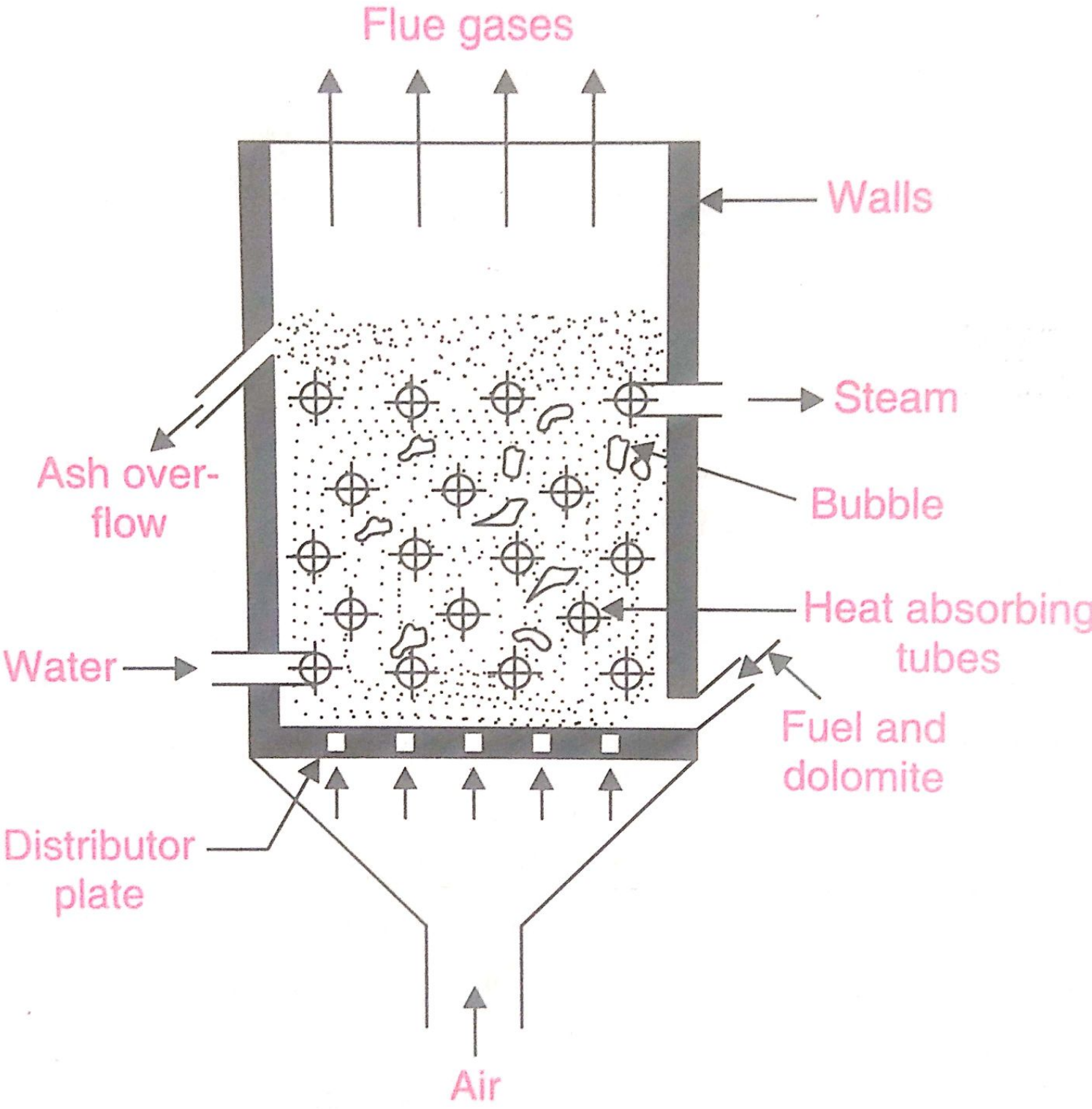
Fluidised Bed Combustion (FBC)

A fluidised bed may be defined as the bed of solid particles behaving like a fluid. The principle is "When a gas is passed through a packed bed of finely divided solid particles, it experiences a pressure drop across the bed. At low gas velocities it does not disturb the particles but if the gas velocity is increased in such a manner, when the particles are suspended in the gas stream and the packed bed becomes a fluidised bed, with rapid increase of velocity the bed becomes turbulent and behaviour of solid particles with gas becomes like the behaviour of fluid flowing. Such fuel in this state is called as FBC

Important

On the distributor plate are fed the fuel and inert high velocity air keeps the solid feed material in suspending condition during burning. The generated heat is transferred to the water passing through tubes


Flue gases
Walls
Steam
Ash over-
flow
Bubble
Heat absorbing
tubes
Water
Fuel and
dolomite
Distributor
plate
Air

13 Wednesday
JULY

# Ash handling

A huge quantity of ash is produced during the generation of power which is of the order of 10 - 20% of the total quantity.

Handling of ash includes
i) Its removal from the furnace
ii) Loading on the conveyors and delivery to the fill or dump from where it can be disposed off.

Ash needs to be quenched before moving out because
i) Quenching reduces corrosion action of ash
ii) It reduces the dust
iii) Ash forms clinkers by fusing in large lumps

Ash handling systems
1. Mechanical handling system
2. Hydraulic system
3. Pneumatic system
4. Steam jet system

Important

Dust collection

The products of combustion of coal fired fires contain particles of solid matter floating in suspension, which may be smoke or dust. If smoke the indication is that combustion conditions are faulty. If dust, the particles are called as flay ash mixed with carbon material called 'sindu'.

A critical characteristics of dust is settling velocity in still air. This velocity is directly proportional to the product of the square of micron size and mass density.

The dust collectors are classified as

1) Mechanical dust collectors
   1) Wet type a) Spray type
      b) Packed type
      c) Impeargement type
   2) Dry type a) Gravitational separators
      b) Cyclone separators
2) Electrical dust collectors
   i) Rod type

Important

15 Friday JULY

## Chimney draught

The small pressure difference which causes a flow of gas to take place is termed as draught.

In coal boiler the draught is to force air to the fire and to carry away the gaseous products of combustion.

- draught
  - natural or Chimney draught
  - Artificial draught
    - Steam jet
      - Induced
      - Forced
    - Mechanical (fan)
      - Induced fan
      - Forced fan
      - Balanced draught

Natural draught is obtained by using chimney. It serves two purpose

i) It produces the draught causing the gas and air forced through the fuel bed, furnace, boiler passes & settings

ii) It carries the products of combustion to such a height before discharging

Important

If $h_w$ is the height in mm of column of water which will produce a pressure drop $\Delta p$. Then

$$h_w = 353 H \left[ \frac{1}{T_a} - \frac{1}{T_g} \left( \frac{m_a + 1}{m_a} \right) \right]$$

1mm of water = 9.81 Pa

Where H = height of chimney

$T_a$ = atmospheric temp$^r$ °K

$T_g$ = temp$^r$ of hot gas °K

$m_a$ = mass of air

Chimney diameter

$$D = 1.128 \sqrt{\frac{m_g}{\rho_g \times c}}$$

Where $m_g$ = mass of hot gas

$\rho_g$ = density of hot gas

$$c = \sqrt{2gH_1}$$

$H_1$ = draught p$^r$ $\Delta p$ = equivalent to height of burnt gases (draught)

Condition of max$^m$ discharge

$$(h_w)_{max} = \frac{176.5}{T_a} H \text{ mm of water}$$

Sunday 17

Important

Efficiency of chimney

$$\frac{H}{J} \left[ \left( \frac{m_a}{m_a + 1} \right) \times \frac{T_g}{T_a} - 1 \right]$$

$$c_p (T' - T'')$$

$T' = T_g$

$T''$ = temp$^r$ during artificial draught

18 Monday
JULY

Boilers / Closed vessel in which steam is produced from water by combustion of fuel

Boiler

A boiler may be defined as the closed vessel in which steam is produced, from water by combustion of fuel.

According to ASME (American Society of Mechanical Engineers) It is a steam generating unit which is a combination of apparatus of producing, furnishing or recovering heat together with the apparatus for transferring the heat so made available to the fluid being heated and vaporised

Purpose — 1) For generating power
2) In industries like bleaching drying etc
3) For producing heat in building during cold and hot water supply.

Important

Primary Requirements: 1) The water must be contained
2) The steam must be delivered in desired condition

Classification of boilers

1) As per the position of the axis of the boiler
1) Horizontal, 2) vertical, 3) inclined

2) As per the relative position of hot gas and water
1) Fire tube 2) Water tube

3) As per the position of firing
1) Externally fired 2) Internally fired.

4) As per the circulation of water
1) Forced circulation 2) Natural circulation

5) As per the pressure of boilers
1) High $p^r$ 2) Low $p^r$

6) As per the position of Boilers
1) Stationary 2) Movable - a) Portable
b) Marine

7) As per the no of tubes in boiler
1) Single tube 2) Multitubular

Boiler 1) Cochran boiler -
Horizontal, Fire tube, Multitubular boiler
internally fired low $p^r$ boiler

2) Cornish boiler

3) Lancashire boiler

4) Locomotive boiler

5) Scotch & Marine boiler

6) Babcock & Wilcox boiler

Important

AUG SEP OCT NOV DEC

20 Wednesday
JULY

7) Stirling boiler 8) Lamont boiler 9) Loeffler boiler

## Mountings & Accessories

Mountings → Mountings are those parts or equipments which are necessary for smooth and safety running of the boiler

Accessories → Accessories are those parts which are an additional parts or equipments ~~which are and~~ to enhance the efficiency of the boiler.

Mountings :- 1) Water level indicator, 2) Pressure Gauge, 3) Safety valve, 4) Steam stop valve, 5) Feed check valve, 6) Manhole, 7) Fusible plug etc

Accessories → 1) Economiser 2) Air preheater 3) Superheater, 4) Injector etc.

Important

Thursday
JULY 21

# Steam turbines.

A steam turbine is a prime mover in which the potential energy of the steam is transformed into K.E. and latter to mechanical energy of the rotation of the turbine shaft.

Classification A) As per action of steam
— 1) Impulse, 2) Reaction, 3) Combination of both Impulse & Reaction

B) Acc to no of pr stages
i) Single stage turbine
ii) Multi stage impulse & reaction turbine

C) Acc to dir of steam flow
i) Axial ii) Radial

D) Acc to no of cylinders
1) Single cylinder, 2) Double cylinder, 3) Three cylinder, 4) Four cylinder, 5) Multiaxial

E) Acc to method of governing
i) Throttle governing ii) Nozzle governing
iii) Pass governing

F) Acc to steam conditions
i) low pr ii) Medium pr, iii) High pr
2011 2 ata 40 ata above 40 ata

G) Acc to usage in industry
1) Stationary turbine with constant speed
2) Stationary turbine with variable speed
3) Non stationary turbine with variable speed

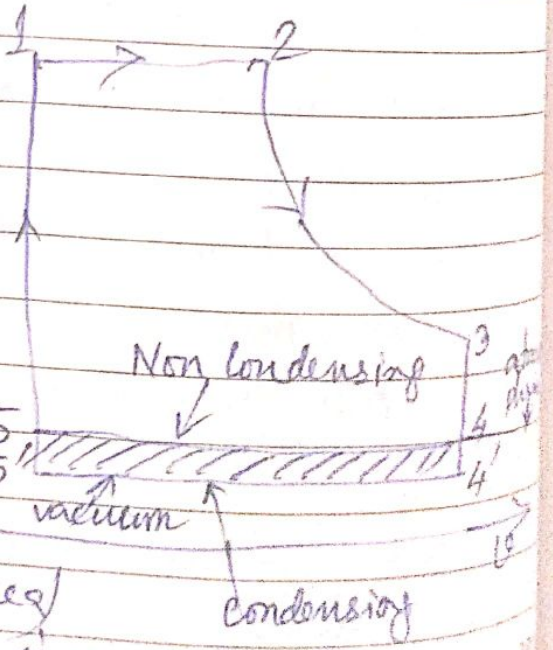
22 Friday
JULY

Methods of reducing wheel or Rotor speed
← The process → Compounding
1) Velocity compounding
2) Pressure compounding
3) Pressure velocity compounding
4) Reaction turbine

## Steam condenser

A steam condenser is a device or an appliance in which steam condenses and heat released by steam is absorbed by water.

It maintains a very low back pressure on the exhaust side of the piston of the steam engine or turbine, Consequently the expands to a greater extent (Shaded area) Which results in an increase in available heat energy for converting into Mechanical work. So thermal efficiency of a condensing unit is more than the non condensing unit for the same



Classification
- (1) Jet Condenser 2) Surface Condenser
3) Evaporative Condenser

Jet Condenser → parallel flow type
→ Counter flow type
→ ~~Ejector~~ Ejector type

## Condenser Efficiency

It is ratio of the difference between the outlet and inlet temperatures of cooling water to the difference between the temp$^r$ corresponding to the vacuum in the condenser and inlet temp$^r$ of cooling water

## Cooling ponds and cooling Towers

The cooling water requirement in an open system is about 50 times the flow of the steam to the condenser. Means the cooling water requirement is 5 to 8 kg/KWh i.e. 1000 MW station will require about 100 thousand tons of circulating water per day even with the use of cooling towers.



Important

25 Monday JULY

# Feed Water Treatment

## Impurities

1. Visible Impurities
   i) Microbiological growth
   ii) Turbidity and sediments.
2. Dissolved gases
   i) $CO_2$, ii) $O_2$, iii) $N_2$, iv) $CH_4$, v) $H_2S$
3. Minerals & salts
   i) Iron & Manganese ii) Na & K Salts
   iii) Flourides iv) Silica.
4. Mineral Acids
5. Hardness → Ca & Mg bicarbonate, chlorides, sulphates etc.

Troubles caused by impurities in water

1. Scale formation. 2. Corrosion
3. Carry over 4. Embrittlement

## Methods of feed water treatment

1. Mechanical treatment
   i) Sedimentation ii) Coagulation
   iii) Filtration iv) Interior Painting
2. Thermal treatment
   i) Deaeration
   ii) Distillation by evaporators

Important

3. Chemical treatment
   i) Cold lime soda softening process
   ii) Hot lime soda softening process
   iii) Lime phosphate softening process
   iv) Ion Exchange process
4. Demineralization
5. Blow down
   i) ~~Hot lime soda~~ Hot & Zeolite process
   ii) Adding acid to control alkalinity & vice versa

pH value of water

- The pH value of water is the logarithm of the reciprocal of hydrogen ion concentration. It is number for 0 to 14 with 7 indicating neutral water.
  less than 7 indicates acidic
  more than 7 indicates basic or alkaline.





Important