SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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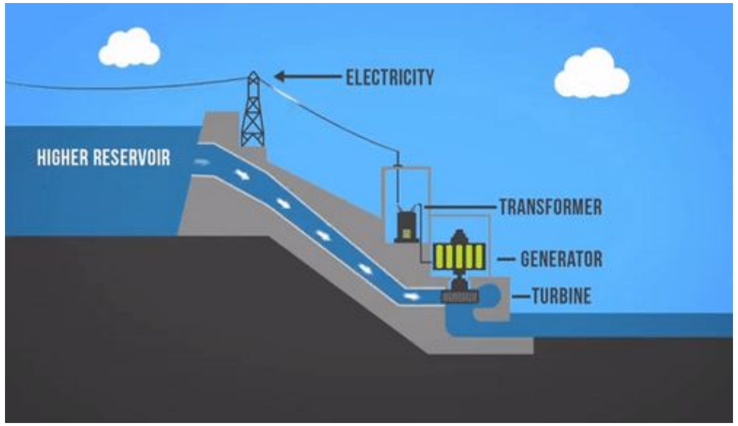
DEPARTMENT OF AGRICULTURE ENGINEERING

19MEB201 – FLUID MECHANICS AND MACHINERY

II YEAR III SEM

UNIT 5– TURBINES

TOPIC 2 – HEADS AND EFFICIENCIES



CONTENT

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- HEADS AND EFFICIENCIES
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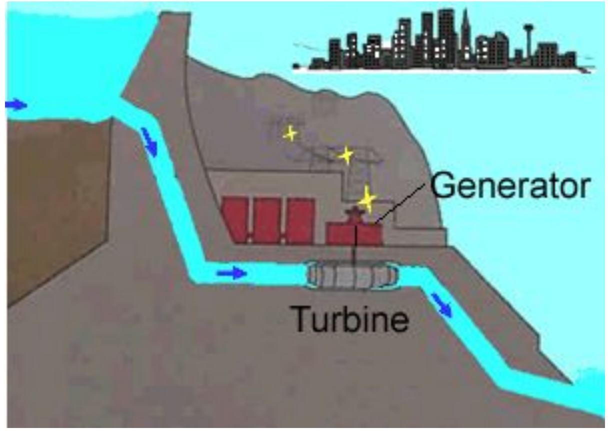


CLASSIFICATION OF HYDRAULIC TURBINES

Turbine	Action of water	Flow direction	Available head	Specific speed
Pelton	Impulse	Tangential flow	H>300m	8-50
Francis	Reaction	Mixed flow	50m<H <300m	50-250
Kaplan/Propeller	Reaction	Axial flow	H<50m	250-850

CLASSIFICATION OF HYDRAULIC TURBINES

Head Classification	Turbine Type		
	Impulse	*Reaction*	*Gravity*
High (>50m)	• Pelton • Turgo		
Medium (10-50m)	• Crossflow • Turgo • Multi-jet Pelton	• Francis (spiral case)	
Low (<10m)	• Crossflow • Undershot waterwheel	• Propeller • Kaplan • Francis (open-flume)	• Overshot waterwheel • Archimedes Screw

DIFFERENCE BETWEEN PELTON,KAPLAN,FRANCIS

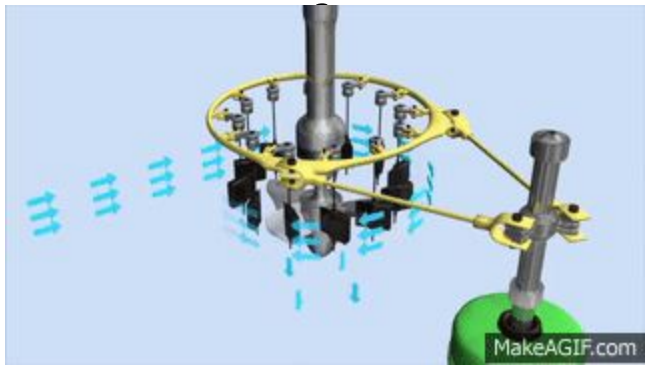
PARAMETERS	PELTON TURBINE	KAPLAN TURBINE	FRANCIS TURBINE
TYPE OF TURBINE	IMPULSE TYPE	PROPELLER TYPPE	INWARD FLOW REACTION TYPE
POWER GENRATION [MW]	400	200	800
SPEED RATE[rpm]	65 - 800	70-429	75 -1000
EFFICIENCY[%]	85	80	90

FLOW RATE

Flow Rate = the quantity of water flowing

- When more water flows through a turbine, more electricity can be produced

- The flow rate depends on the size of the river and the water flowing in it



- Power production is considered to be directly proportional to river flow

Source: https://images.app.goo.gl/UU33MUELacochoAT6

HEAD

Head = the height from which water falls

- The farther the water falls, the more power it has
- The higher the dam, the farther the water falls, producing more hydroelectric power
- Power production is also directly proportional to hea
- That is, water falling twice as far will produce twice as much electricity

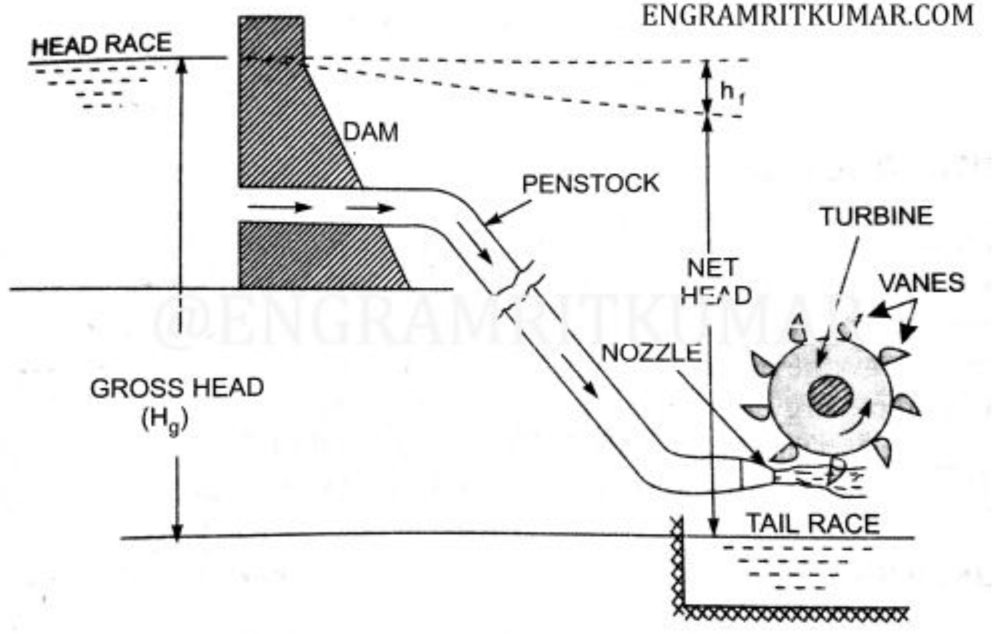
Source: https://images.app.goo.gl/EQoP2U3JEQmXQ6jCA

HEADS AND EFFICIENCIES

- Two types of heads as far as turbines are concerned—gross head and net head
- Gross head indicates the difference in head and tail race levels
- Net head is the actual head available at the turbine inlet and is computed as gross head minus frictional losses in the penstock

Source: https://images.app.goo.gl/w686bafhugu3xHkbA

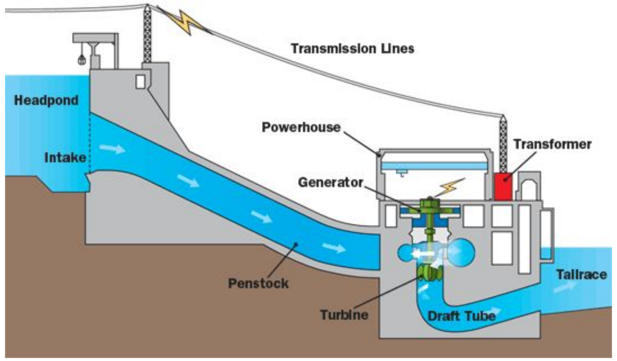
HEADS AND EFFICIENCIES



Layout of a hydroelectric power plant.

$$H_g = H_{net} + Hf$$

$$H_f = 4fLv^2/2Dg$$



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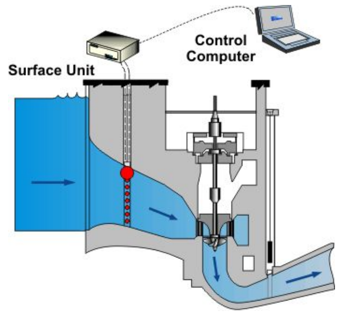
HEADS AND EFFICIENCIES

- Efficiency is usually defined as the ratio of output to the input
- The power input to the system is in the form of hydraulic energy of the stored water (equivalent to the net head) and the output is in the form of electrical energy.
- Losses in different components of the hydroelectric power plant



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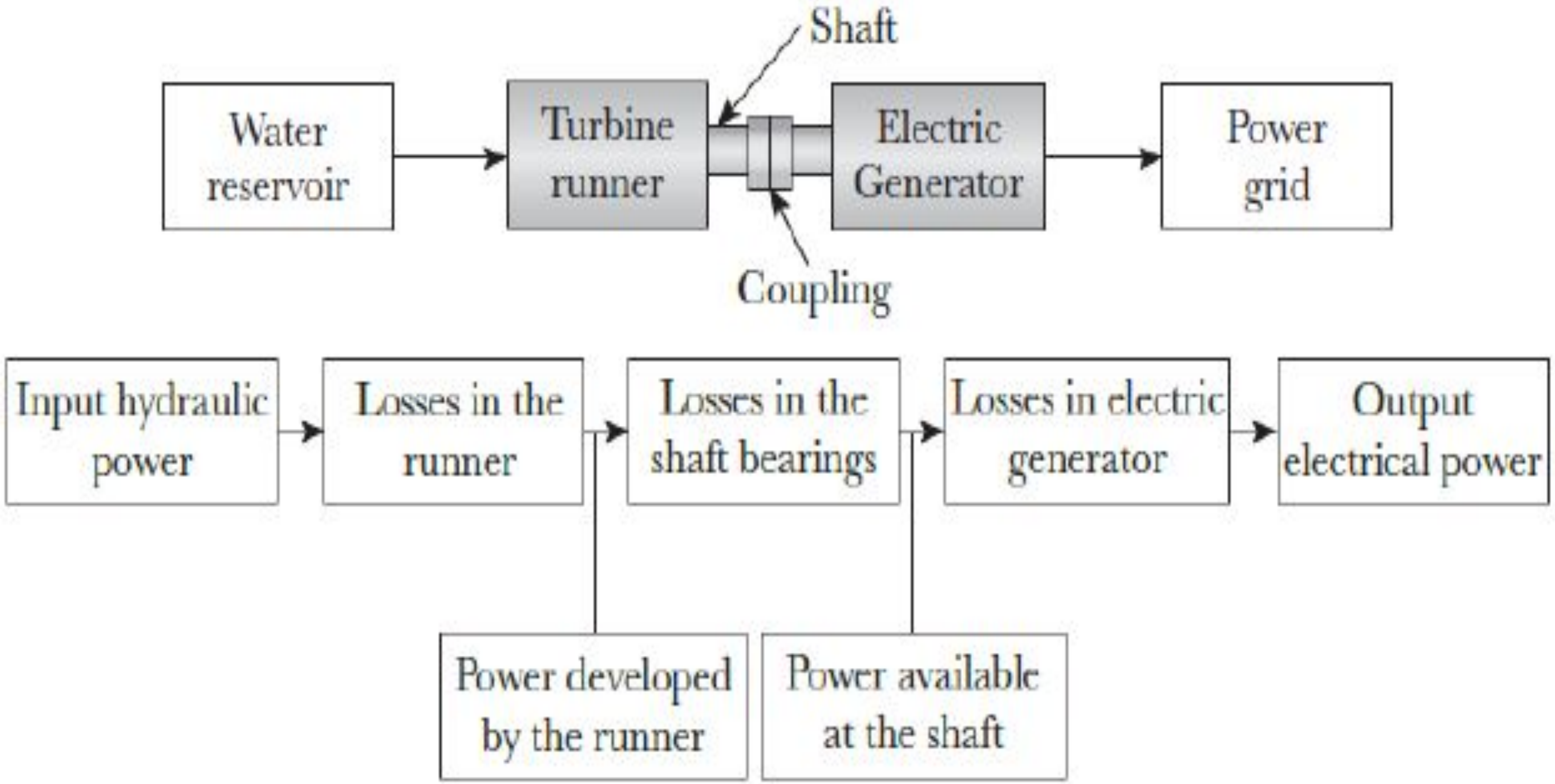
HEADS AND EFFICIENCIES



EFFICIENCIES

Efficiency	Definition	Formula
Hydraulic efficiency	$\eta_h = \dfrac{\text{Power developed by the runner}}{\text{Power available at turbine inlet}}$	$\eta_h = \dfrac{P_{\text{runner}}}{\rho Q gH}$
Volumetric efficiency	$\eta_v = \dfrac{\text{Actual discharge}}{\text{Total discharge}}$	$\eta_v = \dfrac{Q - \Delta Q}{Q}$
Mechanical efficiency	$\eta_m = \dfrac{\text{Power available at the shaft}}{\text{Power developed by the runner}}$	$\eta_m = \dfrac{P_{\text{shaft}}}{P_{\text{runner}}}$
Generator efficiency	$\eta_g = \dfrac{\text{Output electrical power}}{\text{Power available at the shaft}}$	$\eta_g = \dfrac{P_o}{P_{\text{shaft}}}$
Overall efficiency	$\eta_o = \dfrac{\text{Output electrical power}}{\text{Power available at turbine inlet}}$	$\eta_o = \dfrac{P_o}{\rho Q gH}$

A STANDARD EQUATION

- A standard equation for calculating energy production:

  Power = (Head) x (Flow) x (Efficiency)

  Power = the electric power in kilowatts or kW

Efficiency = How well the turbine and generator convert the power of falling water into electric power

This can range from 60% (0.60) for older, poorly maintained hydro plants to 90% (0.90) for newer, well maintained plants

ASSESSMENT - KAHOOT

https://create.kahoot.it/share/turbine-efficiency/8d682c31-bceb-4e4b-adf7-e207782a392f

REFERENCES

TEXT BOOK REFERENCES

- Bansal, R.K., Fluid Mechanics and Hydraulics Machines, Laxmi Publications (P) Ltd., New Delhi. 2011. 10th Edition
- Kumar. K.L., Engineering Fluid Mechanics, Eurasia Publishing House (P) Ltd., New Delhi, 2010. 8th Edison

WEB REFERENCES

- https://www.sanfoundry.com/fluid-mechanics-questions-answers-rayleighs-method/
- https://www.iith.ac.in/~ksahu/class14_FM.pdf
- https://en.wikibooks.org/wiki/Fluid_Mechanics/Dimensional_Analysis#Rayleigh_Method