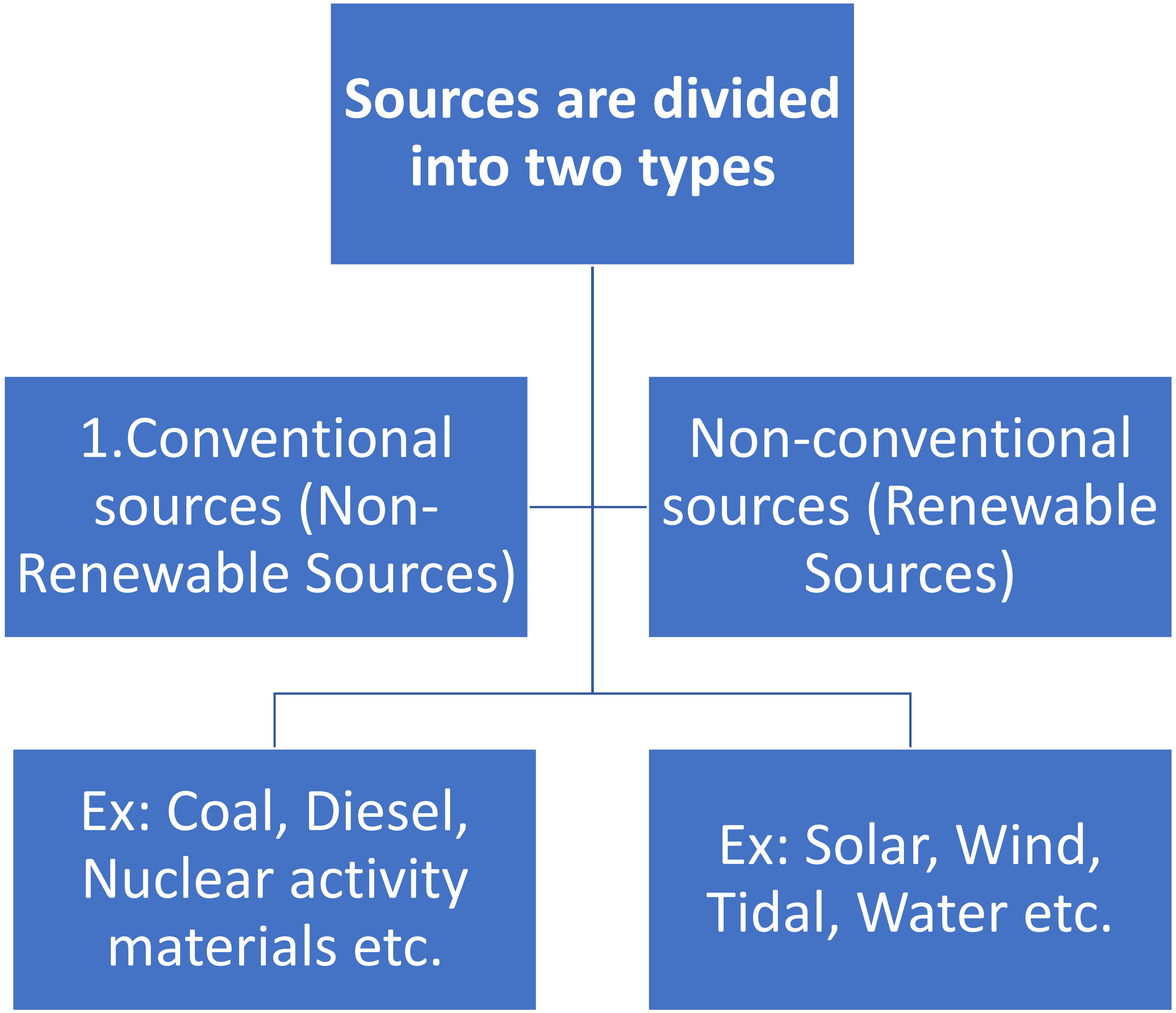
POWERPLANT ENGINEERING

A **power plant** may be defined as a machine or assembly of equipment that generates and delivers a flow of mechanical or electrical energy. The main equipment for the generation of electric power is generator.

When coupling it to a prime mover runs the generator, the electricity is generated. The type of prime move determines the type of power plants.

Introduction to power plant engineering

- A power plant is an industrial facility used to generate electric power with the help of one or more generators which converts different energy sources into electric power.
- A power plant or a power generating station, is basically an industrial location that is utilized for the generation and distribution of electric power in mass scale, usually in the order of several 1000 Watts.
- located at the sub-urban regions or several kilometers away from the cities or the load centers
- Electricity is produced at an electric power plant. Some fuel source, such as coal, oil, natural gas, or nuclear energy produces heat. The heat is used to boil water to create steam.
- the transformer switch yard to regulate transmission voltage also becomes an integral part of the power plant.
- all power generating stations has an AC generator or an alternator


Sources are divided into two types
1.Conventional sources (Non-Renewable Sources)
Non-conventional sources (Renewable Sources)
Ex: Coal, Diesel, Nuclear activity materials etc.
Ex: Solar, Wind, Tidal, Water etc.

Sources are used to generate the power

1. Water energy – It is used in Hydro-Electric Power Plant
2. Coal- It is used in Steam Plant
3. Diesel- It is used in I.C Engine plant
4. Nuclear activity materials- It is used in Nuclear Power Plant
5. Non-conventional sources- These are used in Solar, Wind & tidal power plant.

RESOURCES OF POWER IN INDIA:

- The hydel power source plays a vital role in the generation of power, as it is a non-conventional perennial source of energy.
- Water as a source of power is non-polluting which a prime requirement of power industry today is the world's total waterpower potential is estimated as 1500 million kW at mean flow.
- Energy generated at a load factor of 50% would be 6.5 million kW-hr
- The world hydel installed capacity (as per 1963) estimate is only 65 million kW or 4.3% of the mean flow. India has colossal waterpower resources.
- India's total mean annual river flows are about 1675 thousand million cubic meters(555 thousand million cubic meters are useful)
- India's power potential from hydel source as per the recent estimate is 41500 MW while its present hydel capacity is only 32000 MW.

Water contribution in India

- 60% contribution comes from Himalayan Rivers (Ganga, Indus and Brahmaputra)
- 16% from central Indian rivers (Narmada, Tapti and Mahanadi)
- Remaining from the rivers draining the Deccan plateau (Godavari, Krishna and Cauvery).

factors responsible in its rapid development

- Technological skill
- Material
- cheap labor
- Able to solve the major problem of peak load is as a significant advantage.

The major **difficulty in the development** of hydroelectric projects:

- Relatively longer time required for its hydrological, topographical and geological investigations.

The major **drawback:**

- It operates at the mercy of nature.
- Poor rainfall has on a number of occasions shown the dangers of over dependence on hydropower.
- Coal, oil or gas- the oil and gas resources are very much limited in India.

Classification of fuels

- 1. They occur in natural called primary fuels or are prepared called secondary fuels.
- 2 They are in solid, liquid or gasses state

Types of fuels	Natural(primary)	Prepared(secondary)
solid	Wood, peat & lignite coal	Coke, charcoal & briquettes
liquid	petroleum	Gasoline, kerosene, fuel oil, alcohol, benzol & shale oil
gaseous	Natural gas	Petroleum gas, producer gas, coal gas, coke-oven gas, blast furnace gas, carbureted gas & sewer gas

Coal

- The known resources of coal in India are estimated to be 121,000 million tonnes, which are localized in West Bengal, Bihar, Madhya Pradesh and Andhra Pradesh. The present rate of annual production of coal is nearly 140 million tonnes of which 40 million-tonnes are used for power generation.
- The coal used for power generation is mainly low-grade coal with high ash content (20-40%).
- The high ash content of Indian coal (40–50%) is one of the causes for bad performance of the existing steam power plants and their frequency outages, as these plants have been designed for low ash coals.

A good coal should have:

1. Low ash content and high heating value
2. Small percentage of sulpher (less than 1%)
3. Good burning characteristics
4. High grindability index (in case of ball mill grinding)
5. High weatherability

Ranking of coal: As per ASME and ASTM

1. High ranking coal: based on fixed carbon percentage (dry basis)
2. Low ranking coal: based on heating value (moist basis)

Grading of coal: size, heating value, ash content, ash softening temperature and Sulphur content

Liquid fuels

- **Advantages**
- Require less space for storage
- High calorific value
- Easy to control of consumption/combustion
- Staff economy
- Absence of danger from spontaneous combustion
- Easy handling and transportation
- Cleanliness
- No ash problem
- Non-deterioration of the oil in storage
- **Properties**
- Specific gravity, flash point, fire point, volatility, pour point, viscosity, carbon residue, octane number, cetane number, corrosive property, ash content, gum content, heating value & Sulphur content

Gaseous fuels

- **Advantages:**
- Better control of combustion
- Much less excess air is needed for complete combustion
- Economy in fuel and more efficiency of furnace operation
- Easy maintenance of oxidizing or reducing atmosphere
- Cleanliness
- No problem of storage if supply is available from public supply line
- **Properties:**
- High heating value or calorific value
- Viscosity
- Specific gravity
- Density
- Diffusibility

Nuclear fuel

- The nuclear fuel which is commonly used for nuclear power plants is uranium. Deposits of uranium have been located in Bihar and Rajasthan.
- It is estimated that the present reserves of uranium available in country may be sufficient to sustain 10,000 MW power plants for its lifetime. Another possible nuclear power source is thorium, which is abundant in this country, estimated at 500,000 tonnes.
- One of out standing facts about nuclear power is the large amount of energy that can be released from small mass of active material. Complete fission of one kg of uranium contain the energy equivalent of 4500 tonnes of coal or 2000 tonnes of oil.
- But the commercial use of this nuclear fuel is tied up with development of fast breeder reactor which converts energy economy must wait for the development of economic methods for using thorium which is expected to be available before the end of twentieth century

- Dr. Bhabha’s Projection: had envisaged 8000 MW of nuclear power from nuclear reactors by 1980–81. which was subsequently scaled down to 2700 MW by 1990’s
- Dr. Sarabhai Realized output: materialized only 1040 MW which is less than 1.5% of the country‘s installed power capacity.
- The major hurdle in the development of nuclear power in this country is lack of technical facility and foreign exchange required to purchase the main component of nuclear power plant.

- **The following factors go in favour of nuclear energy**
- Practically independent of geographical factors
- No combustion products
- Clean source of power which does not contribute to air pollution
- Fuel transportation networks and large storage facilities not required.

Wind power

- **Characteristics of wind power/energy**
- No fuel provision and transport are required in wind energy system
- It is a renewable source of energy
- Wind power systems are non-polluting
- Low costs can achieved by mass production
- **Problems associated with wind energy:**
- Wind energy systems are noisy in operation
- Large areas are needed to install wind farms for electrical power generation
- Wind energy available is dilute and fluctuating in nature
- Wind energy needs storage means because of its irregularity

DEVELOPMENT OF POWER IN INDIA:

- The history of power development in India dates back to 1897 when a 200 kW hydro- station was first commissioned at Darjeeling.
- The first steam station was set up in Calcutta in 1899. By the end of 1920, the total capacity was 130 MW, comprising Hydro 74 MW, thermal 50 MW and diesel 6 MW. In 1940, the total capacity goes to 1208 MW.
- There was very slow development during 1935-1945 due to Second World War. The total generation capacity was 1710 MW by the end of 1951.

First five-year plan(1951):

Projects like Bhakra- Nangal, Damodar Valley, Hira Kund and Chambal Valley were constructed with generation capacity stood at 34.2 lakh kW.

Second Plan (1956-61):

At the end of Second Plan reached 57 lakh kW. Comprising 3800 MW thermal and 1900 MW hydel.

Third Plan period (1961-66):

The country was divided into Five Regions to promote power development on a Regional Basis.

Fourth Plan:

Envisaged need for central participation in expansion of power generation programmes

Fifth Plan:

Rising to 313.07 lakh kW compression; 113.86 lakh kW from Hydro-electric Projects, 192.81 lakh kW from Thermal Power Projects and balance of 6.4 lakh kW from Nuclear Projects

Sixth Plan:

Total capacity addition of 196.66 lakh kW comprising Hydro 47.68 lakh kW, Thermal 142.08 lakh kW and Nuclear 6.90 lakh kW was planned.

Seventh Plan :

Envisaged an aggregate generating capacity addition with an anticipated 22,245 MW additional capacity. including 15,999 MW Thermal, 5,541 MW Hydro and 705 MW Nuclear.

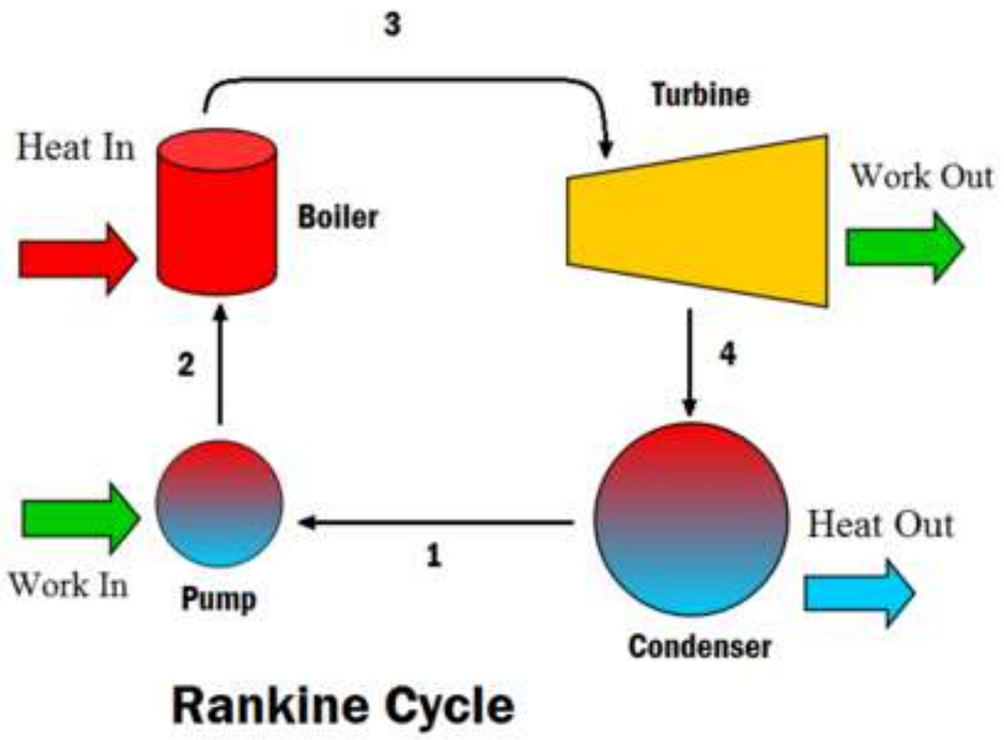
Eighth Plan (1990-91):

Targeted an additional capacity of 4,371.5 MW comprising 1,022 MW Hydro, 3,114.5 MW Thermal and 235 MW Nuclear.

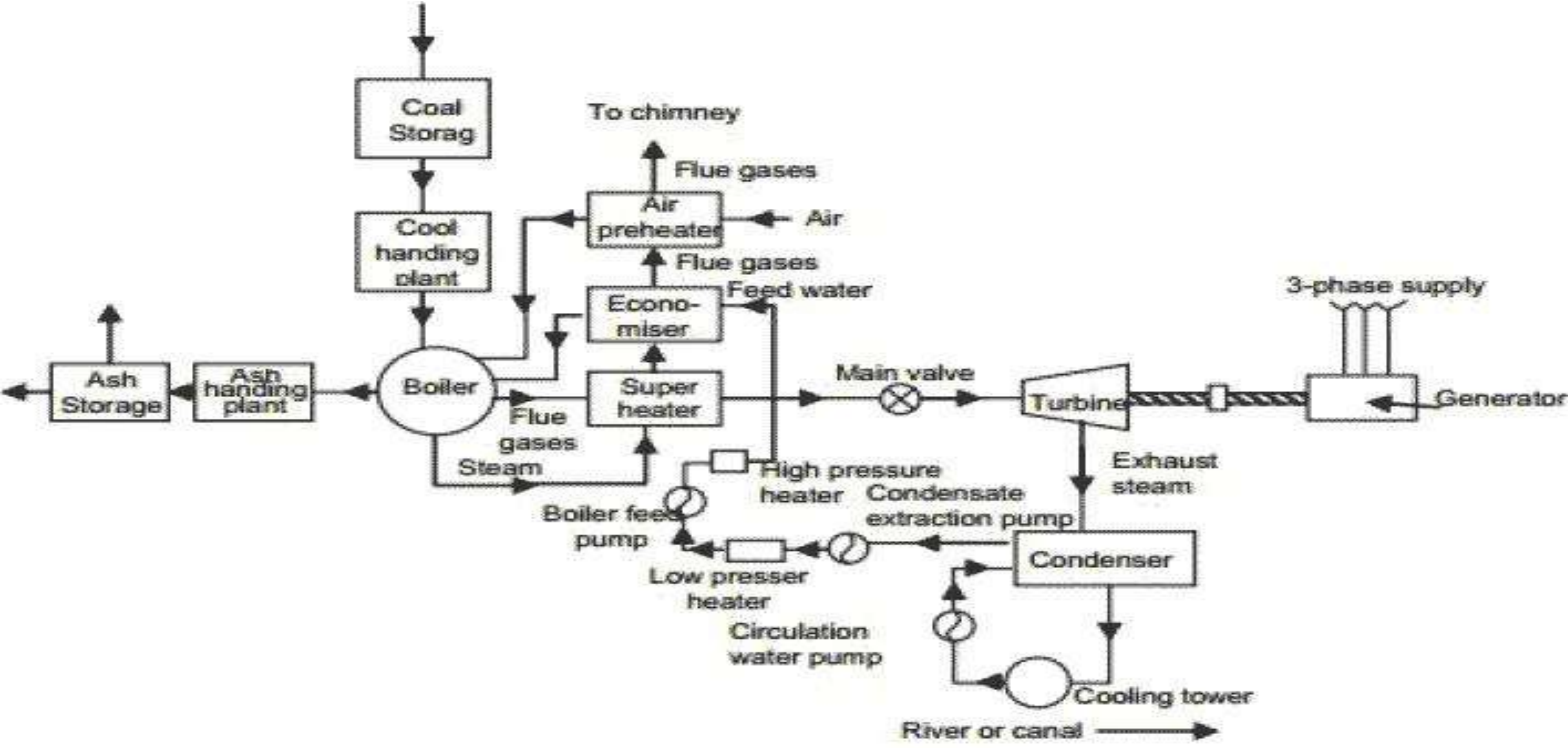
- National Thermal Power Corporation (NTPC)
- National Hydro-Electric Power Corporation (NHPC)
- North-Eastern Electric Power Corporation (NEEPCU)
- Damodar Valley Corporation (DVC)
- Beas Construction Board (BCB)
- National Projects Construction Corporation (NPCC)
- Central Power Research Institute (CPRI)
- Power Engineers Training Society (PETS).
- Rural Electrification Corporation (REC)

Rankine cycle

- ➢The Rankine cycle is an idealized thermodynamic cycle of a heat/steam turbine/engine works, that converts heat into mechanical work while undergoing phase change.
- ➢Rankine cycle is a reversible cycle which have two constant pressure and two reversible adiabatic processes. Working fluid in Rankine cycle undergoes 4 processes,
- 1-2 reversible adiabatic pumping process infeed pump,
- 2-3 constant pressure heat addition in Boiler,
- 3-4 reversible adiabatic expansion in the turbine,
- 4-1 constant pressure heat rejection in Condenser.

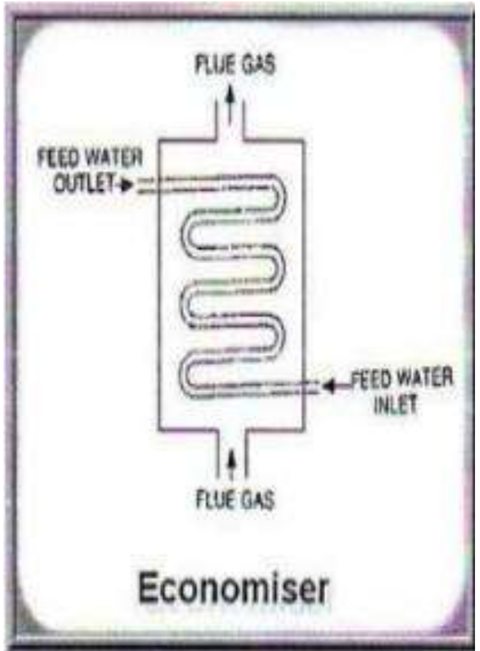


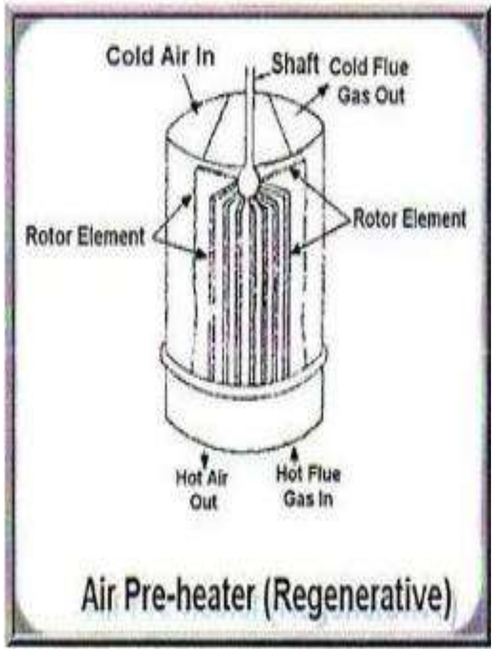
layout of steam power plant



• **Function of economiser** in **thermal power plant** is to recover some of the heat from the heat carried away in the flue gases up the chimney and utilize for heating the feed water to the boiler. It is placed in the passage of flue gases in between the exit from the boiler and the entry to the chimney.

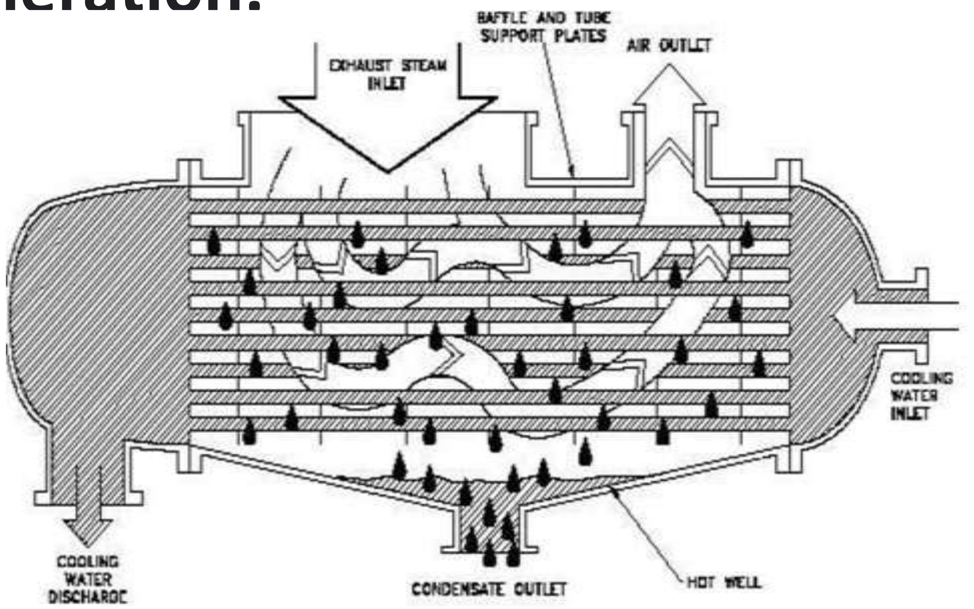
• The **purpose** of the **air preheater** is to recover the heat from the boiler flue gas which increases the **thermal** efficiency of the boiler by reducing the useful heat lost in the flue gas.

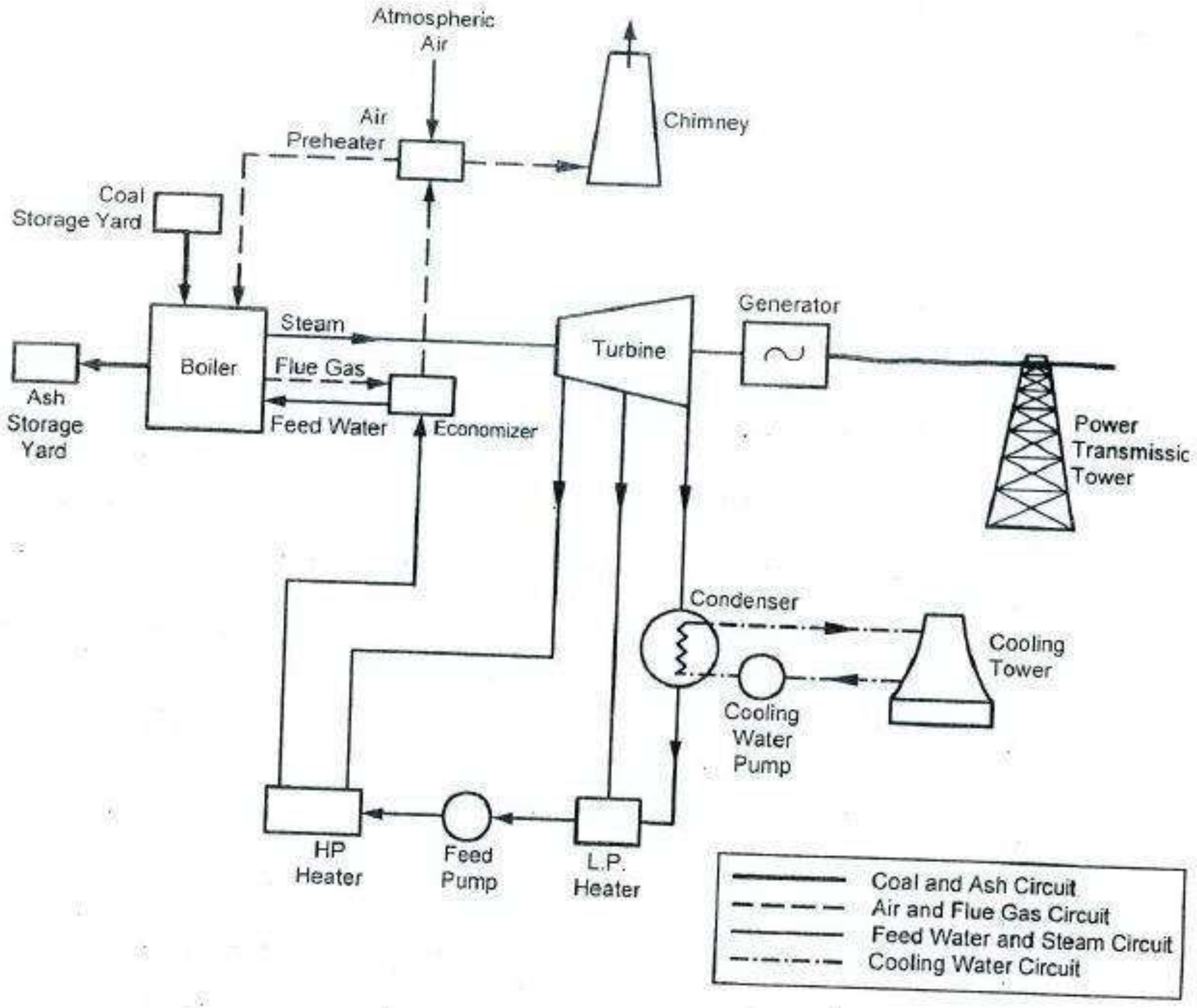




• In a steam engine, the **superheater** re-heats the steam generated by the boiler, increasing its **thermal** energy and decreasing the likelihood that it will condense inside the engine. **Superheaters** increase the **thermal** efficiency of the steam engine, and have been widely adopted

• A **cooling tower** is a heat rejection device, which extracts waste heat to the atmosphere though the **cooling** of a water stream to a lower temperature. Common applications for **cooling towers** are providing **cooled** water for air-conditioning, manufacturing and **electric power generation.**




Atmospheric Air
Air Preheater
Chimney
Coal Storage Yard
Boiler
Steam
Flue Gas
Feed Water
Economizer
Ash Storage Yard
Turbine
Generator
Power Transmissic Tower
Condenser
Cooling Tower
Cooling Water Pump
HP Heater
Feed Pump
L.P. Heater
Coal and Ash Circuit
Air and Flue Gas Circuit
Feed Water and Steam Circuit
Cooling Water Circuit

Layout of thermal plant can be easily understood by dividing the plant components into four circuits.

- Coal and ash circuit.
- Air and gas circuit.
- Feed water and steam circuit.
- Cooling water circuit Layout of thermal plant

1 Coal and Ash Circuit:

- Coal and Ash circuit in a thermal power plant layout mainly takes care of feeding the boiler with coal from the storage for combustion.

- The ash that is generated during combustion is collected at the back of the boiler and removed to the ash storage by scrap conveyors.

- The combustion in the Coal and Ash circuit is controlled by regulating the speed and the quality of coal entering the grate and the damper openings.

2 Air and Gas Circuit:

- Air from the atmosphere is directed into the furnace through the air preheated by the action of a forced draught fan or induced draught fan.

- The dust from the air is removed before it enters the combustion chamber of the thermal power plant layout.

- The exhaust gases from the combustion heat the air, which goes through a heat exchanger and is finally let off into the environment.

3 Feed Water and Steam Circuit:

- The steam produced in the boiler is supplied to the turbines to generate power.

- The steam that is expelled by the prime mover in the thermal power plant layout is then condensed in a condenser for re-use in the boiler.

- The condensed water is forced through a pump into the feed water heaters where it is heated using the steam from different points in the turbine.

- Feed water is purified in a purifying plant to reduce the dissolve salts that could scale the boiler tubes.

4 Cooling Water Circuit:

- The quantity of cooling water required to cool the steam in a thermal power plant layout is significantly high and hence it is supplied from a natural water source like a lake or a river.
- After passing through screens that remove particles that can plug the condenser tubes in a thermal power plant layout, it is passed through the condenser where the steam is condensed.
- The water is finally discharged back into the water source after cooling. Cooling water circuit can also be a closed system where the cooled water is sent through cooling towers for re-use in the power plant.

The different types of systems and components used in steam power plant are as follows:

(i) High pressure boiler

(ii) Prime mover(turbine)

(iii) Condensers and cooling towers

(iv) Coal handling system(wagon tripper, crusher house and coal mill)

(v) Ash and dust handling system(ash precipitator)

(vi) Draught system(induced draught fan, forced draught fan and chimney)

(vii) Feed water purification plant

(viii) Pumping system

(ix) Air preheater, economizer, super heater, feed heaters.

ADVANTAGES:

- 1. They can be located very conveniently near the load centers.
- 2. Does not require shielding like required in nuclear power plants.
- 3. Unlike nuclear power plants whose power production method is difficult, for thermal power plants it is easy if compared.
- 4. Transmission costs are reduced as they can be set up near the industry.
- 5. The portion of steam generated can be used as process steam in different industries.
- 6. Steam engines and turbines can work under 25% of overload capacity.

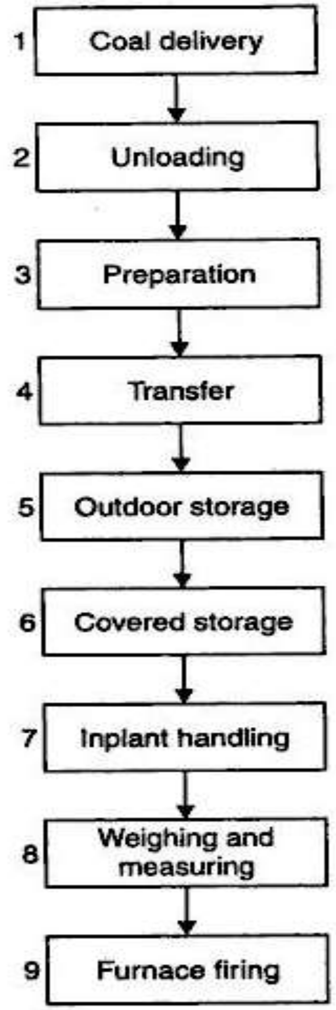
DISADVANTAGES:

- 1. Large amounts of water are required.
- 2. Great difficulties experienced in coal handling and disposal of ash.
- 3. Takes long time to be erected and put into action.
- 4. Maintenance and operating costs are high.
- 5. With increase in pressure and temperature, the cost of plant increases.

FUEL AND HANDLING EQUIPMENTS:

The various stages are involved in the fuel handling system from coal delivery to furnace in the steam plant

- 1. Coal delivery
- 2. Unloading
- 3. Preparation
- 4. Transfer
- 5. Storage
- 6. In plant handling
- 7. Weighing
- 8. Feeding the coal into Furnace.



Various stages in coal handling.

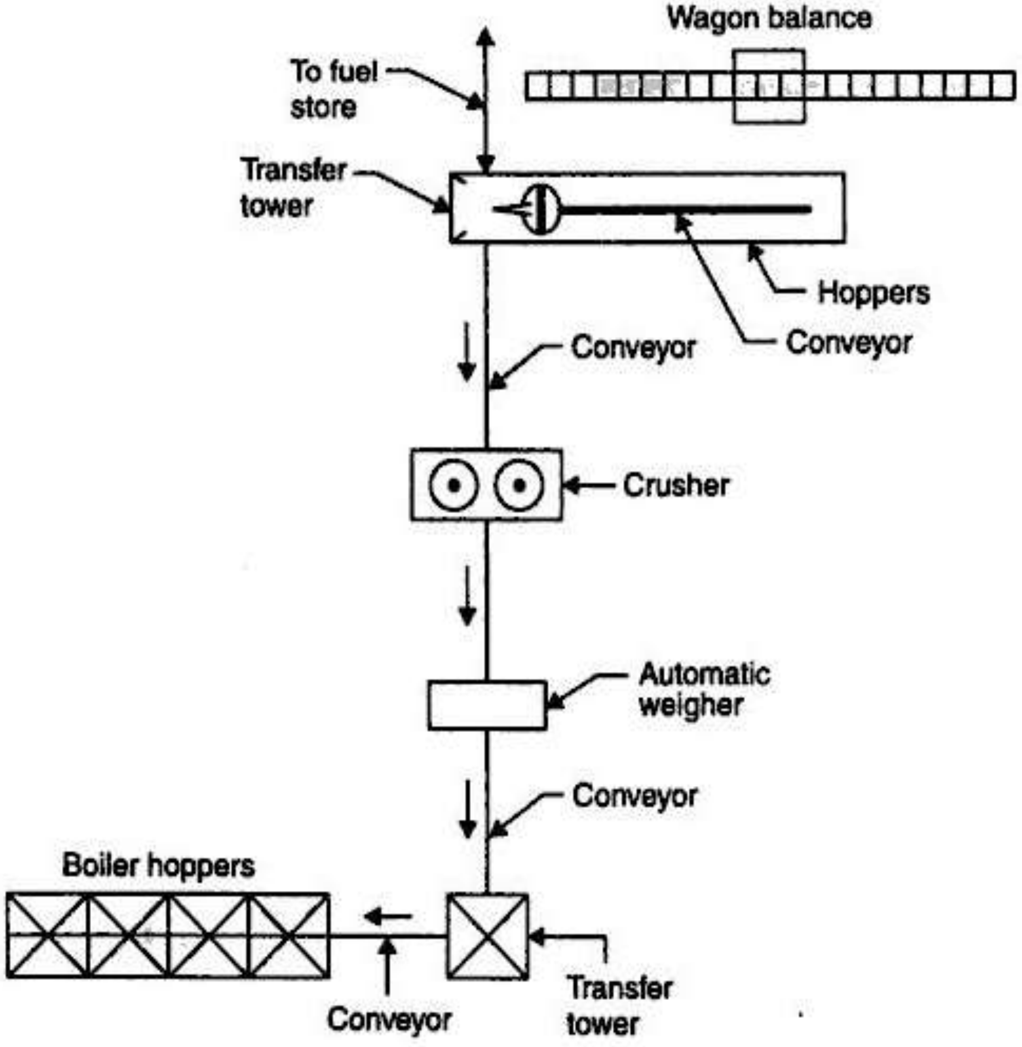


Fig. 2.10. Layout of a fuel handling equipment.

(i) **Coal Delivery:** The coal from supply points is delivered by ships or boats to power stations situated near to sea or river whereas coal is supplied by rail or trucks to the power stations which are situated away from sea or river.

(i) **Unloading:** The type of equipment to be used for unloading the coal received at the power station depends on how coal is received at the power station.

- If coal is delivered by trucks, there is no need of unloading device as the trucks may dump the coal to the outdoor storage.
- Coal is easily handled if the lift trucks with scoop(Litter lifter) are used.

(iii) Preparation: When the coal delivered is in the form of big lumps and it is not of proper size, the preparation (sizing) of coal can be achieved by crushers, breakers, sizers, driers and magnetic separators.

(iv) Transfer: After preparation coal is transferred to the dead storage by means of the following systems :

- 1. Belt conveyors.
- 2. Screw conveyors.
- 3. Bucket elevators.
- 4. Grab bucket elevators.
- 5. Skip hoists.
- 6. Flight conveyor.

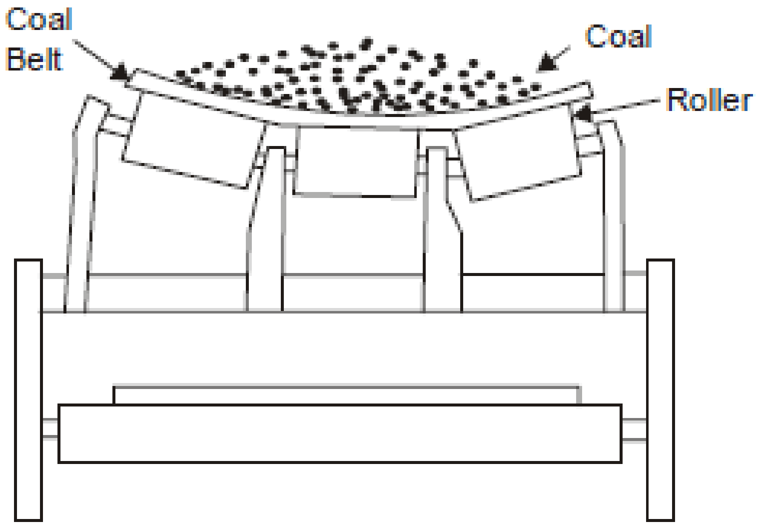
1. Belt conveyor.

• It consists of an endless belt(Continuous loop). Moving over a pair of end drums (rollers). At some distance a supporting roller is provided at the center.

• The belt is made, up of rubber or canvas. Belt conveyor is suitable for the transfer of coal over long distances. It is used in medium and large power plants.

• The initial cost of the system is not high and power consumption is also low. The inclination at which coal can be successfully elevated by belt conveyor is about 20.

• Average speed of belt conveyors varies between 200-300 r.p.m. This conveyor is preferred than other types.

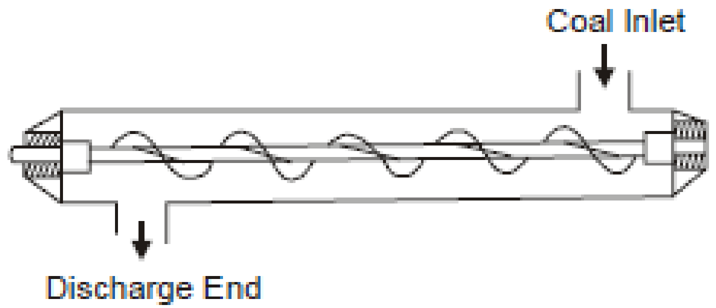


Advantages of belt conveyor:

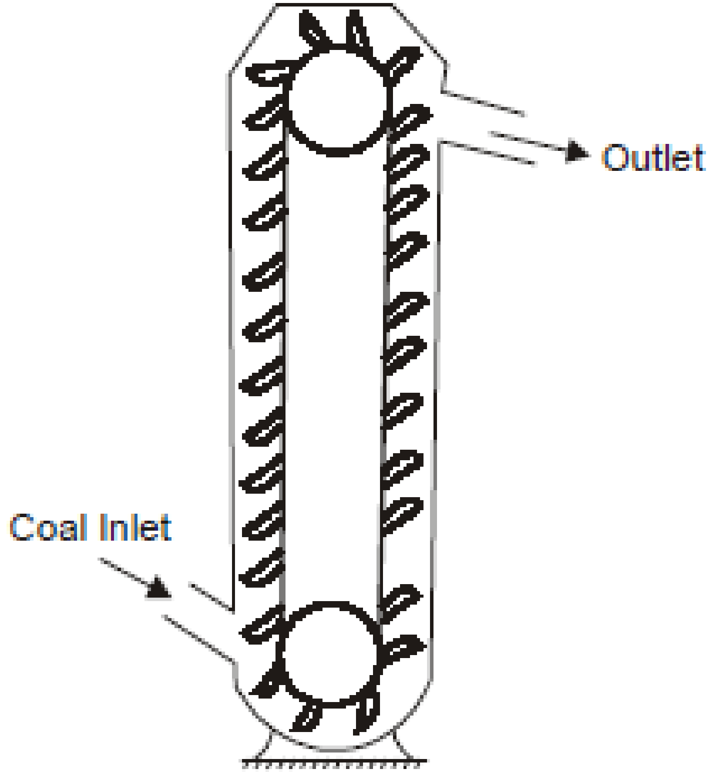
1. Its operation is smooth and clean.
2. It requires less power as compared to other types of systems.
3. Large quantities of coal can be discharged quickly and continuously.
4. Material can be transported on moderates inclines.

2. Screw conveyor.

- It consists of an endless helicoids screw fitted to a shaft .
- The screw while rotating in a trough transfers the coal from feeding end to the discharge end.
- This system is suitable, where coal is to be transferred over shorter distance and space limitations exist.
- The initial cost of the system is low. It suffers from the drawbacks that the power consumption is high and there is considerable wear of screw.
- Rotation of screw varies between 75-125 r.p.m.

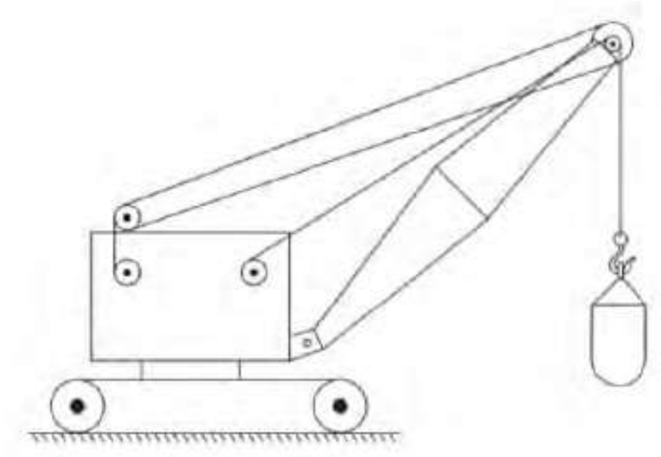


3. Bucket elevator. It consists of buckets fixed to a chain . The chain moves over two wheels. The coal is carried by the buckets from bottom and discharged at the top.

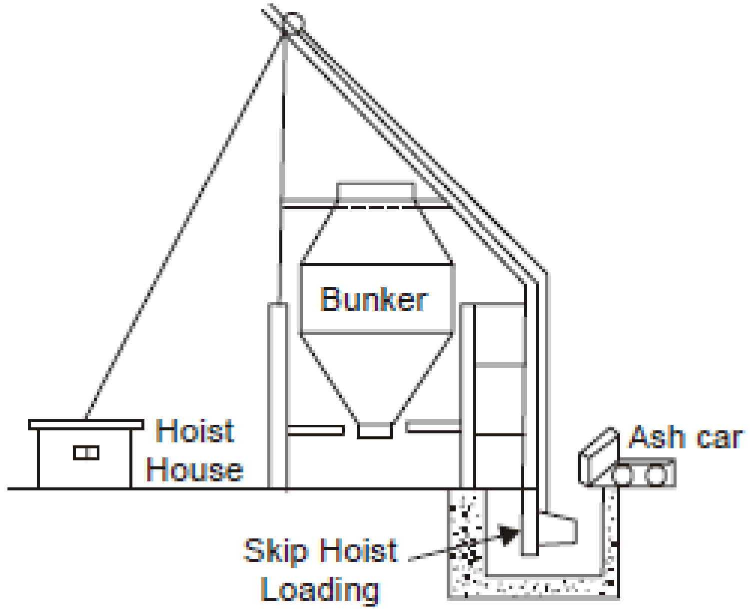


- Advantages:
- 1. Less power is required for operating the equipment
- 2. Coal can be discharged at the elevated places
- 3. Less floor area is required
- Disadvantages:
- Its capacity is limited and hence not suitable for large capacity stations

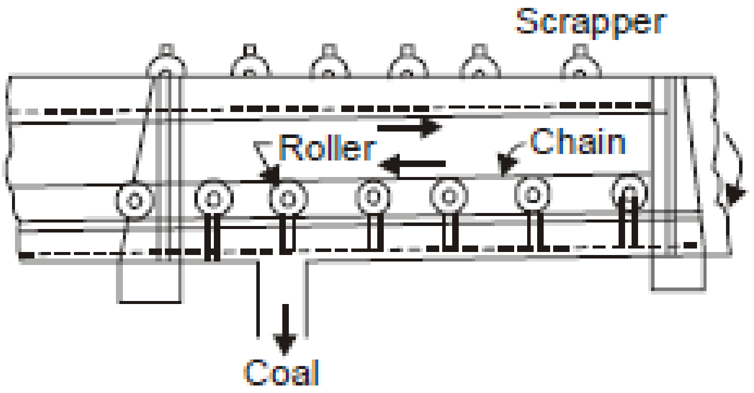
4. Grab bucket elevator. It lifts and transfers coal on a single rail or track from one point to the other.
The coal lifted by grab buckets is transferred to overhead bunker or storage.
This system requires less power for operation and requires minimum maintenance.
The grab bucket conveyor can be used with crane or tower as shown in Fig. Although the initial cost of this system is high but operating cost is less.



5. Skip hoist. It consists of a vertical or inclined hoist way, a bucket or a car guided by a frame and a cable for hoisting the bucket. The bucket is held in upright position. It is simple and compact method of elevating coal or ash.



6. Flight conveyor. It consists of one or two strands of chain to which steel scraper(cleaning from mud) or flights are attached‘ which scrap the coal through a trough having identical shape.



Coal storage

- It gives protection against the interruption/ delay of coal supplies. Also when the prices are low, the coal can be purchased and stored for future use. The amount of coal to be stored depends on the availability of space for storage, transportation facilities, the amount of coal whether away and nearness to coal mines of the power station.
- Usually coal required for one month operation of power plant is stored in case of power stations situated at longer distance from the collieries whereas coal need for about 15 days is stored in case of power station situated near to collieries.

Any disadvantage

- Storage of coal for longer periods is not advantageous because it blocks the capital and results in deterioration of the quality of coal. (oxygen of air). Due to low oxidation the coal may ignite spontaneously. This is avoided by storing coal in the form of piles so that air cannot pass through the coal piles.

Coal storage methods

Stocking the coal in heats. The coal is piled(placed one on top the other) on the ground up to 10-12 m height. The pile top should be given a slope in the direction in which the rain may be drained off.

The sealing of stored pile is desirable in order to avoid the oxidation of coal after packing an air tight layer of coal.

Under water storage. The possibility of slow oxidation and spontaneous combustion can be completely eliminated by storing the coal under water.

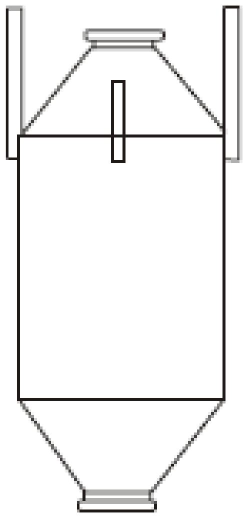
Live storage or Active storage

Live coal storage implies the reclaiming and combustion of coal that has been stored for only a relatively short time, usually less than a week.

Coal from a live coal (storage pile is usually supplied to combustion equipment without the use of mobile equipment). The coal is usually stored in the vertical cylinder bunkers or coal bins or silo.

(v) In plant handling:

From the dead storage the coal is brought to covered storage (Live storage) (bins or bunkers). A cylindrical bunker shown in below figure . In plant handling may include the equipment such as belt conveyors, screw conveyors, bucket elevators etc. to transfer the coal. Weigh Lorries, hoppers(funned shape material which is used for movement of material from one place to another) and automatic scales are used to record the quantity of coal delivered to the furnace.



***(vi)* Coal weighing methods**. Weigh Lorries, hoppers and automatic scales are used to weigh the quantity coal. The commonly used methods to weigh the coal are as follows:
(i) Mechanical (*ii*) Pneumatic (*iii*) Electronic.

The Mechanical method works on a suitable lever system mounted on knife edges and bearings connected to a resistance in the form of a spring of pendulum.

The pneumatic weighers use a pneumatic transmitter weight head and the corresponding air pressure determined by the load applied.

The electronic weighing machines make use of load cells that produce voltage signals proportional to the load applied.

The important factors considered in selecting fuel handling systems are as follows
(i) Plant flue rate,(ii) Plant location in respect to fuel shipping,(iii) Storage area available.

How to select proper type and size of furnace..??

It depends upon the following factors:

- _Type of fuel to be burnt.
- _Type of firing to be used.
- _Amount of heat to be recovered.
- _Amount of steam to be produced
- _Pressure and temperature desired.
- _Grate area required.
- _Ash fusion temperature.
- _Flame length.
- _Amount of excess air to be used.

TYPES OF FURNACES

According to the method of firing fuel furnaces are classified into two categories: 1. Grate fired furnaces & 2 Chamber fired furnaces

1. Grate fired furnaces: They are used to burn solid fuels. They may have a stationary or a movable bed of fuel. These furnaces are classified as under depending upon the method used to fire the fuel and remove ash and slag.

1. Hand fired and Semi-mechanized 2. Stocker fired.

Hand fired and semi-mechanized furnaces are designed with stationary fire grates and stoker furnaces with traveling grates or stokers.

2. Chamber fired furnaces: They are used to burn pulverized (reduced to fine particles) fuel, liquid and gaseous fuels.

What may be the material of furnace ?

Simply furnace walls consists of… an interior face of refractory material such as fireclay, silica, alumina an intermediate layer of insulating materials such as magnesia with the exterior casing made up of steel sheet.

ASH HANDLING SYSTEMS:

- A large quantity of ash is, produced in steam power plants using coal.

Ash produced in about 10 to 20% of the total coal burnt in the furnace.

- Handling of ash includes its removal from the furnace, loading on the conveyors and delivered to the fill from where it can be disposed off.

- Handling of ash is a problem because ash coming out of the furnace is too hot, it is dusty and irritating to handle and is accompanied by some poisonous gases.

- It is desirable to quench the ash before handling due to following reasons:

1. Quenching reduces the temperature of ash.
2. It reduces the corrosive action of ash.
3. Ash forms clinkers by fusing in large lumps and by quenching Clinkers will disintegrate.
4. Quenching reduces the dust accompanying the ash.

ASH HANDLING EQUIPMENT:

Mechanical means are required for the disposal of ash. The handling equipment should perform the following functions:

(1) Capital investment, operating and maintenance charges of the equipment should be low.

(2) It should be able to handle large quantities of ash.

(3) Clinkers, (Poor quality **coal** produces **clinker** problems along with heat.

... **Clinkers** occur in small stoves used for heating a home and in giant commercial/industrial boilers.

(4) The equipment used should remove the ash from the furnace, load it to the conveying system to deliver the ash to a dumping site or storage and finally it should have means to dispose of the stored ash.

(5) The equipment should be corrosion and wear resistant.

(6) The operation of the plant should be noiseless as much as possible.

Outline of ash disposal equipment

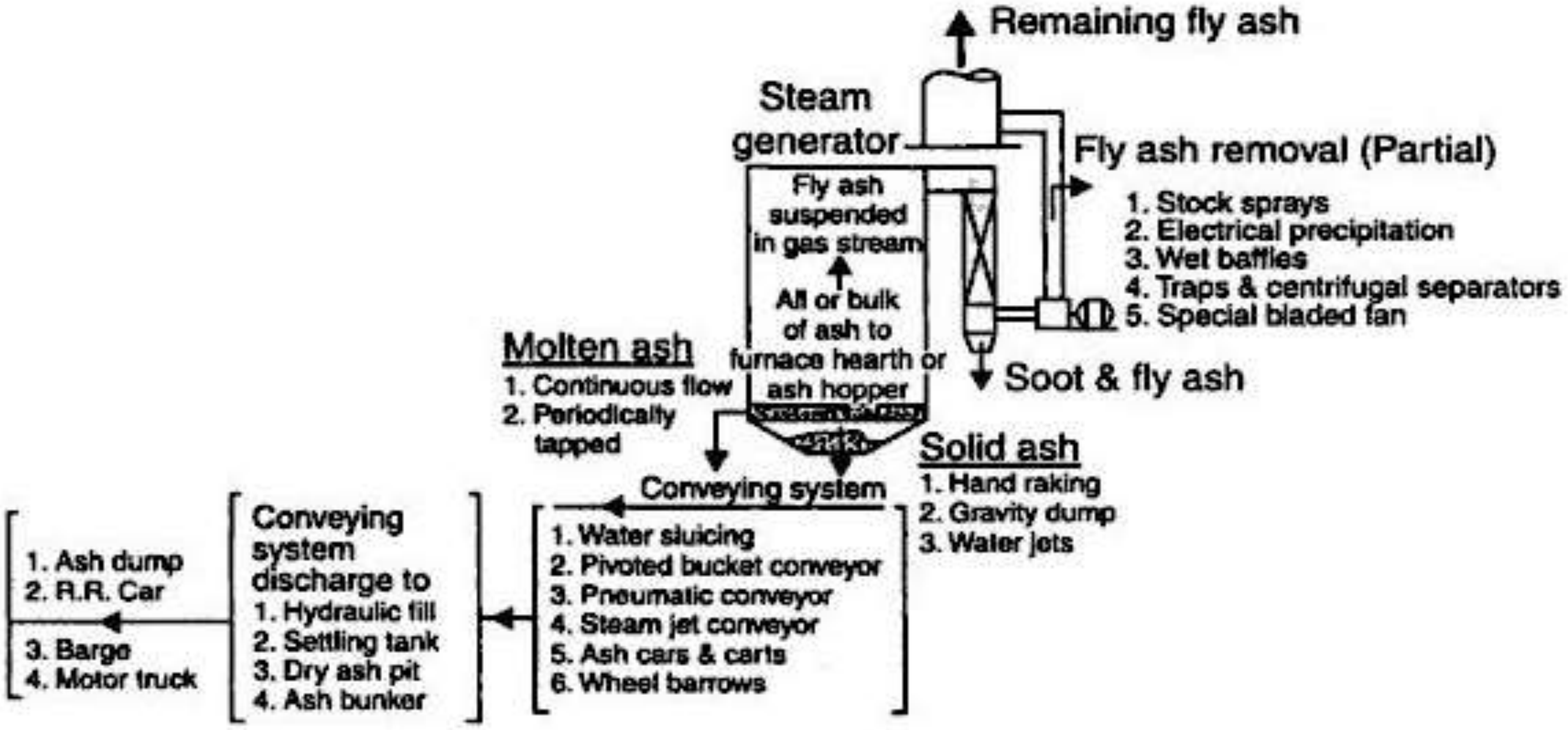


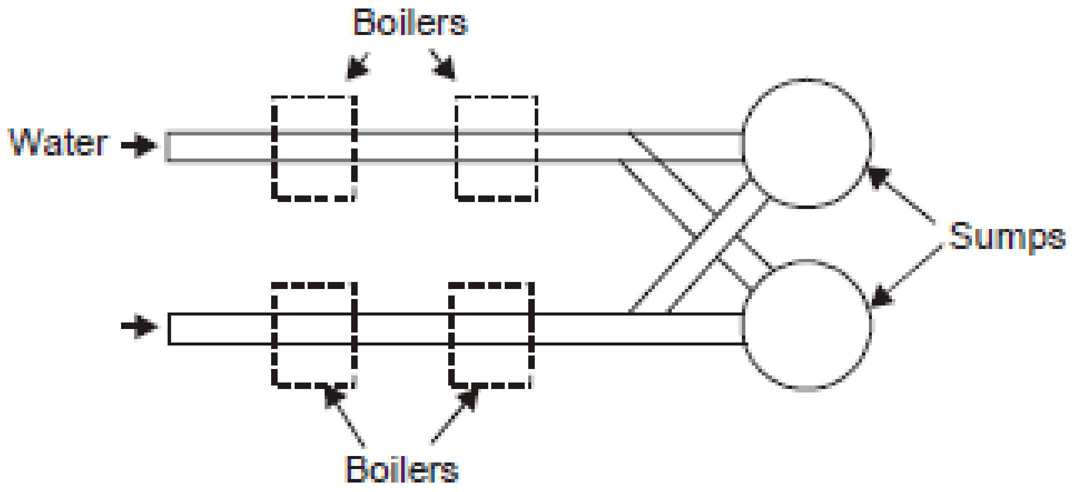
Fig. 2.23. Outline of ash disposal equipment.

Modern used ash handling systems are as follows:

- (i) Hydraulic system
- (ii) Pneumatic system
- (iii) Mechanical system
- (iv) Steam jet system

(i) Hydraulic System.

- In this system, ash from the furnace grate falls into a system of water possessing high velocity and is carried to the sumps.
- It is generally used in large power plants. Hydraulic system is of two types namely low pressure hydraulic system used for continuous removal of ash and high pressure system which is used for intermittent ash disposal.
- In this method water at sufficient pressure is used to take away the ash to sump.
- Where water and ash are separated. The ash is then transferred to the dump site in wagons, rail cars or trucks and water is recirculated.
- The loading of ash may be through a belt conveyor, grab buckets. If there is an ash basement with ash hopper the ash can fall, directly in ash car or conveying system.



Hydraulic System.

- The ash carrying capacity of this system is as large as 120 tonnes per hour and the distance covered is as large as 1000 metres.
- Advantages
- 1. The system is clean and healthy.
- 2. It can also be used to handle stream of molten ash.
- 3. Working parts do not come into contact with the ash.
- 4. It is dustless and totally closed.
- 5. It can discharge the ash at a considerable distance (1000 m) from the power plant.
- 6. The unhealthy aspects of ordinary ash basement work is eliminated.
- 7. Its ash carrying capacity is considerably large, hence suitable for large thermal power plants.

Pneumatic system.

(i) In this system ash from the boiler furnace outlet falls into a crusher where larger ash particles are crushed to small sizes.
(ii) The ash is then carried by a high velocity air or steam to the point of delivery.
(iii) Air leaving the ash separator is passed through filter to remove dust etc.
(iv) so that the exhauster handles clean air which will protect the blades of the exhauster

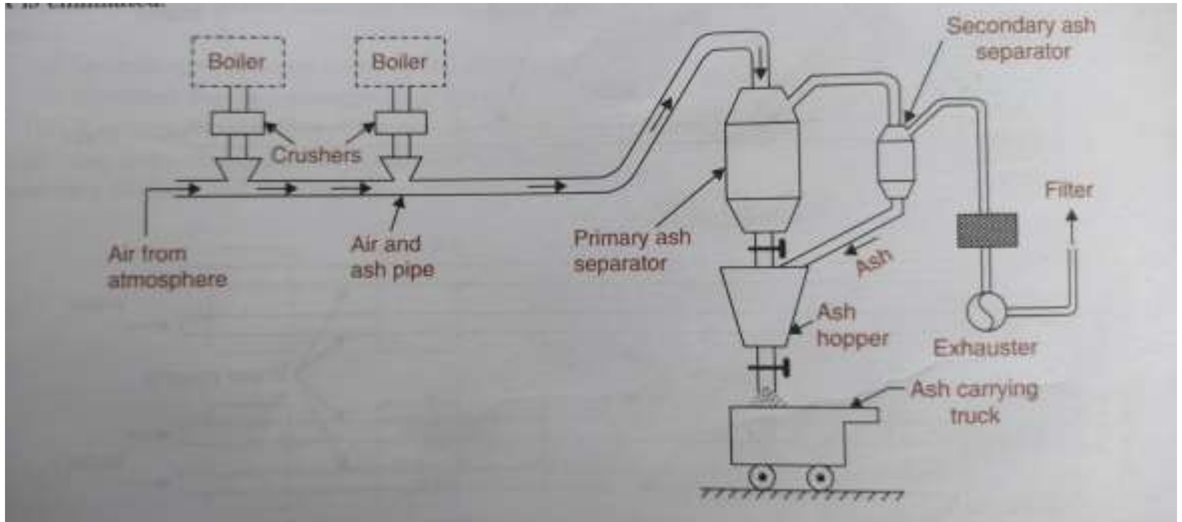


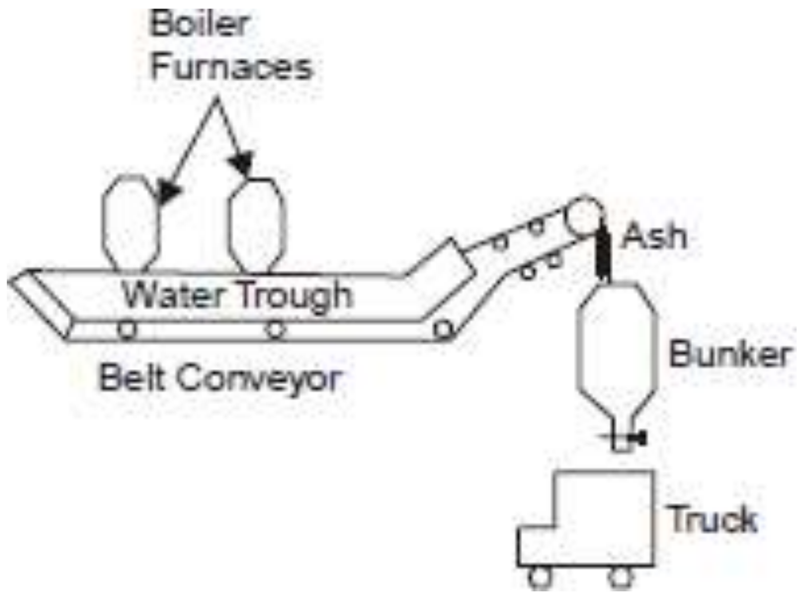
Fig. 3.42. Pneumatic or vacuum extraction ash handling system.

Pneumatic system.

- Advantages:
- 1. No spillage and rehandling.
- 2. High flexibility.
- 3. There is no chance of ash freezing or sticking in the storage bin and material can be discharged freely by gravity.
- 4. The dustless operation is possible as the materials are handled totally in an enclosed conduit.
- 5. The cost of plant per tonne of ash discharged is less in comparison to other systems.
- Disadvantages:
- 1. There is a large amount of wear in the pipe work necessitating high maintenance charges.
- 2. More noisy than other systems.

Mechanical ash handling system.

(i) Fig. shows a mechanical ash handling system. In this system ash cooled by water seal falls on the belt conveyor and is carried out continuously to the bunker.
(ii) The ash is then removed to the dumping site from the ash bunker with the help of trucks.

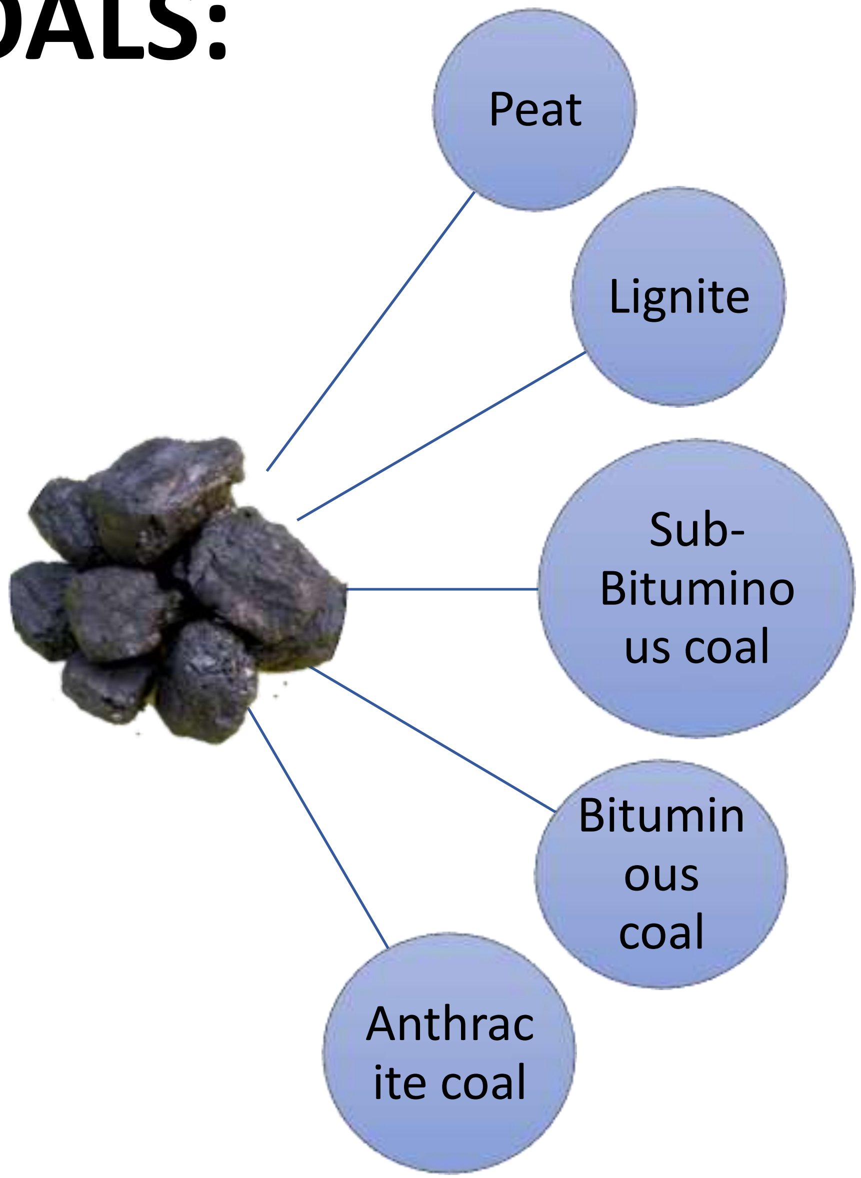


4. Steam jet system

- In this case steam at sufficiently high velocity is passed through a pipe and dry solid materials of considerable size are carried along with it. In a high pressure steam jet system a jet of high pressure steam is passed in the direction of ash travel through a conveying pipe in which the ash from the boiler ash hopper is fed. The ash is deposited in the ash hopper. This system can remove economically the ash through a horizontal distance of 200 m and through a vertical distance of 30 m.

- Advantages:
- 1. Less space requirement.
- 2. Less capital cost in comparison to other systems.
- 3. Auxiliary drive is not required.
- 4. It is possible to place the equipment in awkward position too.
- Disadvantages:
- 1. Noisy operation.
- 2. This system necessitates continuous operation since its capacity is limited to about 7 tonnes per hour.
- 3. Due to abrasive action of ash the pipes undergo greater wear (and to reduce this wearing action the pipes are lined with nickel alloy).

TYPES OF COALS:



- **Peat** Starting stage of coal formation and is not useful in power plants.
- **Lignite** is the youngest form of coal. It is soft and ranges in color from black to shades of brown. As a result, it‘s sometimes called brown coal. Lignite is mainly used for power generation and accounts for 17 percent of the world‘s coal reserves.
- **Sub-bituminous coal:** After millions of years, continued pressure and temperature convert lignite into sub-bituminous coal. It burns more cleanly than other types of coal due to its low sulfur content. Sub-bituminous coal has applications in power generation and also in industrial processes. This type of coal makes up 30 percent of the world‘s coal reserves.
- **Bituminous coal** is harder and blacker than lignite and sub-bituminous coal, and can be divided into two types: thermal and metallurgical. Together, they make up 52 percent of the world‘s coal reserves. Thermal coal is mostly used for power generation, cement manufacturing and other industrial purposes, while metallurgical coal is used primarily for manufacturing iron and steel.
- **Anthracite** is the most mature coal and thus has the highest carbon content of any type of coal. It is frequently used for home heating and, accounting for about 1 percent of the world‘s total coal reserves, represents a very small portion of the overall market. Anthracite coal can be used as a smokeless fuel in domestic and industrial contexts.

COMBUSTION PROCESS:

PROPERTIES OF COAL: The properties of coal are broadly classified as

1. Physical properties
2. Chemical properties

Proximate Analysis

Proximate analysis indicates the percentage by weight of the Fixed Carbon, Volatiles, Ash, and Moisture Content in coal.

The amounts of fixed carbon and volatile combustible matter directly contribute to the heating value of coal.

Fixed carbon acts as a main heat generator during burning. High volatile matter content indicates easy ignition of fuel.

The ash content is important in the design of the furnace grate, combustion volume, pollution control equipment and ash handling systems of a furnace.

Significance of Various Parameters in Proximate Analysis

Fixed carbon:

- Fixed carbon is the solid fuel left in the furnace after volatile matter is distilled off.

It consists mostly of carbon but also contains some hydrogen, oxygen, sulphur and nitrogen not driven off with the gases.

- Fixed carbon gives a rough estimate of heating value of coal

Volatile Matter:

- Volatile matters are the methane, hydrocarbons, hydrogen and carbon monoxide, and incombustible gases like carbon dioxide and nitrogen found in coal.
- Thus the volatile matter is an index of the gaseous fuels present. Typical range of volatile matter is 20 to 35%. Volatile Matter Proportionately increases flame length, and helps in easier ignition of coal.

Sulphur Content:

- Typical range is 0.5 to 0.8% normally. Sulphur Affects clinkering and slagging tendencies Corrodes chimney and other equipment such as air heaters and economizers Limits exit flue gas temperature.

Chemical Properties

Ultimate Analysis:

- The ultimate analysis indicates the various elemental chemical constituents such as Carbon, Hydrogen, Oxygen, Sulphur, etc. It is useful in determining the quantity of air required for combustion and the volume and composition of the combustion gases. This information is required for the calculation of flame temperature and the flue duct design etc.

Basic requirements of combustion equipment

1. Thorough mixing of fuel and air.

2. Optimum fuel-air ratios leading to most complete combustion possible maintained over full load range.

3. Ready and accurate response of rate of fuel feed to load demand (usually as reflected in boiler steam pressure).

4. Continuous and reliable ignition of fuel.

5. Practical distillation of volatile components of coal.

6. Adequate control over point of formation and accumulation of ash, when coal is the fuel.

Selections of combustion equipment for solid fuels

1. Initial cost of the equipment.
2. Sufficient combustion space and its ability to withstand high flame temperature.
3. Area of the grate (over which fuel burns)
4. Operating cost
5. Minimum smoke nuisance.
6. Flexibility of operation.
7. Arrangements for thorough mixing of air with fuel for efficient combustion.

Burning of coal

- **Two methods of are commonly used in burning of coal**

1. **Stroker firing**
2. **Pulverized fuel firing**

Selections of above methods based on the following factors:

1. **Characteristics of coal available**
2. **Capacity of boiler**
3. **Load fluctuations**
4. **Station load factor**
5. **Reliability and efficiency of various types combustion equipment available**

Stoker firing

(stoker is power feeding mechanism)

Advantages of stoker firing :

1. A cheaper grade of fuel can be used.
2. A higher efficiency attained.
3. A greater flexibility of operations assured.
4. Less smoke produced.
5. Generally less building space is necessary.
6. Can be used for small or large boiler units.
7. Very reliable, maintenance charges are reasonably low.
8. Practically immune from explosions.
9. Reduction in auxiliary plant.
10. Capital investment as compared to pulverised fuel system is less.
11. Some reserve is gained by the large amount of coal stored on the grate in the event of coal handling plant failure.

Disadvantages :

1. Construction is complicated.
2. In case of very large units the initial cost may be rather higher than with pulverised fuel.
3. There is always a certain amount of loss of coal in the form of riddling through the grates.
4. Sudden variations in the steam demand cannot be met to the same degree.
5. Troubles due to slagging and clinkering of combustion chamber walls are experienced.
6. Banking and standby losses are always present.
7. Structural arrangements are not so simple and surrounding floors have to be designed for heavy loadings.
8. There is excessive wear of moving parts due to abrasive action of coal.

Mechanical stokers

These are commonly used to feed solid fuels into the furnace in medium and large size power plants. The various advantages of stoker firing are as follows :

(i) Large quantities of fuel can be fed into the furnace. Thus greater combustion capacity is achieved.

(ii) Poorer grades of fuel can be burnt easily.

(iii) Stoker save labor of handling ash and are self-cleaning.

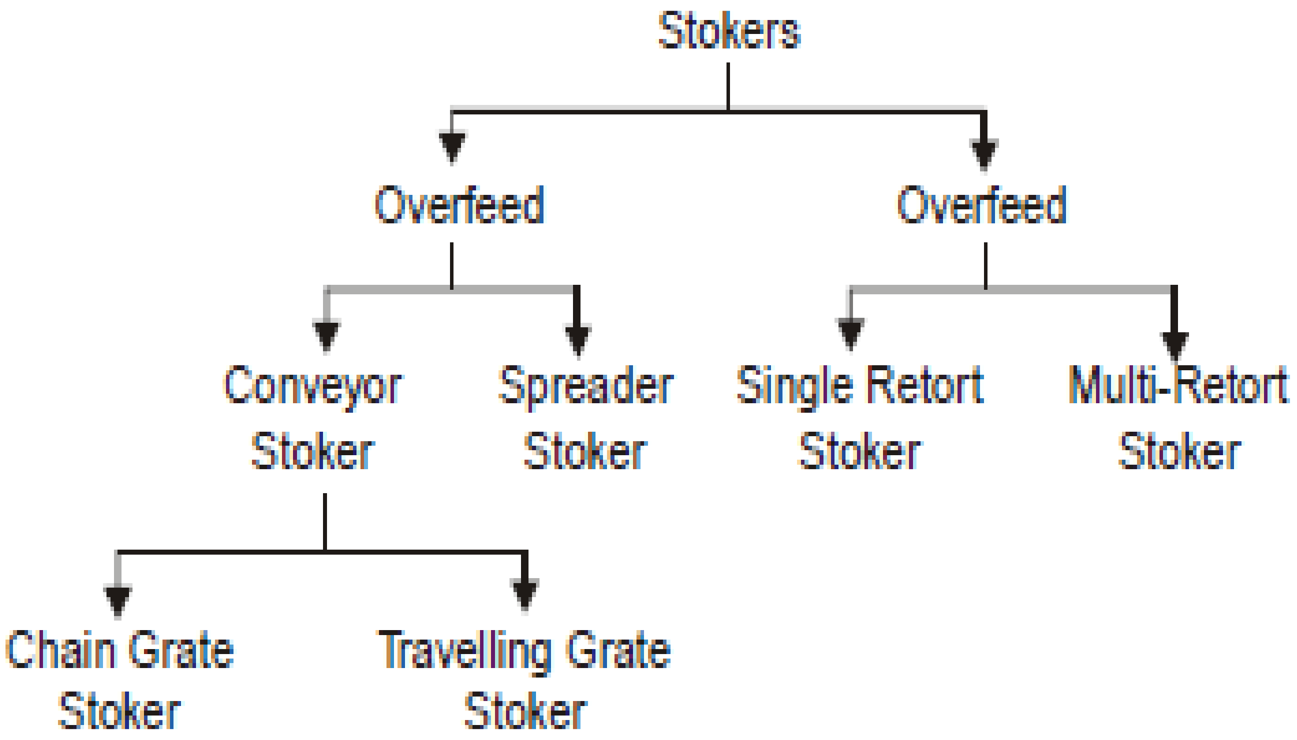
(iv) By using stokers better furnace conditions can be maintained by feeding coal at a uniform rate.

(v) Stokers save coal and increase the efficiency of coal firing. The main disadvantages of stokers are their more costs of operation and repairing resulting from high furnace temperatures.

Types of over feed stokers

(the over feed stokers are used for large capacity boiler installation where the coal is burned with pulverization)

- **These are classified in to:**
- **1. travelling grate stoker**
- **Chain grate stoker**
- **Bar grate stoker**
- **2. spreader stoker**

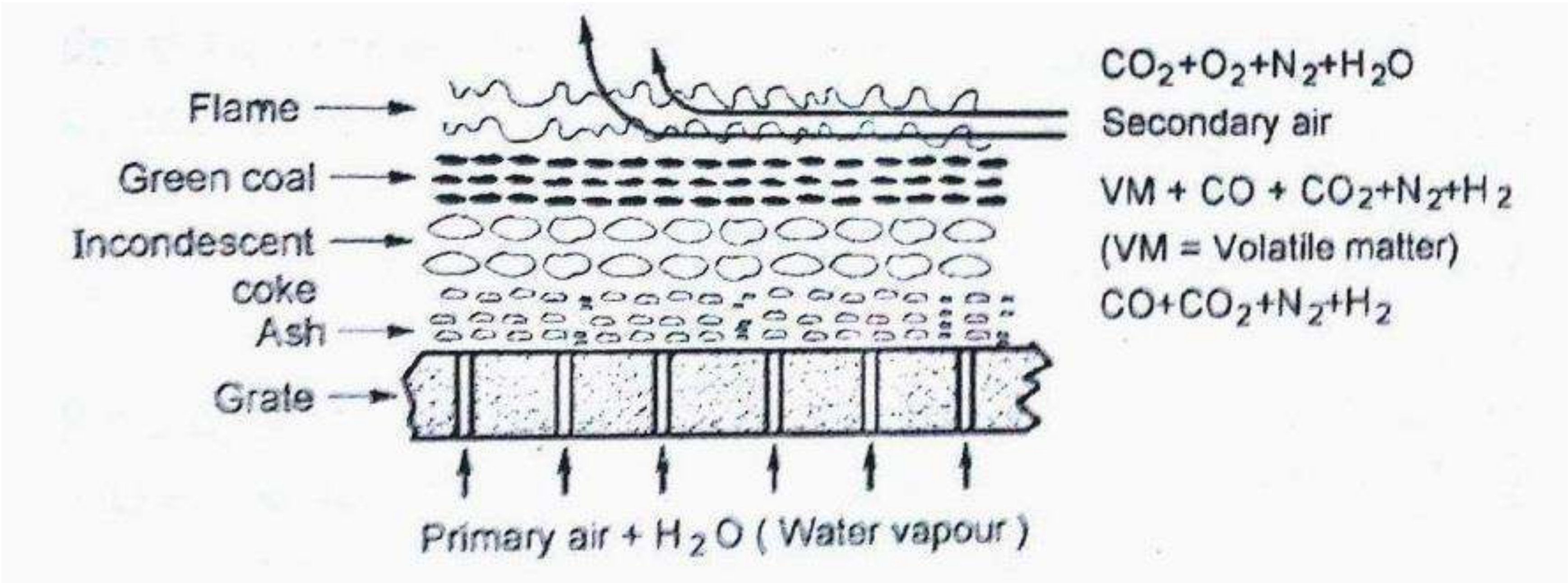


OVERFEED AND UNDERFEED FUEL BEDS:

Overfeed Principle.:

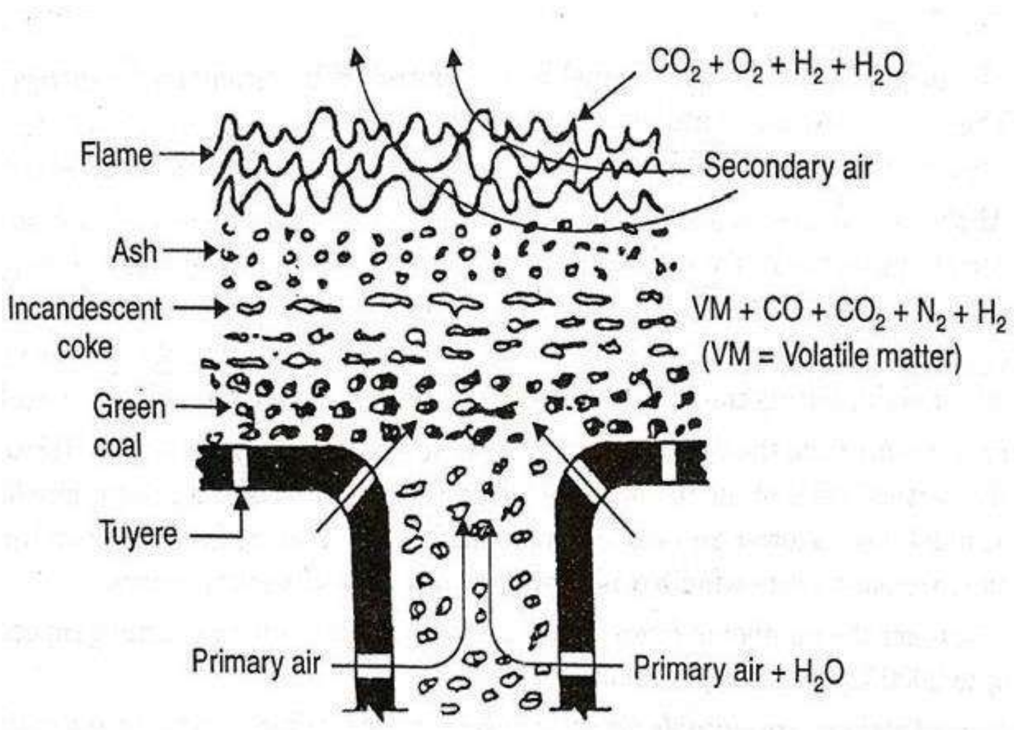
- According to this principle (Fig.) the primary air enters the grate from the bottom. The air while moving through the grate openings gets heated up the air while and the grate is cooled.
- The hot air that moves through a layer of ash and picks up additional energy. The air then passes through a layer of incandescent coke. (a toxic gaseous mixture consisting chiefly of carbon monoxide and hydrogen, prepared from steam and **incandescent coke**: used as an illuminate, fuel, and in organic synthesis.) where oxygen reacts with coke to form-C02 and water vapors accompanying the air react with incandescent coke to form CO_2, CO and free H_2. The gases leaving the surface of fuel bed contain volatile matter of raw fuel and gases like CO_2, CO, H_2, N_2 and H_2O.

- Then additional air known as secondary air is supplied to burn the combustible gases. The combustion gases entering the boiler (**Charcoal** is a fuel that comes from the incomplete burning of wood. ... **Coke** is a fuel that is obtained from the calcination or dry distillation of mineral **coal**. It is composed of carbon and has a high calorific value, but it is highly polluting).



Underfeed Principle:

- Fig. shows underfeed principle. In underfeed principle air entering through the holes in the grate comes in contact with the raw coal (green coal).
- Then it passes through the incandescent coke where reactions similar to overfeed system take place.
- The gases produced then passes through a layer of ash. The secondary air is supplied to burn the combustible gases.
- Underfeed principle is suitable for burning the semi-bituminous and bituminous coals.



Under feed Vs Over feed

- The under-feed method of fuel supply is best for semi bituminous and bituminous coals high in volatile matter.
- The volatile matter gets heated to a high temperature as it passes through incandescent region of coal. The volatile matter being at a higher temperature before entering the furnace burns quickly when mixed with secondary air.
- In case of over-feed burning, the volatile matter will be somewhat cooler than the furnace gases and therefore it requires longer time for complete burning. This may create a tendency to form smoke.

Chain grate stoker

Chain Grate Stoker. Chain grate stoker and travelling grate stoker differ only in grate construction. A chain grate stoker. It consists of an endless chain which forms a support for the fuel bed. The chain travels over two sprocket wheels, one at the front and one at the rear of furnace. The traveling chain receives coal at its front end through a hopper and carries it into the furnace. The ash is tipped from the rear end of chain.

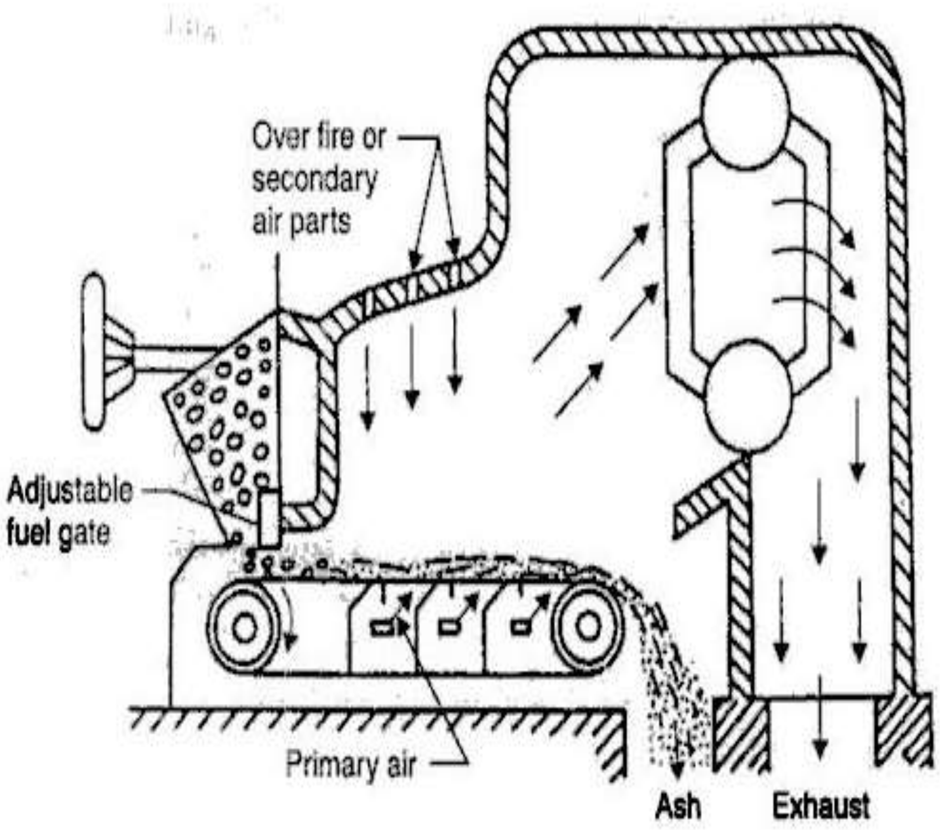


Fig. 2.12. Chain grate stoker.

Advantages of chain grate stoker :

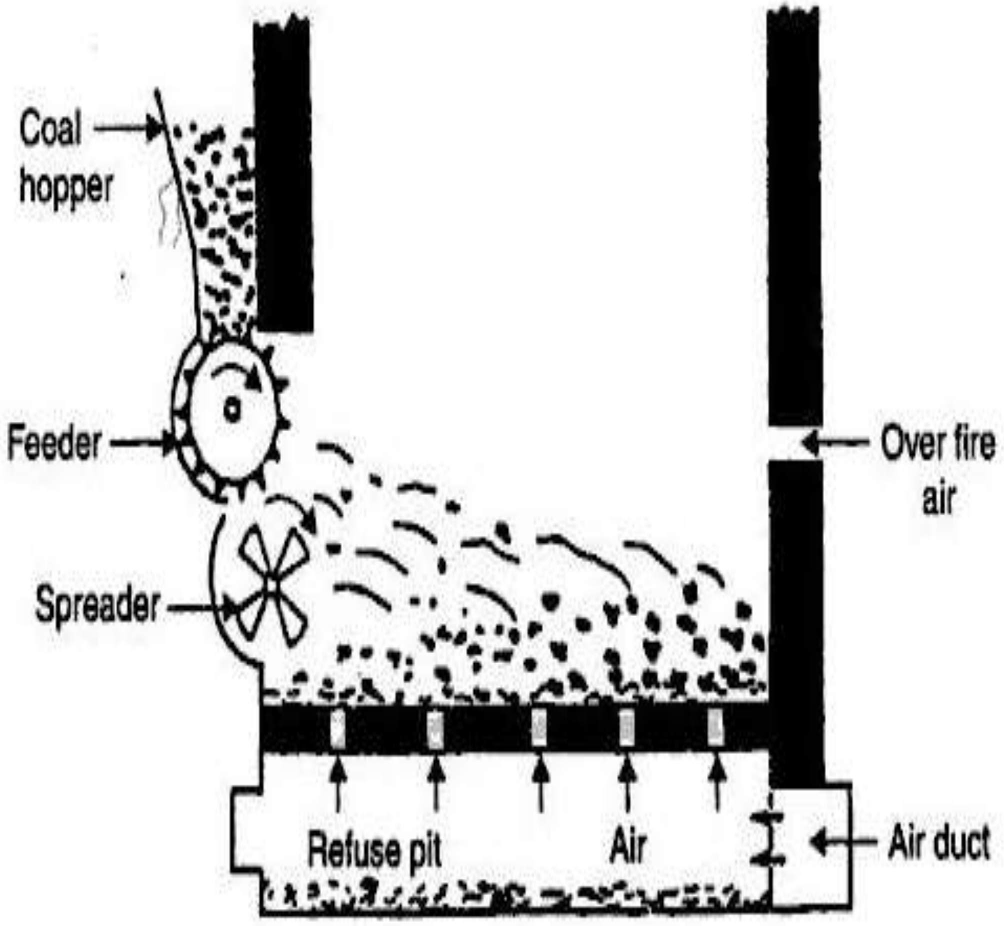
1. Simple in construction.
2. Initial cost low.
3. Maintenance charges low.
4. Self-cleaning stoker.
5. Gives high release rates per unit volume of the furnace.
6. Heat release rates can be controlled just by controlling the speed of chain.

Disadvantages :

1. Preheated air temperatures are limited to 180°C maximum.
2. The clinker troubles are very common.
3. There is always some loss of coal in the form of fine particles through riddlings.
4. Ignition arches are required (to suit specific furnace conditions).
5. This cannot be used for high capacity boilers (200 tonnes/hr or more).

Spreader Stoker

In this stoker the coal from the hopper is fed on to a feeder which measures the coal in accordance to the requirements. Feeder is a rotating drum fitted with blades. Feeders can be reciprocating rams, endless belts, spiral worms etc. From the feeder the coal drops on to spreader distributor which spread the coal over the furnace. The spreader system should distribute the coal evenly over the entire grate area. The spreader speed depends on the size of coal.



Spreader Stoker

Advantages :

1. A wide variety of coal can be burnt.
2. This stoker is simple to operate, easy to light up and bring into commission.
3. The use of high temperature preheated air is possible.
4. Operation cost is considerably low.
5. The clinking difficulties are reduced even with coals which have high clinkering tendencies.
6. Volatile matter is easily burnt.
7. Fire arches etc. are generally not required with this type of stokers.
8. As the depth of coal bed on the grate is usually limited to 10 to 15 cm only, fluctuating loads can be easily met with.

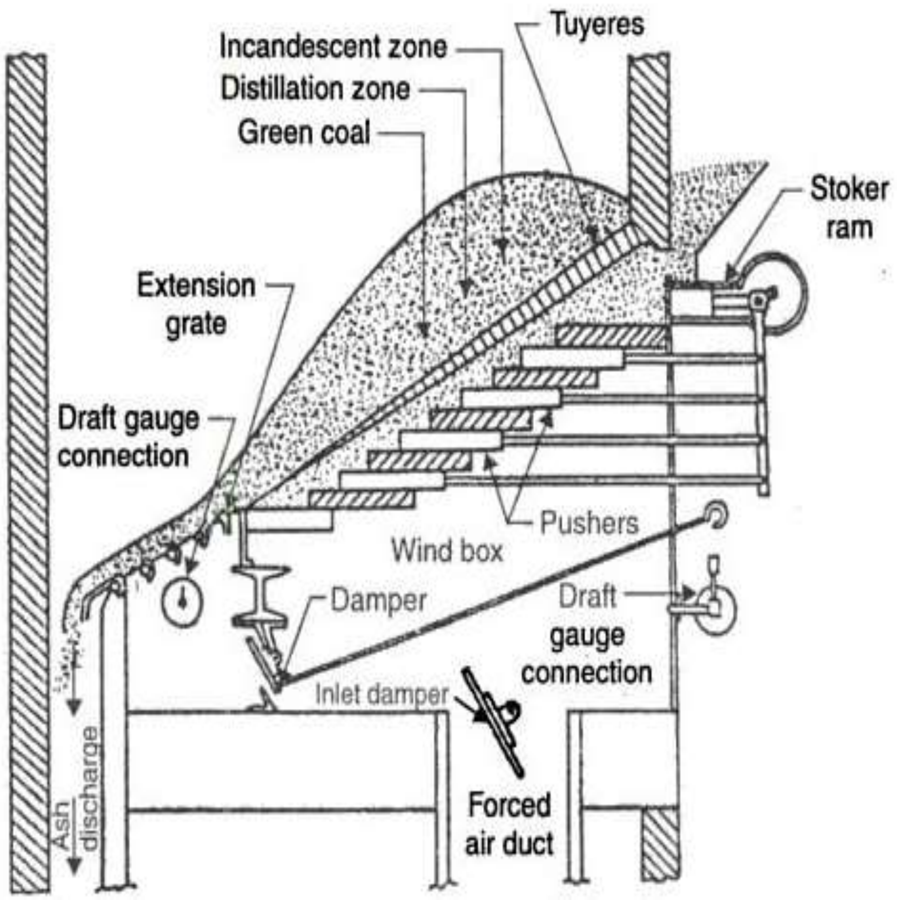
Disadvantages :

1. It is difficult to operate spreader with varying sizes of coal with varying moisture content.
2. Fly-ash is much more.
3. No remedy for clinker troubles.
4. There is a possibility of some fuel loss in the cinders up the stack because of the thin fuel bed and suspension burning.

Multi retort stoker

The stoker consists of a series of sloping parallel troughs formed by tuyere stacks. These troughs are called *retorts*. Under the coal hopper at the head end of the retorts, *feeding rams* reciprocate back and forth. With the ram in the outer position coal from the hopper falls into space vacated by the ram. On the inward stroke the ram forces the coal into the retort.

The height and profile of the fuel bed is controlled by *secondary*, or *distributing rams*. These rams oscillate parallel to the retort axes, the length of their stokes can be varied as needed. They slowly move the entire fuel bed down the length of the stoker.



Multi retort stoker

Advantages :

1. High thermal efficiency (as compared to chain grate stokers).
2. Combustion rate is considerably higher.
3. The grate is self cleaning.
4. Part load efficiency is high particularly with multi-retort type.
5. Different varieties of coals can be used.
6. Much higher steaming rates are possible with this type of stoker.
7. Grate bars, tuyeres and retorts are not subjected to high temperature as they remain always in contact with fresh coal.
8. Overload capacity of the boiler is high as large amount of coal is carried on the grate.
9. Smokeless operation is possible even at very light load.
10. With the use of clinker grinder, more heat can be liberated out of fuel.
11. Substantial amount of coal always remains on the grate so that the boiler may remain in service in the event of temporary breakdown of the coal supply system.
12. It can be used with all refractory furnaces because of non-exposure of stoker mechanism to the furnace.

Disadvantages :

1. High initial cost.
2. Require large building space.
3. The clinker troubles are usually present.
4. Low grade fuels with high ash content cannot be burnt economically.

Pulverized Fuel Burning System

Advantages :

1. Any grade of coal can be used since coal is powdered before use.
2. The rate of feed of the fuel can be regulated properly resulting in fuel economy.
3. Since there is almost complete combustion of the fuel there is increased rate of evaporation and higher boiler efficiency.
4. Greater capacity to meet peak loads.
5. The system is practically free from sagging and clinkering troubles.
6. No standby losses due to banked fires.
7. Practically no ash handling problems.
8. No moving part in the furnace is subjected to high temperatures.
9. This system works successfully with or in combination with gas and oil.
10. Much smaller quantity of air is required as compared to that of stoker firing.
11. Practically free from clinker troubles.
12. The external heating surfaces are free from corrosion.
13. It is possible to use highly preheated secondary air (350°C) which helps for rapid flame propagation.
14. The furnace volume required is considerably less.

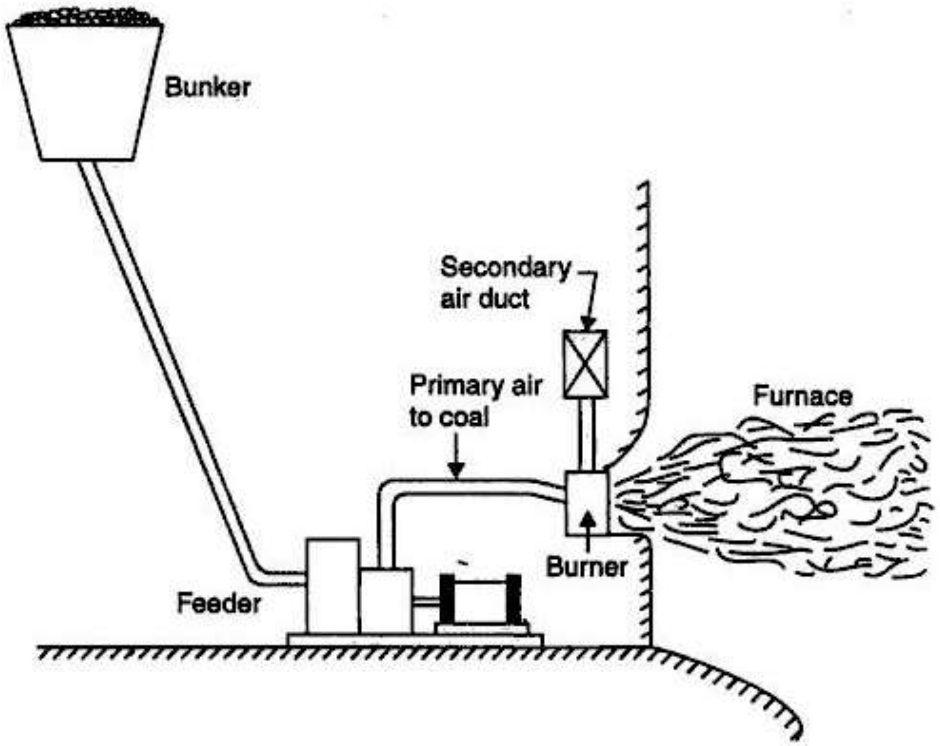


Fig. 2.15. Elements of pulverised coal system.

- In pulverised fuel firing system the coal is reduced to a fine powder with the help of grinding mill and then projected into the combustion chamber with the help of hot air current. The amount of air required (known as secondary air) to complete the combustion is supplied separately to the combustion chamber. The resulting turbulence in the combustion chamber helps for uniform mixing of fuel and air and thorough combustion. The amount of air which is used to carry the coal and to dry it before entering into the combustion chamber is known as 'Primary air' and the amount of air which is supplied separately for completing the combustion is known as 'Secondary air'.
- The efficiency of the pulverised fuel firing system mostly depends upon the size of the powder. The fineness of the coal should be such as 70% of it would pass through a 200 mesh sieve and 90% through 50 mesh sieve.

Disadvantages :

1. High capital cost.
2. Lot of fly-ash in the exhaust, which makes the removing of fine dust uneconomical.
3. The possibility of explosion is more as coal burns like gas.
4. The maintenance of furnace brickwork is costly.
5. Special equipment is needed to start this system.
6. The skilled operators are required.
7. A separate coal preparation plant is necessary.
8. High furnace temperatures cause rapid deterioration of the refractory surfaces of the furnace.
9. Nuisance is created by the emission of very fine particles of grit and dust.
10. Fine regular grinding of fuel and proper distribution to burners is usually difficult to achieve.

Pulverised fuel handling system(Unit system)

The *unit system* is so called from the fact that each burner or burner group and the pulveriser constitute a unit. Crushed coal is fed to the pulverising mill at a variable rate governed by the combustion requirements of the boiler and furnace. Primary air is admitted to the mill and becomes the transport air which carries the coal through the short delivery pipe to the burner. This air may be preheated if mill drying is desirable.

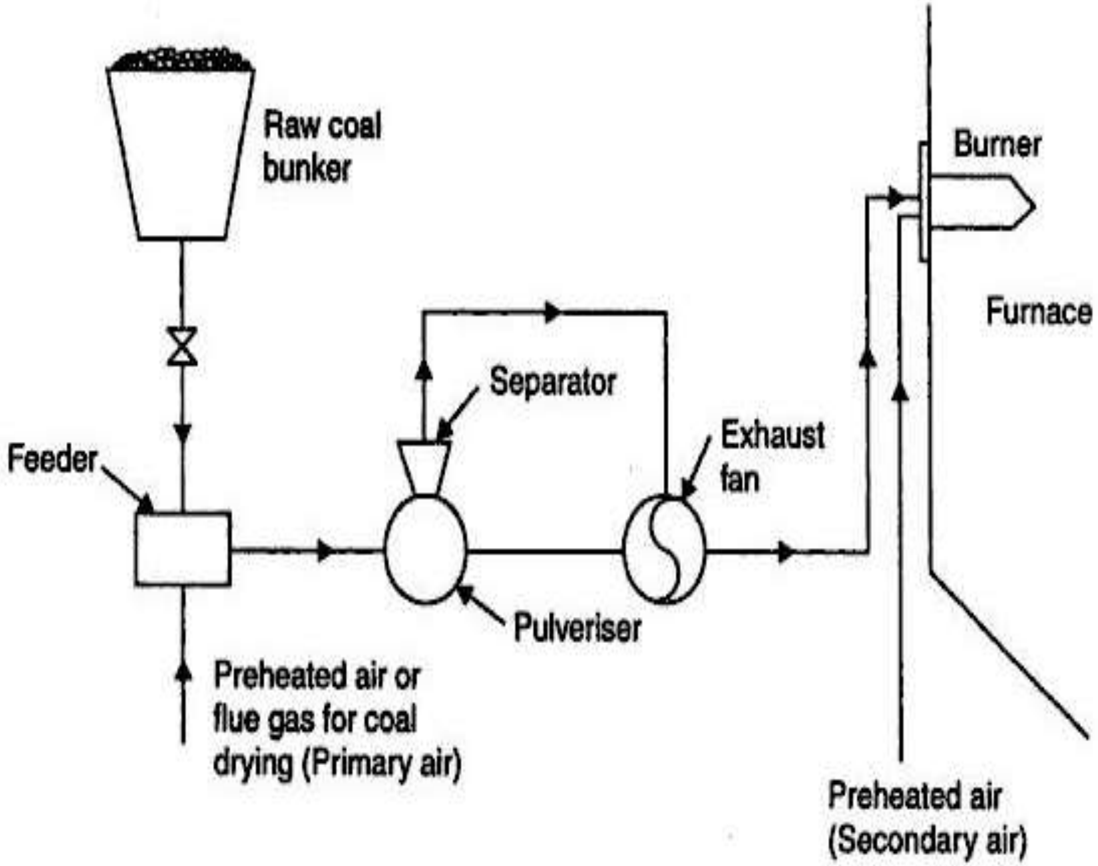


Fig. 2.16. Unit system.

Advantages :

1. The layout is simple and permits easy operation.
2. It is cheaper than central system.
3. Less spaces are required.
4. It allows direct control of combustion from the pulveriser.
5. Maintenance charges are less.
6. There is no complex transportation system.
7. In a replacement of stokers, the old conveyor and bunker equipment may be used.
8. Coal which would require drying in order to function satisfactorily in the central system may usually be employed without drying in the unit system.

Disadvantages :

1. Firing aisle is obstructed with pulverising equipment, unless the latter is relegated to a basement.

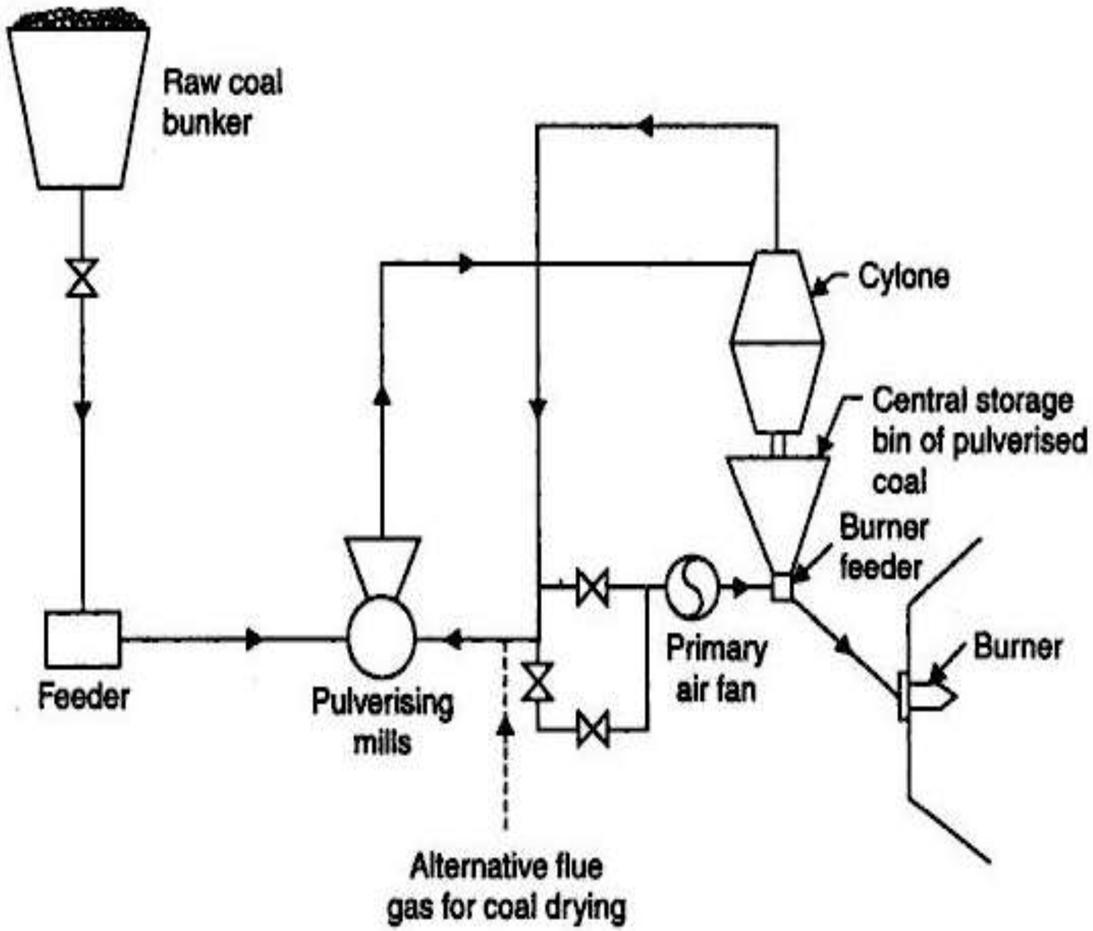
2. The mills operate at variable load, a condition not especially conducive to best results.

3. With load factors in common practice, total mill capacity must be higher than for the central system.

4. Flexibility is less than central system.

Central system

A central pulverising system employs a limited number of large capacity pulverisers at a central point to prepare coal for all the burners. Driers, if required, are conveniently installed at this point. From the pulverisers the coal is transported to a central storage bin where it is deposited and its transporting air vented from the bin through a "*cyclone*". This bin may contain from 12 to 24 hours supply of pulverised coal. From the bin the coal is metered to the burners by motor-driven feeders of varied design. Primary air, added at the feeders, floats the coal to the burners.



Advantages :

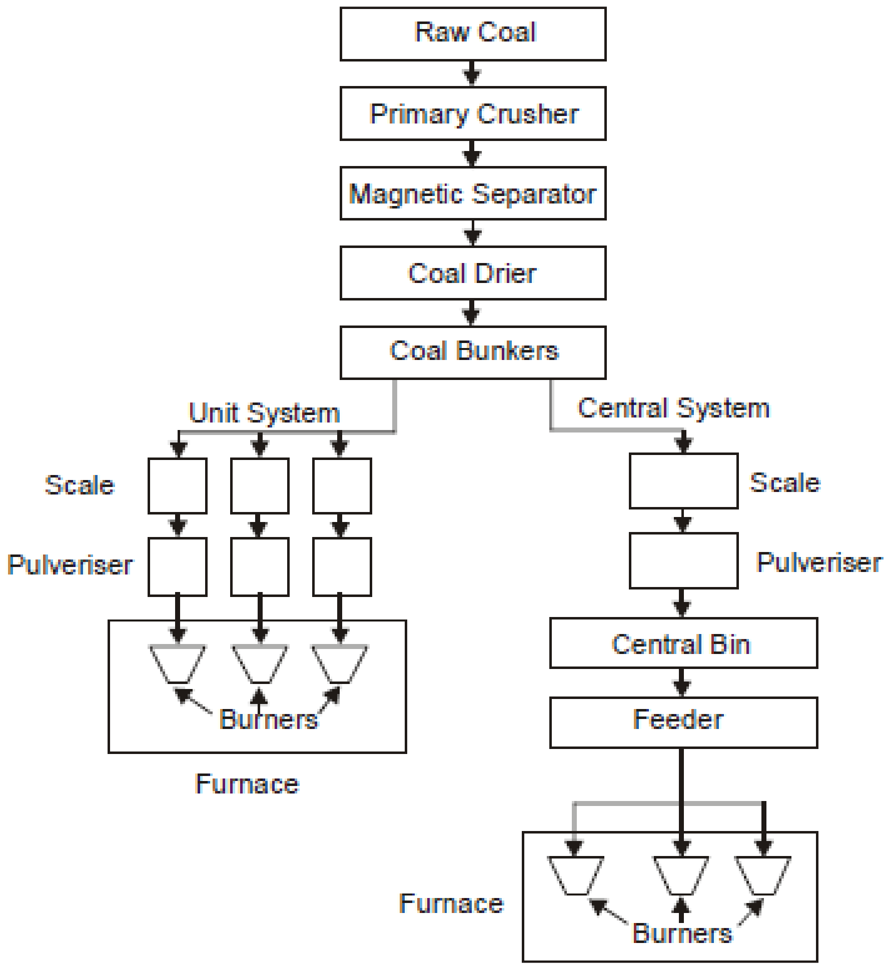
1. Offers good control of coal fineness.
2. The pulverising mill may work at constant load because of the storage capacity between it and the burners.
3. The boiler aisels are unobstructed.
4. More latitude in the arrangement and number of burners is allowed to the designers.
5. The large storage is protection against interruption of fuel supply to the burners.
6. Less labour is required.
7. Power consumption per tonne of coal handled is low.
8. Burners can be operated independent of the operation of coal preparation plant.
9. Fans handle only air, as such, there is no problem of excessive wear as in case of unit system, where air and coal both are handled by the fan.

Disadvantages :

1. Driers are usually necessary.
2. Fire hazard of quantities of stored pulverised coal.
3. Central preparation may require a separate building.
4. Additional cost and complexity of coal transportation system.
5. Power consumption of auxiliaries is high.

Pulverized Fuel Burning System and its Components:

Coal is pulverized (powdered) to increase its surface exposure thus permitting rapid combustion. Efficient use of coal depends greatly on the combustion process employed. For large scale generation of energy the efficient method of burning coal is confined still to pulverized coal combustion. The pulverized coal is obtained by grinding the raw coal in pulverizing mills.



The essential functions of pulverizing mills are as follows:

(i) Drying of the coal

(ii) Grinding

(iii) Separation of particles of the desired size.

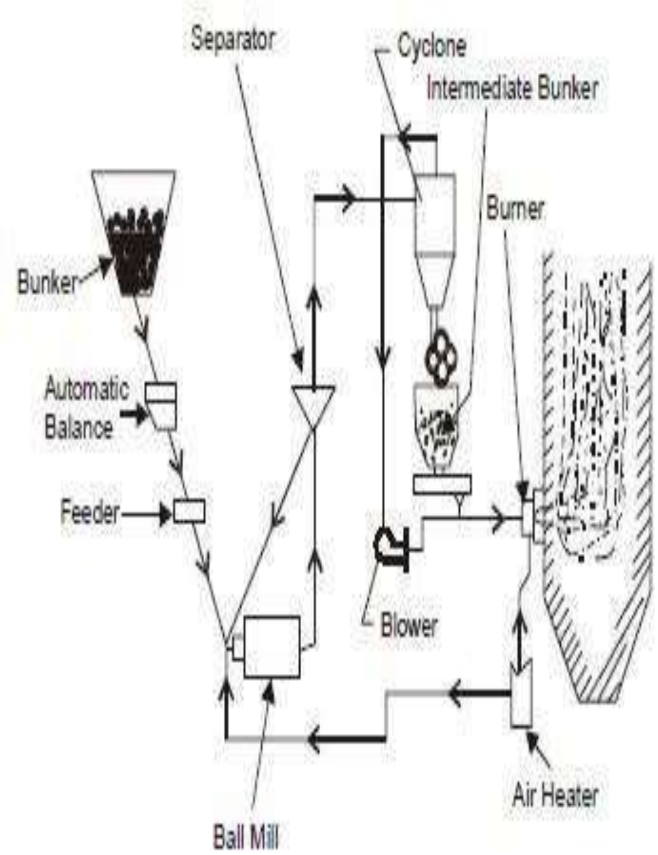
The various pulverizing mills used are as follows:

- (i) Ball mill
- (ii) Hammer mill
- (iii) Ball and race mill
- (iv) Bowl mill.

Proper drying of raw coal which may contain moisture is necessary for effective grinding. The coal pulverizing mills reduce coal to powder form by three actions as follows:(i) Impact (ii) Attrition (abrasion) (iii) Crushing. Most of the mills use all the above mentioned all the three actions in varying degrees. In impact type mills hammers break the coal into smaller pieces whereas in attrition type the coal pieces which rub against each other or metal surfaces to disintegrate. In crushing type mills coal caught between metal rolling surfaces gets broken into pieces. The crushing mills use steel balls in a container. These balls act as crushing elements.

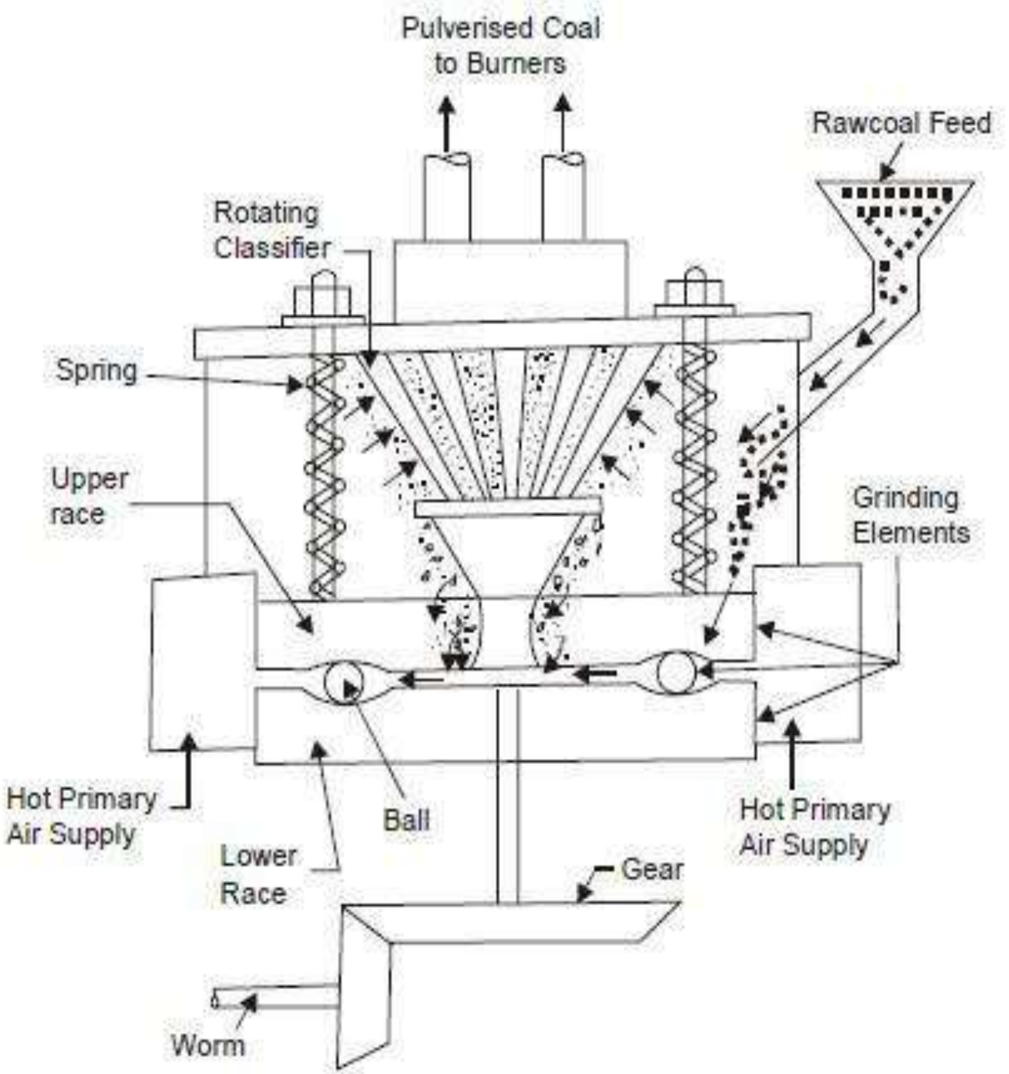
BALL MILL:

A line diagram of ball mill using two classifiers is shown in Fig. It consists of a slowly rotating drum which is partly filled with steel balls. Raw coal from feeders is supplied to the classifiers from where it moves to the drum by means of a screw conveyor.



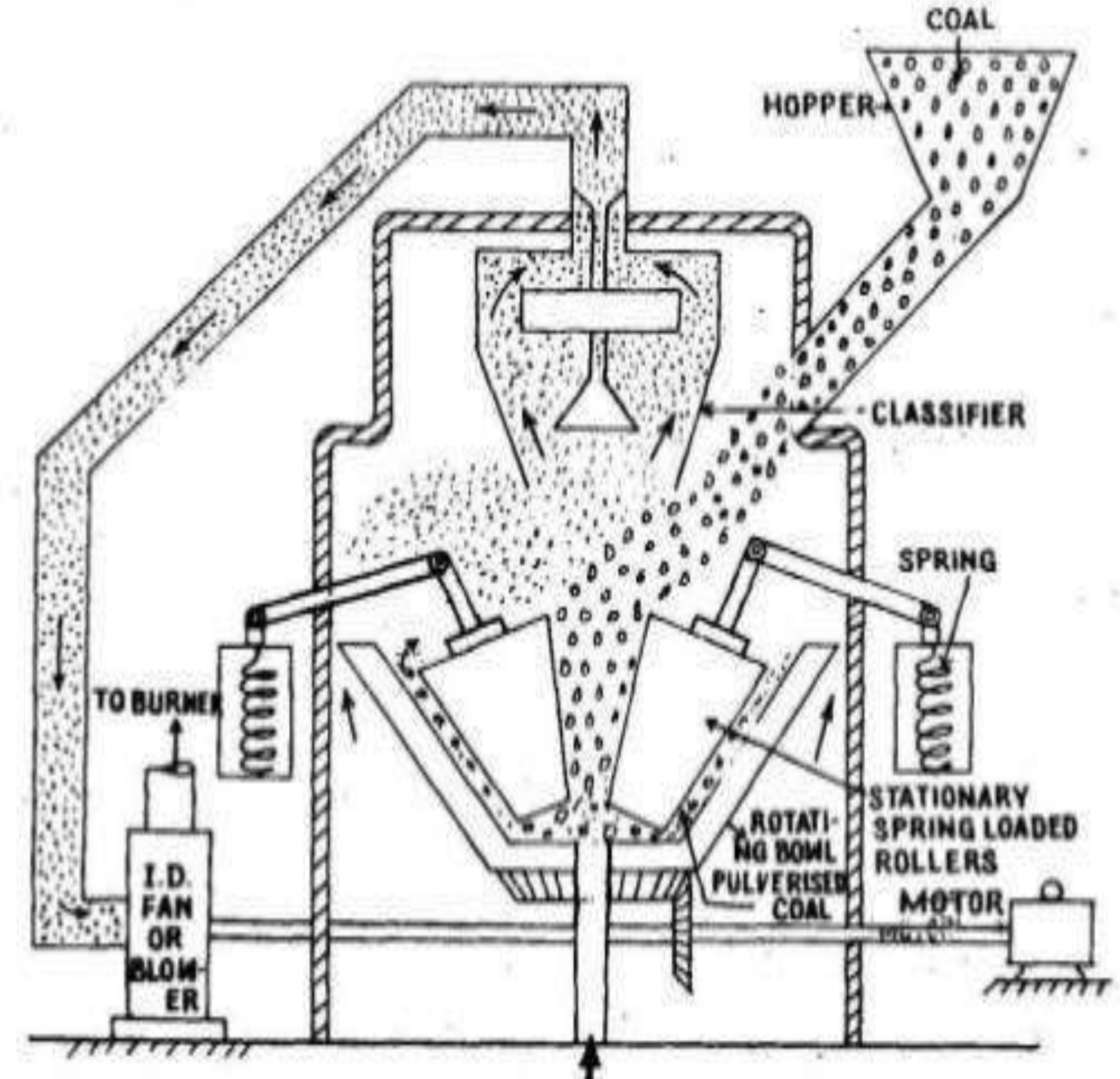
BALL AND RACE MILL

Ball and race mill. This a low speed unit in which grinding pressure is maintained by adjustable springs. The coal passes between the two rotating elements again and again until it has been pulverised to the desired degree of fineness. Fig. shows a ball and race mill. Mill, feeder and fan require up to 14 kWh per tonne of coal pulverised.



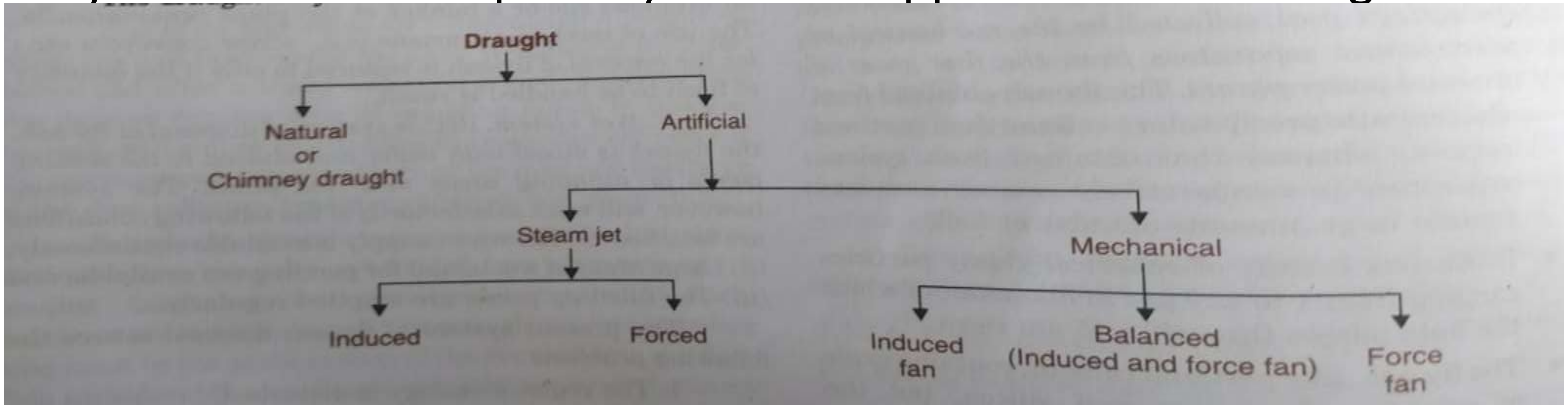
BOWL MILL

Bowl mill. The bowl mill grinds the coal between a whirling bowl and rolls mounted on pivoted axes. Coal fed into the centre is thrown by centrifugal force against the sides of the bowl where it is pulverised between the sides of the bowl and the grinding ring. The fine and intermediate sizes are picked up from the top by an air current and carried into the separator above for classification. It consumes about 5 kWh of electricity per tonne of coal



CHIMNEY DRAUGHT

- . Definition and Classification of Draught
- The small pressure difference which causes a flow of gas to take place is termed as a draught. The function of the draught, in case of a boiler, is to force air to the fire and to carry away the gaseous products of combustion. In a boiler furnace proper combustion takes place only when sufficient quantity of air is supplied to the burning fuel.



Natural DraughtNatural draught is obtained by the use of a chimney. The chimney in a boiler installation performs one or more of the following functions: (i) It produces the draught whereby the air and gas are forced through the fuel bed, furnace, boiler passes and settings; (ii) It carries the products of combustion to such a height before discharging them that they will not be objectionable or injurious to surroundings. A chimney is vertical tubular structure built either of masonry, concrete or steel. The draught produced by the chimney is due to the density difference between the column of hot gases inside the chimney and the cold air outside.

- Draught LossesThe loss in a draught may be due to the reasons mention below:(i) The frictional resistance offered by the flues an gas passages to the flow of flue gases.(ii) Loss near the bends in the gas flow circuit.(iii) Loss due to friction head in equipments lik grate, economiser, superheater etc.(iv) Loss due to imparting velocity to the flue gaseThe loss in draught in a chimney is 20 per cent the total draught produced by it.

- Artificial Draught In the boiler installations of today the total static draugh required may vary from 30 to 350 mm of water column. It may not be possible to build a chimney high enough to produce draught of such a large magnitude. To meet this requirement artificial draught system should be used. It may be a mechanical draught or a steam jet draught. The former is used for central power stations and many other boiler installations while the latter is employed for small installations and in locomotives.

- Forced Draught In a mechanical draught system, the draught is produced by a fan. In a forced draught system, a blower or a fan is installed near or at the base of the boiler to force the air through the cool bed and other passages through the furnace, flues, air preheater, economiser etc. It is a positive pressure draught. The enclosure for the furnace etc. has to be very highly sealed so that gases from the furnace do not leak out in the boiler house.

- Induced Draught. In this system a fan or blower is located at or near the base of the chimney. The pressure over the fuel bed is reduced below that of the atmosphere. By creating a partial vacuum in the furnace and flues, the products of combustion are drawn from the main flue and they pass up the chimney. This draught is used usually when economisers and air preheaters are incorporated in the system. The draught is similar in action to the natural draught.

- Balanced Draught It is a combination of the forced and induced draught systems. In this system, the forced draught fan overcomes the resistance in the air preheater and chain grate stoker while the induced draught fan overcomes draught losses through boiler, economiser, air preheater and connecting flues.

- The forced draught entails following advantages over induced draught:1. Forced draught fan does not require water-cooled bearings.2. Tendency to air leak into the boiler furnace is reduced.3. No loss due to inrush of cold air through the furnace doors when they are opened for fire and cleaning fires.4. Fan size and power required for the same draught are 1/5 to 1/2 of that required for an induced draught fan installation because forced draught fan handles cold air.

- Advantages of Mechanical Draught The mechanical draught possesses the following advantages:1. Easy control of combustion and evaporation. 2. Increase in evaporative power of a boiler,3. Improvement in the efficiency of the plant,4. Reduced chimney height.5. Prevention of smoke.6. Capability of consuming low grade fuel.7. Low grade fuel can be used as the intensity of artificial draught is high.8. The fuel consumption per kW due to artificial draught is 15% less than that for natural draught.9. The fuel burning capacity of grate is 200 to 300 kg/m^2-hr with mechanical draught, whereas, it is hardly 50 to 100 kg/m^2-hr with natural draught

- Steam Jet Draught Steam jet draught is a simple and easy method of producing artificial draught. It may be of forced or induced type depending upon where the steam jet to produće draught is located. If the steam jet is directed into the smoke box near the stack, the air is induced through the flues, the grate and ash pit to the smoke box. If the jet is located before the grate, air is forced through the fuel bed, furnace and flues to the chimney.
- Advantages:(1) Very simple and economical.(ii) Occupies minimum space.(iii) Requires very little attention.(iv) In forced type steam jet draught, the steam keeps the fire bars cool and prevents the adhering of clinker to the fire bars.(v) Several classes of low grade fuels can be used wit this system.

DUST COLLECTORS

- **Dust collectors are may be classified as follows:**
- 1 mechanical dust collectors
- (i) wet type (scrubbers): spray type, packed type and impingement type
- (ii) dry type: gravitational separators and cyclone separators
- 2 electrical dust collectors
- (i) rod type
- (ii) plate type

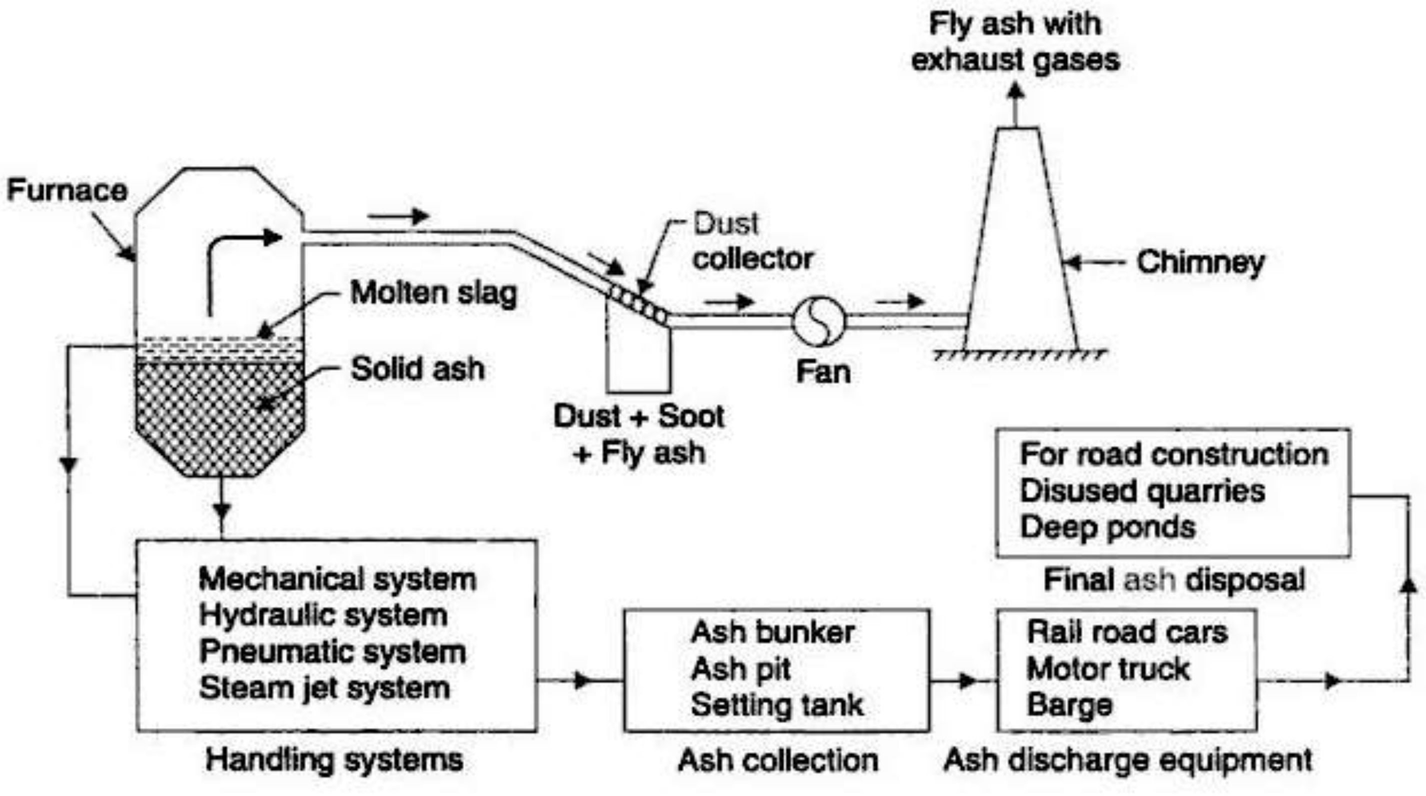


Fig. 2.25. General layout of ash handling and dust collection system.

Gas turbine power plants

- **Advantages of gas turbine power plant over the steam power plant:**
- 1 no ash handling system
- 2 low capital cost
- 3 Gas turbine plants can be installed very near to load centers as required considerable less space
- 4 less auxiliaries are required/used
- 5 gas turbine can be built easy/quickly require less space, civil work and water supply
- 6 gas turbines can be attains peak loads quickly and works on it preferably
- 7 the components and circuits of gas turbine can be arranged quickly and easily than steam power plants
- 8 gas turbine plants can work quite economically for short running time
- 9 storage of fuel is much smaller and handling very easy
- 10 large amount of cooling water required for steam power plant where as open cycle gas turbine does not require any cooling water and closed cycle gas turbine requires 10% of cooling water is required as that of steam power plant.
- 11 above 550^{o} C the efficiency of gas turbine three times greater than steam power plant
- 12 For same inlet pressure and temperature, the ratio of exhaust to inlet volume is 3.95 for gas turbine where as 250 for steam power plant

Classifications of gas turbine power plants

- 1 by application:
- In air craft (jet-propulsion and prop-jets)
- Stationary (peak load unit, standby unit, end of transmission line, base load unit and industrial unit)
- Locomotive
- Marine
- Transport
- 2 by cycle:
- Open cycle, Closed cycle and Semi-closed
- 3 according to arrangement:
- Simple, single shaft, multi shaft, intercooled, reheat, regenerative and combination
- 4 according to combustion:
- Continuous combustion and intermittent combustion
- 5 by fuels:
- Solid fuels, liquid fuels and gaseous fuels

Open cycle gas turbine

(A) Advantages

1. **Warm-up time.** Once the turbine is brought up to the rated speed by the starting motor and the fuel is ignited, the gas turbine will be accelerated from cold start to full load without warm-up time.

2. **Low weight and size.** The weight in kg per kW developed is less.

3. **Fuels.** Almost any hydrocarbon fuel from high-octane gasoline to heavy diesel oils can be used in the combustion chamber.

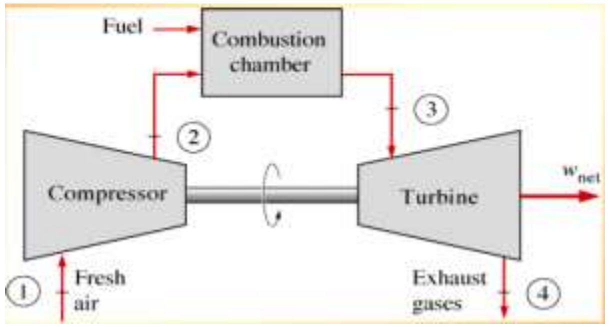
4. Open cycle plants occupy comparatively little space.

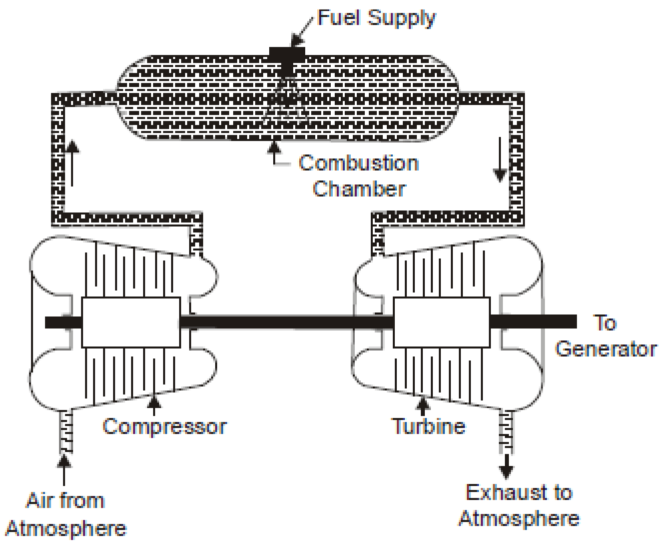
5 Open-cycle gas turbine power plant, except those having an intercooler, does not require cooling water. Therefore, the plant is independent of cooling medium and becomes self- contained.

(B) Disadvantages:

1. The part load efficiency of the open cycle plant decreases rapidly as the considerable percentage of power developed by the turbine is used to drive the compressor.

2. The open-cycle gas turbine plant has high air rate compared to the other cycles, therefore, it results in increased loss of heat in the exhaust gases and large diameter ductwork is necessary





CLOSED CYCLE GAS TURBINE POWER PLANT

(A) Advantages

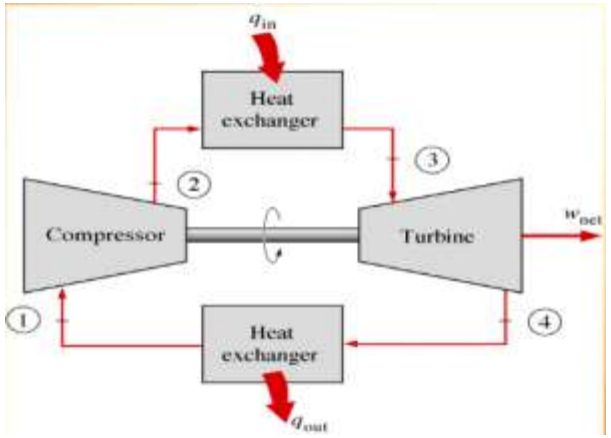
1. The closed cycle avoids erosion of the turbine blades due to the contaminated gases and fouling of compressor blades due to dust.

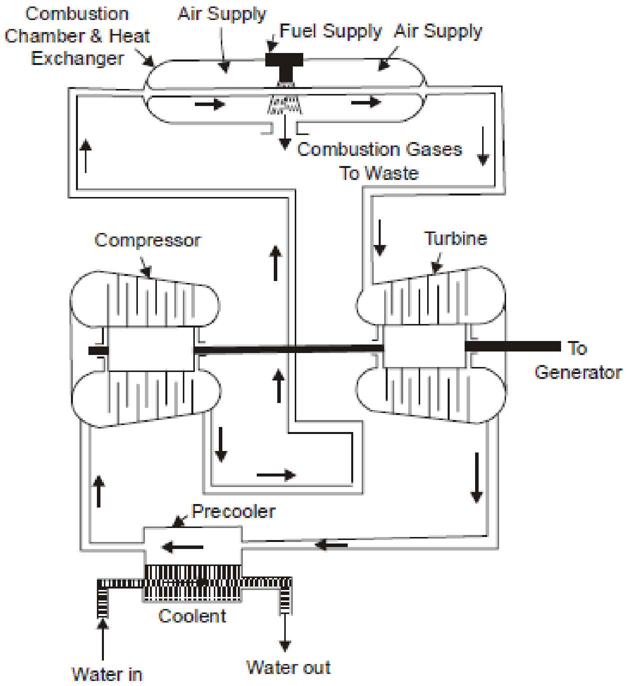
Therefore, it is practically free from deterioration of efficiency in service..

2. The need for filtration of the incoming air which is a severe problem in open cycle plant is completely eliminated.

3 . Load variation is usually obtained by varying the absolute pressure and mass flow of the circulating medium, while the pressure ratio, the temperatures and the air velocities remain almost constant.

4 . The density of the working medium can be maintained high by increasing internal pressure range, therefore, the compressor and turbine are smaller for their rated output. The high density of the working fluid further increases the heat transfer properties in the heat exchanger.





Regenerator and Intercooler