Ministry of Higher Education and scientific research

Middle Technical University

Engineering Technical College-Baghdad

Fuel and Energy Engineering Department

Power Plant

Dr. Kadhum Audaa Jehhef

B. Sc., H. Dip., M.Sc. and Ph.D.

Mechanical Engineering.

Third Stage Year, 1st Course

Bachelor Degree, FS302

Fuel and Energy Engineering Department

Engineering Technical College-Baghdad

Middle Technical University

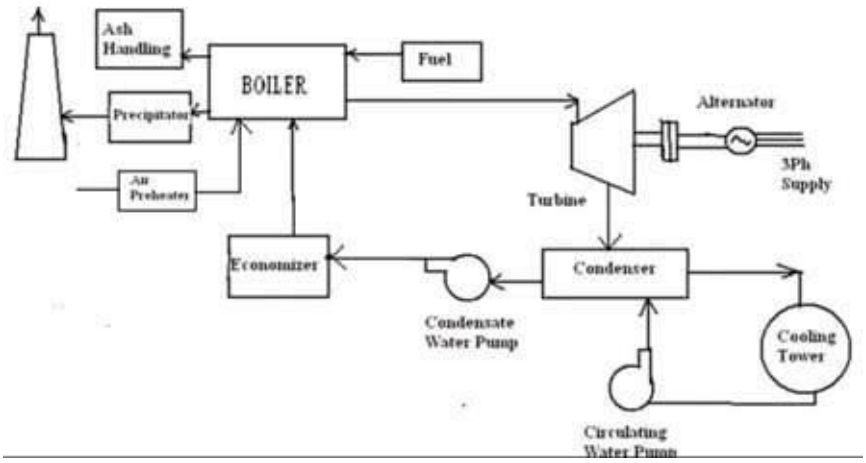
2024-2023

المادة: **محطات القدرة Power Plants**			الرمز: **FS405**
البرنامج:	درجة البكالوريوس Bachelor Degree	**النظام:** سنوي (30 اسبوع)	
المرحلة:	الرابعة	**نوع المادة:** تخصصية	
لغة التدريس:	الانكليزية	**عدد الوحدات: 7**	
الساعات الأسبوعية	النظرية: 2	العملية: 3	
أسلوب التعليم:	محاضرات نظرية تمارين وواجبات بيتية وزيارات ميدانية لمحطات انتاج الطاقة.		

Chapter 2

Power Plant Components

Thermal power station's working principle is "Heat released by burning fuel which produces (working fluid) (steam) from water. Generated steam runs the turbine coupled to a generator which produces electrical energy in Thermal Power Plants.



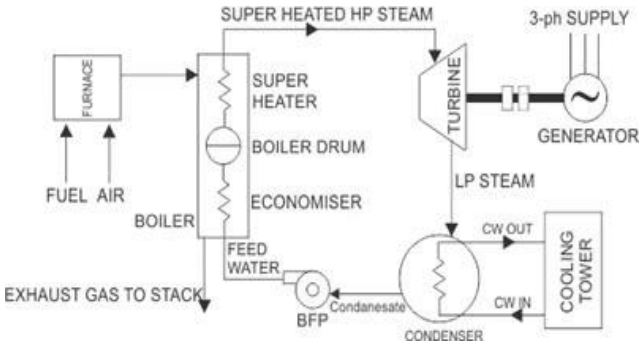
Working Principle of a Thermal Plant

The working fluid is water and steam. This is called feed water and steam cycle. The ideal Thermodynamic Cycle to which the operation of a Thermal Power Station closely resembles is the RANKINE CYCLE.

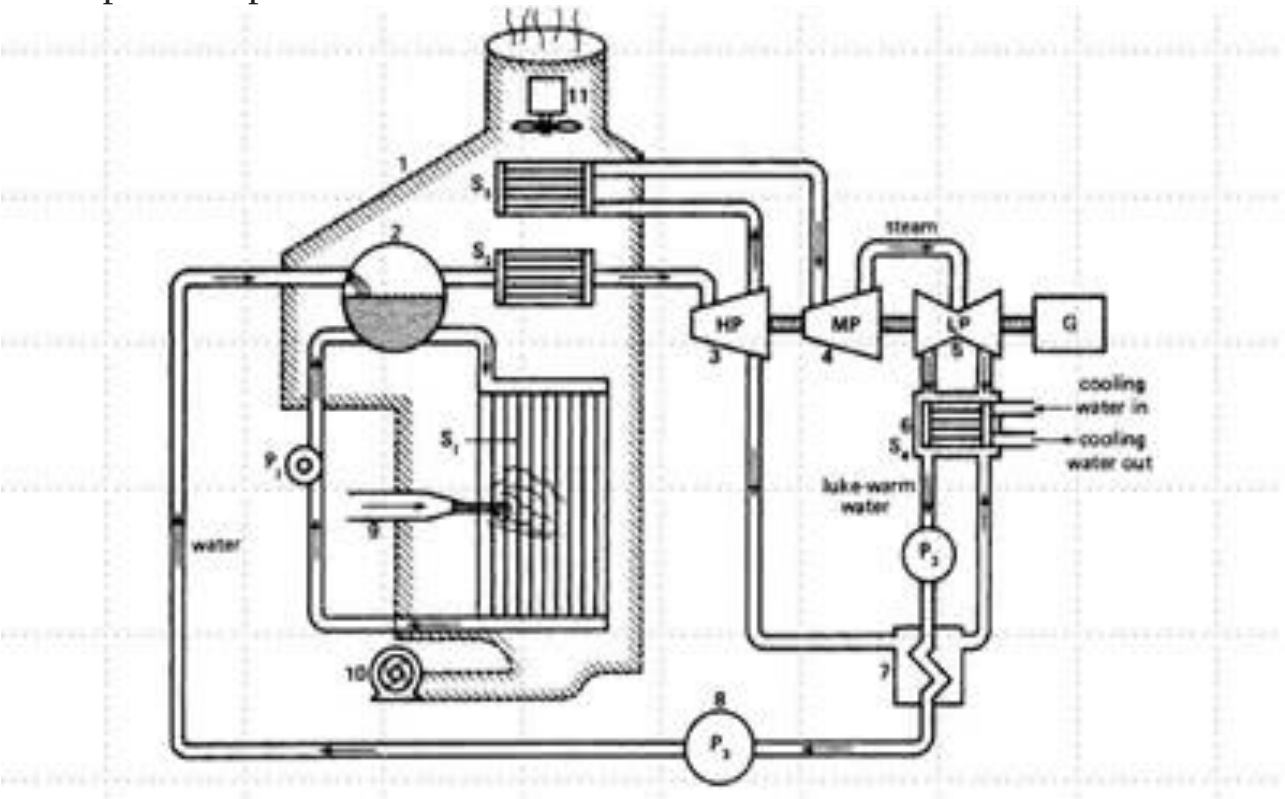
- In a steam boiler, the water is heated up by burning the fuel in the air in the furnace.
- The steam so produced is used in driving the steam Turbines. This turbine is coupled to synchronous generator (usually three-phase synchronous alternator), which generates electrical energy.

- The exhaust steam from the turbine is allowed to condense into the water in steam condenser, which creates suction at very low pressure and allows the expansion of the steam in the turbine to very low pressure.
- The condensate along with some fresh makeup feed water is again fed into the boiler by a pump (called the boiler feed pump).

The total scheme of a typical thermal power station along with different circuits is illustrated below.



Principal Components of a Thermal Power Plant

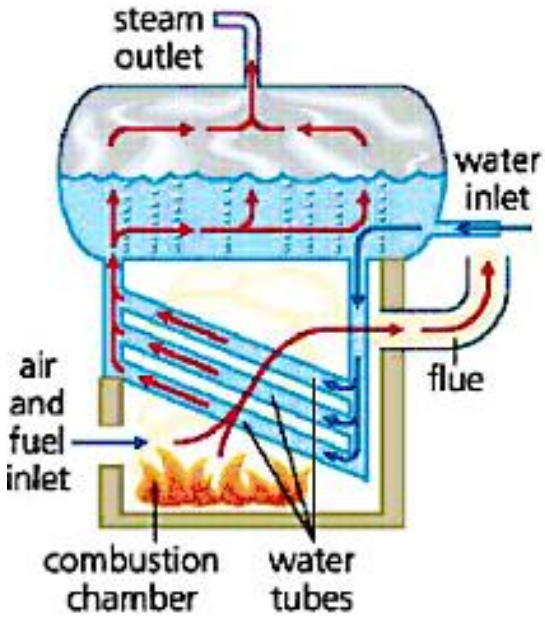


Principal Components of a Thermal Power Plant

- **Boiler (1)**

A huge boiler acts as a furnace transferring heat from the burning fuel to row upon row of water tubes that entirely surround the flames. Water is kept flowing through the tubes by a pump P1.

- **The function of the** boiler is to give dry superheated steam at the required temperature.
- It is an enclosed pressure vessel in which water is converted into steam by gaining heat from any source (coal, oil, gas etc).



Types of boiler

1. Based on Tube Content
   a) Fire Tube
   b) Water Tube
2. Base on Fuel Used

a) Solid Fuel Fired
b) Stoker Fired Boilers
c) Pulverized Fuel Boilers
d) Fluidized Bed Combustion (FBC) Boilers
e) Oil Fired
f) Gas Fired Boilers

3 4 Based on Draught System

a) Natural Draught
b) Mechanical Draught
c) Forced Draught System
d) Induced Draught System
e) Balanced Draught System

- **Drum (2)**
  - It contains water and steam at high pressure and produces a stream for the turbine.
  - It also receives water delivered by boiler-feed pumpP2

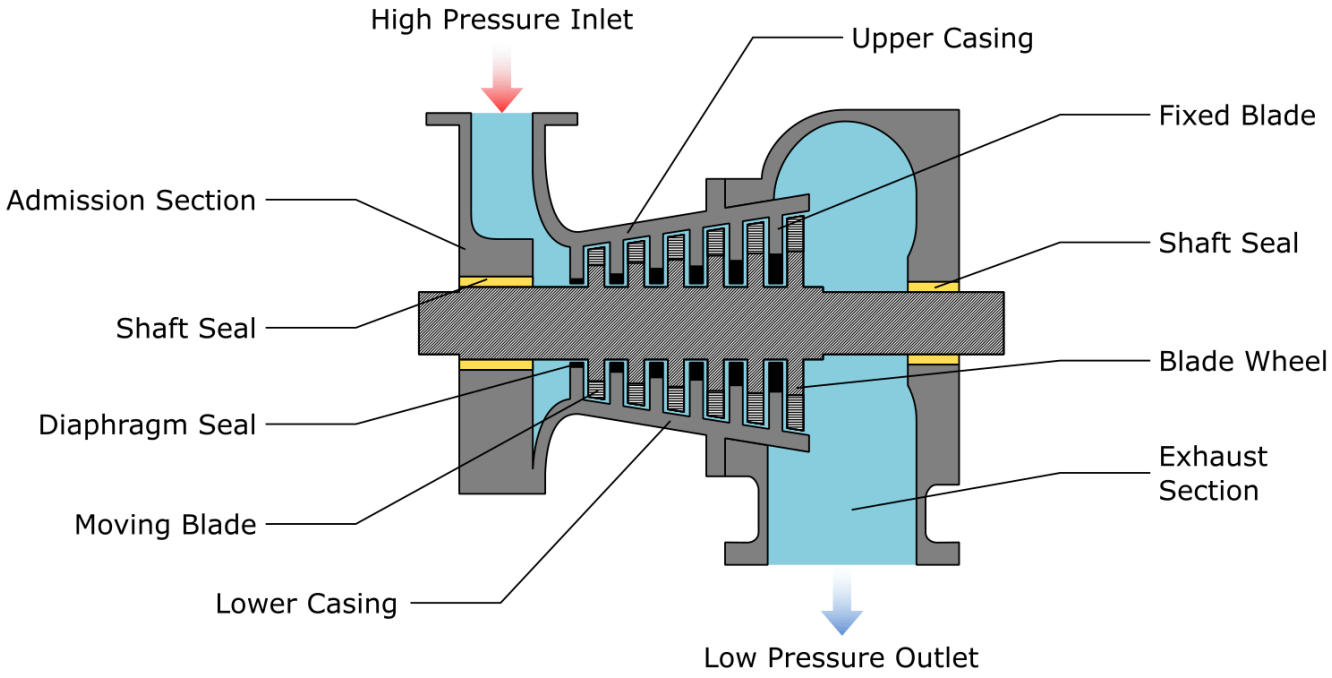
To here 16/2/2026

A turbine

A turbine: is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. The work produced can be used for generating electrical power when combined with a generator. A turbine is a turbomachine with at least one moving part called a rotor assembly, which is a shaft or drum

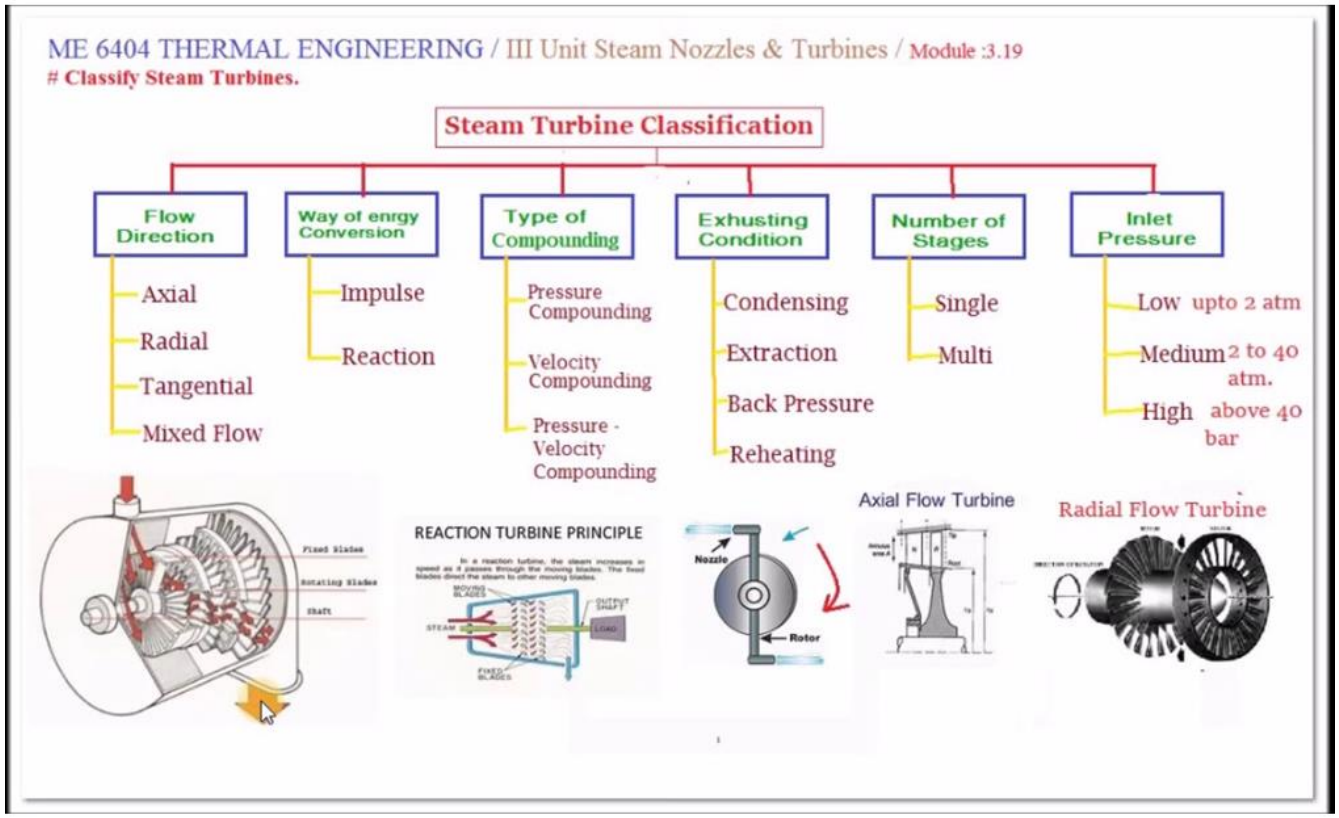
with blades attached. Moving fluid acts on the blades so that they move and impart rotational energy to the rotor.

The function of the turbine extracts energy from a fluid flow and converts it into useful work



Types of turbine

1. Steam turbine
2. Gas turbine
3. Water turbine

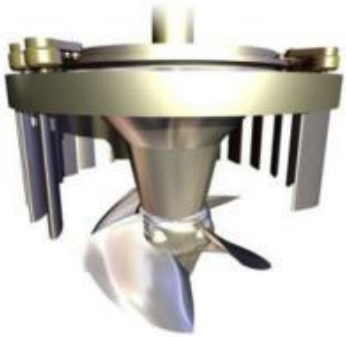


Francis Turbine

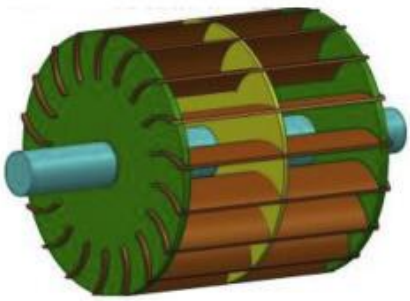
Fixed Pitch Propeller

Turgo

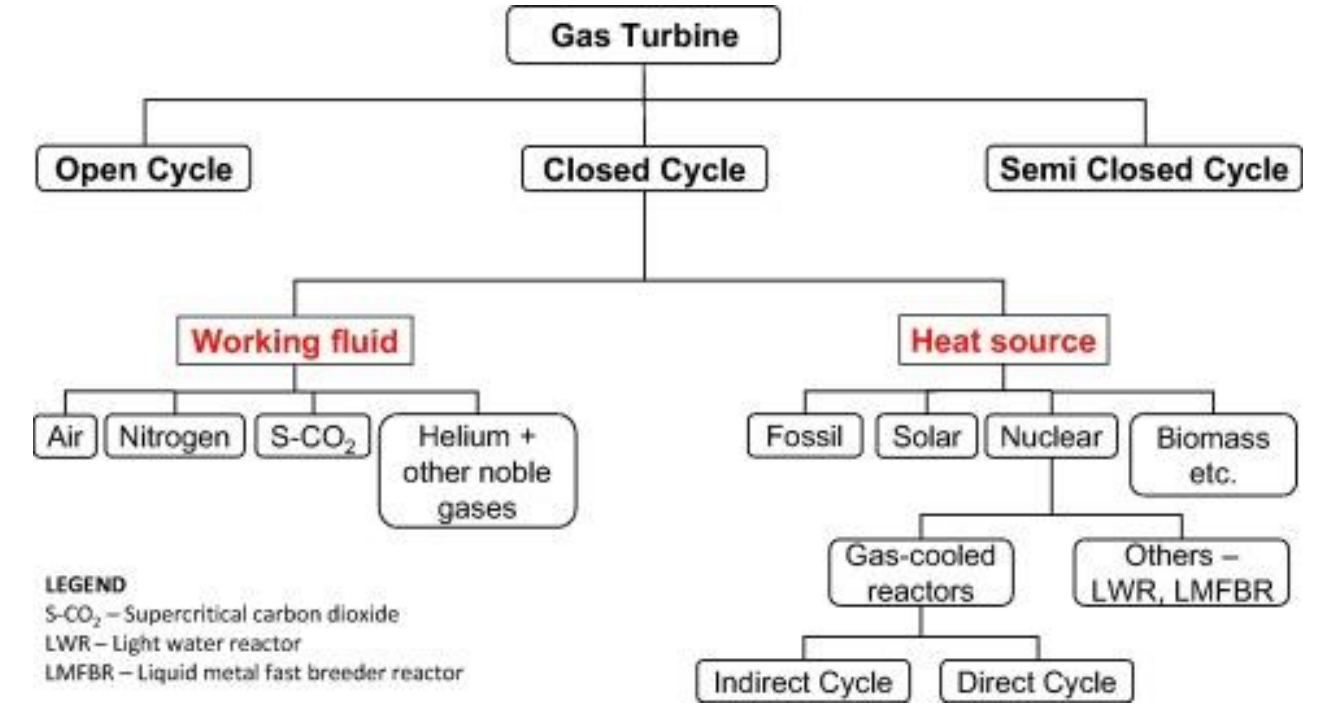
Pelton

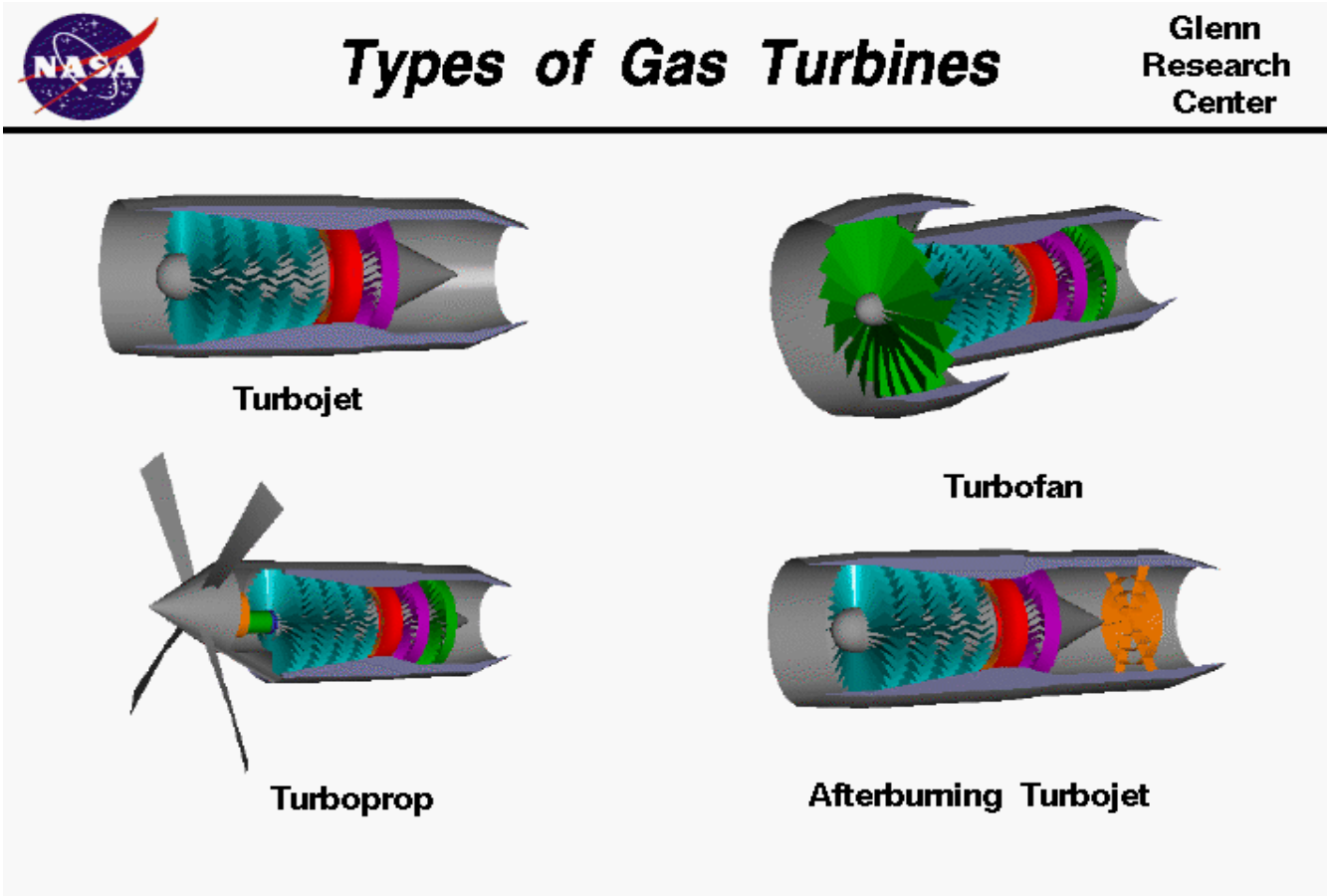


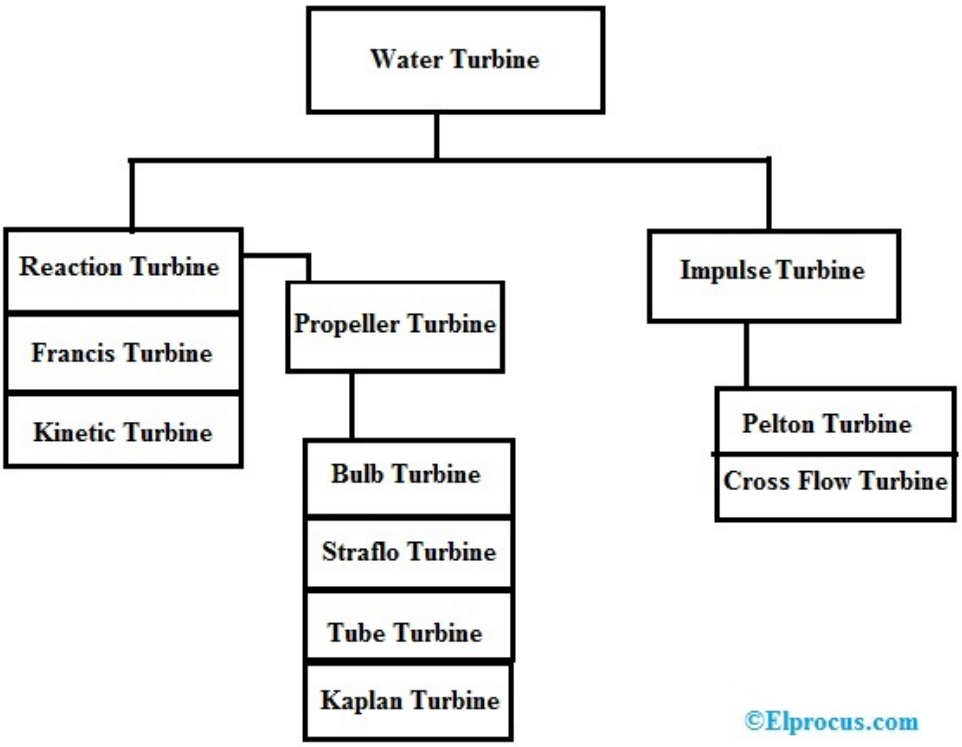
Kaplan

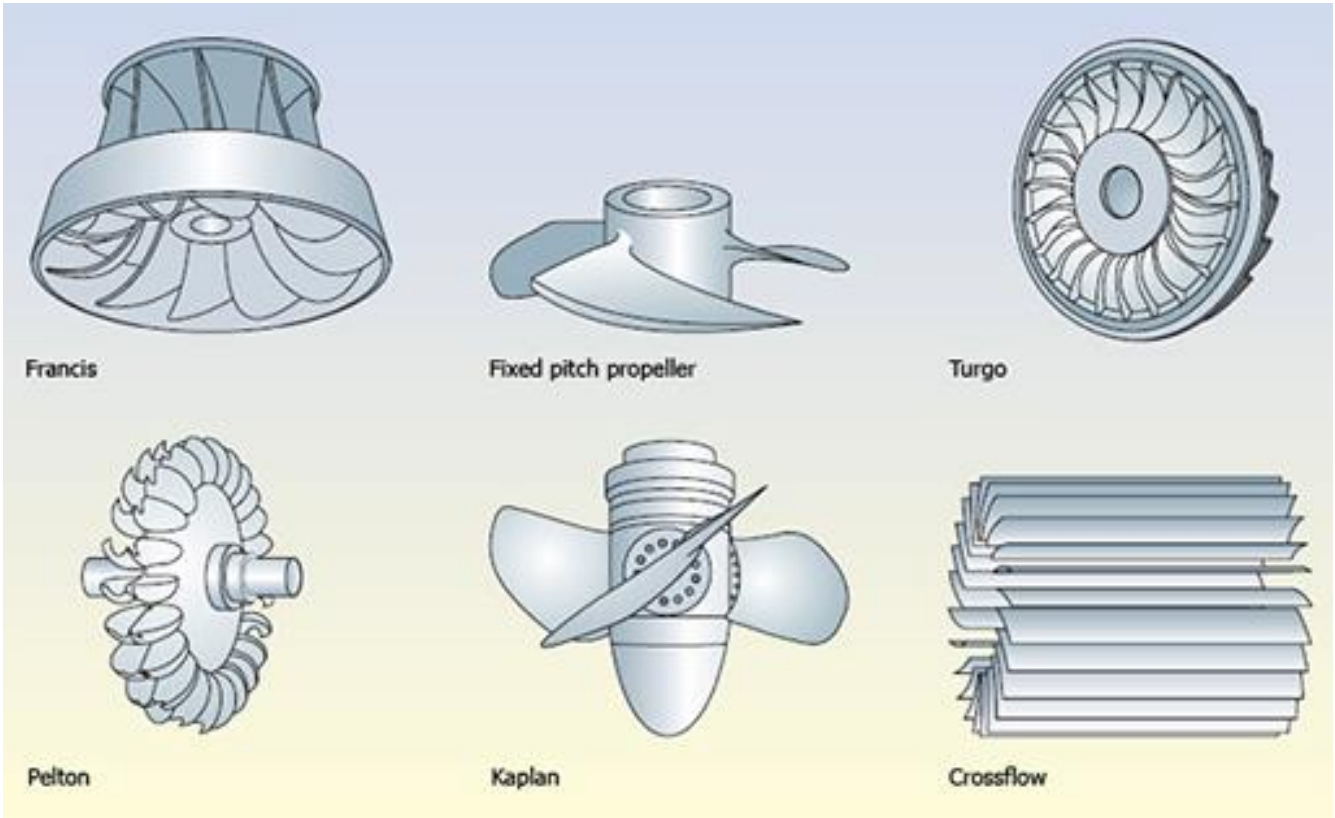


Crossflow


Gas Turbine
Open Cycle
Closed Cycle
Semi Closed Cycle
Working fluid
Heat source
Air
Nitrogen
S-CO2
Helium + other noble gases
Fossil
Solar
Nuclear
Biomass etc.
Gas-cooled reactors
Others – LWR, LMFBR
Indirect Cycle
Direct Cycle
LEGEND
S-CO2 – Supercritical carbon dioxide
LWR – Light water reactor
LMFBR – Liquid metal fast breeder reactor


Types of Gas Turbines
Glenn Research Center
Turbojet
Turbofan
Turboprop
Afterburning Turbojet


Water Turbine
Reaction Turbine
Francis Turbine
Kinetic Turbine
Propeller Turbine
Bulb Turbine
Straflo Turbine
Tube Turbine
Kaplan Turbine
Impulse Turbine
Pelton Turbine
Cross Flow Turbine
©Elprocus.com


Francis
Fixed pitch propeller
Turgo
Pelton
Kaplan
Crossflow

Impulse Turbine	Reaction Turbine
1. All the available energy of the fluid is converted into kinetic energy by an efficient nozzle that forms a free jet.	1. Only a portion of the fluid energy is transformed into kinetic energy before the fluid enters the turbine runner.
2. The jet is unconfined and at atmospheric pressure throughout the action of water on the runner, and during its subsequent flow to the tail race.	2. Water enters the runner with an excess pressure, and then both the velocity and pressure change as water passes through the runner.
3. Blades are only in action when they are in front of the nozzle.	3. Blades are in action all the time.
4. Water may be allowed to enter a part or whole of the wheel circumference.	4. Water is admitted over the circumference of the wheel.
5. The wheel does not run full and air has free access to the buckets.	5. Water completely fills the vane passages throughout the operation of the turbine.
6. Casing has no hydraulic function to perform; it only serves to prevent splashing and to guide the water to the tail race.	6. Pressure at inlet to the turbine is much higher than the pressure at outlet ; unit has to be sealed from atmospheric conditions and, therefore, casing is absolutely essential.
7. Unit is installed above the tail race.	7. Unit is kept entirely submerged in water below the tail race.
8. Flow regulation is possible without loss.	8. Flow regulation is always accompanied by loss.
9. When water glides over the moving blades, its relative velocity either remains constant or reduces slightly due to friction.	9. Since there is continuous drop in pressure during flow through the blade passages, the relative velocity does increase.

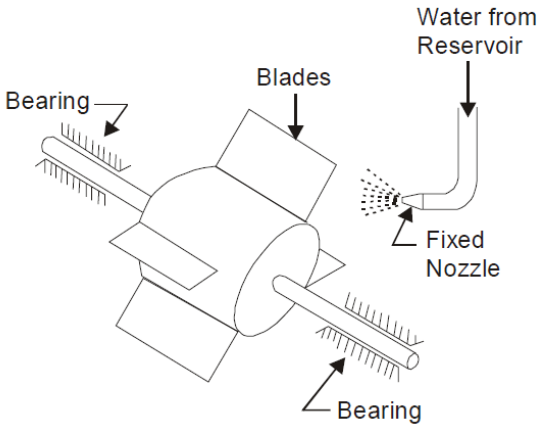


Fig. 1.16. Impulse Turbine.

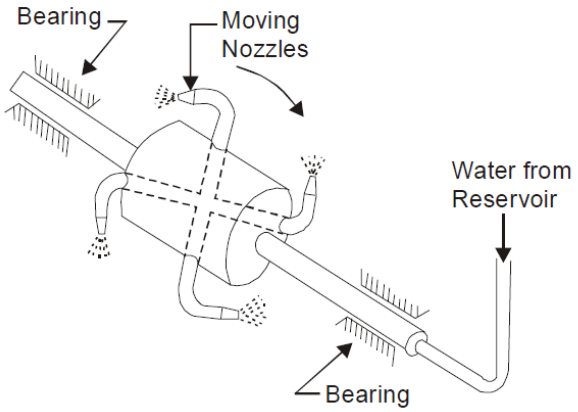
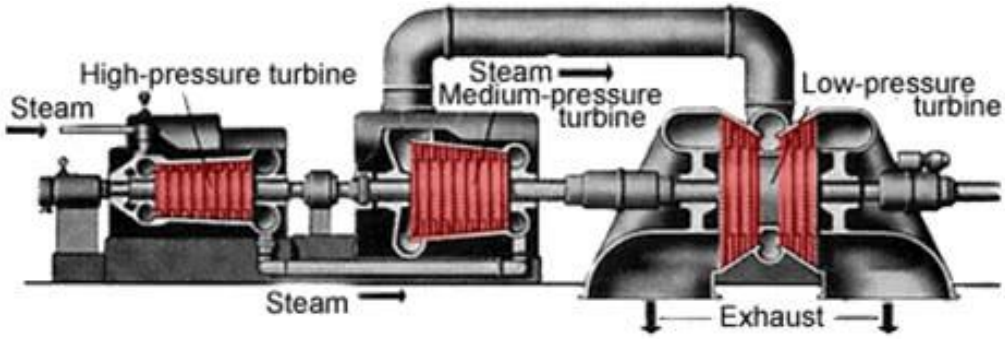


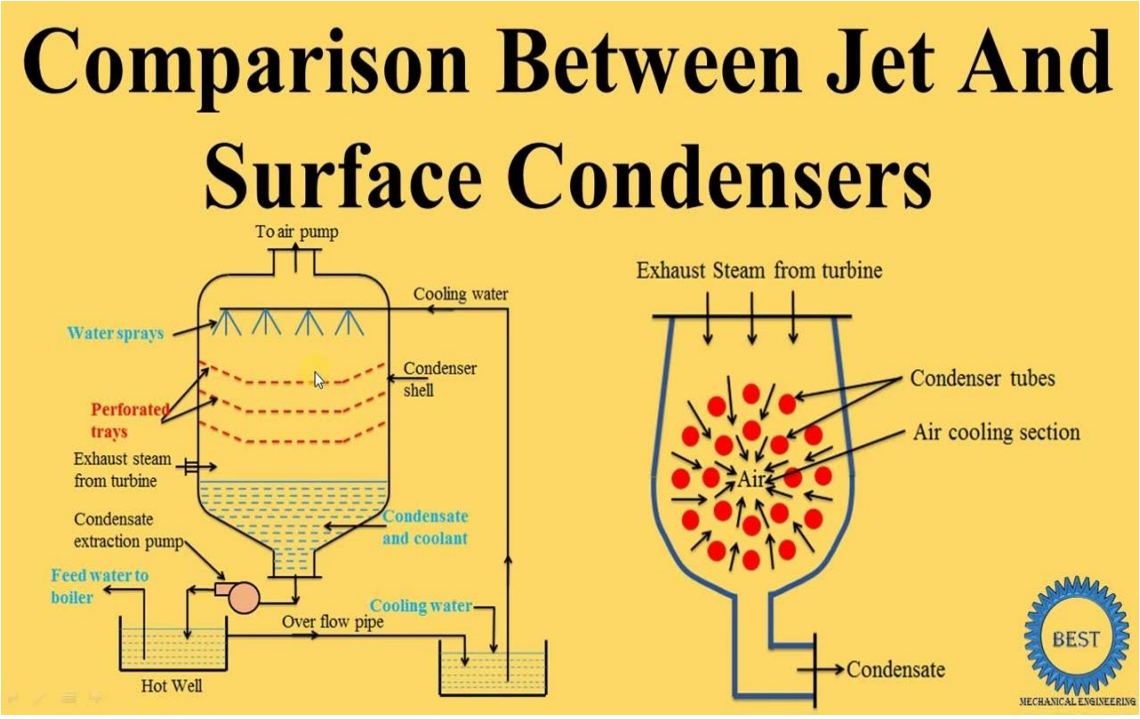
Fig. 1.17. Reaction Turbine.

- **High-pressure (HP) Turbine (3)**
  - Converts thermal energy into mechanical energy by letting the steam expand as it moves through turbine blades.
  - The steam is then passed through a reheater S3 in order to raise the thermal efficiency and to prevent premature condensation.
- **Medium-pressure(MP) turbine (4)**
  - It is similar to HP turbine, except that it is bigger so that the steam ma expands still more. contains water and steam at high pressure and produces stream for the turbine.
- **Low-pressure(LP) Turbine (5)**
  - It is composed of two identical sections and it removes the remaining available energy from the steam. The steam turbine can be of impulse or reaction turbine and sometimes combination of both.



- **Condenser (6)**
  - It causes the steam to condense by letting it flow over cooling pipes.
  - Coldwater from outside sources flowing through pipes carries away the heat. The temperature of cooling water increases by 5oC to 10oC as it flows through the condenser tubes. A condensate pump P2 removes the lukewarm condensed steam and drives it through reheater (7) toward a feedwater pump (8).
    - **The function of the Condenser is to condensing steam to water**
- **Condenser:** *A closed vessel in which steam is condensed by abstracting the heat and where the pressure is maintained below atmospheric pressure is known as a condenser.*

Steam condenser are of two types:
1. Surface condenser.
2. Jet condensers



Surface Condensers

In surface condensers there is no direct contact between the steam and cooling water and the condensate can be re-used in the boiler: In such condenser even impure water can be used for cooling purpose whereas the cooling water must be pure in jet condensers.

Types of Surface Condensers:

(i) Down flow type. Fig. 1.9

(ii) Central flow condenser. Fig. 1.11

(iii) Evaporation condenser. In this condenser (Fig. 1.12)

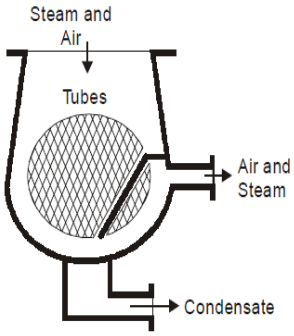


Fig. 1.9

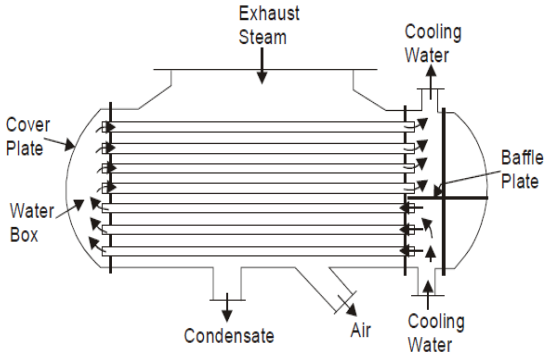


Fig. 1.10

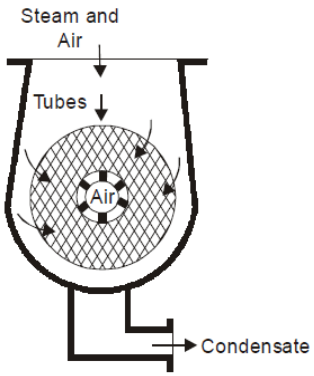


Fig. 1.11

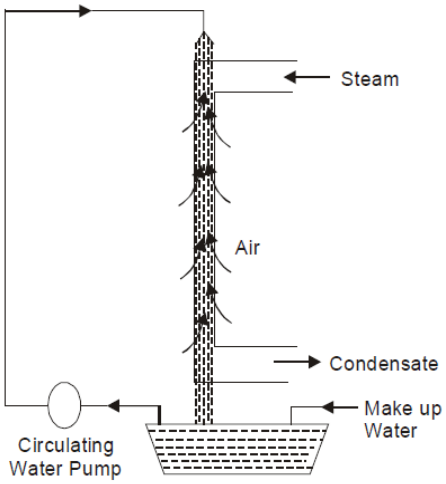


Fig. 1.12

JET CONDENSERS

In jet condensers the exhaust steam and cooling water come in direct contact with each other. The temperature of cooling water and the condensate is same when leaving the condensers.

Types Of Jet Condensers

1. Low level jet condensers (Parallel flow type). (Fig. 1.13)

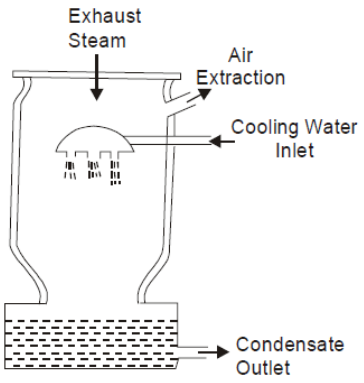


Fig. 1.13

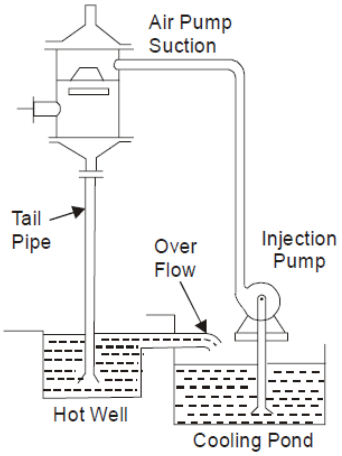


Fig. 1.14

2. High level or Barometric condenser. Fig. 1.14

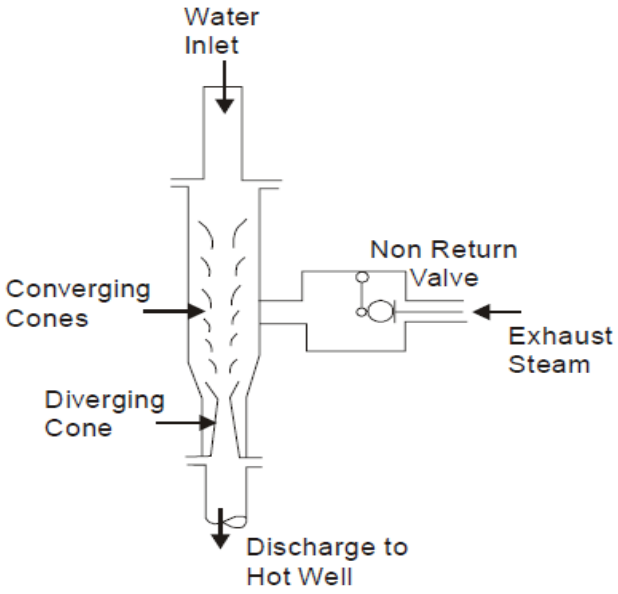


Fig. 1.15

To here 22/2/2026

- **Reheater (7)**
  - Heat exchanger receives hot steam, bled off from high-pressure turbine, to raise the temperature of the feedwater. Thermodynamic studies show that when some steam is bled off this way, the overall efficiency increases.
    - **The function of the_Reheater is to raise the temperature of the feedwater**
- **Burner (9)**
  - Burners supply and control the amount of gas, oil, or coal injected into boiler. Coal is pulverized before it is injected. Similarly, heavy bunker oil is preheated and injected as an atomized jet to improve surface contact with the surrounding air.
    - **The function of the Burner is to supply and control the amount of gas, oil, or coal injected into boiler.**
- **Forced-draft (10)**
  - It furnishes the enormous quantities of air needed for combustion.
- **Induced-draft fan(10)**
- It carries gases and other products of combustion toward the cleansing apparatus and from there to the stack and the outside air.
- **Generator (G)**
- Connected to three turbines converts' mechanical energy into electrical energy.

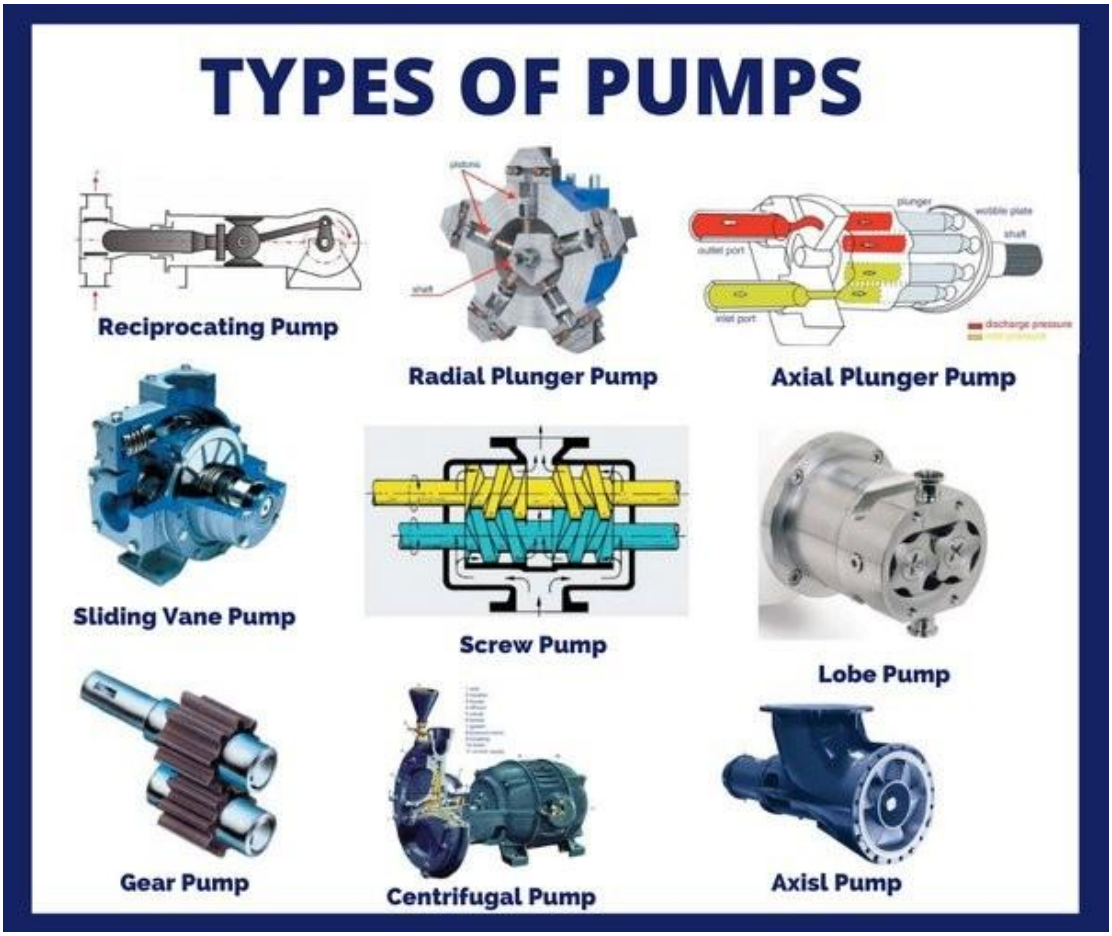
Pumps

Circulating water pump

This is the pump to send cooling water to the condenser. Depending upon the water intake source, the vertical type is usually used when taking water directly from sea, and the horizontal type is commonly used when taking water from the cooling tower.

Condensate pump

This is the pump for pumping condensate from the condenser. This is the important pump that should be regarded, so to speak, as the starting point of the main cycle of the power plant.



Cooling Towers

Whenever one percent of a body of water evaporates, the temperature of the remaining water drops to 5.8 °C. To cool the condenser, the phenomenon of evaporation is used to produce the cooling effect.

Evaporation is produced by exposing large surface of water to surrounding air. The simplest way to do this is to break up the water into small droplets and blow air through this artificial rain.

Forced and natural cooling tower for a power plant

Warm cooling water flows out of the condenser is piped to the top of the cooling tower where it is broken up into small droplets. As the droplets fall toward the open reservoir below, evaporation takes place and the droplets are chilled.

To here 23/2/2026