# Jaipur institute of technology

**DEPARTMENT OF ELECTRICAL ENGINEERING**

**LAB MANUAL -2020**

**LAB NAME: POWER SYSTEM - I LAB (5EE4-21)**

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# EXPERIMENT-1

**Object:-**Generating station design: Design considerations and basic schemes and single line diagram of hydro, thermal, nuclear and gas power plants. Electrical equipment for power stations.

**Theory:-**

**Gas Turbine Power Plant-**

**There are two types of power plant,**

1. **open cycle gas turbine power plant:-**

A Turbine plant consists of a compressor, combustion chamber, gas turbine and alternator. The compressor takes in atmospheric air, compresses it and supplies. The pressurized air to the combustion chamber fuel is injected into the combustion chamber and burnt in the stream of air supplied by the compressor. The combustion raises the temperature of air and increases its volume under constant. The hot pressurized gas expands in the turbine produces mechanical power and turns the rotor of the turbine. Both the compressor and the alternator are coupled to the turbine shaft. Due to the high temperature the products of combustion, the turbine output exceeds, and exhausted to the atmosphere. Such plant is known as open cycle gas turbine power plant the efficiency of an open cycle power plant is very low. The efficiency of an open cycle power plant can be improved through a combination of regeneration, inter cooling and reheating.

**Regeneration-**

Regeneration means transfer of heat energy from exhaust gases to the compressed air flowing between the compressor and the combustion chamber.

**Inter cooling-**

Inter cooling means the removal of heat from compressed air between to stages low pressure and high pressure. Inter cooling reduces the internal consumption of power by the plant.

**Reheating-**

Reheating is the increase of temperature of expanded gas by burning more fuel in it.

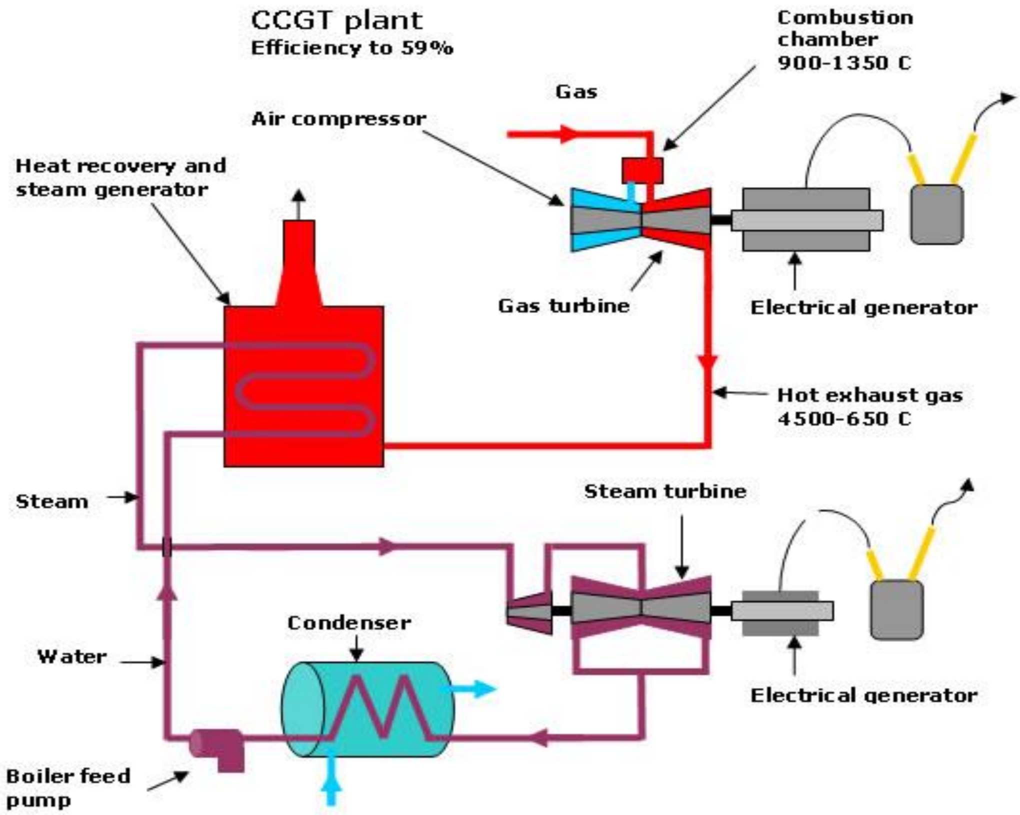
2. **Close Cycle Gas Turbine Power Plant-**

In the open cycle plant the fuel is mixed with air in the combustion chamber and heat rejection process occurs in the atmosphere as the turbine exhaust is discharged into the atmosphere.

In a close cycle plant the fuel is not mixed with air or any other gas. The heat rejection process occurs in heat exchanger or re cooler. Thus, the same working medium is circulated again and again through compressor, heater, turbine and re cooler. The inter cooling, regeneration and reheating features can also be used.

**Gas Turbine Fuels:-**

1. Solid – coal,
2. liquid- kerosene, gas oil, diesel oil,
3. Gas- natural gas and liquid petroleum fuels.




**Comparison of Gas Turbine and Steam Power Plants:-**

- The capital cost of gas turbine plant is lower than steam plant.
- It requires lesser area than steam plant.
- It has less water requirement as compared to a steam plant.
- A gas plant can be located very near the cities and towns.
- The operating cost of a gas turbine plant is very high as compared to the steam plant.
- Gas turbine plant can be used only in small size about 50MW.

**Combined Gas Turbine And Steam Cycles:-**

The heat content of gas turbine exhaust is quite substantial. This exhaust has a temperature of around 500*C. The oxygen content in this exhaust is around 16%. Instead of using regeneration to recover this heat a combined gas turbine and steam cycle can be used. The gas exhaust act as a heat source for the steam cycle.

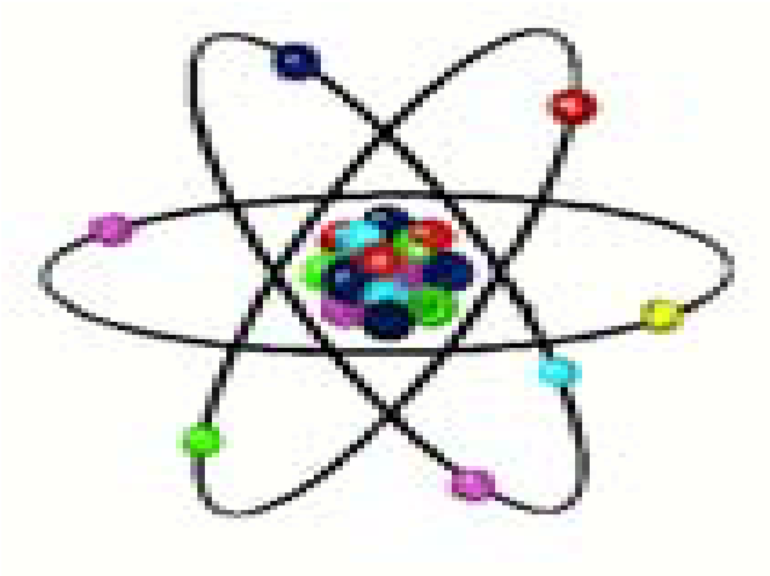
The combined cycle in which gas turbine exhaust passes through a heat exchanger to heat the feed water for the boiler of the steam plant .The full steam supply to the steam turbine is available for expansion and producing mechanical power. About 5% improvement in plant heat rate can be obtained by the use of combined cycle.

**Nuclear Power Stations Mechanism:-**

**Introduction: Atom & Nucleus**

We see many substances around us. What are these made of really? This question has been asked since ancient times. We now know that every substance is simply a collection of a large number of very minute particles known as atoms. It has been found that there are 92 different kinds of atoms present in nature.

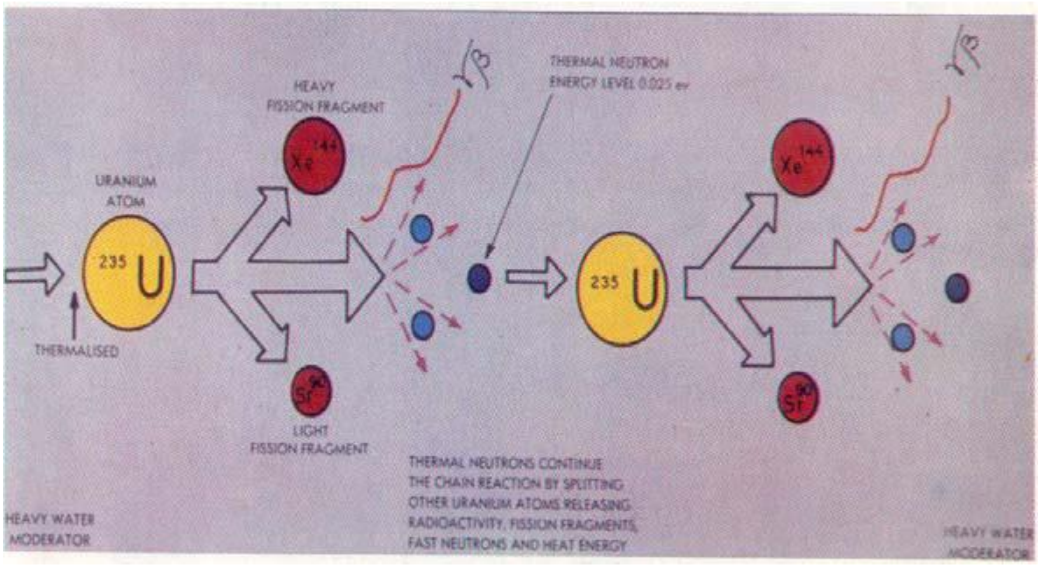
Some substances consist of only one kind of atoms. These substances are known as elements, e.g. hydrogen, carbon, oxygen, uranium. Atoms of hydrogen are very much smaller than atoms of uranium. Other substances contain two or more kinds of atoms joined together in groups, e.g. water which contains atoms of hydrogen and oxygen joined together. Some atoms of hydrogen are heavier than others. When these heavy hydrogen atoms combine with oxygen atoms, we get heavy water. What are the atoms made up of, in their turn? For a long time, it was believed that atoms cannot be broken up into two smaller parts. In fact, the word atom means indivisible. Modern scientific discoveries have shown that an atom itself is a collection of still smaller particles. Three such particles are known namely electrons, protons, and neutrons. The structure of an atom has also been identified.



The neutrons and protons are packed together in the central part of the atom called the nucleus. The electrons keep hovering around the nucleus.

**How is energy released from the atom?**

Atoms of uranium are the largest and also the heaviest known to occur on earth. Being heavy they are also unstable. The nucleus of a uranium atom can easily break up into two smaller pieces. This process is called fission. The two fragments so produced fly apart with tremendous speed. As they collide with other atoms in a lump of uranium they come to a stop. In the process they heat up the uranium lump. This is how energy is released from the atom and converted to heat. The energy produced in fission is described as atomic energy by some and nuclear energy by others. Besides uranium, the atoms of plutonium are also fissionable. But plutonium does not occur in nature. It has been found that 2 or 3 free neutrons are also released as a uranium atom breaks up during fission. When one of these neutrons collides with another uranium nucleus that nucleus also breaks up. In this manner using one neutron from every fission, we can cause another fission. This is known as chain reaction and produces heat at a steady rate. In contrast to fission, when a lump of coal burns, the atoms of carbon in coal combine with atoms of oxygen in the air and form carbon dioxide. Heat is released in the process and we see it as a flame. Smoke is also generated. When fission generates heat in uranium, there is no flame and no smoke.



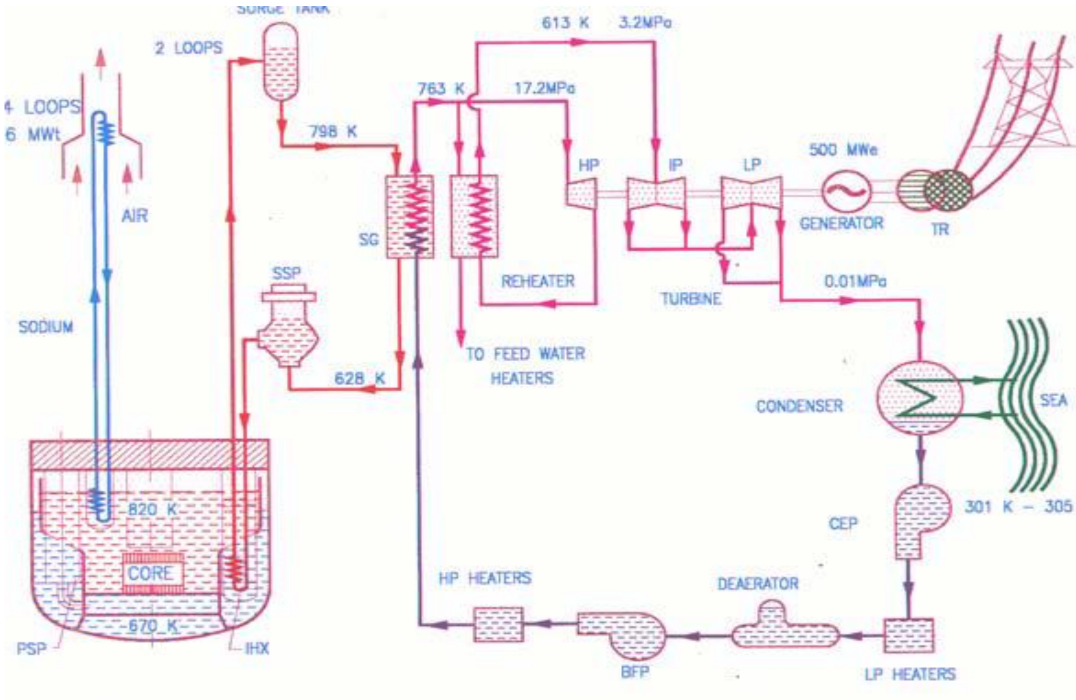

**How does a nuclear power station produce electricity?**

Basically, all power stations adopt the same method to produce electricity. A turbine is caused to rotate. A generator is attached to the shaft of the turbine. As the turbine turns, electricity is produced in the generator. This electricity is sent out through transmission lines to a distribution station of the Electricity Board.

In hydroelectric power stations, the turbine is turned by flowing water. In thermal power stations, steam is produced by heating water in a furnace which burns coal or oil. In nuclear power stations, the steam is produced by the heat generated in the fission process.

**How is power generation controlled in a nuclear power station?**

Control of operation of the nuclear power station involves two things. i.e. regulation of power generation to maintain it at a safe and steady level and secondly total shutdown of the reactor very quickly if needed. At MAPS, the power is kept constant by the use of what are known as adjust errods. These are stainless steel rods. When these rods are introduced into the reactor vessel, the chain reactions lows down and heat generation drops. If the control rods are slightly pulled out of the reactor vessel, the chain reaction picks up and power level rises. To shutdown the reactor completely, the heavy water is drained out of there actor vessel in a fraction of a second. In the absence of heavy water in the vessel, the chain reaction ceases totally.




**What are the fuel requirements for a nuclear power station?**

Compared to the burning of coal, the fission process is far more efficient. One gram of fission able uranium can produce a million times more heat than one gram of coal. At MAPS which produces 400MW of electricity, only 20 kg of uranium fuel is required per day, i.e. about one truck load of fuel per month from Hyderabad where the fuel is produced. In comparison, a coal burning thermal power station of the same capacity would require about 2000 tones of coal daily, i.e. 2-3 train loads of coal to be transported everyday from the coal mines of Singareni over 1000km away. Also the coal has to be continuously fed to the furnace at the rate of 4 tones each minute. At MAPS, fresh fuel is charged into the reactor about once daily.

**What Safety Measures are provided in Nuclear Power Stations?**

Radioactive materials are produced in the core of the reactor when the fission process occurs. Most of these remain within the uranium fuel itself. To prevent their release to the environment at least 3 successive barriers are provided. Failure of all 3 barriers at the same time is indeed highly improbable.

The uranium fuel is packed in a tube and the tube is completely sealed at both ends.

There are 4000 such tubes in the reactor. Experience shows that development of leak in a tube is very rare. If this occurs the defective tube is quickly identified and removed from the reactor. Any radioactive materials released are still contained in the heavy water flowing around the tube. The pipe work, pumps, valves and other parts through which the heavy water flows are highly leak tight. As a further barrier the reactor is housed in a massive containment building. The special feature of the containment at MAPS is that it is of double walled construction. The walls are 60cm thick each. The inner wall is of pre stressed concrete construction and is stronger than the outer one. An area around the station up to 1.5 km is acquired and kept totally free of any habitation.

Any large release of radioactive materials is possible only if the fuel is allowed to overheat and melt. Multiple level safety provisions are included to avoid such a situation. The instruments that monitor the power levels are provided in triplicate, so that even if one fails two others are available to indicate the status. This also helps to check the instruments very frequently even when reactor is in operation. In the same manner, the devices which shut down the reactor are also provided in triplicate. Their operation status is checked every day.

Flow of coolant water through the core is also ensured by providing 2 or 3 pumps and valves wherever one is adequate. This assures that the flow will not be interrupted. As an additional measure of precaution against failure of any pipe, other pathways are also available to send water to the core. If heavy water coolant is not available, provision has been made to pump ordinary water into the core. To ensure that electrical power is always available for all the instruments and equipment which maintain the reactor in a safe condition, four different and independent supply lines have been provided. One of these derives power from Emergency Diesel Generators. Here again 2 or 3generator sets are provided where one will do. Finally, even if the diesel sets do not operate, a battery bank can supply essential power for several hours. The safety provisions in nuclear power stations are indeed unmatched by any other industry.

**Hydro Electric Plants:-**

A generating station which utilizes the potential energy of water at a high level for the generation of electrical energy is known as **hydro electrical power plant**.

**Electrical Equipment:-**

Dam, intake, surge tank, powerhouse, and lubricating oil pumps, constant pumps, drainage pumps, fans, cooling oil pumps, air compressor.

**Hydrology:-**

**Run-off:-** Only a small part of rain fall can be use for power generation. A significant part of water evaporates, another part seeps into soil & forms underground storage and some portion is taken by the vegetation. It contains flow duration curve, mass curve & storage.

**Classification:-**

**Classification according to water flow regulation-**

Hydro plant can be classified, according to extent of water flow regulation available, into following types:

1. Run- off river plants without poundage
2. Run-off river plants poundage
3. Reservoir plant

**Classification according to load:**

According to load, hydro plants can be classified as :

1. Base load plants 2.Peak load plants 3.Pumped storage plants

**Classification according to Head:-**

1. Low head plant 2.Medium head plants 3.High head plants

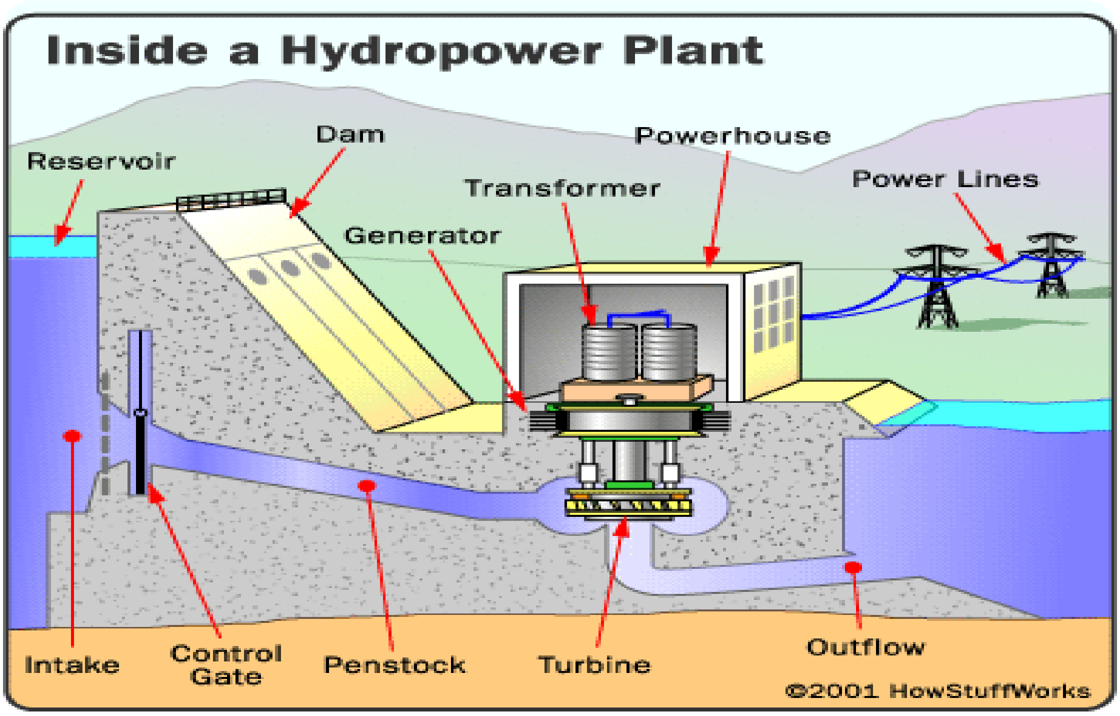
**Hydraulic Turbines:-**

**Types of turbines:-**

Hydraulic turbine convert the energy of water into mechanical energy which drives the alternators. They are highly efficient, simple in construction, can be Control easily and pick up load in a very short time.

1. Peloton Turbine
2. Francis Turbine
3. Propeller & Kaplan turbines
4. Governor and speed regulation
   A. speed regulation of peloton turbine
   B. speed regulation of reaction turbine

**Generation Description of Pumped Storage Plant:-**
A pumped storage plant is a special type of plant meant to supply peak loads. During peak load period, water is drawn from the head water pond through the penstock and generates power for supplying the plead load.




**Pumped Storage Plant For Supplying Peak Loads:-**

Every pumped storage scheme required dual conversion of energy, the efficiency being 60 to 70 percent. Modern generation system is a mixture of hydro, steam and nuclear power stations so that energy can be generated most economically.

**Advantage Of Hydroelectric Plants:-**

1. The useful life of hydro electric plant is around 50 years as compared to around 25 to 30 for a steam station.
2. There is no stand by losses in hydro plants.
3. Hydro plants are more robust as compared to steam plants.
4. The maintenance cost of hydro plants is very low as compared to that of steam and nuclear plants.
5. Hydro plants are free from air pollution due to smoke and exhaust gases.
6. Hydro plant are located in remote areas where land costs are low.

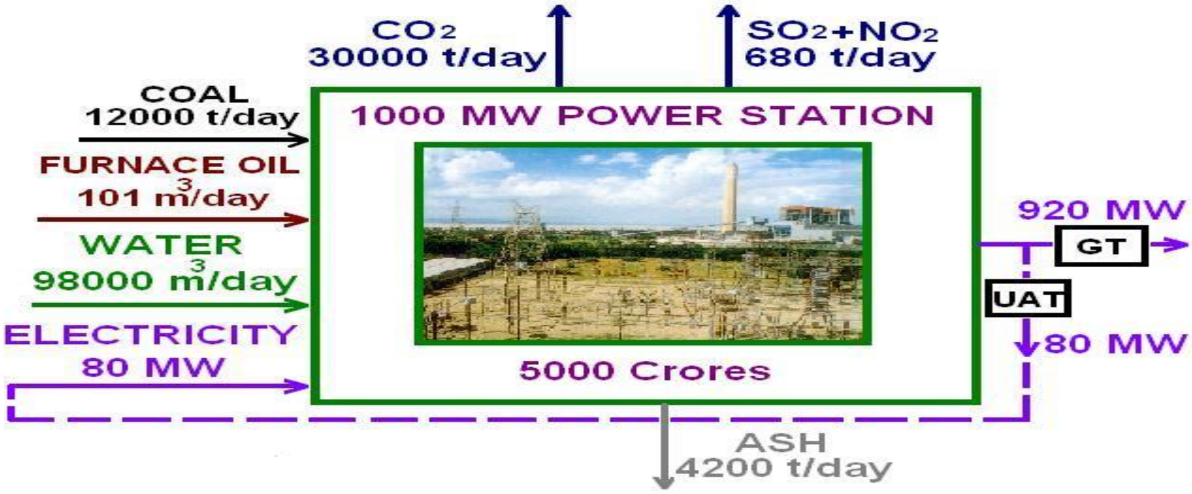
**Disadvantage Of Hydroelectric Plants:-**

1. Due to high cost of civil engineering work, the capital cost per KW of hydro plants is considerably higher than that of steam plants.
2. Hydro power generation is dependent of availability of water.
3. The firm capacity of hydro plant is low and need to be backed up by steam plants.
4. Hydro plant reservoir submerges huge areas, uproots large population and creates social other problems.

**Thermal Power Plant:-**

A **Thermal power station** is a power plant in which the prime mover is steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator.

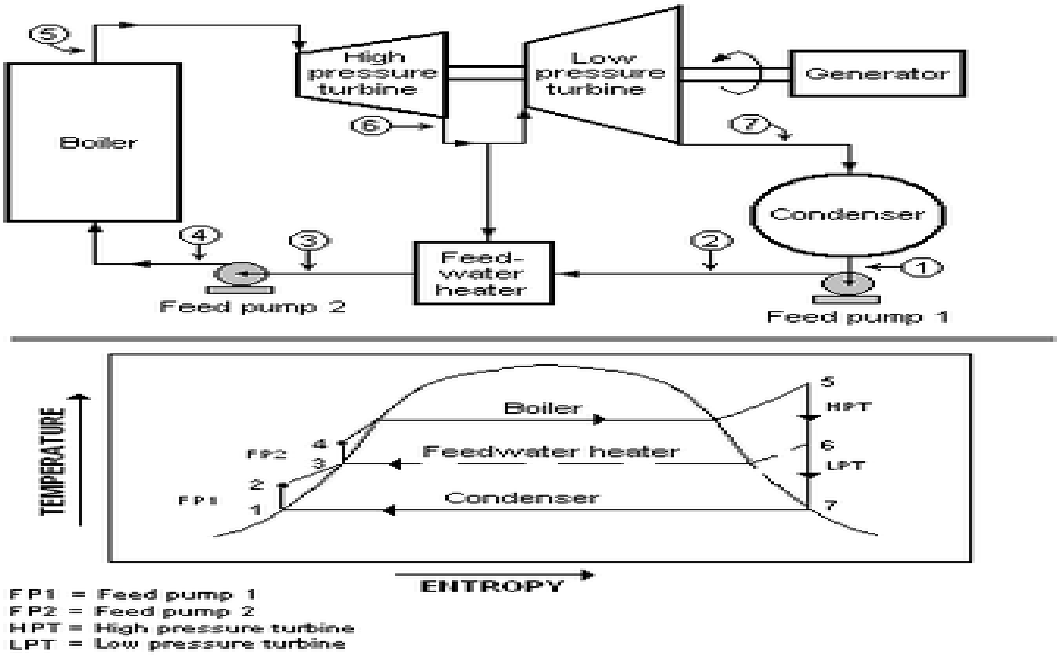
**Introductory:-** Almost all coal, nuclear, geothermal, solar thermal electric, and waste

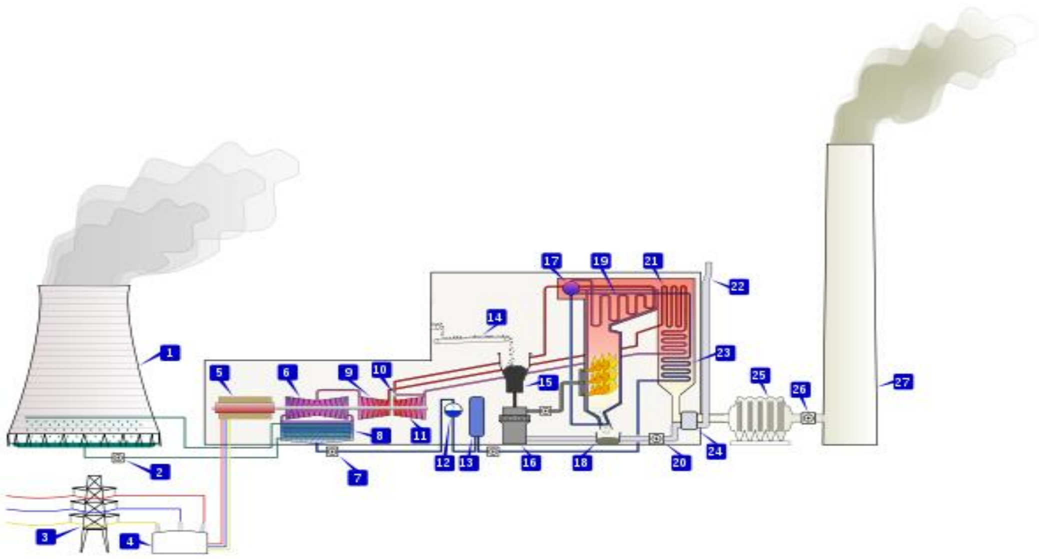



incineration plants, as well as many natural gas power plants are thermal. Natural gas is frequently combusted in gas turbines as well as boilers.

**Efficiency:-**

The energy efficiency of a conventional thermal power station, considered as salable energy as a percent of the heating value of the fuel consumed, is typically 33% to 48%. This efficiency is limited as all heat engines are governed by the laws of thermodynamics.



**Typical diagram of a coal-fired thermal power station**:-

| | | |
|---|---|---|
| 1. Cooling tower | 10. Steam Control valve | 19. Superheated |
| 2. Cooling water pump | 11. High pressure steam turbine | 20. Forced draught (draft) fan |
| 3. transmission line (3-phase) | 12. Desecrators | 21. Reheated |

| | | |
|---|---|---|
| 4. Step-up transformer (3-phase) | 13. Feed water heater | 22. Combustion air intake |
| 5. Electrical generator (3-phase) | 14. Coalconveyor | 23. Economiser |
| 6. Low pressure steam turbine | 15. Coal hopper | 24. Air preheated |
| 7. Condensate pump | 16. Coal pulverized | 25. Precipitator |
| 8. Surface condenser | 17. Boiler steam drum | 26. Induced draught (draft) fan |
| 9. Intermediate pressure steam | 18. Bottom ash hopper | 27. Flue gas stack |

**Boiler and steam cycle:-**

In fossil-fuelled power plants, steam generator refers to a furnace that burns the fossil fuel to boil water to generate steam. In the nuclear plant field, *steam generator* refers to a specific type of large heat exchanger used in a pressurized water reactor (PWR) to thermally connect the primary (reactor plant) and secondary (steam plant) systems, which generates steam. In a nuclear reactor called a boiling water reactor (BWR), water is boiled to generate steam directly in the reactor itself and there are no units called steam generators.

**Feed Water Heating And Deaeration:-**

The feed water used in the steam boiler is a means of transferring heat energy from the burning fuel to the mechanical energy of the spinning steam turbine. The total feed water consists of recirculated condensate water and purified makeup water.

**Steam Condensing:-**

The condenser condensed the steam from the exhaust of the turbine into liquid to allow it to be pumped. If the condenser can be made cooler, the pressure of the exhaust steam is reduced and efficiency of the cycle increases.

**Reheater:-**

Power plant furnaces may have a reheater section containing tubes heated by hot flue gases outside the tubes. Exhaust steam from the high pressure turbine is passed through these heated tubes to collect more energy before driving the intermediate and then low pressure turbines.

**Generator Cooling:-**

While small generators may be cooled by air drawn through filters at the inlet, larger units generally require special cooling arrangements.

**Battery supplied emergency lighting and communication:-**

A central battery system consisting of lead acid cell units is provided to supply emergency electric power, when needed, to essential items such as the power plant's control systems, communication systems, turbine lube oil pumps, and emergency lighting. This is essential for a safe, damage-free shutdown of the units in an emergency situation.

**Transport of coal fuel to site and to storage**:-

Most thermal stations use coal as the main fuel. Raw coal is transported from coal mines to a power station site by trucks, barges, bulk cargo ships or railway cars. Generally, when shipped by railways, the coal cars are sent as a full train of cars. The coal received at site may be of different sizes.

**Advantages of coal based thermal Power Plant:-**

- They can respond to rapidly changing loads without difficulty
- A portion of the steam generated can be used as a process steam in different industries
- Steam engines and turbines can work under 25 % of overload continuously
- Fuel used is cheaper
- Cheaper in production cost in comparison with that of diesel power stations

**Disadvantages of coal based thermal Power Plant:-**

- Maintenance and operating costs are high
- Long time required for erection and putting into action
- A large quantity of water is required
- Great difficulty experienced in coal handling
- Presence of troubles due to smoke and heat in the plant
- Unavailability of good quality coal
- Maximum of heat energy lost

**Result:-**We have successfully studied generating station design**:** design considerations and basic schemes of hydro, thermal, nuclear and gas power plants. Electrical equipment for power stations.

# EXPERIMENT-2

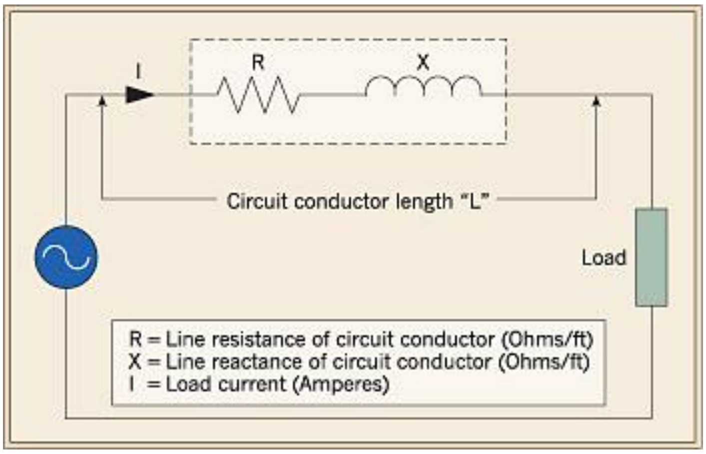
**Object**:-Distribution system design: design of feeders & distributors. Calculation of voltage drops in distributors. Calculation of conductor size using Kelvin's law.

**Theory:-**

When you determine conductor sizes for low-voltage feeder or branch circuits, do you account for voltage drop? Some people believe this is unnecessary, and some believe that doing so is a Code requirement. The first belief is false, but the second is only partly true.

For sensitive electronic equipment, branch circuits can't have more than a 1.5% voltage drop, and the combined voltage drop of feeder and branch-circuit conductors can't exceed 2.5% [647.4(D)]. For all other circuits, the 2005 NEC merely recommends 3% or 5%, depending on the circuit type (feeder or branch) and load type [210.19(A)(1) FPN No. 4 and 215.2(A)(3) FPN No. 2]. Engineering and design standards, coupled with specific user requirements, determine the allowable voltage drop for feeders and branch circuits.

Equipment manufacturers typically recommend or require a minimum circuit voltage or percentage of the equipment voltage rating. For example, one manufacturer may state that voltage at the device must be between 466V and 494V. Another may require that the voltage drop not exceed 3% of the nameplate voltage.




**This simple circuit is useful for explaining voltage drop calculations.**

Low voltage on a system increases maintenance costs and decreases safety and performance. Operating electrical equipment below its acceptable voltage rating can lead to premature failure and hazardous situations. Inductive loads, such as motors and ballasts can overheat, shortening equipment life and increasing energy consumption. If operated below their rated voltage, resistive loads, such as heaters, simply won't provide the desired output. A 10% reduction of voltage reduces the power output by 19%, because power output reduces as the square of voltage. Reduced circuit voltage can cause lights to flicker when other appliances or equipment cycle on.

**Sizing the circuit conductor:-** To correctly determine the minimum conductor size for a given opacity, you first must determine the voltage drop for that circuit. You can do this by one of several methods. For example, you can calculate the voltage drop of the simple two-wire AC circuit in the **Figure** by using the following equation,

$$V_d = \frac{2 \times K \times Q \times L \times I}{CM}$$

where $V_d$ is voltage drop, K is the resistivity constant of conductor metal (circular mil-ohm per foot), Q is the alternating current adjustment factor for skin effect, L is the length of circuit (in feet), I is the load (current draw in amps), and CM is the cross sectional area of conductor (in circular mils). CM may also be denoted as D.

A more efficient approach is to first determine what voltage drop is acceptable. Then use a form of the equation that lets you determine the required conductor size. For example, if you know that your maximum voltage drop is going to be 14V (3% of 480V), you can determine the conductor size with the following equation, which is a reworked version of the first equation.

$$CM = \frac{2 \times K \times Q \times L \times I}{V_d}$$

**Circuit parameters:-**

Regardless of how you determine voltage drop, you must always know certain things about the circuit in question. These are called "circuit parameters." Getting these circuit parameters correct will require some evaluation and perhaps some fact digging.

What do these parameters include? While you need to account for some factors to adjust for accuracy, you need to know conductor resistivity and length, plus the current draw just to “do the math” of the equations.

Conductor resistivity:-. Conductor resistance increases with temperature. Hence, the resistivity constant employed in the calculation should be the value corresponding to the operating temperature of the conductors. The resistivity constant for copper conductor voltage drop calculations is 12.9 ohms at 90°C and 10.8 ohms at 60°C. The resistivity constant for aluminum is 21.2 ohms at 90°C and 17 ohms at 60°C.

Adjustment for skin effect:-For small wires, up to 3 AWG, resistance is the same for 60 Hz AC and DC. But above 3 AWG, AC resistance is larger due to skin effect, which causes the current to flow through the periphery of the conductor, thus reducing its effective cross sectional area. The adjustment factor for skin effect is derived by taking AC resistance value and dividing it by DC resistance value.

$$Q = \frac{0.063}{0.0608} = 1.0362$$

This means that the AC resistance is 1.0362 times the DC resistance.

Voltage Drop Calculations:-

The voltage drop of any insulated cable is dependent upon the route length under consideration (in meters), the required current rating (in amperes) and the relevant total impedance per unit length of the cable. The maximum impedance and voltage drop applicable to each cable at maximum conductor temperature and under a.c. conditions is given in the tables. For cables operating under dc conditions, the appropriate voltage drops may be calculated using the formula:

**2 x route length x current x resistance x $10^{-3}$-**

The values detailed in the tables are given in m/V/Am, (volts/100 per ampere per metre), and the nominal maximum acceptable volt drop specified by the IEE Regulations is 2.5% of the system voltage, i.e. 0.025 x 415 = 10.5 volts for 3 phase working or 0.025 x 240 = 6.0 volts for single phase working.

**Consider a 3 phase system**:-The requirement may be for a load of 100A to be transmitted over a route length of 150m, the cable to be clipped to the wall and close protection provided. The rating tables in the IEE Regulations indicate that a 35mm copper conductor PVC SWA PVC cable would be suitable for the loading required, but the voltage drop must be checked.

Volt drop = Y x current x length

= 1.1 x 100 x 150 milli volts

= 1.1 x 100 x 150 volts/1000

= 16.5 volts

**Kelvin’s law:-**

The cost of conductor material is generally a very considerable part of the total cost of transmission line. Therefore it is necessary to choose the most economic size of conductor. The annual cost of two parts

(1) The fixed charges
(2) The running charges

(1) The fixed charges or capital cost of line:-It consist of the interest on capital cost of the conductor, the allowance for depreciation and the maintenance cost .now ,the conductor cost is proportional to the area of cross section

Annual charge=p1+p2a

Where p1 & p2 are constant
And a is the cross section area

(2) The running charges or the cost of energy:-The annual running cost is on account of energy lost in the conductor due to its ohmic resistance.
Annual cost of energy=p3/a
Where p3 is constant

Now, the total annual cost of conductor is

$$C=p1+p2a+p3/a$$

**Economic Size of conductor: Kelvin's Law:**

The most economical size of conductor is that for which the variable part of the annual charges is equal to the cost of energy losses per year.

Limitations of Kelvin's Law**:**

**1.** The law assumes a linear relation between the cost on account of interest and depreciation on the capital outlay which is not necessarily always valid. Moreover, it is difficult to calculate these values.
**2.** Actual energy loss on a transmission line cannot be estimated without actual load curves. Load curves are not available at the planning stages.
**3.** The conductor size estimated according to this law may not be the optimum as various aspects of safety etc. have not been taken into account.
**4.** The law does not take into account some of the aspects like safe current destiny, mechanical strength, corona loss etc.

**Transmission Lines:-**

Transmission lines are used to transfer electrical power from one place to another. The requirements of transmission lines are:

1. Transmission losses should be least
2. Power must be delivered at the specified voltage
3. No radio interference
4. High availability

**Classification of overhead Lines:-**

**1. Short Transmission lines:-**

When the length of an overhead transmission line is up to 50 km and the line voltage less than 20 kV, it is known as short transmission line. Due to smaller length and lower voltage, the capacitance effects are small and hence are neglected. Thus resistance and inductance are the major parameters considered for these lines.

2. Medium transmission lines:-
These lines are 50 km to 150 km and the range of voltage is 20 kV to 100 kV. Due to sufficient length and voltage of the line, the capacitive effects are not neglected.

3. Long transmission lines:-
The lines are more than 150 km in length and carry voltage higher than 100 kV.

**Result**:-We have successfully studied distribution system design: design of feeders & distributors. Calculation of voltage drops in distributors. Calculation of conductor size using Kelvin's law.

## EXPERIMENT-3

**Object: -** Study of short term, medium Term and long term load forecasting.

**Theory:-**

Load forecasting is vitally important for the electric industry in the deregulated economy. It has many applications including energy purchasing and generation, load switching, contract evaluation, and infrastructure development. A large variety of mathematical methods have been developed for load forecasting. In this chapter we discuss various approaches to load forecasting.

**Introduction:-**

Accurate models for electric power load forecasting are essential to the operation and planning of a utility company. Load forecasting helps an electric utility to make important decisions including decisions on purchasing and generating electric power, load switching, and infrastructure development. Load forecasts are extremely important for energy suppliers, ISOs, financial institutions, and other participants in electric energy generation, transmission, distribution, and markets. Load forecasts can be divided into three categories: short-term forecasts which are usually from one hour to one week, medium forecasts which are usually from a week to a year, and long-term forecasts which are longer than a year. The forecasts for different time horizons are important for different operations within a utility company. The natures of these forecasts are different as well.

**Important Factors for Forecasts & its advantages:-**

For short-term load forecasting several factors should be considered, such as time factors, weather data, and possible customers' classes. The medium- and long-term forecasts take into account the historical load and weather data, the number of customers in different categories, the appliances in the area and their characteristics including age, the economic and demographic data and their forecasts, the appliance sales data, and other factors. The time factors include the time of the year, the day of the week, and the hour of the day. There are important differences in load between weekdays and weekends. The load on different weekdays also can behave differently. For example, Mondays and Fridays being adjacent to weekends, may have structurally different loads than Tuesday through Thursday. This is particularly true during the summer time. Holidays are more difficult to forecast than non-holidays because of their relative infrequent occurrence.

Weather conditions influence the load. In fact, forecasted weather parameters are the most important factors in short-term load forecasts. Various weather variables could be considered for load forecasting. Temperature and humidity are the most commonly used load predictors. An electric load prediction survey published in indicated that of the 22 research reports considered, 13 made use of temperature only, 3 made use of temperature and humidity, 3 utilized additional weather parameters, and 3 used only load parameters. Among the weather variables listed above, two composite weather variable functions, the THI (temperature-humidity index) and WCI (wind chill index), are broadly used by utility companies. THI is a measure of summer heat discomfort and similarly WCI is cold stress in winter. Most electric utilities serve customers of different types such as residential, commercial, and industrial. The electric usage pattern is different for customers that belong to different classes but is somewhat alike for customers within each class. Therefore, most utilities distinguish load behavior on a class-by-class basis.

**Classifications Of Load Forecasting:-**

Load forecasting results have been used for operation planning of electric system as well as maintenance and fuel reserved planning. The load forecasting can be classified into three different types according to the forecast period.

- Short-term load forecasting,
- Mid-term load forecasting,
- Long-term load forecasting

In each load forecasting, period of time, forecasted values and aims of forecasting are noticeably different. Because of the difference of time period, forecasted values and aims of each load forecasting type, researchers in the past proposed many different algorithms and methods in order to obtain the precise load forecasting values.

**Short term load forecasting:-**

Short Term Load forecasting in this paper uses input data dependent on parameters such as load for current hour and previous two hours, temperature for current hour and previous two hours, wind for current hour and previous two hours, cloud for current hour and previous two hours. Forecasting will be of load demand for coming hour based on input parameters at that hour. In this paper we are using multi parameter regression method for forecasting which has error within tolerable range. Algorithms implementing these forecasting techniques have been programmed using MATLAB and applied to the case study. Other methodologies in this area are ANN, Fuzzy and Evolutionary Algorithms for which investigations are under process. Adaptive multi parameter regression for load forecasting, in near future will be possible.

**Medium term load forecasting:-**

This paper develops medium term electric load forecasting using neural networks, based on historical series of electric load, economic and demographic variables. The neural network chosen for this work is the Time Lagged Feed forward Network (TLFN), which combines conventional network topology (multilayer preceptor) with good handling of time dependencies by means of gamma memory. This is a versatile mechanism that generalizes the short term structures of memory, based on delays and recurrences. This scheme allows smaller adjustments without requiring changes in the general network structure. The neural model gave satisfactory results exceeding those obtained by classical statistical models like multiple linear regression.

**Long term load forecasting:-**

Sierra Pacific Power Company d/b/a NV Energy ("Sierra") has prepared an updated load forecast for this 2011-2030 Integrated Resource Plan ("IRP forecast"). The starting point for the updated forecast was the load forecast used in Sierra's Eighth Amendment to the 2007-2026 IRP (Docket No. 10-03023) ("8th Amendment forecast"). The IRP forecast is presented and described below.
Historical Data-Even with the exit of several large mines from Sierra's system,2 from 1998 until 2008, Sierra's weather normalized system peak demand increased from 1,425 MW in 1998 to 1,674 MW in 2008, an average of 1.6 percent per year. Over that same period, the number of residential customers grew on average 2.3 percent per year. Beginning in 2008 and continuing into 2009, electric demand in Sierra's system declined due to the down tom in the economy. In 2009, Sierra's residential customer base actually declined by 0.1 percent. Residential weather normalized sales declined by 0.9%, Small C&I weather normalized sales declined by 3.5%, and total weather normalized sales fell 5.5% from 2008 to 2009. The recorded summer peak declined from 1,664 MW to 1,554 MW (-5.7%) and from 1,674 MW to 1,566 MW (-6.5%) weather adjusted. Excluding Barrack’s Cortez mine, which exited the system in late 2008, total weather adjusted sales fell 3.4%.

**Forecasting methods:-**

Over the last few decades a number of forecasting methods have been developed. Two of the methods, so-called end-use and econometric approach are broadly used for medium- and long-term forecasting. A variety of methods, which include the so-called similar day approach, various regression models, time series, neural networks, expert systems, fuzzy logic, and statistical learning algorithms, are used for short-term forecasting. The development, improvements, and investigation of the appropriate mathematical tools will lead to the development of more accurate load forecasting techniques.

**Short-term load forecasting methods:-**

A large variety of statistical and artificial intelligence techniques have been developed for short-term load forecasting.

**Similar-day approach-**This approach is based on searching historical data for days within one, two, or three years with similar characteristics to the forecast day. Similar characteristics include weather, day of the week, and the date. The load of a similar day is considered as a forecast. Instead of a single similar day load, the forecast can be a linear combination or regression procedure that can include several similar days. The trend coefficients can be used for similar days in the previous years.

**Regression methods-**Regression is the one of most widely used statistical techniques. For electric load forecasting regression methods are usually used to model the relationship of load consumption and other factors such as weather, day type, and customer class. Engle *et al.* [9] presented several regression models for the next day peak forecasting. Their models incorporate deterministic influences such as holidays, stochastic influences such as average loads, and exogenous influences such as weather. Describe other applications of regression models to loads forecasting.

**Time series:-**Time series methods are based on the assumption that the data have an internal structure, such as autocorrelation, trend, or seasonal variation. Time series forecasting methods detect and explore such a structure. Time series have been used for decades in such fields as economics, digital signal processing, as well as electric load forecasting. In particular, ARMA (autoregressive moving average), ARIMA (autoregressive integrated moving average), ARMAX (autoregressive moving average with exogenous variables), and ARIMAX (autoregressive integrated moving average with exogenous variables) are the most often used classical time series methods. ARMA models are usually used for stationary processes while ARIMA is an extension of ARMA to nonstationary processes. ARMA and ARIMA use the time and load as the only input parameters. Since load generally depends on the weather and forecasting.

**Medium and long-term load forecasting methods:-**

The end-use modeling, econometric modeling, and their combinations are the most often used methods for medium- and long-term load forecasting. Descriptions of appliances used by customers, the sizes of the houses, the age of equipment, technology changes, customer behavior, and population dynamics are usually included in the statistical and simulation models based on the so-called end-use approach. In addition, economic factors such as per capita incomes, employment levels, and electricity prices are included in econometric models. These models are often used in combination with the end-use approach. Long-term forecasts include the forecasts on the population changes, economic development, industrial construction, and technology development.

**End-use models-**The end-use approach directly estimates energy consumption by using extensive information on end use and end users, such as appliances, the customer use, their age, sizes of houses, and so on. Statistical information about customers along with dynamics of change is the basis for the forecast. End-use models focus on the various uses of electricity in the residential, commercial, and industrial sector. These models are based on the principle that electricity demand is derived from customer's demand for light, cooling, heating, refrigeration, etc. Thus end-use models explain energy demand as a function of the number of appliances in the market. Ideally this approach is very accurate. However, it is sensitive to the amount and quality of end-use data. For example, in this method the distribution of equipment age is important for particular types of appliances. End-use forecast requires less historical data but more information about customers and their equipment.

**Econometric models-**The econometric approach combines economic theory and statistical techniques for forecasting electricity demand. The approach estimates the relationships between energy consumption (dependent variables) and factors influencing consumption. The relationships are estimated by the least-squares method or time series methods. One of the options in this framework is to aggregate the econometric approach, when consumption in different sectors (residential, commercial, industrial, etc.) is calculated as a function of weather, economic and other variables, and then estimates are assembled using recent historical data. Integration of the econometric approach into the end-use approach introduces behavioral components into the end-use equations.

**Statistical model-based learning-**The end-use and econometric methods require a large amount of information relevant to appliances, customers, economics, etc. Their application is complicated and requires human participation. In addition such information is often not available regarding particular customers and a utility keeps and supports a profile of an "average" customer or average customers for different type of customers. The problem arises if the utility wants to conduct next-year forecasts for sub-areas, which are often called load pockets. In this case, the amount of the work that should be performed increases proportionally with the number of load pockets. In addition, end-use profiles and econometric data for different load pockets are typically different. The characteristics for particular areas may be different from the average characteristics for the utility and may not be available.

In order to simplify the medium-term forecasts, make them more accurate, and avoid the use of the unavailable information, Feinberg *et al.* developed a statistical model that learns the load model parameters from the historical data. Feinberg *et al.* studied load data sets provided by a utility company in Northeastern US. The focus of the study was the summer data. We compared several load model sand came to the conclusion that the following multiplicative model is the most accurate

$$L(t) = F(d(t), h(t)) \cdot f(w(t)) + R(t),$$

where $L(t)$ is the actual load at time $t$, $d(t)$ is the day of the week, $h(t)$ is the hour of the day, $F(d, h)$ is the daily and hourly component, $w(t)$ is the weather data that include the temperature and humidity, $f(w)$ is the weather factor, and $R(t)$ is a random error.

**Result**:-We have successfully studied short term, medium term, long term load forecasting.

# EXPERIMENT-4

**Object:** Sending end and receiving end power circle diagrams.

**Theory:-**

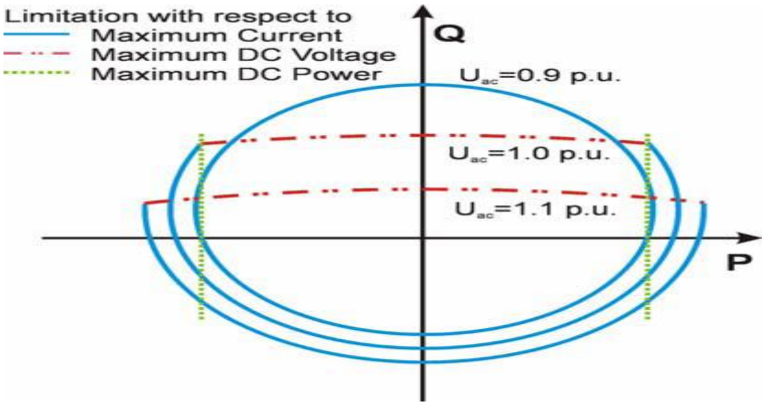
Transmission line bottlenecks caused by system stability limitations form one particular area of interest. Series and shunt compensation may have been used already to alleviate the congestion and right of way Problems may prohibit new transmission lines. A VSC transmission system can be laid (cable) and installed in parallel with the AC system without lengthy right of ways discussions alleviating the bottleneck constraints. In case of asynchronous in feed of power where the two ends of a VSC transmission system do not have any mutual coupling the control of the VSC transmission can improve stability further in the connection point.

**Introduction:-**

The VSC transmission system can also be connected in series with a (long and/or weak) AC-line. Methods to utilize the weak AC line as high as possible will also be discussed in the paper. This paper treats symmetrical three phase stability problems related to fundamental power transfer in the power grid. A VSC Transmission system is also capable of influencing unsymmetrical grid conditions, power quality and harmonic problems. These issues are not covered further in this paper. A more thorough presentation of the technology discussed can be found in [1]. We start with a presentation of different stability issues that are treated with regard to the specific characteristics of a VSC transmission. The strategies for some applications are discussed followed by simulation results in a 'text-book'-type example. Note that many of the proposed strategies will be applicable for temporary solving instability situations. Criterions like (N-1) or similar are used to establish the maximum amount of load that a critical grid section can transfer. If a large generator or transmission line trips, the VSC transmission can change its operating mode and temporary strengthen the grid until other remedial actions restore grid security.

**The capability curve of a VSC transmission system:-**

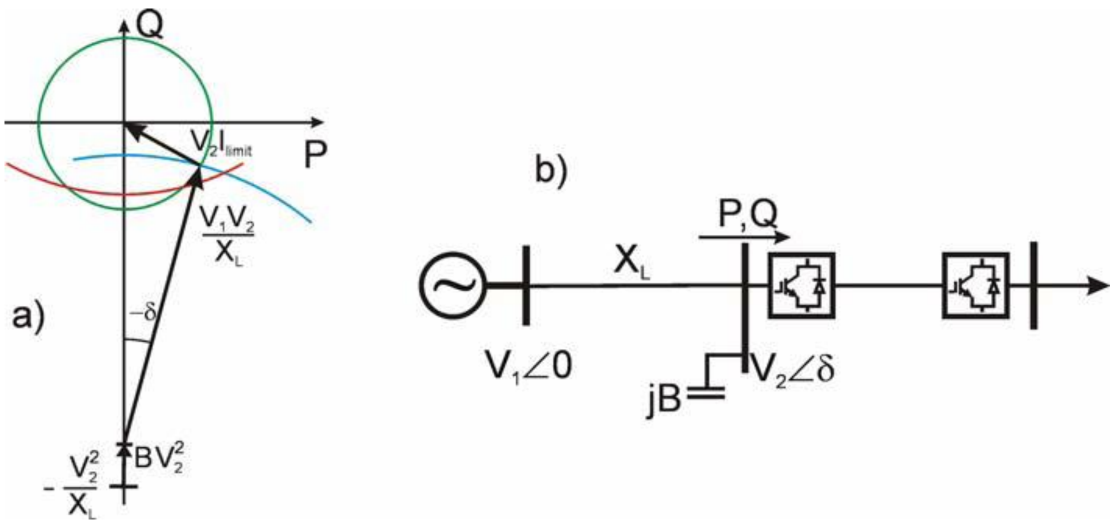
There are mainly three factors that limit the capability seen from a power system stability perspective. The first one is the maximum current through the IGBT's. This will give rise to a maximum MVA circle in the power plane where maximum current and actual AC voltage is multiplied. If the AC voltage decreases so will also the MVA capability. The second limit is the maximum DC voltage level. The reactive power is mainly dependent on the voltage difference between the AC voltage the VSC can generate from the DC voltage and the grid AC voltage. If the grid AC voltage is high the difference between the maximum DC voltage and the AC voltage will be low.




The reactive power capability is then moderate but increases with B decreasing AC voltage. This makes sense from a stability point of view. The third limit is the maximum DC current through the cable. The different limits are shown in Figure 1. For a decreasing AC voltage level the maximum DC voltage level will vanish and the maximum current level will decide the capability. The small bias in Q-axis direction is due to the line reactor and the filter capacitance within the VSC transmission system [1]. Smaller adjustments in the calculations presented below will therefore be necessary when evaluating the qualitative results of a VSC transmission. Also the tap changer on the converter transformers will play a role during certain cases. Note the similarities with this capability curve and a capability curve for a generator. Maximum DC voltage level corresponds to maximum field current in the rotor winding and IGBT current corresponds to armature current.

**Strategy for series connection and voltage instability:-**

A typical situation can be illustrated as in Figure 2b. Illustrating the power flow equations for the receiving end in a power circle diagram [4] combined with the (mirrored) capability curve of the VSC transmission system shown in Figure 2a will immediately reveal the maximum transferable active power.
The crossing between the capability curve of the VSC transmission and receiving end circle will indicate the stable solution for that particular voltage level. If sending end voltage drops it is possible to immediately establish the new stable solution in the power circle plane by recalculate the figure.



**Strategy for parallel connection and voltage instability:-**

If the VSC transmission system is connected in parallel to an AC line the control of the VSC transmission will have impact on the AC flow. By varying the power factor of the DC transmission we will be able to utilize the AC system better. In order to enhance system operation we must pick the best power factor operation for the VSC transmission when the system becomes stressed. Figure 3a)-b) shows a parallel case with the associated power circle plane [4]. If we begin studying the receiving end circle we can see the power flow on the AC-line (following the arc with angle δ) to which the power flow via the VSC transmission is added (the vector within the smaller circle). In this example, the AC line is requiring some reactive power which is fed from the VSC system. In the figure, the MVA circle (the small one) is valid for the VSC transmission. We see that the MVA capacity is at its maximum point for the DC system i.e. we can not transfer more power over the combination. An increase of DC flow or AC flow (requiring more reactive power to keep AC voltage) would violate the capability curve. If we now decrease DC power transfer and are able to inject more reactive power one can see that it is possible to transfer more active power over the combination. A best choice is made according to:

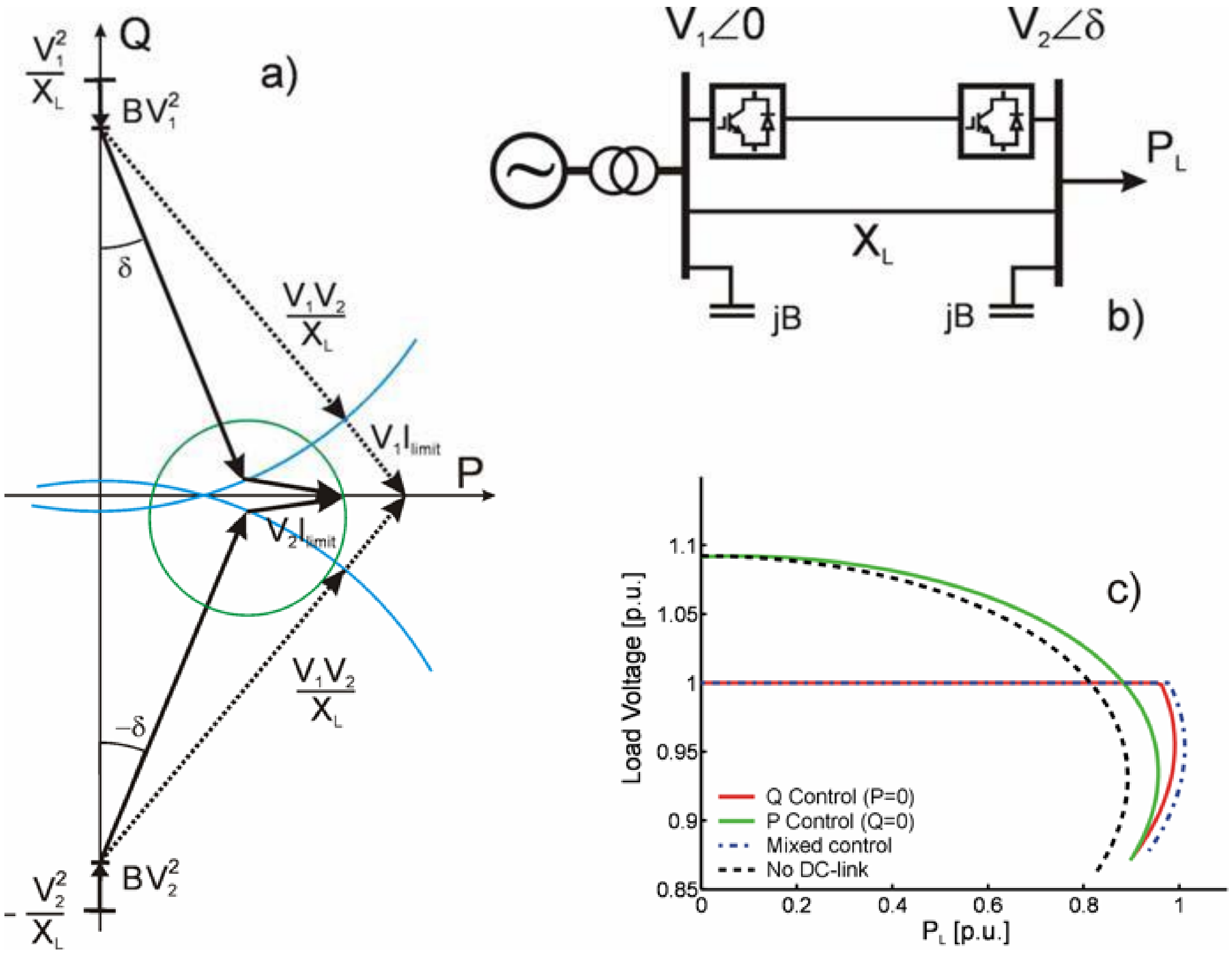
sin( ) 2 1 2 *P* = *I* ·*V* δ −δ *dc* limit and cos( ) 2 1 2 *Q* = *I* ·*V* δ −δ *dc* limit (1)

where limit is the maximum steady state current allowed in the converter. If the maximum DC voltage level limit is included in the figure its role is directly disclosed in the drawing.

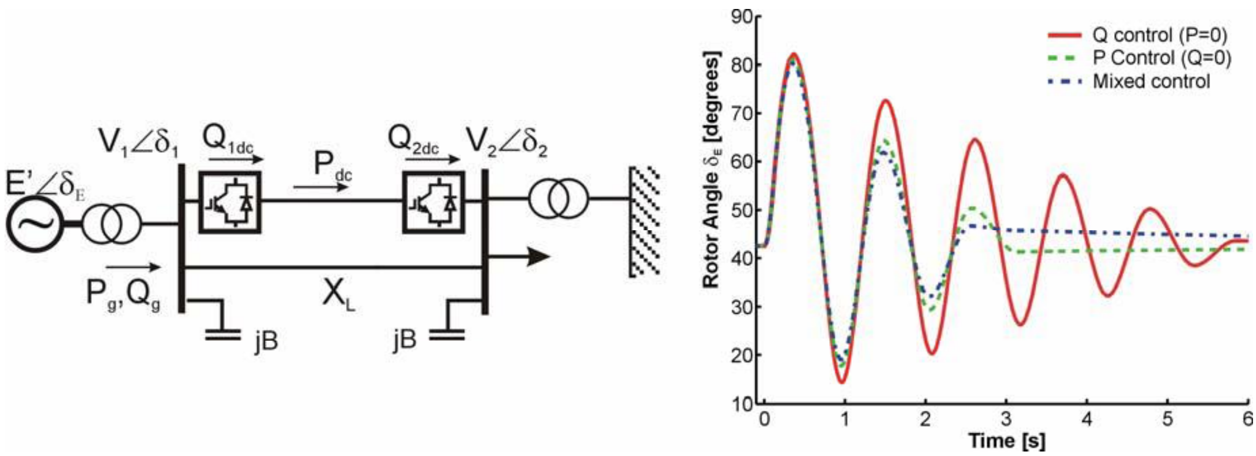
Figure 3 A parallel case b) with a power circle plane, a) to indicate 'best' solution. PV curve in c). Key grid

Parameters are XL=0.5, B=0.2, (SIL=0.872 p.u.), Xt=0.2 p.u. and converter size=0.08 p.u.

The associated PV-curve is plotted in Figure 3c). It shows three different ways to utilize the capacity in the VSC transmission system. The first one is active power transfer only, the second is only reactive power generation in each end (STATCOM operation) and the third one is a mixture according to the best choice described above. Point of Maximum Load ability, Pmax for the three possibilities are indicated in Table I. The best choice in this example increases the point of maximum load ability with 149% of installed MVA capacity.




**Parallel connection**-A slightly different tactic is used when a VSC transmission is connected in parallel with the AC transmission system compared with the voltage stability scenario presented above. A simple and fairly robust modulation can be achieved with: where Ilimit is the maximum steady state current allowed in the converter. The sign for the reactive power in the respective end is chosen so it supports damping. A grid example and a simulation are illustrated in Figure 8. A fault applied on 'node 1' is cleared after 100 ms. The rotor angle oscillations is presented for three different control strategies for the VSC transmission where the Mixed control described by equation (2) give the highest damping.



AC line fault cleared after 100 ms and the associated rotor oscillation for three different strategies for VSC transmission. Key grid parameters are XL=0.5, B=0.2 (SIL=0.872 p.u.), H=4 and converter size=0.08 p.u.

The problem is rather complex even in its simplest version presented here. The difference in damping between the methods will vary and a thorough investigation is necessary before the benefits for a specific case can be determined. For one parameter setup a mixed control with a third of the rating of Q control had the same damping i.e. a gain of 3. For another setup the gain was a factor 2. A more complex grid will have many aspects to consider before the actual benefits are established but VSC transmission systems do have a possibility to significantly improve damping for certain grid configurations.

**Result**:-We have successfully studied sending end and receiving end power circle diagrams.

# EXPERIMENT-5

**Object:** Substations: Types of substations, various bus–bar arrangements. Electrical equipment for substations.

**Theory:-**

Substation, Its Function and Types

An electrical sub-station is an assemblage of electrical components including bus-bars, switchgear, power transformers, auxiliaries etc.

These components are connected in a definite sequence such that a circuit can be switched off during normal operation by manual command and also automatically during abnormal conditions such as short-circuit. Basically an electrical substation consists of No. of incoming circuits and outgoing circuits connected to a common Bus-bar systems. A substation receives electrical power from generating station via incoming transmission lines and delivers elect. Power via the outgoing transmission lines.

Sub-station are integral parts of a power system and form important links between the generating station, transmission systems, distribution systems and the load points.

**Main tasks:-**

Associated with major sub-stations in the transmission and distribution system include the following:

1. Protection of transmission system.
2. Controlling the Exchange of Energy.
3. Ensure steady State & Transient stability.
4. Load shedding and prevention of loss of synchronism. Maintaining the system frequency within targeted limits.
5. Voltage Control; reducing the reactive power flow by compensation of reactive power, tap-changing.
6. Securing the supply by proving adequate line capacity.

**Types of substation:-**

The substations can be classified in several ways including the following:

1. **Classification based on voltage levels**- e.g: A.C. Substation : EHV, HV, MV, LV; HVDC Substation.

2. **Classification based on Outdoor or Indoor**- Outdoor substation is under open sky. Indoor substation is inside a building.

3. **Classification based on configuration**- e.g. :
   - Conventional air insulated outdoor substation or
   - SF6 Gas Insulated Substation (GIS)
   - Composite substations having combination of the above two

4. **Classification based on application-**
   - Step up Substation: Associated with generating station as the generating voltage is low.
   - Primary Grid Substation: Created at suitable load centre along Primary transmission lines.
   - Secondary Substation: Along Secondary Transmission Line.
   - Distribution Substation: Created where the transmission line voltage is Step Down to supply voltage.
   - Bulk supply and industrial substation: Similar to distribution sub-station but created separately for each consumer.
   - Mining Substation: Needs special design consideration because of extra precaution for safety needed in the operation of electric supply.
   - Mobile Substation: Temporary requirement.

   **Note:**

   - Primary Substations receive power from EHV lines at 400KV, 220KV, 132KV and transform the voltage to 66KV, 33KV or 22KV (22KV is uncommon) to suit the local requirements in respect of both load and distance of ultimate consumers. These are also referred to 'EHV' Substations.

   - Secondary Substations receive power at 66/33KV which is stepped down usually to 11KV.

   - Distribution Substations receive power at 11KV, 6.6 KV and step down to a volt suitable for LV distribution purposes, normally at 415 volts

**Substation parts and equipments-**

Each sub-station has the following parts and equipment.

1. **Outdoor Switchyard**
   - Incoming Lines
   - Outgoing Lines
   - Bus bar
   - Transformers
   - Bus post insulator & string insulators
   - Substation Equipment such as Circuit-beakers, Isolators, Earthing Switches, Surge Arresters, CTs, VTs, Neutral Grounding equipment.
   - Station Earthing system comprising ground mat, risers, auxiliary mat, earthing strips, earthing spikes & earth electrodes.

- Overhead earthwire shielding against lightening strokes.
- Galvanized steel structures for towers, gantries, equipment supports.
- PLCC equipment including line trap, tuning unit, coupling capacitor, etc.
- Power cables
- Control cables for protection and control
- Roads, Railway track, cable trenches
- Station illumination system

2. **Main Office Building-**
   - Administrative building
   - Conference room etc.

3. **6/10/11/20/35 KV Switchgear, LV-**
   - Indoor Switchgear

4. **Switchgear and Control Panel Building-**
   - Low voltage a.c. Switchgear
   - Control Panels, Protection Panels

5. **Battery Room and D.C. Distribution System-**
   - D.C. Battery system and charging equipment
   - D.C. distribution system

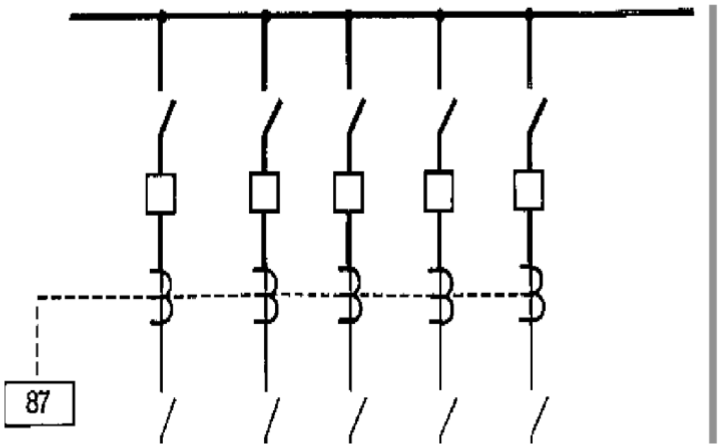
6. **Mechanical, Electrical and Other Auxiliaries-**
   - Fire fighting system
   - D.G. Set
   - Oil purification system

Typical Bus-bar Arrangements
– Single Bus-bar
– Double Bus-bar with Coupler
– Breaker and a Half
– Double Breaker
– Double Bus-bar with Transfer Bar
– Segregated Bus-bars with Coupler

**Bus-bar-**

An aluminium or copper conductor supported by insulators that interconnects the loads and the sources of electric power in an electric power system. A typical application is the interconnection of the incoming and outgoing transmission lines and transformers at an electrical substation. Bus-bars also interconnect the generator and the main transformers in a power plant. In an industrial plant such as an aluminium smelter, large bus-bars supply several tens of thousands of amperes to the electrolytic process.

**Typical Single Bus-bar Arrangement-**




**Result**:-We have successfully studied of substation, types of station, bus-bar arrangement and equipment for substation.

## EXPERIMENT NO-6

**Object: -** Study high voltage testing of electrical equipment: line insulator, cable, bushing, power capacitor, and power transformer.

**Theory:** Various type of line insulators:-

1. Pin type
2. Post type
3. String insulator unit
4. Suspension type

5. Tension

Arrangement of insulators for tests:-

String insulators hung by a suspension eye from earthed metal cross arm. Test voltage applied between the cross arms and conductor vertically from metal part on lower side of insulator unit suspension string hung from an earthed metal cross arms conductor of actual size to be used in service of diameter not less than 1 cm and length 1.5 limits the length of string secured in the suspension damp and should lie in horizontal plane.

High voltage testing of electrical equipments requires 2 types of tests:-

1. Type test

2. Routine test

Type test involves quality testing of equipment at the design and development level of the product are taken and are tested when anew a product is being developed and designed or an old products is to be designed and developed whereas the routine tests are meant to check the quantity of the individual test place.

High voltage test includes

1. Power frequency tests
2. Impulse tests

Testing of cables: following tests are there:-

1. **Bending test**: - voltage test should be made before a bending test. Cable bent around a cylinder of specified diameters to make 1 complete turn.
2. **Loading cycle test**: test loop consisting cable and its accessories subjected to 20 load cycle with minimum conductor temperature 5 degree centigrade.
3. **Thermal stability test**: after test cable energized with voltage 1.5 times working voltage for cable of 132 kv rating.
4. **Dielectric thermal resistance test**: ratio of temp. Differentiate between the core and sheet of cable and the heat flow from cable gives thermal resistance of sample of cable.

Testing of circuit breakers:

1. **Short circuit test**:
   a. Making capacity test
   b. Braking capacity test
   c. Operating duty test
   d. Short time current test
2. **Dielectric test**
   a. One minimum wet withstand test

b. One minimum dry withstand test
c. Impulse voltage drive instant test

**Result**: Study high voltage testing of electrical equipment: line insulator, cable, bushing, power capacitor, and power transformer.

## EXPERIMENT NO-7

**Object:** Design an EHV transmission line.

**Theory: -**Apply Kelvin's law to determine the economic cross- section for the conduction of a 3-10 km long 33kv overhead lines .

**Solution: -** let the area of cross – section be a $nm^2$ resistance 1 km length of live.

$$=\frac{0.0286}{a} \times 100$$

$$\frac{0.0286}{a} \text{ ohm per phase}$$

For 4 MW load-

=87.48A

Energy loss in one day due to cross section and current 1, in , 1 km length of line.

$$=3(87.48)^2\ (\frac{28.6}{a})\ (\frac{10}{1000})$$

$$=\frac{6566.1}{a}\text{ Kwh}$$

For 2 MW load

=43.74A

Energy loss in one day

$$=3(43.74)^2\ (\frac{28.6}{a})\ (\frac{6}{1000})$$

$$=\frac{984.9}{a}\text{ Kwh}$$

For 1mw load the current

=21.87A

Total cost per Km of line

=8500+1000a+2300726.4/a

$$A^2+\ \frac{2300726.4}{2000} = 1150.36$$

A= 33.91 sq nm

**Programming in C language:-**

```
#inclued<stdio.h>

#inclued<conio.h>

#inclued<main.h>

Float load [555],P[555],t[585],curr[555],energy loss[555];

Void main ()

{int i,n;
```

Float R, area , total =0.00;

Clrscr();

Print f “enter”.

**Result: -** Thus we have study the transmission line.

# EXPERIMENT: 8

**Object**:-Study filtration and treatment of transformer oil.

**Theory:-**Oil, besides being a good insulating medium, it allow better dispersion of heat. It allows a transfer and absorption of water, air and residue streamed by the ageing of the solid insulation. In order to achieve requirement, it must be treated to attain high degree of purity, whatever be the nature of the impurities whatever solid, liquid and gaseous. These begin down the dielectric strength of oil material. The pressure of water in paper not only increases the loss angle tanδ, it accelerates the process of ageing. Similarly air dissolved oil produces a risk of forming bubble and reduces the dielectrics strength of the oil.

**Air Absorption:-**The process of air absorption can be compared to a diffusing phenomenon in which a gaseous substance in the air is in contact with liquid. If the viscosity of the liquid is low, the convection movement bring about a continuous inter-mixing thereby a uniform concentration is achieved. This phenomenon can be checked in a tank where the air content or the water content, measured both at the top and the bottom are approximately equal.

Let G (t)=Air content of oil after time t.

Gm=Air content under saturation condition

P= Probability of absorption for unit time

S=Surface of oil

V=Volume of Oil

The absorption of air by oil can be given by the equation

$dG/dt= P.\delta/V(Gm-G(t))$

with boundary condition at t=0, $G=G^o$

Solving the above equation

$dG/(Gm-G(t))=p.(S/V)dT$

or $\ln\{Gm-G(t)\}=-p(S/V)t+A$

At t=0, $G=G^o$

Therefore $A=\ln[Gm-G(t)/Gm-G^o]= -P[S/V]t$

Or $Gm-G(t)=(Gm-G^o)e-P(s/v)t$

Thus from fig (1) shows the schematic for measurement of air absorption by insulating oil which is previously been diagramed as a function of absorption time. The oil is digest and dried with the help of vacuum pump

(1)and introduced into the insulating until the desired is absorbed by the oil, the pressure being maintain at constant value by reducing the volume in absorption in motor.

(2) Thus air content of oil by volume can be measured precision monometer

(3) Is used calibrate the absorption meter

Phosphorous pentaoxide trap take in the reminder of water vapor

**Filtration And Treatment Under Vaccum:-**Due to hygroscopic properties of paper, oil is predicted before filtering. Therefore this oil cannot be used for high voltage insulation subsequently; process of drying is carried out in specially designed tank under vaccum. The oil is distributed over large surface by so called “RASCLIN G – RING”

The oil from transformer of storage tank is prefiltered so as to protect the feeder pump, in the oil is heated up and is allowed to flow for the filter into degeassing tank. Is either connected with the gaseous tank in parallel with pump or can be used for evacuating the transformer tank which is to be heated.

**Centrifugal Method:-**The method is helpful partially extracting solid impurities and free water. It is totally ineffective as far as the removal of water and dissolved gases is concerted and oil treated in the banner is even oversaturated with as air is thoroughly mixed into it during the process. However if the centrifugal device is kept in the take kept under vaccum, partial improvement can be obtained. But the light increased in efficiency of oil achieved is out of proportion to the additional cost involved.

**Absorption Columns:-**Here the oil may to flow through one or several column filled with and absorbing agent have been used:-

**Fuller Earth:-**activated fuller earth absorb carbonyl and hydroxyl group. Best result of oil treatment is obtained by the combination of fuller earth and subsequent drying under vaccum.

**Silica Gel:-**Silica gel and its particular series diameter measure $4A^{o}$ show a strong affinity for water. Molecular seines are capable of absorbing water 20% of its original weight at $25^{o}C$ and water vapor pressure 1tore

**Molecular Sillies:-**It is synthetically product zeolites which are activated by removal of the crystallization water. Their absorption capacity remains constant up to saturation point.

**Electrostatic Filter:-**The oil to be treated is passed between the two electrode placed in a container. The electrostatic field charges the impurities and trace of water which are the attracted and retained by the foam coated electrode. This method of drying oil is foamed to be economical if the water contained of the oil is less than 2ppm. It is therefore essential that the oil is dried before and hand if the water contains large.

**Result:-**The filtration treatment of oil has been studies successfully.

## EXPERIMENT NO-9

**Object: -** Determine dielectric strength of transformer oil.

**Theory: -** The oil is poured in a container known as test cell which has internal dimension of 55* 40 * 100 mm. The electrodes are polished shores of 12.7 *13 mm diameter, preferably of brass, arranged horizontally with their axis not less than 40 mm the bottom of the cell. For the test of distance between the spheres shall be 410.02 mm. A suitable gauge is used to adjust the gap.

Next the voltage is brought back to zero and started with 40% of the rapidly applied voltage and wait for a minute. It observes that if the gap is broken or not, the voltage and waited for 1 minute to fill the flashover in the MCB trips. Then again zero voltage is started to a value just obtain in the previous step

**Result: -** The study of calculating dielectric strength of transformer oil done successfully.

## EXPERIMENT NO-10

**Object**: - Determine capacitance and dielectric loss of an insulating material using Schering Bridge.

**Theory**: High voltage Schering Bridge is widely used for capacity and dielectric loss measurement of all kind of capacitances, for instance cables, insulators and liquid insulating materials. The high voltage equipments have low capacitance and low power factor.

The special features of bridge are

1. High voltage supply, consists of transformer with regulation, protective circuitry and special screening.

2. Screening standard capacitor of Cs of 100pF±5% 10RV max and dissipation factor $\tan\delta = 10^{-5}$. It is gas filled capacitor having negligible loss factor over a wide range of frequency.
3. The impedance of arms 1 and 2 are very large and therefore, the current drawn by these arms are small from the source and are sensitive detector is required for obtaining the balance. Also, since the impedance in arm 1 and 2 are very large as compared to 3 and 4, the detector and the impedance of arm 3 and 4 are at a potential of only a few volts (10 to 20 volts). Above the earth even when the voltage is 10 KV, except of course, in case of breakdown of one of the capacitors of arms 1 and 2.
4. The null detector: an oscilloscope is used as a null detector. The gamma plates are supplies with the bridge voltage Vab and the x plate with the supply voltage v. however if the magnitude balance is not reached, an ellipse will appear on the screen.
5. Automatic guard potential regulator is used to determine the stray capacitances between bridge junction and the ground adversely affect the measurement.

Balancing the bridge:-

The bridge is balanced by successive R1 and C2 until on the oscilloscope a horizontal straight line is observed:

At balance

$$\frac{Z_I}{Z_{II}} = \frac{Z_{III}}{Z_{Iv}}$$

Now,

$$Z_I = \frac{R_p}{1 + j\omega C_P R_p}$$

$$Z_{II} = \frac{1}{j\omega C_s}$$

$$Z_{III} = R_1$$

$$Z_{IV} = \frac{R_p}{1 + j\omega C_2 R_2}$$

From balance equation we have

$$\frac{\frac{R_p}{1 + j\omega C_P R_p}}{R_1} = \frac{\frac{1}{j\omega C_s}}{\frac{R_p}{1 + j\omega C_2 R_2}}$$

$Z_1 = Rs - j/wsc$

And equation becomes

$(Rs-j/wsc)/R_1= (1+jwc_2r_2)/jw$

$$\frac{Rs}{R_1} - \frac{j}{wc_s R_1} = \frac{-j}{wc\,{}_s^1 R_1} + \frac{C_2}{C_s'}$$

Equating real part, we have

$$\frac{Rs}{R_1} = \frac{C_2}{C_s'}$$

Similarly equating imaginary part, we have

$C_S=C_s{}' R_2/R_1$

To find out tanδ, we draw the phasor diagram of the bridge ckt.

**Result**: - Study of calculation and dielectrically loss of an insulating material using bridge has been done successfully.