STEAM TURBINES

A Turbine is a Form of Engine Requires a suitable working fluid in order to function- a source of High Grade Energy and a Sink for Low Grade energy. When a Fluid Flows through the Turbine ,Part of Energy Content is Continuously Extracted and Converted in to Useful mechanical Work.
Steam turbine depends completely upon the dynamic action of the steam. According to Newton's second law of motion, the FORCE is proportional to the rate of change of MOMENTUM (mass x velocity). If the rate of change of momentum is caused in the steam by allowing a high velocity jet of steam to pass over curved blade, the steam will impart a force to the blade. If the blade is free, it will free off (rotate) in the direction of force.

The steam from the boiler is expanded in a passage or nozzle , where due to fall in pressure of steam is converted into Kinetic energy of steam & this KE of steam is converted into work moving blade

Types of turbine
On the basis of principle of operation
Impulse turbine
Reaction turbine
Impulse- Reaction turbine

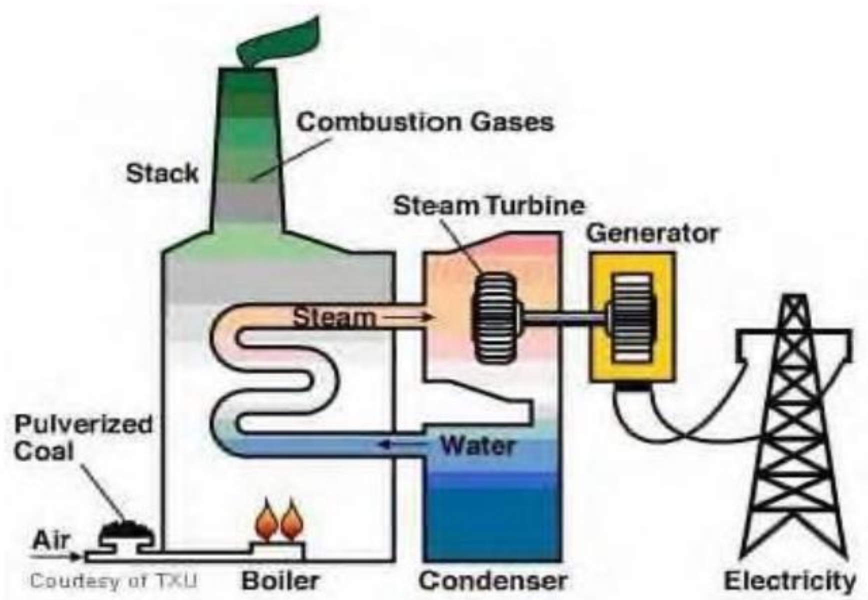
<u>Impulse Turbine</u> ..
In impulse the drop in pressure of steam takes place only in nozzle & not in moving blades. This is obtained by making the blade passage of constant cross section area it may be noted that energy transformation takes place only in nozzles. Moving blades only cause energy transfer

Reaction turbine:-
Pressure drop take place in rotor (M.B.). Energy transformation takes place in rotor. Energy transfer only in rotor.

Impulse- Reaction turbine:-
In this turbine drop in pressure of steam takes place in fixed blade as well as moving blade. It may be noted that energy transformation occur in both fixed blade & moving blade. The rotor blade cause energy transfer & energy transformation.

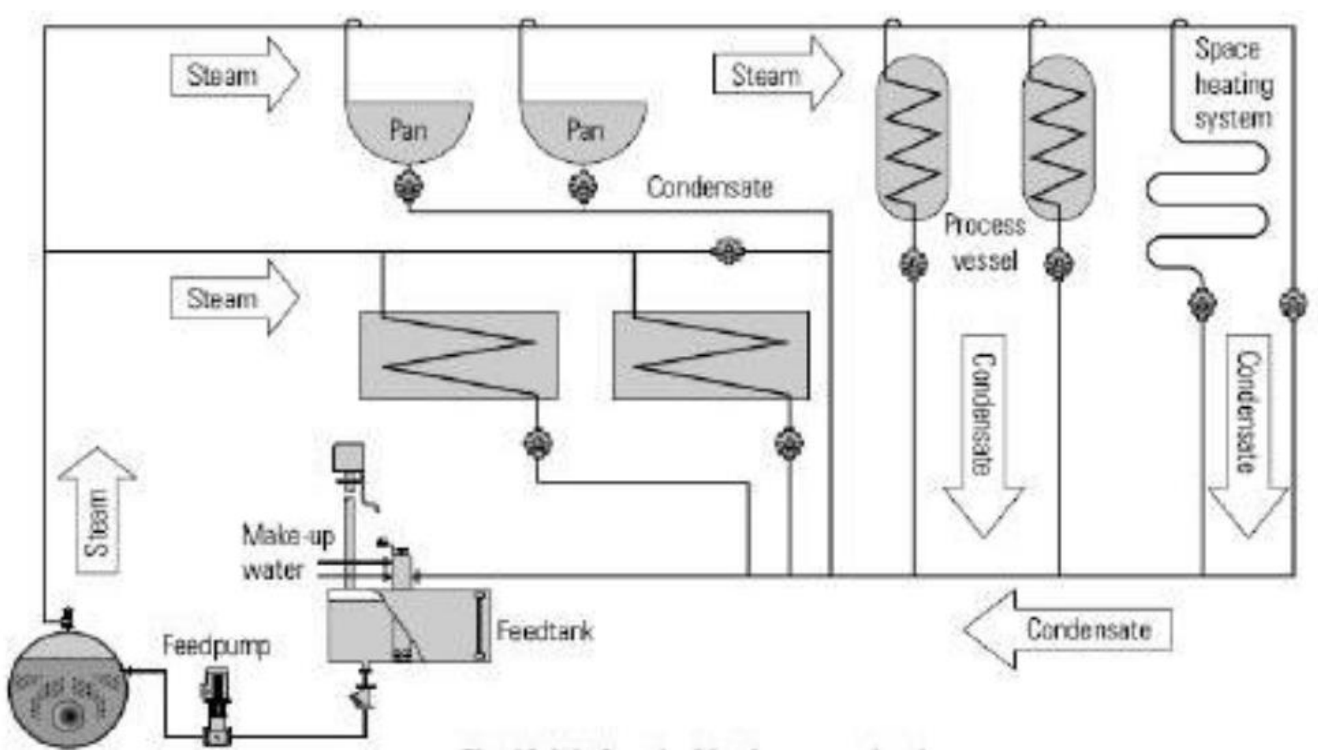
THE STEAM DISTRIBUTION SYSTEM

- The steam distribution system is the essential link between the steam generator and the steam user.
- The most important components of a steam distribution system can be given as follows:
  - Pipes
  - Drain points
  - Branch lines
  - Strainers
  - Filters
  - Separators
  - Steam traps
  - Air vents



- There are various methods to carry steam from a central source to the point of use.
- The central source might be a boiler house or the discharge from a co-generation plant.
- Whatever the source, an efficient steam distribution system is essential if steam of the right quality and pressure is to be supplied, in the right quantity, to the steam using equipment.
- Installation and maintenance of the steam system are important issues, and must be considered at the design stage.

A typical Steam circuit



Pipes

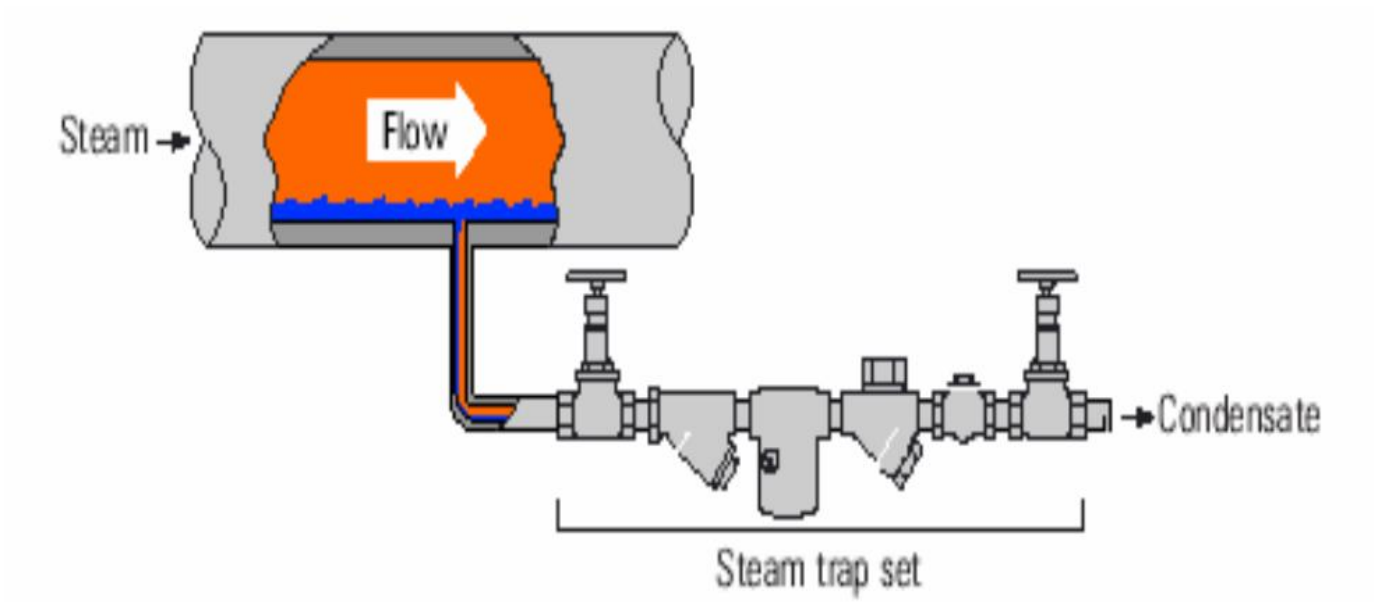
- Pipe material
  - Pipes for steam systems are commonly manufactured from carbon steel (0.12% to 2% C).
  - The same material may be used for condensate lines, although copper tubing is preferred in some industries.
  - For high temperature superheated steam mains, additional alloying elements, such as chromium and molybdenum, are included to improve tensile strength and creep resistance (any kind of distortion) at high temperatures.
  - Typically, pipes are supplied in 6- meter lengths.

Carbon Steel Pipes

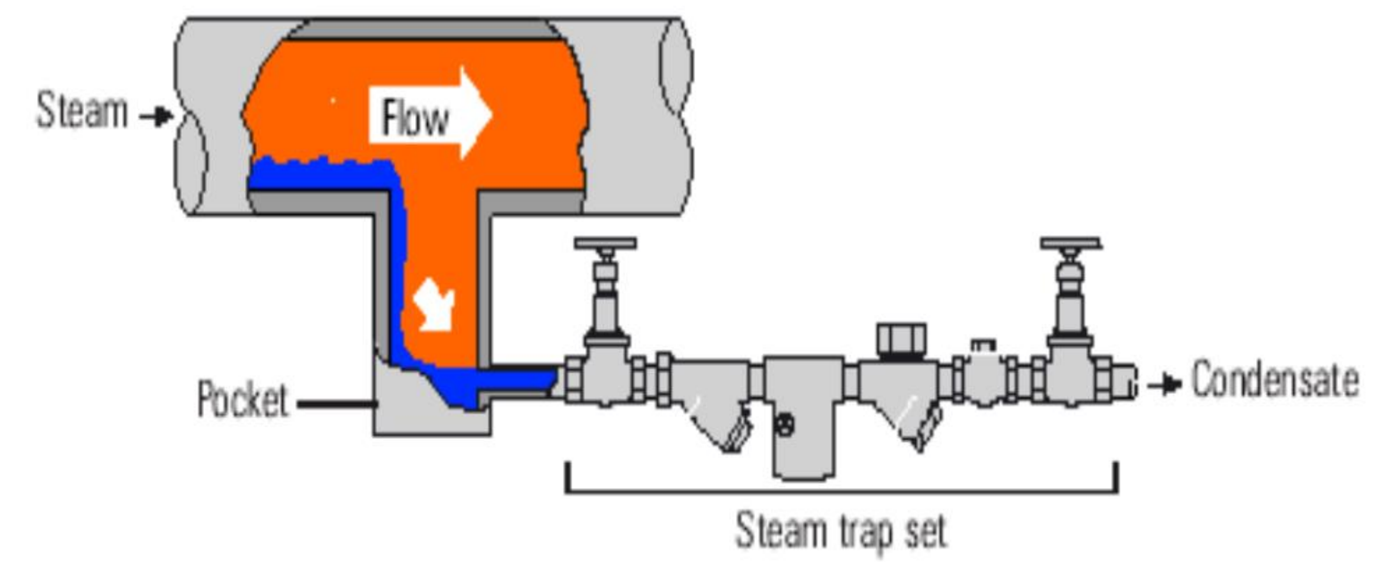
- Oversized pipe-work will result in
  - Pipes, valves, fittings, etc. will be more expensive than necessary.
  - Higher installation costs will be incurred, including support work, insulation, etc.
  - More steam trapping is required or more wet steam is to be delivered to the point of use.
- Undersized pipe-work will result in
  - There is a greater risk of erosion, water hammer and noise due to the inherent increase in steam velocity.

Drain points

- In normal operation, steam may flow along the main at speeds of up to 145 km/h, dragging condensate along with it.
- The drain point must ensure that the condensate can reach the steam trap (device to discharge condensate).
- Careful consideration must therefore be given to the design and location of the drain points.
- Gravity will ensure that the water (condensate) will run along sloping pipe work and collect at low points in the system.
- Steam traps should therefore be fitted to these low points.

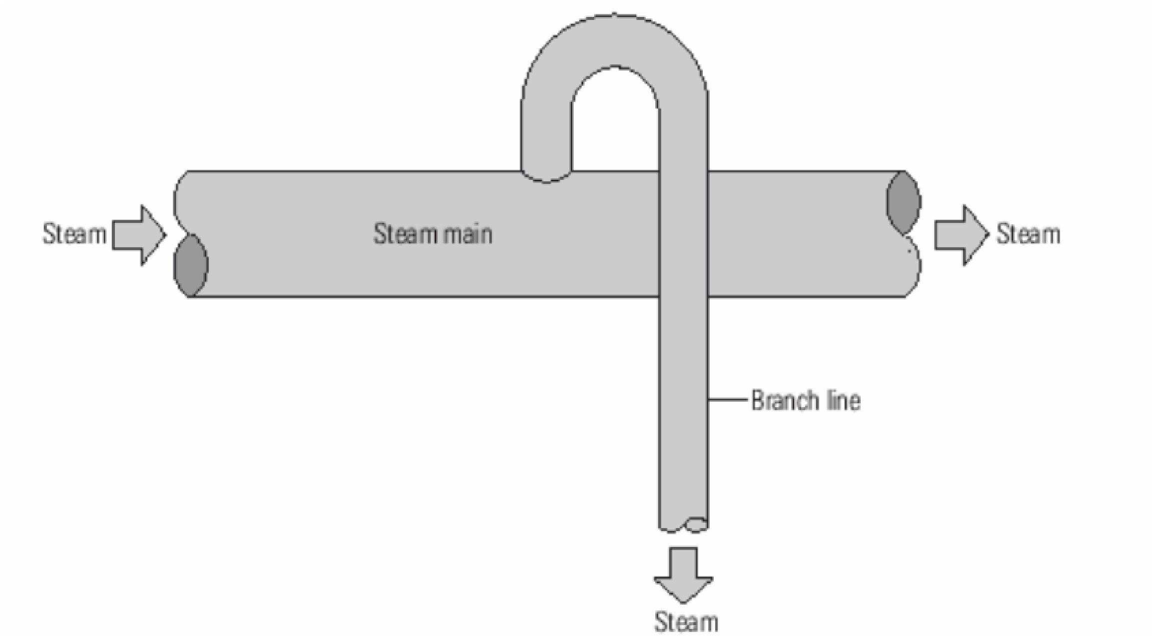


Improper draining pipe



Proper draining pipe

- Branch lines are normally much shorter than steam mains.
- As a general rule, branch line is not more than 10 metres in length, and the pressure in the main is adequate.
- If the sizing of the branch pipe on a velocity of 25 to 40 m/s, the problems due to pressure drop in the line can be avoided.



A branch line

Branch line connections

- Branch line connections taken from the top of the main line, carry the driest steam.
- If connections are taken from the side, or even worse from the bottom, they can accept the condensate and debris from the steam main.

Strainers

- In steam and condensate systems, damage to plant is frequently caused by pipeline debris such as scale, rust, joining compound, weld metal and other solids, which may find their way into the pipeline system.
- Strainers are devices which arrest these solids in flowing liquids or gases, and protect equipment from their harmful effects, thus reducing downtime and maintenance.
- A strainer should be fitted upstream of every steam trap, flow meter and control valve.
- Strainers can be classified into two main types according to their body configuration; namely the
    - Y-type and the basket type.

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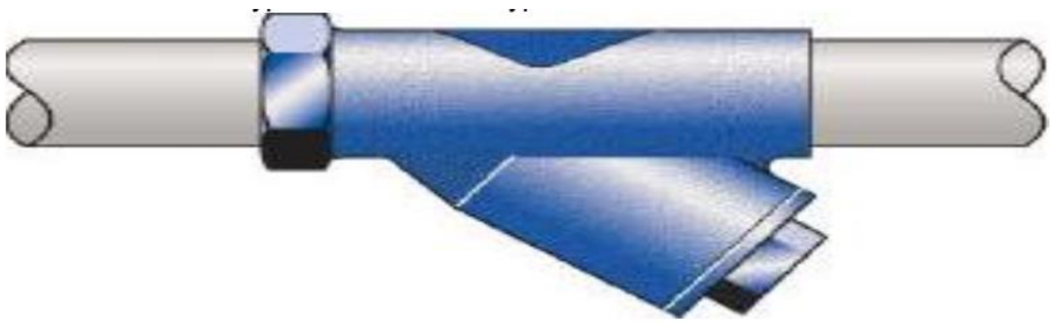
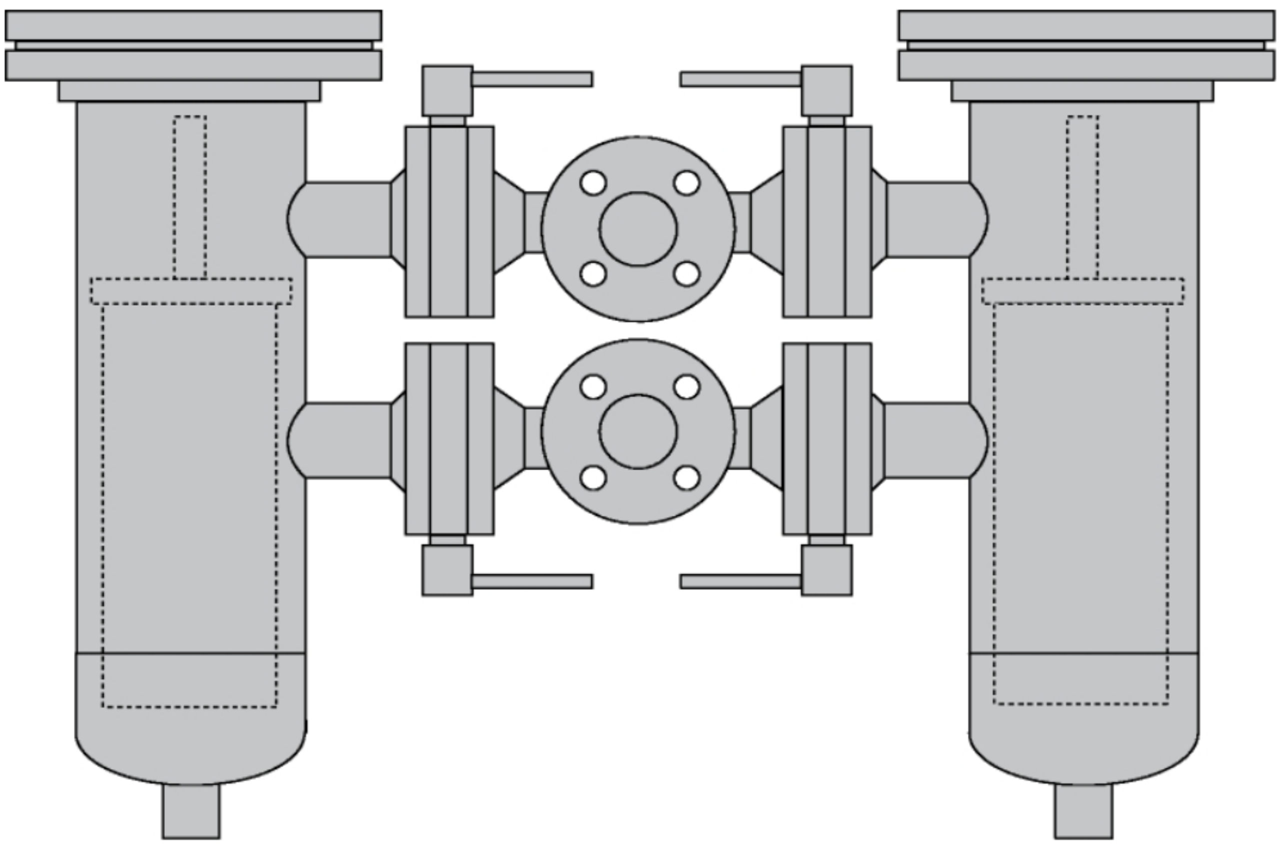
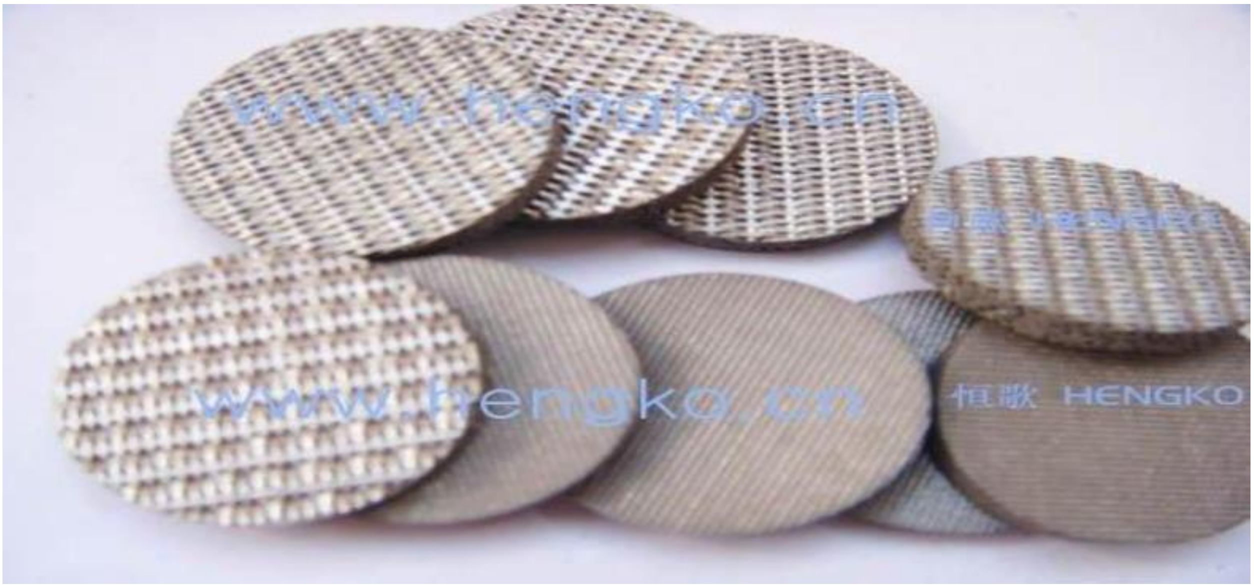


- **Basket type strainer**



5 Filters

- Filters are used to remove smaller particles.
- Required in the clean steam applications
- Typical one is made up of sintered stainless steel.
- Always there will be a strainer operation before the filtration operation in the steam line.



Separators

- Separators are used to remove suspended water droplets from steam.
- Reduction of the water in the steam can improve the quality of the steam.

The presence of water in steam can cause a number of problems:

- As water is an extremely effective barrier to heat transfer, its presence can reduce plant productivity and product quality.

- Water droplets traveling at high steam velocities will erode valve seats and fittings, a condition known as **<u>wiredrawing</u>**. The water droplets will also increase the amount of corrosion.
- Increased scaling in pipe work and heating surfaces from the impurities carried in the water droplets.
- Erratic operation of control valves and flow meters.
- Failure of valves and flow meters due to rapid wear or water hammer

Steam traps

- This is the most important link between the steam line and the condensate loop because it connects steam usage with condensate return.
- A steam trap simply 'purges' (removes) condensate, (as well as air and other incondensable gases), out of the system, allowing steam to reach its destination in as dry a state/condition as possible to perform its task efficiently and economically.
- Steam traps operates at a varying range of pressures ranging from vacuum to 200 bar.

Thermostatic (operated by changes in fluid temperature).

- *The temperature of saturated* steam is determined by its pressure. In the steam space, steam gives up its enthalpy of evaporation (heat), producing condensate at steam temperature.
- As a result of any further heat loss, the temperature of the condensate will fall.
- A thermostatic trap will pass condensate when this lower temperature is sensed. As steam reaches the trap, the temperature increases and the trap closes.

Mechanical (operated by changes in fluid density). *This range of steam traps operates by* sensing the difference in density between steam and condensate.

- These steam traps include 'ball float traps' and 'inverted bucket traps'.
- In the 'ball float trap', the ball rises in the presence of condensate, opening a valve, which passes the denser condensate.
- With the 'inverted bucket trap', the inverted bucket floats when steam reaches the trap and rises to shut the valve.
- Both are essentially 'mechanical' in their method of operation.

Thermodynamic (operated by changes in fluid dynamics).

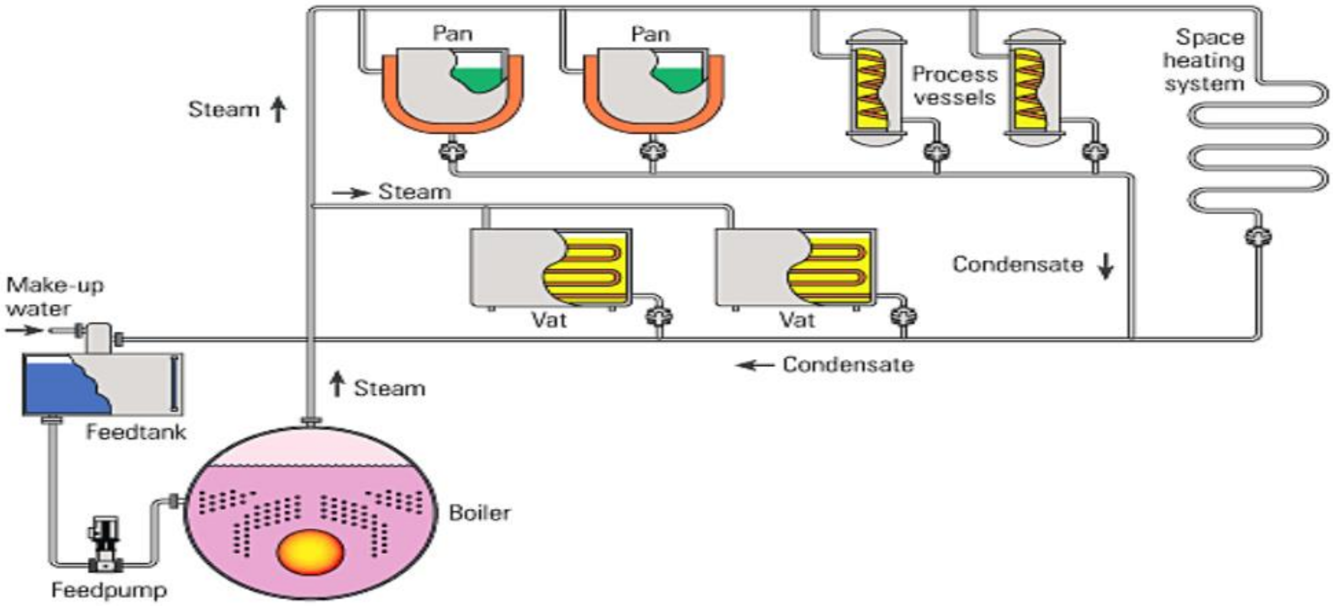
- Thermodynamic steam traps rely partly on the formation of flash steam from condensate.
- Mostly Disc or Impulse types.

Air Vents

- Air is present within steam pipes and steam equipment at start-up and shut down.
- **Signs of air are:**
  - A gradual fall off in the output of any steam heated equipment
  - Air bubbles in the condensate
  - Corrosion

Condensate recovery

- An effective condensate recovery system, collecting the hot condensate from the steam using equipment and returning it to the boiler feed system, can pay for itself in a remarkably short period of time.



Reasons for the condensate recycle

- Quality of the feed water
- Economic Operation
- Maximizing the boiler efficiency

Insulation

- A thermal insulator is characterized by a low thermal conductivity.
- Insulation materials are porous and contain a large number of dormant air cells.
- A large amount of heat energy may be lost without insulation or if insulation is inefficient or improperly installed.

Benefits

- Reduction of fuel consumption.
- Better process control by maintaining process temperatures at a constant level.
- Corrosion prevention by keeping the exposed surface of system of operation above dew point

Types of insulation

- Up to 90 ^{o}C – Low temperature
- 90 to 325 ^{o}C – medium temperature
- More than 325 ^{o}C – high temperature

Selecting insulating materials

Important factors that should be considered when choosing insulating materials are:

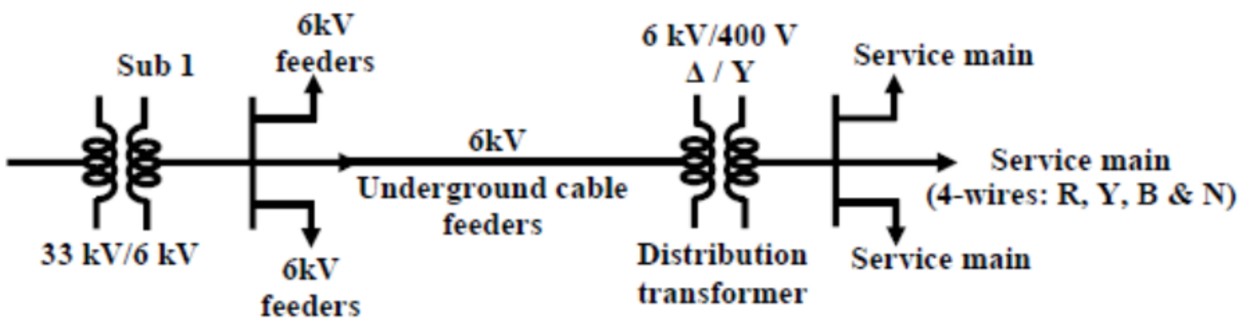
- Operating temperature of the system
- Resistance of the materials to heat, weather and adverse conditions
- Thermal conductivity of the material
- Thermal diffusivity of the material
- Ability of the material to withstand the various conditions, such as thermal shock, vibration and chemical attack
- Resistance of the material to flames/fire
- Permeability of the material
- Total cost, including material purchase, installing and maintenance

STEAM ECONOMY

- Steam economy, which is defined as the mass of water vapor generated per mass of steam is the process parameter most significant in evaluating the performance of multiple effect evaporators

ELECTRIC POWER DISTRIBUTION IN PROCESS PLANTS

The loads of a big city are primarily residential complexes, offices, schools, hotels, street lighting etc. These types of consumers are called LT (low tension) consumers. Apart from this there may be medium and small scale industries located in the outskirts of the city. LT consumers are to be supplied with single phase, 220 V, 40 Hz. We shall discuss here how this is achieved in the substation receiving power at 33 kV.



Typical Power distribution scheme.

Power receive at a 33 kV substation is first stepped down to 6 kV and with the help of under ground cables (called feeder lines), power flow is directed to different directions of the city. At the last level, step down transformers are used to step down the voltage form 6 kV to 400 V. These transformers are called distribution transformers with 400 V, star connected secondary. You must have noticed such transformers mounted on poles in cities beside the roads. These are called pole mounted substations. From the secondary of these transformers 4 terminals (R, Y, B and N) come out. N is called the neutral and taken out from the common point of star connected secondary. Voltage between any two phases (i.e., R-Y, Y-B and B-R) is 400 V and between any phase and neutral is 230 V(=4003 . Residential buildings are supplied with single phase 230V, 50Hz. So individual are to be supplied with any one of the phases and neutral. Supply authority tries to see that the loads remain evenly balanced among the phases as far as possible. Which means roughly one third of the consumers will be supplied from R-N, next one third from Y-N and the remaining one third from B-N. The distribution of power from the pole mounted substation can be done either by (1) overhead lines (bare conductors) or by (2) underground cables. Use of overhead lines although cheap, is often accident prone and also theft of power by hooking from the lines take place. Although costly, in big cities and thickly populated areas underground cables for distribution of power, are used.