Hydropower

UNIT- 33-34

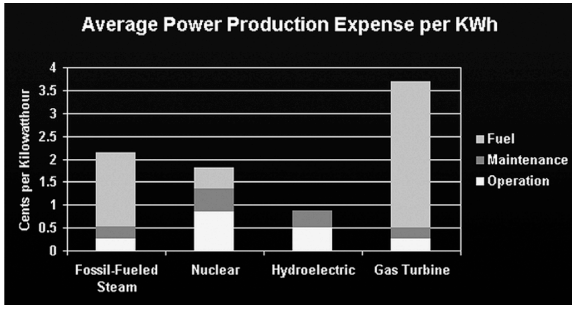
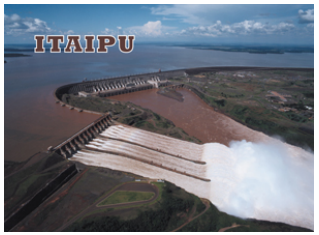


fig_03_01

Major plants in World

Three Georges, 18460 MW, China

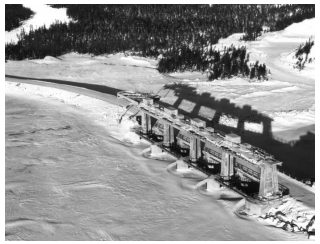
Itaipu, 14750 MW, Brazil/ Paraguay



Major plants in Canada

James Bay, 5616 MW

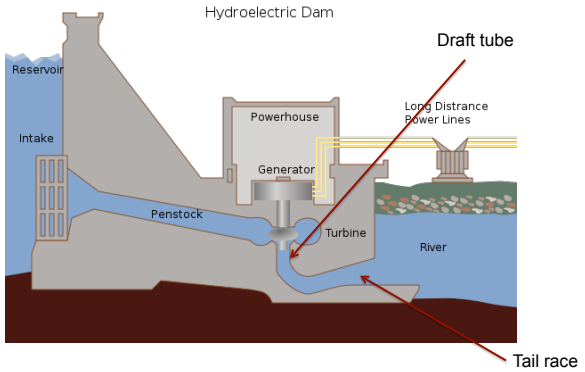
Churchill Falls, 5429 MW



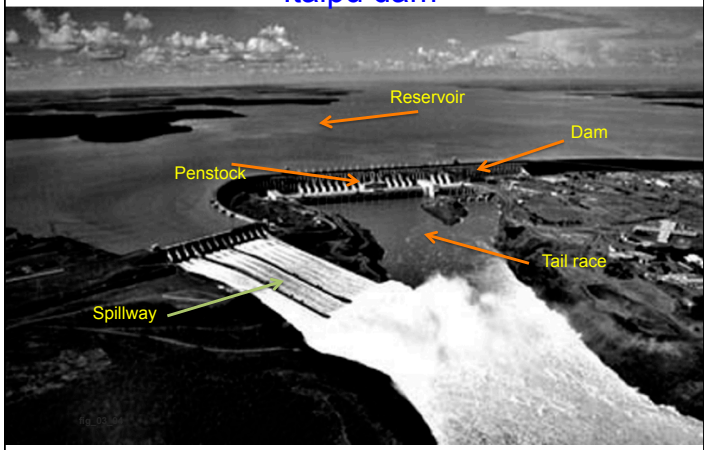
Some components of hydro plants

1. **SPILLWAYS** release water downstream that is not used to make energy
2. **Penstock** collects water from a upstream leading it to the turbine
3. **Draft tube** is the passage below turbine
4. **Tailrace** is the water passage from the draft tube to the river downstream
5. **Surge tank** is a reservoir that vents sudden pressure built up in turbine.

Components of hydroelectric plants



Itaipu dam

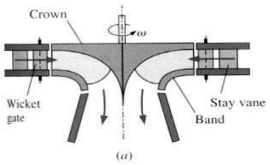


TURBINES CHOICE

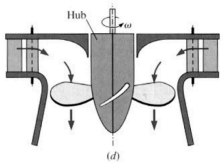
(Dynamic machine to extract energy from fluid)

1. **Reaction** (Static pressure changes) :
   Converts both Flow & Kinetic energy
   1.1 Axial flow or propeller turbine (Kaplan, Bulb)
   1.2 - Radial or Mixed flow (Francis turbine)
2. **Impulse:** (Static pressure unchanged)
   Converts only Kinetic energy
   2.1 -Tangential flow on buckets (Pelton)

Reaction turbines



Francis turbine



Kaplan turbine

fig_03_11

1.1 Kaplan Turbine

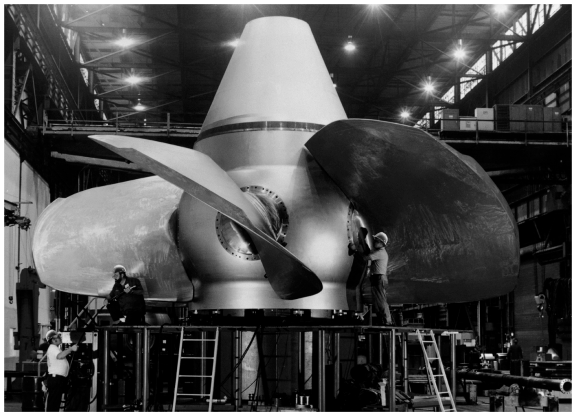
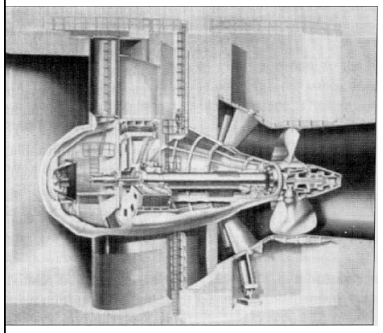


fig_03_20

1.1 Axial flow (Bulb) Turbine (propeller type) (Reaction)



- Used for very low head high volume flow
- Ideal for tidal power plant –

1.2 Francis Turbine

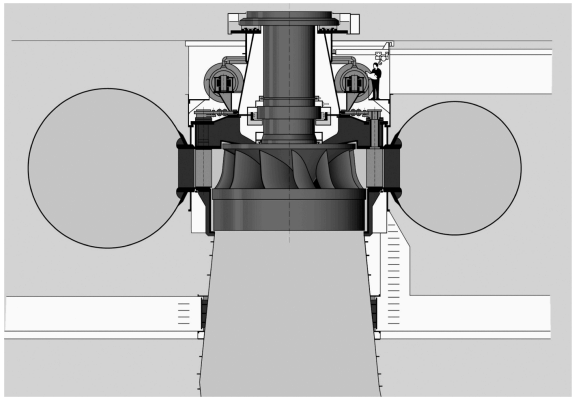


fig_03_18

2.1 Pelton (Impulse) Turbine

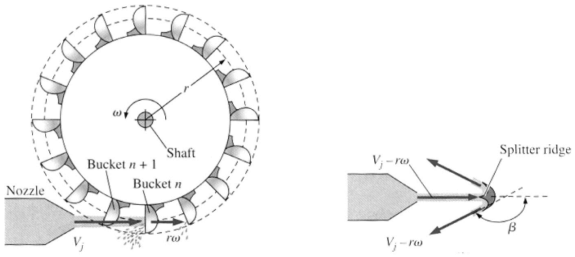
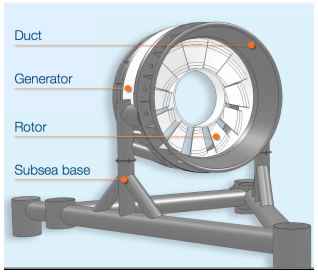


fig_03_10

2.1 Pelton turbine photograph

fig_03_13

1 MW in-stream (axial flow) turbine in Nova Scotia



Hydraulic analysis

$$\frac{P_A}{\rho g} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B + H_L + \Delta H_T$$

Power extraction,
P = density x flow rate x head difference across turbine
$P = (\rho Q)\,(\Delta H_T g)$

Specific Speed

- To help selection of a turbine we need a parameter which will include all items except for the size.
  Specific speed is such a parameter.
- Dimensionless Sp. speed Ω_T **for turbine**

$$\Omega_T = \frac{C_P^{0.5}}{C_H^{1.25}} = \frac{\omega\sqrt{P}}{\sqrt{\rho}(gH)^{1.25}}$$

Where ω is in rad/s, Q, H, P, ρ are in m^3/s, m, watt and kg/m^3. where H is height difference.

- Specific speed refers to the best efficiency condition of a particular machine.
- The 'best' efficiency of a family of machines depends on its specific speed
- Specific speed allows one to represent the whole family of machines by a single plot.

Range of dimensionless Specific speeds for turbine

Types	Application	Turbine specific speed (Ω_T)
Axial flow	High flow, low head	7.0 – 14.0
Mixed flow		3.5 – 7.0
Centrifugal or Radial flow		1.0 – 3.5
Impulse	High head	0 – 1.0

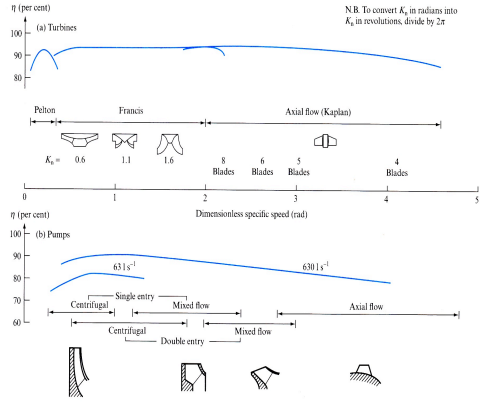
Specific speed with dimensions

- Specific speed Ω_P is dimensionless, but sometime g or ρ is dropped making Specific speed dimensional N'_{sp} (SI) or N'_{sd} (British):
- $$N'_{sd} = \frac{N\sqrt{HP}}{(H)^{1.25}} \quad \text{Imperial unit}$$

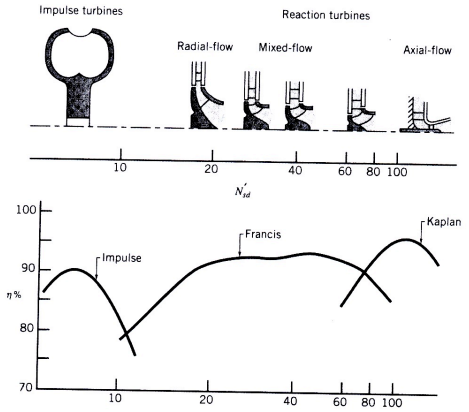
  where N - rpm, HP- horsepower, H –ft
- $$N'_{sp} = \frac{N\sqrt{P}}{H^{1.25}} \quad \text{SI unit}$$

  where N - rpm, P- kW, H –m

Efficiency vs Non-dimensional Sp. speed



Efficiency against Dimensional specific speed



Dimensional specific speed in Imperial units

Choice of turbine type depends on specific speed

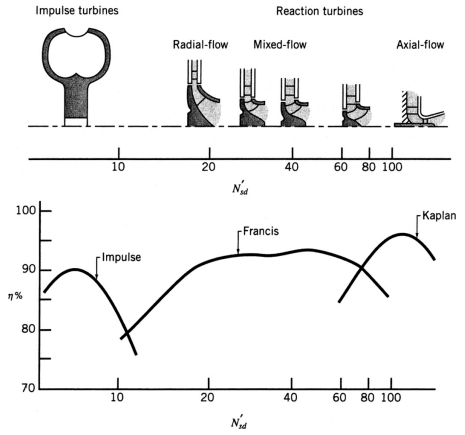


fig_03_09 Dimensional specific speed in Imperial units

Micro-hydro

- **Micro hydro is a term used for** hydroelectric power installations that typically **produce up to 100 kW** of power. It can provide power to an isolated home or small community.
- Micro hydro is frequently accomplished with pelton wheel for high head, low flow.
- There are currently about 2000 MW worth of installed small hydro capacity in Canada.
- Nova Scotia operates about 40 small hydro plants supplying about 11% of provincial capacity