G.PULLAIAH COLLEGE OF ENGINEERING AND TECHNOLOGY: KURNOOL

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

CLASS/SEM: IV.B.Tech I-SEM **SUB: UTILISATION OF ELECTRICAL ENERGY**

UNIT-V

BASIC TERMS AND DEFINITIONS:

Power Factor	The cosine of an angle between voltage and current in a circuit.
Load Factor	load factor is defined as the total load divided by the peak load in a specified time period
Synchronous Condenser	When a Synchronous motor operates at No-Load and over-exited then it's called a synchronous Condenser
Peak Load	The peak demand of an installation or a system is simply the highest demand that has occurred over a specified time period
Waste Heat Recovery	A waste heat recovery unit (WHRU) is an energy recovery heat exchanger that recovers heat from hot streams with potential high energy content, such as hot flue gases from a diesel generator or steam from cooling towers or even waste water from different cooling processes such as in steel cooling

CONCEPTS

POWER FACTOR IMPROVEMENT

The following devices and equipment are used for Power Factor Improvement.

1. Static Capacitor
2. Synchronous Condenser
3. Phase Advancer

1. STATIC CAPACITOR

We know that most of the industries and power system loads are inductive that take lagging current which decrease the system power factor . For Power factor improvement purpose, Static capacitors are connected in parallel with those devices which work on low power factor. These static capacitors provides leading current which neutralize (totally or approximately) the lagging inductive component of load current (i.e. leading component neutralize or eliminate the lagging component of load current) thus power factor of the load circuit is improved. These capacitors are installed in Vicinity of large inductive load e.g Induction motors and transformers etc, and improve the load circuit power factor to improve the system efficiency.

Advantages:

- Capacitor bank offers several advantages over other methods of power factor improvement.
- Losses are low in static capacitors

- There is no moving part, therefore need low maintenance
- It can work in normal conditions (i.e. ordinary atmospheric conditions)

Disadvantages:

- The age of static capacitor bank is less (8 – 10 years)
- With changing load, we have to ON or OFF the capacitor bank, which causes switching surges on the system
- If the rated voltage increases, then it causes damage it

2. SYNCHRONOUS CONDENSER

When a Synchronous motor operates at No-Load and over-exited then it's called a synchronous Condenser. Whenever a Synchronous motor is over-exited then it provides leading current and works like a capacitor. When a synchronous condenser is connected across supply voltage (in parallel) then it draws leading current and partially eliminates the re-active component and this way, power factor is improved. Generally, synchronous condenser is used to improve the power factor in large industries.

Advantages:

- Long life (almost 25 years)
- High Reliability
- Step-less adjustment of power factor.
- No generation of harmonics of maintenance
- The faults can be removed easily

Disadvantages:

- It is expensive (maintenance cost is also high) and therefore mostly used by large power users.
- An auxiliary device has to be used for this operation because synchronous motor has no self starting torque
- It produces noise

3. PHASE ADVANCER

Phase advancer is a simple AC exciter which is connected on the main shaft of the motor and operates with the motor's rotor circuit for power factor improvement. Phase advancer is used to improve the power factor of induction motor in industries. As the stator windings of induction motor takes lagging current 90° out of phase with Voltage, therefore the power factor of induction motor is low. If the exciting ampere-turns are excited by external AC source, then there would be no effect of exciting current on stator windings. Therefore the power factor of induction motor will be improved. This process is done by Phase advancer.

Advantages:

- Lagging kVAR (Reactive component of Power or reactive power) drawn by the motor is sufficiently reduced because the exciting ampere turns are supplied at slip frequency (fs).
- The phase advancer can be easily used where the use of synchronous motors is Unacceptable

Disadvantage:

- Using Phase advancer is not economical for motors below 200 H.P. (about 150kW)

Power Factor Improvement in single phase and three phase star & delta connections

Power factor improvement in three phase system by connecting a capacitor bank in

(1). Delta connection

(2). Star Connection)

IMPROVEMENT OF LOAD FACTOR

Increasing your load factor will diminish the average unit cost (demand and energy) of the kWh. Depending on your situation, improving your load factor could mean substantial savings. The load factor corresponds to the ratios between your actual energy consumption (kWh) and the maximum power recorded (demand) for that period of time.

Load Factor equals:

Consumption during the period (kWh) x 100

Demand x Number of hours in that period.

By analyzing your load profile and your needs, you may be able to improve your load factor by doing the following:

A – Demand reduction

Reduce demand by distributing your loads over different time periods.

B – Increase production

Keeping the demand stable and increasing your consumption is often a cost-effective way to increase production while maximizing the use of your power.

*In both cases, the load factor will improve and therefore reduce your average unit cost per kWh.

The load factor percentage is derived by dividing the total kilowatt-hours (kWh) consumed in a designated period by the product of the maximum demand in kilowatts (kW) and the number of hours in the period. In the example below, the monthly kWh consumption is 36,000 and the peak demand is 100 kW. There were 30 days in the billing period.

To determine the load factor, you can use the following formula:

Total kWh for the billing period x 100

(Peak Demand X # of Days X 24 Hours)

OFF-PEAK LOADS

Peak demand is considered to be the opposite to off-peak hours when power demand is usually low. There are off-peak time-of-use rates. Sometimes, there are 3 time-of-use zones: peak, shoulder and offpeak. Shoulder is often the time between peak and offpeak in weekdays. Weekends are often just peak and off peak in terms of managing electricity loads for the network. The peak demand of an installation or a system is simply the highest demand that has occurred over a specified time period . Peak demand is typically characterized as annual, daily or seasonal and has the unit of power. Peak demand, peak load or on-peak are terms used in energy demand management describing a period in which electrical power is expected to be provided for a sustained period at a significantly higher than average supply level.

Peak demand fluctuations may occur on daily, monthly, seasonal and yearly cycles. For an electric utility company, the actual point of peak demand is a single half-hour or hourly period which represents the highest point of customer consumption of electricity. At this time there is a combination of office, domestic demand and at some times of the year, the fall of darkness. Some utilities will charge customers based on their individual peak demand. The highest demand during each month or even a single 15 to 30 minute period of highest use in the previous year may be used to calculate charges.

USE OF EXHAUST STEAM:

Steam condenser is a device in which the exhaust steam from steam turbine is condensed by means of cooling water. The main purpose of a **steam condenser in turbine** is to maintain a low back pressure on the exhaust side of the steam turbine. After releasing from nozzles, the steam has to expand to a great extent for converting available energy into it to usable mechanical work. So, if the steam after doing its, work, does not get condensed, it will not give required space to other steam behind it, to expand to its required volume. Condensation of steam in a closed system, creates an empty place by reduction of volume of the low pressure steam. It is found that, 1 Kg of dry steam at 1.033 kg/cm^2 absolute pressure has a volume of 1.673 m^3 when it is condensed into water at 100^oC in a steam condenser, its volume becomes 0.001044 m^3. The volume of steam would be thus 1/1644 parts of the space inside the vessel, and the pressure would fall to 0.2 kg/cm^2 absolute pressure. This means, pressure in the exhaust of the turbine falls to 0.2 kg/cm^2 from 1.033 kg/cm^2.

Elements of Steam Condenser

A steam condensing plant or simply steam condenser consists of

1. Condenser chamber – where steam gets condensed.
2. Cooling water supply – which provides cold water to condense steam by heat exchanging.
3. Wet Air pumps – They collect condensed steam, the air and un-condensed water vapour and gases from condenser.
4. Hot well in which the condensed steam is collected and from it steam boiler feed water may be taken if required.

Types of Steam Condenser

In a steam condenser, steam is always condensed with help of cooling water, but the techniques are different for different condensers. Depending upon condensation techniques, there are mainly two types of steam condensers. They are mainly

1.Jet Steam Condenser .2.Surface Steam Condenser

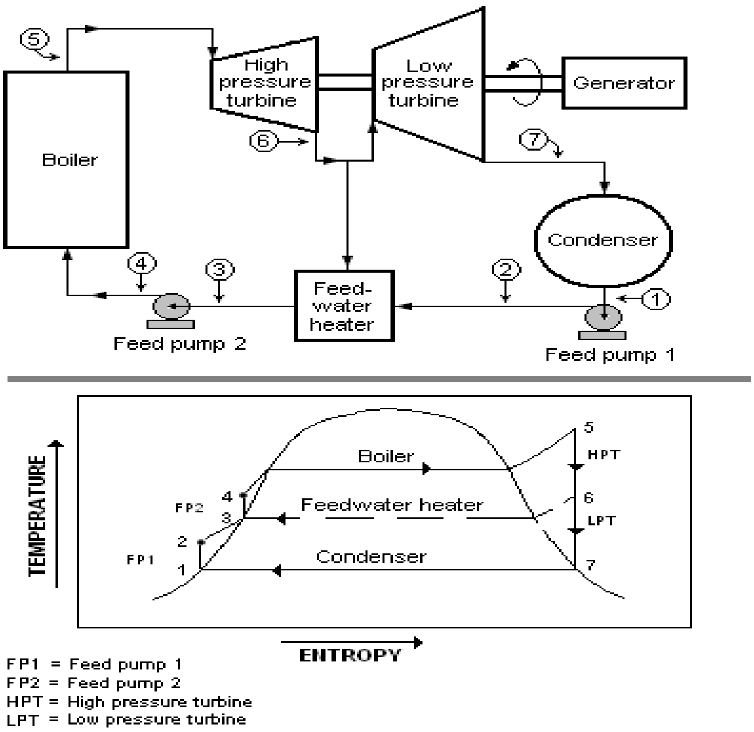

Fig.5.1. Layout of Steam Condenser

WASTE HEAT RECOVERY UNIT

A waste heat recovery unit (WHRU) is an energy recovery heat exchanger that recovers heat from hot streams with potential high energy content, such as hot flue gases from a diesel generator or steam from cooling towers or even waste water from different cooling processes such as in steel cooling.

Heat recovery units

Waste heat found in the exhaust gas of various processes or even from the exhaust stream of a conditioning unit can be used to preheat the incoming gas. This is one of the basic methods for recovery of waste heat. Many steel making plants use this process as an economic method to increase the production of the plant with lower fuel demand. There are many different commercial recovery units for the transferring of energy from hot medium space to lower one:

1. Recuperators: This name is given to different types of heat exchanger that the exhaust gases are passed through, consisting of metal tubes that carry the inlet gas and thus preheating the gas before entering the process. The heat wheel is an example which operates on the same principle as a solar air conditioning unit.
2. Regenerators: This is an industrial unit that reuses the same stream after processing. In this type of heat recovery, the heat is regenerated and reused in the process.
3. Heat pipe exchanger: Heat pipes are one of the best thermal conductors. They have the ability to transfer heat hundred times more than copper. Heat pipes are mainly known in renewable energy technology as being used in evacuated tube collectors. The heat pipe is mainly used in space, process or air heating, in waste heat from a process is being transferred to the surrounding due to its transfer mechanism.
4. Thermal Wheel or rotary heat exchanger: consists of a circular honeycomb matrix of heat absorbing material, which is slowly rotated within the supply and exhaust air streams of an air handling system.
5. Economizer: In case of process boilers, waste heat in the exhaust gas is passed along a recuperator that carries the inlet fluid for the boiler and thus decreases thermal energy intake of the inlet fluid.
6. Heat pumps: Using an organic fluid that boils at a low temperature means that energy could be regenerated from waste fluids.
7. Run around coil: comprises two or more multi-row finned tube coils connected to each other by a pumped pipe work circuit.

DIESEL POWER PLANTS

Diesel power plants produce power from a diesel engine. Diesel electric plants in the range of 2 to 50 MW capacities are used as central stations for small electric supply networks and used as a standby to hydroelectric or thermal plants where continuous power supply is needed. Diesel power plant is not economical compared to other power plants. The diesel power plants are cheaply used in the fields mentioned below.

1 . Mobile electric plants

2. Standby units

3. Emergency power plants

4. Starting stations of existing plants

5. Central power station etc.

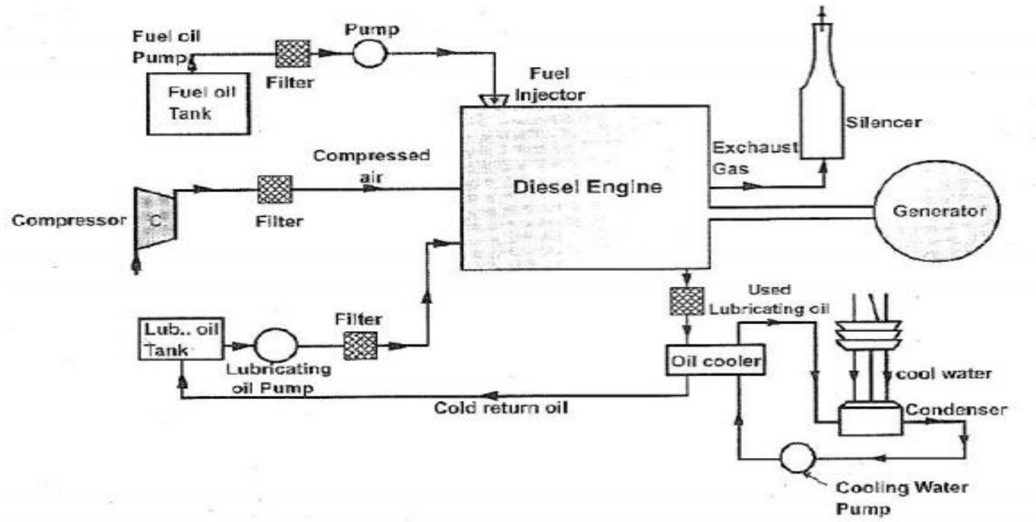

Fig.5.2. Layout Of Diesel Power Plant

Figure shows the arrangements of the engine and its auxiliaries in a diesel power plant. The major components of the diesel power plant are:

1) Engine

Engine is the heart of a diesel power plant. Engine is directly connected through a gear box to the generator. Generally two-stroke engines are used for power generation. Now a days, advanced super & turbo charged high speed engines are available for power production.

2) Air supply system

Air inlet is arranged outside the engine room. Air from the atmosphere is filtered by air filter and conveyed to the inlet manifold of engine. In large plants supercharger/turbocharger is used for increasing the pressure of input air which increases the power output.

3) Exhaust System

This includes the silencers and connecting ducts. The heat content of the exhaust gas is utilized in a turbine in a turbocharger to compress the air input to the engine.

4) Fuel System

Fuel is stored in a tank from where it flows to the fuel pump through a filter. Fuel is injected to the engine as per the load requirement.

5) Cooling system

This system includes water circulating pumps, cooling towers, water filter etc. Cooling water is circulated through the engine block to keep the temperature of the engine in the safe range.

6) Lubricating system

Lubrication system includes the air pumps, oil tanks, filters, coolers and pipe lines. Lubricant is given to reduce friction of moving parts and reduce the wear and tear of the engine parts.

7) Starting System

There are three commonly used starting systems, they are;

1) A petrol driven auxiliary engine
2) Use of electric motors.
3) Use of compressed air from an air compressor at a pressure of 20 Kg/cm.

8) Governing system

The function of a governing system is to maintain the speed of the engine constant irrespective of load on the plant. This is done by varying fuel supply to the engine according to load.

Advantages

Diesel power plants can be quickly installed and commissioned.

Quick starting.

Disadvantages

Capacity of plant is low.

Fuel, repair and maintenance cost are high.

Life of plant is low compared to steam power plant.

Important Questions

1. What do you mean by Power Factor Improvement. How can you improve the load factor.
2. Give a detailed general comparison of private plant and public supply in the following aspects.
   a. Initial Cost and Efficiency b. Capitalization of Losses c. Choice of Voltage.
3. What are the benefits derived from improving the load factor.
4. How can you utilize the electrical energy in most economical point of view with the following Justify a.Use of exhaust steam b. Pit head generation c. Waste heat recovery
5. Give a detail note on economic aspects of utilizing electrical energy
6. What is meant by Power Factor? What are the causes and disadvantages of low power factor.