PPE – Coal & Ash Handling Systems

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Steps in Coal Handling

Coal Delivery

- Unloading
- Preparation
- Transfer

Outdoor Storage (Dead Storage)

- Covered Storage (Live Storage)

In Plant Handling

- Weighing and Measuring
- Furnace
Coal Delivery: The coal from supply points is delivered by
- ships or boats to PP if near to sea or river
- rail or trucks to the power stations which are situated away from sea or river.
- trucks is used if railway facilities are not available.

Unloading: The type of equipment to be used for unloading the coal received at 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.
- In case the coal is brought by railway wagons, ships or boats, the unloading may be done by car shakes, rotary car dumpers, cranes, grab buckets and coal accelerators.
  Rotary car dumpers although costly, are quite efficient for unloading closed wagons.
This thing shaks the rail car to move the coal @ bottom

This mechanism tilts the rail car to move the coal @ side
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.
Transfer:

- After preparation coal is transferred to the dead storage by means of the following systems:
  
  1. Belt conveyors.  
  2. Screw conveyors.  
  4. Grab bucket elevators.  
  5. Skip hoists.  
  6. Flight conveyor.
BELT CONVEYOR:

It consists of an endless belt, moving over a pair of end drums (rollers). 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.

**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.
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.
A. Conveyor Screw
B. Self-Locking Coupling Bolts
C. Hangers and Bearings
D. Trough Ends
E. Troughs, Covers, Clamps and Shrouds
F. Flange
G. Feed and Discharge Spouts
H. Supporting Feet and Saddles
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.
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.
SKIP HOISTS

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 up right position. It is simple and compact method of elevating coal or ash.
FLIGHT CONVEYOR:

It consists of one or two strands of chain to which steel scraper or flights are attached, which scrap the coal through a depression having identical shape.

It is used to drag or push pulverized or granulated solid materials. This coal is discharged in the bottom of trough.

It is low in first cost but has large energy consumption. There is considerable wear.

It may be used for coal as well as ash.

Skip hoist - bucket elevators lift coal vertically while Belts - flight conveyors move coal horizontally or on inclines.
**COAL STORAGE**

**Why 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.

**How much??**

The amount of coal to be stored depends on the availability of space for storage, transportation facilities, the amount of coal that will 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.
Dead storage or Outdoor storage

The coal stored has the tendency to whether (to combine with 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.

The coal is stored by the following methods:

- **Stocking the coal in heats.** The coal is piled 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. Asphalt, fine coal dust and bituminous coating are the materials commonly used for this purpose.

- **Under water storage.** The possibility of slow oxidation and spontaneous combustion can be completely eliminated by storing the coal under water.
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. Coal from silos is transferred to the boiler grate.
In plant handling

It is referred to transferring coal from dead or live storage to the boiler furnace. For inplant handling, the same equipments are used as used for coal transfer like belt conveyors, screw conveyors, bucket elevators etc.
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** weighters use a pneumatic transmitter weight head - 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.
Dewatering of Coal

Excessive surface moisture of coal reduces heating value of coal and creates handling problems. *The coal should therefore be dewatered to produce clean coal.*

*Cleaning of coal has the following advantages:*
- Improved heating value.
- Easier crushing and pulverizing
- Easy handling and transportation
- Improve boiler performance
- Reduce amount of ash handling
Fuel is burnt in a confined space called furnace. In the furnace: Burners are used to burn powdered (Pulverized) coal and liquid or gaseous fuels; Grate with stoker require for solid fuels.

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.

   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 fuel, liquid and gaseous fuels.
Solid Fuel Firing

- Hand fired
  - Overfeed stokers
    - Chain grate
    - Travelling grate
    - Spreader type
  - Underfeed stokers
    - Single retort
    - Multi-retort
      - Unit system
      - Central system
- Stoker feed
- Pulverised fuel fired
What may be the material of furnace?

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

Smaller boilers used solid refractory walls but they are air cooled. In larger units, bigger boilers use water cooled furnaces.
HAND FIRING

- This is a simple method - less capital investment and used for smaller plants. This method of fuel firing is discontinuous process, and there is a limit to the size of furnace which can be efficiently fired by this method.

- While burning coal the total area of air openings varies from 30 to 50% of the total grate area.

- Hand fired grates are made up of cast iron.
Fig. shows a hand fire grate furnace with a stationary fuel bed.

- The grate divides it into the furnace space... in which
  - the fuel is fired and
  - an ash pit through which the necessary air required for combustion is supplied.

- The grate is arranged horizontally and supports a stationary bed of burning fuel.

- The fuel is charged by hand through the fire door.

- In a hand fired furnace the fad is periodically shovelled on to grate, and is heated up by the burning fuel and hot masonry of the furnace.
The various types of hand fired grates are shown in Fig.
The heat liberation per unit of furnace volume is given by the following expression:

$$h = (W \times C) \times V$$

where

- $H =$ Heat liberation per unit volume
- $W =$ Rate of fuel consumption (kg/sec)
- $C =$ Lower heating value of fuel (kcal/kg)
- $V =$ Volume of furnace ($m^3$).
MECHANICAL FIRING (STOKERS)

Mechanical stokers 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:
- Large quantities of fuel can be fed into the furnace. Thus greater combustion capacity is achieved,
- Poorer grades of fuel can be burnt easily.
- Stoker save labour of handling ash and are self-cleaning.
- By using stokers better furnace conditions can be maintained by feeding coal at a uniform rate.
- 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.
Principles of Stokers. The working of various types of stokers is based on the following two principles:
1. Overfeed Principle and 2. Under feed Principle

The selection of firing method adopted for a particular power plant depends upon the following factors:
(1) The characteristics of the available coal.
(2) Capacity of the plant.
(3) Load factor of the power plant.
(4) Nature of load fluctuation, and
(5) Reliability and efficiency of the various combustion equipments available.
Overfeed supply of coal:

In case of overfeed stoker, coal is fed on to the grate above the point of air admission as shown in Fig.
The mechanics of combustion in overfeed stoker is described below:

(1) The pressurized air coming from F.D. fan enters under the bottom of the grate. The air passing through the grate is heated by absorbing the heat from the ash and grate itself, whereas the ash and grate are cooled.

The hot air then passes through a bed of incandescent coke. As the hot air passes through incandescent coke, the $O_2$ reacts with $C$ to form $CO_2$.

Generally, for a fuel bed of 8 cm deep, all the $O_2$ in the air disappears in the incandescent region.

The gases leaving the incandescent region of fuel bed consist of $N_2$, $CO_2$, $CO$, $H_2$ and $H_2O$. 
(2) The raw coal is continuously supplied on the surface of the bed. Here it loses its volatile matter by distillation.

(3) The gases leaving the upper surface of the fuel bed contain combustible volatile matter formed from the raw fuel, N\textsubscript{2}, CO\textsubscript{2}, CO, H\textsubscript{2} and H\textsubscript{2}O. Additional secondary air is supplied at top of the bed to burn the remaining combustible gases (volatile matter + CO + H\textsubscript{2}). The secondary air is supplied at a very high speed to create turbulence which is required for complete combustion of unburned gases.

(4) The burned gases entering boiler contain N\textsubscript{2}, CO\textsubscript{2}, O\textsubscript{2} and H\textsubscript{2}O and some CO if the burning is incomplete.
Under-feed supply of coal: In this type of stokers, the fuel and air move in the same direction.
The mechanism of combustion in under-feed stoker is described below:

1. Air after passing through the holes in the grate as shown in Fig. meets the raw coal. The heat for distillation comes by conduction from the mass of incandescent fuel bed which exists above the raw coal.
   The air mixes with the formed volatile matter and passes through the ignition zone and then enters into the region of incandescent coke.

2. The reactions which take place in the incandescent zone of under-feed stoker are very much similar as in the incandescent zone of over-feed stoker.

3. The gases coming out of raw fuel bed pass through a region of incandescent ash on surface of the fuel and finally discharged to the furnace with the constituents like over-feed stoker.

4. The supply of secondary air is required in this case as the gases coming out of fuel bed also contain combustible matter.
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.
OVER FEED STOKER
These types of stokers are used for large capacity boiler installations where the coal is burned without pulverization.

The overfeed stokers are of mainly two types (a) Traveling grate stoker, and (b) Spreader stoker.

**Travelling Stoker.**
The travelling stoker may be chain grate type or bar grate type.

These two differ only in the details of grate construction.

- The grate surface of a chain grate stoker is made of a series of cast iron links connected by pins to **form an endless chain.**

- The grate surface of a bar grate stoker is made of a series of cast iron sections mounted on **carrier bars.** The carrier bar rides on two endless type drive chains.
The air required for combustion is supplied through the air inlets situated below the grate. The secondary air is supplied through the openings provided in the furnace wall above the grate as shown in figure.
The **advantages** of chain grate stoker are listed below:

- It is simple in construction and its initial cost is low.
- It is more reliable in service therefore maintenance charges are low.
- It is self-cleaning stoker.
- The heat release rates can be controlled just by controlling the speed of chain.
- It gives high heat release rates per unit volume of the furnace.
Disadvantages:

- The amount of coal carried on the grate is small as the increase in grate size creates additional problems. This cannot be used for high capacity boilers 200 tons/hr or more.
- The temperature of preheated air is limited to 180°C.
- The clinker troubles are very common.
- There is always some loss of coal in the form of fine particles carried with the ashes.
These grates are suitable only when fuel burns before it reaches the rear end of the furnace. The rate of burning with this stoker is \(200\) to \(300\) kg \(\text{per m}^2\) \(\text{per hour}\) when forced draught is used.

- Another type of travelling stoker is **vibrating grate stoker**. It operates in a manner similar to that of chain grate stoker except that the fuel bed movement are accomplished by vibration. The vibration and the inclination of the grate cause the fuel bed to move through furnace towards ash pit.
Chain grate stokers are best suited for non-caking, high volatile and high ash coals.

The bar grate stokers burn lignite and small size anthracite coals successfully.

Vibrating grate stokers are suitable for medium volatile bituminous coals and lignites but at reduced burning rates.

The travelling stokers are not suitable for caking coal as it requires agitation during burning.
Spreader Type or Sprinkler Stoker:

This is a overfeed type stoker. The coal burns on this stoker remains partly in suspension and partly on the grate.
The spreader stoker installation consists of variable feeding device, a mechanism for throwing the coal uniformly on the grate and with suitable openings for admitting the air.

Air supplied by F.D. fan enters the furnace through the openings provided in the grate. A portion of this air is used to burn the fuel on the bed and remaining air is used to burn volatile matter in suspension.

Secondary supply of air creates high turbulence and complete the combustion of volatile matter and suspended particles.
The advantages of spreader stoker are:

- A wide variety of coal from lignite to semi anthracite as well as high ash coal can be burn easily.

- Clinkering difficulty is reduced by spreading action.

- The coking tendency of the coal is reduced before it reaches the grate by the release of volatile gases which burn in suspension.

- The use of high temperature preheated air is possible.

- It gives quick response to load change similar to pulverized fuel system because there is only a small amount of fuel on the grate at any time and most of heat is released during burning of the coal in suspension.

- This form of fixing provides thin and even firebed and results in high rate of combustion (350 kg/m²-hr). Therefore, it gives quick response to the load change and with less sensitivity to the swelling characteristics of the fuel.

- This fire bed gives equal pressure drop and proper air distribution so that combustion can be completed with minimum quantity of excess air.

- Its operation cost is considerably low.
Disadvantages

➢ It is always difficult to operate spreader with varying sizes of a coal and with varying moisture content.

➢ A natural result of suspension burning of fine fuel particles is the entrainment of ash in the products of combustion. To avoid the nuisance of fly ash, a dust collector is almost necessary with this stoker.

➢ Many fine unburnt carbon particles are also carried with the exhaust gases and it is necessary to trap these and return to the furnace for burning. Otherwise it would add as a loss to the combustion system.
UNDERFEED STOKERS

- In underfeed stokers, the fuel is fed from underneath the fire and moves gradually upwards. The primary air is supplied just below the level at which combustion takes place.

- The fuel releases the volatile matter as it passes through the initial fuel bed from bottom. The released volatile matter mixes with fresh air and enters into the combustion zone.

- Therefore, the entire combustion process is highly efficient and gives high rates of heat release.

- The underfeed stokers fall into two main groups, the single retort and multiple retort stokers.
Single Retort Stoker
The fuel is placed in large hopper on the front of the furnace, and then it is further fed by reciprocating ram or screw conveyor into the bottom of the horizontal trough.

The air is supplied through the tuyeres provided along the upper edge of the grate.

The ash and clinkers are collected on the ash plate provided with dumping arrangement.

The coal feeding capacity of a single retort stoker varies from 100 to 2000 kg per hour.
Multi retort stoker

Draft gauge connection

Ash discharge

Extension grate

Incandescent zone

Green coal

Distillation zone

Tuyeres

Stroker

Forced damper

Wind box

Pushers

Draft ram

Inlet air

Draft box
The multi retort stoker consists of alternate retorts for pushing coal and tuyere boxes for supplying air.

The coal falling from the hopper is pushed by reciprocating ram during the inward stroke.

The ash is collected at the another end as shown in figure.

The amount of coal and air pressure in main wind box is varied to meet the variable load demand.

The number of retorts may vary from 2 to 20 with capacity from 300 to 2000 kg per hr per retort.