NORTH EASTERN ELECTRIC POWER CORPORATION LIMITED

(A GOVERNMENT OF INDIA LIMITED)

A Govt. of India Enterprises

PROJECT REPORT

SUBMITTED BY: SHASHWATA DATTA

BRANCH- ELECTRICAL ENGINEERING (2021-2025)

ENROLLMENT NO.-21UEE120

NATIONAL INSTITUTE OF TECHNOLOGY, AGARTALA

ACKNOWLEDGEMENT

I would like to express my gratitude to **Er. Milton Das, Head of the Department, EC&I Wing,** without whose permission and wise counsel and able guidance it would have not been possible to pursue my Training in this manner.

I am very grateful **Er. Animesh Das, Manager (E/M), EC&I Wing,** for providing academic inputs, guidance and encouragement throughout the Training Period.

I would also like to thank all officer/officials who guided and helped me at each and every step in the online training programme.

Yours faithfully,

(Shashwata Datta)

(21UEE120,EE,NIT AGARTALA)

Date: Place: NEEPCO AgGBPS

AGARTALA GAS BASED POWER STATION

(NEEPCO, AgGBPS)

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CERTIFICATE

This is to certify that **Mr. Shashwata Datta**, 3rd year studying Electrical Engineering at **National Institute of Technology, Agartala** has successfully completed his winter training from ***North Eastern Electric Power Corporation, Limited, AgGBPS*** from **1st December 2023 to 15th December 2023**. During this period his work was found good and satisfactory. He was found to be sincere, hardworking and has the potential to be a good executive.

Training Co-ordinator ***Mentor***

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ABSTRACT

I have undergone in-plant training in AgGBPS (Agartala Gas Based Power Plant) NEEPCO, where I learnt many things theoretically as well as practically.

As we know, the field of fossil fuel-based technologies, natural gas combined cycle (NGCC) power plant is currently the best position for electricity generation, having an efficiency close to 60%. Since this type of power plant is new for me, I got an exposure to it. I learned the working of various types of machines like Turbines, Generators, Boilers etc.

This training provided me with the much-needed industrial exposure and will definitely be helpful in coming years.

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INTRODUCTION TO AGGBPS, NEEPCO

'North Eastern Electric Power Corporation Limited (NEEPCO) is a schedule -A 'MINI RATNA 'Category-1 Central public sector Enterprise owned by the Government of India under the Ministry of Power, formed on 2 April 1976 to plan, investigate, design, construct, generate, operate and maintain power stations in the North Eastern Region of the country.

It has 60% of total installed capacity of North East region, which is 1347 MW. NEEPCO is embarking on a plan to generate at least 1500 MW power from non-conventional sources of energy, especially by tapping solar power and wind in the next five years. With it headquarter in the charming town of Shillong, the capital of Meghalaya, NEEPCO is a power sector enterprise with its plants in various states of North East India. The various projects of NEEPCO are

Sl.	Plant Name	Installed Capacity (MW)	CoD
1	Khandong Power Station	2X25=50	04.05.1984
2	Kopili Power Station	4X50 =200	12.07.1997
3	Kopili Stage II	1X25 =25	26.06.2004
4	Doyang HEP	3X25 = 75	08.07.2000
5	Ranganadi HEP	135X3=405	12.04.2002
6	Tuirial HEP	2X 30 MW= 60	NA
		Sub Total (Hydro)	**815**
6	AGBP	6X33.5+3X30= 291	01.04.1999
7	AgGBPS	4X21+2X25.5= 135	01.09.2015
8	TGBP	65.42+35.58 = 101	31.03.2017
		Sub Total (Thermal)	**527**
9	5 MWp Grid Interactive Solar PV Power Plant, Monarchak, Tripura	5	04.02.2015
		Sub Total (Solar)	**5**
		GRAND TOTAL	**1347**

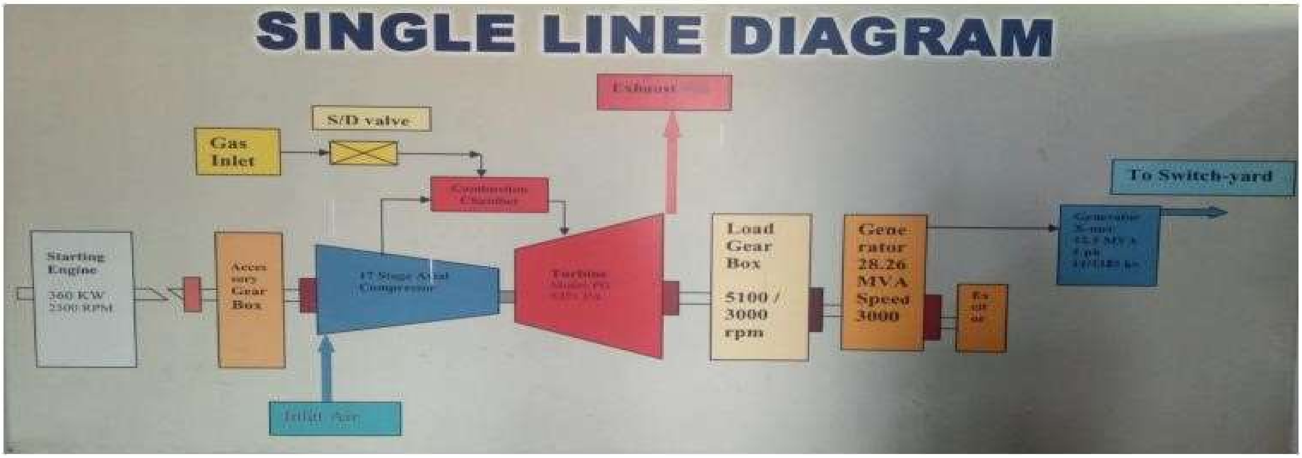
AGARTALA GAS BASED POWER STATION

This 135 MW (4 x 21 MW + 2 x 25.5 MW) Combined Cycle Power Plant is divided into 2 parts among which one consist of Gas Turbine power plant of (21 X4) MW and the other part consist of Steam Turbine power plant of (25.5 X 2) MW which is located in Ram Chandra Nagar, Agartala, Tripura (West).

The four Gas Turbines of 21 MW each of European Gas Turbine make operating on natural gas obtained from the gas fields of M/S ONGC at Tripura. The Project was financed through the budgetary support of the Government of India and partially through external commercial borrowings from the Deutsche Bank, Germany. The Project was completed in 1997-98 at a cost of Rs.322.55 Crores with a 50:50 debt equity ratio.

The plant has been converted to combined cycle power plant with installation & commissioning of 4 Nos. HRSG of Thermax make and 2 Nos. Steam turbine of Siemens make of capacity 25.5 MW each. The project was financed through internal resource and external commercial borrowings from SBI, Singapore with 30:70 debt equity ratio.

The plant is presently running as a combined cycle unit with 2 (two) modules consisting of two Gas Turbines, two HRSGs and one Steam Turbine in each module.



FEATURES:

Name: AGARTALA GAS BASED POWER PLANT
Capacity: 135 MW (4 x 21 MW + 2 x 25.5 MW)
Location: Ramchandra Nagar, TRIPURA (WEST)

Date of Commissioning:	GTG # I	6-February-1998
	GTG # II	25-February-1998
	GTG # III	29-March-1998
	GTG # IV	26-June-1998
	STG # I	01-September-201
	STG # II	29-July-2015

Beneficiary States: Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura.

Technical Features:

Type of Fuel: Natural Gas
Gas Turbine Type: Frame V
Gas Turbine Generator Type: T 600
Evacuation System: 3 Nos 132 kV feeder (2 Agartala, 1 Kumarghat).

COMBINE CYCLE POWER PLANT

Introduction:

Combined cycle is a characteristic of a power producing engine or plant that employs more than one thermodynamic cycle. Heat engine are only able to use a portion of the energy of their generation usually less than 50%. The remaining heat from combustion is generally wasted. The combining of two or more cycle such as **Brayton cycle** and **Rankine cycle** results in improved overall efficiency. In a combined cycle power plant (CCPP) or combined cycle gas turbine (CCGT) plant, as gas turbine generator generates electricity and waste heat is used to make steam to generate additional electricity via a steam turbine, this last step enhances the efficiency of electricity generation. As a rule, in order to achieve high efficiency, the temperature difference between the input and output heat levels be as high as possible. This is achieved by combined the Brayton (gas) and Rankine (steam) thermodynamics cycle. The energy efficiency of modern combined cycle power plants is in the range of 50 – 62%.

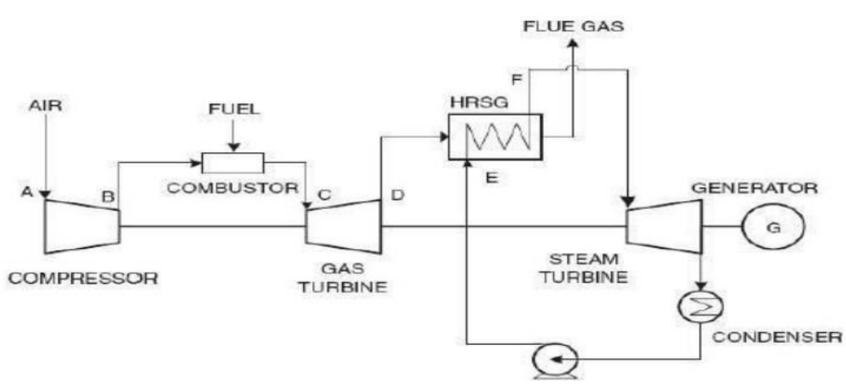


Fig: Schematic Diagram of a Combine Cycle Power Plant.

A general over view of combined cycle power plant:

Energy distribution in CCPP: Energy flow diagram below shows the distribution of the entering energy in to its useful component and the energy losses which are associated with the condenser and stack losses. This distribution will vary some with different cycle as the stack losses decreased with more efficient multi-level pressure heat recovery steam generating (HRSG) units.

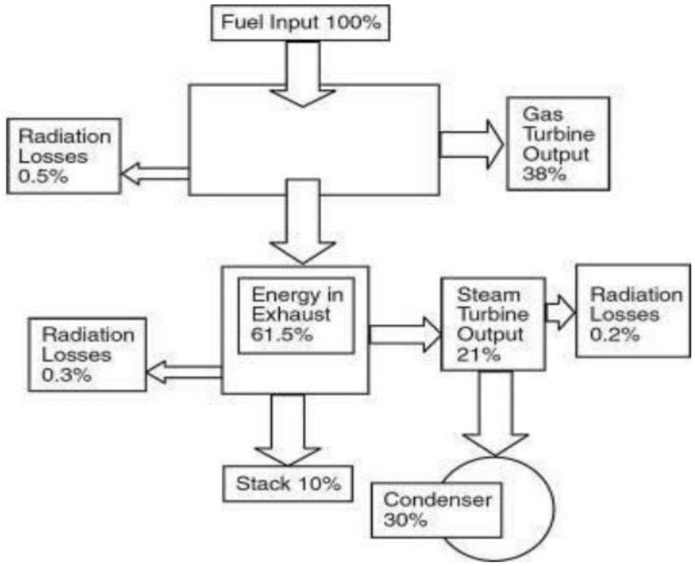
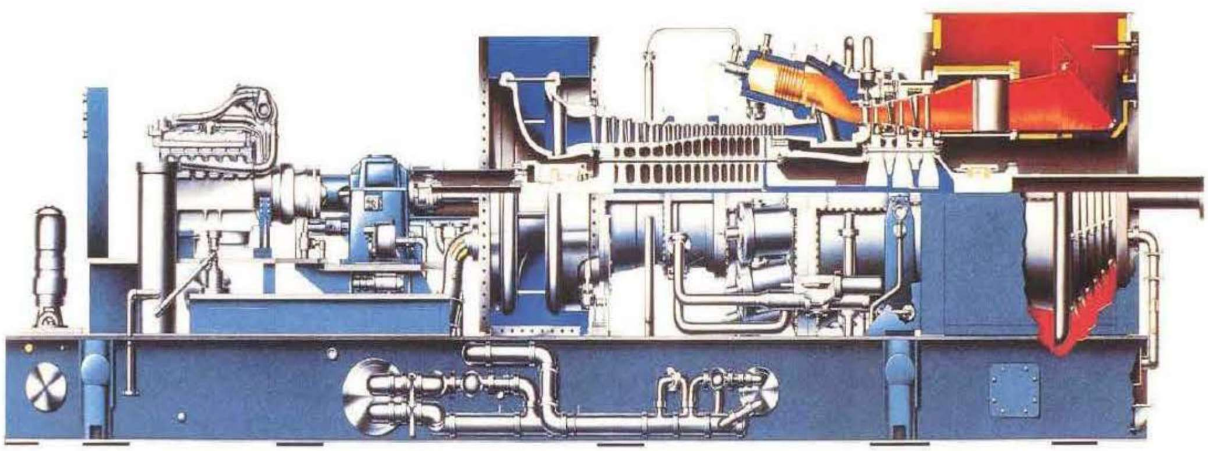


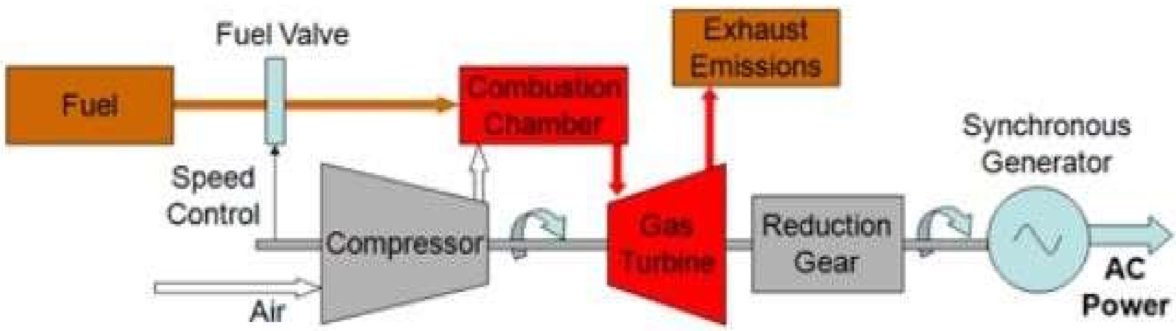
Fig: Energy distribution in a combined cycle power plant

GAS TURBINE



Gas Turbine Working Principle:

Gas turbine engines derive their power from burning fuel in a combustion chamber and using the fast-flowing combustion gases to drive a turbine in much the same way as the high-pressure steam drives a steam turbine.



Gas Turbine Electric Power Generation

One major difference however is that the gas turbine has a second turbine acting as an air compressor mounted on the same shaft. The air turbine (compressor) draws in air, compresses it and feeds it at high pressure into the combustion chamber increasing the intensity of the burning flame.

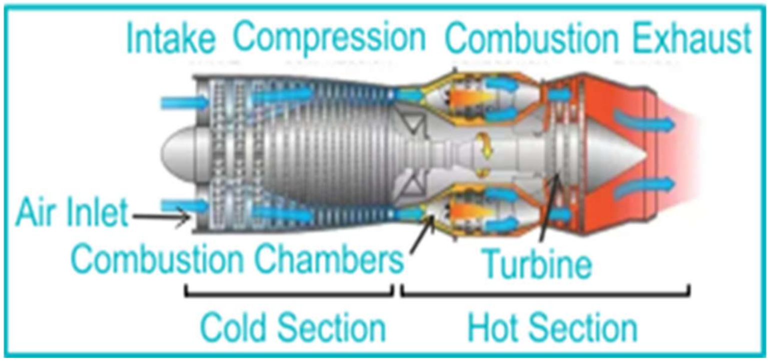
Fig: Gas Turbine at AgGBPS

As the gas turbine speeds up, it also causes the compressor to speed up forcing more air through the combustion chamber which in turn increases the burn rate of the fuel sending more high-pressure hot gases into the gas turbine increasing its speed even more. Uncontrolled runaway is prevented by controls on the fuel supply line which limit the amount of fuel fed to the turbine thus limiting its speed. The thermodynamic process used by the gas turbine is known as the Brayton cycle. Analogous to the Carnot cycle in which the efficiency is maximised by increasing the temperature difference of the working fluid between the input and output of the machine, the Brayton cycle efficiency is maximised by increasing the pressure difference across the machine. The gas turbine is comprised of three main components: a compressor, a combustor, and a turbine. The working fluid, air, is compressed in the compressor (adiabatic compression - no heat gain or loss), then mixed with fuel and burned by the combustor under constant pressure conditions in the combustion chamber (constant pressure heat addition). The resulting hot gas expands through the turbine to perform work (adiabatic expansion). Much of the power produced in the turbine is used to run the compressor and the rest is available to run auxiliary equipment and do useful work. The system is an open system because the air is not reused so that the fourth step in the cycle, cooling the working fluid, is omitted.

Fig: Power Generation of gas plant at AgGBPS

ABOUT GAS TURBINES AND IT'S PARTS

1) STARTING OF GAS TURBINES:



In order to generate electricity, the gas turbine heats a mixture of air and fuel at very high temperatures, causing the turbine blades to spin. The spinning turbine drives a generator that converts the energy into electricity.

The gas turbine can be used in combination with a steam turbine in a combined-cycle power plant to create power extremely efficiently.

1. Air-fuel mixture ignites:
The gas turbine compresses air and mixes it with fuel that is then burned at extremely high temperatures, creating a hot gas.

2. Hot gas spins turbine blades:
The hot air-and-fuel mixture moves through blades in the turbine, causing them to spin quickly.

3. Spinning blades turn the drive shaft:
The fast-spinning turbine blades rotate the turbine drive shaft.

4. Turbine rotation powers the generator:
The spinning turbine is connected to the rod in a generator that turns a large magnet surrounded by coils of copper wire.

5. Generator magnet causes electrons to move and creates electricity:
The fast-revolving generator magnet creates a powerful magnetic field that lines up the electrons around the copper coils and causes them to move. The movement of these electrons through a wire is electricity.

2) AUXILIARY:

In a gas turbine power plant, the auxiliary motor typically refers to an electric motor that serves various functions in the system. Its role is to support and facilitate the operation of the gas turbine. Some of the common functions of the auxiliary motor before the turbine in a gas turbine power plant includes startup, Pre-rotation or Pre-spinning, Cooling, System Pressurization, Load Variation.

3)AIR COMPRESSOR:

Positioned between the combustion chamber and the turbine, both the air compressor and the turbine are mounted on a common shaft. Gas turbines require a starting motor as they lack self-starting capabilities. The air compressor's role is to draw in and compress air, elevating its pressure. Axial design compressors with multiple stages are preferred for advanced and large gas turbines.

4) SPARK PLUG:

A **spark plug** is an electrical device used in an internal combustion engine to produce a spark which ignites the air-fuel mixture in the combustion chamber. As part of the engine's ignition system, the spark plug receives high-voltage electricity (generated by an ignition coil in modern engines and transmitted via a spark plug wire) which it uses to generate a spark in the small gap between the positive and negative electrodes. The timing of the spark is a key factor in the engine's behaviour, and the spark plug usually operates shortly before the combustion stroke commences.

5) FLAME DETECTOR:

Most fire detection technology focuses on detecting heat, smoke (particle matter) or flame (light) the three major characteristics of fire. All of these characteristics also have benign sources other than fire, such as heat from steam pipes, particle matter from aerosols, and light from the sun. Other factors further confound the process of fire detection by masking the characteristic of interest, such as air temperature, and air movement.

In addition, smoke and heat from fires can dissipate too rapidly or accumulate too slowly for effective detection. In contrast, because flame detectors are optical devices, they can respond to flames in less than a second. This optical quality also limits the flame detector as not all fires have a flame. As with any type of detection method its use must match the environment and the risk within the environment.

PARTS IN TURBINE SECTION:

1) LINER IN TURBINES:

A combustion liner for a gas turbine combustion system is provided. The combustion liner comprises a combustion zone between an inlet end and an exhaust end. The combustion liner comprises a one-piece casting construction. The combustion liner is formed from a nickel-based superalloy having strength characteristics.

A combustor liner is provided having first and second annular bands which define an overlapping circumferential joint area, wherein a weld is disposed in the joint area encompassing substantially all of the axial length of the joint area. A method for producing such a combustor liner is also provided.

2) CROSS FIRE TUBE:

A gas-turbine engine combustion system comprises a plurality of combustors interconnected by crossfire tube assemblies adapted to pass an ignition flame from an ignited combustor to another combustor on start-up of the engine. Each crossfire tube assembly comprises a cooling air inlet for introducing air into the assembly to film-cool its inner ignition flame-facing surface, and a cooling sleeve surrounding the crossfire tube assembly in the region in which it opens into the combustor. The cooling sleeve directs the cooling air so as to cool the outer surface of the assembly, the inside of the sleeve and the inside surface of the combustor wall adjacent the cooling sleeve.

3)TRANSITION PIECE:

The transition piece (TP) is a critical part of a gas turbine, leading the hot gas from the combustion chambers to the turbine guide vanes. Due to its complex design, however, it experiences high thermal stress levels, limiting its life expectations and making it one of the most critical components of the entire engine. The reliable prediction of such thermal loads is hence a crucial aspect to increase the transition piece life span and to assure safe operation. Best practices when it comes to TP design – focusing on the selection of a cooling concept, optimal support design, and stringent airflow testing – is therefore of great importance.

4)TURBINE BUCKET (1st and 2nd STAGE):

Turbine buckets are an important part of gas turbine stage design. Each stage unit contains a nozzle with a wheel and accompanying bucket. Further turbine sections include the turbine rotor, turbine shell, nozzle, shroud, exhaust diffuser, spacers, and exhaust frame.

A turbine bucket consists of a leading edge, trailing edge, root portion, and tip portion. Turbine buckets also include cooling holes for cooling liquid running through the bucket. First stage buckets are the first surface that the gases from the first nozzle encounter. Given this, they require high heat resistance to function at standard operating temperatures without failure.

As the air passes through the first stage bucket, it flows through cooling holes and exits out of the recessed bucket tips. Cooling holes spaced evenly around the turbine bucket's interior allow air through the plenum and function to cool the airfoil without requiring compressor air.

Due to the pressure drop between each stage of a gas turbine, progressive turbine buckets need to be larger than the previous. The second stage buckets do not require shank cooling, so they use cooling holes to reduce airfoil temperature without losing energy during the cycle. Enclosing the third stage bucket is a turbine shroud that connects to each bucket to dampen vibrations from rotor motion.

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5) EXCITER IN TURBINES:

Exciter or DC generator relay is a device which forces the DC machine-held excitation to build up during starting or which functions when the machine voltage has built up to a given value.

HEAT RECOVERY STEAM GENERATOR

The **HRSG** is basically a heat exchanger, or rather a series of heat exchangers. It is also called a boiler, as it creates steam for the steam turbine by passing the hot exhaust gas flow from a gas turbine or combustion engine through banks of heat exchanger tubes. The HRSG can rely on natural circulation or utilize forced circulation using pumps. As the hot exhaust gases flow past the heat exchanger tubes in which hot water circulates, heat is absorbed causing the creation of steam in the tubes. The tubes are arranged in sections, or modules, each serving a different function in the production of dry superheated steam. These modules are referred to as economizers, evaporators, superheaters/ reheaters and preheaters.

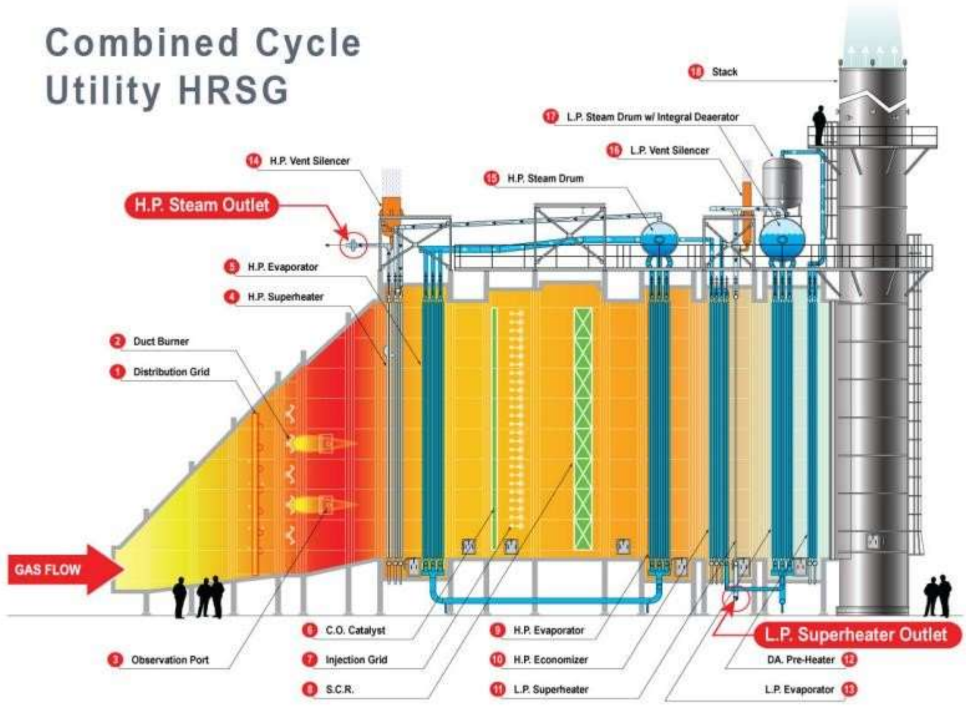


Fig: Section of HRSG

Principles of Operation:

The economizer is a heat exchanger that preheats the water to approach the saturation temperature (boiling point), which is supplied to a thick-walled steam drum.

The drum is located adjacent to **finned evaporator** tubes that circulate heated water. As the hot exhaust gases flow past the evaporator tubes, heat is absorbed causing the creation of steam in the tubes. The steamwater mixture in the tubes enters the steam drum where steam is separated from the hot water using moisture separators and cyclones. The separated water is recirculated to the evaporator tubes. Steam drums also serve storage and water treatment functions.

The superheated steam produced by the HRSG is supplied to the steam turbine where it expands through the turbine blades, imparting rotation to the turbine shaft. The energy delivered to the generator drive shaft is converted into electricity. After exiting the steam turbine, the steam is sent to a condenser which routes the condensed water back to the HRSG.

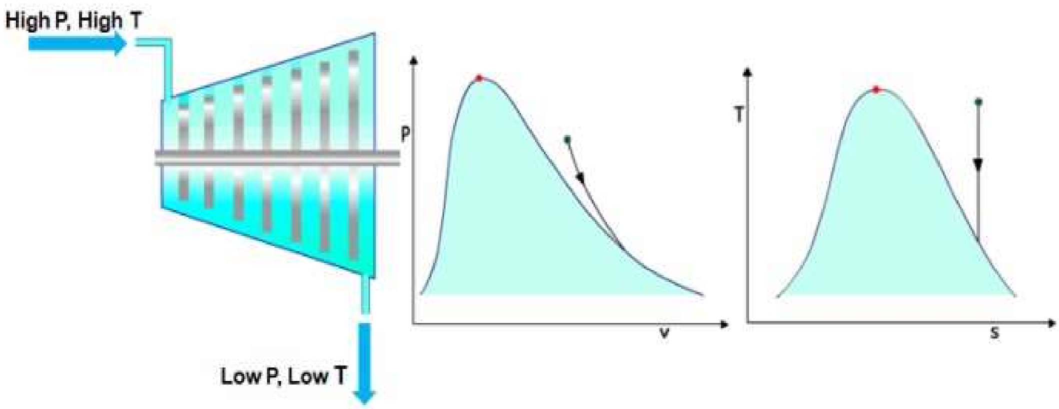
STEAM TURBINE:

A steam-electric power station is a power station in which the electric generator is drive by steam. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser. The greatest variation in the design of steam-electric power plants is due to the different fuel sources. Worldwide, most electric power is produced by steam-electric power plants, which produce about 86% of all electric generation. The only other types of plants that currently have a significant contribution are hydroelectric and gas turbine plants, which can burn natural gas or diesel. Photovoltaic panels, wind turbines and binary cycle geothermal plants are also non-steam electric, but currently do not produce much electricity.

Fig: Steam Turbine of AgGBPS

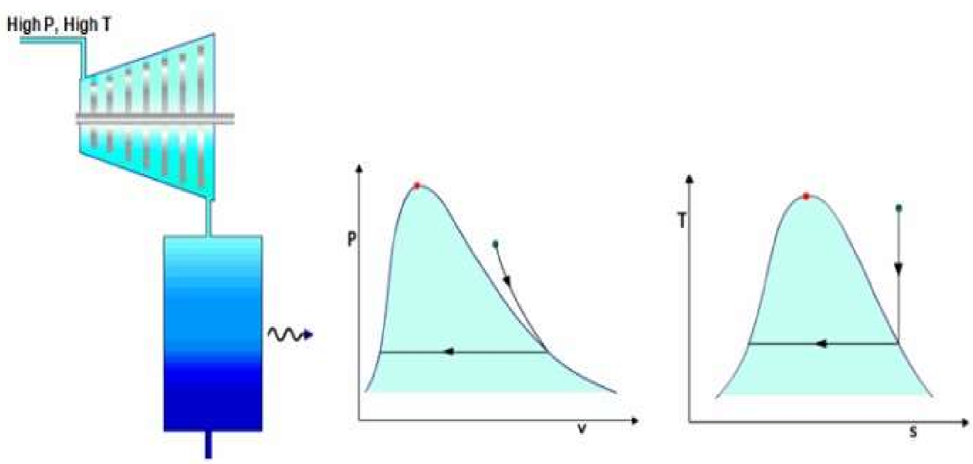
ENERGY ABSORPTION FROM STEAM:

When turbine blades get rotated by high pressure high temperature steam, the steam loses its energy. This in turn will result in a low pressure and low temperature steam at the outlet of the turbine. Here steam is expanded till saturation point is reached. Since there is no heat addition or removal from the steam, ideally entropy of the steam remains same. This change is depicted in the following p-v and T-s diagrams. If we can bring this low pressure, low temperature steam back to its original state, then we can produce electricity continuously.



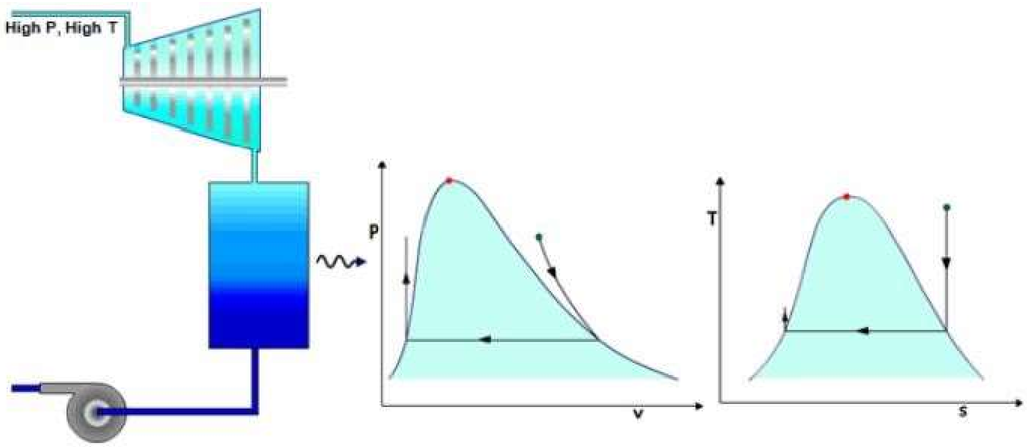
CONDENSER:

Compressing a fluid which is in gaseous state requires a huge amount of energy, so before compressing the fluid it should be converted into liquid state. A condenser is used for this purpose, which rejects heat to the surrounding and converts steam into liquid. Ideally there will not be any pressure change during this heat rejection process, since the fluid is free to expand in a condenser. Changes in fluid are shown in the p-v and T-s diagram below.



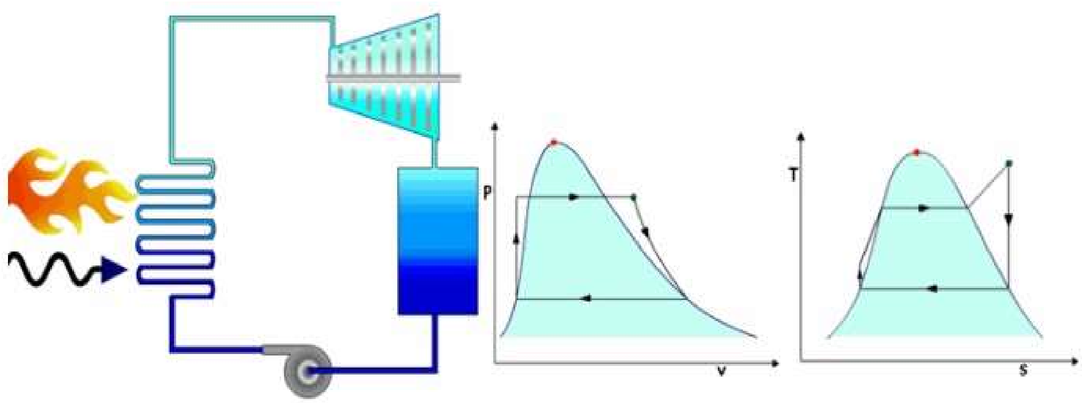
PUMP:

At exit of the condenser fluid is in liquid state, so we can use a pump to raise the pressure. During this process the volume and temperature (2-3 deg.C rise) of fluid hardly changes, since it is in liquid state. Now the fluid has regained its original pressure.



HEAT ADDITION IN BOILER & RANKINE CYCLE:

Here external heat is added to the fluid in order to bring fluid back to its original temperature. This heat is added through a heat exchanger called a boiler. Here the pressure of the fluid remains the same, since it is free to expand in heat exchanger tubes. Temperature rises and liquid gets transformed to vapour and regains its original temperature. This completes the thermodynamic cycle of a thermal power plant, called Rankine Cycle. This cycle can be repeated and continuous power production is possible.



ELECTRICITY GENERATION:

- The generator coupled to Turbine through reduction gear generates 11KV power which is given to 132KV switchyard via step-up transformer where the 11KV is being stepped up into 132 KV.

- There is tapping of 11 KV which is given to UAT (unit auxiliary transformer) where 11 KV is stepped down to 6.6 KV.

- This 6.6 KV is required to run the 8 no. Of BFP.

- Again 6.6 KV is being stepped down to 415 Volt in VFD (variable frequency drive). VFD is used to operate the ACC fans.

- 6.6 KV is also stepped down to 415 volts in station transformer. Station transformer is used for CEP (Condensate Extraction Pump), Battery charge, HRSGMCC, STGMCC, Emergency MCC.

- From station transformer 415 volt is stepped down to 220 volts in lightning transformer.

A STUDY ON ELECTRICAL SYSTEM OF AGGBPS

GENERATOR:

Generator is a machine that converts mechanical energy into electrical energy. It works based on principle of Faraday's law of electromagnetic induction. The Faraday's law states that whenever a conductor is placed in a varying magnetic field, EMF is induced and this induced emf is equal to the rate of change of flux linkages. This EMF can be generated when there is relative time variation between the conductor and magnetic field. So, the important elements of the generator are:

- ***ROTOR:*** Magnetic field is induced by the rotor, which is a two-pole cylindrical one. It is a moving component of an electromagnetic system in the electrical generator or alternator. It creates flux that rotates inside, the rotor winding to generate electrical energy across the stator winding.

- ***STATOR:*** The stator is the stationary part of a Rotary system found in electrical generators. The stator converts, the rotating magnetic flux to electrical energy at the generator terminal.

- ***EXCITATION SYSTEM:*** Excitation system can be defined as the system that provides field current to the rotor winding of a generator A well-designed excitation system provides reliability of operation stability and fast transient response. To excite the field winding of the rotor of the synchronous machine, direct current is required.
  The amount of excitation required depends on the load, current cloud, power factor and speed of the machine. The more excitation is needed in the system when the load current is large, the speed is less and the power factor of the system becomes lagging.

- ***BRUSHLESS EXCITATION SYSTEM*:** A brushless exciter is a direct coupled AC generator with its field circuit on the stator in the armature circuit on the rotor. The three-phase output of the AC exciter generator is rectified by solid state rectifiers. The rectified DC output is connected directly to the field winding, thus eliminating the use of brushless and slip rings.
- ***GENERATOR AVR:*** AVR makes the terminal voltage constant by adjusting the excitation of Alternator. Because we know if load increases terminal voltage will decreases and if Reactive Power increases by any means, then terminal voltage profile improve (increase).

- ***COOLING SYSTEM:*** In this power plant water cooling system is used, water cooling system refers liquid cooled system. The heat from the generator transformer transfer naturally to the coolant, i.e., watered it's passed through the heat exchanger for cooling in an isolated cooling tower system.

SPECIFICATION OF GAS TURBINE GENERATORS:

- Type -T600
- Speed - 3000 rpm
- Frequency - 50 HZ
- Year of manufacture-1995
- Make-European Gas Turbine
- Cooling by- Water
- Excitation -193V, 372 A
- Rated Output -28962 MVA
- Rated Voltage -11000 V
- Rated Current -1520 A
- Power factor - 0.8

SPECIFICATION OF STEAM TURBINE GENERATORS:

- Frame: TC210
- Male: Siemens
- KVA: 32500
- KW: 26000
- Voltage: 11000
- Amps: 1706
- Frequency:50 Hz
- PF: 0.8
- Machine Nos: T-02458

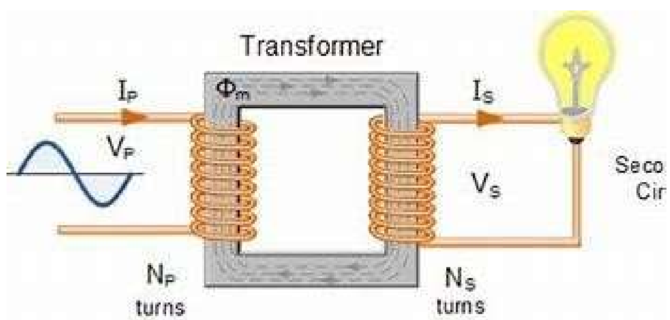
TRANSFORMER:

Transformers are the very vital components in almost all the parts of electrical power systems like generation, transmission, distribution and essential utilisation area. It can be either step-up or step- down the voltage at these areas, but it is needed in all the parts of human life, right from home to industry

whatever the industrial revolution. Transformers are known to be more reliable and higher energy efficient of the order of around 98% as on date.
A transformer is a device that transfers electrical energy from one alternating current circuit to one or more other circuits.

WORKING PRINCIPLE OF TRANSFORMER:

A transformer has two windings placed on common magnetic core. It works on induction principle. When primary winding is connected to AC supply. In alternating magnetic flux is produced in it. This alternating flux in the primary winding produces n EMF in each by self-induction. This alternating flux in primary winding also linked with secondary winding through the magnetic core. These alternating flux in the secondary winding produces an EMF and if the circuit is closed. A current will flow in secondary winding by mutual induction.



DIFFERENT PARTS OF A TRANSFORMER:

There are two inductive coils of super enamelled copper wire for primary and secondary windings. The two windings are insulated from the core and from each other. The quills used for former wound.

LAMINATED STEEL CORE: The core of transformer is made of
thin silicon Steel laminations insulated from each other by a coat of varnish. The Eddy current loss is minimised by laminating the core. The thickness of the lamination on stampings varies from 0.35 mm to 0.5 mm. The iron core is

rectangular in cross section for small size Transformer and circular for large size Transformer to reduce the quantity of copper required

HOUSING: Assembled transformer generally housed in lightly fitted sheet metal tanks fitted with special insulating oil, known as Transformer oil The insulating oil serves two purposes.

I. Cooling of coils and core
II. Insulating property

The insulating oil used with a transformer should have high dielectric strength, low viscosity to provide good heat transfer and good resistance to emulsion.

TYPE OF COOLING: In case of liquid filled transformers, the type of cooling is indicated by alphabetic letters.

ONAN= Oil Natural Air Natural
ONAF= Oil Natural Air Forced
OFAF= Oil Forced Air Forced
It is known that each forced cooling will increase the capacity by 15 to 25% due to better heat dissipation.

BUSHING: To insulate and to bring out the terminals of the Transformer bushing are used bushing are of three types:

- **Porcelain bushing** used for low voltage Transformers.
- **Oil filled bushing** used for voltage up to 33kv.
- **Condenser type bushing** used for voltage up to 33kv.

CONSERVATOR: It is sometimes called as expansion tank. It is a small tank mounted on the main tank and two are connected by a pipe. The main tank is completely filled with oil but Conservator tank is partially filled with oil. The function of Conservator is to take into account the rise and fall of oil level due to heating and cooling of the oil.

SILICA GELBREATHER: Moisture is very harmful to theTransformer oil. The simplest method prevents the entry of moisture inside the Transformer tank is to provide the breather. The breather contains silica gel when air is taken in or taken out of the transformer due to construction or expansion of oil in the tank the silica gel absorbs, the moisture and allows the air free from moisture to enter the transformer.

TEMPERATURE GAUGE: Every transformer is provided with a temperature gauge to indicate the temperature of the hot oil in the Transformer tank.

OIL GAUGE: Every transformer is provided with an oil gauge to indicate the oil level. The oil gauge may be provided with the alarm context which gives an alarm when the oil level has dropped below permissible height due to oil leak etc.

BUCHHOLZ RELAY: Its function is used to indicate the presence of gas in case of some Minor fault and take the Transformer out of service in case of serious fault. It is connected between the main tank and Conservator tank.

TAPPING: It used for voltage regulation purpose by maintaining EMF per turns as constant. The tap changes is used to add or remove some turns from winding (generally HV) to maintain constant voltage at other side (generally LV).

RADIATORS: Due to losses in the Transformer the oil near the windings gets heated and travels in words the top of the tank. In large capacity Transformer (about 50 KVA and above) this increase in the oil temperature is quite high. To dissipate this heat, radiation are provided in the Transformer.

TRANSFORMER SPECIFICATION:

POWER TRANSFORMER: Power Transformer is a static machine used for transforming power from one circuit to another without changing the frequency. There is no rotating or moving parts in a transformer and thus classified as a static device. Transformer operate on an AC supply.

Generation of electrical power in low voltage level is very much cost effective. Theoretically, this low voltage level power can be transmitted to the receiving end. This low voltage power if transmitted results in greater line current which indeed causes more line losses. But if the voltage level of a power is increased, the current of the power is reduced which causes reduction in ohmic or I2R losses in the system, reduction in cross-sectional area of the conductor i.e. reduction in capital cost of the system and it also improves the voltage regulation of the system. Because of these, low level power must be stepped up for efficient electrical power transmission.

SPECIFICATION OF TRANSFORMER USE IN AGTCCPP NEEPCO LTD:

- Specification Ref No.- IS 1977
- Rating- 12.5 MVA
- Rated Voltage- HV-140/3 KV LV-11 KV
- Rated Current- HV-156.5 A, LV-1968.2 A
- Type of Cooling - ONAF
- Frequency-50Hz
- Vector Group- Ynd 11
- Insulation- HV KV-LI 550 PF 230
- Level- HVn KV-LI 95 PF 38
- Core and winding mass-14,200 kg
- Tank and Fitting mass -8,300 kg
- Mass of Oil-6,700 kg
- Total Mass-29,200 kg
- Volume of oil-7600 litres /24700 kg

1. ***Power rating of 12.5 MVA:*** Generally it will be given as MVA (large rated). Being a source, the power factor of loads which are fed from time to time is changing based on type of load. Hence rating is either in MVA or KVA.

2. ***Year of manufacturing**:* This is required to know the age of Transformer at any time and also helpful in attending regular preventive maintenance and overhauling systematically.

3. ***Type (Core):*** It is required to know whether it is core type (of CRGO i.e. Cold Rolled Grain Oriented or Amorphous) or shell type. CRGO core type is used for normal power and distribution purpose where as shell is type is used for larger power transformers. Amorphous material is latest in which core losses are very low and is presently used for distribution purpose.

4. ***Voltage at No-load:*** Here the line to line voltages of both HV (140/3 KV) and LV (11 KV) windings are given at rated tap. Higher voltages cannot be given to primary side since it may be leads to winding instantaneous failure.

5. ***Current:*** The rated current of both HV (156.5 Amps) and LV (1968.2 Amps) windings are given. This is the maximum value to which Transformer can be loaded beyond which the temperature will go high and damages windings, wires and insulations.

6. ***Phases and frequency**:* The number of phases of HV and LV windings and supply frequency (50 Hz) are given. Transformers are to be charged with voltage of rated frequency only otherwise it may lead to over fluxing or higher core losses.

7. ***Temperature (in °C):*** The value of ambient temperature (generally 50° C) and permissible temperature rise of oil (in case of immersed windings) and winding. These are the values for monitoring and setting of oil and winding temperature gauges for alarm and trip.

8. ***Vector Group (Ynd 11):*** This is an connection symbol used to inform about type of connection of 3 phase windings and angle. The phase angle between

HV and LV induced EMF's is given by a clock number and to be specified in anti-clockwise direction. e.g : 11 =11° clock i.e. LV leads HV by 30°. Others like;
1= 1° clock i.e. LV lags HV by 30°,
0 = 12° clock i.e. LV and HV are in phase,
6= 6° clock i.e. LV and HV opposite by 180°.

The information is required in parallel operation. Since same vector grouped Transformers only to be connected in parallel.

Figure: Transformer of AgGBP

SWITCHYARD

Before electricity is consumed, three steps are followed: production, transmission and distribution. In the first, the generator produces the electricity from a primary energy source. The transmission step consists of moving the electricity produces at generating stations to consumption locations. Thereafter, the electricity must be distributed to each house, factory or business. Electricity generated by the generators flows to transformers that step up the voltage in preparation for travel over long distances.

MAIN COMPONENTS:

- BUS BARS
- LIGHTING ARRESTER
- CIRCUIT BREAKER
- ISOLATOR
- CURRENT TRANSFORMER
- CAPACITIVE VOLTAGE TRANSFORMER
- WAVE TRAPPER

DESIGN :

- The whole switchyard is grounded with MAT grounding.
- In MAT grounding, 5 conductors are placed horizontally & conductors are placed vertically.
- All switchyard equipment is grounded by two earthing connections.
- In switchyard grounding, 32 mm earthing conductor is used & 75/2 Gl earth sheet is used.
- All switchyard is gravelled to make the tower footing resistance high.

DESCRIPTIONS OF ALL THE EQUIPMENTS

LIGHTNING ARRESTOR:

It is a device used for the protection of transmission lines, transformers and other equipment of the switchyard from the lightning. When lightning falls on the transmission line or transformer, and there is a high voltage over the rated voltage, then this high voltage may damage the transformer or other equipment.
So, the lightning arrestor diverts the high voltage to the ground without providing any damage to the equipment.

SPECIFICATION:

Made by- ELPRO, Voltage-120 kV,
Normal discharge- 10 kA.
Materials: Silicon Zinc Oxide Location
Used: Transmission Lines.

ISOLATORS:

Isolator is also known as Disconnector which is a mechanical switching device used to disconnect some portion of the circuit. Isolators are operated on NO Load condition as it simply isolates the live part of the circuit from the dead part. Isolators connected on any line or circuit can be electrically or manually operated. Isolators are mainly used for the maintenance purpose of the transmission line.

SPECIFICATION:

Made by-ELPRO, Voltage - 132 kV,
Current-800A
Frequency-50HZ, ***Type -*** DBR Isolator.
Location Used: Transmission Lines, Potential Transformer& Station Transformer

CIRCUIT BREAKER:

A Circuit Breaker is a switching device which is used for the protection of transmission line, transformer and other equipment in an electrical circuit from the damage caused by overcurrent, overload or short circuit. Circuit breaker is also known as CB. In most of the substations, SF circuit breakers are used. The full from of SF, is Sulphur Hexafluoride. Circuit breakers are connected in side of the transformer.

SPECIFICATION:

Made By- AAB
Rated Voltage - 145 kV, ***Rated Curent-***2000 A
Frequency- 50 HZ,
Type-Spring Operated SF, Circuit Breaker.
Location Used: Transmission Lines, Generator Transformer & Station Transformer

CURRENT TRANSFORMER(CT):

A current transformer, is a device used for measuring the value of current in the transmission lines. During measurement purpose it lowers the current signal in which the secondary current is proportional to the primary current and differs from voltage by an angle i.e., approximately Zero. This type of transformer is designed to measure flow of current and protection of the system.

SPECIFICATION:

Made By - CG. ***Ratio -***800/1, ***Class-***0.5 (In Transmission Line)
Made By-CG, ***Ratio -***50/1 (In Station Transformer)

BUS BAR:

Bus Bar is an arrangement to improve the redundancy of the system, when there is need of isolation of a system for any section during maintenance works or emergency Generally, the Bus Bar is connected through Bus Coupler arrangement during normal operation well in AgGBPS, there are two bus bar configurations

CAPACITIVE VOLTAGE TRANSFORMER:

Capacitive voltage transformers are used for measurement of ultra-high voltages in a transmission line. It also provides electrical isolation. In capacitor voltage transformers capacitors are used as voltage divider, as these capacitors are connected in series voltage drop takes place.

SPECIFICATION:

Rated Voltage - 132 kV.
RatedCurrent-800A
Frequency- 50 HZ
Ratio - 132/110 kV.

POTENTIAL TRANSFORMER:

Potential transformer is a voltage step-down transformer which reduces the voltage of a high voltage circuit to a lower level for the purpose of measurement. These are connected across or parallel to the line which is to be monitored. The primary winding consists of a large number of turns which is connected across the high voltage side or the line in which measurements have to be taken or to be protected. The secondary winding has lesser number of turns which is connected to the voltmeters, or potential coils of wattmeter and energy meters, relays and other control devices. These can be single phase or three phase potential transformers. Irrespective of the primary voltage rating, these are designed to have the secondary output voltage of 110 V.

WAVE TRAP:

A wave trap is a prevention device that is used to prevent high frequency to go through low frequency equipment like circuit breaker, mainly Bus bar and transformer Lightning arrester is used in wave trap to protect from lightning Wave trap connected with the transmission lines.

Signals from main centres are sent which are captured by the routers placed in, these are high frequency signals much higher above the power frequency (in kHz), these signals are then trapped by a coupling circuit and are routed to the fields.

They work at higher frequencies and allows power frequency signals to pass through and traps the communication signals and hence are named wave traps. The communication signals captured and decoded contain signals like trip the CB, or change the tap changer or something of the kind.

RELAYS:

A protective relay is devices that detects the fault and initiate the operation of circuit breaker to isolate the detective element from the rest of the system. The Relay constantly measures the electrical quantities which are different under normal and fault condition. Having defected the fault, the relay operates to close the trip circuit of the breaker The trip circuit is operated by a direct voltage A relay must be highly selective to the normal and fault conditions to avoid unwanted tripping. It must operate with suitable speed so that fault is eliminated before it can cause any damage Relay must also be sensitive to work with low values of current.

ABOUT DM(DE-MINERALISED) PLANT

Fig: DM Plant at AgGBPs

What is DM Plant ?
DM plant full form is Demineralization Plant

The ion exchange process is used to remove mineral salts or dissolved ions from water, which is known as demineralization or deionization.

Demineralization can be used with most natural water sources to produce water of greater quality than traditional distillation process. Only dissolved solids are removed in DM Plant.

Water contains both positive and negative charged ions.Positive charged ions like calcium, magnesium, sodium, potassium etc. called cations.

DM PLANT PROCESS:

First, Understand five useful abbreviation of DM plant which are frequently used.

SAC - Strong Acid Cation
WAC- Weak Acid Cation
DG or DGT – Degasser Tower
SBA - Strong Base Anion
WBA- Weak Base Anion

The complete DM plant process divided in four parts called cation exchange, degassification, anion exchange and mixed bed polishing process.

1. CATION EXCHANGE PROCESS:

Cation resin has a negative functional group therefore it attracts positive charged ions called cations.
Cation exchanger vessel is constructed with steel inside rubber lined. It has 50 to 75% void space to allow free expansion of resin during back wash.
Cation Exchange process contains two types of exchanger namely SAC & WAC.

2. DEGASSIFIER:

The effluent is acid after the cation exchanger, and all of the bicarbonate in the water is converted to CO_2.This CO_2 may be eliminated for a very low cost in a Degasser. A Degasser has a low initial investment and ongoing operating costs. Otherwise, CO_2will be extracted via an anion exchanger. As a result, the Degasser lessens the load on the anion exchanger.
There are different types of degasser. The unit essentially consists of a tower mounted on a tank to hold 1-2 minutes supply of degassified (decarbonated) water. Degasser internal packing of wooden slant trays or ceramic raschig rings or ceramic / plastic ball rings etc. over which water trickles down from a spray pipe (corrosion resistant) at the top. Filtered air is blown in at the bottom and rises counter current to the downward water.

The spray and packing divide the water into droplets or thin films, exposing new surfaces to the gas phase. Packing materials also provide agitation am thus allows the dissolved gases to leave the water readily.
Packing also provides adequate detention time for near approach to equilibrium solubility of the gas in water. The height required for packing material ~ when the amount of influent CO_2 is higher, when the amount of effluent CO_2 derived is lower and when the water temperature is lower.
In general, economics favor use of a forced-draft degasifier when the carbon dioxide content (including bicarbonate alkalinity) is greater than 50 ppm and the service flow rate is greater than 50 gal./min.

For bicarbonate alkalinity plus CO_2 loads of less than 50 ppm, and/or for flow rates less than 50 gpm, the economics do not generally favor the use of a degasifier.
Normally, degassifier is designed to reduce CO_2 level to less than 5 ppm.

3. ANION EXCHANGE PROCESS:

The function of the anion exchange process is to remove anions from the water. Constructional features of anion exchanger are similar to cation exchanger unit.
Anion resin has a positive function group attached therefore it attracts negative charged ions called anions.

4. MIXED BED SYSTEM:

In a mixed bed system, strong acid cation and strong base anion resins are intermixed. This basically transforms the mixed bed tank into a tank with thousands of dual bed units.
The cation and anion exchange process occurs repeatedly inside the mixed bed. Because of the large number of cation/anion exchanges that occur, sodium leakage is addressed.

QUALITY OF EFFLUENT WATER:

The quality of effluent water of SAC, Degasifier, SBA & MB will have the following property.

SAC Outlet Water Parameter:

PH at 25 ℃	***2.8 to 3.5***
Free Mineral Acidity (FMA)	***Should be Equal to Equivalent Mineral Acidity(EMA)***
Hardness ppm as $CaCO_3$	***NIL***
Sodium ppm as Na^+	***<0.005***

Degasifier Outlet Water Parameter:

Residual free CO2 ppm	***<5.0***

SBA Outlet Water Parameter:

pH at 25 ℃	***7.5 to 9.0***
Total silica SiO_2 ppm	***<0.05***
Conductivity(µs/cm)	***< 2.0 preferably < 1.0***
Chloride (ppm as Cl)	***NIL***

MB Outlet Water Parameter:

pH at 25 ℃	***6.8 to 7.2***
Total silica SiO_2 ppm	***<0.02***
Conductivity(µs/cm)	***< 0.2***
Sodium ppm as Na^+	***<0.003***

CHEMICAL REACTIONS INVOLVED IN DM PLANT:

1) $NH3PO4 \leftrightarrow Na2PO4 + Na+ \leftrightarrow (+H2O) \leftrightarrow NaOH + H+$
$(Main\ Reason\ for\ pH\ boost)$

$$\begin{array}{l} \downarrow \\ \downarrow \leftrightarrow (+O2) \\ \quad\quad \downarrow \\ \quad\quad H2O \end{array}$$

2) $C4H9NO \leftrightarrow Basic\ in\ Nature\ in\ all\ phase\ (Water\ or\ Steam).$
$(Morpholine)$

3) $N2H4 + O2 -> 2NH3 + H2O ->$
$NH4OH\ (Low\ Pressure\ Drum\ pH\ increases)\ (Hydrazine\ Reaction)$

LOADING CHARATERISTICS

1) ***GENERAL:***
Once the unit has been synchronised either manually or automatically it can be located by several loading sequences. For instance, a unit can be loaded manually or automatically upto a temperature control limit, or a (MW) output load limit. Units operating under iso-chronous control will accept existing load or be liited by temperature control.

2) ***SYNCHRONISATION:***
Automatic synchronisation is achieved using a microprocessor synchronising circuit. The circuit inputs are transmitted through an interface module. The interface module contains an isolation transformer for the generator and line input signals and the breaker closing relay. The synchronising software is part of the SPEEDTRONIC computer.

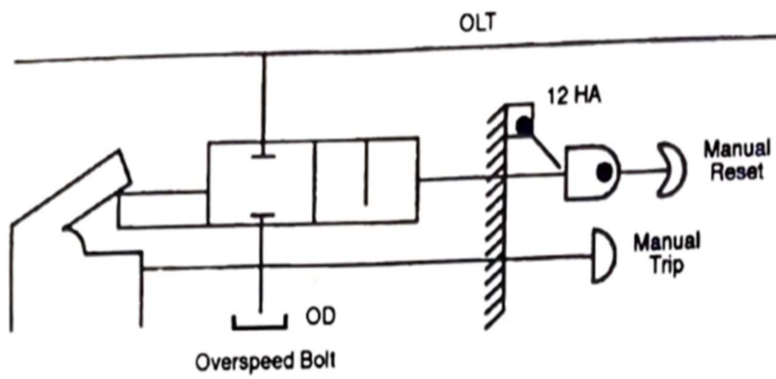
3) ***FULL-SPEED, NO-LOAD:***
The reason that the “Full-Speed, No-Load” adjustments is important is that it actually collaborates speed with the called-for speed using the digital setpoint. The 100.3% setpoint will cause an increase in fuel command necessary to raise the speed 0.3% above 50Hz synchronous frequency. It is essential that the generator and system frequency be matched within 0.33 Hz to synchronise quickly with synchronising relay. “Full-Speed, No-Load” therefore is an important setting to assure proper speed for synchronising.

4) LOAD CONTROL:

Speed Load control increases fuel through the digital setpoint to maintain output value. Most units have three values of output control; reference to the Control Specifications for settings is required.

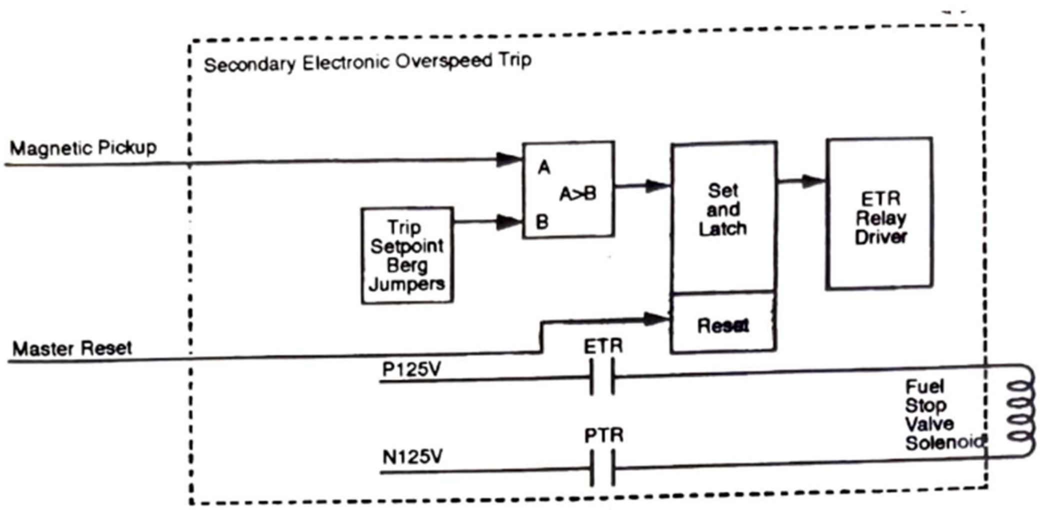
OVERSPEED PROTECTION SYSTEM

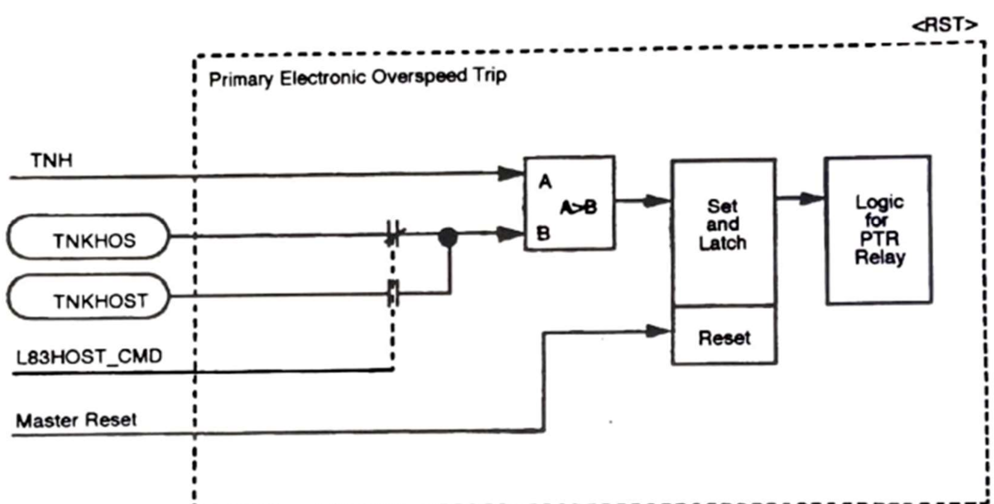
The SPEEDTRONIC electronic overspeed systems is designed to protect the gas turbine against possible damage caused by over-speeding of the turbine. Under normal operation, the speed of the shaft is under the control of the speed loop, or temperature loop. This overspeed system would not be called on except after the failure of these other systems.



The overspeed protection system consists of primary and secondary electronic system and a mechanical overspeed protection system. The primary overspeed protection system is incorporated as part of the control system and consists of magnetic pickups to sense turbine speed, speed detection software and associated logic circuits. The level settings is made by adjustable constants.

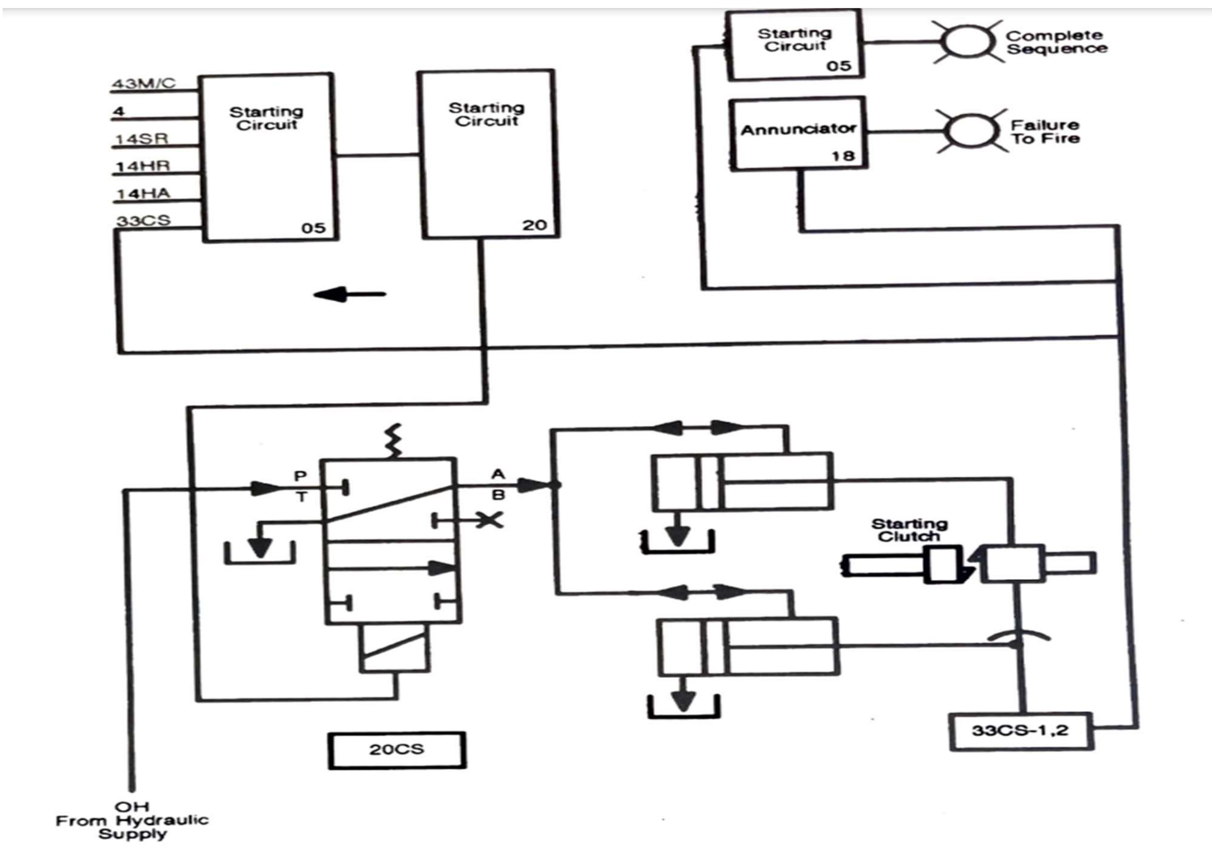
The mechanical overspeed protection system consists of the overspeed bolt assembly in the accessory gear shaft and the overspeed trip mechanism. This system trips the fuel stop valve hydaulically.


Secondary Electronic Overspeed Trip
Magnetic Pickup
A
A>B
B
Trip Setpoint Berg Jumpers
Set and Latch
ETR Relay Driver
Reset
Master Reset
ETR
P125V
Fuel Stop Valve Solenoid
PTR
N125V


<RST>
Primary Electronic Overspeed Trip
TNH
TNKHOS
TNKHOST
L83HOST_CMD
Master Reset
A
A>B
B
Set and Latch
Reset
Logic for PTR Relay

STARTING CLUTCH

The starting clutch system operates on hydraulic supply pressure and is controlled by SPEEDTRONIC circuits using two devices; clutch solenoid valve 20CS and clutch limit switches 33CS-1 and -2. Valve 20CS is a four-way, solenoid-operated, spring-return valve used to engage the starting clutch. Clutch limit switch switches 33CS-1 and -2 sense starting clutch engagement and permit the startup of the starting means only if the clutch is engaged.



HYDRAULIC SUPPLY SYSTEM

The hydraulic supply system is the source of high pressure oil which modulates the fuel control valves, the inlet guide vain control actuator, and engages the starting clutch. It contains pumps to increase lube oil pressure to approximately 1200PSI (8273, 7kPA) and provides filteration of the oil for servo valve use, and includes devices to protect the turbine if hydraulic pressure is adequate to support essential control system.

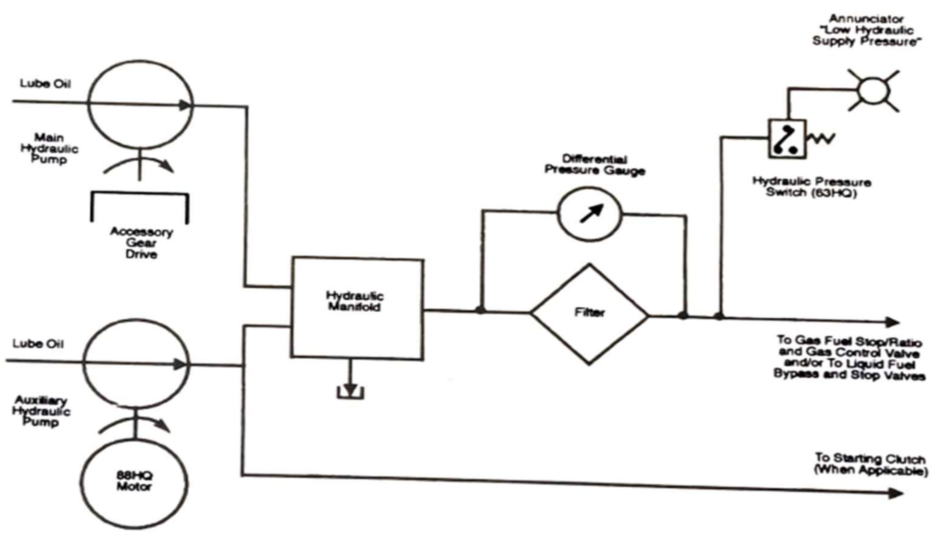


Figure CPC852-1. Hydraulic Supply

TRIP OIL

A hydraulic trip system called "Trip oil" is the primary protection between the turbine control and protection system and the components on the turbine which admit, or shut-off fuel. The system contains devices which are electrically operated by SPEEDTRONIC control signals as well as some totally mechanical devices.

Besides the tripping functions, trip oil also provides a hydraulic signal to the fuel stop valves for normal start-up and shutdown sequences.

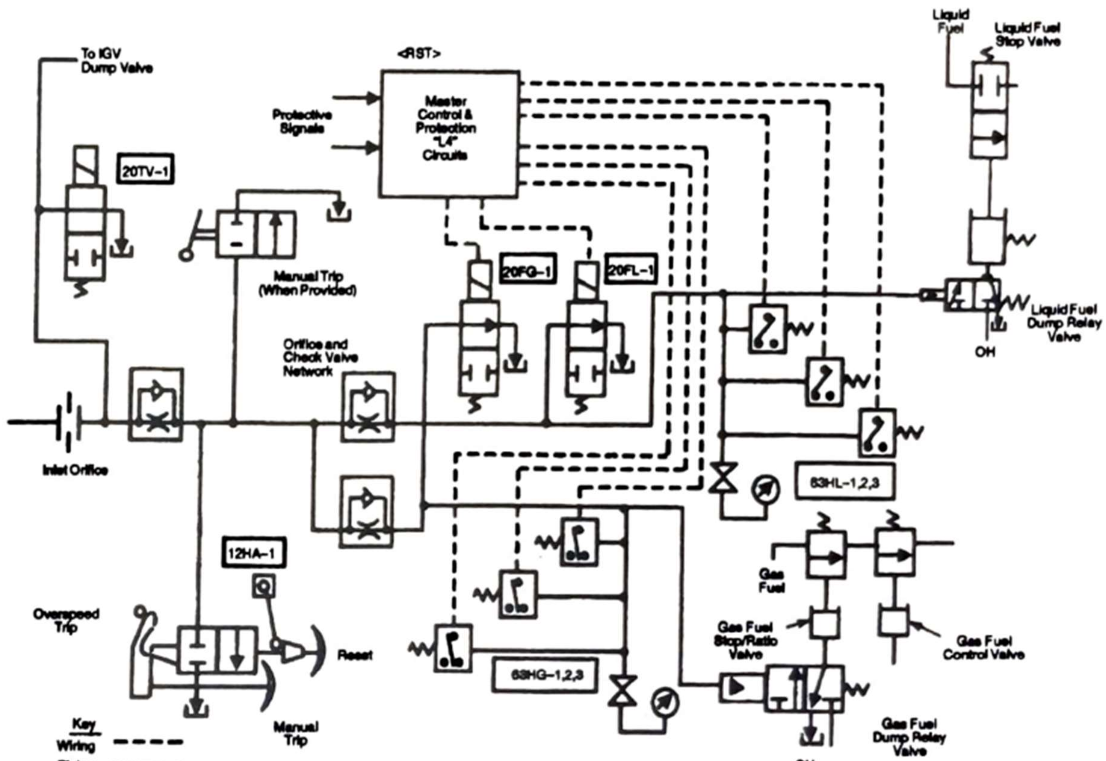


Figure CPC819-1. Trip Oil and Protection - Dual Fuel

SAFETY PRECAUTIONS

- All personnel must wear the correct protective clothing.
- All personnel must avoid contact with turbine casing, valve bodies, drains and gas lines, which could result in serious burns.
- Do not wear loose clothing, neckties, etc. near rotating machinery.
- All personnel should develop safety awareness.
- All personnel are to wear correct ear protection when working in the vicinity of the turbine.
- All personnel must wear glasses in the plant sight.

CONCLUSION

I have undergone 14 days in-plant training in AgGBPS, NEEPCO, where I have learnt basics of the gas based thermal power plant both theoretically as well as practically.

As we know, in field of fossil fuel-based technologies, Natural Gas based Combined Cycle power plant are currently at the best position for electricity generation, having efficiency close to 60%. Since this type of power plant is new for me, I got an exposure to it. I have learnt about the working of various type of machines like Turbine, Generators, Boilers, and Motors etc. I have learnt about Cooling Systems, Gas Turbine and Steam Turbine, Electrical Transmission and Switchyard.

This training provided me the much-needed industrial exposure and will definitely be helpful in our future.

THE END