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Nuclear power plant

Nuclear power plants today are generating 16% of worlds electricity.

Nuclear power is the only source that can supply future energy demands of world.

Energy we obtain by burning 1 kg Uranium is equal to burning 2000 tones of coal.

→ Main parts of Nuclear plant -

Nuclear reactor
heat exchanger.
steam turbine
alternater.

They are similar with steam power plant but boiler has been replaced with heat exchanger and reactor.

→ Site selection :-

1- Availability of water -

Ample quantity of water is needed because water is secondary fuel.

2- Distance from populated Area -

In views of dangers of radio activity in the plant, they should be made far from over populated area.

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3- Disposal of waste -

Waste of a nuclear power plant is radio active, hence it should be disposed carefully.

4- Transport -

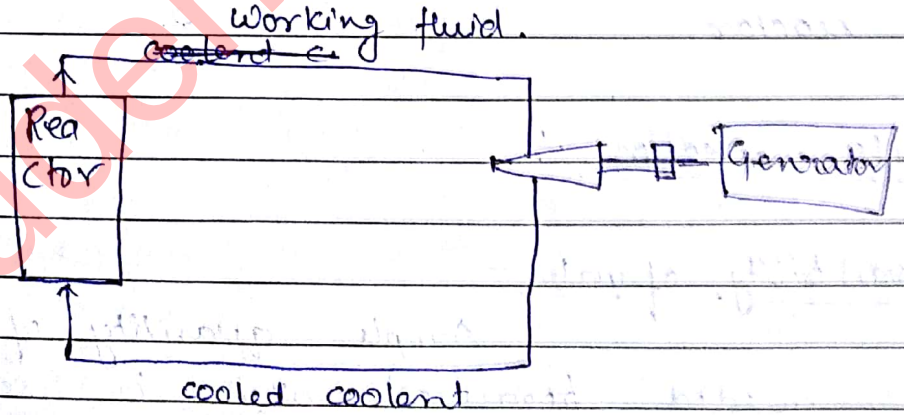
Transport should be easy avaible as during erection, heavy equip- are needed.

5- Land use -

The substrata must be strong enough to support heavy structure of plant.

→ General layout :-

① - Direct cycle



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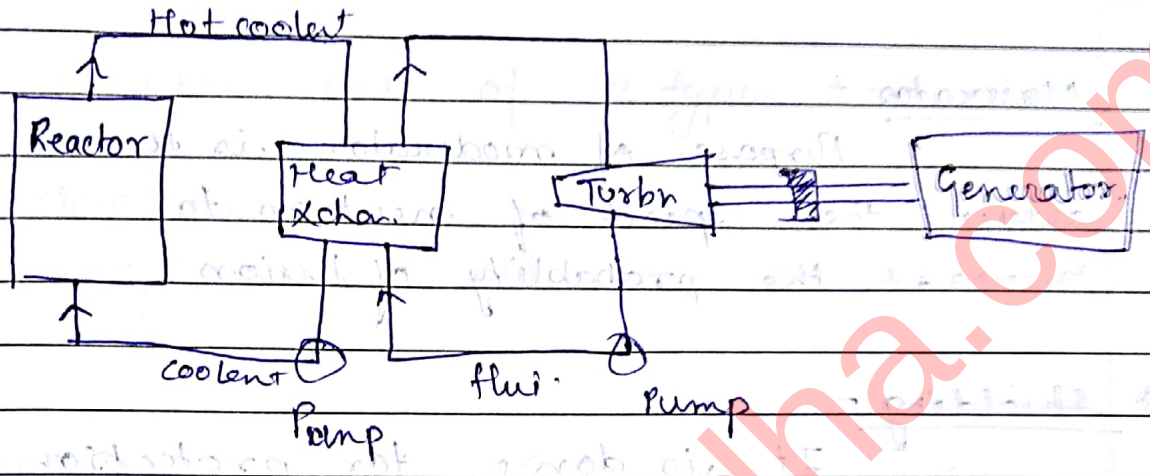
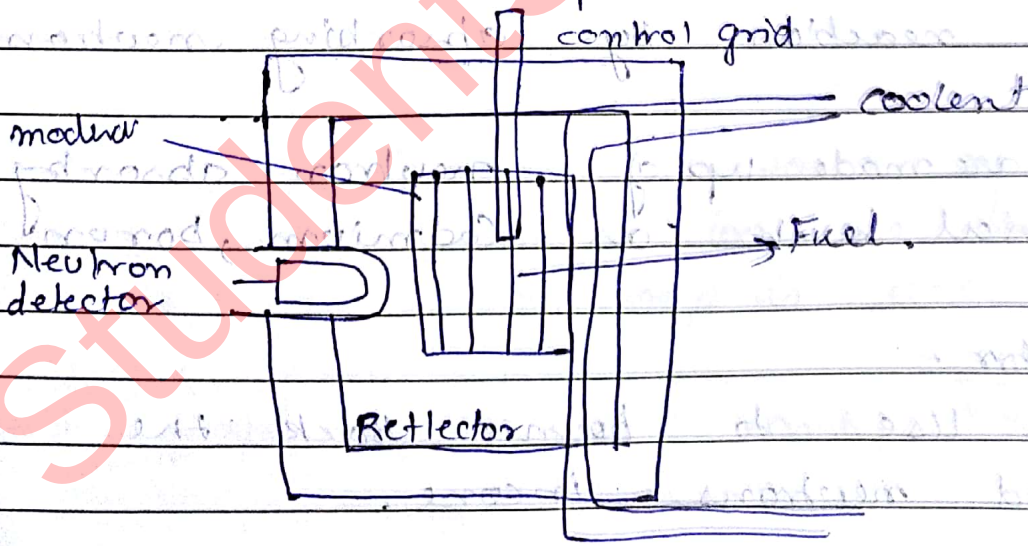
② Indirect cycle



→ Components of Nuclar reactor-

Nuclar reactor is the part of Nuclar Plant where Reaction takes place.



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① Fuel -

Generally used fuel in Reactor -

① $^{235}_{92}U$, $^{233}_{92}U$, $^{233}_{92}Pu$

② Moderator :

Purpose of moderator is to reduce the speed of neutron to increase the probability of fission.

③ Shielding -

It is done for protection from deadly α and β rays.

④ Control rods -

Control rods are used to break chain reaction by absorbing neutron.

They are made up of neutron absorbing material such as Cadmium, boron.

⑤ Reflector -

Use to bounce back the escaped neutrons in core.

6- Coolent -

It is used to transfer heat from reactor to heat exchanger pro for further utilisation.

→ Types of reactor - (on last Page).

Reactors are of 2 types.

① Heterogenous
② Homogenous → not very common.

→ Pressurized water reactor -

In a PWR, the coolent pressure must be greater than the saturation pressure at 300°C (85.93 bar) to supress boiling. The pressure is maintained at 155 bar to prevent bulk boiling.

A PWR power plant composed of two loops in series. Coolent loop is primary and working fluid loop is secondry.

Coolent picks up heat and transfers it in heat exchanger.

In PWR, fuel used is slighly enriched Uranium in the form of rods/plates. The steel pressure vessel used is of 20-25 cm thick

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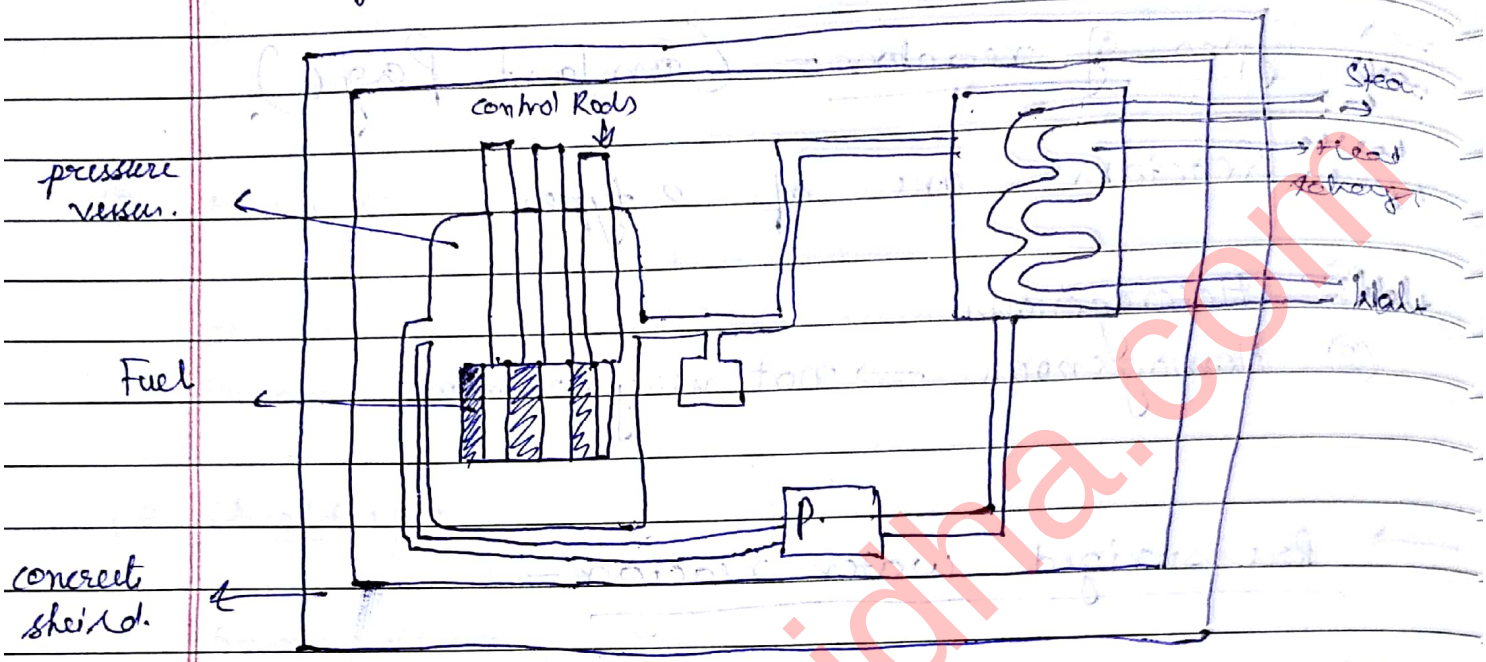
Pressurized water is used, both as coolent and moderator.
Water enters the reactor at 190°C and discharged at 270°C.



P.W.R

Advantage

— PWR is of compact size as compared to oth
— Has high power density.
~~Due to use of heat exchanger, containment of fission product possible~~
→ Steam supplied is free from contamination.

Dis-advantage.

→ Xpensive cladding
→ heat loss due to heat exchanger
→ design of high strength pressure vessel.

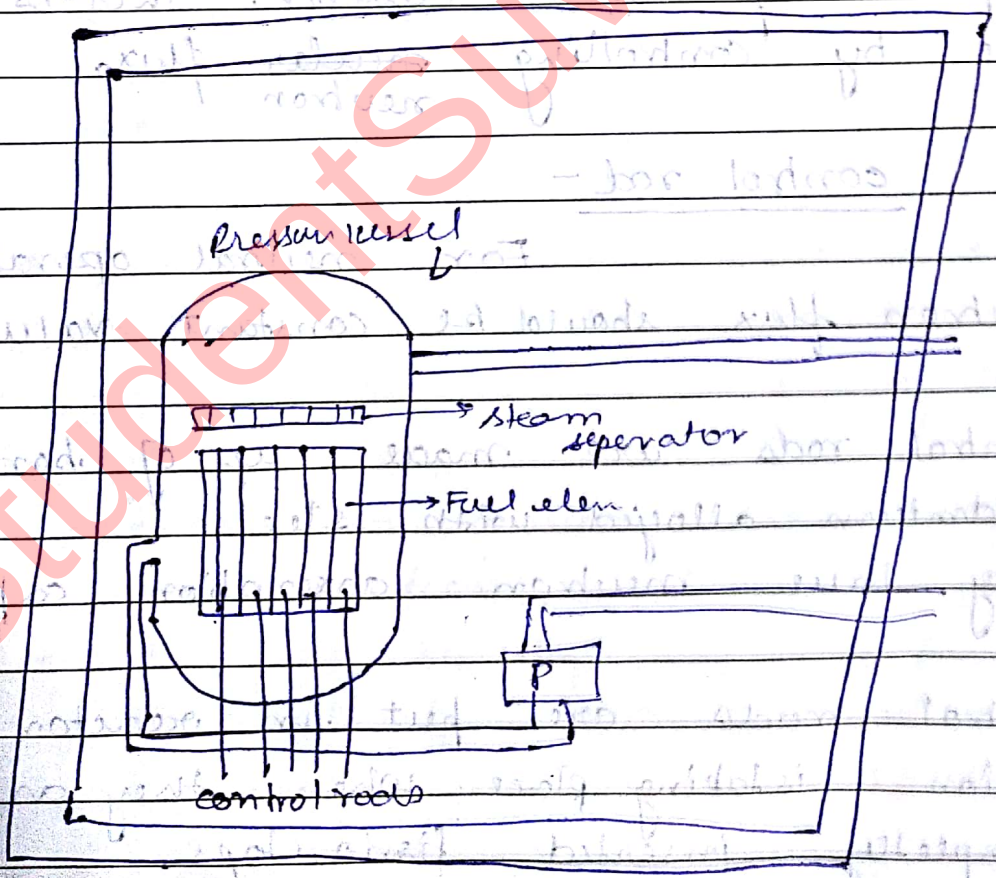
→ Boiling water Reactor

A BWR differs PWR, in that the steam flowing is directly produced in Reactor. After passing through condenser and turbine it returns to reactor.

The coolent in BWR has less pressure than PWR

BWR also uses enriched Uranium oxide as fuel and has steel pressure vessel surrounded by concrete sheild.

It is a direct cycle reactor.



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→ Advantage & Disadvantage

- No Heat exchanger, hence cost ↓
- More efficient than PWR
- More stable.

- Possibility of radioactive contamination
- Wastage of steam.
- Power density is half than PWR

→ Control of Nuclear Reactor

It is necessary to control the heat output of nuclear reactor. This is done by controlling ~~nuclear~~ neutron flux.

a control rod -

For neutral operation, neutron flux should be constant value.

Control rods are made up of boron, cadmium alloyed with steel.
They have neutron absorption capability.

Control rods are put in reactor where fission is taking place. when they are completely inserted fission stops.

They are of 8 types.

→ shut off rods = used for reducing the reactivity.

→ regulation rod = for starting and continuous control.

→ Coarse rod = taking reactor to req. power level after start.

b- Through flow of coolent -

At constant temp - power output is proportional to rate of flow of coolent.

→ Disposal of nuclear waste :

The disposal of solid, liquid and gaseous waste from nuclear power plant needs special attention because of danger of radiation.

It is essential to monitor the loss of carbon monoxide from reactor, loss should not exceed 1 ton per day.

Solid wastes like fuel cans, control rods (used) should be kept in concrete vaults.

most highly radioactive material is irradiated fuel elements, these wasts are kept under water or air cooled shielded are for 100 days.

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→ Shielding-

Adequate shelding is to be provided to guard personal and delicate instrument.

Materials used-

a- Lead → low cost and high density.
b Concrete → density is more than lead but less effic.
c- steel → has good structural properties.
d- Cadmium → can absorb slow neutrons.

→ Advantages & disadvantages

1- less space required
2- best for large power requirment.
3. fuel consumption very small
4. more reliable
5- More Capacity.

Disadvantage-

1- Capital cost high.
2- maintainace cost high.
3. disposal of waste is a problem.
4. Cannot be operated a varying load.
5- danger of radioactivity.

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→ Types -

① Type of fission.

1- Slow → Neutron Kinetic E. less than .1eV
2- Intermediate → " " " .1ev — .1MeV
3- Fast → " " 1MeV —<

② Fuel -

1- Natural uranium
2 Enriched "
3 Plutonium

③ State of fuel.

1- Solid
2- Liquid

④ - Coolent used

1- Gas
2- Water
3- heavy water

⑤ - Moderator

1- Heavy water
2- Graphite
3- Organic.

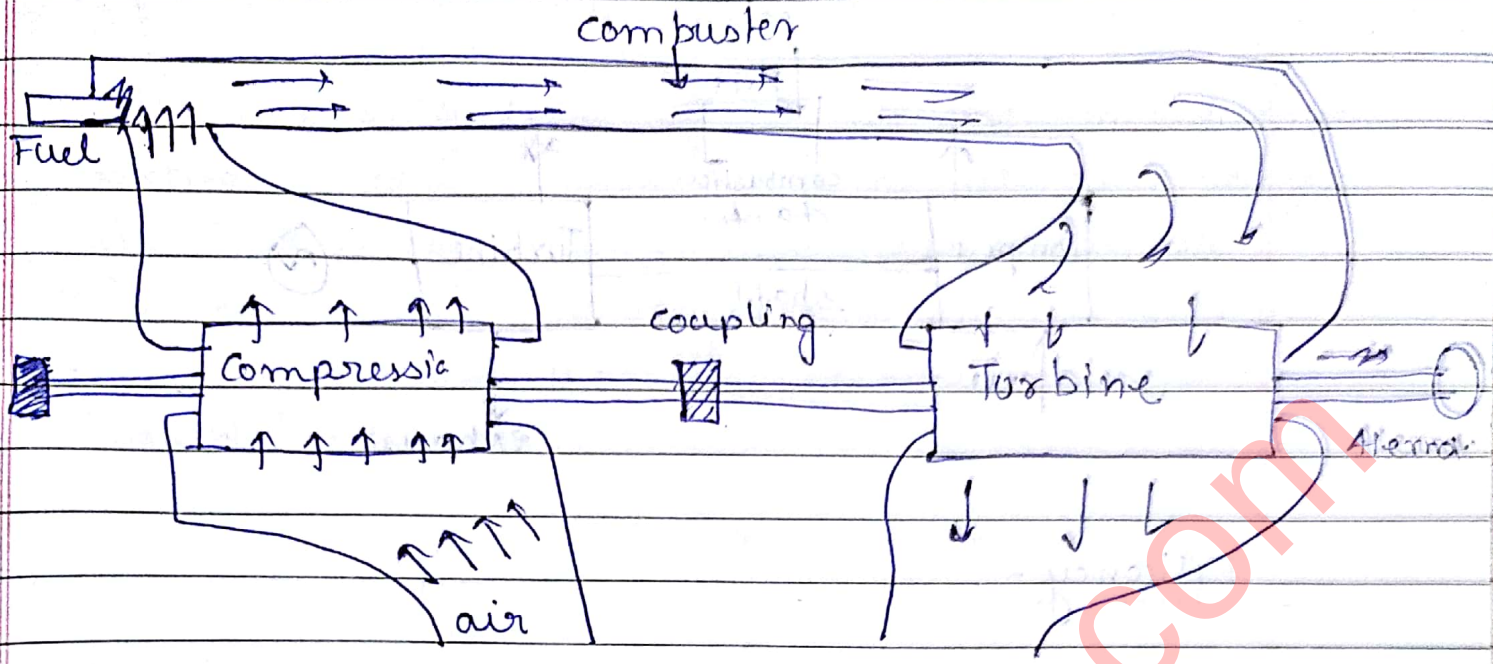
Gas turbine plants

→ Principle of operation-

- A gas turbine plant consists of compressor, combustion chamber, gas turbine, alternator.
- The compressor take the air and compress it then it is supplied to combustion chamber.
- Fuel is injected in combustion chamber and burned in the air.
- Combustion raises temp. of air and increase its volume under constant pressure.
- The hot pressurized air expands in turbine, produces mechanical power.
- Alternator produce electrical power from mechanical power.

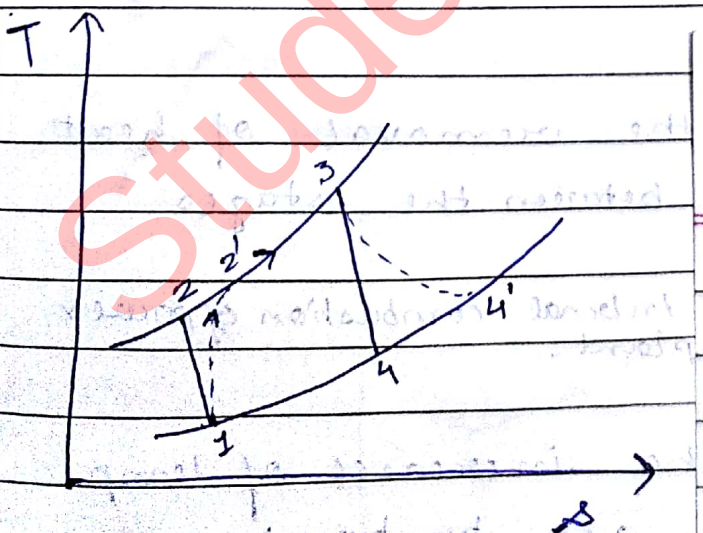
* Turbine o/p exceeds the I/p to the compressor, therfore turbine drive compresser and surplus power drives alternator.

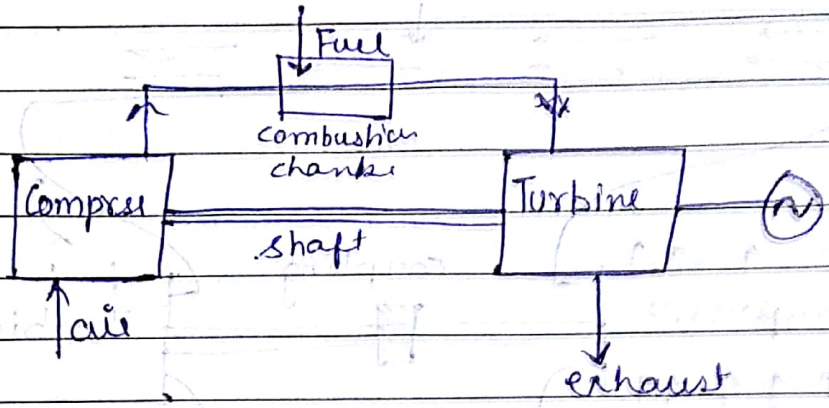
* Pressure ratio is 5 : 1
  Compr. : Alternator.



→ Open cycle plant -

- In Open cycle plant, compressor and turbine are mounted on a common shaft.
- Air is drawn in to compressor then that compressed air is sent to compression chamber.
- In chamber fuel is injected and burned, hot air expands and pass through turbine to atmosphere.





Efficiency -

low efficiency because 65% of developed mechanical power is used to drive compressor.

It can be improved by a combination of regeneration, intercooling and reheating.

- **Regeneration-**

Means transfering the heat from exhaust gases to the air flowing between compressor and combustion chamber.

- **Intercooling -**

Means the removal of heat from compressed air between the stages of compression.

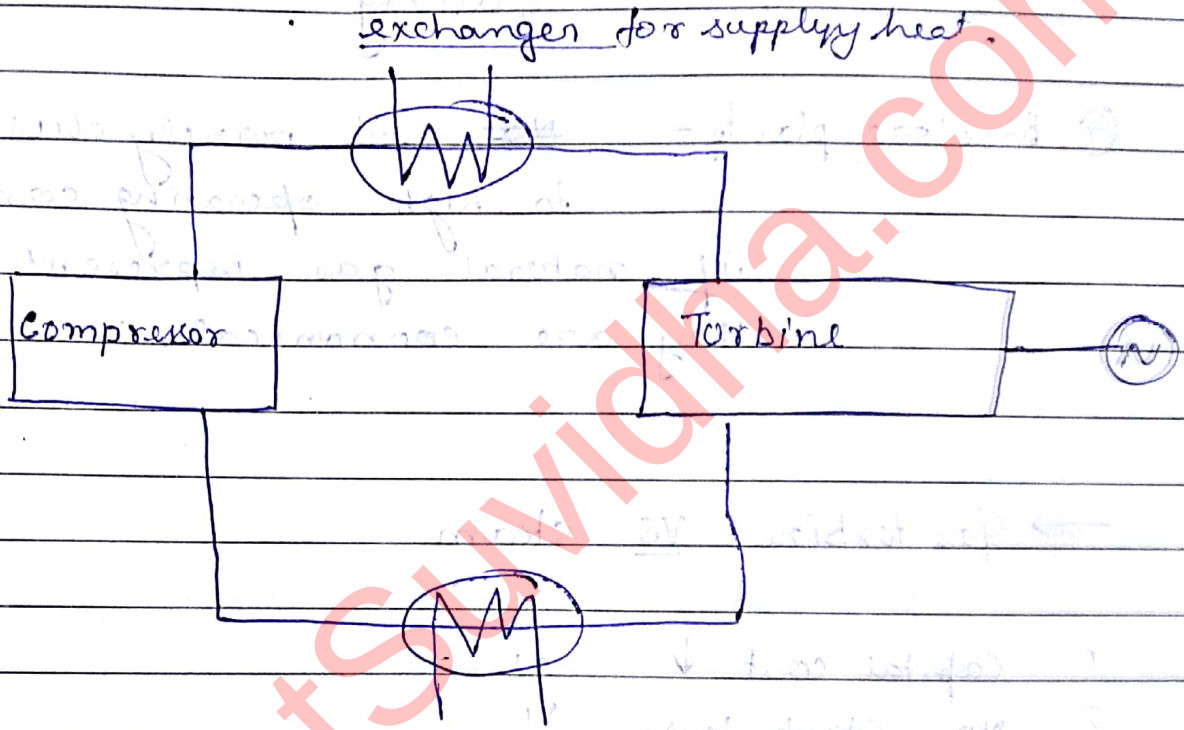
Intercooling reduces internal combustion of power by plant.

- **Reheating-**

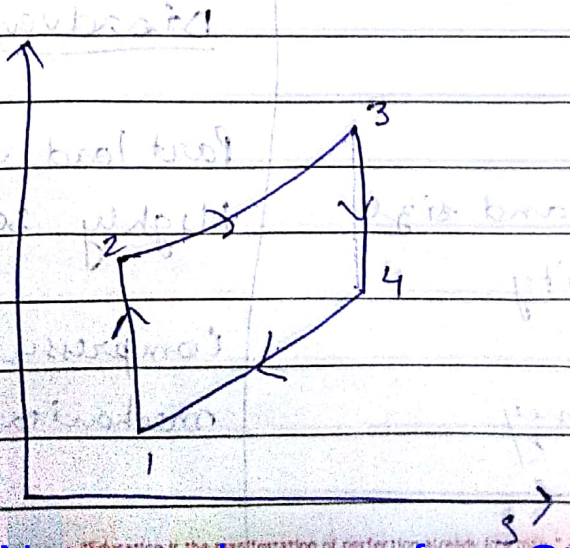
It is the increases of temp. of partially expanded gas by burning more fuel.

→ Closed cycle -

- In closed cycle, fuel is not mixed with working medium which can be air or other gas.
- Heat rejection occurs at heat exchanger. Thus the same working medium is circulated again and again through turbine, recooler, compressor and compressor.



Regeneration, Intercooling and Reheating process can be used.



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→ Applications -

① To supply mechanical drive of Auxiliaries.
② To work as combination plant with conventional steam boiler.
③ Peak load plants → Very suitable for use as peak load plant because they can be started and loaded quickly.
④ Base load plants - ~~Not~~ used rarely due to high operating cost but if natural gas is present abundantly they are economical.

→ Gas turbine VS steam

1	Capital cost ↓	"
2	NO Standby loss	"
3	less area than steam	
4	Operating cost ↑	
5	foundation are simple	

→ Advantage -	Disadvantage
① Warm up time	Part load efficiency is low.
② How weigh and size	Highly sensitive to ambient
③ Fuel Flexibility.	
④ Floor space	Compressor takes 65% of mechanical power.
⑤ High efficiency.	

Diesel plant

→ Advantages	Disadvantages
① Design and installation is simple	Only be used in small sizes.
② less space for fuel storage	high cost of fuel
③ free from ash handling	life is short about 5 yrs.
④ Capital cost per KW is low	overload capacity is small.
⑤ can be located very near to load	more polluting.

→ Applications -

① As Emergency plants
② Mobile plants
③ peak load plants
④ Used for starting Auxillary in steam power plants.

→ Plant Equipments

① Diesel Engine
② Fuel system
③ Air - Intake system
④ Engine cooling system
⑤ " lubricating system.
⑥ Exhaust system
⑦ Engine starting system.

① Diesel Engine

Diesel Engine, for a diesel electric plant, may be a 4 stroke or 2 stroke.

In 4 stroke, cycle complete in 4 stroke (2 revolution) the 4 stroke being suction, compression, working and exhaust.

In 2 stroke, all four operation done in 2 stroke (one revolution).

② Fuel system -

Function of fuel system is to supply correct amount of fuel to each cylinder in advance.

③ Air- Intake system -

Air is drawn from outside and delivered to inlet passing through filter.

④ Engine cooling system -

Xtra heat, not used for doing useful work has to be removed.

Pump circulates water through cylinder and head jacket to carry away heat.

⑤ Engine Lubricating system-

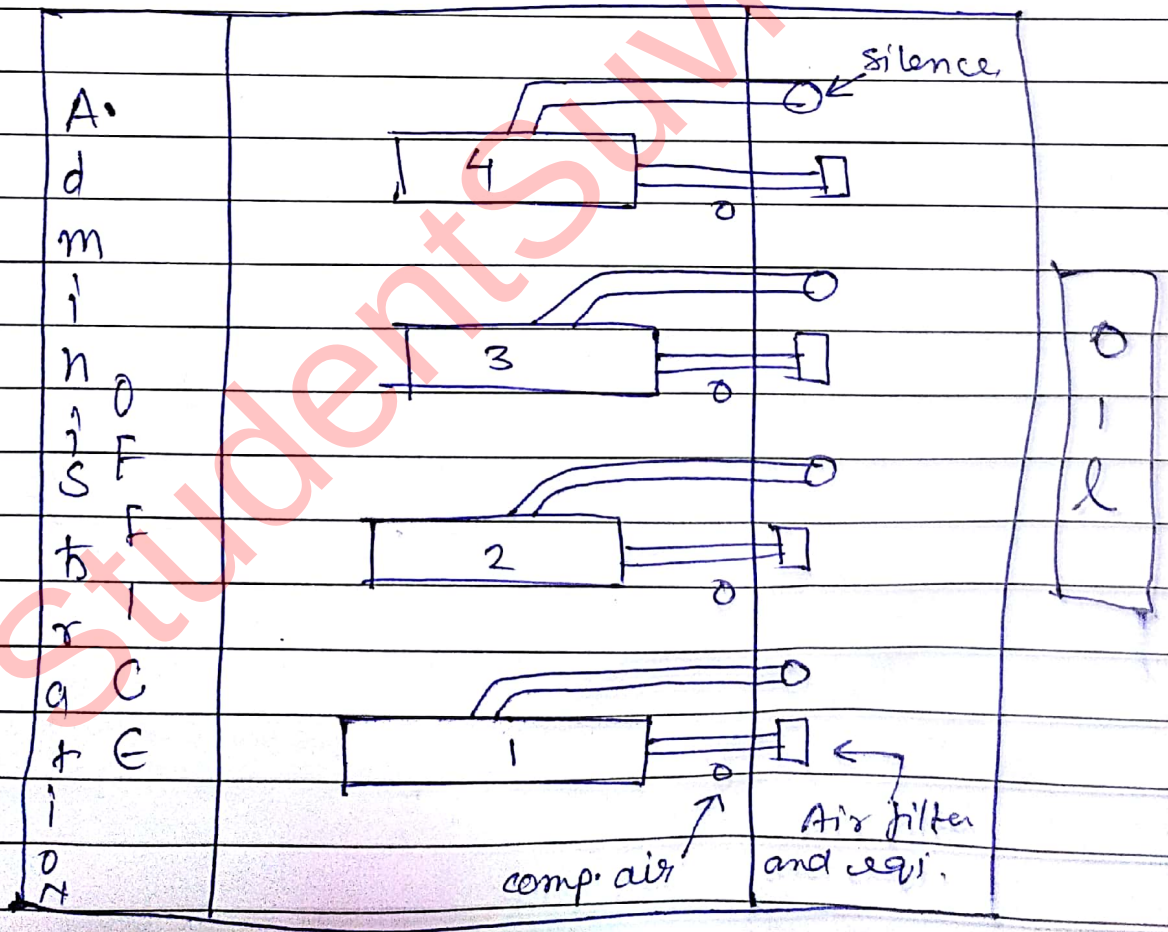
Function is to reduce friction of moving parts and reduce wear and tear.

⑥ Exhaust system-

Includes silencer and conneting duct Used to reduce noise.

⑦ Engine starting system-

Includes storage battery, compressed air tanks, self starter etc. Function is to start the engine from cold by supplying compresed air.



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