**STUDY OF CO-GEN POWER PLANT**

**ABSTRACT**

The every infringing use of electric power for domestic power, commercial &industrial purpose necessitates providing bulk electric power economically. This is achieved with the help of suitable producing units, known as POWER PLANTS or ELECTRIC POWER GENERATING STATIONS

The highlights of our project constitute the following phases:

Firstly, it involves a brief introduction about cogeneration power plant, selection of plant site, its advantages and disadvantages and about fuels used in the plant.

Secondly, it involves a study of boiler and axillaries, turbines, synchronous generator and brushless type exciter.

Lastly, it involved a study regarding protection of alternators and transformers.

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CHAPTER-1

INTRODUCTION

Energy provides the power to progress. The natural resources of a country may be large but they can only be turn into wealth if they are developed use and exchanged for other good. This cannot be achieved without energy.

As a country develops the pattern of its energy usage under goes a distinct change. Though in a simple society it almost a consumer good, its effective use is small and contribution to the development of economy negligible. However once energy is made available in excess of domestic needs it has been found that it is not used solely as a consumer good but becomes a factor of production.

The dependence on electricity is so much that is has become a part and parcel of our life. The every infringing use of electric power for domestic, commercial & industrial purpose necessitates providing bulk electric power economically. This is achieved with the help of suitable producing units, known as POWER PLANT or ELECTRIC POWER GENERATING STATIONS.

A generating station essentially employees a prime mover coupled to an alternator for the production of electric power. The prime mover (E.g. steam turbines, steam engines, water turbines etc.,) converts mechanical energy of the prime-mover into electric energy. The electrical energy produced by the generating station is transmitted and distributed with the help of the conductors to various is transmitted and distributed with the help of the conductors to various is transmitted and distributed with the help of the conductors to various consumers. It may be emphasized here that a part from prime mover alternator combination, a modern generating station employs several auxiliary equipment and instruments to ensure that cheap reliable and continuous service.

CHAPTER-2

**SELETION OF PLANT SITE**

The following points should be considered while selecting a site for a steam power station.

1. **Supply of water:**

The steam amount of water is required for the condensers: therefore, such a plant should be located at bank of river or near a canal to ensure the continuous supply of water.

1. **TRANSPORTATION OF FACILITIES:**

A modern steam power station often requires the transportation of material and machinery. Therefore adequate transportation facilities must exist.

1. **Cost and type of land:**

The steam power station should be located at a place where level land is cheap and further extension, if necessary is possible. Moreover, the bearing capacity of the ground should be adequate so they heavy equipment could be installed

1. **Nearness to load centers:**

In order to reduce the transmission cost the plant should be located near the load center. This is particularly important of D.C supply system is adopted. However if A.C supply system is adopted this factor becomes relatively less important. It is because A.C power can be transmitted at high voltage with consequent reduced transmission cost.

1. **Distance from populated area**:

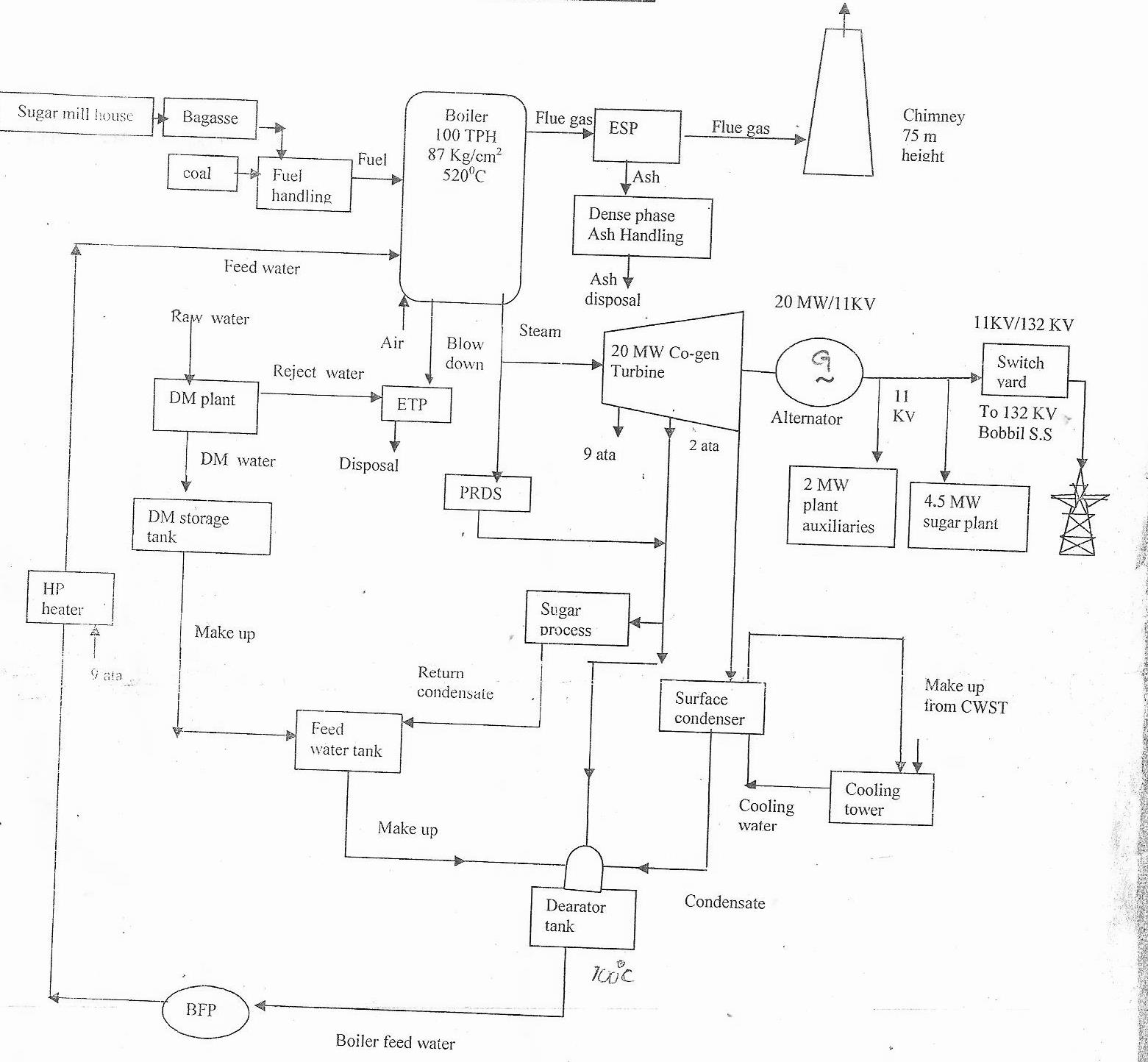
A huge amount of coal is burnt a steam power station, therefore, a smoke and fumes pollute the surrounding areas. This necessitates that the plant should be located at the considerable distance from polluted areas.

**Advantages:**

* Fuel used is cheaper:
* Less space is required in comparison with that for hydro electric plants.
* Cheaper in initial cost comparison with other types power stations of same capacity.
* Cheaper in production cost in comparison with that of diesel power station. Such plants can be installed at any place irrespective of the existing of fuels, while hydro electric plants can be developed only at the source of water power. Such plants can be located near the coal centers. While the hydro electric plants have essentially to be installed at the source of power which is usually located from urban areas.

**Disadvantages:**

* Costlier in running cost in comparison with that of hydro electric plants. Atmosphere is polluted by fumes and residue from pulverized



**Fig 2.1 Block diagram of co-gen power plant**

**CHAPTER-3**

**FUELS**

The following types of fuels are used for the production of heat energy.

a) Solid fuels E.g. Coal, Baggasse etc.,

B) Liquid fuels E.g. Diesel oil etc.,

C) Gaseous fuels E.g. Natural Gas etc.,

The heat energy of these fuels is converted into mechanical energy by suitable prime movers such as seam engines, steam turbine, internal combustion engines etc.,

**Fuel GCV**

1. Baggasse 3800 K.cal/kg
2. Imported coal 5200 K.cal/kg

**Methods of fuel firing:**

The solid fuels are fired into the furnace by the following methods.

* Hand firing
* Mechanical firing

**Hand firing:**

This is a simple method of firing Baggasse into the furnace. It is required no capital investment. It is used for smaller plants. This method of fuel firing is discontinuous process, and there is a limit to the size of furnace which can be efficiently fired by the method. Adjustments are to be made every time for the supply of air when fresh Baggasse is fed into furnace**.**

**Mechanical firing:**

In thermal power plant mechanical firing is used. The various advantages of stoker are as follows.

1. Large qualities of fuel can fed into the furnace. Thus greater combustion capacity achieved.
2. Poor grades of fuel can be burnt easily.

CHAPTER-4

**BOILER AND ITS AUXILLARIES**

The boiler is one of the most essential elements in thermal power stations. Essentially it consists of a closed vessel into which is put in it and heated until the water is turned into steam at the rated pressure. This steam is further heated in a super heater better than pressure and temperature and greater the efficiency.

**Types of boilers:**

**According the flow of water and hot gases:**

* Water tube
* Fire tube

**According to position of furnace :**

* internally fired
* externally fired

**According to the position of principle axis:**

* vertical
* horizontal
* inclined

**According to application:**

* stationary
* mobile(marine locomotive)

**According to the circulation of water:**

* Natural
* Forced

**According to steam pressure:**

* Low
* Medium
* High

In water tube boiler, water circulates through the tubes and hot products composition flow of these tubes

E.g. Babcock and Wilcox boiler

In fire tube boilers the hot products of combustion pass through the tubes which are surrounded

E.g. Cornish, Lancashire

Generally for pressure above 10 Kg/cm2 and capacities in excess 2Kg of steam per hour water tube boilers are used. Water tube boilers may available in many designs. But most familiar boiler is Babcock and Wilcox boiler.

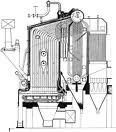
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Fig 4.1 TBW WATER TUBE BOILER

|  |  |  |
| --- | --- | --- |
| Evaporation (MCR) |  | 100TPH |
| Operating pressure |  | 86Kg/cm2 |
| Design pressure |  | 100Kg/cm2 |
| Final steam temperature |  | 515±̊̊5̊̊̊ C |
| Type of boiler |  | Spreader stoker fired |
| Type of boiler |  | Spreader stoker fired. |

**Table 4.1 specifications: Water tube boiler:**

**Water and steam circulation path:**

De mineralized water tank→ Dearator→ Feed water pumps→ Economizer→ Steam drums→ Bank tubes→ Mud drums→ Mud drums down comers→ Side heaters → Bed coils→ Water walls → Steam drums → Primary super heaterinlet header→ Primary super heater outlet header→ Secondary super heater inletheader→ Secondary super heater outlet header→ Main steam line→ Main steam line outlet →Turbine.

**Feed water suction:**

1. **Pump Suction piping:**

Deaerated water from the deaerator is connected to the suction of the feed pump through this piping. From the deaerator, water flows to the pumps suction header through the isolation valve. To avoid the entry foreign particles suction filters are provided before the inlet of each pump. Both pump suction piping are provided with pressure indicators.

1. **Discharge piping:**

Both boiler feed water pumps are connected to common discharge header through auto recirculation valves and discharge valves. Both pump discharge piping are provided with pressure indicator.

For feed water controlling purpose isolation valves are provided before and after the 100% feed control valves and additionally a bypass valve is also provided.

**Economizer**:

Lot of heat energy is going out of chimney with exhaust gases. This heat energy is utilized in an economizer to heat the feed water enters the boiler. Figure shows the green’s economizer which is mostly used with the Lancashire boiler.

Vertical tubes are connected with horizontal pipes. These tubes are made of cast iron. Scrapers are provided over the vertical tubes. These scrapers are providing over the vertical tubes to remove soot or carbon, that is form on the vertical tube. The scrapers are connected by the chains, which pass over pulleys as that one group of scrapers balances the adjustment group. The pulley is connected to the worm wheel which is driven shaft. As worm rotates the pulleys rotate and move the scrapers over the vertical tubes. Thus the vertical tubes are clean. The feed water enters at the bottom by opening the inlet valve. The water go up through the vertical tubes at the same time the exhaust gas, is observed the water inside the tubes. The hot water pass out of the tubes is collected in the sort chamber. As safety valve is provided at the opposite to the horizontal pipe to safe guard the economizer.

**Advantages of economizer:**

1. 50%to 20% coal is saved.
2. Rising of steam is quick.
3. Is saves time also
4. Scales will not form in the boiler. The scales may be formed only in economizer tubes.
5. As hot water enters the boiler there is no problem of thermal strain in the boiler plates.

**Air pre heater:**

The temperature of flue gases leaving the economizer is quite high and this heat can still be used in heating the air, which is supplied to the furnaces for combustion of fuel.

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**Fig 4.2 Air pre heater**

**Steam drum right hand side and left hand side connections and openings:**

Steam drum receives mixture of water and steam from the water walls penetrates through the riser tubes of the boiler drums.

The combination of water and steam flows through the demisters called primary scrubbers and secondary scrubbers and finally through the perforate sheets. In this

flow water which is heavier separated from steam and trickled down to with water in the drum

**Feed water connection:**  
 Uniform distribution of feed water in the entire steam drum.

**Continuous blow down pipe:**

It is used to maintain drum level uniformly.

**Chemical dosing pipe:**

It helps to maintain the required PH, phosphate in the boiler water.

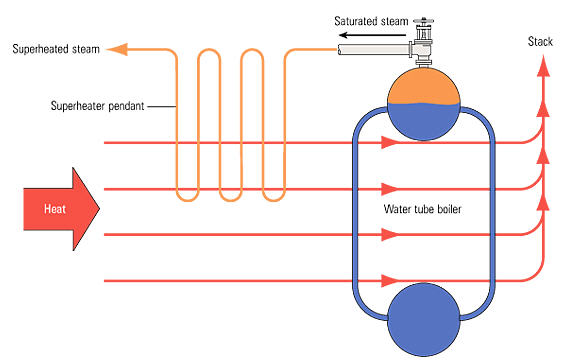
**Super heater:**

Super heater is a device to super heat the wet or dry steam. Wet and dry steam should not be used in a turbine as it under goes expansion in a nozzle and the dry steam becomes wet. This decreases the efficiency to the turbine plant.

It is shown in fig and is located in path of furnace gases so that heat is recovered from the hot gases. Such type of super heater is called convention super heater.

When a super heater is placed in one or more valve of the boiler furnace, where the super heater tubes receive heat by direct radiation is called RADIANT SUPER HEATER.

In large boilers a super heater may be an independent unit having it own furnace independently fired such type of super heater is known as portable super heater.



**Fig 4.3 Super heater**

**Main steam line:**

From the secondary super heater outlet header, the steam enters the maim steam line. In the main steam line main steam stop valve and this across bypass valve and start up vent is arranged.

1. Main stop valve for isolation
2. By pass valve, warming during initial charging of the steam line
3. Start up vent isolation valve is provided. It is used to maintain the steam flow through the super heater coils during boiler start up and low load conditions and during emergencies.

**NRV on main stream line:**

One NRV is provided on the main steam line. NRV will help to prevent back flow of steam mains to the boiler when the boiler trips or when the pressure is lower than that of the steam mains.

**Steam flow element:**

Steam flow element is provide in the main steam line for measuring the steam flow. Impulse lines with valves are provided and connected to the steam flow transmitter. A sample cooler is provided with suitable valve for analyzing the steam quality

**Function of condenser in a stem power plant:**

The purpose of steam condenser is to receive the exhaust steam from the turbine or steam engine, condense it and maintain at a pressure lower than atmospheric. Some extra work is obtained due to exhaust at a pressure lower than the atmospheric. This improves the efficiency of the power plant. Another advantage is that condensed steam can be recovered and this provides a source of good and pure feed water to the boiler. This performance of the condenser is judged by degree of vacuum and capability of producing high temperature condensate. A vacuum of 15to40 mm is maintained.

**Types of condensers:**

1. Jet condensers or contact condensers
2. Surface condensers

**Jet condensers:**

In a jet condenser the steam to be condensed mixes with the cooling water and the temperature of the condensate cannot be recovered for use as feed water to the boiler, heat transfer is by direct conduction. Jet type condensers in which steam and circulating water mixer are limited to small industrial application (1000Kw), where best vacuum are not required(50mmto125mm of Hg). These are low in cost not is used in modern power plants.

One of the types jet condenser is low level jet condenser are center flow type jet condenser.

**Surface condensers:**

In thermal power plants the primary purpose of surface condenser is to condense the exhaust steam from a steam turbine at as low as lower pressure as possible and obtain pure water (steam condensate). So that it may be pre used in the steam generator or boiler as boiler feed water.

The steam turbine itself is a device to convert the heat in system to mechanical work. Condensing exhaust steam of turbine at a pressure below atmospheric pressure, increases that enthalpy difference and therefore increases the work and output of the turbine.

**Draught:**

**The purpose of draught as follows:**

1. To supply required amount of air to the furnace for the combustion of fuel. The amount of fuel that can be burnt per square foot or grate area depends up on the quantity of air circulated to the fuel bed.
2. **To remove the gaseous products of combustion:**

Draught is defined as the difference between absolute gas pressure at any point in a gas flow passage and the ambient (same elevation) atmospheric pressure. Draught is achieved by small pressure difference which causes the flow of air or gas to take place, It is measured in millimeter of water.

**The various types of draught system as follows:**

1. Natural
2. Mechanical
3. Steam jet

**Natural draught:**

If only a chimney is used to create the necessary draught, the system is called natural draught system. The system is used if boilers of smaller capacities. Natural draught is created by difference in weight of column of cold external air and that of similar column of hot gases in the chimney. This system is dependent up on the height of chimney and average temperature of the gases in the chimney.

**Mechanical draught**:

In boilers large capacity fans are employed to create the necessary draught in order to reduce the height of chimney to obtain draught is independent of weather condition and to control the draught easily. This draught may be induced, forced or balanced draught.

**Stem jet draught:**

Steam jet draught may be induced or forced draught depending up on the location of steam jet producing the draught. Induced draught produced by steam jet system is used in locomotive boilers. Exhaust steam from the engine enters the smoke box through a nozzle to crackled draught. The air is induced through the flues. The grate and ash pit to the smoke box. A forced draught developed by steam jet. Steam from boiler is passed through a throttle valve, and its pressure being 1.5to 2 Kg/ cm2 gauge. Then the steam passes through the nozzle projecting in diffuser pipe. The steam comes out of the nozzle with great velocity and drags a column of air along with it thus allowing the fresh air to enter. The mixture of steam and air posses high kinetic energy gets converted in to pressure energy and thus air is forced through the furnace and flows to the chimney. This system requires less space and is economical. But it can be used if steam at high pressure is available.

**Dust collector:**

The various types of dust collector as follows:

1. Mechanical dust collectors.
2. Electrical dust collectors.

**Electrostatic precipitators:**

It has two sets of electrodes, insulated from each other that maintain an electrostatic field between them at high voltage. The flue gasses to pass between these two sets of electrodes. The electric field ionizes the dust particles that pass through it attracting them to the electrode of opposite charge. The other electrode is maintained at a negative potential of 30,000to60, 000 volts. The dust particles are removed from the collecting electrode by raping the electrode fine ash particles and are superior to that of any other type.

**Performance test of electrostatic precipitators**:

The performance or efficiency of ESP is obtained by carrying out source monitoring at inlet and outlet of the ESP.

The percentage efficiency of ESP=

CHAPTER-5

**TURBINES**

In turbines there are two types

1. Gas turbine
2. Steam turbine

Steam turbines are used in co-gen power plant. It is a prime mover in which the heat energy in the steam is converted in to kinetic energy and kinetic energy is absorbed by the turbine blades to rotate the shaft while steam flowing through the turbine.

**Table5.1 specifications of turbines:**

|  |  |
| --- | --- |
| Power (kw) | 20 MW |
| Inlet steam pressure | 86 Kg/cm2 |
| Exhaust steam pressure | 0.1Kg/atm |
| Inlet steam temperature | 510⁰c |
| Turbine speed | 6234 rpm |
| Alternator speed | 1500 rpm |
| Trip speed range | 6700-6800 rpm |

**Classification of steam turbines:**

Steam turbines are classified as shown below

A) According to the action of steam

1 ) Impulse turbine

2) Reaction turbine

3) Impulse reaction turbine

B) According to the steam flow

Axial flow turbine steam flow in a direction parallel to the axis of turbine, radial flow turbine steam flows in a direction perpendicular to the axis of turbine

C) According to the exhaust conditions of turbine

1. Condensing turbines-Steam at a pressure less than atmosphere is exhausted into the condenser

2. Non condensing turbine pressure of exhaust steam is greater that the atmosphere

D) According to initial conditions

1. Low pressure (1.2 to 2 bar)

2. Medium pressure (up to 40 bar)

3. High pressure (above 40 bar)

E) According to the number of stages

1. Single stage

2. Multi stage

F) According to use

1. Stationary turbine used in power plants, and for driving turbo blowers and pumps

2. Non stationary turbines used to drive ships and steamers

**Impulse turbines:**

There is only one set of nozzles and two or more rows of moving blades. There is row of fixed blades in between the moving blades. The function of fixed blades is to direct the steam coming out from first moving row to the next moving row. The kinetic energy of the steam gained is the nozzles is successively used by the row of moving blades and finally exhausted. This is also known as velocity compounded steam turbine.

In thermal power plant, impulse reaction turbine is used. Speed of this turbine is 6234 rpm. This turbine is used in three stages. Steam pressure is of 86 Kg/cm2 and steam temperature is of 510⁰C.

**Reaction turbine:**

In this arrangement the turbine is provided with one or two of fixed plates(works as nozzles) at the entrance of each row of moving blades.

As the pressure gradually decreases the volume of steam gradually increases therefore the blade height has to be increased towards the low pressure side.

**Impulse reaction turbine:**

This turbine is a combination of impulse and reaction turbines. The total pressure drop of the steam from boiler to condenser pressure is divided into number of stages are done on pressure compounding and velocity obtained in each stage is also compounded.

This type of arrangement is required less stages and compact turbine can be designed for a given pressure drop.

CHAPTER-6

**SYNCHRONOUS GENERATOR**

A synchronous machine which generates alternating current is called synchronous generator or AC generator or alternator.

**Working principle of synchronous generator:**

When the rotor winding of an alternator is supplied by excitation, produces north and south poles. The flux produced by the rotor is steady flux or constant flux. The rotor rotates by an external prime mover to a particular speed. The constant flux produced by the rotor passes through the air gap and links with the conductor available in the inner periphery of the armature.

According to Faraday’s law of electromagnetic induction EMF is induced in the armature conductor. This induced EMF is alternating in nature because alternatively the armature conductor faces north and southpole and direction of induced EMF is given by Fleming’s right hand rule. Hence the working principle of an alternator is based on Faraday’s law of electromagnetic induction.

**Table 6.1 name plate details of alternator:**

|  |  |
| --- | --- |
| Out put | 25000 KVA |
| Number of phases | 3 |
| Number of poles | 4 |
| Voltage | 11000 V |
| Current | 1312 A |
| Frequency | 50 Hz |
| Speed | 1500 rpm |
| Limiting Speed | 1800 rpm |
| Power factor | 0.8 |
| Type of Stator connection | Star |
| Excitation Voltage | 251 V |
| Excitation current | 629 A |

**Construction:** This machine is characterized by small diameter more axial length with uniform air gap throughout the periphery.

A synchronous generator consists of two main parts:

Stator or armature

Rotor



Fig 6.1 Synchronous generators

**Stator:**

It is a stationary part of the machine. It is called armature. The stator consists of the yoke core and stator winding and parts of enclosure. The slots of stator core accommodate a double layer coil winding for carrying more current. The core is made up of silicon steel lamination in order to reduce eddy current loss.

The stator carries three phase winding which was always star connected with neutral is grounded. The star connection is either advantage that all the third harmonics are eliminated from line voltage. The star point leads ABC can be arranged in the form of an open star point inside the outer casing. The terminal ABC is installed in a terminal board.

**Rotor:**

The rotor consists of shaft, the rotor core, field winding, the damper winding, the fans, the slip rings (if provided) or the rotor of the brush less exciter. It has a cylindrical core. The shaft transmits the torque to the machine. The rotor is carried by two bearings. The field winding is inserted in the slot groups of the rotor core , connected and linked to the terminals of direct coupled exciter by leads run through the hallow shaft. The bars of damper winding are driven into slots at the periphery of the core and are connected to end disc either end.

**Bearings:**

The rotor runs in two floating type guide bearings, designed as pedestal bearings, with forced oil or the bearings of self aligning type. The end bearing is secured to the base frame and insulated with the later. All the connections arranged to prevent short circuiting of the insulation.

**Enclosure:**

The enclosure consists of inner and outer compartments. The inner compartment comprise the winding shields which form an angular enclosure of the end turns of the stator winding and are also used as air guides. The outer enclosure is designed as required for the particular degree of protection. The ventilating circuit is of the double ended symmetrical arrangement.

**Excitation:**

Depending on the service condition involved, the synchronous machine may be excited from a “THYRIPART excitation system”, a rotating exciter(E.g.: Brushless exciter system) or another external excitation system. If a brushless is employed, the excitation power is supplied to the field circuit through rotating rectifier and through brush and slip rings with all the other

Excitation system .If brushless is employed, the excitation power is supplied to the field circuit through the rotating brushless assembly and slip rings with all the other excitation system.

**Base frame:**

The base frame carries stator, the bottom section of the outer casing, the sleeve bearings and the exciter. The base frame transmits the forces occurring in the machine to the foundation. Depending on the mounting condition at the site, base frame is installed on sole plates on a steel foundation by means of anchoring elements.

**Accessories:**

The fixing accessories include shims and leveling plates, various instruments for measuring temperature and pressure fittings, Space heaters and anchoring accessories.

CHAPTER-7

**BRUSHLESS TYPE EXCITER**

In **M/S NCS Sugars limited, 20 MW Co-GEN** Plant brush less type exciter is used. The excitation is controlled by voltage regulator.

**Table 7.1 specifications of brush less exciter:**

|  |  |
| --- | --- |
| Excitation amps | 19.1 amps |
| Excitation volts | 76 volts |
| Connection | Y |
| Output power | 191KW |
| Voltage | 276V |
| Current | 692A |
| Enclosure systems | 1P54 |
| Cooling system | IC 01 |
| Class of INS | F |
| Standard | IS:4722 |

**Construction**:

The rotor is mounted over hung on the shaft of the main machine. The stator may be fixed to the either to the base frame of the main machine or to a separate steel or concrete foundation.

A permanent magnet three phase pilot exciter driven directly by the common shafting or a static auxiliary excitation is used to for exciting the field of the stationary field generator via voltage regulator. The three phase current flowing in the rotor winding is rectified by the silicon diodes in the rotating rectifier and fed into the field winding of the main machine via the excitation loads which passes through the hallow shaft of the main machine.

**Rotor:**

The rotor hub is of welded construction and carries the laminated core which is compressed axially by means of a clamping ring welded to a hub. Specially shaped supporting elements for the rotating rectifier modules are welded between the arms of rotor spider within the ring formed by the laminated core. Three phase rotor winding inserted in the slots of the laminated core is connected in star. It is a two layer winding to insulation of class F. This winding is impregnated with epoxy resin. The rectifier accommodated inside the rotor core winding comprises six diodes assembly and the protection circuit.

**Stator**:

The stator frame of the brush less exciter consists of a rolled yoke ring with welded on mounting. The pole pieces carrying the exciter ending are bolted to the inside of the yoke ring. The coil wound on the pole pieces are of insulated copper wire and impregnated with resin. They are connected in series in such a way that the ends leads of the north pole are crossed over while those of south poles are un crossed. The excitation end leads are the lead to the terminal box. An earthen terminal is provided on the stator frame at a point below the terminal box.

The brush less exciter uses closed circuit cooling and the ventilation is provided by tapping from generator. Cooling is must needed for the exciter to overcome the thermal stability. Depending on the degree of the protection of the machine, the end shields have either ventilating slots or welded on connection pieces for ventilating ducts or for air circulating. The stator spider is provided with openings permitting the passage of cooing air past the rectifier heat sinks and also over the bus rings together with the varistors and the carrier storage effect circuit. To intensify the cooling air circulation an additional fan impeller can be screwed on to the end clamping ring.

**Generator field flashing:**

Generator field flashing is required when generator voltage does not build up and the generating system (including the voltage regulator) does not have field flash capability. This condition is usually caused by insufficient residual magnetism in the exciter and generator fields. In some cases, a generator that has been out of service for an extended period may loose its residual magnetism and require flashing. Residual magnetism can be conductor components may be induced in the voltage regulator. Perform field flashing according to he manufacturer’s instruction to avoid equipment damage.

CHAPTER-8

**PROTECTION OF ALTERNATERS AND TRANSFORMERS**

It is desirable and necessary to protection to cover the wide range of faults which may occur **in** the modern generating plant.

**Protection of alternators:**

**Stator side protection:**

1. Voltage restrained over current protection**:**

When an over current fault occurs , due to higher current levels there would be drop in terminal voltage. For the same fault impedance, the fault current will reduce(with respect to terminal voltage) to a level below the pickup setting. Consequently normal IDMT may not pickup. It is necessary to have a relay whose pickup setting will automatically reduce in proportion to terminal voltage. Hence over current protection is required low set and high set.

1. Thermal over load:

The protection is must-it monitors thermal status of machine currents between 105% to the low set O/C level (normally 150%). This protection is done by using RTD’s in stator.

1. Negative phase over current :

Generators are expected to feed un balanced loads whose level has to be monitored. If the un balance exceed 20%, it may cause over heating of the windings. This heating will not be detected by the thermal over load relay-since the phase current will be well with in limits. A two level monitoring for unbalanced is preferred –first level for alarm and second level for trip.

1. Loss of excitation:

When the excitation is lost in running generator, it will draw reactive power from the bus and get over heated. This condition is detected from the stator side CT inputs by monitoring the internal impedance level and position of the generator

1. Reverse power:

Generator of this size may operate in parallel with other sources, which may cause reverse power flow at certain time. When the reverse power happens, the generator along with the prime mover will under go violent shock; hence reverse power production is absolute must.

1. Under power:

It may not be economical to run generators below a certain load level. This production will monitor the forward power delivered by the machine and give alarm when the level goes below a set point.

**7**. Under/over voltage:

This will protect the machine from abnormal voltage levels, particularly during synchronization and load through off conditions.

1. Under/over frequency:

This will protect the machine from abnormal frequency levels, particularly during synchronization and load through off conditions. This will also help in load sheddig schemes for the generator.

1. Breaker failure protection:

This protection detects the failure of breaker to open after receipt of trip signal. Another trip contact generated under break fail conditions, with which more drastic measures can be taken.

1. Stator earth fault:

This protection detects the earth fault due to failure of insulation in between phase and ground. To avoid a serious damage from this fault relay can be used.

1. Differential protection:

This protection is very important-since the machine of this size have protected from severe damage that may occur due internal faults.

Consider the larger power levels, it is necessary to have a percentage biased, low impedance differentiate relay.

* It provides percentage biased differential with dual slope characteristics.
* It has a built in REF protection element, which will monitor the generator for internal earth faults.
* It has a built in O/C protection, as a backup.

1. PT fuse failure protection:

This relay will detect any blowing of PT secondary fuse and give a contact which can be used to block the under voltage trip.

1. Over current:

This relay is used to give alarm for a continuous over current occur below the set point of voltage restrained over current relay.

1. Inadvertent breaker closure:

This will avoid closing of generator to bus during coasting to stop or when standstill or before synchronization.

**Rotor side protection:**

1. Rotor excitation under current: This is a DC under current relay,which will monitor the excitation current.
2. Rotor excitation under voltage: This is a DC under voltage relay, which will monitor rotor voltage.
3. Diode failure relay: Brushless excitation system will have rotor mounted diode, which can become short or open during operation. Diode failure relay will monitor the condition of these diodes, for both open and short circuit and give alarm.
4. Rotor earth fault: Relay will monitor the rotor winding status for the earth fault.

**Table 8.1 Ratings of power transformer** with on load tap changes

|  |  |
| --- | --- |
| No of phases | 3 |
| Rated power | 25000KVA |
| Rated voltage | 132KV |
| Rated frequency | 50Hz |
| Cooling | ONAN |
| Setting position | OUTDOOR |
| Temperature rise of oil above ambient | 50k |
| Temperature rise of winding above ambient | 55k |

|  |  |
| --- | --- |
| No of phases | 3 |
| Rated power | 2500KVA |
| Cooling method | ONAN |
| Rated voltage | 11KV/.433KV |
| Tapping range | ±2\*2.5% |
| Rated current | 131.2A/3333A |
| Impedance | 7.32% |
| No load loss | 2.657KW |
| Load loss | 24.780KW |
| Rated frequency | 50 Hz |
| Temperature rise of winding | 53.3k |
| Temperature rise of oil | 46.8k |

Table 8.2 Distribution transformer Table 8.3 Converter transformer

|  |  |
| --- | --- |
| No of phases | 3 |
| Rated power | 2500KVA |
| Cooling method | ONAN |
| Rated voltage | 11KV/.433KV |
| Tapping range | ±2\*2.5% |
| Rated current | 131.2A/1667A |
| Impedance | 4,78% |
| No load loss | 1,779KW |
| Load loss | 22.613KW |
| Rated frequency | 50 Hz |
| Temperature rise of winding | 50K |
| Temperature rise of oil | 45K |

**Protection of transformer:**

Transformer is a static device totally enclosed and generally oil immersed. Therefore chances of faults occurring on them are very rare. Mostly power transformers may suffer only from:

Open circuits:

This condition is relatively harm less on the occurrence of such fault the transformer can be disconnected manually from the system.

Over heating:

Over heating of the transformer is usually caused by sustained over loads are short circuits and very occasionally by the failure of the ONAN(oil natural air natural) cooling system .

1. Winding short-circuits:

It is also called as internal faults on the transformer arise from deterioration of winding insulation due to over heating or mechanical injury.

**Fuses:**

**Necessity:**

The function of a fuse is to protect the electrical apparatus when fault current flows. It is the cheapest form of protection against excessive currents.

**Description:**

It consists of a thin wire of low melting point under normal operating condition. It can with stand up to certain temperature. When the current above its rating flows the fuse metal cannot withstand the heavy current and blows off. So a fuse must be designed to such a capacity. So that it can carry the normal currents safely without melting.

**Types of fuse materials:**

Tin and lead are mostly used fuse materials because

1. they should have low melting point
2. free from oxidation
3. low cost

**Types of fuses:**

1) For high voltages

a) Cartridge fuse

b) Liquid type

c) Metal clad fuse

2) For low voltages

a) semi enclosed rewirable fuse

b) H.R.C. fuse

c) H.R.C. fusewith tripping device

**Reactors:**

**Necessity:**

When a short circuit occurs on a system heavy current flows. To limit this current to safe value reactors or current limiting reactors are used.

**Construction:**

The reactors usually of bare standard copper coils of large size are embedded in a number of specially shaped concrete slab and these coils are wound for high self inductance and very low resistance as the resistance is small the losses are less. According to the location these are used.

**Circuit breaker**

**Necessity:** Circuit breakers are mechanical devices designed to close/ open an electrical circuit under normal/ abnormal conditions. A circuit has a similar function to that of a fuse when fault current flows the fuse melts and opens the circuits thus protects the equipment from damage. But only the disadvantage is it takes a long time for replacement of fuse and also it is unsuitable for high voltage circuits due to this disadvantage the fuse is not is used in high voltage circuits. These draw backs are over come by the circuit breaker. Circuit breakers consists mainly fixed contacts and moving contacts.

**Classification of circuit breakers:**

The circuit breakers are generally classified on the basis of arc extinguishing.

They are:

1) Oil circuit breaker

2) Air blast circuit breaker

3) SF6 circuit breaker

4) Vacuum circuit breaker

**Oil circuit breaker:**

In This type circuit breaker oil is used as an insulating medium for arc quenching. The contacts are open under oil. As the contacts are opened an arc established between them, due to this heat is generated and evaporates the surroundings oil and dissolves it into substantial volume of gases hydrogen at high pressure. Due to the hydrogen gas the oil is pushed away from the arc.

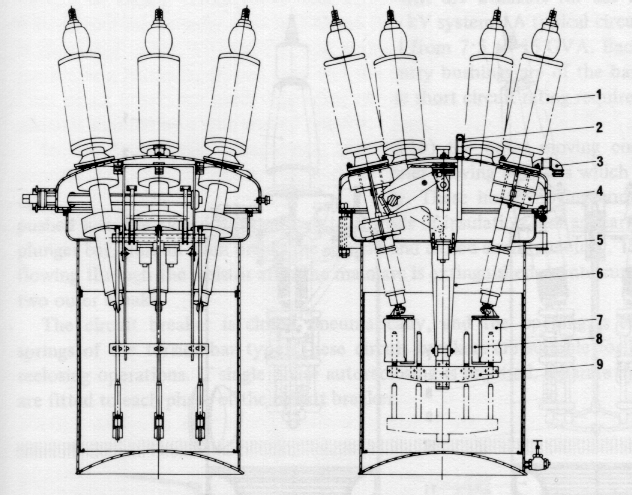


Fig 8.1 Oil circuit breaker

**Air blast circuit breaker:**

This type of circuit breakers employs air as an insulating media for arc extinction it consists of a valve provided at the top when the fault current flow the moving contacts move away from the fixed contacts and at the same time valve opens and air rushes insideAnd cools the arc which is produce due to separation of contacts.

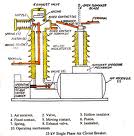


Fig 8.2 Air blast circuit breaker

**Sulpher hexa fluoride (SF6)circuit breaker**:

SF6 consists of fixed and moving contacts enclosed in a chamber consists of SF6 gas. SF6 gas is electro negative gas and has strong tendency to absorb free electron. Lesser the electrons lesser the current and lesser the arcing produced. Still the electrons are absorbed by SF6 less current is produced and the arc is very less. When the fault current flows the valve opens and the SF6 absorbs the electrons.

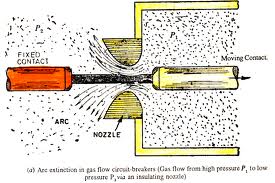


Fig 8.3SF6 Circuit breaker

**Vaccum circuit breaker:**

In this type of circuit breaker vacuum is used as an insulating medium for arc quenching. The contacts are separated with vacuum. When heat generated during arc quenching are absorbed by vacuum. The vacuum absorbs the electrons

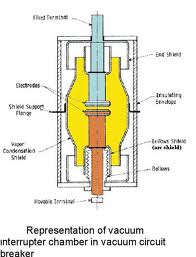


Fig 8.4Vaccum circuit breaker

**Protective relays**

Relay is a piece of apparatus used for protecting high voltage circuits in place of fuse in substations.

**Definition**: it is device that detects the fault and initiates the operation of a circuit breaker to isolate the defective element from the rest of the system.

**Short circuit occurs due to these conditions:**

1) Over voltage due to switching and direct lightning

2) Bridging of conductor by birds

3) Break down of insulation

4) Mechanical damage

**Basic requirements of protective relaying:**

1) Selectivity

2) Sensitivity

3) Speed

4) Reliability

5) Simplicity

6) Economy

**Classification of relays:**

a) On the basis of construction and principle of operation

1) Electromagnetic relay 2) induction relay

3) Electro thermal relay 4) Physio electric relay

5) Static relays 6) Electro dynamic relay

b) On the basis of time of operation

1) Instantaneous relays 2) definite time lag relays

3) Inverse time lag relays 4) inverse definite minimum time lag relay

**Operation:** when fault occurs in transmission wire the protective relay connected to the CT actuates and closes its contacts. Current flows from the battery in the trip circuit. As the trip coil gets energized, the circuit breaker operating mechanism is actuated and it operates for the opening operation, under normal condition circuit breaker contacts will be closed

Mostly used relays are for AC induction relay and for DC&AC electromagnetic relays.

**Relay protection:**

When a fault occurs in a power transformer, the damage will be proportional to the fault clearance time. The power transformer therefore must be disconnected, as quickly as possible. It is of at most important that quick and reliable protection relays are used to detect faults and initiate tripping. Monitors at the power transformer can also be used for detecting the abnormal condition which may develop into a fault. Transformer with oil conservators usually is equipped with the following protection and monitoring.

Transformers larger than 5MVA

1) Pressure guard (Buchholz relay)

2) Over load protection

3) Over current protection

4) Earth fault protection

5) Differential protection

6) Pressure relay for tap changer compartment

7) Oil level monitor

Transformers smaller than 5MVA

1) Pressure guard (Buchholz relay)

2) Over load protection

3) Over current protection

4) Earth fault protection

The principle relays and systems used for transformer protection are:

**Buchholz relay:**

In case of incipient faults within the transformer, the heat due to fault causes the decomposition of some transformer oil in the main tank. The products of decomposition contain more than 70% of hydrogen gas. The hydrogen gas being light to go into the conservator and in the process gets entrapped in the upper part of relay chamber. When a pre determined amount of gas gets accumulated, it exerts sufficient pressure on the float to cause it to tilt and close the contacts of mercury switch attached to it. This completes the alarm circuit to sound an alarm.

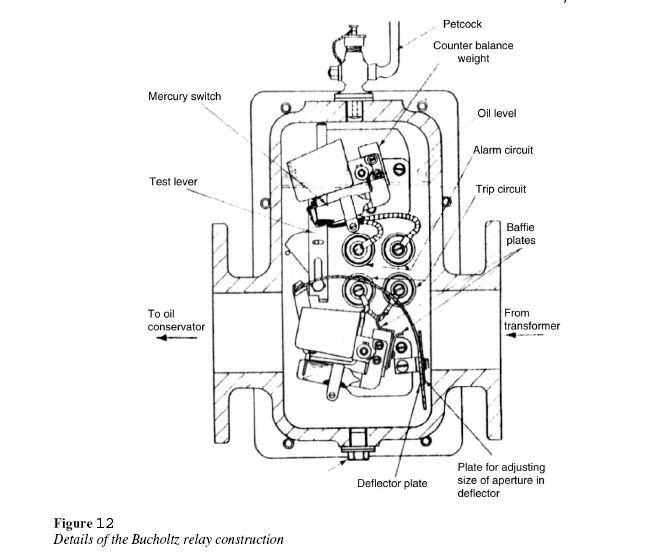


Fig 8.5 Buchholz relay

If a serious fault occurs in the transformer, an enormous amount of gas is generated in the main tank. The oil in the main tank rushes towards the conservator via the buchholz relay and in doing so tilts the flap to close the contacts of mercury switch. This completes the trip circuit to open the Circuit Breaker controlling the transformer.

**Earth fault relays:**

Providing protection against earth faults only

The fault statistic shows that earth faults are the dominating fault type and therefore the earth fault protection is of main importance in network. The type of earth fault protection used is dependent of the system ear thing principle used. In the effectively earthed systems all the transformers are normally connected to earth and will thus feed earth fault current to the fault

**Restricted Earth fault**  **protection (REF):**

For solidly earthed systems a restricted earth fault protection is often provided as a compliment to the normal transformer differential relay. The advantage with the REF is their high sensitivities. Sensitivities are 2-8% can be achieved. The level is dependent of the current transformer magnetizing currents where as the normal differential relays will have sensitivities of 20-40%

Restricted earth fault relays are also very quick due to the simple measuring principle and the measurement of winding only. The differential relay requires percentage through fault and second harmonic inrush stabilization which always limit the minimum operating time.

The connection of a REF is shown in figure it is connected across each transformer winding in the figure

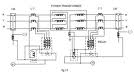


Fig 8.6 Earth fault relay

Over current relay**:**

Providing protection mainly against phase to phase faults an overloading

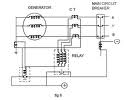


Fig 8.7 Over current relay

**Differential systems or circulating current systems:**

Providing protection against both earth and phase faults the complete protection of transformers usually requires the combination of the systems

Inter winding faults (short circuits) and ground faults with in power transformers can be detected by this protection scheme. Failure to detect these faults and quickly isolate the transformers may cause serious damage to the device. A differential relay is basically an instantaneous over current relay that operates on the difference of current flowing into and out of protected zone. A differential is basically an instantaneous over current flowing and out of protected zone.

**Operation:**

When ever any fault occurs externally to the protected zone, current flowing through the C.Ts will be equal and opposite then the current flows through the relay is zero. So, the relay does not operate. If at all any fault occurs internally to the protected zone ,then the both currents will be in same direction. So, they will be added therefore the resultant will flows through relay. Now the relay will operate.

CHAPTER-9

**CONCLUSION**

Thus detailed study on the over view of co-gen power plant helps in increasing the contribution of power plant in the country’s total energy production.