CMR INSTITUTE OF TECHNOLOGY

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Internal Assesment Test - I

Sub:	Power Generation and Economics							Code:	17EE42
Date:	20/04/2019	Duration:	90 mins	Max Marks:	50	Sem:	4	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1.a	Discuss in detail the factors to be considered for selection of the site for a thermal power plant.	[5]	CO2	L2
1.b	Discuss the advantages of gas-turbine power plant over steam power plant.	[5]	CO2	L2
2.a	Explain the working of steam power plant with neat schematic diagram.	[7]	CO2	L1
2.b	List out and explain the points to be considered for site selection of diesel electric plant?	[3]	CO2	L2
3.a	Explain the functions of the following in a thermal plant (i)Air preheater , (ii)Boiler , (iii)Condenser.	[6]	CO2	L1
3.b	Discuss the general merits of gas-turbine power plant	[4]	CO2	L2
4.a	Explain any three methods used for disposal of ash in steam power plant.	[6]	CO2	L1
4.b	Compare of hydro power plant and steam power plant.	[4]	CO2	L2
5.a	Explain with a line-diagram, fuel handling system of a thermal power plant.	[5]	CO2	L1
5.b	With a neat sketch explain fluidized bed combustion.	[5]	CO2	L1
6.a	Discuss the methods of increase the thermal efficiency in gas turbine plant	[6]	CO2	L1
6.b	Explain the techniques of dust collection in thermal power station	[4]	CO2	L1
7.a	Discuss the working principles of stokers used in steam power plants.	[5]	CO2	L1
7.b	Explain the principle of working of a gas-turbine plant. Also explain open cycle and closed cycle gas turbines.	[5]	CO2	L1

SOLUTIONS

1.a) Discuss in detail the factors to be considered for selection of the site for a thermal power plant.

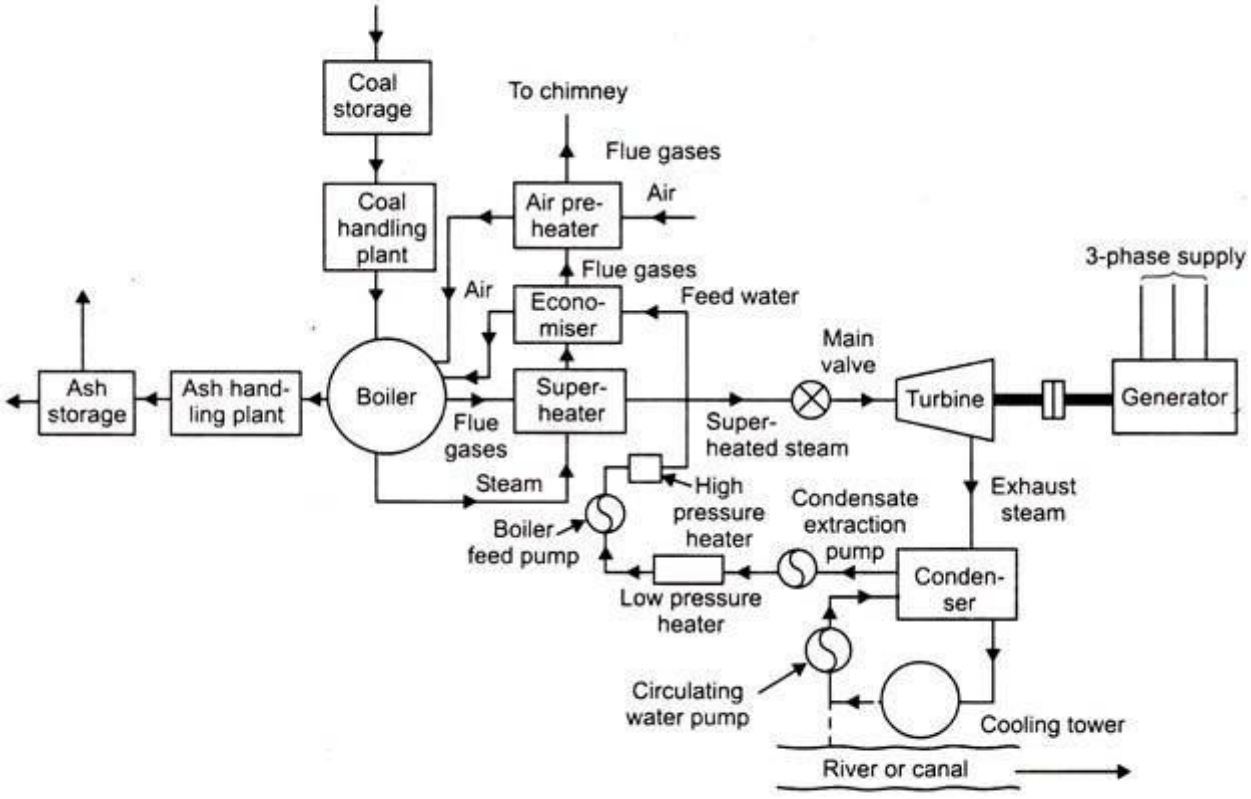
- ***Supply of fuel-*** Thermal power station as close as possible to the coal mine, economy consideration , considering transmission & transportation charges.
- ***Ash disposal facility-*** Ash content of the coal should be as low as possible, Indian coal has ash content 20-40% & sufficient space is required for storing ash.
- ***Availability of water-*** Feed water for the boiler, Huge quantity of water is required for condenser & disposal of ash.

- ***Land requirement-*** Average land requirement is 3 to 4 acres per MW capacity. Land should be available cheap rate & good bearing capacity.
- ***Transportation facility-*** Huge quantity of coal is required, rail & road facility should be available very near.
- ***Distance from the populated area-***As huge amount of coal is burnt in steam power station, therefore smoke & fumes pollute the surrounding area. This necessitates that the plant should be located at a considerable distance from the populated area.
- ***Labour supplies-*** Skilled labours should be available at reasonable rates near the site of the plant.

1.b) Discuss the advantages of gas-turbine power plant over steam power plant.

- Compact – same capacity
- Fewer auxillaries – lesser personnels;
- Installation takes less time
- No condensor maintainance – almost no water requirement
- Simple lubrication systems
- Light foundation
- Easily controlled
- Can be started quickly
- Fuel consumption during starting and shutting low
- Clean exhaust – no stack required
- Low weight power ratio
- Less capital cost

2.a) Explain the working of steam power plant with neat schematic diagram.



The schematic arrangement of a modern steam power station can be divided into the following stages:

- *Coal and ash handling plant*
- *Steam generating plant*
- *Steam turbine*
- *Alternator*

- *Feed water*

- *Cooling arrangement*

COAL AND ASH HANDLING PLANT

- Coal is transported to power station by rail or road and stored in coal storage plant and then pulverised
- Pulverised coal is fed to fed to the boiler by belt conveyers
- Coal gets burned in the boiler and ash produced is removed to the ash handling plant and then delivered to ash storage plant for disposal
- A 100MW station operating at 50% LF may burn about 20000 tons of coal per month and produce 3000 tons of ash

The Ash from the boiler is collected in two forms:

1. **Bottom Ash(Slurry):It's a waste which is dumped into a Ash Pond**
2. **Fly ash: Fly ash is separated from Flue Gases in ESP(Electro static Precipitator).**

STEAM GENERATING PLANT

The steam generating plant consists of a boiler for the production of steam and other auxiliary equipment for the utilization of flue gases

1) ***Boiler:*** The heat of combustion in the boiler is utilized to convert water into steam at high temperature and pressure
2) ***Superheater:*** The steam produced in boiler is wet and is passed through a superheater where it is dried and superheated. Increases efficiency
3) ***Economiser:*** It's essentially a feed water heater and derives heat from the flue gases
4) ***Air Preheater:*** Increases the temperature of the air supplied for coal burning by deriving heat from flue gases. Air is drawn from the atmosphere by a forced drought fan and is passed through air preheater before supplying to the boiler furnace.

STEAM TURBINE

- Dry and superheated steam from superheater is fed to the steam turbine.
- The heat energy of steam when passing over the blades of turbine is converted into mechanical energy.
- After giving energy to the turbine, the steam is exhausted to the condenser which condenses the exhausted steam by means of cold water circulation

ALTERNATOR

- Steam turbine is coupled to an alternator which converts the mechanical energy to electrical energy
- The electrical output of the alternator is delivered to the bus bars through transformer, circuit breakers and isolators.

FEED WATER

- The condensate from the condenser is used as feed water to the boiler.
- The water that may be lost in the cycle is made up from the external source
- The feed water on its way to boiler gets heated up by water heaters and economiser.
- This helps to improve the overall efficiency of the plant

COOLING ARRANGEMENT

- Condenser condenses the steam exhausted from the turbine
- Water is drawn from natural sources like river, lake, canals…
- Circulating water takes up the heat and itself gets heated up
- This hot water can be discharged away or used again by using a cooling tower

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3.b) Discuss the general merits of gas-turbine power plant

- Storage of fuel require less area & handling is easy.
- Maintenance cost is less.
- Simple in construction. There is no need for boiler, condenser etc.
- Cheaper fuels such as kerosene, paraffin, benzene & powered coal can be used which are cheaper than petrol & diesel.
- Suitable in water scarcity area.
- More reliable.
- Less pollution and water requirement.

4.a) Explain any three methods used for disposal of ash in steam power plant.

- **Belt Conveyer System.**

- In this system ash is carried with the belt conveyor with a water bed carrier, through a channel and finally dumped in the sump.
- This is continuous handling & the power consumption is low.

❖ **Pneumatic System**

➢ Air is employed as the medium for driving the ash through a pipe over long distance.
➢ The ash is passed from boilers & then into conveying pipe.
➢ Air is sucked through the delivery end which makes the ash to flow into separators where ash is collected in hoppers.
➢ The dusty air is filtered & exhausted to atmosphere through the exhaust fan.

Advantage

▪ Can carry ash through long distance.

Disadvantage

▪ High maintenance charges & noisy operation.

❖ **Hydraulic System**

➢ In this system a stream of water carriers ash along with it in a closed channel & disposes it off to the proper site.
➢ This system can be used for large capacity power plants where the ash is to be disposed off over long distances.
➢ This is a healthy, clean dustless & completely enclosed system.
➢ Hydraulic system are

▪ **High pressure system.**
▪ **Low pressure system.**

4.b) Compare of hydro power plant and steam power plant.

Steam Power Plant:

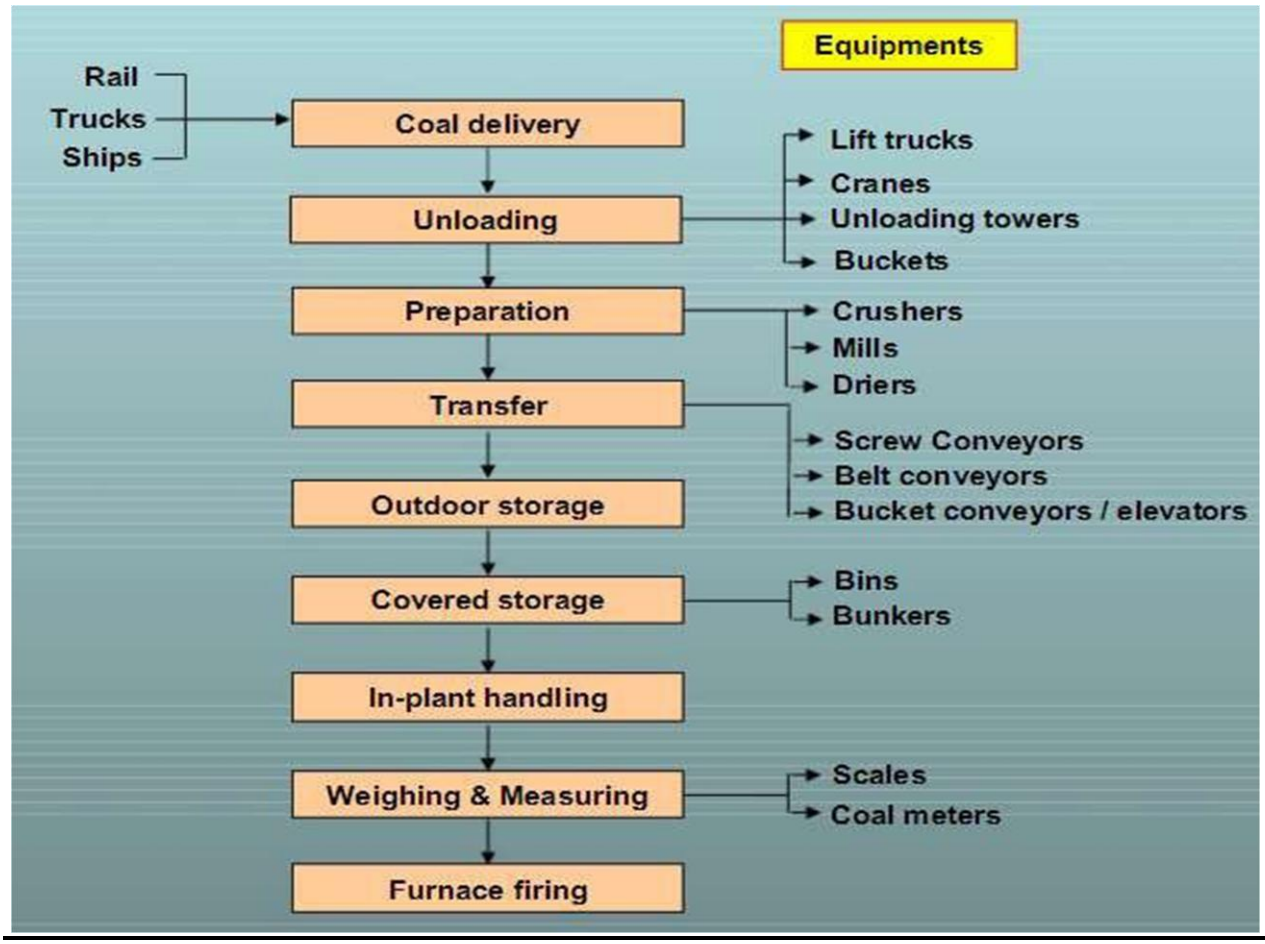
a. It should be set up a place where available for water, coal transportation.
b. Initial cost is low compare to hydraulic power plant.
c. Its running cost is higher than nuclear power plant running cost.
d. Its source of power is coal.
e. Its fuel transportation cost is high.
f. Lowest environment friendly.
g. Its efficiency is 25 %
h. Its maintenance cost is very high.

Hydro-electric Power Plant:

a. It is set up a place where available is water resource.
b. It's initial cost is higher than Steam power plant.
c. It has no running cost.
d. Its source of power is water.
e. It's transportation cost is very low.
f. It is most environment friendly.
g. Its efficiency is about 85 %
h. It's maintenance cost is quite low.

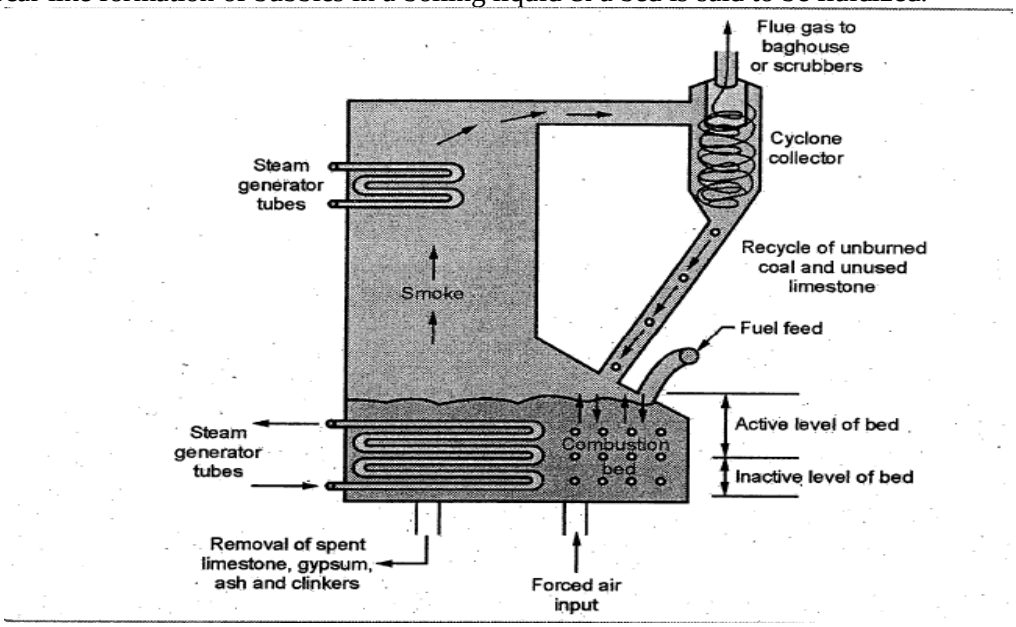
5.a) Explain with a line-diagram, fuel handling system of a thermal power plant.

➢ Coal can be handled manually or mechanically
➢ Mechanical handling is usually adopted as it is reliable and economical.
➢ Large quantity of coal is required to be handled everyday, mechanical handling has become necessary.
➢ The main requirement of a coal handling plants are reliability, soundness & simplicity requiring a minimum of operatives & minimum of maintenance.



5.b) With a neat sketch explain fluidized bed combustion.

- A fluidized bed may be defined as the bed of solid particles behaving as a fluid.
- When an evenly distributed air is passed upward through a finely divided bed of solid particles at low velocity, the particles remain undisturbed
- But if the velocity is steadily increased, a stage is reached when individual particles are suspended in the air stream.
- If air velocity is further increased , the bed becomes highly turbulent (moving unsteadily) & rapids mixing of particles occur.
- This appear like formation of bubbles in a boiling liquid & a bed is said to be fluidized.



- There are two basic systems in FBC namely
- **Atmospheric FBC**
- **Pressurized FBC**

Advantages of FBC

- High thermal Efficiency
- Easy ash Removal system
- Short Erection and Commissioning period.
- Fully Automatic & Safe operation
- Reduced maintenance & Uniformity of temperature.

6.a) Discuss the methods of increase the thermal efficiency in gas turbine plant

- The efficiency of a simple gas turbine power plant can be improved by employing regenerator, intercooler and reheater.
- **Regenerator** is usually of shell and tube construction. The exhaust gases are made to flow inside the nest of tubes while air flows outside the tubes in the shell in the counter flow and heated up by the heat given out by the exhaust gases. Thus the regenerator utilizes the heat of exhaust gases to heat the compressed air before it is sent to the combustion chamber, reduces the fuel consumption of the plant and improves the cycle thermal efficiency. It is noteworthy that addition of the regeneration in the circuit makes no change in the duties/work of the compressor and turbine but the quantity of fuel supplied is substantially reduced as the temperature of the air entering the combustion chamber is raised. The other noteworthy point is that the gain in efficiency is greater at lower pressure ratios.
- The heat transfer from the regenerator can be improved either by increasing the surface area or by increasing the flow turbulence. Increasing of surface area regenerator involves higher initial cost, while the increasing of flow turbulence involves increased pressure drop. Thus the design of a regenerator is a compromise between the gain in heat recovery on the one hand and higher initial cost and operating cost on the other.
- However, for short time operation such as peak loads, the cost of regenerator may not justify its use in gas cycle.
- Also, a greater part (about two – third) of power developed by the turbine is used in driving the compressor. This requirement of power, however, can be reduced if the compression of air could be done in two or more stages and an **intercooler** is introduced between the two. This is because of reduction in volume of air due to cooling in the intercooler.
- The cooling of air between two stages of compression is known as **intercooling**. This reduces the work of compression and increases the specific output of the plant with a decrease in the thermal efficiency. In intercooling, a heat exchanger is used to cool the compressor gases at the time of compression process. When the compressor involves the high and low pressure unit in it, the intercooler could be installed between them to cool down the flow. This cooling process decreases the work needed for the compression in the high pressure unit thus improves the thermal efficiency, air rate and work ratio.

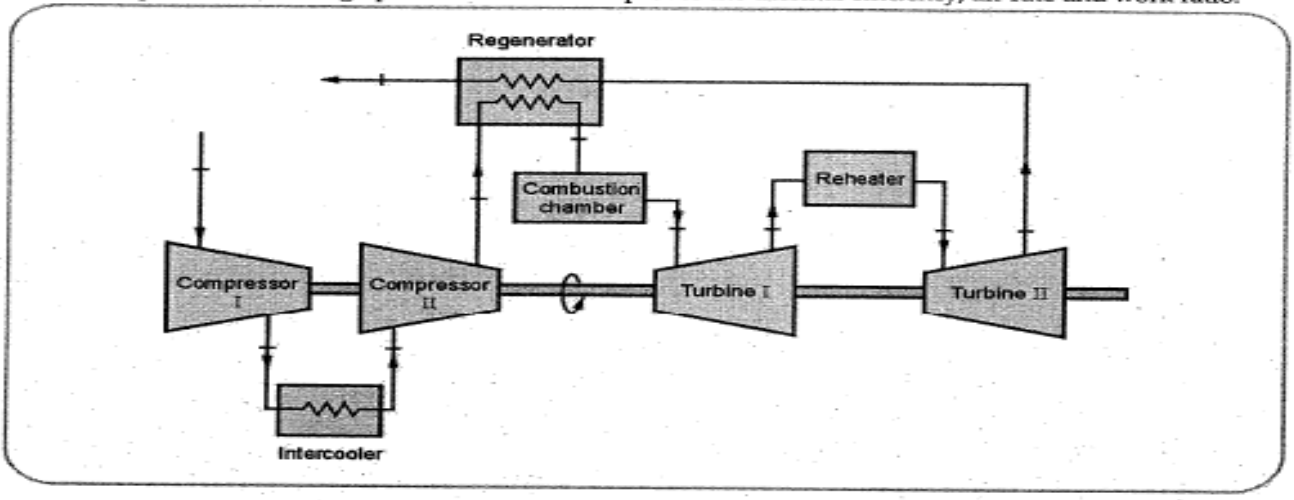


Fig. 4.6.1 A Gas-Turbine Engine with two - stage compression with Intercooling, two – stage expansion with Reheating, and Regeneration.

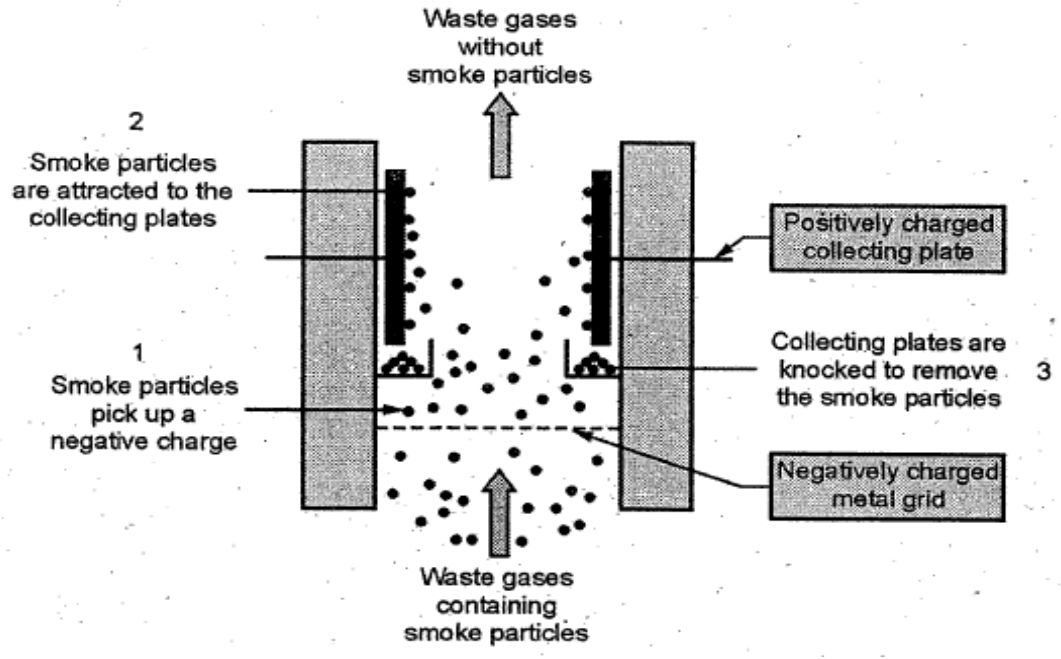
- Some large compressors have several stages of compression with intercooling between stages. The determination of the number of stages and the conditions at which to operate the various intercoolers is a problem in optimization. The use of multistage compression with intercooling in a gas turbine power plant increases the net work developed by reducing the compression work. A lower temperature at the combustor inlet would require additional heat transfer to achieve the desired turbine inlet temperature. The lower temperature at the compressor exit enhances the potential for regeneration, however, so when intercooling is used in conjunction with regeneration, an appreciable increase in thermal efficiency can result.
- In **reheating** the combustion gases are not expanded in one turbine only but in two turbines. The exhaust of the high pressure turbine is reheated in reheater and then expanded in a low pressure turbine. Reheating improves the output from the turbine due to multiple heating in the same way as intercooling improves the performance of the compressor.

6.b) Explain the techniques of dust collection in thermal power station

- The exhaust gases leaving the boiler contain particles of dust, fly ash or carbon as a material called Cinder.
- The quantity of solid particles depends upon the method of fuel firing.
- In pulverised fuel firing 60 to 80 % of the total ash produced in the furnace, escapes through the chimney as flue dust.
- Removal of dust from exhaust gases is very important because the environment gets polluted.
- Dust collectors are classified into **Mechanical & Electrical ones (Electrostatic Precipitator).**
- Mechanical dust collectors can be further classified as Wet & Dry dust collectors.
- **Electrostatic Precipitator**
- It is a device that removes dust particles from a flowing gas using the force of an induced **electrostatic** attraction.
- It consists of two electrodes which are completely insulated from each other.
- One set is called **emitting or discharge electrode.**
- Other set is called **Collecting electrode.**
- The emitting or Discharge plates are connected to **negative polarity** of hvdc source.
- While the Collecting electrodes are connected to **positive polarity.**
- High electrostatic field is set up between two sets of electrodes creates corona discharge & ionizes the gas molecules as flue gases flow in between the plates.
- The dust particles acquire negative charge & are attracted to positive polarity & gets deposited there.

Types of Electrostatic precipitator

- **Plate or Tubular type.**
- **Horizontal & Vertical flow type.**
- **Dry or Wet type**



7. a) Discuss the working principles of stokers used in steam power plants.

- Stoker gives mechanical feeding of a coal
- Mechanical Stokers receive fuel by gravity, carry it to the furnace for combustion & after combustion discharge of ash at appropriate point.

❖ **Advantages**

- Uniform feeding of fuel into furnace.
- Greater combustion facility.
- Saving labour cost.
- Fluctuations of load demand can be met because of control of combustion.
- Very reliable & maintenance charges are reasonably low.

Disadvantages

- Complicated construction.
- Loss of fuel in the form of riddling's (remove ashes) through the gates.
- Standby losses are always present.
- With very large units the initial cost may be rather high than with pulverized fuel.

❖ **Mechanical Stokers are of two types.**

- **Underfeed Stokers.**
- **Overfeed Stokers.**

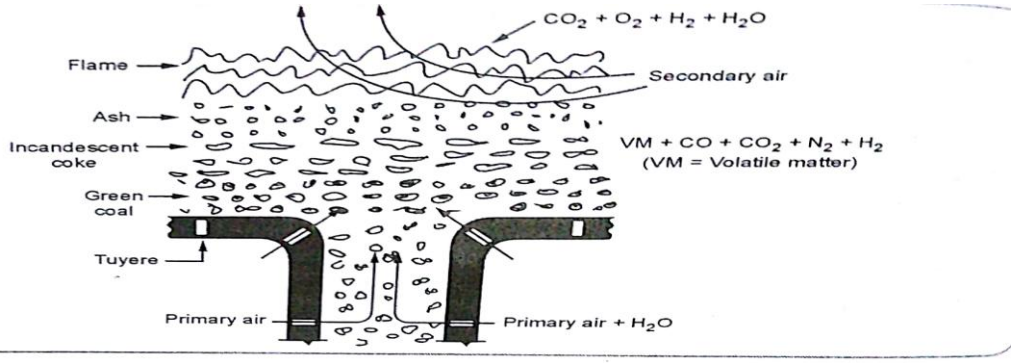


Fig. 2.10.1 Underfeed Stoker

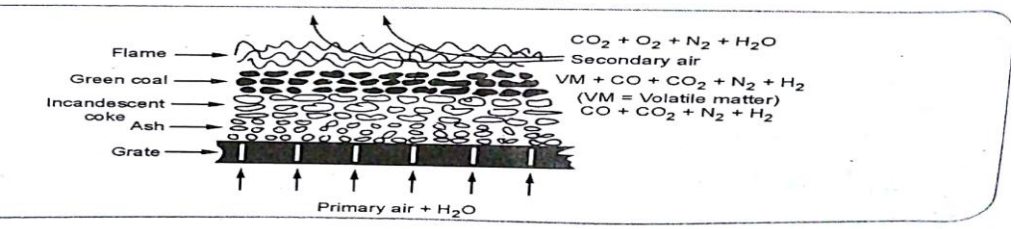


Fig. 2.10.2 Overfeed Stoker

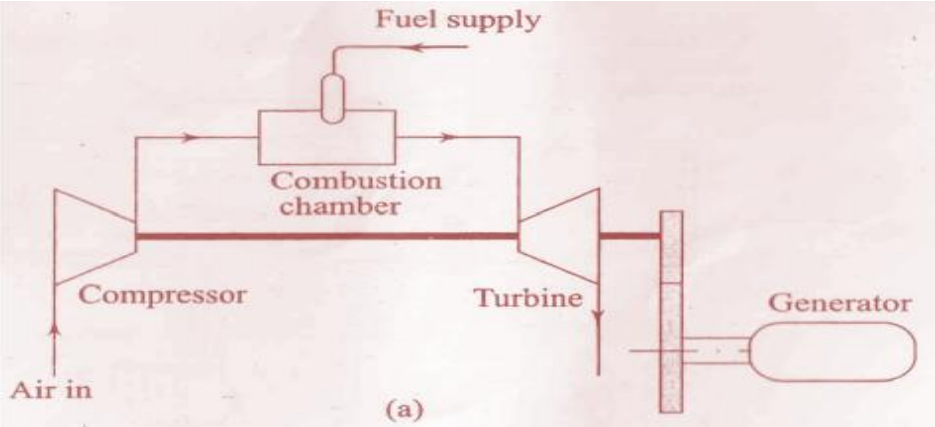
Underfeed Stokers

- ❑ The coal is fed into the furnace below the point of admission of air.
- ❑ Coal from the container discharges into furnace.
- ❑ When coal gets heated up all volatiles in it are distilled & when coal reaches active combustion it is in the form of coke & ash.
- ❑ The ash discharge plates are at back of furnace & by time coal is washed down on the plates, all combustion has been complete.
- ❑ Here air is admitted through holes in furnace sides.

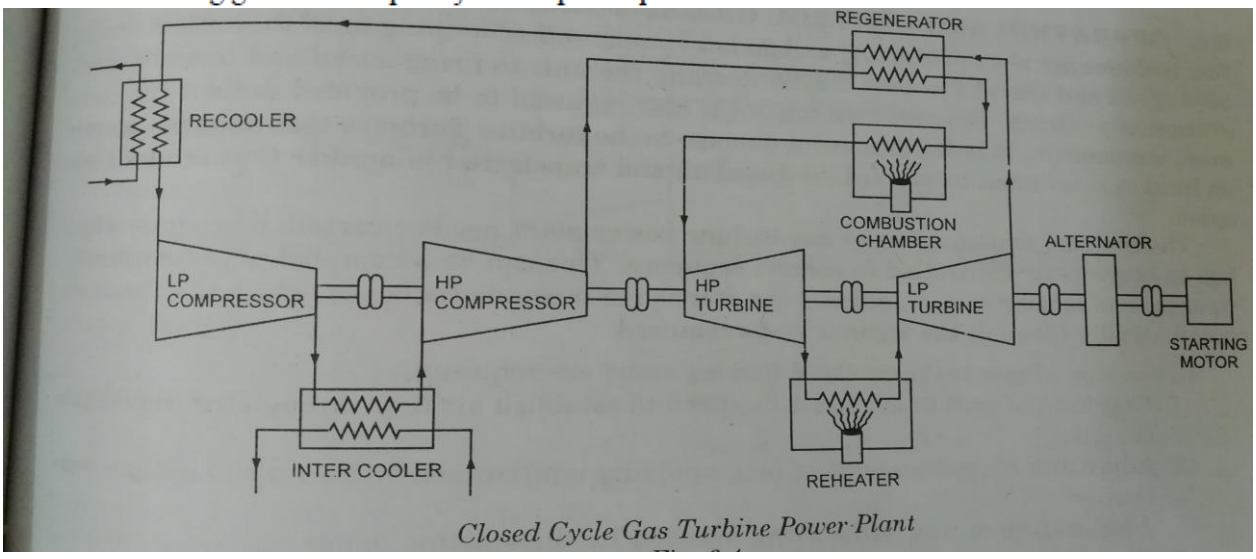
Overfeed Stokers

- ❑ Overfeed stokers are used for large capacity boilers where coal is burnt as lumps (i.e., without pulverization).
- ❑ In this type of stoker, the fuel bed receives fresh coal on top surface.
- ❑ In the first layer (top layer), fresh coal is added
- ❑ Second layer is the drying zone, where coal losses moisture
- ❑ Third layer is distillation zone, where coal loses volatile matter
- ❑ Fourth layer is the combustion zone, where the fixed carbon in coal is consumed.
- ❑ Fifth layer is the ash cooling zone

7,b) Explain the principle of working of a gas-turbine plant. Also explain open cycle and closed cycle gas turbines.



- The open cycle power plants (as shown in fig.) are most widely used in majority of GT power plants.
- In open cycle GT power plants, atmospheric air is continuously drawn into the compressor and compressed to high pressure.
- The compressed air then enters the combustion chamber, where it is mixed with fuel and combustion occurs at constant pressure.
- The heated gases coming out of combustion chamber are then expanded in the gas turbine to produce mechanical work.
- The part of the mechanical work produced by the turbine is utilized to drive the compressor and other accessories and remaining is used for power generation.
- The gases leaving turbine are exhaust to surroundings.
- The working gas is air in open cycle GT power plant.



Closed Cycle Gas Turbine Power Plant

- In a closed cycle GT power plants (as shown in fig.), the working gas coming out of compressor is indirectly heated at constant pressure in heat exchanger by an external heat source.
- The external heat source may be gas cooled nuclear reactor or flue gases resulting from the combustion chamber or furnace.
- The high pressure high temperature working gas coming from heat exchanger is expanded through the gas turbine.
- The working gas leaving the turbine after expansion is cooled in heat exchanger with help of surrounding and supplied to the compressor to repeat cycle of operation.
- The working gas may be air, helium, argon, carbon di oxide and so on.