Steam Power Station (Thermal Station)

Lecture 4

Equipment of Steam Power Station

A modern steam power station is highly complex and has numerous equipment and auxiliaries. However, the most important constituents of a steam power station are :

1. Steam generating equipment

2. Condenser

3. Prime mover

4. Water treatment plant

5. Electrical equipment.

2. Condensers.

A condenser is a device which condenses the steam at the exhaust of turbine. It serves two important functions. Firstly, it creates a very low * (By liquidating steam at the exhaust of turbine, a region of emptiness is created. This results in a very low pressure at the exhaust of turbine) pressure at the exhaust of turbine, thus permitting expansion of the steam in the prime mover to a very low pressure. This helps in converting heat energy of steam into mechanical energy in the prime mover. Secondly, the condensed steam can be used as feed water to the boiler. There are two types of condensers, namely:

(*i*) Jet condenser

(*ii*) Surface condenser

In a jet condenser, cooling water and exhausted steam are mixed together. Therefore, the temperature of cooling water and condensate is the same when leaving the condenser. Advantages of this type of condenser are : low initial cost, less floor area required, less cooling water required and low maintenance charges. However, its disadvantages are : condensate is wasted and high power is required for pumping water.

In a surface condenser, there is no direct contact between cooling water and exhausted steam. It consists of a bank of horizontal tubes enclosed in a cast iron shell. The cooling water flows through the tubes and exhausted steam over the surface of the tubes. The steam gives up its heat to water and is itself condensed. Advantages of this type of condenser are : condensate can be used as feed water,less pumping power required and creation of better vacuum at the turbine exhaust. However, disad-vantages of this type of condenser are : high initial cost, requires large floor area and high maintenance charges.

3. Prime movers.

The prime mover converts steam energy into mechanical energy. There are two types of steam prime movers *viz*., steam engines and steam turbines. A steam turbine has several advantages over a steam engine as a prime mover *viz*., high efficiency, simple construction, higher speed, less floor area requirement and low maintenance cost. Therefore, all modern steam power stations employ steam turbines as prime movers.

Steam turbines are generally classified into two types according to the action of steam on moving
blades *viz*.

(*i*) Impulse turbines
(*ii*) Reactions turbines

In an impulse turbine, the steam expands completely in the stationary nozzles (or fixed blades), the pressure over the moving blades remaining constant. In doing so, the steam attains a high velocity and impinges against the moving blades. This results in the impulsive force on the moving blades which sets the rotor rotating. In a reaction turbine, the steam is partially expanded in the stationary nozzles, the remaining expansion takes place during its flow over the moving blades. The result is that the momentum of the steam causes a reaction force on the moving blades which sets the rotor in motion.

4. Water treatment plant.

Boilers require clean and soft water for longer life and better efficiency. However, the source of boiler feed water is generally a river or lake which may contain suspended and dissolved impurities, dissolved gases etc. Therefore, it is very important that water is first purified and softened by chemical treatment and then delivered to the boiler.

The water from the source of supply is stored in storage tanks. The suspended impurities are removed through sedimentation, coagulation and filtration. Dissolved gases are removed by aeration and degasification. The water is then *'softened'* by removing temporary and permanent hardness through different chemical processes. The pure and soft water thus available is fed to the boiler for steam generation.

5. Electrical equipment.

A modern power station contains numerous electrical equipment.
However, the most important items are :

(*i*) *Alternators*. Each alternator is coupled to a steam turbine and converts mechanical energy of the turbine into electrical energy. The alternator may be hydrogen or air cooled. The necessary excitation is provided by means of main and pilot exciters directly coupled to the alternator shaft.

(*ii*) *Transformers*. A generating station has different types of transformers, *viz*.,

(*a*) main step-up transformers which step-up the generation voltage for transmission of power.

(*b*) station transformers which are used for general service (*e.g*., lighting) in the power station.

(*c*) auxiliary transformers which supply to individual unit-auxiliaries.

(***iii***) ***Switchgear***. It houses such equipment which locates the fault on the system and isolate the faulty part from the healthy section. It contains circuit breakers, relays, switches and other control devices.

Example 1.

A steam power station has an overall efficiency of 20% and 0·6 kg of coal is burnt per kWh of electrical energy generated. Calculate the calorific value of fuel.

Example 2.

A thermal station has the following data :

Max. demand = 20,000 kW ; Load factor = 40%

Boiler efficiency = 85% ; Turbine efficiency = 90%

Coal consumption = 0·9 kg/kWh ; Cost of 1 ton of coal = Rs. 300

Determine (i) thermal efficiency and (ii) coal bill per annum.

Example 3.

A steam power station spends Rs. 30 lakhs per annum for coal used in the station. The coal has a calorific value of 5000 kcal/kg and costs Rs. 300 per ton. If the station has thermal efficiency of 33% and electrical efficiency of 90%, find the average load on the station.

Example 4.

The relation between water evaporated (*W kg*), *coal consumption* (*C kg*) *and kWh generated per 8 hour shift for a steam generating station is as follows :*

$$W = 13500 + 7{\cdot}5\ kWh \quad ....(i)$$

$$C = 5000 + 2 \cdot 9\ kWh \quad ....(ii)$$

(*i*) *To what limiting value does the water evaporating per kg of coal consumed approach as the station output increases ?*

(*ii*) *How much coal per hour would be required to keep the station running on no load ?*