"শেখ হাসিনার উদ্যোগ, ঘরে ঘরে বিদ্যুৎ"

আশুগঞ্জ পাওয়ার স্টেশন কোম্পানী লিঃ

ASHUGANJ POWER STATION COMPANY LTD.

Industrial Training Report

Submitted by:

Nabil Shahriar Dhrubo (1710002)

Reazul Hasan Prince (1710003)

Shahriar Hassan Ronok (1710046)

Department of Electrical and Computer Engineering

Rajshahi University of Engineering & Technology (RUET)

Submitted to:

Md. Ahsan Habib

Assistant Engineer (HRD)

Ashuganj Power Station Company Ltd.

Ashuganj, Brahmanbaria.

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Abstract

Ashuganj Power Station Company Ltd. is a government-owned public limited company and the largest power hub in Bangladesh. The current total power generation capacity of its 08 units is 1690 MW. Bangladesh as a developing country, the demand of energy is increasing with a higher ramp rate than many other countries of the world. To meet up the increasing demand of this country, Ashuganj Power Station Company Limited (APSCL) has taken a lot of development projects and many are in pipeline.

The main purpose of our Industrial Training is to learn the practical applications of our theoretical knowledge. In APSCL, we have seen the combination of the topics of generator, transformer, switchgear, protection relay, turbine, Controlling Panels, DCS, EDG that we have learnt separately in our courses. Here, we came to know about not only Electrical field, but also Mechanical knowledge is also required to maintain the whole operation, such as, Boiler, HRSG, Economizer, Evaporator, Super-heater, Cooling Systems etc. We have learnt about the efficient use of power systems through Combined Cycle Power Plant and how to extract maximum amount of power from the system. And we also came to know about the mapping system of the plant by implementing in a Single Line Diagram. We got the overall idea about the entire generation, transmission and distribution system of the whole country and how it is connected to the national grid.

Considering the facts, we chose Ashuganj Power Station Company Limited as our training organization, which is trying to keep the generation maximum by proper operation, maintenance and overhauling the existing units.

Acknowledgement

We express gratitude and sincere thanks to our training coordinator Md. Ahsan Habib, Assistant Engineer, Human Resource Department, Ashuganj Power Station Company Limited, for his valuable guidance, encouragement and help for completing this training.

We are also very grateful to the following members for helping us through the entire training:

1. Md. Shahiduzzaman, Executive Engineer, APSCL
2. Abu Noman Mohammad Iqbal, Sub-Divisional Engineer, APSCL
3. Md. Shahid Ullah, Executive Engineer, APSCL
4. Oli Ahad Khan, Executive Engineer, APSCL
5. Mosiur Rahman, Assistant Engineer, APSCL

Chapter 1

Introduction

1.1 Power Stations

In this modern world, the dependence on electricity is so much that it has become a part and parcel of our life. The ever-increasing use of electric power for domestic, commercial and industrial purposes necessitates to provide bulk electric power economically. This is achieved with the help of suitable power producing units, known as Power plants or Electric power generating stations.
The conversion of energy available in different forms in nature into electrical energy is known as generation of electrical energy. Bulk electric power is produced by special plants known as generating stations or power plants.
A generating station essentially employs a prime mover coupled to an alternator for the production of electric power. The prime mover (e.g., gas turbine, steam turbine etc.) converts energy from some other form into mechanical energy. The alternator converts mechanical energy of the prime mover into electrical energy. The electrical energy produced by the generating station is transmitted and distributed with the help of conductors to various consumers. It may be emphasized here that apart from prime mover-alternator combination, a modern generating station employs several auxiliary equipment and instruments to ensure cheap, reliable and continuous service.

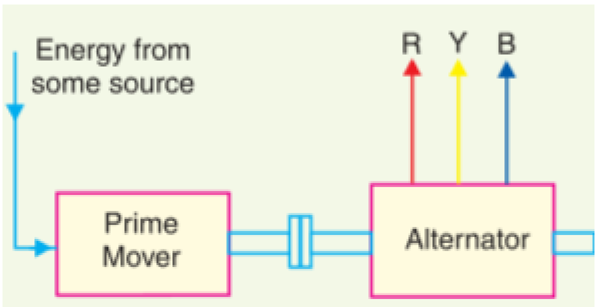

Fig 1.1: Basic Configuration of a generating station

1.2 Selection Criteria of Power Station Location

There are some basic criteria for selecting a location for a power station. These are some of the followed criteria for selecting the power plant site, which are given below;

- A power plant should be located as near to the load center as possible. This reduces the transmission costs and losses in transmission.
- The cost of fuel is an important consideration in deciding the type of power plant for a particular location. With hydroelectric power plants, there is no cost of fuel as the source of power is water but water should be available in huge quantity and at sufficient head.

- The cost of land near a load center (in a big city) may be very high as compared to that at remote place. The taxes also would be higher for land in the center of a commercial city. This is therefore, an important point to be considered in the economic selection of site.
- In deciding the type of power plant for a given location, it is desirable to investigate whether any suitable source of water and sites are available for the development of hydroelectric power plant.
- A steam (coal-based) power plant needs space for storage of coal in amounts depending on the size of plant. A supply of coal for the next 2/3 weeks at least should always be available on site.
- It is necessary to have a railway line available and extended to the yard for bringing in heavy machinery for installation in the beginning and for bringing in fuel-coal or oil as well as material required for maintenance. Alternatively, the plant may be located on the bank of a river where facilities are available for transport by barges or ships.
- A steam power plant produces huge quantity of ash. A site where ash can be disposed of easily will naturally be beneficial.

1.3 Power Perspective of Bangladesh

Demand for electricity in Bangladesh is projected to reach 34,000 megawatts (MW) by 2030 and the Government of Bangladesh has plans to increase power generation beyond expected demand to help propel growth in the export-oriented economy and to meet the demands of a growing middle class. Total investment in the sector over the next 15 years is estimated at $70 billion. While installed generation capacity including captive power (as of June 30, 2018) has increased to 18,753 MW, shortfalls exist due to poor distribution infrastructure and a mismatch between the types of energy plants and fuel mix available. Private power production units are approaching half of total installed capacity.

The fuel mix of Bangladesh's power plants is heavily based on natural gas. The Government of Bangladesh plans to reduce dependence on natural gas and move towards coal with plans to generate 50 percent of total electricity using coal-based power plants by 2030. Other solutions include importing electricity from neighboring countries, importing liquefied natural gas (LNG), and expanding use of renewable resources, including solar and wind.

U.S. companies play a strong role in the power and energy industry in Bangladesh. U.S. companies produce over 55 percent of Bangladesh's domestic natural gas supply and are among the largest investors in power projects. U.S.-origin power turbines currently provide 80 percent of Bangladesh's installed gas-fired power generation capacity.

Power Generation Capacity of Bangladesh (Fuel Type wise) is given in the following chart:

Fuel Type	Capacity (Unit)	Total (%)
Coal	524.00 MW	2.86%
Gas	9843.00 MW	53.8%
HFO	4332.00 MW	23.68%
HSD	2205.00 MW	12.05%
Hydro	230.00 MW	1.26%

Imported	1160.00 MW	6.34%
Total	18294.00 MW	100%

Table 1.1: Installed Capacity of BPDB Power Plants as on May 2019

1.4 Objective of this Industrial Training

The main goal of this industrial training is to achieve practical knowledge and experience about power station. In this report, we focused on generation process, various protection systems, control system, substation, and maintenance of the equipment such as generator, transformer and transmission of electricity at APSCL. In APSCL, we saw the power generation process of both Gas Turbine Generator, and the Steam Turbine Generator. We have also withstood the process of Gas fired combined cycle system. We have observed the sub stations to see the transmission and distribution system as well as the protection (transformer oil, circuit breaker, relay, switch gear etc.) system. During our training session, we went through the experience of how the theory knowledge gets coped up with the practical field and what are the difficulties the fresh graduates have to face after getting into the job for the first time. We have been taught by our supervisor some important facts, which would be very much crucial for us in our job viva and after joining in our practical field work. So, we can say that this industrial training was very much effective for us to cope up with the practical work relating to our theoretical knowledge.

1.5 1690 MW Power Plant by APSCL

Ashuganj Power Station Company Limited, also known as APSCL, is a 1690 MW Gas based Combined Cycle Power Plant.

The foundation of Ashuganj Thermal Power Plant was laid in 1966. For this purpose, a land of 311 acre situated north-east of Meghna Railway Bridge was acquired. With the financial help of the then German Government the establishment of two units (Unit-1 & 2) having the generation capacity of 128MW was started. In 1968 the establishment of main equipment was started and in April/July of 1970 the two units were commissioned. After the liberation war Ashuganj Power Station has played an important role for the reconstruction & economic development of war-stricken Bangladesh.

After the independence the economic condition of Bangladesh started to change. Gradually the demand of electricity started to rise. To meet the extra demand of electricity an expansion plan of Ashuganj Thermal Power Plant was taken. After examining the possibility of expansion of Ashuganj Thermal Power Plant a plan was taken to establish 3 units having a generation capacity of 150MW each.

From 1986 to 1989, 3 units (Ashuganj 3, 4 & 5) were established with the financial help of IDA, KFW (German Government), Kuwait & OPEC fund and ADB.

From 1982 to 1986 for the first time in the Bangladesh, a Combine Cycle Power Plant having a generation capacity of 146MW was establish with the financial support of British Government.

In 1989 the established generation capacity of Ashuganj Thermal Power Plant was as below:

SL no.	Unit	Establish generation capacity (MW)
1.	Unit-1	64
2.	Unit-2	64
3.	Unit-3	150
4.	Unit-4	150
5.	Unit-5	150
6.	GT-1	56
7.	GT-2	56
8.	ST	34
Total		724

From 1989 to 2010 no new plant was establish in Ashuganj. Till June 2000 the Ashuganj Thermal Power Plant was directed by Bangladesh Power Development Board. After the transformation to Company a new unit having a generation capacity of 53 MW was establish with the self-fund of the company in 2011.

As a part of the Power Sector Development and Reform Program of the Government of Bangladesh (GOB) Ashuganj Power Station Company Ltd. (APSCL) has been incorporated under the Companies Act 1994 on 28 June 2000. The Registration No. of APSCL is C-40630 (2328)/2000. Ashuganj Power Station (APS) Complex (with its Assets and Liabilities) had been transferred to the APSCL through a Provisional Vendor's Agreement signed between BPDB and APSCL on 22 May 2003. All the activities of the company started formally on 01 June 2003. From that day the overall activities of the company along with operation, maintenance and development of the Power Station are vested upon a Management Team consisting of the Managing Director, the Director (Technical) & the Director (Finance).

According to the Articles of Association of the Company, 51% of total shares is held by BPDB and the rest 49% is distributed among Ministry of Planning, Power Division, MOPEMR & Energy Division, MOPEMR of GOB.

Fig 1.2: Gas Fired CCPP by APSCL

1.6 Overview of APSCL

Following image shows a short overview of the Ashuganj Power Station Company Limited:

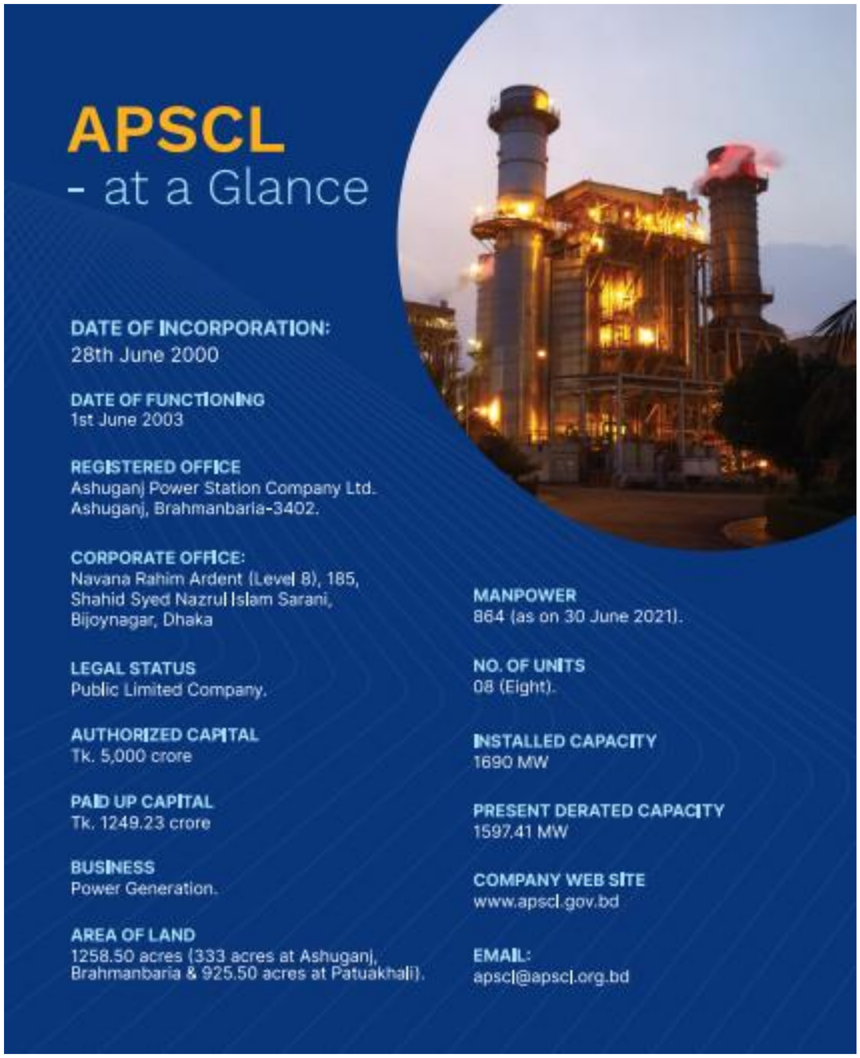

Fig 1.3: Overview of APSCL

1.7 Company Vision & Mission

Vision

To become the leader in power generation in Bangladesh in line with the government's target to provide electricity to all

Mission

Empowering Bangladesh by expanding the company's power generation capacity to meet the growing demand of the country

Chapter 2
Familiarization with APSCL

2.1 Power Generation Process in APSCL

Bangladesh is a developing country. But the country's power generation capacity has not yet met the power demand. Due to this lacking of power generation the government of Bangladesh and many private power companies are taking so many necessary and impacting actions. The power generation industry is leaning towards combined cycles, which are in high demand for their minimal delivery time and higher efficiency. Enhanced efficiency is beneficial for both countering the greenhouse effect and reducing fuel expenses. Considering this perspective, Max group has taken an initiative to build a combined cycle power plant which is 50% more efficient than the single cycle power plant.

So, first we have to know, what is combined cycle power plant:

"The process for converting the energy in a fuel into electric power involves the creation of mechanical work, which is then transformed into electric power by a generator. Depending on the fuel type and thermodynamic process, the overall efficiency of this conversion can be as low as 30%. This means that two third of the latent energy of the fuel ends up wasted. For example, steam electric power plants which utilize boilers to combust a fossil fuels average 33% efficiency. Simply cycle gas turbine (GTs) plants average just under 30% efficiency o natural gas, and around 25% on fuel oil. Much of this wasted energy ends up as thermal energy in the hot exhaust gases from the combustion process."

2.2 Reasons of using Combined Cycle in APSCL

In combined cycle power plant, the heat rejected by the higher temperature cycle is recovered and used by the lower temperature cycle to produce additional power and gives high efficiency. Some of the combined cycles are: gas-steam, steam-organic fluids and gas-organic fluids. But APSCL used gas-steam combined cycles.

The higher temperature cycle is known as topping cycle whereas the lowering temperature cycle is known as bottoming cycle. The topping cycle can be Diesel, Brayton and Rankine cycles but the bottom cycle is basically Rankine cycle.

In APSCL, Gas fired combined cycle is used. It has the following advantages:

- High efficiency
- Low specific investment cost
- Short Construction Period
- A saving on Area & Water Consumption
- High automaticity
- High operation utilization rate
- Ease of quick Start-up
- Clean Fuel & Little pollution

There are also some disadvantages of the combined cycle power plant:

- Long start-up time required for the Steam Turbine (usually 3 to 4 hours)
- It takes longer time to synchronous the Gas Turbine Generator and Steam Turbine Generator during the start-up period.
- The Steam Turbine can trip if the Gas Turbine trips due to any kind of fault.
- The operation of Steam Turbine requires more equipment than that of the single cycle Gas Turbine. Among these components are HRSG, cooling towers, feedwater pump, blowdown tank and so on.

2.3 Combined Cycle Operation of APSCL

In power plants, a widely used combination is a gas turbine (operating by the **Brayton cycle**) burning natural gas whose hot exhaust powers a steam power plant (operating by the **Rankine cycle**). This is called a Combined Cycle Gas Turbine (CCGT) plant. Combined Cycle Gas Turbine (CCGT) plant can achieve thermal efficiency of around 54% in base-load operation, in contrast to a single cycle steam power plant which is limited to efficiencies of around 35–42%. Combining two or more thermodynamic cycles result in improved overall efficiency, reducing fuel costs. In a combined cycle power plant (CCPP), or combined cycle gas turbine (CCGT) plant, a gas turbine generator generates electricity, and the heat of its exhaust is used to make steam, which in turn drives a steam turbine to generate additional electricity. CCPP can be operated by both single shaft and multi shaft generator.

The following figure illustrates the basic operation of the combined cycle of the APSCL:

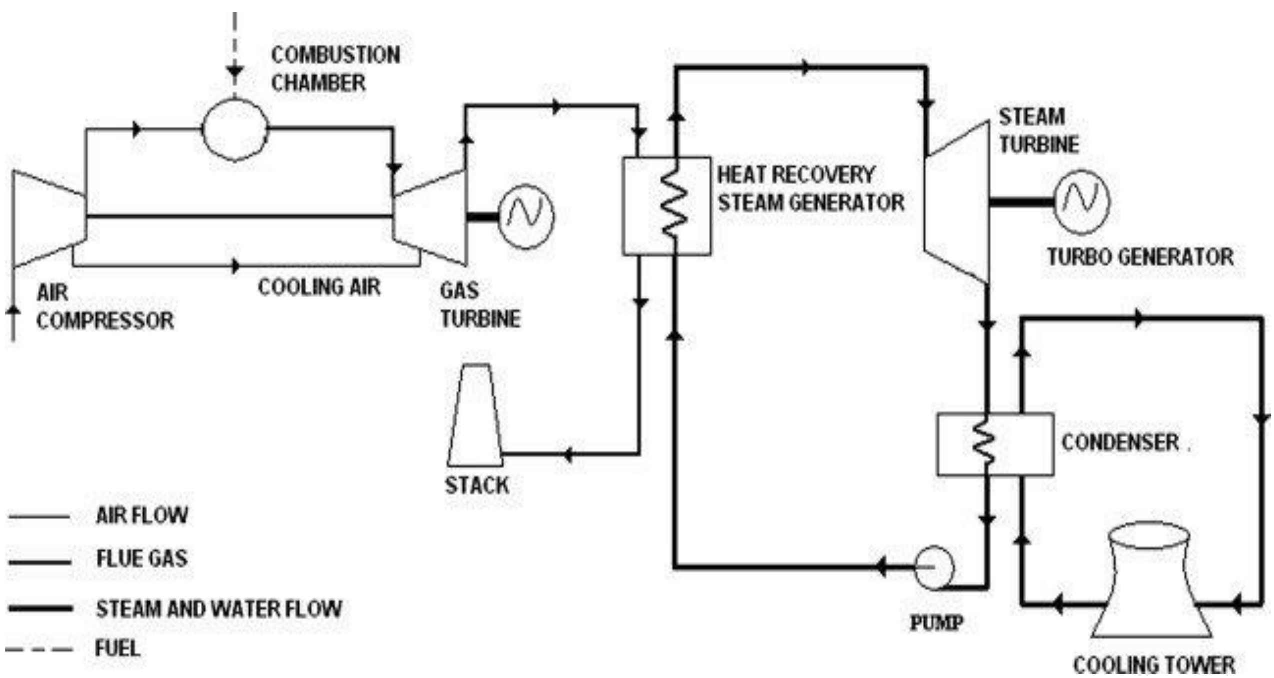

Fig 2.1: Operational Diagram of Combined cycle in APSCL

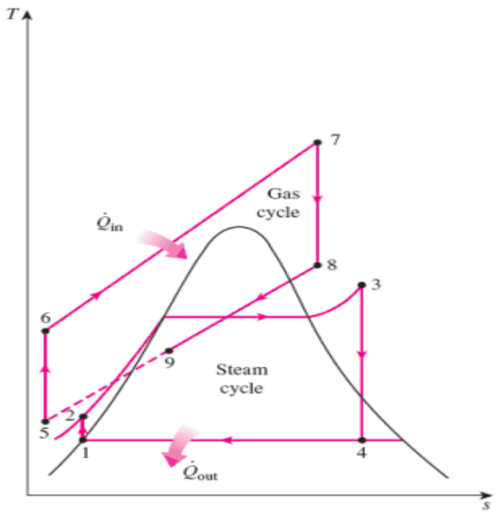

Fig. 2.2: Rankine cycle and Brayton cycle in CCPP

The gas is used as fuel in a gas turbine which produces electrical power. In a combined cycle power plant, "waste heat" from the gas turbine's exhaust is used to generate steam by passing it through a heat recovery steam generator (HRSG) with a live steam temperature between 420 and 580 °C. The condenser of the Rankine cycle is usually cooled by water from a lake, river, sea or cooling towers. This temperature can be as low as 15 °C. Combined gas and steam (COGAS) power plant consists of gas and steam turbines. The steam turbine gets its input heat from the high temperature exhaust gases from gas turbine. The steam generated thus can be used to drive steam turbine. No combustion of fuel means that there is no need of a fuel handling plant, and it is simply a heat exchanger. Exhaust enters in HRSG. Feed water comes in through the economizer and then exits after having attained saturation temperature in the water or steam. If the temperature of the gases entering the heat recovery steam generator is higher, then the temperature of the exiting gases is also high. In this way, some of the lost energy can be reclaimed and the specific fuel consumption of the plant can be decreased. Large (land-based) electric power plants built using this combined cycle can reach conversion efficiencies of over 60%.

2.4 Sub-station of APSCL

A sub-station is a subsidiary station where electricity is transformed for distribution by low voltage network. The sub-station is interconnected to generators, transformer, transmission and distribution lines and all other protecting and maintaining equipment’s. We observed the activities of substation were i) transformation of power from one voltage level to another switching for alternate connections, ii) isolation of failed or overloaded lines and equipment, iii) controlling system voltage and power flow, iv) suppression of over voltage and v) detection of faults, monitoring, recording of information, power measurements, and remote communications. There are two types of substations in APSCL:

- AIS (Air Insulated System)
- GIS (Gas Insulated System)

2.4.1 Gas Insulated Substation

Gas insulated substation (GIS) consist of components where active parts on high voltage potential are located in the middle of the aluminium alloy pipes and held in this location by epoxide resin insulators. The pipes are filled in with insulating gas and have earth potential. The GIS consists of typical HV components such as disconnectors, CBs, busbars, voltage and current transducers. GIS can save up to 90% of space compared with air insulated substation. It is particularly suitable for indoor and outdoor applications. For insulation in GIS, SF6 gas is used in APSCL.

Fig. 2.3: GIS in North and South 450MW CCPP.

2.4.2 Air Insulated Substation

An air-insulated substation (AIS) is one where the main circuit potential is insulated from the ground by air using porcelain or composite insulators and/or bushings. AIS is fully composed from air-insulated technology components such as circuit breakers, disconnecting switches (disconnectors), surge arrestors, instrument transformers, power transformers, capacitors, bus bars, and so on, and the components are connected to each other by stranded flexible conductors, tubes, or buried power cables. AIS is the most common type of substation, accounting for more than 70% of substations all over the world.

Fig. 2.4: AIS in old power plant.

2.5 Main Equipment of the Substation

1. Power Transformer:

    (i) Single Phase Transformer,

    (ii) Earthing Transformer,

    (iii) Auxiliary Transformer and

    (iv) Coupling Transformer.

2. Instrument Transformer:

    (i) Current Transformer (CT) and

    (ii) Potential Transformer (PT).

3. Circuit Breaker (CB):

    i) SF6 CB and

    ii) Oil CB.

4. Isolator.

5. Bus Bar:

    (i) Single Bus Bar and

    (ii) Double Bus Bar.

6. Incoming and Outgoing Feeder.

7. Bus Coupler.

8. Lighting Arrester.

9. Sky Wire.

10. Support Insulator.

11. Wave Tray.

12. Earth Switch.

13. Relay.

14. Battery Room.

15. Control Room.

Chapter 3
Schematic Arrangement of APSCL

3.1 Different Sections of APSCL

APSCL's Power Plant consists of the following main sections:

1. Gas Turbine Generator
2. HRSG (Heat Recovery Steam Generator)
3. Steam Turbine Generator
4. Transformers
5. WTP (Water Treatment Plant)
6. ETP (Effluent Treatment Plant)
7. RMS plant
8. GBC (Gas Booster Compressor)
9. PEECC
10. CWPH
11. Fire Fighting System
12. Control Room

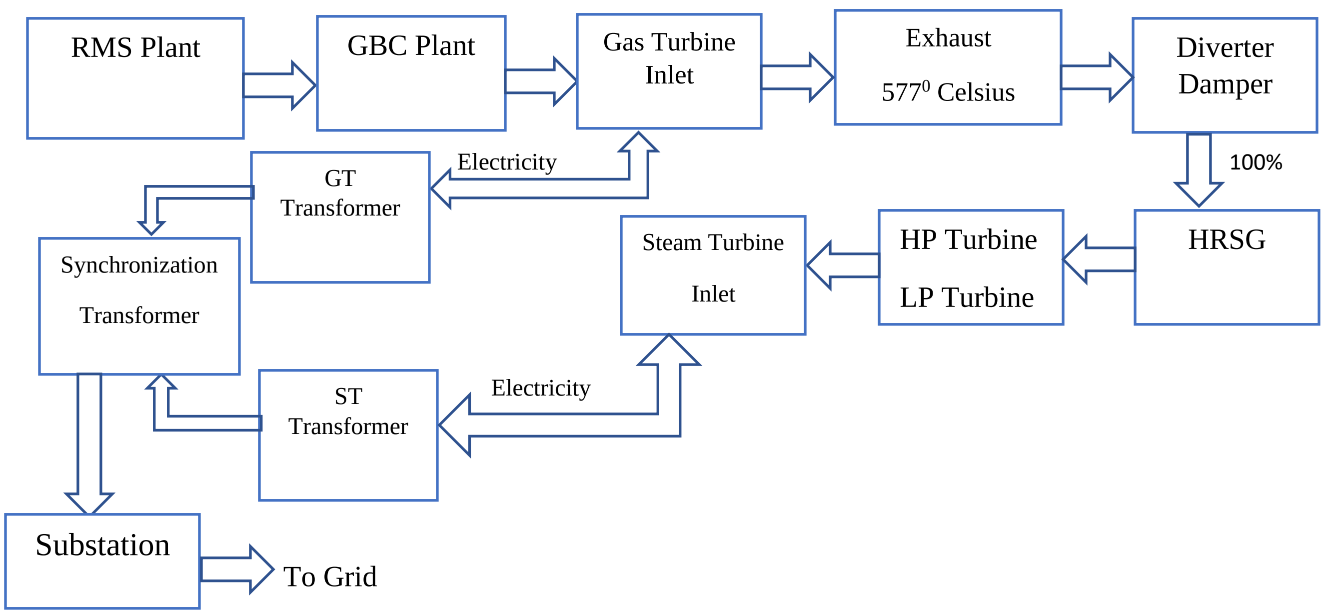

Fig 3.1: A schematic Diagram of APSCL Power Plant

3.2 Gas Turbine Generator

The gas turbine's model of APSCL is 9E.03 supplied by GE power. The name plate data of the Gas turbine Generator is given below:

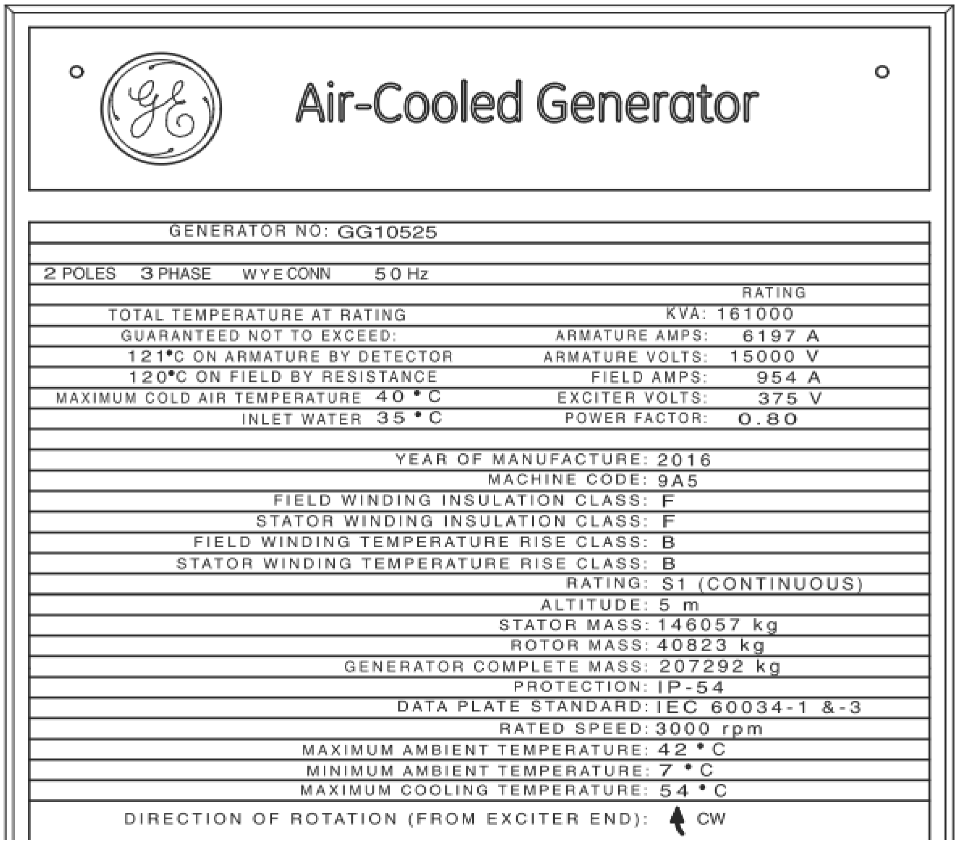

Fig 3.2: Name plate data of Air-Cooled Generator

Facilities of 9E.03 Gas Turbine:

From desert climates to the tropics, to the arctic cold, the rugged 9E.03 heavy-duty gas turbine provides essential power and performs in a vast number of duty cycles and applications. The 9E.04 heavy-duty gas turbine provides increased power and performance while maintaining the simplicity and operational strengths of the 9E.03 gas turbine.

- ❖ 9E turbines can use more than 52 types of fuel, almost the entire fuel spectrum and can even switch fuels while running under full load.
- ❖ With order to operation demonstrated in as few as six months, and fast-start and load capabilities, the 9E has quick installation and operational flexibility.

- The 9E.04 has multiple features that help reduce fuel costs and increase revenue, such as a 225 MW output and 51 percent combined cycle efficiency.

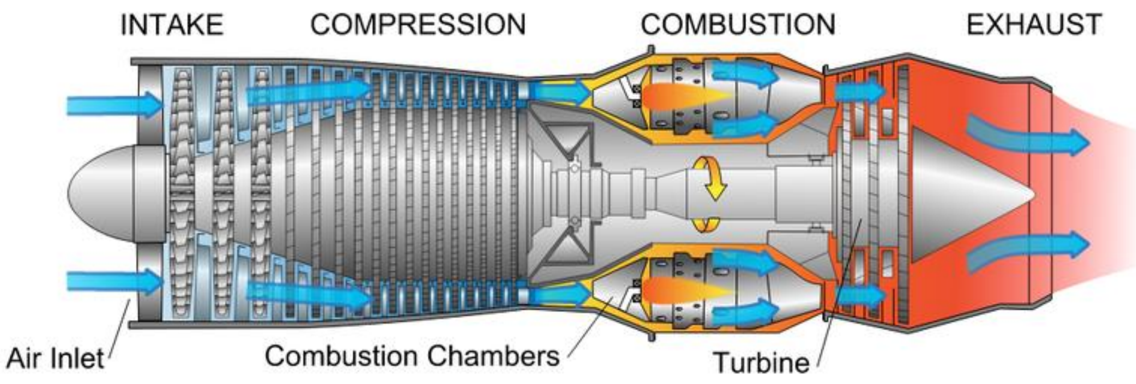

Fig 3.3: 9E.03 Gas Turbine

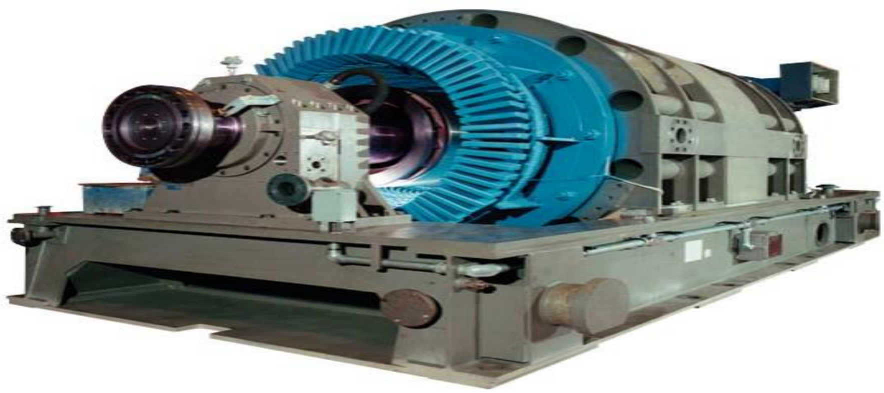

Fig 3.4: Air-Cooled Generator

The Generator facilities are given below:

- Increase turbine output up to 150 megawatts (MW) in simple-cycle operation and up to 225 MW in a combined-cycle configuration.
- Achieve up to 37 percent efficiency in simple cycle and up to 51 percent efficiency in combined-cycle configuration.
- Deliver maintenance intervals of up to 32,000 hours or 900 starts, equivalent to approximately four years of typical plant operation.
- The heavy-duty 9E gas turbine is known to deliver extraordinary performance even under tough conditions – ranging from -40°F to 120°F, while capable of running on a wide range of fuels – more than 50 types.
- Offset as much as 2-3 percent of normal performance degradation between maintenance intervals in extreme ambient operating conditions.

Fig 3.5: Gas Turbine Generator Shaft

Fig 3.6: Gas Turbine Generator Exciter

Fig 3.7: Gas Turbine Shaft Lube Oil pump

3.3 Steam Turbine Generator

The GE power has supplied the SC2 – 26 steam turbine, Heat Recovery Steam Generator (HRSG), Condenser and Distributed Control System (DCS) for APSCL's CCPP.
The Steam Turbine Generator can supply up to 75MW when the GT is at its full load.
The steam turbine of APSCL is divided into two sections:

1. High Pressure (HP) Turbine
2. Low Pressure (LP) Turbine

3.3.1 HP Turbine

HP Turbine (high-pressure turbine) is usually double-flow turbine element with an impulse control stage followed by reaction blading in each end of the element. There are about 10 stages with shrouded blades in the HP turbine. It the produces about 30-40% of the gross power output of the power plant unit.
HP turbine is equipped usually with 3 or 4 self-regulating extraction lines, which are used to provide steam for:

- the deaerator
- the high-pressure feedwater heaters
- the feedwater pumps (when driven by steam turbines)

In HP turbine the high-pressure stage receives steam (this steam is nearly saturated steam – x = 0.995 – point C at the figure; 6 MPa; 275.6°C) from a steam generator and exhaust it to moisture separator-reheater (MSR – point D – ~1.15 MPa; ~186°C; x ≈ 0.9). The steam must be reheated in order to avoid damages that could be caused to blades of steam turbine by low quality steam. High content of water droplets can cause the rapid impingement and erosion of the blades which occurs when condensed water is blasted onto the blades. The reheater heats the steam (point D) and then the steam is directed to the low-pressure stage of steam turbine, where expands (point E to F).

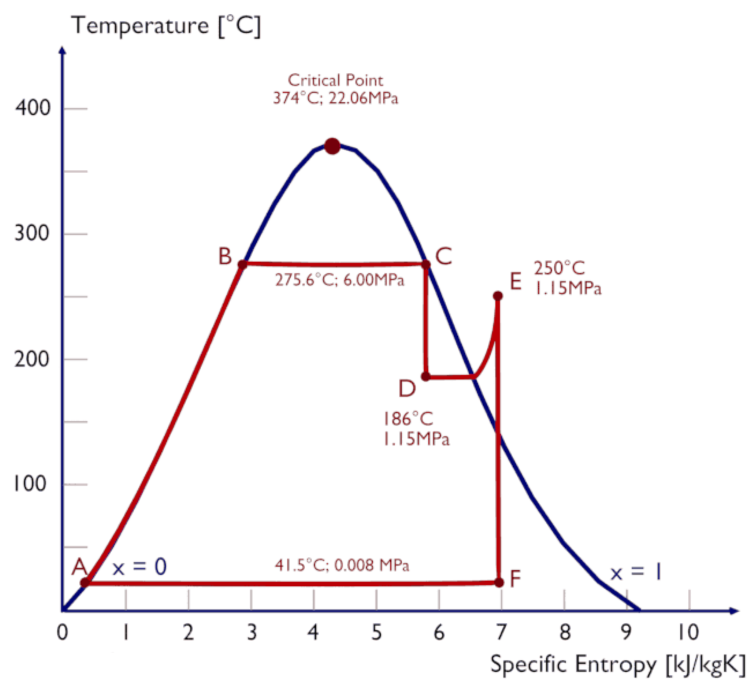

Fig 3.8: Steam Turbine Rankine Cycle - Ts diagram

3.3.2 LP Turbine

Each LP Turbine (low-pressure turbine) is usually double-flow reaction turbine with about 5-8 stages (with shrouded blades and with free-standing blades of last 3 stages). LP turbines produce approximately 60-70% of the gross power output of the power plant unit. Each turbine rotor is mounted on two bearings, i.e., there are double bearings between each turbine element.

LP turbine is equipped usually with 3 or 4 self-regulating extraction lines, which are used to provide steam for:

- the low-pressure feedwater heaters

In LP turbine the low-pressure stage receives steam (this steam is usually superheated steam – point E at the figure; ~1.15 MPa; 250°C) from a moisture separator-reheater (MSR). The steam from the HP turbine must be reheated in order to avoid damages that could be caused to blades of steam turbine by low quality steam. High content of water droplets can cause the rapid impingement and erosion of the blades which occurs when condensed water is blasted onto the blades. The moisture-free steam is superheated by extraction steam from the high-pressure stage of turbine and by steam directly from the main steam lines.

In the low-pressure turbine the steam continuously expands from point E to F. The exhausted steam then condenses in the condenser and it is at a pressure well below atmospheric (absolute pressure of 0.008 MPa). The steam is in a partially condensed state (point F), typically of a quality near 90%. High pressure and low-pressure stages of the turbine are usually on the same shaft to drive a common generator, but they have separate cases. The main generator produces electrical power, which is supplied to the electrical grid.

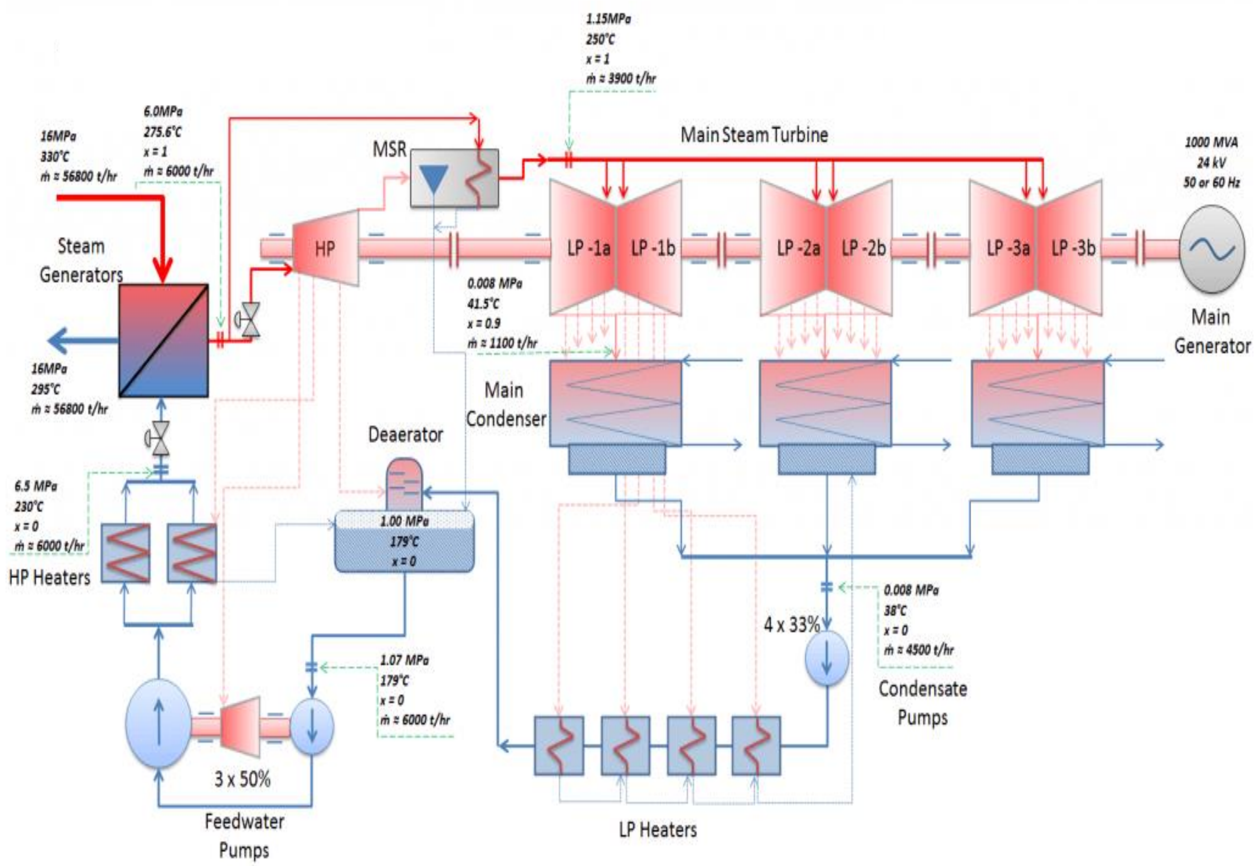

Fig 3.9: Graphical Overview of Steam Turbine with HP & LP Turbine

Fig 3.10: Steam Turbine Generator of APSCL

Fig 3.11: Steam Turbine Generator Exciter

3.4 Turning Gear Motor

A jacking gear (also known as a turning gear) is a device placed on the main shaft of an engine or the rotor of a turbine. The jacking gear rotates the shaft or rotor and associated machinery (such as reduction gears and main turbines), to ensure uniform cool-down.

The major purposes of turning gear operation during turbine startup are:

1. To rollout shaft hogging or sagging before runup is begun. As mentioned in the previous module, any attempt to run up the turbine with an excessively deformed shaft is bound to fail because high vibration would sooner or later force a turbine trip. Meanwhile, the turbine generator would be unnecessarily exposed to increased risk of damage due to high vibration and/or rubbing.
2. To enable uniform prewarming of the turbine generator. If the turbine generator were prewarmed with the rotor held stationary, rotor and casing hogging would develop due to thermal stratification of the atmosphere inside the machine as outlined in the earlier turbine courses. This would make runup impossible until the hogging is roiled out.

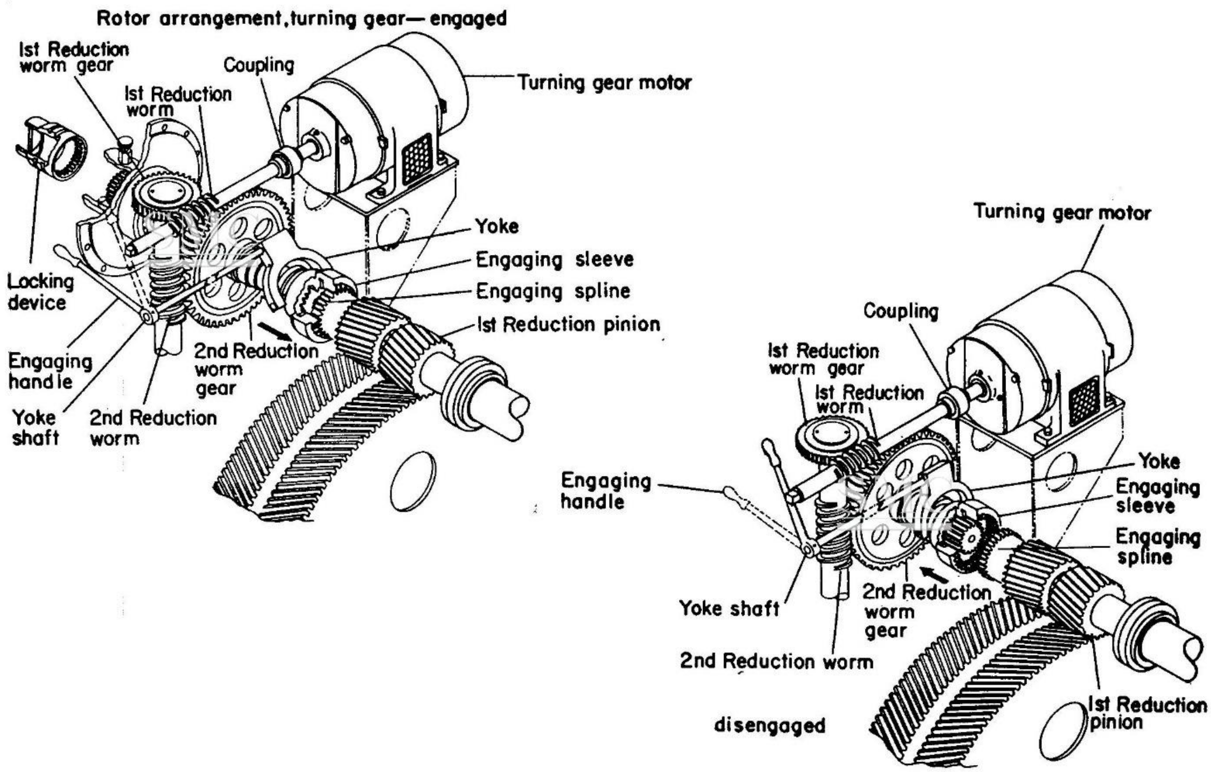

Fig 3.12: Turning Gear Motor arrangement with the turbine

3.5 Heat Recovery Steam Generator (HRSG)

One of the most important components in combined cycle and cogeneration power plants is the Heat Recovery Steam Generator (HRSG), which is sandwiched between the gas turbine and the steam turbine.

The HRSG can be used to drive a steam turbine for power generation**,** or to generate steam for factory processes or district heating. When used for cogeneration purposes, the HRSG-produced steam is for process applications. In the combined cycle mode, the steam produced goes to a steam turbine generator for power generation. The two modes are demonstrated in the figure below.

When used in cogeneration, these devices offer environmental and economic benefits. They also enhance overall plant efficiency to as much as 90%. In combined cycles, the HRSG has been seen to enhance efficiency of the combined system to as much as 60%.

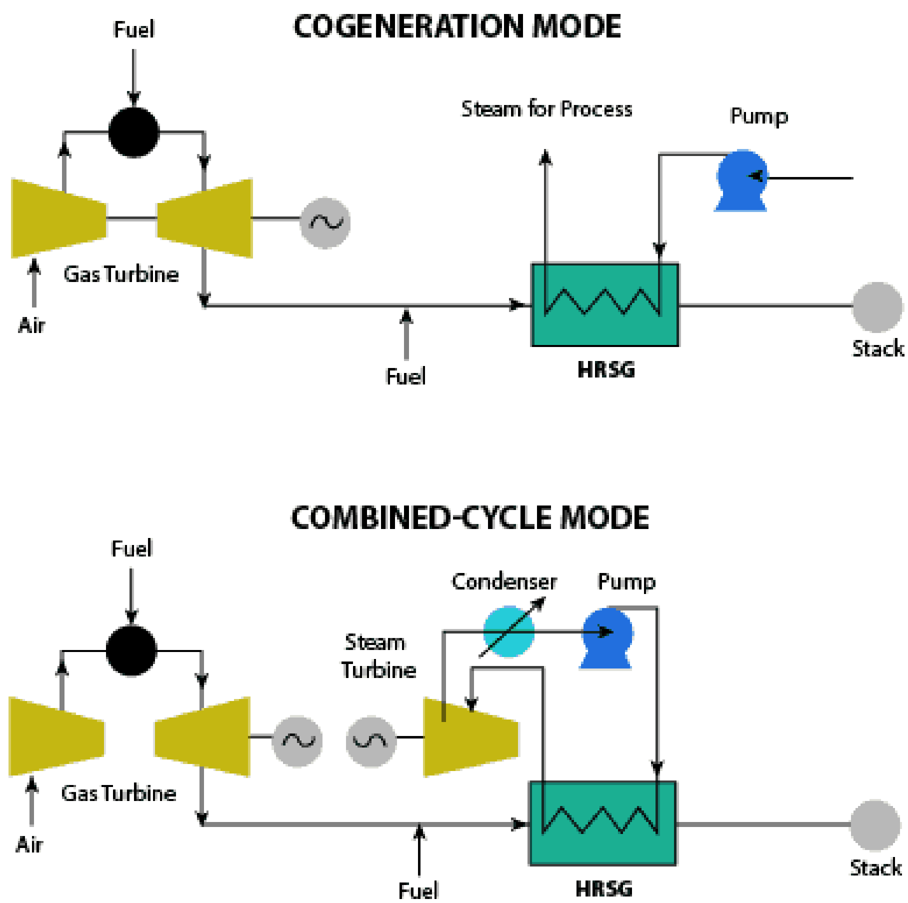

Fig 3.13: Uses of HRSG

Even with the numerous brands of HRSG in the market, the basic design has remained largely the same. The generator is simply a group of tubes placed within an exhaust gas path. The exhaust gases that heat the water-containing tubes are at a temperature of up to 650ºC. Heat absorption from the flue gases is often through convection method, but some designs use convection or

radiation. To produce steam, the water is held at a temperature of 200ºC and extremely high pressures.
Essentially, the HRSG is composed of several heat exchangers making it a large heat exchanger. The Heat exchanger tubes are set in different modules or sections, popularly known as:

1. Economizer
2. Evaporator
3. Super-heater

3.5.1 Economizer

The function of the economizer is to preheat the feed-water and replace the steam removed**.** Once the water approaches the boiling point (saturation temperature), it supplied to the steam drum.

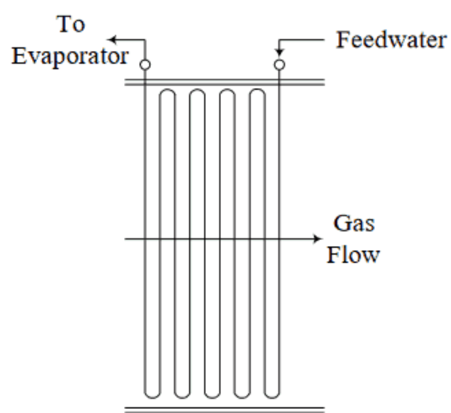

Fig 3.14: Economizer

3.5.2 Evaporator

The evaporator refers to the section where the water in the tubes turns into steam from the heat of the gas turbine exhaust.

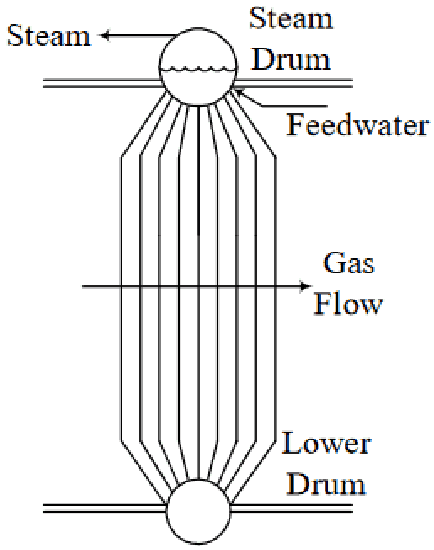

Fig 3.15: Evaporator

As shown in the figure above, water/steam moves from the lower drum to the upper drum (steam drum). Steam leaves the upper drum via the steam separating equipment.

3.5.3 Super-heater

When saturated steam leaves the evaporator, it goes to the superheaters/reheaters where it is turned into dry steam. This is important because steam turbines run on dry steam. The movement of the steam through this section is as showed in the diagram below.

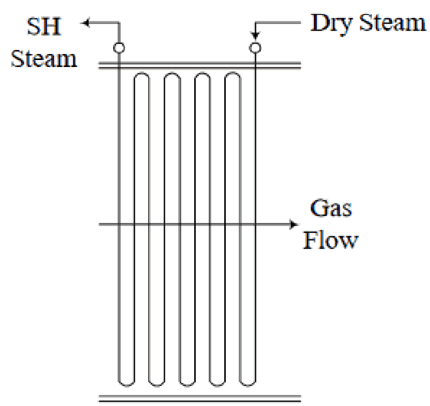

Fig 3.16: Super-heater

3.6 Water Treatment Plant (WTP)

Boiler (or HRSG) water quality has long been an important factor in the operation of boilers. As the power plant operating pressures increase, water quality requirements also become stricter. With the current units operating at Supercritical pressures, the requirements are tough. Continuous improvements and changes in the methods of maintaining water quality, understanding the corrosion mechanisms, and the development of new chemicals have resulted in a more economical and efficient water regime management.

There are four main reasons why water quality is so important. Impurities in water form scales.

- Water contains dissolved salts, which upon evaporation of water forms scales on the heat transfer surfaces. Scales have much lower heat transfer capacity than steel: the heat transfer coefficient of the scales is 1 kcal/m/°C/hr against 15 kcal/m/°C/hr for steel . This leads to overheating and failure of the boiler tubes. Scale also reduces flow area, which increases pressure drop in boiler tubes and piping.

- Low pH or dissolved oxygen in the water attacks the steel. This causes pitting or lowering the thickness of the steel tubes, leading to rupture of the boiler tubes. Contaminants like chlorides, a problem in seawater cooled power plants, also behave in a similar way.
- Flow assisted corrosion occurs in the carbon steel pipes due to the continuous removal of the protective oxide layer at high flows.

- Impurities carried over in the steam, causing deposits on turbine blades leading to reduced turbine efficiency, high vibrations, and blade failure. These contaminants can also cause erosion of turbine blades. Silica at higher operating pressures volatilizes and carries over to the turbine blades.

Fig 3.17: Water Treatment Plant (WTP) of APSCL

3.6.1 Water Treatment Procedure

The raw water is collected from the Meghna River for treatment and further use in the plant. This raw water of the river has two types of substances:

- Dissolved solid and
- Un-dissolved solid

Dissolved solids are different types of ions and minerals. Un-dissolved solids are clay, mud etc. By following several steps, the solids can be removed.

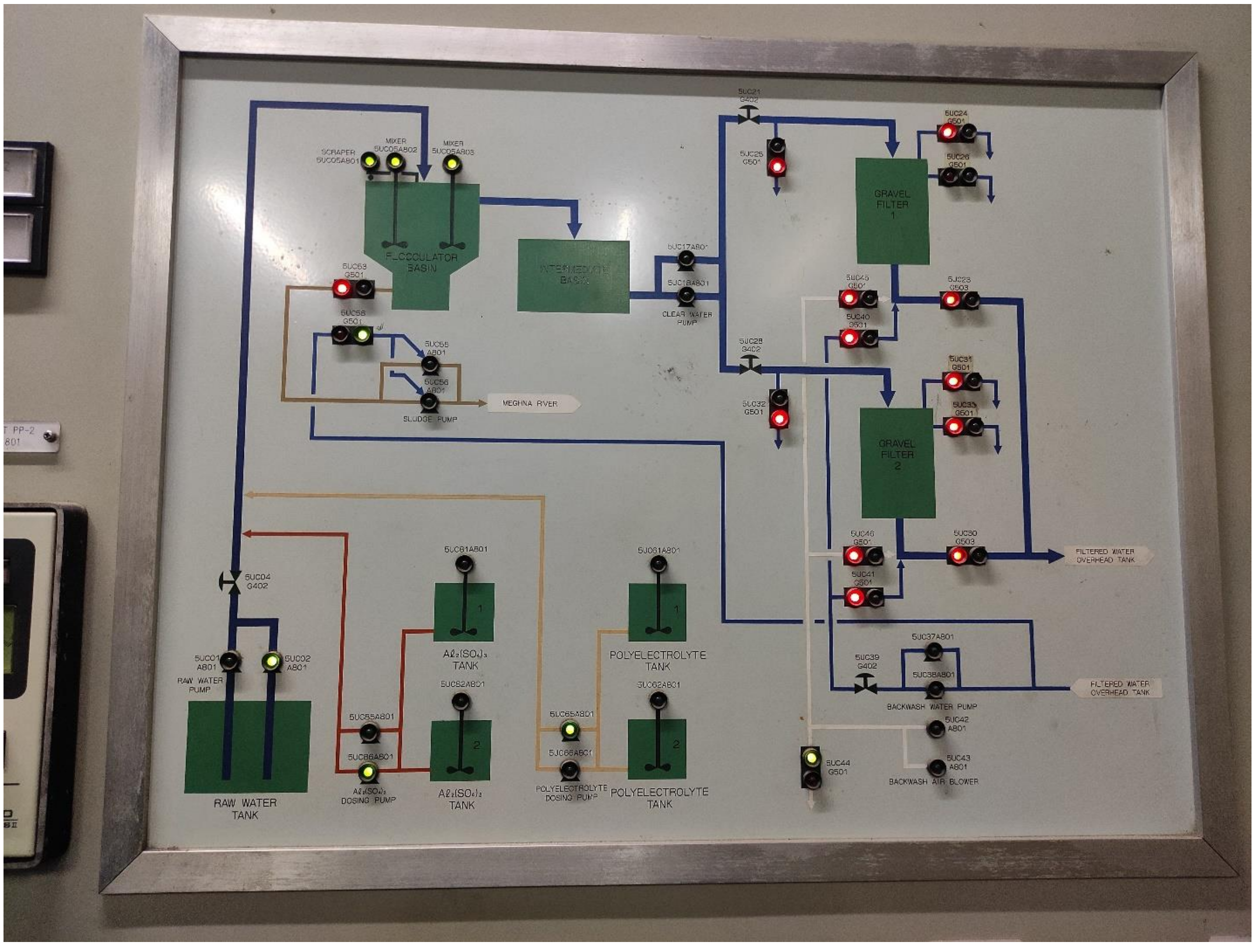

Fig 3.18: Water Treatment Plant (WTP) Procedure

The water treatment procedure is illustrated below with the figure:

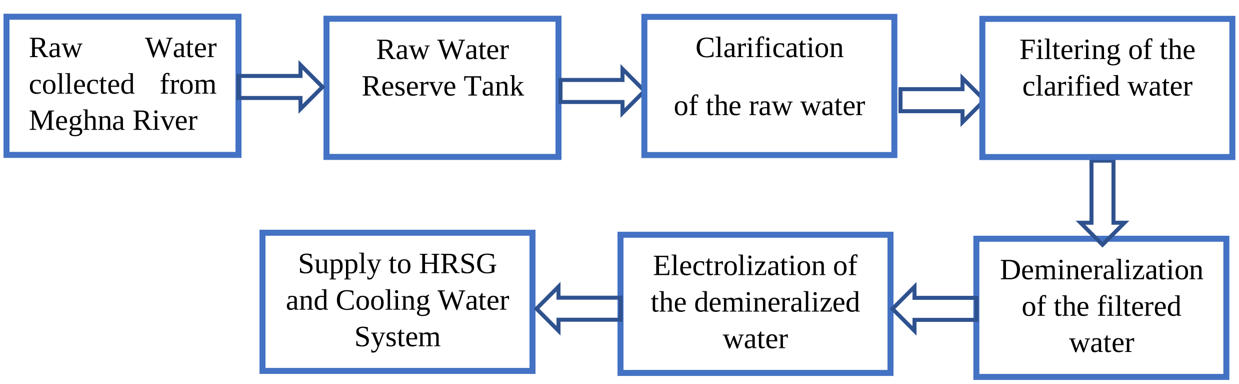

Fig 3.19: Water treatment procedure of APSCL

3.6.2 Clarification

Three chemicals are used in the clarification stage of the water treatment plant of APSCL. These chemicals are:

- Poly Aluminum Chloride (PAC)
- Sodium Hydroxide (Caustic Soda)
- Poly Acrylamide

The mixture of these three chemicals is directly applied to the raw water collected from the river. These mixtures do the following changes to the raw water:

- Pre and Post pH adjustment (lime, caustic etc.)
- Sludge Treatment (flocculation/dewatering)
- Solids Disposals
- Alkaline cleaners
- Heavy Metal precipitant

After the clarification stage the water is transferred into the filtering stage for further processing.

3.6.3 Filtering

The clarified water is used for filtering. After clarification, the water contains a lot of small or big particles which are harmful and destructive to the plant. The filter removes any solid particle like sand, silt etc.

3.6.4 Demineralization

Demineralization is the process of removing mineral salts from water by using ion exchange process [4]. Demineralized water is also known as deionized water with removed mineral ions. Mineral ions such as cat-ions of sodium, calcium, iron, copper, etc. and anions such as chloride, sulphate, nitrate, etc. are common ions present in water. This deionized water contains positive ion like Mg++, Fe+++, Al+. When it is passing through cat-ion exchanger resin, these cat-ions are caught by the following reactions.

$$R\text{-}H_2+Ca(HCO_3)_2 \rightarrow R\text{-}Ca+2H_2CO_3$$

$$R\text{-}H_2+Mg(SO_4) \rightarrow R\text{-}Mg+H_2SO_4$$

$$R\text{-}H+NaCl \rightarrow R\text{-}Na+HCl$$

This water also contains negative ion like Cl^-, SO_4^{2-}, NO_3^-. When passing this water through anion exchanger resin, these anions are caught by the following reactions.

$$R\text{-}(OH)_2+H_2SO_4 \rightarrow R\text{-}SO_4+2H_2O$$

$$R\text{-}OH+HCl \rightarrow R\text{-}Cl+H_2O$$

This demi water is stored in demi tank. Then this water is used for producing steam.

3.6.5 Electrolyzer Plant

Electrolysis of water is decomposition of water (H_2O) into Oxygen and Hydrogen gas due to an electric current passed through the water.

Electrolysis of pure water requires excess energy in the form of over potential to overcome the various activation barriers. Without the excess energy the electrolysis of pure water occurs very slow or not at all. This is in part due to the limited self-ionization of water.

Followings are the different elements of electrolyzer plant of APSCL:

Separation Column:

Separator columns are intended for separation of gases from electrolyte and for cooling and circulation of electrolyte.

Pressure Regulator:

Pressure regulator is a vertical vessel used for maintaining equal pressure of hydrogen and oxygen in electrolyzer.

Surge Tank:

Surge tank serves for keeping a stock of demi-water feeding into electrolyzer. Demi-water is used to restock the electrolyzer cell.

Alkali Tank:

Alkali tank serves for preparation of electrolyte. It is equipped with electrolyte pumps.

Water-locks:

Water-locks are devices serving for release of oxygen to the atmosphere and at the same time for prevention of air into the electrolyzing plant system.

Receivers:

Receivers are vessels introduced for storing a stock of hydrogen and supplying of hydrogen into generator cooling system

3.7 Diverter Damper

HRSG Bypass/Diverter dampers are installed between a gas turbine and the heat recovery steam generator (HRSG) on a combined cycle plant. Therefore, the dampers must be designed for the extreme conditions they are subjected to.

The Diverter Damper system controls the flow of turbine exhaust gas (TEG) between a bypass stack or the HRSG. HRSG isolation damper allows exhaust to enter the HRSG while the bypass damper is closed, and upon closing the isolation damper and opening the bypass damper, forces the exhaust gases up the bypass stack.

During the evaluation of the HRSG Diverter Damper the following basic requirements should be met properly:

- The damper must guarantee zero damper leakage when closed to either the bypass stack or the HRSG under maximum gas flow conditions.
- The HRSG should be safe for entry by maintenance personnel with the combustion turbine running at full load, when the dampers have the HRSG isolated, and the seal air system operating with proper ventilation.

The following figure illustrates the configuration of Diverter Damper with HRSG:

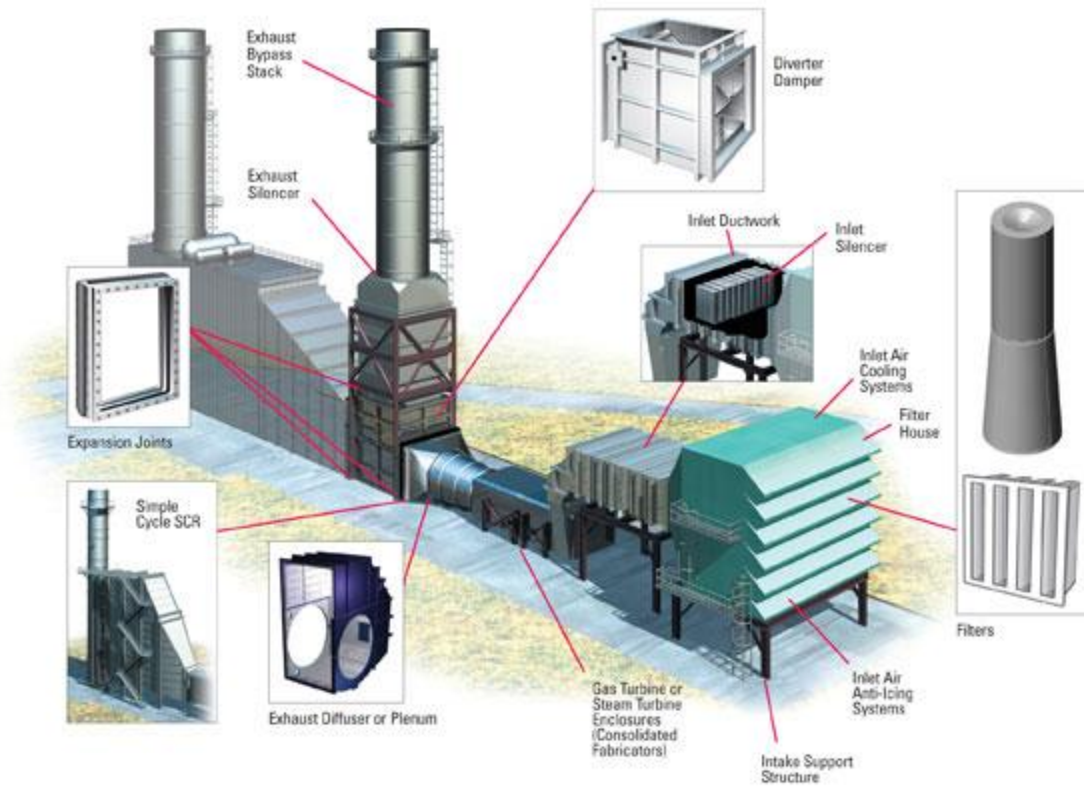

Fig 3.20: Graphical illustration of the diverter damper position with HRSG

3.8 Blowdown Tank:

Boiler/HRSG blowdown is the removal of water from a boiler. Its purpose is to control boiler/HRSG water parameters within prescribed limits to minimize scale, corrosion, carryover, and other specific problems. Blowdown is also used to remove suspended solids present in the system. These solids are caused by feedwater contamination, by internal chemical treatment precipitates, or by exceeding the solubility limits of otherwise soluble salts.
In effect, some of the boiler water is removed (blowdown) and replaced with feedwater. The percentage of boiler blowdown is as follows:

$$\frac{\text{quantity blowdown water}}{\text{quantity feedwater}} \text{ X } 100 = \text{\% blowdown}$$

The blowdown can range from less than 1% when an extremely high-quality feedwater is available to greater than 20% in a critical system with poor-quality feedwater. In plants with sodium zeolite softened makeup water, the percentage is commonly determined by means of a chloride test. In higher-pressure boilers, a soluble, inert material may be added to the boiler water as a tracer to determine the percentage of blowdown.

The blowdown rate required for a particular boiler depends on the boiler design, the operating conditions, and the feedwater contaminant levels. In many systems, the blowdown rate is determined according to total dissolved solids. In other systems, alkalinity, silica, or suspended solids levels determine the required blowdown rate.
There are mainly three types of blowdown arrangement available and these are:

- Manual Blowdown
- Continuous Blowdown
- Automatic Blowdown

In APSCL, the Continuous Blowdown arrangement is used.
Usually, continuous blowdown equipment is installed by the boiler manufacturer. The exact location of the continuous blowdown take-off line depends primarily on the water circulation pattern. Its position must ensure the removal of the most concentrated water. The line must also be located so that boiler feedwater or chemical feed solution does not flow directly into it. The size of the lines and control valves depends on the quantity of blowdown required.

The blowdown process and its arrangement are illustrated below using a figure:

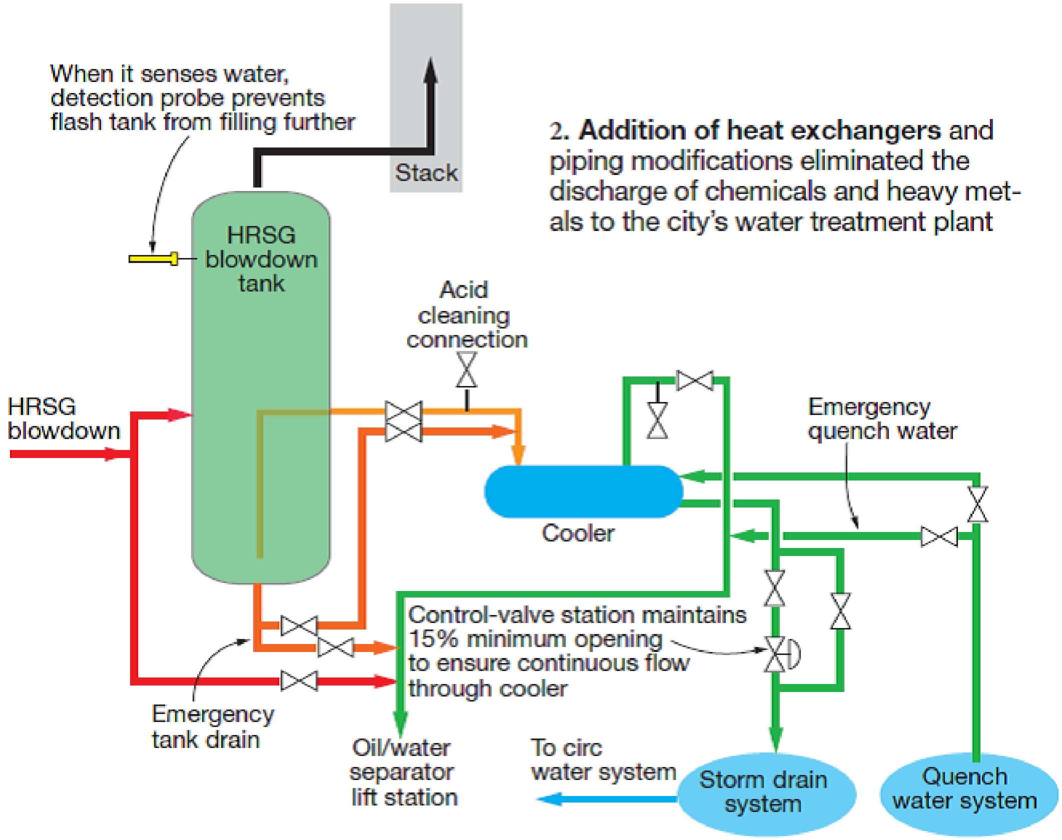

Fig 3.21: Blowdown Tank arrangement with HRSG

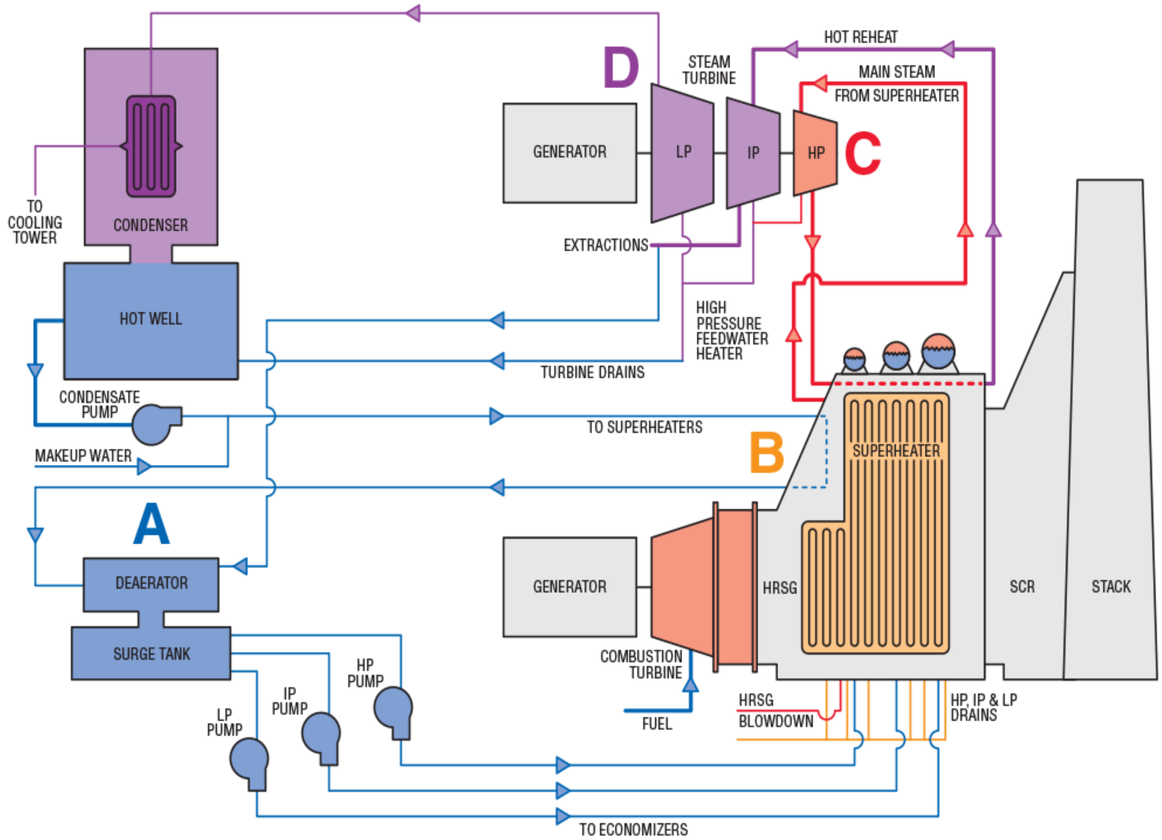

Fig 3.22: Overall pictorial view of a Steam Turbine Generator with necessary compartments

3.8.1 Steam Cycle Heat Transfer

For the purpose of heat transfer from the core, the water is circulated continuously in a closed loop steam cycle and hardly any is lost. It is turned to steam by the primary heat source in order to drive the turbine to do work making electricity, and it is then condensed and retuned under pressure to the heat source in a closed system. A very small amount of make-up water is required in any such system. The water needs to be clean and fairly pure.

This function is much the same whether the power plant is nuclear, coal-fired, or conventionally gas-fired. Any steam cycle power plant functions in this way. At least 90% of the non-hydro -electricity in every country is produced thus.

3.8.2 Recirculating or Once through Cooling

If the power plant does not have access to abundant water, cooling may be done by passing the steam through the condenser and then using a cooling tower, where an updraught of air through water droplets cools the water. Sometimes an on-site pond or canal may be sufficient for cooling the water. Normally the cooling is chiefly through evaporation, with simple heat transfer to the air being of less significance. The cooling tower evaporates up to 5% of the flow and the cooled water is then returned to the power plant's condenser. The 3 to 5% or so is effectively consumed, and must be continually replaced. This is the main type of recirculating or indirect cooling.

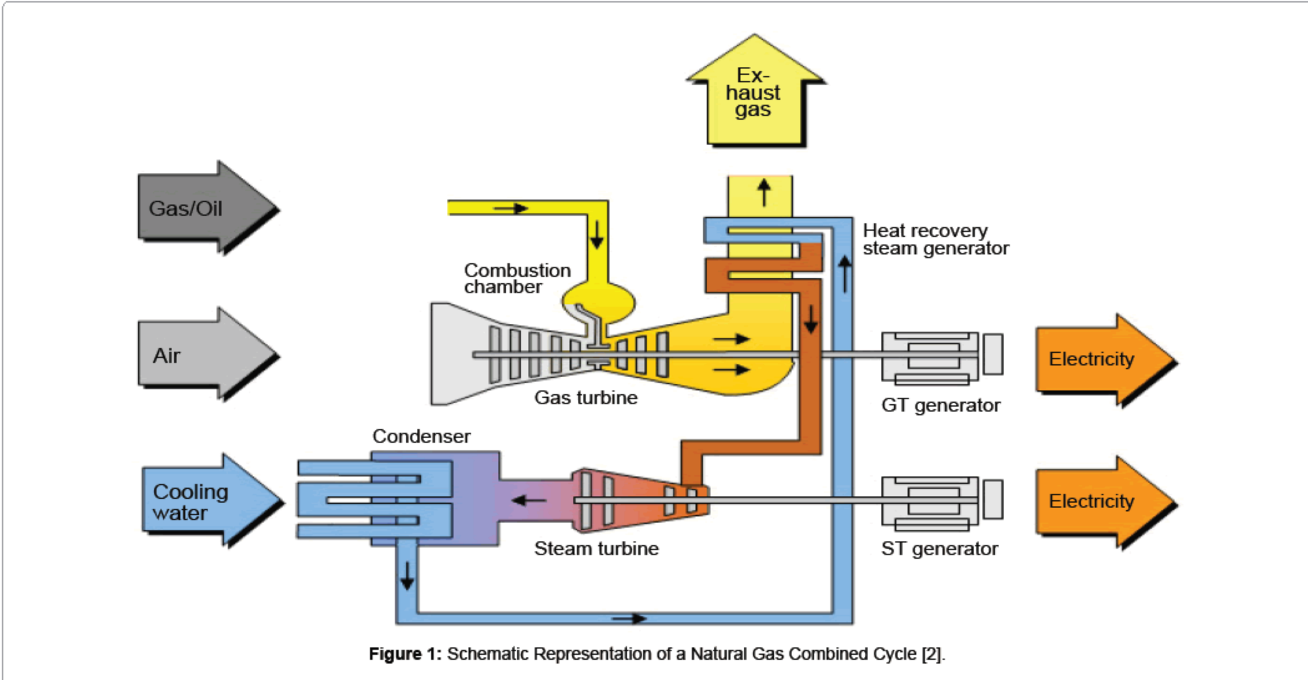

Fig 3.23: Cooling system of the GT and ST in a combined cycle power plant

3.9 Effluent Treatment Plant (ETP)

Effluent Treatment Plant or ETP is one type of waste water treatment method which is particularly designed to purify industrial waste water for its reuse and its aim is to release safe water to environment from the harmful effect caused by the effluent.

Industrial, especially power plant effluents contain various materials, depending on the industry. Some effluents contain oils and grease, and some contain toxic materials (e.g., cyanide). Effluents from food and beverage factories contain degradable organic pollutants. Since industrial waste water contains a diversity of impurities and therefore specific treatment technology called ETP is required.

Followings are some benefits of Effluent treatment plant in power plants:

- To clean power plant effluents and recycle it for further use.
- To reduce usage of fresh water in power plant
- To preserve natural environment against pollution
- To meet the standards for emissions of pollutants set by Government & avoid heavy penalty
- To reduce expenditure on water acquisition

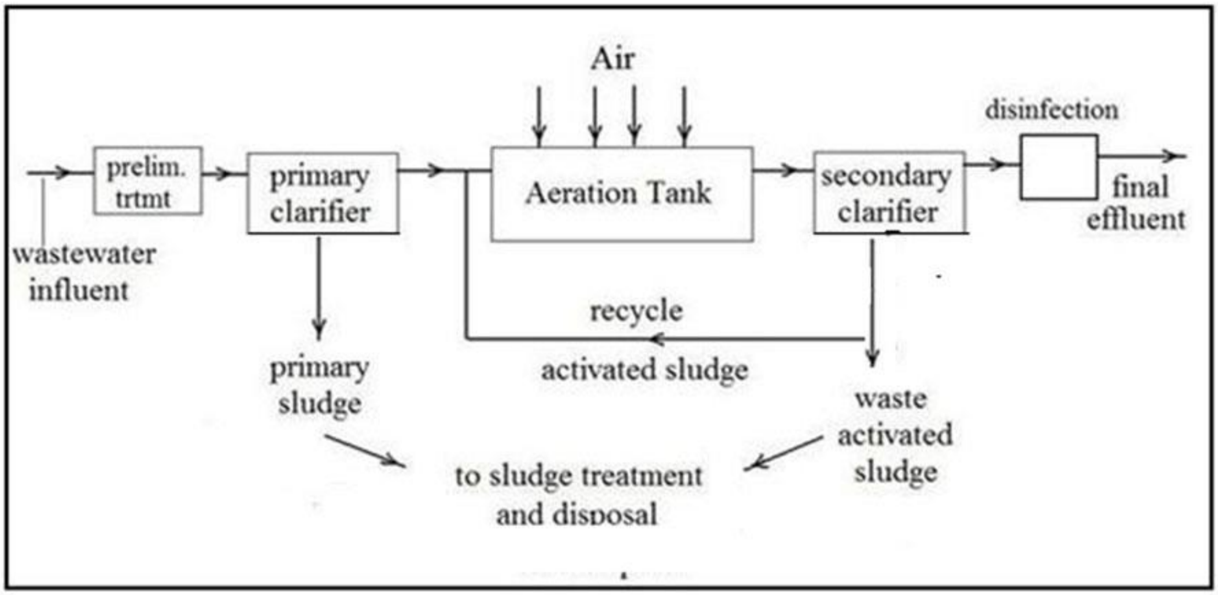

Fig 3.24: Design of a typical Effluent Treatment Plant

3.10 Transformers

A transformer is the most fundamental device a power station which is used to transmit power and receive power using the same circuit during the shutdown condition of the plan. It's the most basic electrical device without which a power plant cannot be imagined. So, let's discuss about the transformers of APSCL.

First of all. We have to know that what is a transformer.

A Transformer is a static electrical machine which transfers AC electrical power from one circuit to the other circuit at the constant frequency, but the voltage level can be altered that means voltage can be increased or decreased according to the requirement.

It works on the principle of Faraday's Law of Electromagnetic Induction which states that "the magnitude of voltage is directly proportional to the rate of change of flux."

The following figure illustrates a basic structure of transformer:

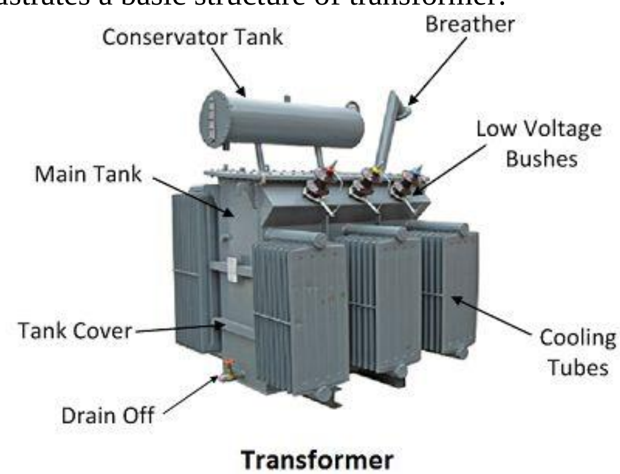

Fig 3.25: Basic structure and components of a Transformer

3.10.1 Types of Transformers

In substation two types of transformers are mainly used. These are:

1. Power transformers:
- Single Phase Transformer,
- Earthing Transformer,
- Auxiliary Transformer and
- Coupling Transformer.

2. Instrument transformers:
- Current Transformer and
- Potential Transformer

3.10.2 Power Transformers

The power transformers are used in substations to step up or step down the voltage level. It can be single phase transformer banks of three each or three-phase transformer. For efficient use three single phase transformer are used in high voltage level. When single-phase transformers are operating in parallel, their voltage rating should be identical and impedance should equal.

3.10.3 Single Phase Transformer

In APSCL, almost all the high voltage level (HV) power transformers were single phase transformers. We saw that single phase transformers were used at 132 kV & 230 kV voltage levels. For power transmission, the generated voltage from generators was low voltage either 11 kV or 15 kV. The single-phase transformers were step up from low voltage to high voltage like 15.6 kV to 132 kV and 15.6 kV to 230 kV. In single phase transformers, generation side or primary side was Δ connected and grid side or secondary side was Y connected. A single phase transformer is shown in figure below:

Fig 3.26 Single Phase Transformer at APSCL

3.10.4 Earthing Transformer

Our supervisor showed the earthing transformer and told us that earthing transformers are used to create a neutral point in a three-phase system, which provides possibility for neutral earthing. The earthing can be through an arc-suppression reactor, a neutral earthing reactor or resistor or directly. When the neutral point is not available or does not exist with a delta secondary winding of the transformer, a neutral point needs to be created. We had seen some earthing transformers at 33 kV line in APSCL [5].

Earthing transformers are used to create a neutral point in a three-phase system, which provides possibility for neutral earthing. Neutral earthing transformers are normally provided in 3-phase system, which without neutral and earth fault protection. An earthing transformer is shown in figure 3.2 below:

Fig 3.27: Earthing Transformer at APSCL

3.10.5 Auxiliary Transformer

We found out that every unit at APSCL has an auxiliary transformer. Unit auxiliary transformer is the power transformer that provides power to the auxiliary equipment of a power generating station during its normal operation. This transformer was connected directly to the generator out-put by a tap-off of the isolated phase bus duct and thus became the cheapest source of power to the generating station. It is generally a three-winding transformer i.e. one primary and two separate secondary windings. Primary winding of UAT is equal to the main generator voltage rating. The secondary windings could be same or different voltages i.e. generally 11 kV and or 6.6 kV as per plant layout. Some auxiliary transformers are shown in figure 3.3 below.

Fig 3.28: Auxiliary Transformers at APSCL

3.10.6 Coupling Transformer

When we visited the substation switchyard, we observed the coupling transformer. The coupling transformer is the power transformer that provides power between two different voltage level buses. In APSCL the coupling transformers are used between the 132 kV bus and 230 kV bus or 33 kV bus and 132 kV bus. It is a three-phase power transformer which transferred power one bus to another. Coupling transformer is shown in figure 3.4.

Fig 3.29: Coupling Transformers at APSCL

3.11 Gas Supply to GT

There are two stages of gas supply in Gas Turbine for combustion. These are:

1. Regulator Monitoring Station (RMS)
2. Gas Booster Compressor (GBC)

3.11.1 Regulator Monitoring Station (RMS)

Regulator monitoring station (RMS) is the primary receiving station of gas from the Bakhrabad Gas Field (BGF). Here the gas pressures are 1000PSI and 150 PSI in the inlet and outlet respectively. As per the Petro-Bangla law, they don't sell gas above 150PSI, and the gas has to be boosted up in the Gas Booster Compressor (GBC) for rising up the pressure of the gas received from the outlet of the RMS.

The fundamental process in RMS is given below in the diagram:

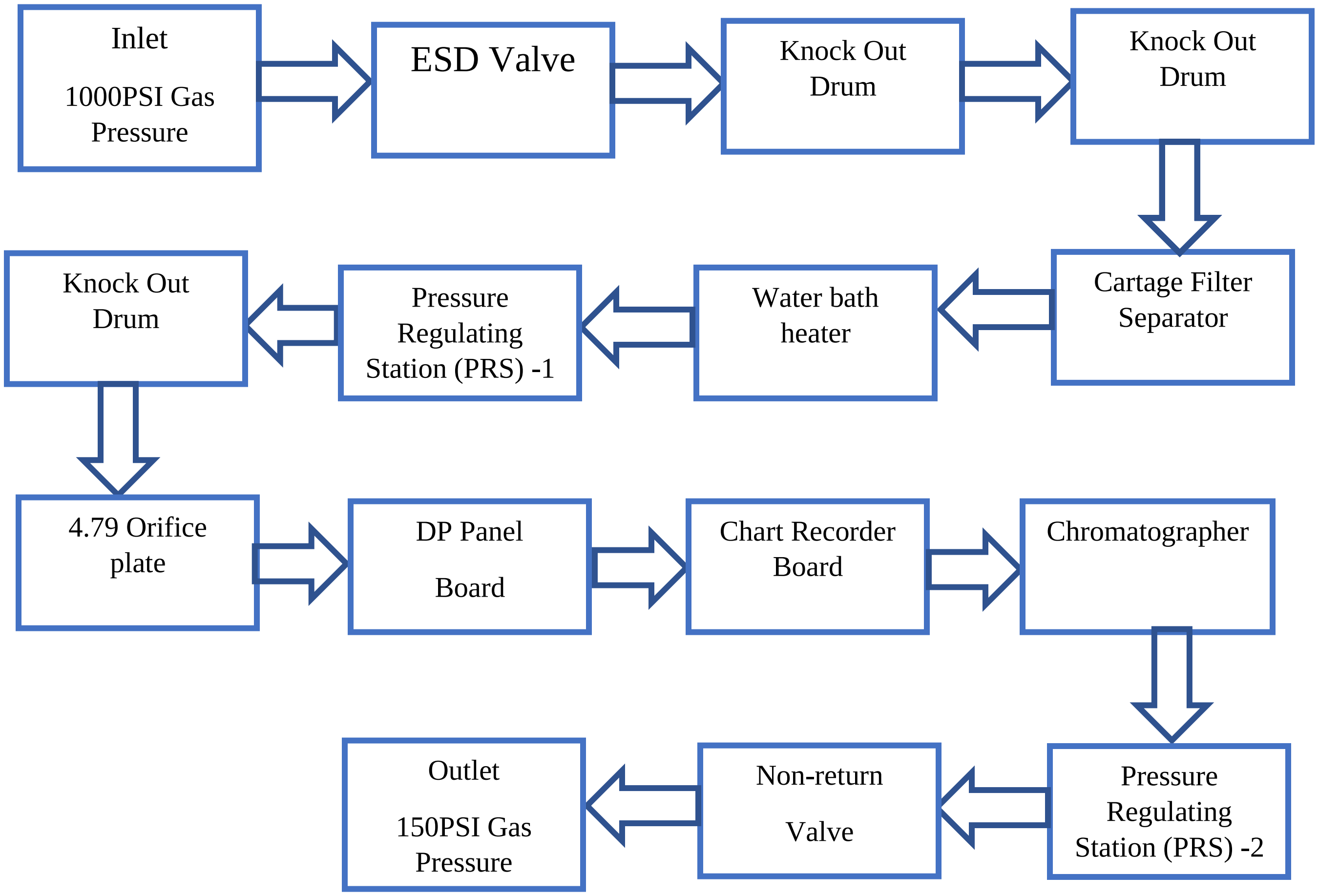

Fig 3.30: Schematic diagram of the Regulator Monitoring Station (RMS) of APSCL

Fig 3.31: Regulator Monitoring Station (RMS) of APSCL

3.11.2 Gas Booster Compressor (GBC)

In GBC, the pressure of the gas is boosted up for giving input to the gas inlet of the Gas turbine. The gas pressure is maintained 300PSI in the outlet of the GBC. GBC system is not so complex in comparison with the RMS. The following diagram illustrates the basic working procedure of the GBC:

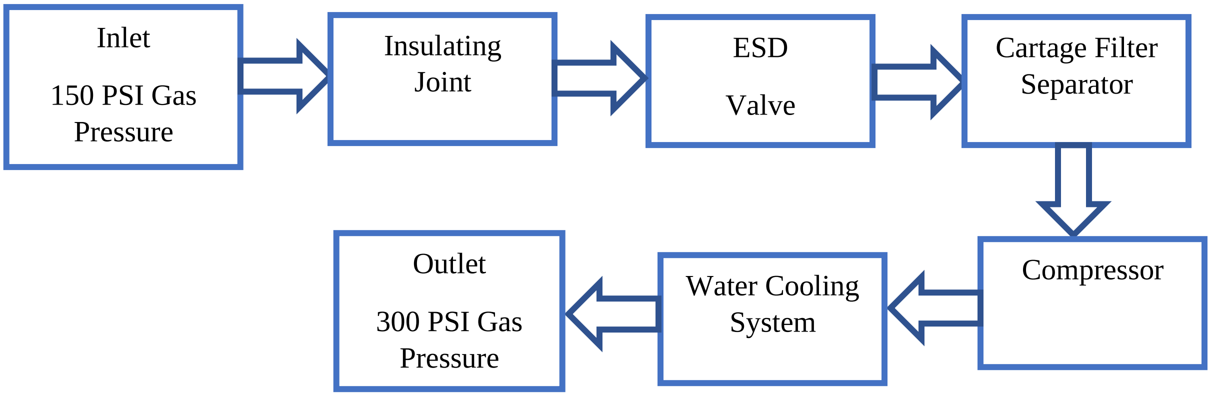

Fig 3.32: Schematic diagram of Gas Booster Compressor (GBC)

Fig 3.33: A photograph of the compressor used in GBC

3.12 Emergency Diesel Generator (EDG)

APSCL has an Emergency Diesel Generator (EDG) in case of the trip or shut of the plant, to supply the backup power to the generators turning gear motor, jacking pump motor which would in case save the generators shaft from being bended. It also supplies the lube oil during the emergency case when the plant trips or gets in shut down condition.

Fig 3.34: Emergency Diesel Generator of APSCL

Emergency Diesel Generator (DG) sets will be provided to feed the essential auxiliaries required for safe shutdown of the unit and important station loads in the event of total AC supply failure.

- Gas Turbine essential loads for shut down
    - AC lube Oil Pump
    - Turning Gear Motor
    - Generator jacking oil pump motor
    - GCB switch Motor
    - PEECC Standby Power Supply
- 230kVSwitchyad ACDB
- Station 125V DC system
- Station UPS

3.12.1 Supplies from Emergency Diesel Generator

Emergency Diesel Generator (EDG) has the following usage in APSCL:

- Emergency Lighting Distribution Board (ELDB)
- EDG Auxiliary Distribution Board
- Steam Turbine Lube Oil Main pump motor
- Steam Turbine jacking oil pump motor
- Steam Turbine Generator jacking oil pump motor
- Steam Turbine Turning gear motor
- Steam Turbine Turning gear control panel
- Valve ACDB for HRSG

3.13 Turning Gear Motor

A reversible electric motor which, through a system of gears, can be used to turn slowly a large diesel engine or steam turbine and gearbox assembly. It enables precise positioning for overhaul or examination. The engaging and disengaging of the turning gear is accomplished by the lever. [27]

There are turning gear motors for both Gas Turbine and Steam Turbine.

- The Gas Turbine turning gear motor rotates the shaft at 130rpm during the shut-down condition.
- The Steam Turbine turning gear motor rotates the turbine at 17rpm during the shut-down condition.

3.14 Overview of the Plant

The overall system of the plant is given below in both design and schematic view with all the necessary sections discussed above:

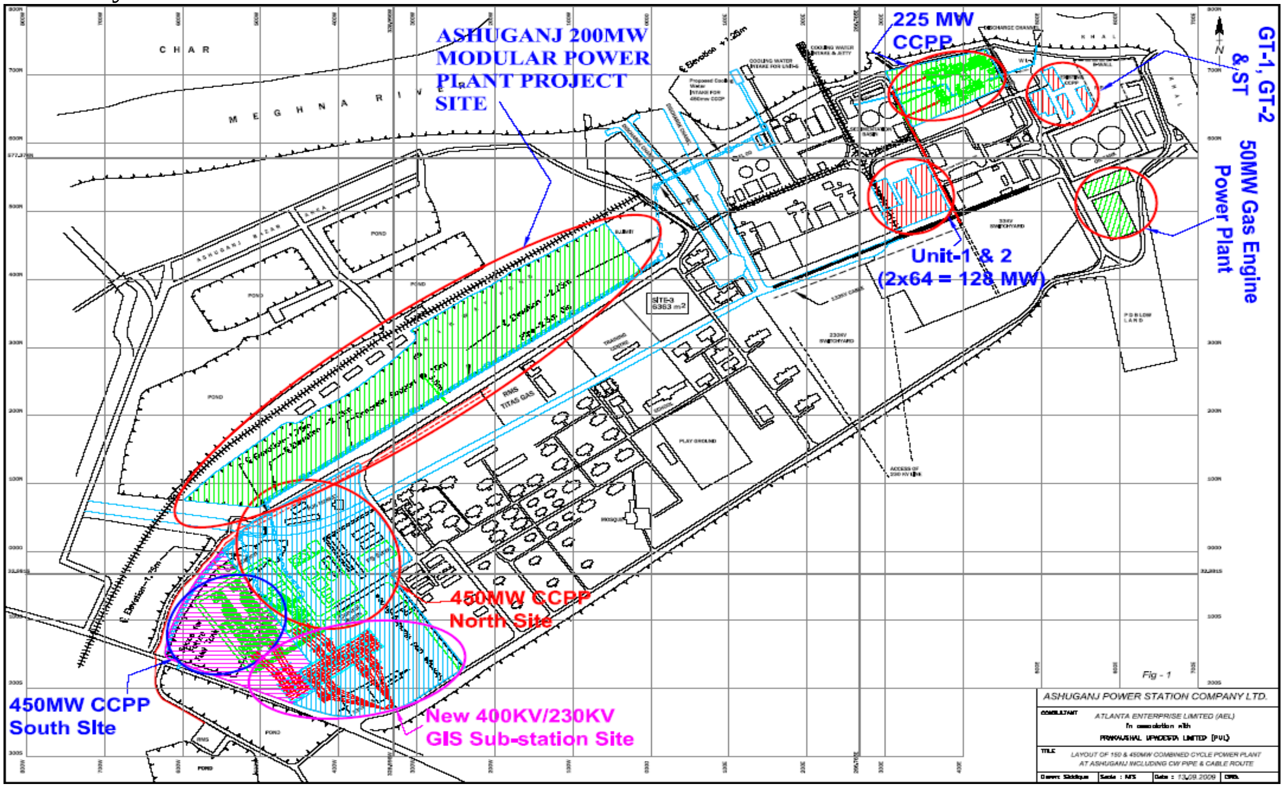

Fig 3.35: Overview of the APSCL plant

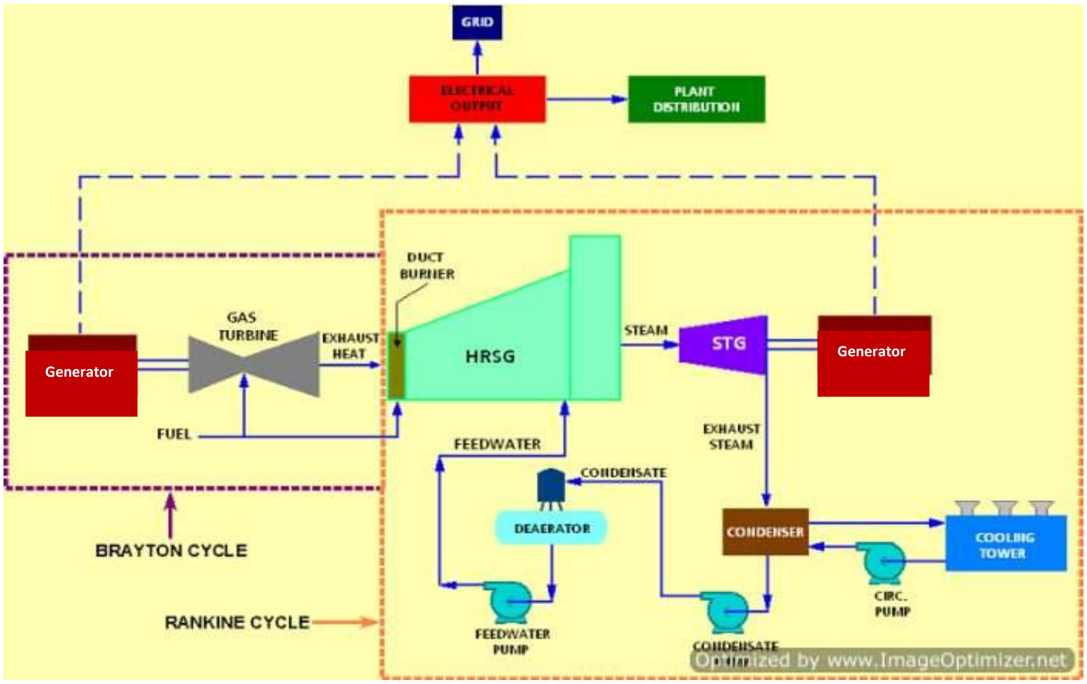

Fig 3.36: Overall schematic view of the combined cycle system with all the necessary equipment

Chapter 4
Start Up and Shut Down Process

4.1 Plant Start-Up Sequence

There are some sequential works which have to done before the starting of the plant:

1. Energizing of Electrical and I&C System.
2. Check of Battery Limit (BL) condition.
3. Start-up of Cycle Make-up System.
4. Waste water transfer system.
5. Plant Base utility Start-up sequence.
6. Start-up of Aux. Circulating Water System.
7. Start-up of Fuel Gas System.
8. Start-up compressed Air System.
9. Start-up of closed cooling system.
10. Start-up of feed water system.

4.2 Filling

The Details of the filling sequence shall be described in the operation manual and the system description of auxiliary systems.

The filling shall be confirmed by the following conditions:

Equipment/System	Condition
Fuel Gas Supply Line	Gas pressure in normal pressure
HRSG HP drums	Level ≥ Startup level
HRSG LP drums	Level ≥ Startup level
Condenser hot well	Level > Low
Circulating water pump pit	Level > Low
Closed cooling water head tank	Level > Low
Raw water storage tank	Level > Low
Demi. water storage tank	Level > Low
Diesel oil day tank of diesel engine fire water pump	Level > Low
Diesel oil day tank of emergency diesel engine generator	Level > Low
Main cycle chemical solution tanks	Level > Low
Sodium hypochlorite tank	Level > Low
Condenser vacuum pump separators	Level > Low
GTG lube oil tanks	Level > Low
STG lube oil tank	Level > Low
Aux boiler drum	Level > Low
H2, CO2, N2 Gas Storage System	Level > Low

Table 4.1: Filling system list that are needed to be confirmed during starting

4.3 Power Block Start-Up Sequence

Following sequences should be maintained during the start-up of the power block:

1. GTG on barrier gear option.
2. HRSG on ready to start.
3. STG on Turing gear operation.
4. Condenser Vacuum up.
5. ST pre-warming.
6. Automatic Start-up of power block.

4.4 Preparation of HRSG for Start-Up

The HRSG has to be prepared following some steps using the following steps:

1. Check and remove any foreign material from HRSG.
2. Ensure all manholes, access doors and opening in HRSG ducting area are securely closed.
3. Ensure proper functioning of all interlocks and protections of HRSG, all auxiliaries, dampers and valves.
4. Ensure availability of seal air, scanner air, instrument air, power, chemicals, cooling water etc.
5. Check and keep ready supplementary fuel systems.
6. Check tightness of diverter damper towards HRSG as well as Bypass Stack side and confirm with the remote and local indications.
7. Keep all the dampers in air and gas system in start up condition.
8. Fill the HRSG up to the start-up water level
9. GT to run in appropriate condition to purge the HRSG limiting the Gas temperature as indicated supplier/logic/NEPA requirement.
10. Check that no HRSG trip condition exists.

4.5 Plant Shut Down Sequence

Following sequential works have to be done to shut down the plant:

1. GTG/HRSG isolation
2. GTG load down to less than 100MW.
3. HRSG LP steam isolation.
4. HRSG HP bypass valve open.
5. HRSG HP and Reheat system isolation.
6. GTG shut down.
7. HRSG bypass valve close
8. STG stop signal.
9. STG shut down.

4.6 Emergency Shut-Down Sequence

If there is any sudden shut down of the plant, then the followings might occur:

1. GTG trip.
2. HRSG trip.
3. STG trip.

Chapter 5
Controlling

5.1 Introduction to distributed control system (DCS)

A distributed control system (DCS) is a specially designed automated control system that consists of geographically distributed control elements over the plant or control area. It differs from the centralized control system wherein a single controller at central location handles the control function, but in DCS each process element or machine or group of machines is controlled by a dedicated controller. DCS consists of a large number of local controllers in various sections of plant control area and are connected via a high-speed communication network. In DCS control system, data acquisition and control functions are carried through a number of DCS controllers which are microprocessor-based units distributed functionally and geographically over the plant and are situated near area where control or data gathering functions being performed as shown in the figure above. These controllers able to communicate among themselves and also with other controllers like supervisory terminals, operator terminals, historians, etc.

Distributed individual automatic controllers are connected to field devices such as sensors and actuators. These controllers ensure the sharing of gathered data to other hierarchal controllers via different field buses. Different field buses or standard communication protocols are used for establishing the communication between the controllers. Some of these include Profibus, HART, arc net, Modbus, etc.

DCS is most suited for large-scale processing or manufacturing plants wherein a large number of continuous control loops are to be monitored and controlled. The main advantage of dividing control tasks for distributed controllers is that if any part of DCS fails, the plant can continue to operate irrespective of failed section.

5.2 System Overview

The following figure illustrates the overall system of the DCS system:

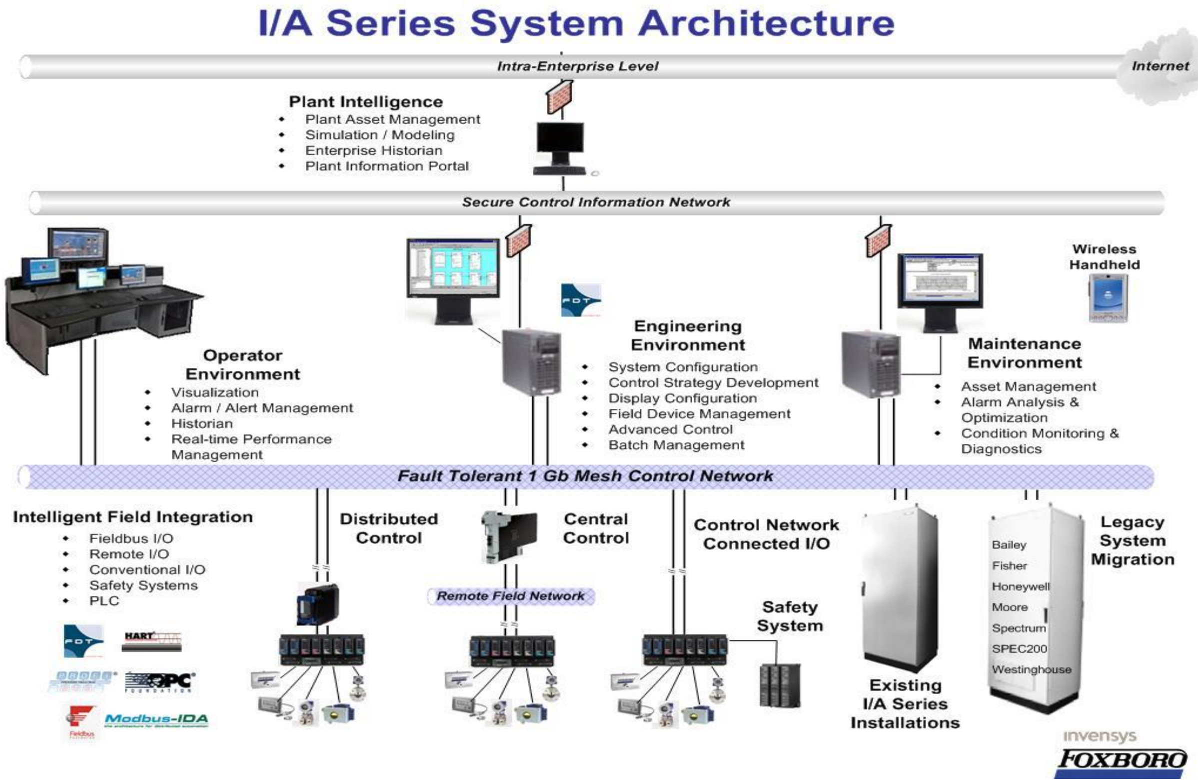

Fig 5.1: Overview of the DCS system for the controlling of the CCPP

Fig 5.2: Inside the control room of APSCL

5.3 Advantages of Using DCS System

Using DCS as the controlling system has the following advantages:

- DCS can control thousands of control loops
- DCS promotes safety, security, and sudden breakdown of large plants.
- DCS regulates information exchange to run the manufacturing plants without breakdown.
- DCS is designed to manage geographically distributed plants with minimum numbers of errors.
- DCS is ideal for production scheduling and preventative maintenance scheduling.
- DCS fails in power supplies and input/output modules.
- DCS has wide-ranging application areas.
- DCS requires low troubleshooting expenses.

Chapter 6
Protection System

6.1 Switchgear

In an electric power system, switchgear is composed of electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment. Switchgear is used both to de-energize equipment to allow work to be done and to clear faults downstream. This type of equipment is directly linked to the reliability of the electricity supply.

The earliest central power stations used simple open knife switches, mounted on insulating panels of marble or asbestos. Power levels and voltages rapidly escalated, making opening manually operated switches too dangerous for anything other than isolation of a de-energized circuit. Oil-filled equipment allowed arc energy to be contained and safely controlled. By the early 20th century, a switchgear line-up would be a metal-enclosed structure with electrically operated switching elements, using oil circuit breakers. Today, oil-filled equipment has largely been replaced by air-blast, vacuum, or SF_6 equipment, allowing large currents and power levels to be safely controlled by automatic equipment.

There are two types of switchgears in APSCL. These are:

1. High Voltage Switchgear
2. Low Voltage Switchgear

Fig 6.1: Switchgear Panels of APSCL

Fig 6.2: Bus bar connection of the Switchgear panel

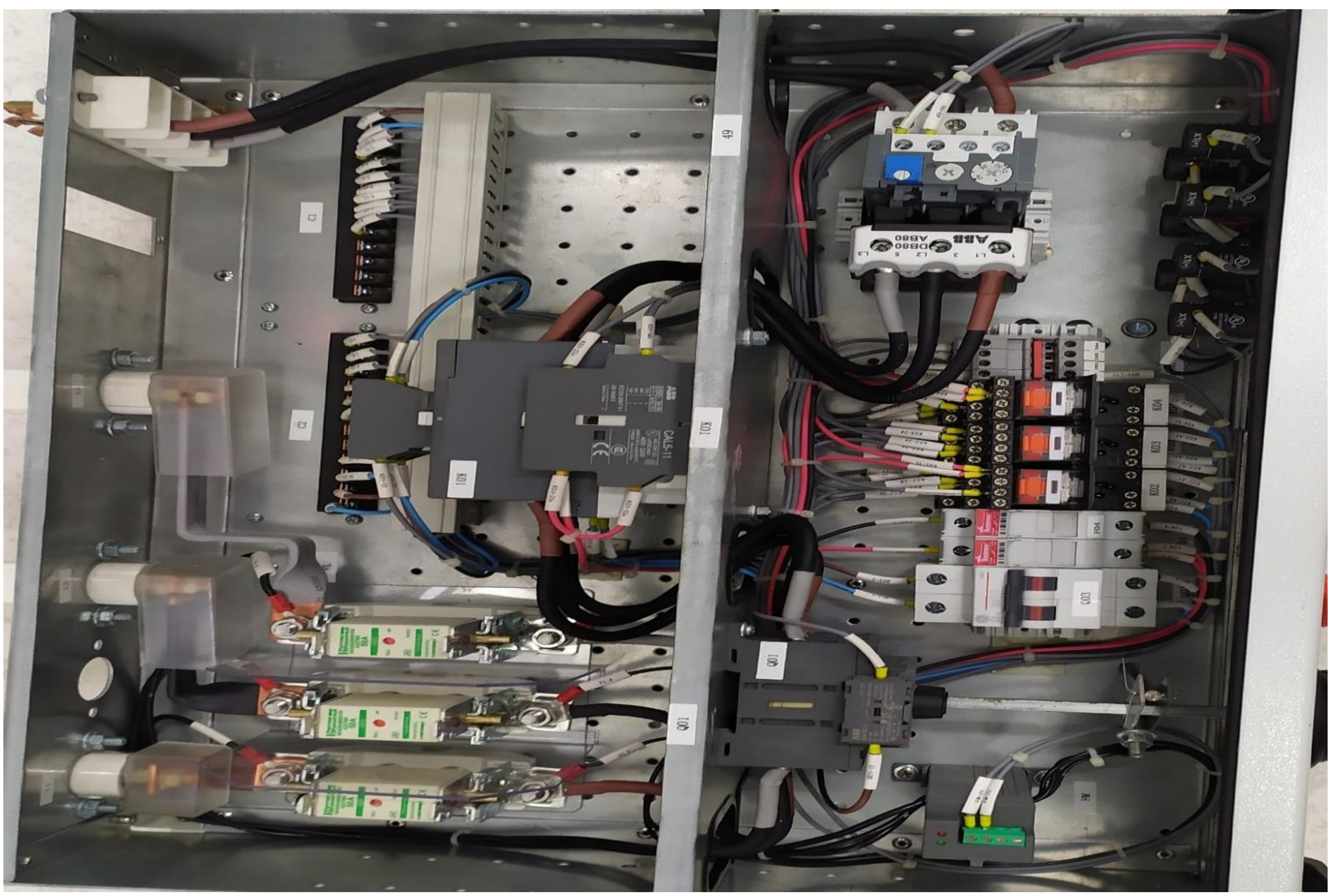

Fig 6.3: Inside of a Switchgear Panel

6.1.1 Low Voltage Switchgear

Following places in APSCL uses the low voltage switchgear:

- Cooling Water Pump House Switchgear (1P series 12 panel)
- Emergency Switchgear (2P series 08 panel)
- STG MCC (3P series 11 panel)
- Water Treatment Plant MCC (4P series 14 panel)
- HRSG MCC (5P series 06 panel)
- Station Service Switchgear (6P series 14 panel)
- Unit Switchgear (7P series 07 panel)
- Fire Protection MCC (8P series 03 panel)
- Fuel Gas RMS station MCC (9P series 02 panel)
- Gas Compressor Facility MCC (10P series 03 panel)
- Effluent Treatment Plant MCC (11P series 02 panel)

Main parts of low voltage switchgear are given below:

- Non-segregated Phase Bus Duct
- Bus-Bar
- Incoming ACB
- Load Control ACB
- Switch Fuse Unit

6.1.2 ACB Isolation of Switchgear

The isolation procedure follows the followings for isolation purpose:

- Check the breaker mechanical indication is in OFF condition on breaker
- Check the breaker OFF led indication is present on breaker panel
- Take a screw driver and turn the shutter release button in clock wise.
- Take handle from the breaker bottom and insert the handle.
- Turn the handle anti-clockwise until the breaker indication comes to rack out position
- Lock out the breaker shutter lock for isolating the breaker in rack out position.
- Keep the rack out handle back in its slot

6.1.3 ACB Normalization of Switchgear

Followings are the normalization procedure of switchgear:

- Check the breaker mechanical indication is in OFF condition on breaker
- Remove Lock on the breaker
- Take a screw driver and turn the shutter release button in clock wise.
- Take handle from the breaker bottom and insert the handle.
- Turn the handle clockwise until the breaker indication comes to SERVICE position
- Keep the rack out handle back in its slot

Fig 6.4: Unit switchgear of APSCL

Fig 6.5: Emergency Switchgear of APSCL

6.2 Relay

A protective relay is a device that detects the fault and initiates the operation of the circuit breaker to isolate the defective element from the rest of the system.

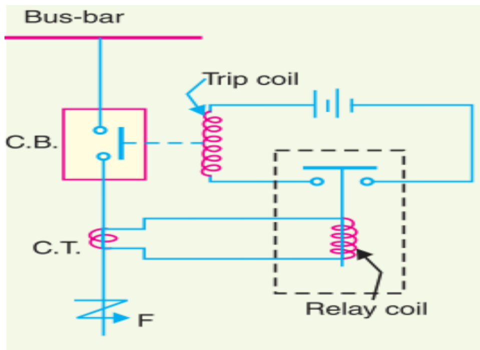

Fig 6.6: Basic Circuit diagram of a Relay

6.2.1 Protection Relay

Protection relay works under the following condition:

- under voltage and overvoltage detection
- overcurrent detection
- over frequency and under frequency detection
- the protection of motor starters against overload
- checking phase balance
- the protection of generators from loss of field
- the supervision of electrical conditions in circuits

There are the following requirements of the selectivity of protective relay:

- Selectivity It is the ability of the protective system to select correctly that part of the system in trouble and disconnect the faulty part without disturbing the rest of the system.
- Speed: The relay system should disconnect the faulty section as fast as possible to protect from damage.
- Sensitivity: It is the ability of the relay system to operate with low value of actuating quantity.
- Reliability: It is the ability of the relay system to operate under the pre-determined conditions. Without reliability, the protection would be rendered largely ineffective and could even become a liability.
- Simplicity: The relaying system should be simple so that it can be easily maintained. reliability is closely related to simplicity. The simpler the protection scheme, the greater will be its reliability.
- Economy: The most important factor in the choice of a particular protection scheme is the economic aspect.

6.2.2 Electro-Mechanical Relay Working Principle

Electro-mechanical relay follows the following two working principle:

- ❖ Electromagnetic attraction
- ❖ Electromagnetic induction

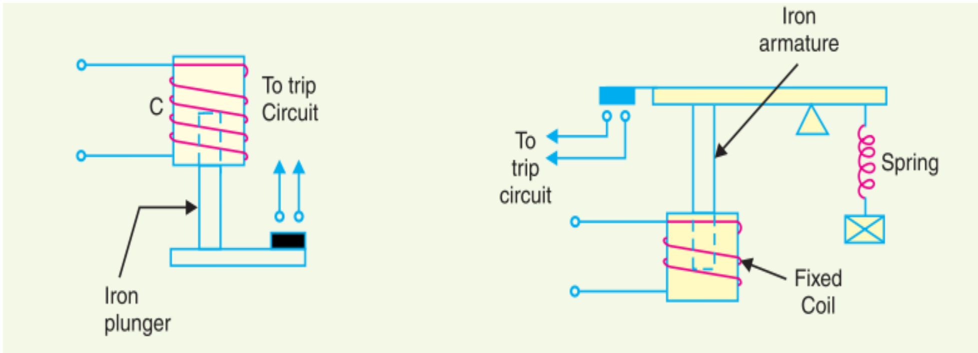

Fig 6.7: Basic working of electromagnetic attraction

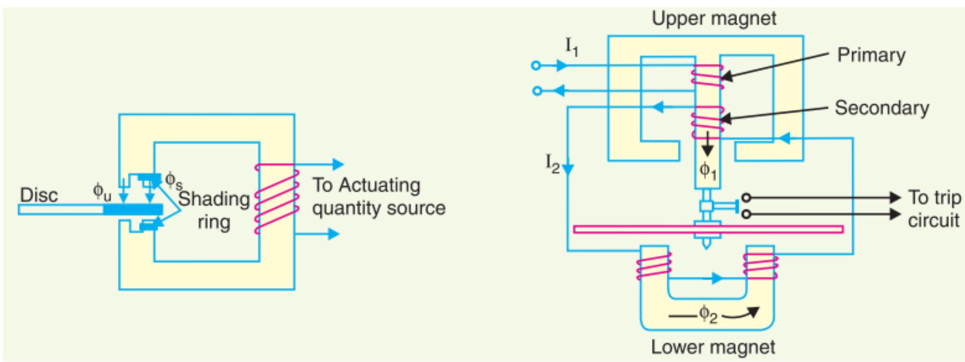

Fig 6.8: Basic working of electromagnetic induction

6.2.3 Reasons of the failure of the operation of the Relay

A Relay may fail to operate due to any of the followings:

- ❖ The protective relay itself is defective.
- ❖ DC Trip voltage supply to the relay is unavailable.
- ❖ Trip lead from relay panel to circuit breaker is disconnected.
- ❖ Trip coil in the circuit breaker is disconnected or defective.
- ❖ Current or voltage signals from CT or PT respectively is unavailable.

6.2.4 Protection of Relay

A Relay has the following types of protections:

- Primary Protection
- Back-up Protection

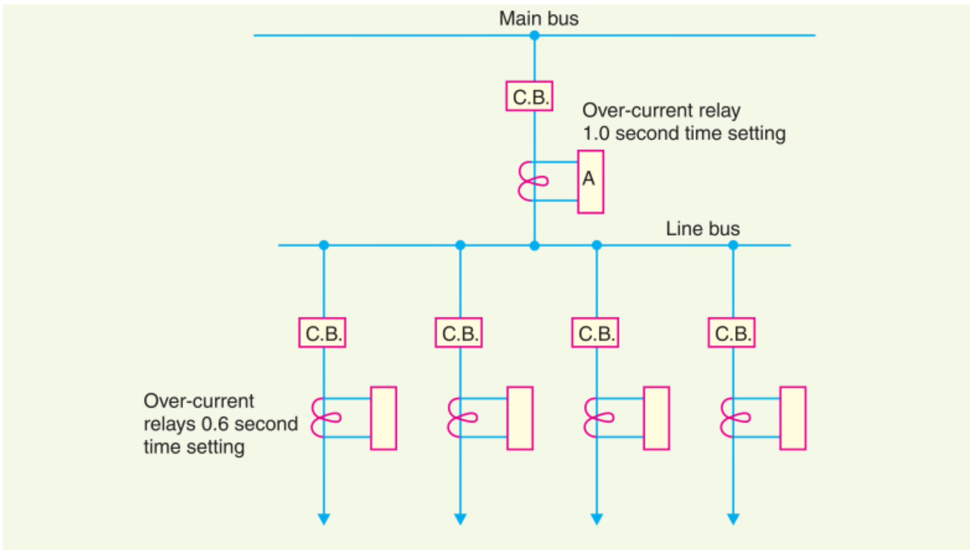

Fig 6.9: Relay protection

6.3 Circuit Breaker

A circuit breaker is a piece of equipment which can

i. make or break a circuit either manually or by remote control under normal conditions
ii. break a circuit automatically under fault conditions
iii. make a circuit either manually or by remote control under fault conditions

Thus, a circuit breaker incorporates manual (or remote control) as well as automatic control for switching functions. The latter control employs relays and operates only under fault conditions.

The following are some important components common to most of the circuit breakers:

i. Bushings
ii. Circuit breaker contacts
iii. Instrument transformers
iv. Bus-bars and conductors

6.3.1 Selection Criteria of Circuit Breakers

The choice of circuit breaker type for a particular power system depends upon several main factors:

- Ambient and environmental conditions, derating may be required for high ambient temperatures.
- Rated normal rms current.
- Fault peak making current with the appropriate DC offset.

- Fault rms breaking current with the appropriate DC offset if it is still present.
- Fault withstand duty.
- Cost and economics.
- Variety of choice in the market so that a technical and economic comparison can be made.
- History of operation in similar plants and locations.
- Single or duplicate busbar system requirements.

6.3.2 Circuit Breaker Details

Following figure illustrates the details of a circuit breaker:

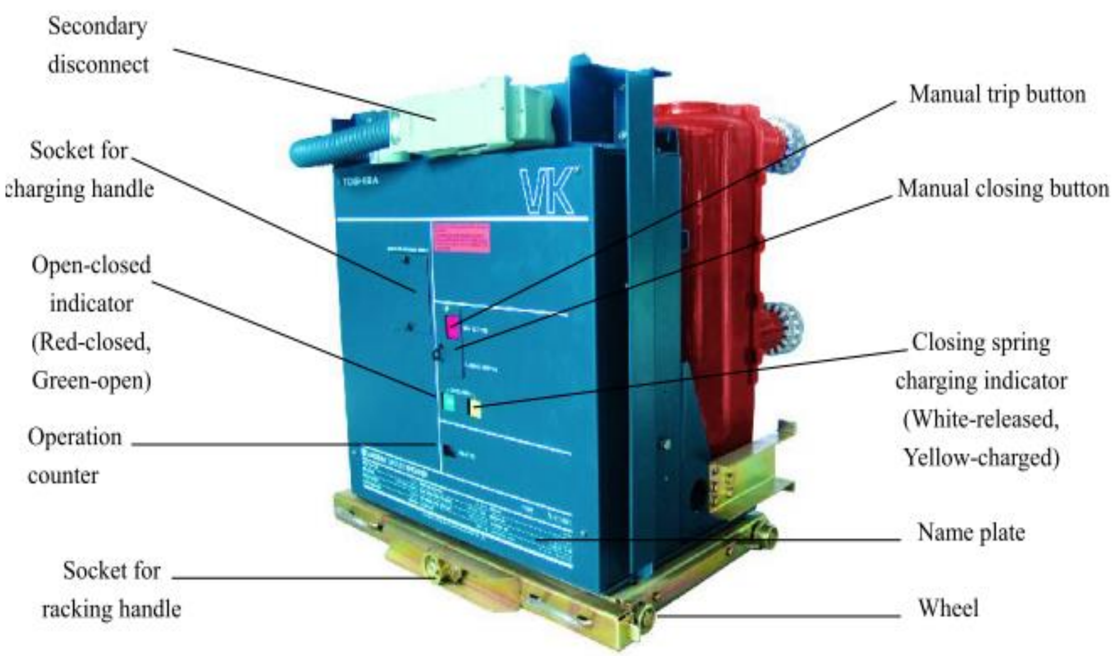

Fig 6.10: Outside view of a circuit breaker and items to be checked (1)

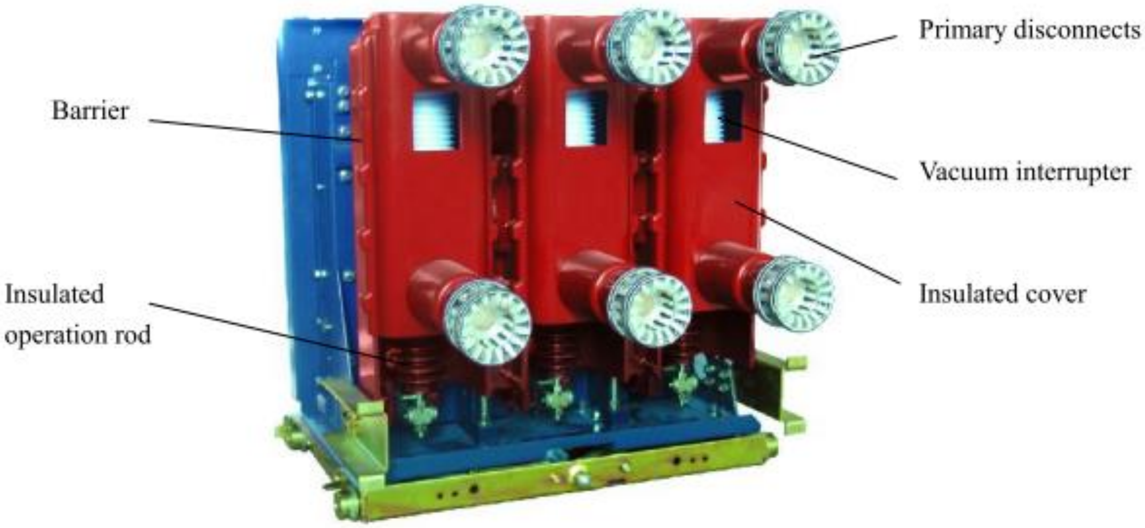

Fig 6.11: Outside view of a circuit breaker and items to be checked (2)

Fig 6.12: The circuit breaker chamber, cable chamber and main bus-bar chamber

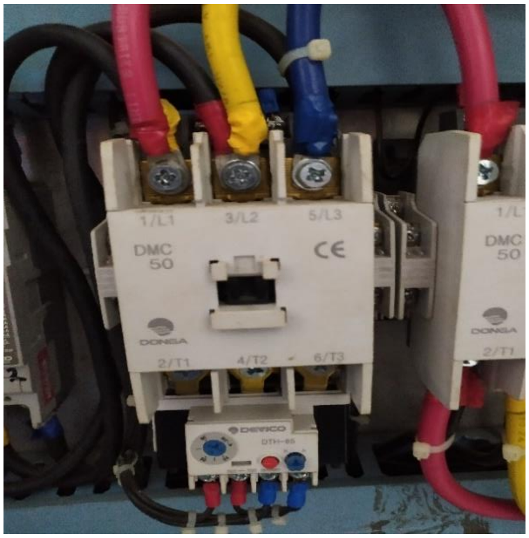

Fig 6.13: Miniature Circuit Breaker (MCB)

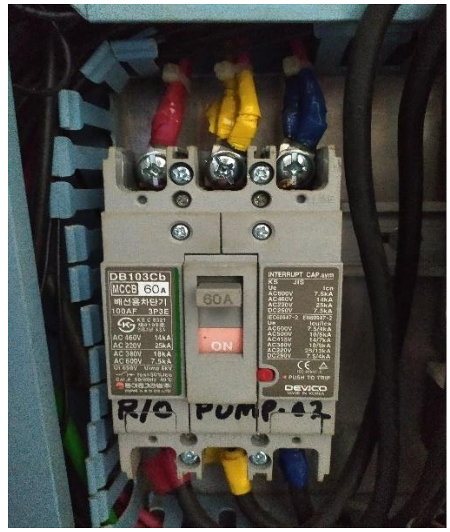

Fig 6.14: Molded Case Circuit Breaker (MCCB)

Chapter 7
DC System

7.1 DC System

The auxiliary DC control power system consists of the battery, battery charger, distribution system, switching and protective devices, and any monitoring equipment. Proper design, sizing, and maintenance of the components that make up the dc control power system are required.

7.2 Necessity of DC System in Power Plant

DC system is so necessary in every aspect of the power plant that it can be called as the heart of a power plant. It’s mainly used in the following sections of the power plant:

1. Protection
2. Control
3. Monitoring
4. Relay
5. Trip Coil
6. Induction

So, all the sections in which DC system is used, are the most essential and also the most crucial part of a power plant. Hence, there is no doubt saying that, without DC system, no power plant can be run.

7.3 DC System of APSCL

The following diagram shows the schematic block diagram of the DC system of APSCL:

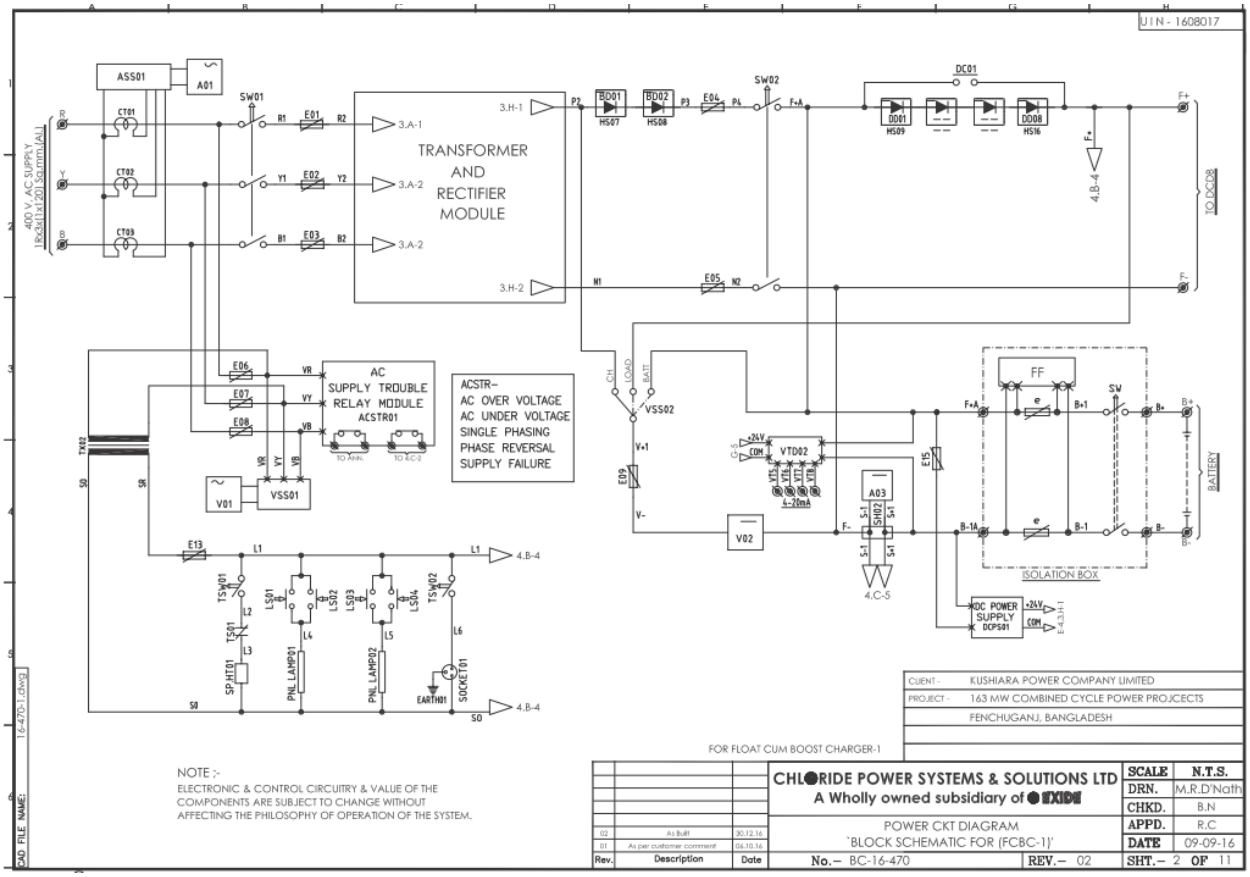

Fig 7.1: Schematic Block Diagram of DC system of APSCL

7.4 DC Distribution Board

In DC distribution board (DCDB) operation, there are the following few sequential operations:

1. Switching On sequence
    a. Incomer-01 Isolator/Switch ON
    b. Incomer-02 Isolator/Switch ON
    c. Bus Coupler Isolator/Switch On
    d. Respective Load Isolator/Switch On
2. Switching Off Sequence
    a. Respective Load Isolator/Switch off
    b. Bus Coupler Isolator/Switch Off
    c. Incomer-01 Isolator/Switch Off
    d. Incomer-02 Isolator/Switch Off
3. Isolation Procedure
    a. Respective Load Isolator/Switch off
    b. Bus Coupler Isolator/Switch Off

c. Incomer-01 Isolator/Switch Off
d. Incomer-02 Isolator/Switch Off
e. Battery Isolation Box-01 Isolator/Switch off
f. Charger-01 output Isolator/Switch off
g. Battery Isolation Box-02 Isolator/Switch off
h. Charger-02 output Isolator/Switch off

Fig 7.2: DC Distribution Board of APSCL

7.5 Alarm and Remedy

Alarm and remedy system have the following checking and remedy procedures:

- AC SUPPLY TROUBLE
- OVER CURRENT
- CHARGER FAILURE
- DC UNDER VOLTAGE
- DC OVER VOLTAGE
- DC EARTH FAULT
- BOOST CHARGE REQUIRED
- Input supply Check
- DC current higher than preset value
- DC voltage lower than preset value
- DCDB voltage lower/higher than preset value
- Ground bus current more than 5mA
- Battery Bank voltage lower than preset value

7.6 Battery Bank

There are two battery banks in APSCL for DC supply:

Bank-01

- Cell Type-KPM 750 P
- Brand Name-AMCO saft
- Total Cell-102
- Cell voltage-1.2V
- Float Cell Voltage-1.4V
- Boost Cell voltage-1.7V
- Bank voltage-144.2

Bank-02

- Cell Type-KPM 750 P
- Brand Name-AMCO saft
- Total Cell-103
- Cell voltage-1.2V
- Float Cell Voltage-1.4V
- Boost Cell voltage-1.7V
- Bank voltage-144.2

Fig 7.3: Battery Bank-01

Fig 7.4: Battery Bank-02

Chapter 8
Maintenance

8.1 Generator Maintenance

Amongst all the equipment in the power plant generators are the most core component. So, for serving with a required voltage and frequency, the generators of the power plant must go through under proper maintenance.

Generally, generator maintenances are done using the following ways:

1. Periodic brush gear inspection/filters cleaning
2. Major overhaul/inspection of the Generator
3. Diagnostic Testing of Generator
4. Testing of Generator Protection Relay

1. **Periodic Brush Gear Inspection**: Following figure illustrates how the periodic brush gear inspection is done:

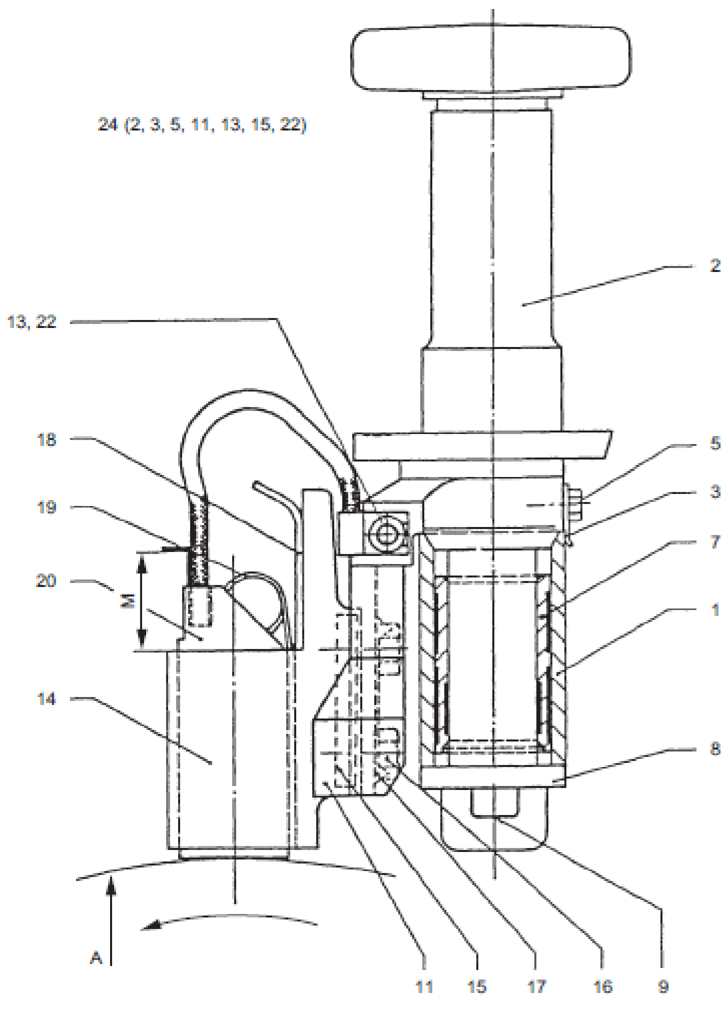

Fig 8.1: Periodic Brush gear inspection in pictorial description

2. **Major Overhaul of the Generator**: The major overhauling of the generator is does with the following ways:
    - ❖ Dismantling the Exciter
    - ❖ Dismantling the Generator
    - ❖ Dismantling Generator coolers
    - ❖ Threading out the Generator Rotor
    - ❖ Cleaning of Stator, Rotor & coolers
    - ❖ Diagnostic Testing of Stator & Rotor for any flaws
    - ❖ Assembling back

3. **Diagnostic Testing of Generator**: The following figure illustrates the procedures for the diagnostic testing of generator:

Fig 8.2: Diagnostic Testing of generator

8.2 Maintenance of Transformer

Transformer is the heart of any power system. Hence preventive maintenance is always cost effective and time saving. Any failure to the transformer can extremely affect the whole functioning of the organization.

Sl No	Inspection frequency	Items to be inspected	To be checked	Action required if inspection shows unsatisfactory conditions
1	Hourly	Ambient temperature		
2	Hourly	Winding temperature	Ensure that temperature rise is within specified limits.	
3	Hourly	Oil temperature		
4	Hourly	Load (amps)	Check against rated figures given on the name plate	
5	Hourly	Voltage		
6	Daily	Oil level in transformer	Check oil level gauge	If low, top with dry oil find whether there is any leak.
7	Daily	Oil level in bushing	--	--
8	Daily	Dehydrating breather	Check that air passages are free. Check colour of active agent	If silicagel is pink, change by new charge. The old charge may be reactivated for using again.
9	Daily	Oil level in OLTC conservator	Check oil sight window or oil level gauge	If low, top with new dry oil

Sl No	Inspection frequency	Items to be inspected	To be checked	Action required if inspection shows unsatisfactory conditions
10	Daily	Relief diaphragm of OLTC explosion vent	--	Replace if cracked or broken
11	Daily	Cooler fan, bearing motor & operating mechanism	Check the bearings. Examine contacts, check manual control and interlock	Lubricate the bearing. Replace burnt or worn contacts.
12	Quarterly	Bushings	Examine for cracks and dirt deposit	Clean the dirt. If cracked or broken replace the bushing.
13	Quarterly	Oil in transformer	Check for dielectric strength and water content	Take suitable action to restore quality of oil.
14	Half yearly or at the end of 5000 operations	Oil in the diverter switch of OLTC	a. Dielectric strength	Filter or replace if BDV is less than specified value.
			b. Water content	Measure the water content using KARL FISHER method. Replace/ recondition if exceeds that limits specified
15	Yearly	Oil in transformer	Check acidity resistivity, tan delta and sludge	Filter or replace
16	Yearly	Oil filled condenser bushing	Refer to the maintenance schedule for OIP condenser bushings	As recommended
17	Yearly	Gasket joints		Tighten the bolts evenly to avoid uneven pressure
18	Yearly	Cable boxes	Check sealing arrangements and find out whether there is any leak	Replace gasket if leaking
19	Yearly	Relays alarm and other circuits	Examine relay and alarm contacts, their operation fuses etc. check relay accuracy.	Clean the components. Replace contacts and fuse if necessary
20	Yearly	Painting	Rusting/colour	Touch up to be done
21	Yearly	Earth resistance	--	Take suitable action if earth resistance is high
22	After 50000 operations of the OLTC	Arcing contacts	--	Replace if necessary
23	-do-	Lubricating oil in the gear box of driving mechanism	Low oil level	Add or replace with lubricating oil
24	5 yearly	1000 kVA to 2000 kVA	Overall inspection including core and coil	Wash the core and coils with clean oil
	7 – 10 yearly	above 3000 kVA		

Fig 8.3: Maintenance list for transformers with the checking list and procedure

8.2.1 Maintenance Procedure of Transformer

The maintenance procedures for transformer are given below based on the maintenance types:

1. **OIL:**
   - Oil level checking. Leakages to be attended.
   - Oil BDV & acidity checking at regular intervals. If acidity is between 0.5 to 1mg KOH, oil should be kept under observation.
   - BDV, Color and smell of oil are indicative.
2. **Bushings**:
   - Bushings should be cleaned and inspected for any cracks.
   - Dust & dirt deposition, Salt or chemical deposition, cement or acid fumes depositions should be carefully noted and rectified.
3. **Others**:
   - Sludge, dust, dirt ,moisture can be removed by filtration.
   - Oil when topped up shall be of the same make. It may lead to sludge formation and acidic contents.
   - Insulation resistance of the transformer should be checked once in 6 months.
   - Megger values along with oil values indicate the condition of transformer.
   - Periodic Dissolved Gas Analysis can be carried out.
   - Periodic checking of any loose connections of the terminations of HV & LV side.
   - Breather examination. Dehydration of Silica gel if necessary.
   - Explosion vent diaphragm examination.
   - Conservator to be cleaned from inside after every three years.
   - Regular inspection of OIL & WINDING TEMPERATURE METER readings.
   - Cleanliness in the Substation yard with all nets, vines, shrubs removed.

8.3 Maintenance and Inspection of Circuit Breakers

Circuit breaker is an important and the must have protective component in a power plant. With all other electrical components and equipment, the circuit breakers also need some maintenance for the purpose of regular usage and quicker operation during the protection purpose.

The following list illustrates the check list, check method, criteria and the necessary doings for the circuit breaker maintenance:

No.	Check point	Check item	Check method	Criteria	What to do	Remarks
1	Entire circuit breaker	Tightness of Hardware.	By tightening them with screw driver and wrench.	There should be no loose fastenings.	Retinghten loose fastenings.	
		Dust and foreign matter	Visual check	The circuit breaker shall be clean and contain no foreign matter.	Clean by pressure air and wipe with a clean dry cloth.	
		Deformation, excessive wear and damage.	Visual check	There should be no deformation, excessive wear or damage.	Remove cause and replace parts.	
		Lost or missing parts.	Visual check	There should be no missing parts .	Reinstate to the normal condition.	
2	Operation mechanism	Dust and foreign matter	Visual check	There should be no dust and foreign matter.	Remove foreign matter by pressure air.	
		Smooth operation.	Manual operation	Operation shall be smooth.		
		Lubrication of berring pins.	Check by feel and sight.		Supply a small amount of machine oil.	
		Sharf of closing and tripping portion.	Visual check	Must rotate smoothly.		

No.	Check point	Check item	Check method	Criteria	What to do	Remarks
3	Vacuum interrupter	Contact wear	Visual check	Red marking shall be seen.	If the red marking is not visible, replace the vacuum interrupter.	Fig.48
		Vacuum pressure	See section 6-2		Replace when vacuum pressure is not sufficient.	Fig.30 Fig.49
		Number of open-close operation	Counter	When the counter reading reaches 5,000(for the rated current interruption), check the i nternal pressure.But be sure to replace the vacuum interrupter when the counter reading reaches 10,000. For the method of checking the vacuum pressure See section 6-2.	Replace the vacuum interrupter if the internal pressure is not sufficient or when the counter reading reaches 10,000.	
4	Auxiliary switch	Terminals	Tighten by screw driver.	There should be no loose screws.	Retighten	Fig.16
		Case and contacts.	Visual check.	There should be no damage nor deformation.	Replace when damage.	Fig.16
5	Primary disconnects	Discoloration of contact surfaces by heat.	Visual check	There sould be a thin film of Toshiba B8 grease on the contact surface.There must be no discoloration.	If the contact surface has no grease on it, apply a small amount of B8 grease. Please if the contact is discolored.	Fig.5
6	Control circuit	closing and tripping by electricity.	Check at the test position or the disconnected position.	The closing and tripping operations can be done smoothly	Check circuits and the closing and tripping devices, also check the micriswitches and fuse.	

No.	Check point	Check item	Check method	Criteria	What to do	Remarks
7	Secondary disconnects	Insulating portion.	Visual check	There should be no damage.	Replace if there is any dama ge.	Fig.57 Fig.58
		Contact surface. (only for auto-matic coupling)	Visual check	There should be a thin film of Toshiba B8 grease on the contact surface.	If the contact surface has no grease on it, apply a small amount of B8 grese.	
8	Barrier (vacuum interrupter support)	Contamination and discoloration.	Visual check	There should be no dust and foreign matter. There should be no cracks or damage.	Clean by pressure air and then wipe with a clean cloth. Replace when cracked or damage.	Fig.5
9	Measureme-nt of insulation resistance.	(see table below)			When the insulation resistance between the main circuit is low,clean the surface of the wacuum interrupter with a dry cloth and then take measurements again.	

Measuring location	Insulation resistance	megger
Main circuit-Ground	500Mohm or more	1000V
Control circuit-Ground	2Mohm or more	500V
Between main circuit	500Mohm or more	1000V

Fig 8.4: Maintenance and Inspection list with procedure for circuit breakers

8.4 DC System Maintenance

The dc system is the heart of any power plant and that's why it should be taken cared of very well with proper maintenance. DC system need regular maintenance as all other sections of the power plant as it is one of the major sections of the power plant. This maintenance of the dc system has some procedures to be followed and some scheduled which should be maintained during this maintenance. Followings are the maintenance procedure and schedule of the dc system of the power plant:

- The charger system is very robust requiring minimum maintenance system.
- The indication & metering is exhaustive and periodic record keeping can be as per customer requirement - Input, output voltages, charger input, output current & battery charging current respectively. Periodic cleaning & dusting of the charger can prevent false alarms & erratic operation of the charger.
- Monthly Maintenance
    - Cleaning & Dusting of the Charger.
    - Tightness of the connection points.
    - Cell voltage Measurement
- Yearly Maintenance
    - Over All Operation & Functional Checkup of the Charger

Chapter 9

Conclusion

9.1 Conclusion

The industrial attachment at 1690MW Gas Fired CCPP by APSCL, at Ashuganj, Brahmanbaria was a great opportunity for us to gain practical knowledge on power generation and transmission systems. We received insight of the whole plant right from the fuel procurement, processing, combustion, generation and transmission of electricity. We also learnt practical knowledge on transformer and its application, switchgear with different kinds of protection, maintenance of an equipment, various sorts of buses and their connections etc. We observed the different types of feeders, CT, PT, transformers, CB, relays and control system which improved our technical skills. The whole process of power generation and transmission to substation was explained in detail by the engineers working in Ashuganj Power Station Company Limited (APSCL) with the description about each equipment with their specifications. The authorities of APSCL are very considerate about all kinds of safety and security of the plant. During the whole training days, we felt that, the safety issue is the foremost condition of a power plant. We experienced a lot of things about power plant and power system practically. This attachment program helped us in absorbing the theoretical aspects of power system more efficiently. We hope this attachment will play an important role in our future life to apply our knowledge and experience in the related practical field efficiently and we would really appreciate more such visits in the future.

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