TURBINES

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INTRODUCTION

- A turbo machine is a rotating device that extracts energy from or adds energy to fluids.
- Energy is transferred to or from a continuously flowing fluid by the dynamic action of moving blades or rotors.
- *"Turbines" is Latin in origin and implies that which spins or whirls around.*
- Early examples are wind mills and water mills.
- Turbines are classified as:
  - Steam turbines
  - Hydraulic turbines
  - Gas Turbines

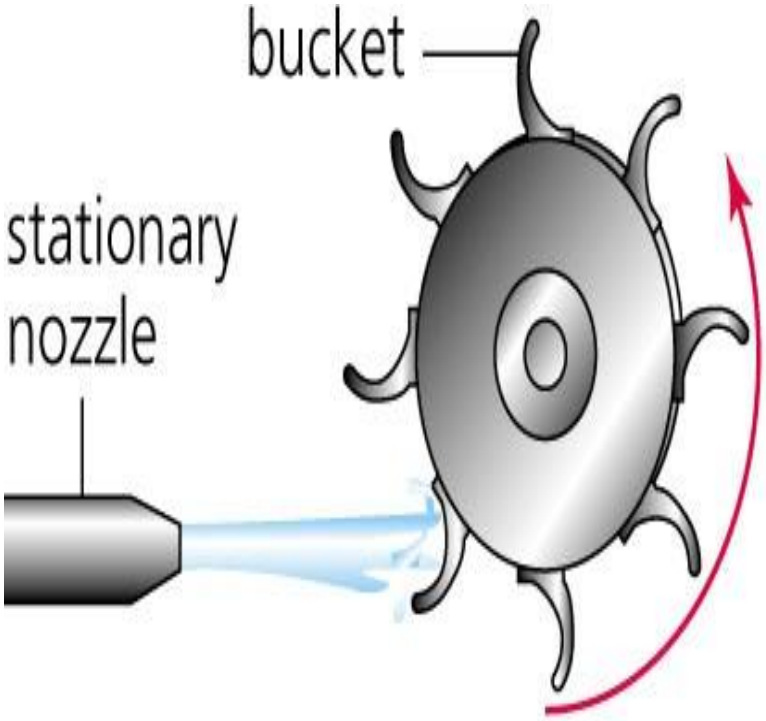
STEAM TURBINES

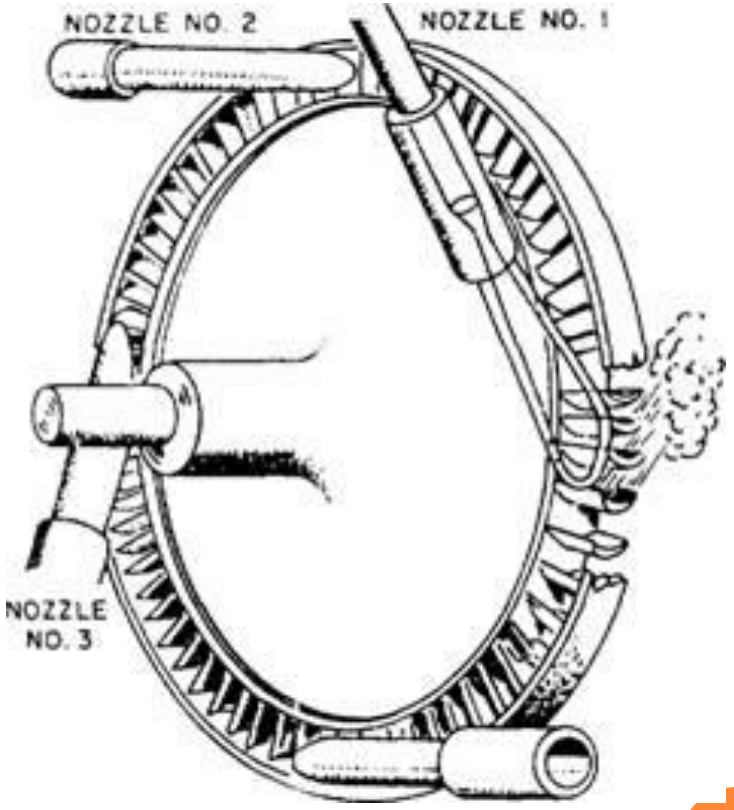
- It is a prime mover in which the heat energy of steam transformed into mechanical energy in the form of rotational motion.
- Heat energy➔ kinetic energy➔ mechanical energy of rotation
- Used as prime mover to drive the electrical generators in thermal power plants, propelling of ships, to drive uniform speed machines like centrifugal gas compressors, textile and sugar industry machineries.
- Steam turbines are made in a variety of sizes ranging from small <0.75 kW units used as mechanical drives for pumps, compressors and other shaft driven equipment, to 1,500 MW turbines used to generate electricity.
- Basic types of Steam turbines:
  - Impulse turbine *Ex: De Laval turbine* and
  - Reaction turbine *Ex: Parson's turbine*

Principle of Impulse turbine

- Steam initially expanded in nozzle from high pressure to low pressure.
- If high velocity steam from nozzle impinges onto a curved blade➔ change in direction of steam➔change in momentum➔ force, centrifugal in nature.
- Steam exerts force on curved surface of blades. The blades move in the direction of the force.
- A number of blades fixed on periphery of a disc (rotor). The successive movement of blades sets the rotor in continuous motion.
- Rotation of rotor makes all blades on rim of rotor to get exposed to steam jet in succession.

Basic principle of impulse steam turbine



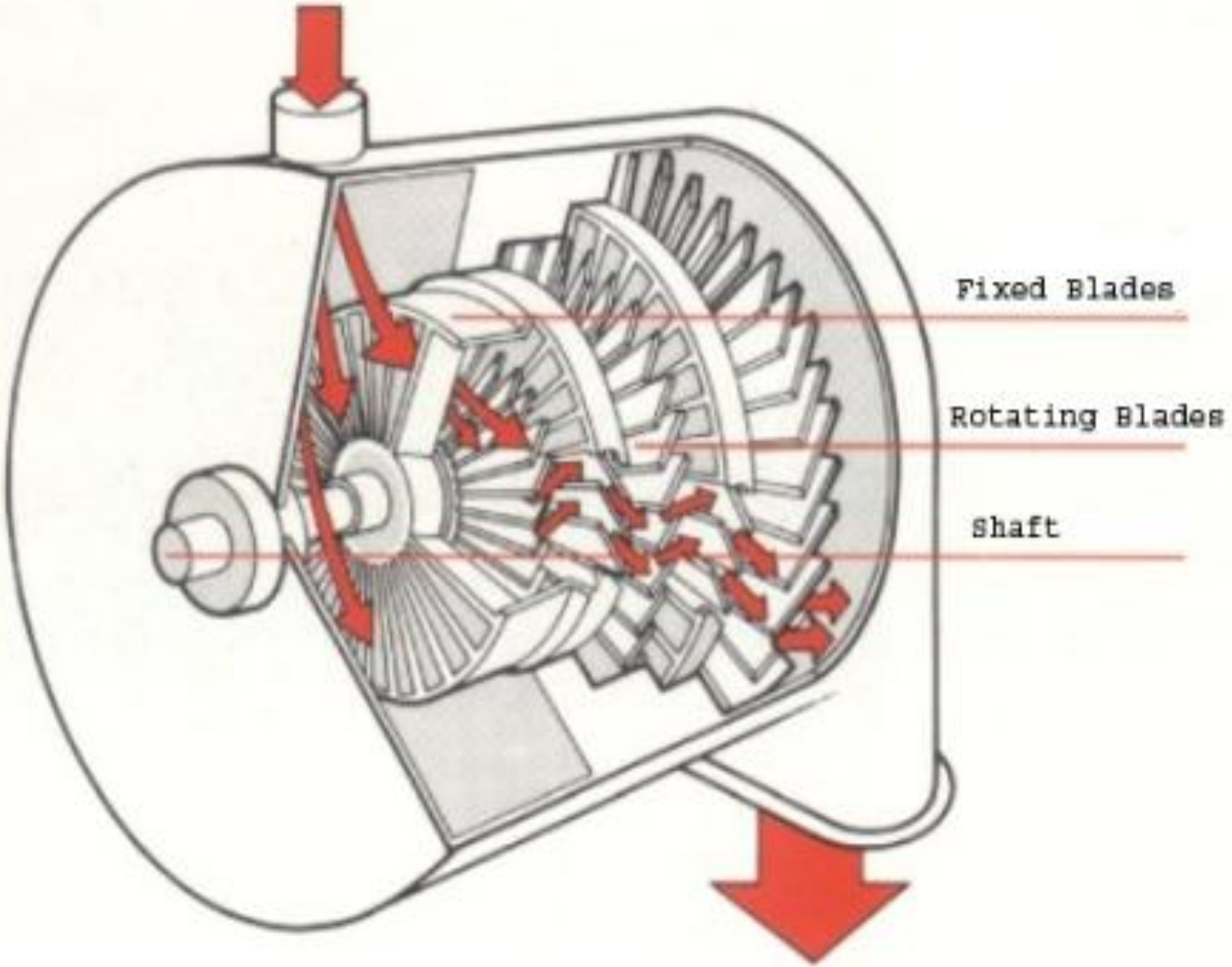


Principle of reaction turbine

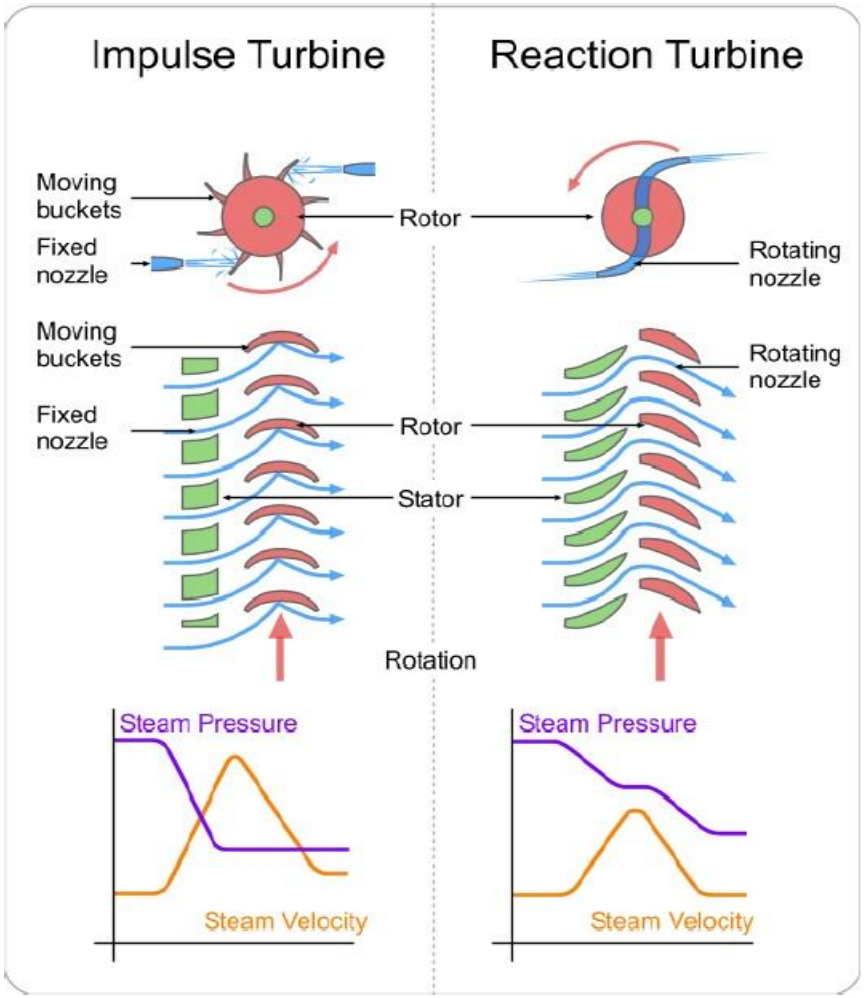
- Here, steam not expanded initially in nozzle.
- Gradual pressure drop over the fixed and moving blades.
- The fixed blades act as nozzles in which the velocity of the steam is increased also steam is correctly directed onto the moving blades.
- Steam also expands in the moving blades with consequent pressure drop and velocity increase. This expansion in the moving blades gives an extra reaction force to the moving blades.
- Therefore total driving force is sum of centrifugal force and reaction force.

Reaction turbine contd…

- The arrangement of blades facilitate the drop in pressure of steam on fixed as well as on moving blades.
- The pressure of steam decreases while passing through moving blades and specific volume increases therefore the height of the blades are increased along the flow direction of steam.
- This type of turbine is very commonly used in thermal power plants.



Parson's reaction turbine



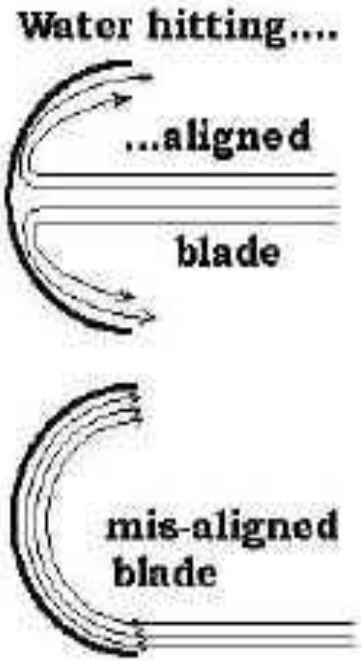
- *The main difference between the two is in the way the steam is expanded . In the former, steam expands in the nozzle and its pressure doesn't alter as it moves over the blades while in latter, pressure drops gradually and steam expands continuously as it passes over the blades.*

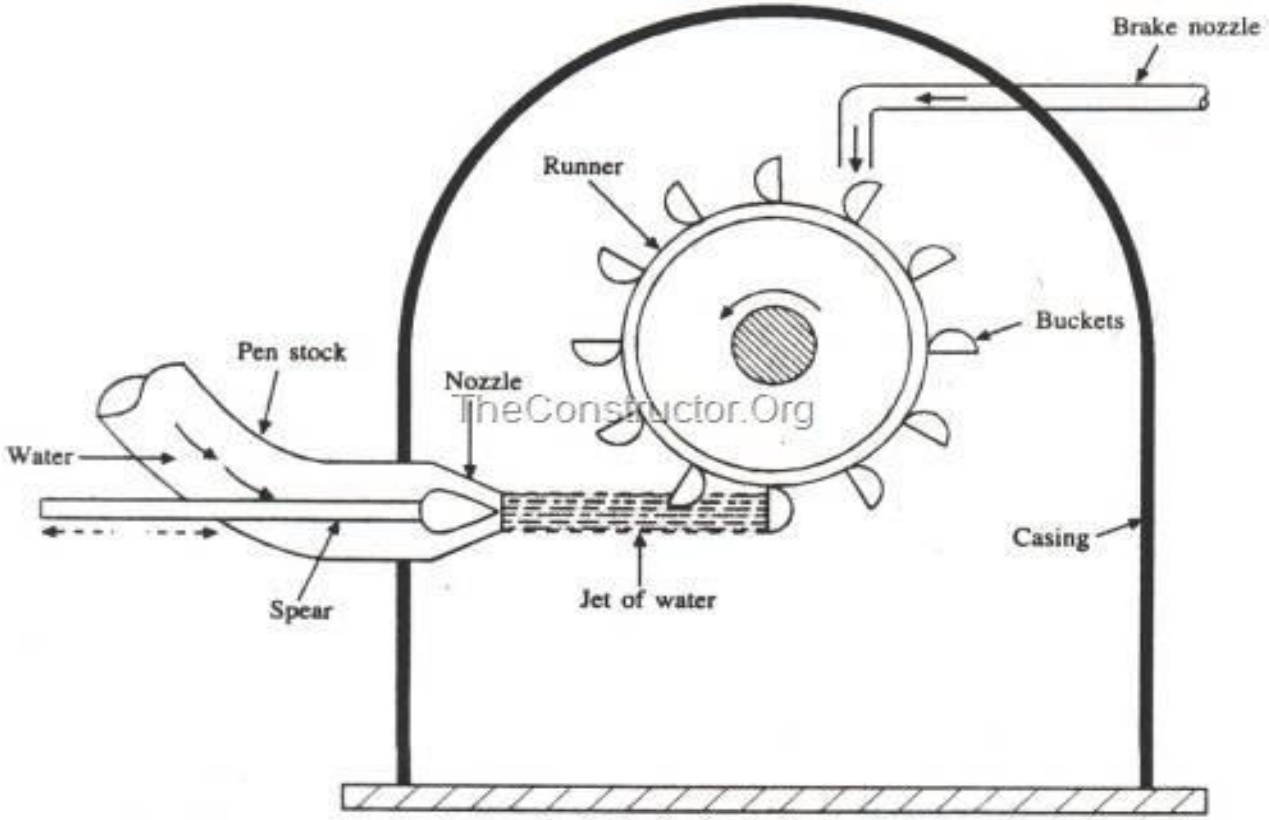
HYDRAULIC TURBINES

CLASSIFICATION OF HYDRAULIC TURBINES:

- According to type of energy at inlet
  - Impulse turbine- Pelton wheel
  - Reaction turbine-Francis turbine
- According to direction of flow through runner
  - Tangential flow turbine-Pelton wheel
  - Radial flow turbine- Francis turbine
  - Axial flow turbine- Kaplan turbine
  - Mixed flow turbine- Modern Francis turbine(radially inward and axial flow combined)
- According to head at the inlet of turbine
  - High head turbine- Pelton wheel
  - Medium head turbine- Francis turbine and
  - Low head turbine- Kaplan turbine
- According to quantity of water available
  - High discharge- Kaplan turbine
  - Medium discharge-Francis turbine
  - Low discharge - Pelton wheel
- According to the specific speed of turbine
  - Low specific speed turbine- Pelton wheel
  - Medium specific speed turbine- Francis turbine
  - High specific speed turbine- Kaplan turbine

PELTON WHEEL





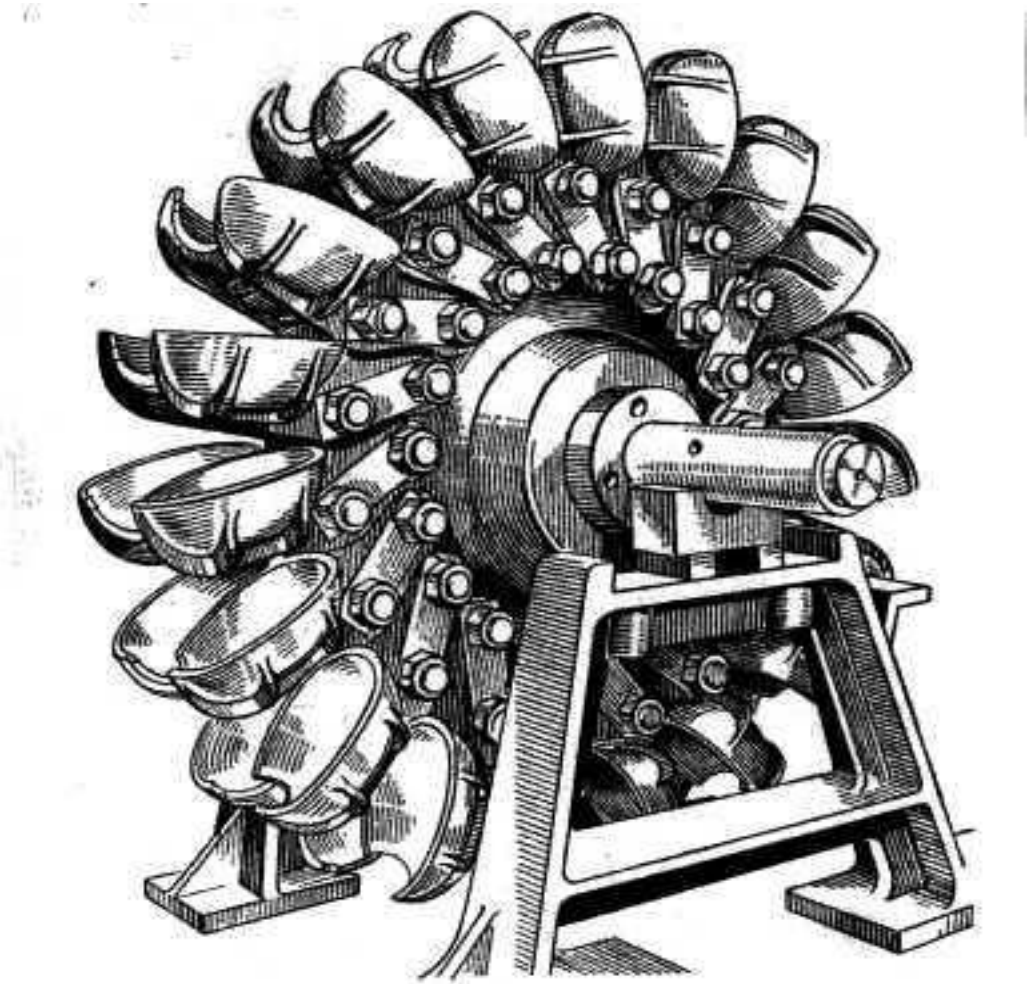
Parts of a pelton wheel

- Essential component parts of a Pelton Wheel are
  - Guide mechanism consisting of a spear rod and spear valve and deflector
  - Bucket and shaft carrying the buckets
  - Water tight casing
  - Brake nozzle
  - Governor

Pelton wheel

- Tangential Flow Impulse Turbine used for high heads of water.
- Requires low discharge and low specific speed as compared to other turbines.
- The water strikes the bucket along the tangent of the runner. The energy available at the inlet of the turbine is only Kinetic Energy. The pressure at the inlet and outlet is atmospheric pressure.
- The nozzle increases the kinetic energy of the water flowing through the penstock. At the outlet of the nozzle, the water comes out in the form of a jet and strikes the buckets (vanes) of the runner.
- Pelton Wheel Turbine is used for High Heads, low discharge and low specific speed.

Image of a pelton wheel



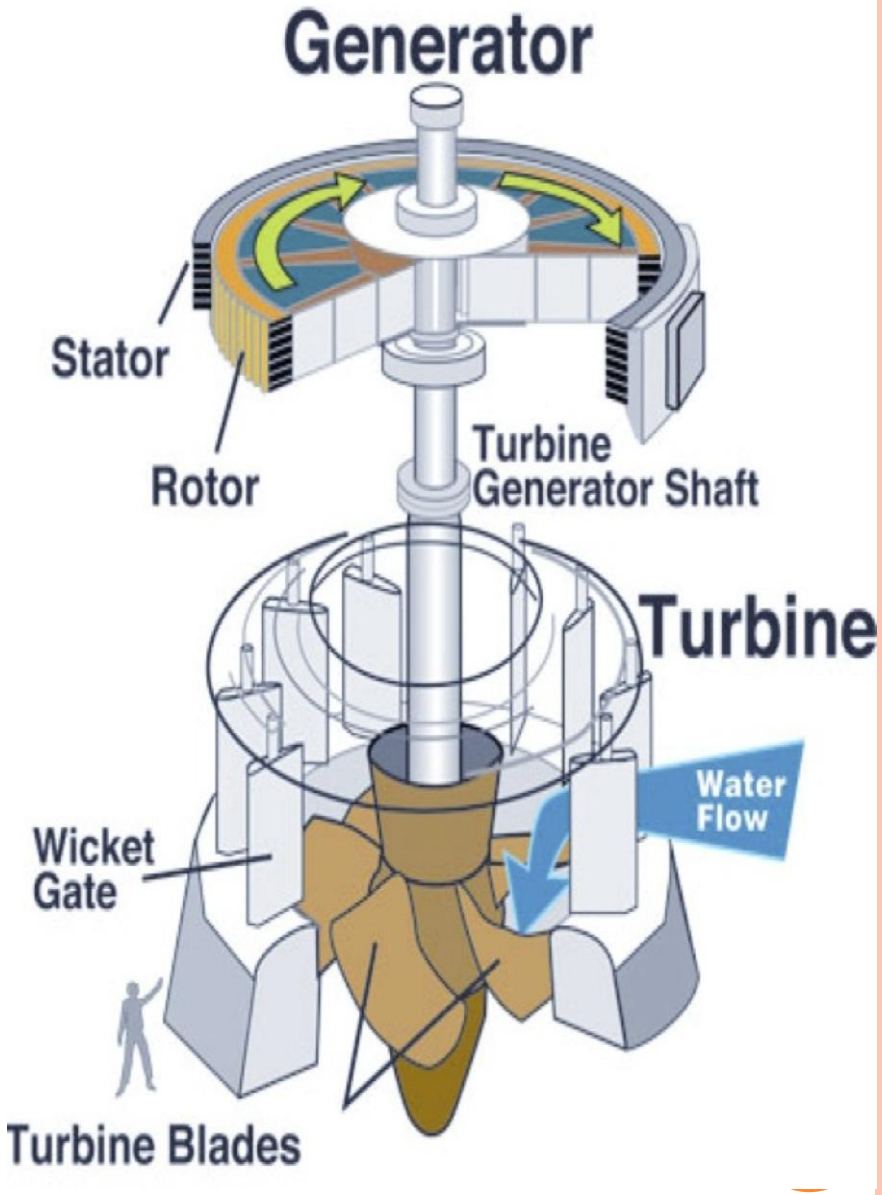
Pelton Wheel (2)

Francis turbine

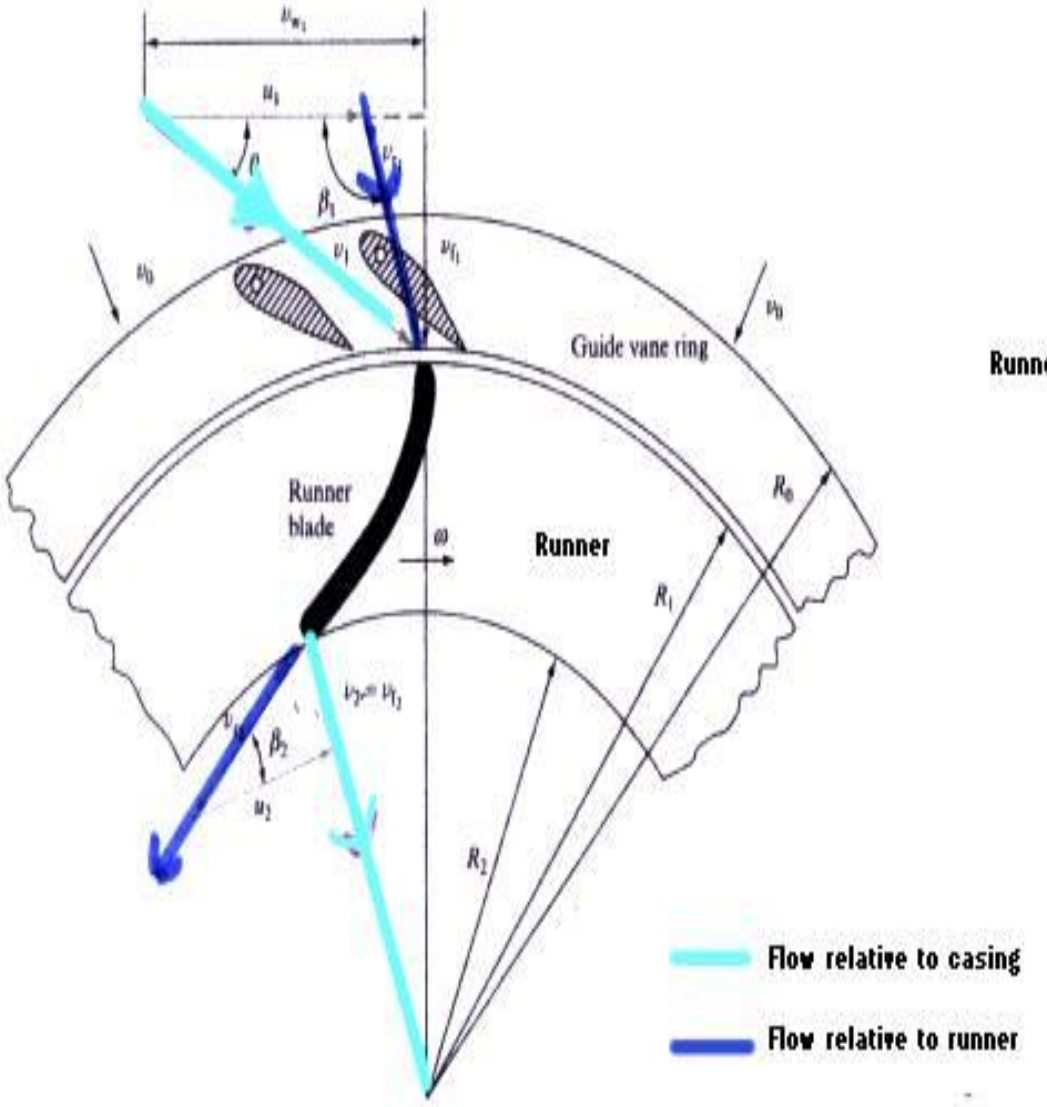
- Francis Turbine is the first hydraulic turbine (reaction type) with radial inflow.
- The major part of pressure drop occurs in the turbine itself, unlike the impulse turbine where complete pressure drop takes place up to the entry point.
- In Francis Turbine, water flows radially into the turbine and exits axially. Water pressure decreases as it passes through the turbine imparting reaction on the turbine blades making the turbine rotate.

Working of Francis Turbine

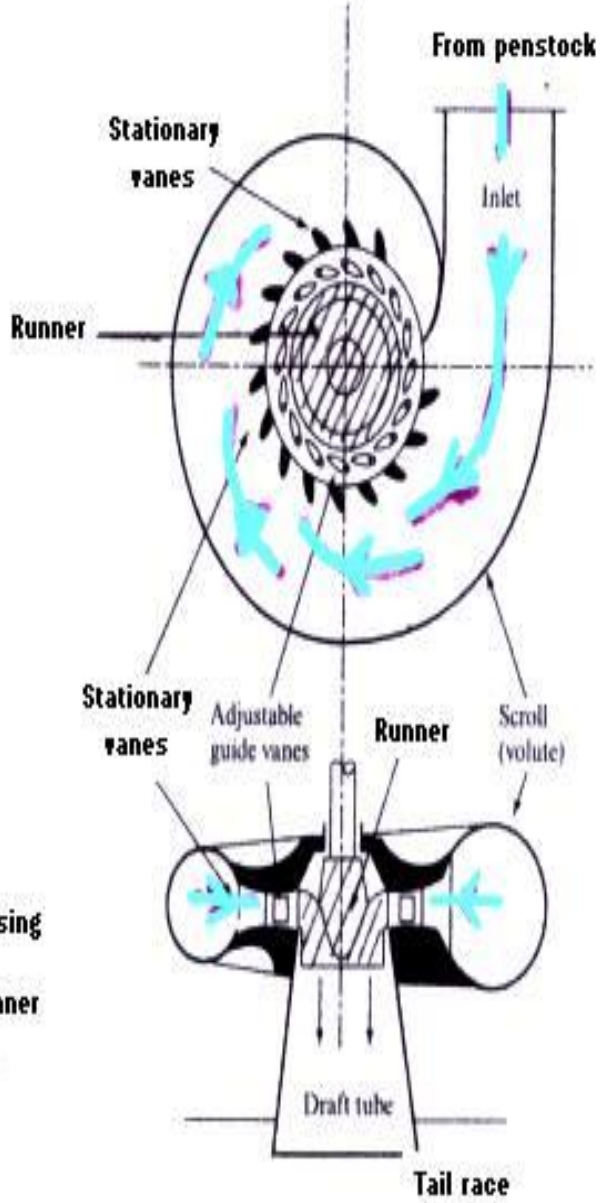
- Generally installed with their axis vertical. Water with high head (pressure) enters the turbine through the spiral casing surrounding the guide vanes. The water looses a part of its pressure in the volute (spiral casing) to maintain its speed. Then water passes through guide vanes where it is directed to strike the blades on the runner at optimum angles. As the water flows through the runner its pressure and angular momentum reduces. This reduction imparts reaction on the runner and power is transferred to the turbine shaft.
- If turbine operates at the design conditions the water leaves the runner in axial direction. Water exits the turbine through the draft tube, which acts as a diffuser and reduces the exit velocity of the flow to recover maximum energy from the flowing water.



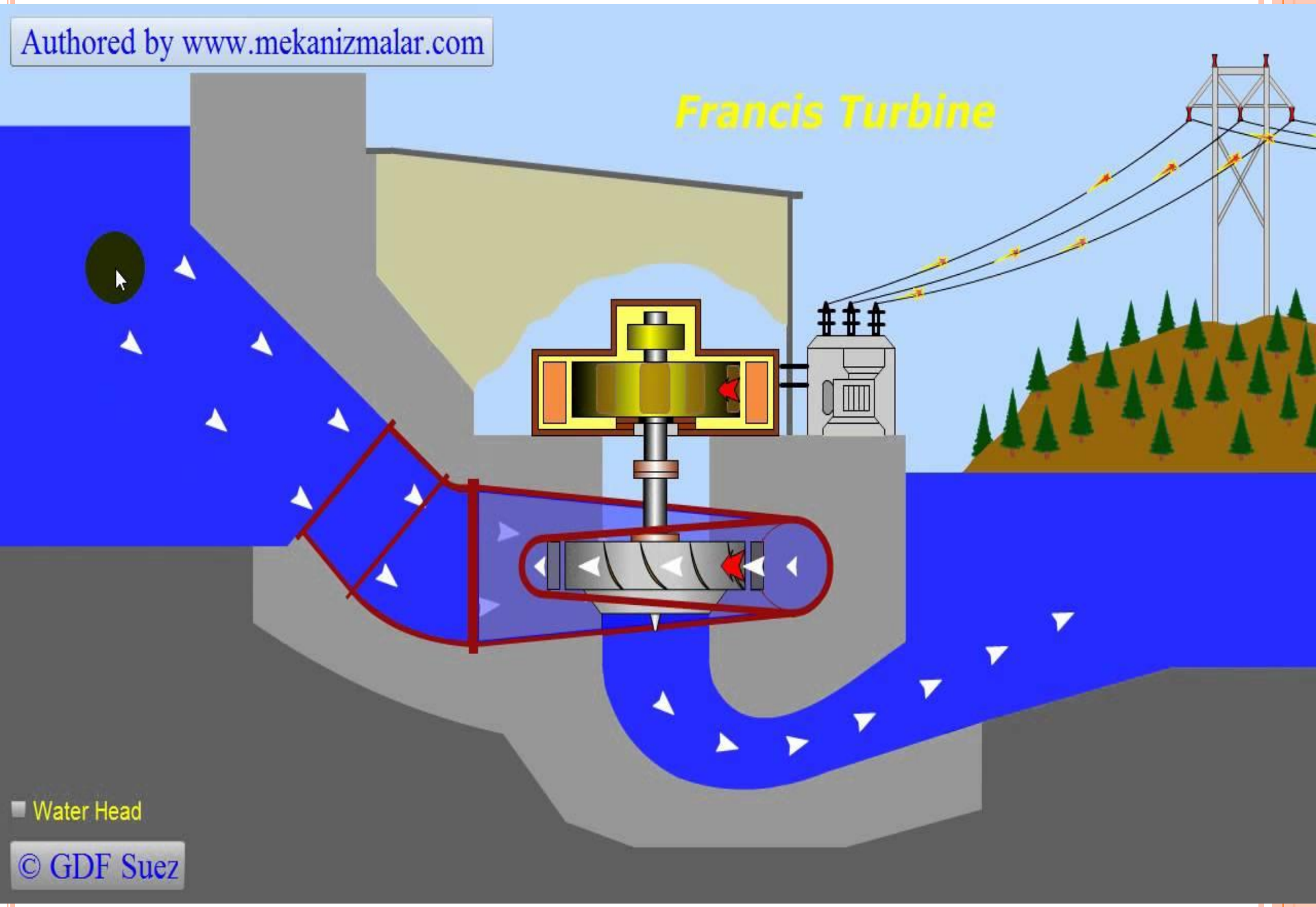
FRANCIS TURBINE



Francis Turbine



Francis Turbine


Authored by www.mekanizmalar.com
Francis Turbine
Water Head
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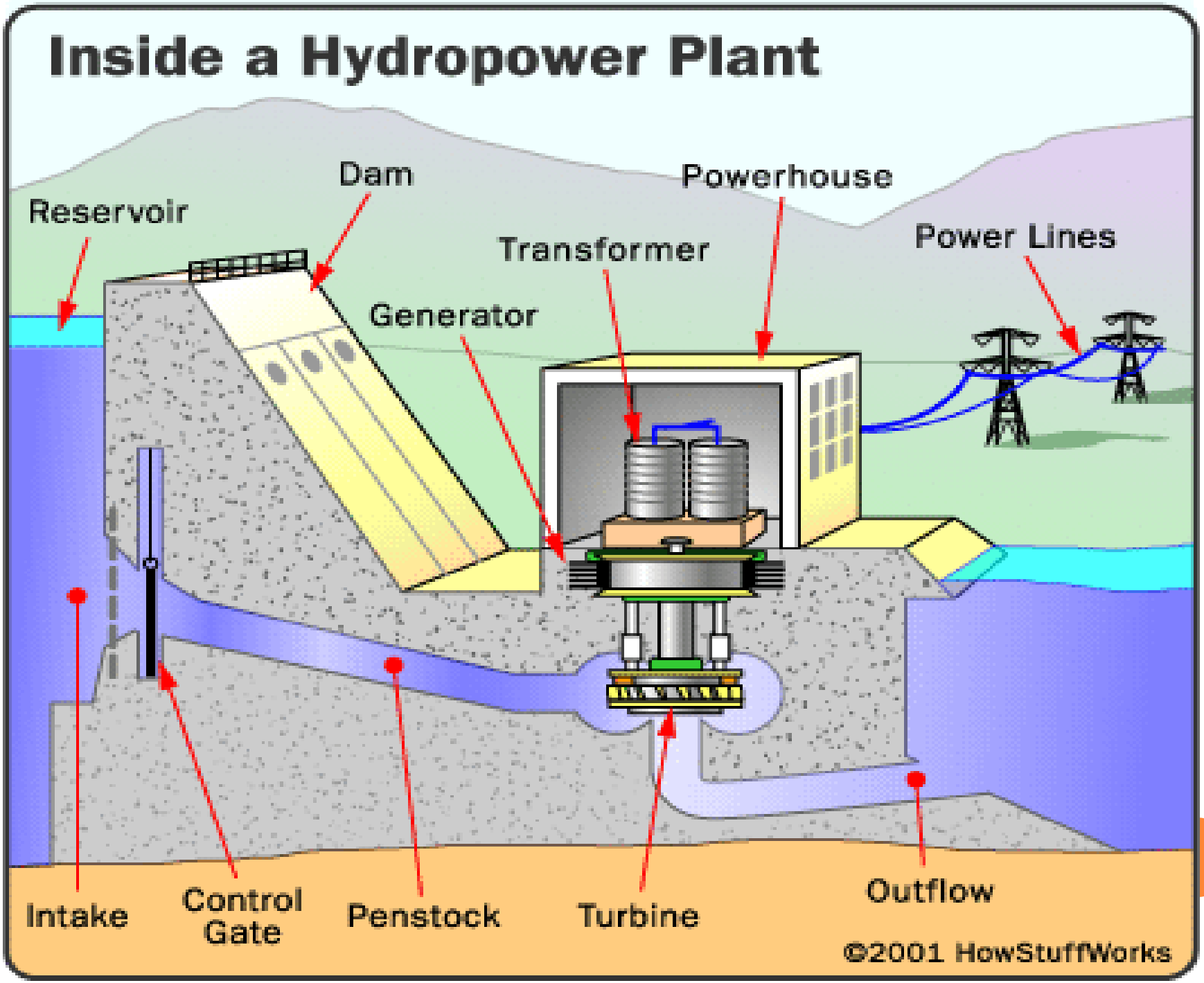
Inside a Hydropower Plant
Reservoir
Dam
Powerhouse
Transformer
Power Lines
Generator
Intake
Control Gate
Penstock
Turbine
Outflow
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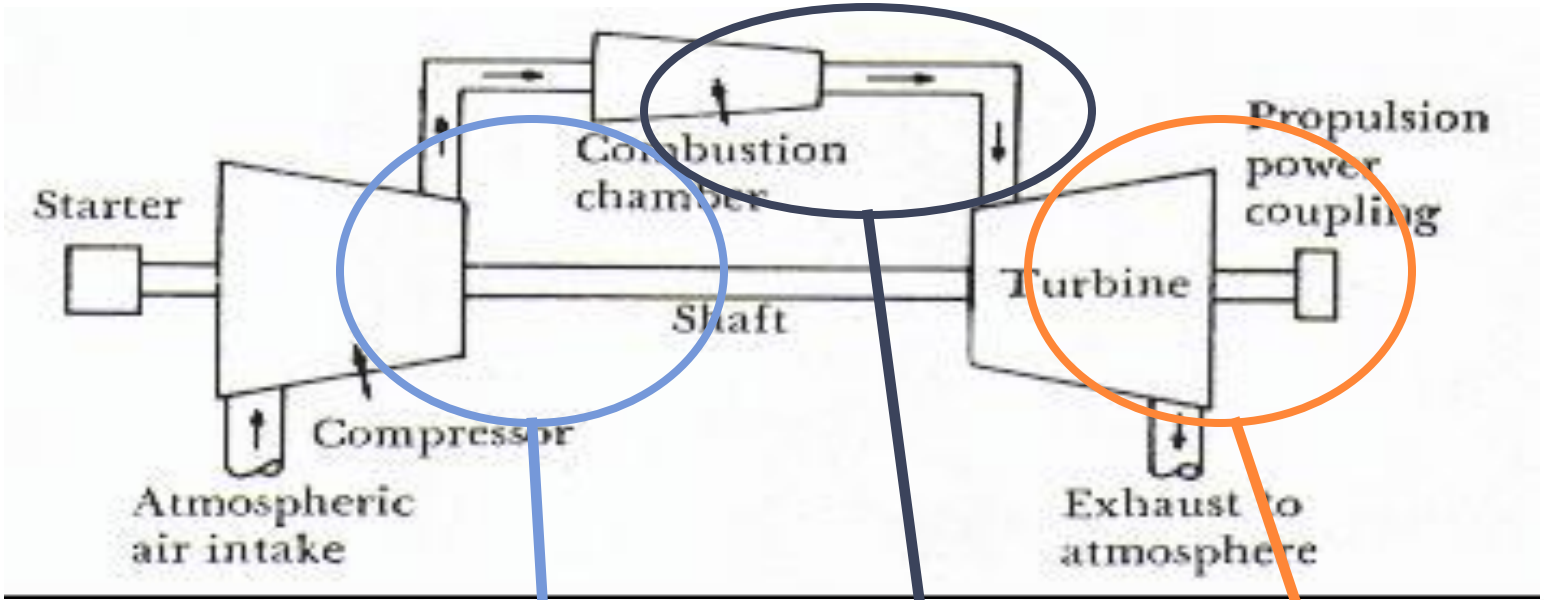
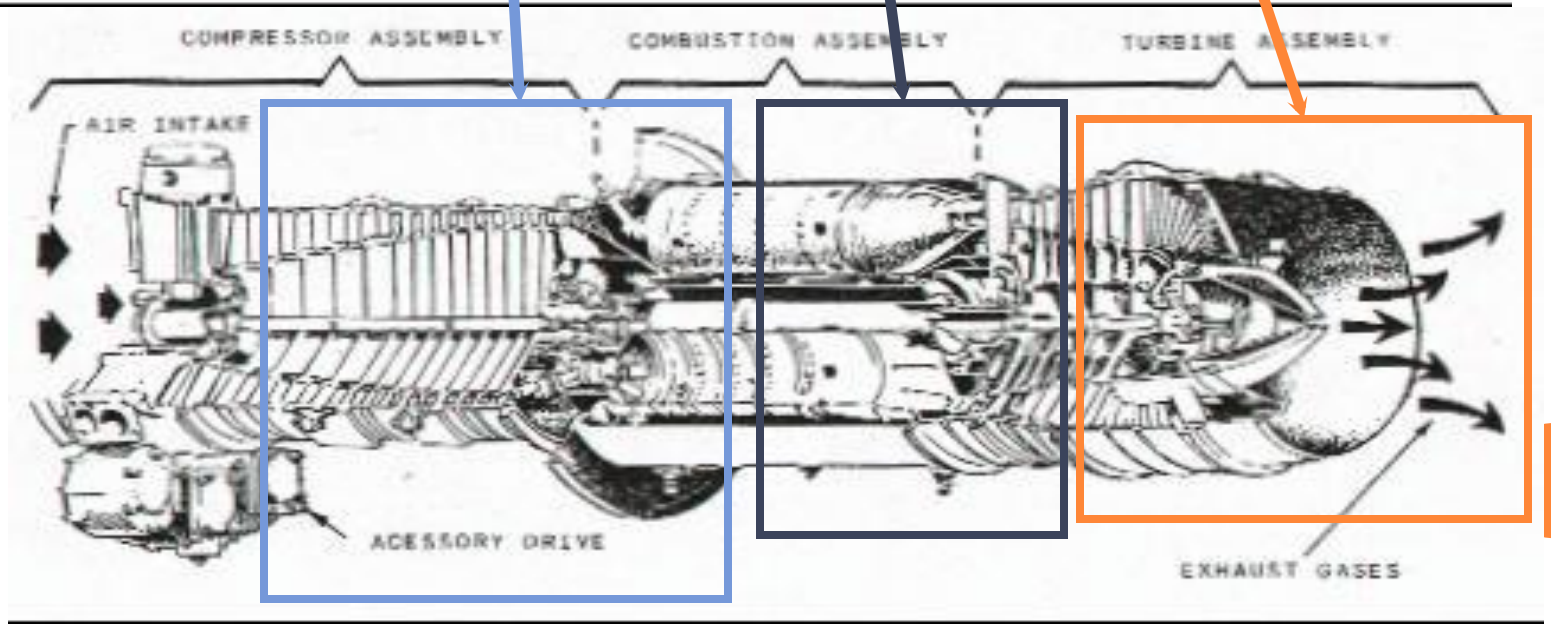
GAS TURBINE

- A gas turbine is a machine delivering mechanical power .
- *Probably a wind mill was the first turbine to produce useful work.*
- Gas turbine uses a gaseous working fluid.
- The mechanical power generated can be used by, for example, an industrial device. The outgoing gaseous fluid can be used to generate thrust. In the gas turbine, there is a continuous flow of the working fluid.
- **Applications:**
  - Aircraft propulsion
  - Marine propulsion
  - M-1 tanks
  - At stationery power plants to generate electricity as back up units.
  - Oil and gas industry

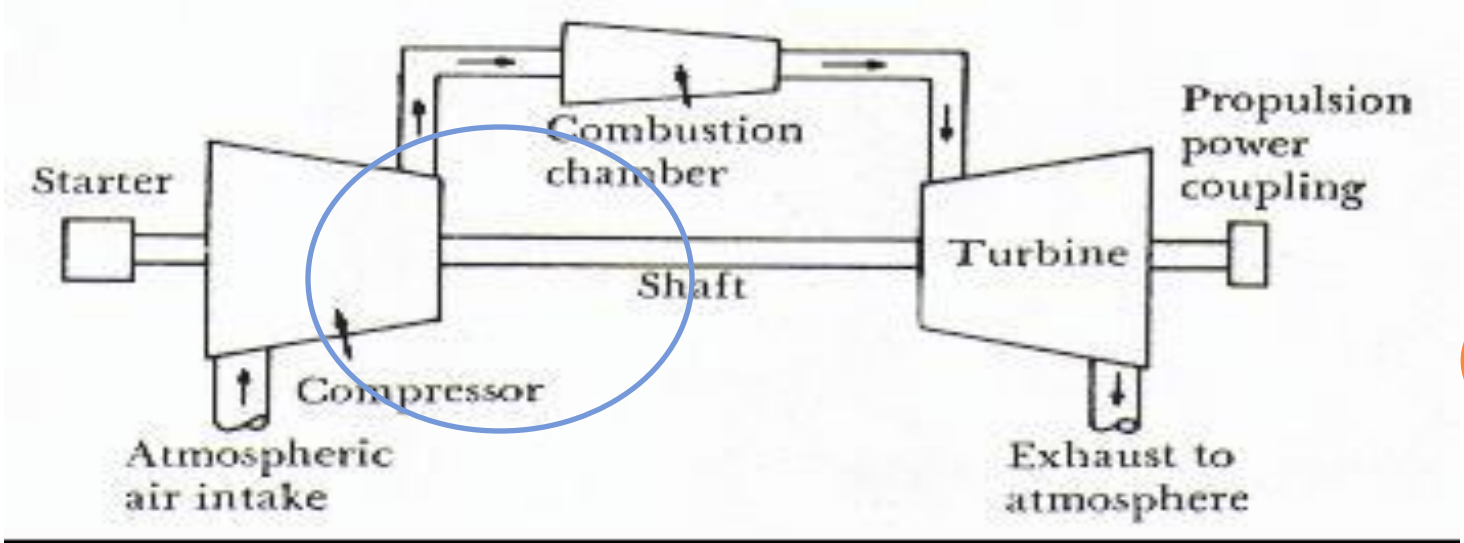
Basic Components





Basic Components

- Compressor
  - Draws in air & compresses it
- Combustion Chamber
  - Fuel pumped in and ignited to burn with compressed air
- Gas turbine
  - Hot gases converted to work
  - Can drive compressor & external load– Compressor and turbine mounted on a common shaft.



WORKING OF GAS TURBINE

- Air drawn in compressor➔ compressed➔passes to a combustion chamber
- Fuel injected in combustion chamber➔combustion of fuel+air takes place at constant volume with the help of a spark plug.
- Resulting hot gases expand through turbine and exit to atomsphere, hence Open gas cycle.

To get positive from unit, the turbine must develop more groos output than is required to drive the compressor and to overcome mechanical losses in the drive.

Gas turbine