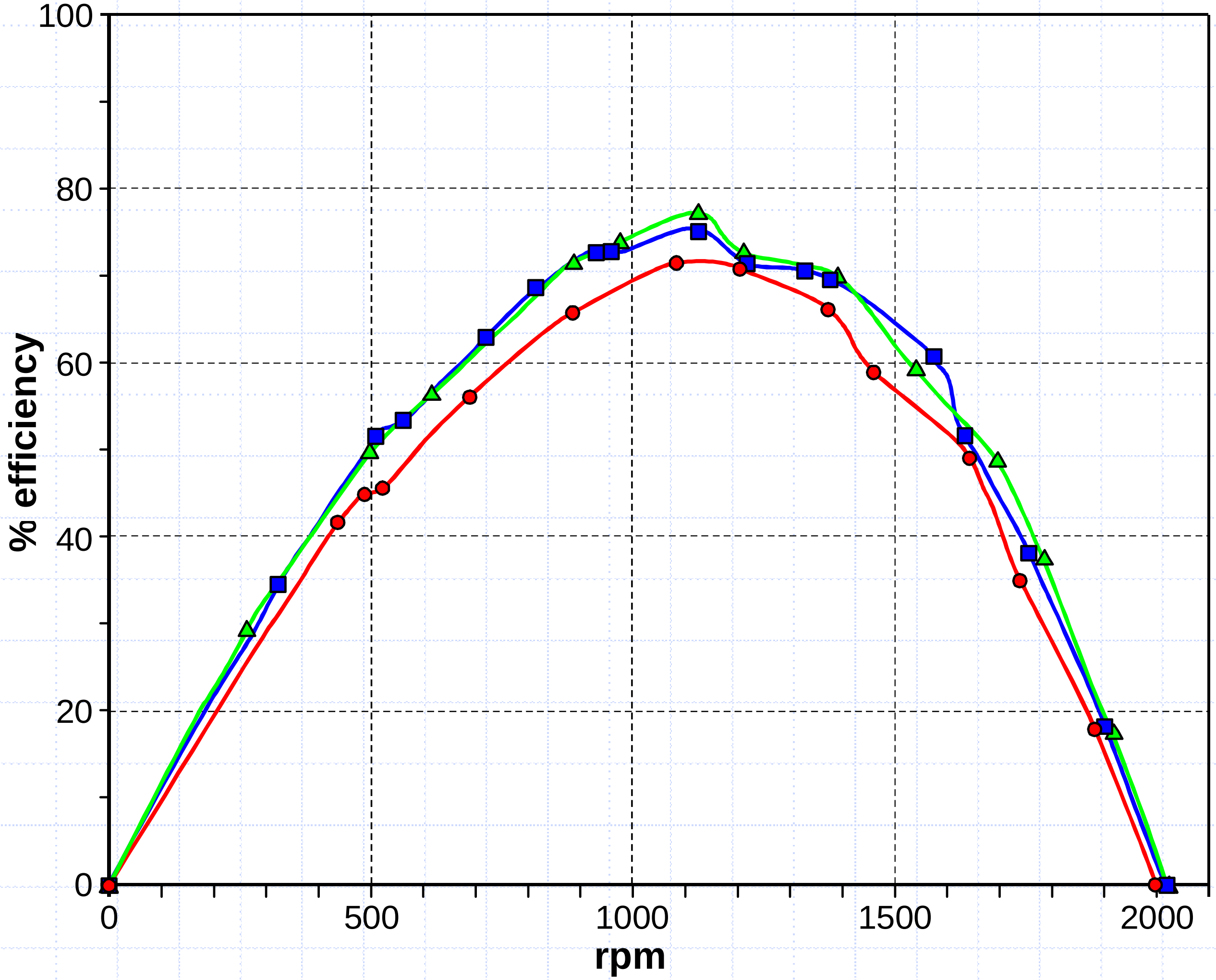
Data Sheet

	Data Acquisition					Data Reduction				
	H_0	H_1	Pres.	T	N	Q	γ	P_{avai}	P	η
Run 1										
Run 2										

Laboratory Analysis

- Determine the discharge using $Q=2.49(H_1-H_0)^{2.48}$.
- Determine the efficiency of the turbine.
- Plot the rotational speed vs. the efficiency of the turbine.
- Show results for the two different discharges.

Sample Result



Engineering Analysis

- Recommend a turbine operating condition (e.g., rotational speed) for the winter and summer operations.
- Determine the energy generation (kWh/yr) for the recommended operating condition.
- Estimate the revenue generated ($/yr).
- Provide the client (the museum director) with a *concise* report that answers the project objectives