INTERNSHIP REPORT

ON

POWER GENERATION, TRANSMISSION, DISTRIBUTION AND PROTECTION SYSTEM EQUIPMENTS OF ASHUGANJ POWER STATION COMPANY LIMITED (APSCL)

By

Md Ibrahim Hossain :2007 -3-80-011
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Submitted to the
Department of Electrical and Electronic Engineering
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East West University
In partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering
(B.Sc in EEE)

[Spring, 2012]

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Dr. Khairul Alam

Date of Report Submission: 7th June, 2012

ASHUGANJ POWER STATION COMPANY LTD. (APSCL)
(An Enterprise of Bangladesh Power Development Board)

APSCL

CIRIFICATION FOR INDUSTRIAL ATTACHMENT
TRAINING PROGRAMME

Certified that Shahriar Rahman, Student. ID No- 2008-2-80-038 of Electrical & Electronic Engineering Départemement of East- West University, Dhaka, has participated the Industrial Attachment Training Program from 26-12-2011 to 11-01-2012 and successfully completed the course.

Rahman.
11-01-2012

Course Coordinator
&
Manager (HRD)
Ashuganj Power Station Company Ltd.
Ashuganj, B-Baria.

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Acknowledgment

To begin with, we wish to convey our heartfelt gratitude to Almighty Allah for his help to complete the Internship successfully. We also thank to the management of Ashuganj Power Station Company Ltd (APSCL) for providing us such opportunity to accomplish our industrial training. We would specially thank to Engr. MD. Nurul Alam, Managing Director, who gave us the permission to do internship work at his company.

We would like to thank Fakir Mashuque Alamgir, our advisor, for his constant support and many suggestions, but also for his patience and gentleness in those times, where I had to slug through problems.

We want to thank all those people who helped to complete our internship report successfully. In this process our special thanks goes to Engr. Lutfurrahman (Principal of Trainnig Center, APSCL) who coordinated our internship program and helped us to get acquainted with other engineers. We are very grateful to Engr. Bikash Ranjan Roy,manager(I & C), Engr. Md. Azizur Rahman, senior engineer (combine cycle power plant) Engr. Noor Mohammad,manager (Sub-station), Engr. Md. Kamruzzaman, senior engineer (Generator and switchgear protection),), Engr. Md. Anwar Hossain, manager (Operation) for their supportive guidance. They helped us to learn the scheduled topic which was present in our internship training schedule. We also want to thank each and every employee of APSCL for their continual support.

We would also like to mention the name of Dr. Anisul Haque, ex Chairperson & Professor of the Department of Electrical & Electronic Engineering and Dr. Khairul Alam, Chairperson and Professor, Department of Electrical & Electronic Engineering, for being so kind during the period of our internship. We are also grateful to all of our teachers and friends for their cooperation and encouragement throughout our whole academic life in East West University.

Executive Summary

We did our internship at Ashuganj Power Station Company Ltd (APSCL) located on the left bank of the river Meghna from 26th of Dcember to 11th of January and this internship report is the result of those 15 days attachment with the APSCL.

Ashuganj Power Station Company Ltd. (APSCL) owns the second largest power station in Bangladesh. Ashuganj Power Station fulfills about 15% of power requirements of the country. The installed capacity by its 9 units is 777 MW.

Our duration of stay was divided to work in five sections as generator,sub-station, ccpp, I & C and operation. During our internship we gathered practical knowledge about production of electricity, operation, ccpp, major equipments e.g. Generator, Transformer and Switchgear equipments required for distribution and protection of the system.

Protection and controlling of the equipments of the power station is a very important and complicated task. With the help of the plant engineers we observed the control room and protective equipments such as: relays (digital and electrical), circuit breakers etc very closely and understood the functions and controlling system of those equipments.

Substation is an important part of a power station to distribute power and protection purpose. We acquired knowledge about various types of transformers, bus-bars, circuit breakers (SF6 and Oil), lightning arresters, CT, PT and other equipments of the substation which were clearly taught and shown by the senior engineers of the substation of APSCL.

Training Schedule of internship program

Date	Division	Time	Mentor
31-11-2012	Power plant training center	8am to 5pm	Eng .Achinta kumer sarker DGM(MM)
26-12-12 To 28-12-12	Manager (I and Control)	8am to 5pm	Eng .Bikash ranjan Roy Manager(I&C)
29-12-12 To 01-12-12	Combined cycle power plant (CCPP)	8am to 5pm	Eng .Md.Azizur Rahman Assistant Engineer Manager(CCPP)
02-12-12 To 04-12-12	Substation	8am to 5pm	Eng.Nur Mohammad Manager(Substation)
05-12-12 To 08-12-12	Generator and protection	8am to 1pm	Eng .Md.Kamruzzaman Senior Engineer
09-05-2011 To 11-01-12	Operation	8am to 5pm	Eng. Md Anwer Hossain Manager (Operation)

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1.1 Introduction

Ashuganj Power Station Company Ltd. (APSCL) owns the second largest power station in Bangladesh. The installed capacity by its 9 units is 777 MW and present de-rated capacity is 642 MW. Electricity generated in this power station is supplied to the national grid and distributed to the consumers throughout the whole country. This power station plays a significant role in the national economic development by generating more than 15% of the total demand of electricity in the country.

Power Sector Development and reform Program of the Government of Bangladesh, Ashuganj Power Station Company ltd, has been incorporated under the companies Act 1994 on 28 June 2000. All the activities of the company started formally on 01 June 2003. From that day the overall activities of the company along with the operation, maintenance and development are vested upon a Management Team consisting of the Managing Director, the Director (technical) and the Director (Finance).

In this power station Natural Gas from Titas Gas Transmission and Distribution Company Ltd. is used as fuel. Water from Meghna is used through in-take channels for steam generation and cooling of generated steam. Used water (for cooling) is again thrown into the Meghna through discharge channels. Huge water from the discharge channels is used for irrigation in the dry season. Approximately 36,000 acres of land of Ashuganj are irrigated by this water.

Table 5: Power generation units of APSCL.

Units	Date of Commission	Capacity(MW)	
		Commissioned	De-rated(Present)
Unit-1	17-07-1970	64	64
Unit-2	08-07-1970	64	64
Unit-3	17-12-1986	150	150
Unit-4	04-05-1987	150	150
Unit-5	21-03-1988	150	150
GT-1	15-11-1982	56	40
GT-2	23-03-1986	56	40
CC-ST	28-03-1984	34	20
GE	30-04-2011	53	53

1.2 Main Objective of APSCL

- To carry out the business of electric power generation.
- To supply and sell electricity to Bangladesh Power Development Board through National Grid.
- To undertake projects to increase the power generation of APSCL to meet the
- Growing demand of electric power in the country.
- To increase the net worth of the company.

1.3 Generation Details of APSCL

Table 2: Generation Details of APSCL

Particulars of Operation	Unit - 01	Unit - 02	Unit - 03	Unit - 04	Unit - 05	GT - 01	GT - 02	ST (cc)	Gas Engine
Make & Capacity of Turbo-Alternator	Brown Boveri 80 Mva, 11Kv, 0.5 pf	Brown Boveri 80 Mva, 11Kv, 0.5 pf	Brown Boveri 190 Mva, 15.75Kv, 0.5 pf	Brown Boveri 190 Mva, 15.75Kv, 0.5 pf	Brown Boveri 190 Mva, 15.75Kv, 0.5 pf	GEC, 69.6 Mva, 13.8 Kv	GEC, 69.6 Mva, 13.8 Kv	GEC, 43 Mva, 13.8 Kv	Genbacher
Date of Commissioning	17-08-70	08-07-70	17-12-86	04-05-87	21-03-88	15-11-82	23-03-86	28-03-84	30-04-11
Year of Last Overhauling	1989	1994	2003	2011	2008	2004	2000	n/a	n/a
Generated energy since installation(Gwh)	10575.44	9807.24	22455.89	21306.43	29952.39	5985.33	6662.45	1745.36	5983.88
Load factor (in 2011) %	68.96	68.96	69.24	71.35	84.80	99.42	92.29	98.03	95.00
Station heat rate Kcal/Kwh	11979	11696	12076	11017	10356	18175	18175	0	9366
Stationary Thermal Efficiency in 2011	29.97	30.87	29.89	31.75	34.86	19.86	19.86	0	38.54
Cost of fuel per unit generation in Tk	0.93	0.87	0.90	0.90	0.79	1.30	1.30	0.00	0.69

1.4 Future Projects of APSCL

APSCL is a power generation company and its position is second in the country. Over the years some of its plants have become outlived and overall thermal efficiency is not up to the mark. It is APSCL challenges to replace outlived inefficient plants. To cope up the growth of the demand and its business APSCL have under taken the following some important high efficient projects.

1.4.1 Ashuganj 225 MW Combine Cycle Power Plant Project

The company has taken a project to install 225 MW combine cycle power plant using ECA fund. The construction of the project will start soon. The salient feature of the project is given below:

Table 3: Information of Ashuganj 225 MW CCPP Project.

Capacity	225 MW
EPC Contract Price	USD61,970,240 + EURO60,362,742+ BDT 2,530,772,664
ECA Backed Project Financer	Expecting ECA support
Mandated lead arranger	Standard Chartered Bank
Contract Agreement signing Date	05 October, 2011
Expected date of completion	April, 2014
Project duration	25 months
Fuel	Natural Gas

1.4.2 Ashuganj 450 MW Combine Cycle Power Plant Project

The company has also initiated the process to install another 450 MW combined cycle power plant using ECA funding. The evaluation of the Bid is under process. Key information of the project is placed bellow:

Table 4: Information of 450 MW Combine Cycle Power Plant Project.

Capacity	450 MW
Estimated Cost of Project	BDT 3,333 Crore
Expected project financing	ECA backed project finance
Project completion time	27 months
Expected contract agreement	June, 2012
Expected date of completion	September, 2014
Current status	Selection of EPC contractor in progress
Fuel	Natural Gas

1.4.3 Ashuganj 450 MW Combine Cycle Power Plant(North) Project

The company is also taken up program to installed another 450MW Combine Cycle Power Plant, jointly financed by Asian Development Bank (ADB) and Islamic Development Bank (IDB). A brief particulars of the project is furnished below:

Table 5: Information of 450MW Combine Cycle Power Plant project.

Capacity	450 MW
Estimated project Cost	BDT 3,400.02 Crore
Project finance	ADB & IDB
Expected Completion	October, 2015
Current status	Engagement of Consultant is in process
Fuel	Natural Gas

1.5 Finance Performance

Despite adversities APSCL maintained a substantial progress during the year 2010-11.increase revenue by 5.8% over the last year resulted increase the net profit ,before interest and h Tex to TK 1408 million as against TK 749 million of 2009-10 a 87%increase .after changing the interest ,provision for WPPF and income Tex the net profit during the year stood at tk 616.34million as against tk 250.05 million of previous year (2009-10) .the profit growth was at a phenomenal rate of 146.49%.A comparative detail of financial result of 2009-10 is given below

Table 6: Comparative financial performance of APSCL.

Description of item	2010-11	2009-10	In taka increase and increase/(decrease)%
Sales	6621,164,145	6,258,110,680	5.80
Fuel cost	3,197,188611	4,013,874,956	(20.35)
Operating profit	1,163985,710	686,691,441	69.5
Non Operating profit	244,175,566	61,863,776	294.7
Net profit	962,250,119	391,5490,49	145.75
Provision for taxation	345,908,849	141,500,000	144.46
Net profit after tax	616,341,270	250,049,049	146.49

Chapter 2 Steam Turbine Power Plant

At the first day of our internship we visited I&C. Our instructor was Bikash Ranjon Roy, manager of I&C. Here we saw steam turbine unit, gas distribution, water pump, water purification process and turbine. We spent two days here.

2.1 Introduction to Steam Turbine

Asuganjo Power Station Company ltd. (APSCL) uses gas as fuel to generate the heat. This heat is used to heat water and create steam. Then the steam passes through a turbine which transfers the thermal energy of the steam to the mechanical energy. A generator rotor is attached with this turbine and generator transfer mechanical energy to the electrical energy. There are five steam turbine power plants in APSCL. Installed capacity of steam turbine power plant in APSCL is 578MW.

2.2 Air collection

To burn gas in the boiler house, oxygen is needed. This oxygen is collected from air.

2.2.1 Force Draft Fan

Force Draft (FD) fan is used to collect air from nature. In every steam power plant there are two FD fan. There are FD fan inlet vane actuator which control air collection. When load is increased then it also increases air collection from nature.

Figure 2.8: Force Draft Fan in APSCL. [Source: Author]

2.2.2 Air Pre Heater

In the air pre heater chamber air is heated to remove moisture from air. There are a drive in the chamber which uniformly distribute heat all over the chamber. If the motor's rpm is less than 2 rpm then it gives a signal to the control room. If this low speed persists for a 3 minutes it trips boiler. A tachometer is connected with the driver to measure the speed.

2.2.3 Flow Transmitter

Flow transmitter measures the flow of air to the boiler. It works by measuring pressure difference **of** two points. Formula is used $F \propto \sqrt{(\Delta P)}$, here F= air flow and P= pressure.

2.3 Fuel Gas

In APSCL natural gas is used as a fuel for ignition in comparsion in the boiler and produce heat. Natural gas supplied by Titas gas transmission and distribution co.ltd, Bangladesh. This gas and air collected by FD fan from atmosphere are fired in the boiler to produce heat.

2.3.1 Line Gas Control Valve

Control gas line valve control the gas flow into the boiler by changing position of valve in pipe. It can be controlled manually or automatic.

2.3.2 Flow counter

Flow counter count flow of gas into the pipe per hour.

Figure 9.2: Gas flow counter in the gas field. [Source: Author]

2.3.3 Gas Heater

Gas heater is used to dry gas. Gas pipe is taken through the steam chamber so gas is heated by steam. This heat removes moisture and different particle from gas.

2.4 Water collection

In the steam turbine power plant water is one of the important thing. Boiler requires clean and soft water for longer life and efficiency. The source of boiler water is generally river or lake. APSCL collects water from Meghna River and treats this water to make demineralized water which used in boiler to produce steam.

2.4.1 Pump

In APSCL there are three circulating water pumps for collecting water from river. In every place there are two pump one is working and another is standby. There are a discharge valve behind the pump which is driven by oil. This valve works as either o% close or 100% open. If it takes time from 0% close to 100% open more than 90 sec then the pump will trip. This water which collect from river goes to condenser to condensate steam. Rest of the water goes to purify then goes to river again.

2.4.2 Water purifying basin

Water comes from river in the water purifying basin directly. This water is purified in two stages in the basin. Different particle and waste are fallen under the basin. Next this purified water goes to the water filter house.

2.4.3 Water Filter House

In the water filter house there are different type tanks and filters which purify the water. There are four polyelectrolyte tanks where two is used for checking ph. There are two gravel filters. It works very effectively by pulling water down through the gravel, where the solid debris is trapped close to the surface, and the soluble waste is broken down by bacteria that grows on the gravel surface further down. The clean water is then taken back to the surface. The lower level of impurities not only reduces corrosion rates in the boiler but also reduces the erosion of the turbine blades.

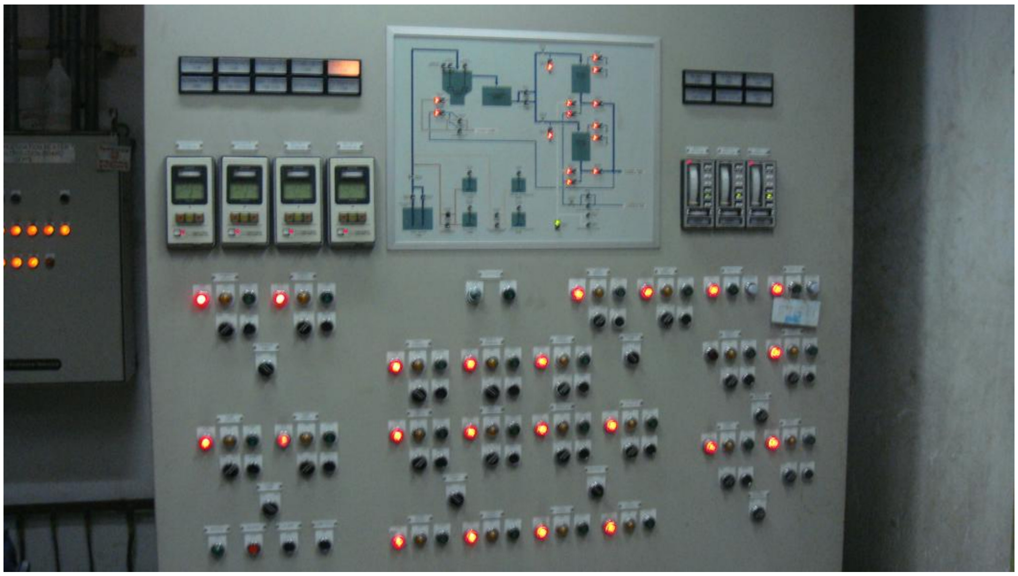


Figure 2.3: Clean and filtered water local control panel.

2.4.4 De – Hydronization process

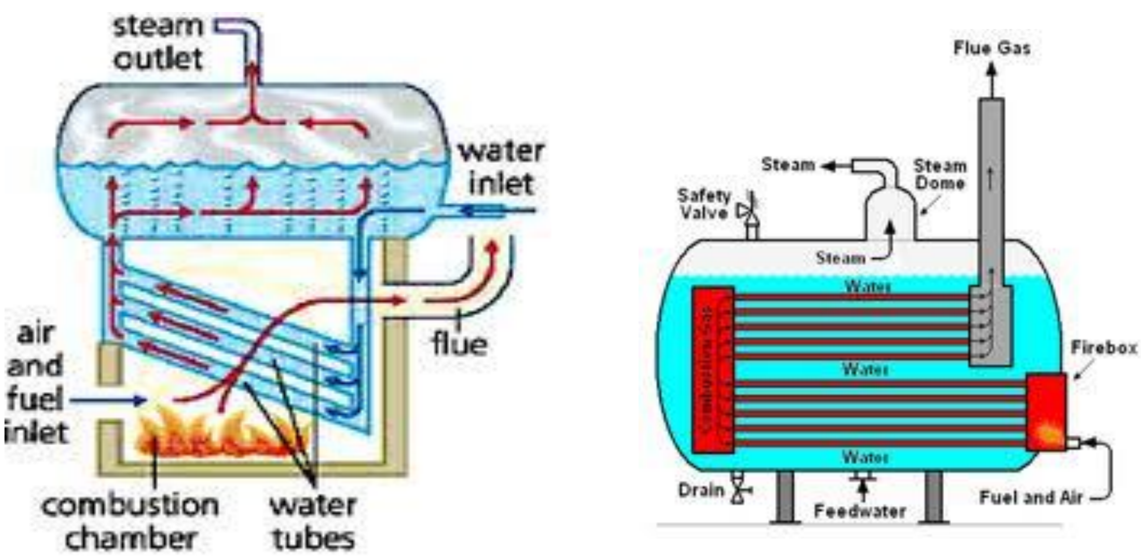
De-hydronization process is about decreasing pressure and increasing temperature. In general process temperature will increase with decreasing carbon number to maintain conversion at pressure. When this dehydrates water is fully fit to get the heat then this water is sent to the water tube.

2.5 Boiler

The basic purpose of a boiler is to turn water into steam, in this case super heated steam. This operation sounds relatively simple but is actually more complicated. The boilers utilized on campus are of the stack drum type, which means there are drums within the boilers and flue gas through the stack to atmosphere. The upper drum is called a boiler drum and is where saturated steam leaves the boiler. While the lower drum is called the mud drum and is where liquid feed water enters. Tubes called rises and down comers are used to connect the two drums. All the energy required within the boiler is produced by the combustion of a fuel.

2.5.1 Classification of boiler

1. **Water tube boiler**: The tubes contain water and the hot gases produced by combustion of fuel flow outside. A bank of water tubes is connected with steam-water drum through two sets of headers. The hot flue gases from the furnace are made to flow around the water tubes a sufficient number of times. The gases thus give up their heat to an appreciable extent, get cooled and are discharged to the stack. The steam formed separates from water in the drum and gets accumulated in the steam space. In APSCL water tube boiler is used. In every steam power plant there are three stage water tube boiler.



a **b**

Figure 2.4: Different types of boiler (a) water tube boiler and (b) fire tube boiler.

[Source: Author]

2. **Fire tube boiler:** The hot gases pass through the tubes that are surrounded by water. The products of combustion leaving the furnace are passed through fire tubes

which are arranged within the water space. The heat energy of the flue gas is transferred to water which is converted into steam. The spent gases are then discharged to atmosphere through chimney. The fire tube boilers are known by certain common names such as horizontal return tubular, locomotive fire box etc.

2.5.2 Ignition

The ignition coil is the component that connects directly with electricity line and includes two transformer windings. The primary winding feeds into the distributor, while the secondary winding connects to the spark plugs. When enough energy has been created, the spinning cam opens a breaker, which causes a high-voltage jump in the ignition coil. This voltage surge is transported to the spark plugs, resulting in the necessary electric spark to begin ignition. At the **beginning** of the firing of the burner small amount of natural gas and air is needed. This small amount of gas is known as ignition gas which is supplied into the burner by ignition pipe or line. After the burner is on the ignition line is turned off and main line for fuel and air supply is turned on.

2.5.3 Burner

Burner is the chamber in the boiler where natural gas or coal is burned with the presence of air for producing heated gas or flue gas. In Ashuganj Power Station Company Ltd (APSCL) natural gas is burned with the presence of air for generating heat for making steam. In steam turbine power plant of APSCL each furnace chamber has nine furnaces. The temperature inside the furnace chamber is 1200-1500°C. The treated water from the feed water tank through economizer enters into the boiler through tubes and the flue gas produced inside the furnace passes through the tubes.

Figure 2.5: Burner room and water tube boiler. [Source: Author]

2.5.4 Boiler Drum

It is the place where the water is reserved which comes through the economizer. Inside the drum upper and lower level of amount of water is measured by the level transmitters. If the level crosses the upper limit or goes below the lower limit then the plant will trip. So it is very important to control the level of the water. This is done by an automatic system. From the boiler drum the saturated steam is transferred into super heater.

2.5.5 Safety Valves

The function of the safety valve is to permit the steam in the boiler to escape to atmosphere when the pressure in the steam space exceeds a certain specified limit. Thus the safety valve prevents the building up of excessive pressure in the boiler. The safety valve is located above the steam space in the boiler. The safety valves operate on the principle that a valve is pressed against its seat through some agency such as strut, screw or spring by external weights or force. When the steam force due to boiler pressure acting under the valve exceeds the external force, the valve gets lifted off its seat and some of the steam rushes out until normal pressure is restored again.

2.5.6 Pressure Gauge

Each boiler has to be provided with a pressure transmitter, which measure the pressure at which the steam is being generated in the boiler. The transmitter is usually mounted at the front top of the boiler shell or drum. The gauge has to be clearly visible to the attendant so that he can easily record the pressure reading. These gauges are used to measure gas and air pressures.

2.5.7 Boiler Efficiency

Boiler efficiency is defined as the ratio of heat energy utilized by feed water in converting it into steam in the boiler to the heat energy realized by complete combustion of fuel during the same time.

$$Boiler\ efficiency = \frac{energy\ absorbed\ by\ feed\ water}{energy\ absorbed\ by\ fuel}$$

2.5.8 Stack

Stack or chimney is a passage through which flue gas escape from a fire or furnace. From the furnace flue gas is produced. This flue gas is used to create the steam for rotating the turbine. The flue gas passes through several equipments and finally goes into the nature through stack.

2.6 Turbine

A steam turbine is a mechanical device that extracts thermal energy from pressurized and converts it into rotary motion. The turbine mainly consists of nozzle and rotary and fixed blade wheel. The steam is expanded from a high pressure to a low pressure either in nozzles or in the blade where it is transformed into the mechanical work. The steam power plant of APSCL has a casing around the blades that contains and controls the working fluid.

Figure2.6: Steam turbine. [Source: Author]

2.6.1 Types of steam turbine

Depending upon the method by which the kinetic energy of steam is converted into shaft work, the steam turbines are classified as follows:

1. **Impulse turbine**: An impulse turbine has fixed nozzles that orient the steam flow into high speed jets. These jets contains significant kinetic energy, which the rotor blades, shaped like buckets, convert into shaft rotation as the steam jet changes direction. A pressure drop occurs across only the stationary blades, with a net increase in steam velocity across the stage. As the steam flows through the nozzle its pressure falls from inlet pressure to the exit pressure. Due to this higher ratio of expansion of steam in the nozzle the steam leaves the nozzle with a very high velocity. The steam leaving the moving blades has a large portion of the maximum velocity of the steam when leaving the nozzle. The loss of energy due to this higher exit velocity is commonly called the carry over velocity or leaving loss.

2. **Reaction turbine** : In a reaction turbine the steam expands through the nozzles which are moving. The steam from the boiler at high pressure and temperature is piped through a hollow shaft to a hollow disc. The disc has four radial openings through tubes, the ends of which are shaped as nozzles. When the steam escapes through the tubes, it expands and there is increase in steam velocity relative to the rotating disc. The resulting reaction force sets the disc in rotation. The disc and the shaft rotate in a direction opposite to the direction of steam jet.

2.6.2 Section of steam turbine in APSCL

The steam turbines used in Ashuganj Power Station Company Ltd (APSCL) are kept in three different sections or chambers. The size and characteristics of the blades of the turbines in these sections are different from each other.

1. **High Pressure Turbine (HP):** From the super heater the high speed steam first enters to the high pressure turbine. The blades in the high pressure turbine are the smallest of all turbine blades; this is because the incoming steam has very high energy and occupies a low volume. The blades are fixed to a shaft and as the steam hits the blades it causes the shaft to rotate.

2. **Intermediate Pressure Turbine (IP**): From the boiler re-heater the steam enter into the intermediate pressure turbine. The steam has expanded and has less energy when it enters this section, so here the turbine blades are bigger than those in the high pressure turbine. The blades are fixed to a shaft and as the steam hits the blades it causes the shaft to rotate. From here the steam goes straight to the next section of turbine set.

3. **Low Pressure Turbine (LP):** From the intermediate pressure turbine steam enters into the low pressure turbine and continues its expansion. The blades of the

turbine of this section are larger than the previous two sections but the energy of steam is lesser than the previous two sections.

2.6.3 Casing or Shaft Arrangements

These arrangements include single casing, tandem compound and cross compound turbines. Single casing units are the most basic style where a single casing and shaft are coupled to a generator. Tandem compound are used where two or more casings are directly coupled together to drive a single generator. A cross compound turbine arrangement features two or more shafts not in line driving two or more generators that often operate at different speeds. A cross compound turbine is typically used for many large application.

Figure 2.7: Casing of turbine. [Source: Author]

2.6.4 Operation and Maintenance

When warming up a steam turbine for use, the main steam stop valves have a bypass line to allow superheated steam to slowly bypass the valve and proceed to heat up the lines in the system along with the steam turbine. Also, a turning gear is engaged when there is no steam to the turbine to slowly rotate the turbine to ensure even heating to prevent uneven expansion. After first rotating the turbine by the turning gear, allowing time for the rotor to assume a straight plane, then the turning gear is disengaged and steam is admitted to the turbine, first to the astern blades then to the ahead blades slowly rotating the turbine at 10–15 RPM (0.17–0.25 Hz) to slowly warm the turbine. Any imbalance of the rotor can lead to vibration, which in extreme cases can lead to a blade breaking away from the rotor at high velocity and being ejected directly through the casing. To minimize risk it is essential that the turbine be very well balanced and turned with dry steam - that is, superheated steam with a minimal liquid water content. If water gets into the steam and is blasted onto the blades, rapid impingement and erosion of the blades can occur leading to imbalance and catastrophic failure. Also, water entering the blades will result in the destruction of the thrust bearing for the turbine shaft. To prevent this, along with controls and baffles in the boilers to ensure high quality steam, condensate drains are installed in the steam piping leading to the turbine. Modern designs are sufficiently refined that problems with turbines are rare and maintenance requirements are relatively small.

2.6.5 Turbine efficiency

To maximize turbine efficiency the steam is expanded, doing work, in a number of stages. These stages are characterized by how the energy is extracted from them and are known as either impulse or reaction turbines. Most steam turbines use a mixture of the reaction and impulse designs: each stage behaves as either one or the other, but the overall turbine uses both. Typically, higher pressure sections are impulse type and lower pressure stages are reaction type.

2.6.6 Turbine losses

In actual practice, not all of the energy in the steam is converted to useful work because there are many losses.

1. **Clearance leakage:** A 100% efficiency cannot be obtained because of friction in the blading and clearance between the stationary and rotating parts, and because the nozzle angle cannot be zero degrees. Axial clearance increases in the stages further from the thrust bearing to satisfy the need to maintain a minimum clearance at extreme operating conditions when the differential expansion between the light rotor and heavy casing is at its worst. To reduce this leakage, radial spillbands are used. These thin, metal-strip seals may be attached to the diaphragm or casing and extend close to the shroud bands covering the rotating blades.

2. **Nozzle leakage:** Leakage around the nozzles between the bore of the blade ring or nozzle diaphragm and the drum or rotor must be kept to a minimum. This leakage is controlled through the use of a metallic labyrinth packing which consists of a single ring with multiple teeth arranged to change the direction of the steam as well as to minimize the leakage area. Labyrinth packing is also used at the shaft ends to step the pressure down at the high-pressure end and to seal the shaft at the vacuum end.

3. **Rotation loss:** Rotation of the rotor consists of losses due to the rotation of the disks, the blades, and shrouds. Partial-arc impulse stages have a greater windage loss within the idle buckets. Rotation losses vary directly with the steam density, the fifth power of the pitch diameter, and the third power of the rpm. In general, the windage loss amounts to less than 1% of stage output at normal rated output.

4. **Super saturation and moisture loss:** Moisture in the steam causes super saturation and moisture losses in the stage. The acceleration of the moisture particles is less than that of the steam, causing a momentum loss as the steam strikes the particles.

The moisture particles enter into the moving blades (buckets) at a negative velocity relative to the blades, resulting in a braking force on the back of the blades. Super saturation is a temporary state of super cooling as the steam is rapidly expanded from a superheated state to the wet region before any condensation has begun.

Chapter 3 Combine Cycle Power Plant

In this section we visited Combine Cycle Power Plant (CCPP). Our mentor was Md Azizur Rahman, manager of Combine Cycle Power Plant. Here we saw and learned about gas turbine generation, steam turbine generation in CCPP. We spent three days in combine cycle power plant.

3.1 Introduction of CCPP

Combined Cycle power plants (CCPP) are those which have both gas and steam turbines supplying power to the network. Combined cycle power plants employ more than one thermodynamic cycle – steam and gas. In a combined cycle power plant, a gas turbine generator generates electricity and the waste heat is used to make steam to generate additional electricity through a steam turbine, which enhances the efficiency of electricity generation. Additionally, combined cycles are characterized by flexibility, quick part-load starting, suitability for both base-load and cyclic operation, and a high efficiency over a wide range of loads. In APSCL there are two gas turbines and one steam turbine in combine cycle power plant.

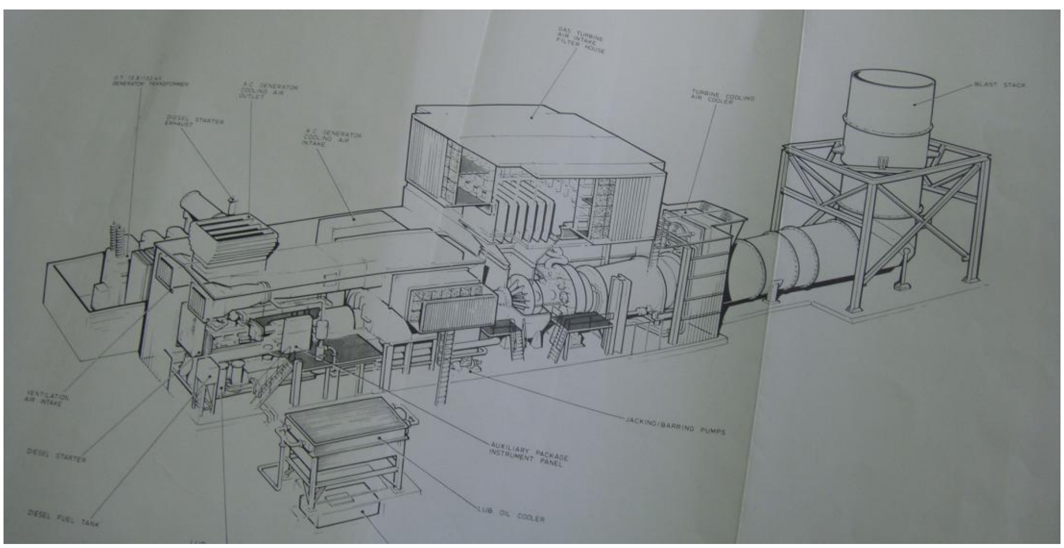


Figure 3.1 Design diagram of combine cycle power plant in APSCL. [Source: Author]

Table 7: Information of Combine cycle power plant [Source: Author]

Unit	Installed year	Rated output (MW) (Installed)	Rated output(MW) (Now)
GT-1	15-11-1982	56	40
GT-2	23-03-1986	56	40
ST	28-03-1984	34	18

Table 8:One day(date=31-12-2011) information 0f ccpp of APSCL.

Unit	Max. Load MW	Generation KWH	Fuel consumption M^3/KWH	Diesel Level
GT-1	35	139038	.5812	45%
GT-2	40	837820	.4812	52%
ST	Off	Off		

3.2 Gas Turbine Engine

The fuel and air burns in a combustion chamber in the gas turbine engine. The resulting high-pressure gases are directed through nozzles toward the turbine blades and produce work by turning the turbine shaft. This is a continuous process in the continuous-combustion or constant pressure gas turbine. A portion of the compressed air is mixed with fuel and ignited in a combustion chamber. The balance of the compressed air passes around the chamber to absorb heat, and then it is merged with the burned products of combustion. The pressurized mixture, usually at 1010°F or higher, flows into a reaction turbine. The turbine drives the compressor and also produces work by driving the generator. A portion of the exhaust gas may be re-circulated and it is possible to recover heat energy from the waste exhaust. The compressor uses a relatively large portion of the thermal energy produced by the combustion. The engine efficiency is highly dependent on the efficiencies of the compressor and turbine.

3.2.1 Compressor

The compressor is driven by the turbine through a common shaft. Air enters the compressor via an inlet duct. The compressor increases the air pressure and reduces the air volume as it pumps air to the combustor and through the engine. At the begging of the generation compressor is routed by diesel engine in APSCL.

3.2.2 Combustion Chamber

In combustion chamber combustion causes an increase in gas temperature proportionate to the amount of fuel being injected, a moderate increase in velocity, and a negligible decrease in pressure. Approximately 25 percent of the compressor's total air flow is used for combustion at an air/fuel ratio of about 15:l. The remaining 75 percent of compressor air output is fed to the combustor and to cool combustor liners for cooling combustion gases before they enter the turbine. Electrical igniters in the combustion chamber provide a spark to ignite the fuel/air mixture for engine start-up. The igniters are deactivated after start-up has been accomplished. Hot combustion gases are expelled through the turbine.

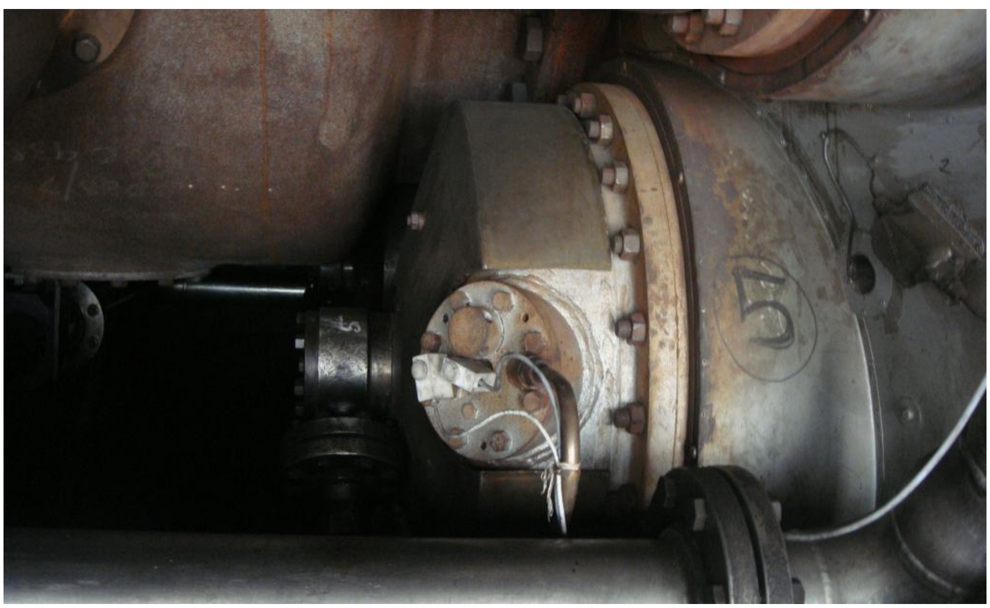


Figure 3.2: Combustion Chamber in CCPP of APSCL. [Source: Author]

3.2.3 Diesel Engine

The gas turbine is not a self exciting machine. The turbine only can be rotated if fuel and air is burned inside the combustion chamber. But before the turbine starts the air cannot be sucked by the compressor automatically because the compressor is coupled with the turbine. So a diesel engine is coupled with the turbine to rotate the turbine at the beginning for helping to suck air by the compressor. At first the diesel engine starts. When the turbine starts to move by the diesel engine at 2008rpm speed then the diesel engine is turned off.

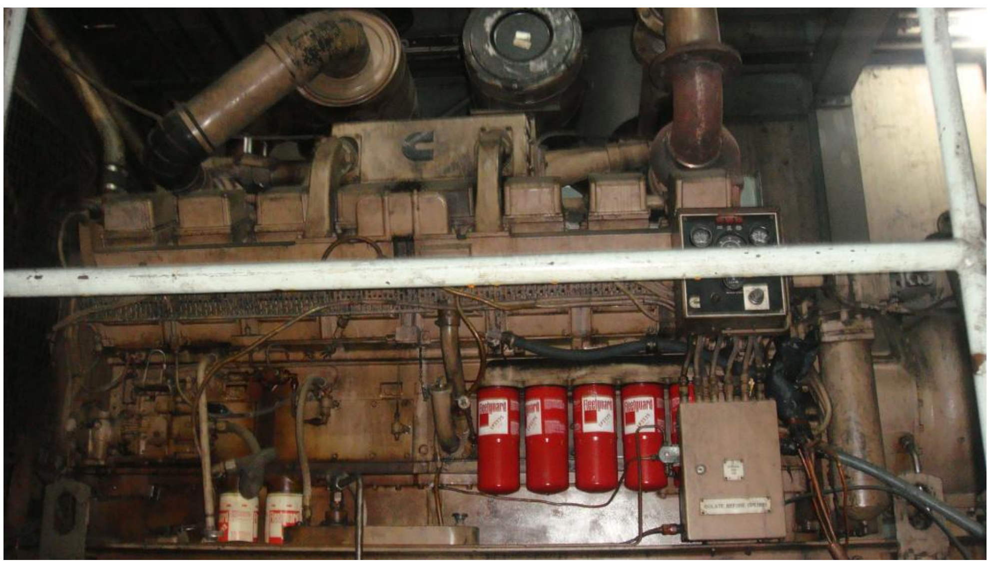


Figure 3.4 Diesel engine of combine cycle power plant.

[Source: Author]

3.2.4 Governor or Speed Control

A diesel engine used in an auxiliary generator must have a governor to regulate and control engine speed. Since an automatic governor functions only with a change in speed, constant engine speed may not be totally possible and “hunting” can occur due to over-correction. The governor’s sensitivity is determined by the minimum change in speed of the prime mover which will cause a change in governor setting; its speed regulation is the difference in generator speeds at full-load and no-load divided by the arithmetical mean of the two speeds.

3.3 Sub System of Combine Cycle

3.3.1 Fuel System

The system provides the engine with the proper amount of fuel to sustain operation. System components include filters, a fuel manifold, fuel tubes, and nozzles. Off-engine components include the fuel control equipment and a supply system. Fuel (in APSCL it is natural gas) enters the tubular fuel manifold ring via the supply system. The fuel tubes direct the fuel from the manifold to the fuel nozzles which are mounted in the fuel. In APSCL gas comes from Titas.

Figure 3.5 Fuel annex room in combine cycle power plant of APSCL.

[Source: Author]

3.3.2 Lubrication System

The lubrication system for a gas turbine engine is usually self-contained with the engine and supplies oil for lubrication and cooling during engine operation. Engine bearings in the compressor, combustor, and turbine areas are supplied by the system. System pressure is usually maintained by a supply and scavenge pump. Most systems include a heat exchanger to cool the oil and an oil supply tank.

3.3.3 Cooling System

Cooling is one of the most important elements in any power plant. Diesel engines are designed to be either air cooled or liquid cooled. Cooling is used to prevent the Cylinder Walls, the head, the exhaust manifold, and the lube oil from overheating. For turbine cooling approximately 25 percent of the air entering a combustor is mixed with fuel and burned. The remaining air is mixed with the products of combustion to reduce the temperature of gases entering the turbine to a safe operating level. Cooling is accomplished by engine airflow. In APSCL there are two cooling system in combine cycle power plant. One is air cooled and another is liquid cooled.

3.3.4 Air Intake System

In APSCL air and fuel ratio is 15:1. Intake air carries dust particles, water vapor and other foreign material. Since these materials can damage moving parts within the engine, filtration of the intake air is necessary. An air intake system must collect, filter, and distribute the required air to the engine cylinders. This must be accomplished with a minimum expenditure of energy (pressure drop). The objective of air filtration is the reduction of engine component wear. Several types of air filters or air cleaners are used. The pleated-paper type are strainers, porous enough to pass air but able to remove solid particles larger than 0.002 of an inch.

3.3.5 Starting System

In APSCL normally generator starts by a diesel engine. At first diesel engine starts to rotate the shaft and when it rotates at 700rpm then it is fired. Usually after 2008rpm, diesel engine disconnects and gas engine began working independently. On the time of starting if there is any fault occurs related with firing or starting of gas engine, immediately they turn off the diesel engine and reset the machine in first position.

3.4 Steam Turbine Section

In combined cycle power plant the exhaust gas which comes out from the gas turbine is used to produce steam and run a steam turbine. The exhaust gas has very high temperature (almost 500^0C) which can be used to create steam by using several equipments. There is no furnace in steam turbine section in combine cycle power plant. In combined cycle power plant of APSCL there is one steam turbine section which runs by the exhaust gas of gas turbine-1 & 2. But now steam turbine runs only the exhaust gas of gas turbine -1

3.4.1 Steam Generation Process

In combined cycle power plant of Ashuganj Power Station Company Ltd (APSCL) following equipments are used.

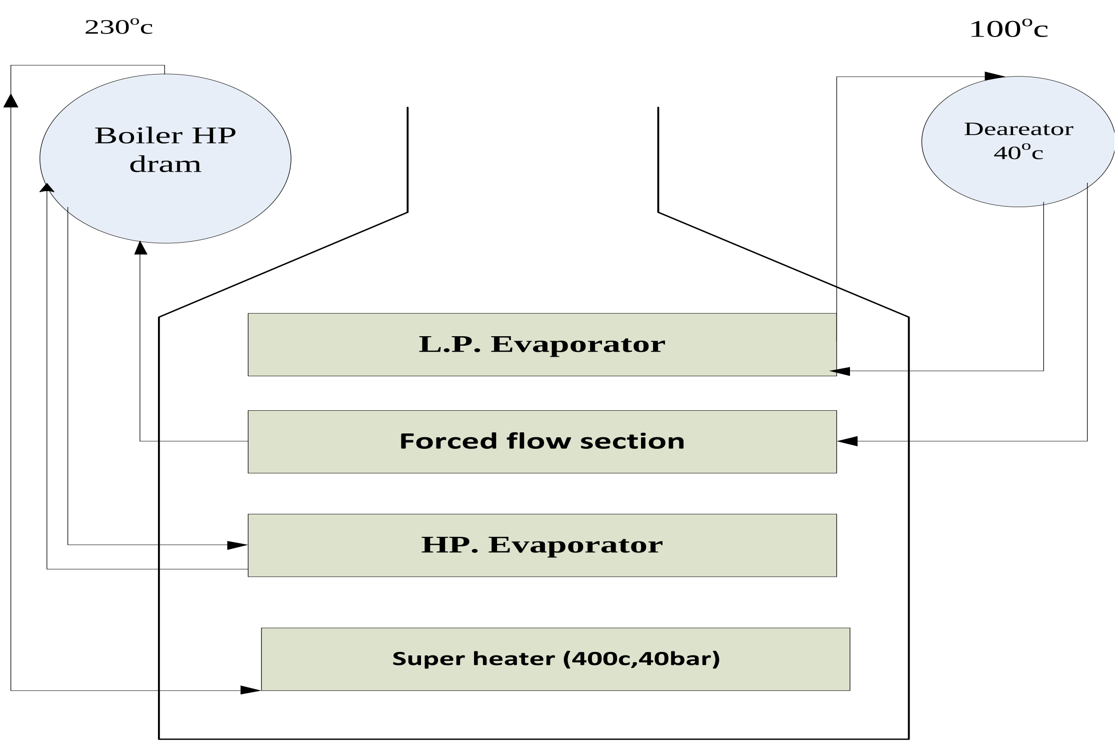


Figure 3.6 Design of Steam Generation process in CCPP. [Source: Author]

3.4.1.1 Deaerator

In combine cycle power plant it is used as the preserver of feed water which comes from the condenser by extraction pump. At this stage the temperature of feed water which enters the deaerator is 40°C. From deaerator the feed water is flowed into the low pressure evaporate again goes to deaerator. When feed water through the LP Evaporate then it gains heat which is 100^{o}C.

3.4.1.2 Low Pressure Evaporate

The feed water is heated in this section before it goes to the boiler at low pressure. Boiler feed pump is used to circulate feed water to the low pressure evaporator. Feed water is inside the tubes and exhaust gas is flowed over the tubes. This part is at the top of the boiler where the temperature of exhaust gas becomes relatively low. From the LP evaporator the feed water goes to deaerator.

3.4.1.3 Forced Flow Section

At high pressure feed water goes through into the forced floe section and the temperature of feed water raises higher. Then the feed water is supplied to the high pressure boiler drum. Boiler feed pump is used to flow the water from LP boiler drum to HP boiler drum. When feed water passes through the forced flow section the temperature raises up to 220°C.

3.4.1.4 High Pressure Evaporator

From the HP boiler drum feed water is transferred to the high pressure evaporator where the feed water becomes saturated steam by the help of the heat of exhaust gas. Feed water is inside the tubes and exhaust gas is flowed over the tubes. By this way the heat is exchanged. From the HP evaporator the steam is then transferred to the HP boiler. At this stage the steam gathers at the top of the HP boiler drum. Boiler circulation pump is used for this circulation of feed water. From the HP boiler drum the steam is then flowed to the super heater.

3.4.1.5 Super Heater

This part is at the bottom of the boiler where the temperature of the exhaust gas is hugest. At this part the saturated steam becomes super heated steam. Exhaust gas is flowed over the bundle of tubes which carry the steam. At the super heater the temperature of the exhaust gas that comes from the gas turbine is about 500°C. From the super heater the super heated steam goes to the high pressure turbine at a temperature of 400°C and pressure of 40 bars.

Chapter 4 Substation

In this section we visited Substation of APSCL. Our instructor was Noor Mohammad, manager of Substation. We saw different types of elements which are used in substation. We spent three days here.

4.1 Substation

The term substation may defined as assembly of apparatus installed to change some characteristic of electric supply such as voltage, frequency, power factor etc .

The purpose of substation is to take power at high voltages from the transmission or sub transmission level, reduce its voltage and supply it to a number of primary voltage feeders for distribution area. Besides that, it performs operational and emergency switching and protection duties at both the transmission and feeder lines.

4.2 Types of Sub-stations

A sub-station has many components (*e.g.* circuit breakers, switches, fuses, instruments etc.) which must be set up properly to ensure continuous and reliable service. According to constructional features, the sub-stations are classified as follows:

1. **Indoor sub-stations.** These types of sub-station are used for voltages upto 11 kV, the equipment of the sub-station is installed indoor because of economic considerations but when the atmosphere is contaminated with impurities, these sub-stations can be erected for voltages up to 66 kV.
2. **Outdoor sub-stations.** These types of sub-station are used for voltages beyond 66 kV, where equipment is installed outdoor. Because for such voltages, the clearances between conductors and the space required for switches, circuit

breakers and other equipment becomes so great that it is not economical to install the equipment indoor.

3. **Underground sub-stations.** In thickly populated areas, the space available for equipment and building is limited and the cost of land is high. Under such situations, the sub-station is created underground.
4. **Pole-mounted sub-stations.** This is an outdoor sub-station with equipment installed overhead on *H*-pole or 4-pole structure. It is the cheapest form of sub-station for voltages not exceeding 11kV (or 33 kV in some cases). Electric power is almost distributed in localities through such substations.[9]

4.3Equipment of Substation

Depend upon the type of sub-station it required various type of equipment. Whatever, more commonly equipments are given below:

4.3.1 Bus Bars

A bus bar is used for a conductor carrying current to which many connections are made. These are generally used in sub-stations where the need number of incoming and outgoing lines at a same voltage. Normally bus bars used in the substations are of copper or aluminum and they are basically round and solid.

Figure 4.1: A typical bus bar of a substation [Source: Author]

4.3.2 C.T (Current Transformer)

In electrical engineering, a current transformer (CT) is used for measurement of electric currents. When current in a circuit is too high to directly apply to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments. A current transformer also isolates the measuring instruments from what may be very high voltage in the monitored circuit. Current transformers are commonly used in metering and protective relays in the electrical power industry.

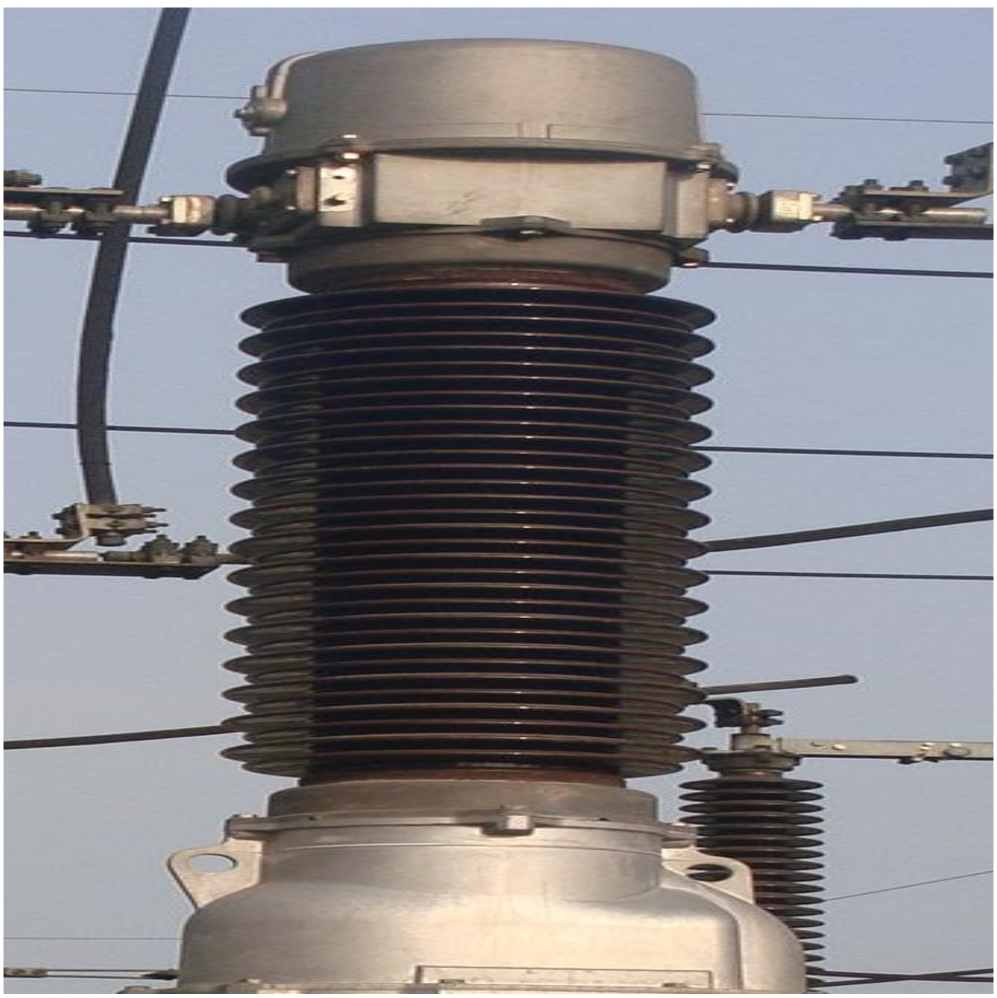


Figure 4.2: A typical current transformer (CT). [Source: Author]

4.3.3 P.T *(*Potential transformer)

PT is used to measure or monitor the voltage on transmission lines and to isolate the metering equipment from the lines. It is also known as a voltage transformer (VT). PTs are designed to have a precise voltage ratio to accurately step down high voltages so that metering and protective relay equipment can be operated at a lower potential. Normally the secondary of a voltage transformer is rated for 69 V or 120 V at rated primary voltage.

Figure 4. 3: A typical potential transformer (PT) [Source: Author]

4.3.4 Transformer

Transformer is a static device used to transform power from one voltage level without changing the frequency. There are different parts of a transformer given below:

1. **Bushing:** This maintains the incoming and outgoing connection of a transformer

Figure 4.4: Bushing of a transformer [Source: Author]

2. **Radiator:** This is used to radiate the heat of a transformer when transformer is heated up at a certain level.
3. **Oil temperature meter:** This meter indicates the temperature of transformer oil. If temperature crosses a certain level then it makes an alarm.
4. **Winding temperature meter:** This meter indicates the temperature of transformer windings. If temperature crosses a certain level then it starts the winding fans.
5. **Oil level meter:** This meter indicates the oil level of transformer. If oil is low than a certain amount it makes an alarm that means that transformer have to feed oil.
6. **Silica gel:** It works like breathing. There have a little amount oil under the silica gel which suck the moisture of air and further sends this air to silica gel which further sucks the rest of the moisture of the air.

Figure 4.5: Silica gel in a cylinder. [Source: Author]

7. **Exchanger:** Regulate voltage through winding selection between primary & secondary side.
8. **PRD (Pressure relief device):** release the oil pressure by releasing oil when oil pressure is high.

4.3.5 Insulator

Porcelain or ceramic insulator is used in substation to support the live conductors and bus bars.

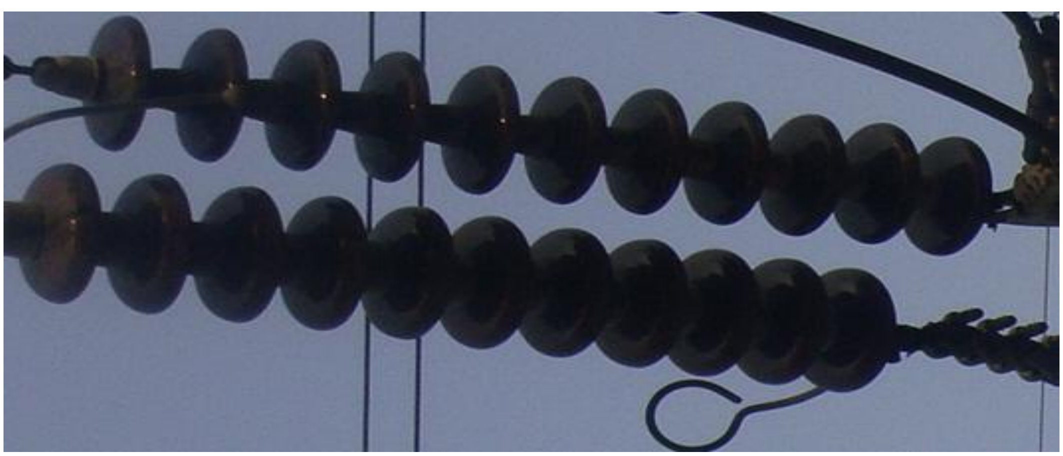


Figure 4.6: Insulator used in APSCL sub-station [Source: Author]

4.3.6 Isolators

Islators are used for isolating the circuit when the current has already been interupted. They allow currents into the circuit until curcuit is repair again. Isolators re used for connecting and disconnecting parts of electrical installation after de-energizing.

Figure 4.7: Isolators used in APSCL [Source: Author]

4.3.7 Lightning Arresters

All equipment those are feeding from power stations should be protected against direct lightning stroke. When stroke lightning stroke happens, a huge amount of surge voltage is created on the transmission line and this high voltage can damage any equipment within a short time. So this huge amount of lighting voltage are directly grounded through lightning arrester hence equipment are remains safe.

Figure 4.8: Lightning Arrester. [Source: Author]

4.3.8 Sub-station Auxiliary Supply

In any substation, there are many equpinment and arrengements to supply power. Sometimts these equipments and arrangements are out of order due to different reasons and there have also several equipments (eg: circuit breakers, relay, isolator) to protect others. If the feeding line of protection provider equipment is failing then there should be an auxilary power system. Generally this auxilary power supply is DC supply.

4.4 Types of bus bar

Normally there are two types of bus bar in APSCL

1. 230 KV bus bar : Generated units are stepped up to 230 KV bus bar
2. 132 KV bus bar : Generated units are stepped up to 132 KV bus bar

4.4.1 Arrangement of bus bar

Bus bar is one of the most important elements in the electrical substation. Bus bar acts as nodal point in the substation which connects different incoming and outgoing circuits. Substations use different types of bus bar arrangements or switching schemes depends upon the application, reliability of the supply and cost of installation. In every substation bus bar plays a common role to connect different circuits.

Bus bar arrangement system can be several types:

1. **Single Bus-bar arrangement**

   This is the simplest bus-bar arrangement among all schemes. Here a single set of bus-bars connected to the generators, transformers and load feeders where feeders are connected by circuit breaker and isolators. This arrangement helps to remove the connecting elements (Generators, transformers, etc) for maintenance by opening the circuit breaker and isolators.

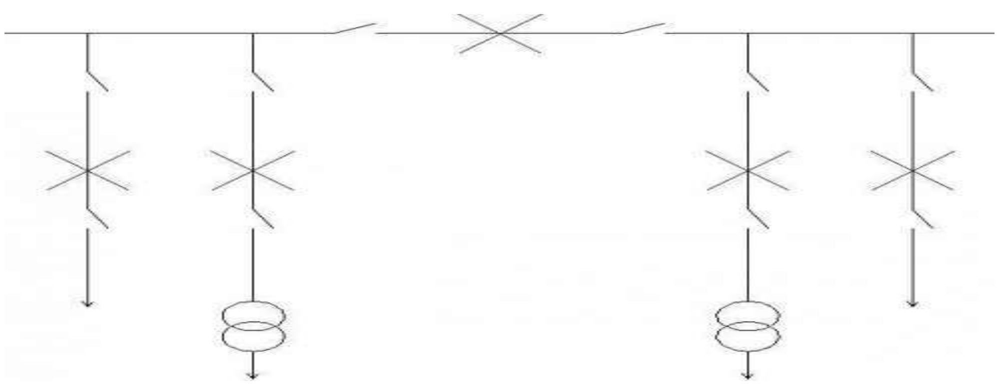


Figure 4.9: Typical diagram of a single bus bar arrangement. [9]

Table 9: Advantages and Disadvantages of a single bus bar arrangement

Advantages:	**Disadvantages:**
1. This arrangement needs less cost of installation. 2. Less maintenance. 3. Simple operation.	1. When any fault occurs on the bus bar then all the feeders connected to the bus bars have to disconnect. 2. When Bus bar is needed maintenance then total supply and all feeders have to disconnect. 3. Less flexibility and reliability

2. **Double Main Bus-bar arrangement**

Here each circuit is connected to both the buses. In some cases half of the circuits can be connected and operated on each bus when circuit breaker failure would cause loss to half of the circuits. In double main bus bar arrangement one or two breakers can be connected for each circuit. Double main bus bar and double breaker scheme provides high reliability for any type of fault in transmission line or circuit breaker. [10]

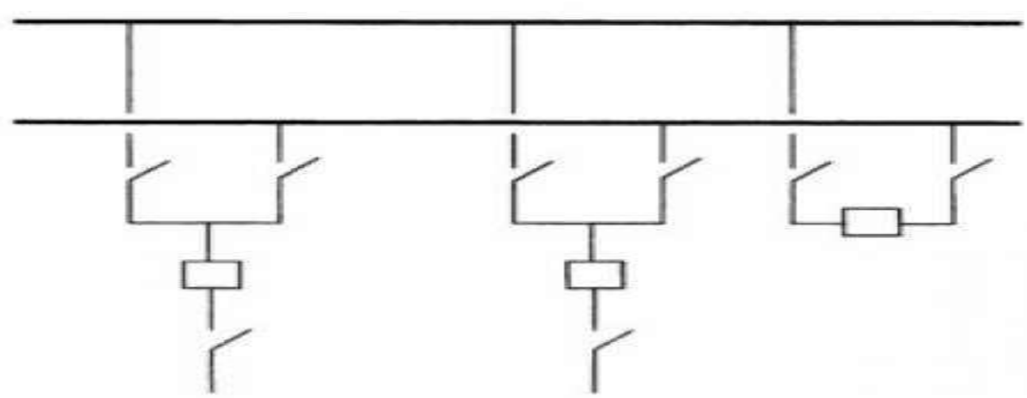


Figure 4.10: Typical diagram of a double main bus bar arrangement. [9]

Table 60: Advantages and Disadvantages of a double main bus bar arrangement

Advantages:	**Disadvantages:**
1. Any circuit can be maintenance without harming the system. 2. Flexible for connecting feeder circuit to any bus bar	1. Most expensive 2. Loose circuits connected to bus bar when fault occurs on the bus bar

APSCL Uses double line bus bar arrangement scheme for their transmission purpose. They provide their generated power to Shajibazar, Ghorashal, Kishoregonj through double bus bar system.

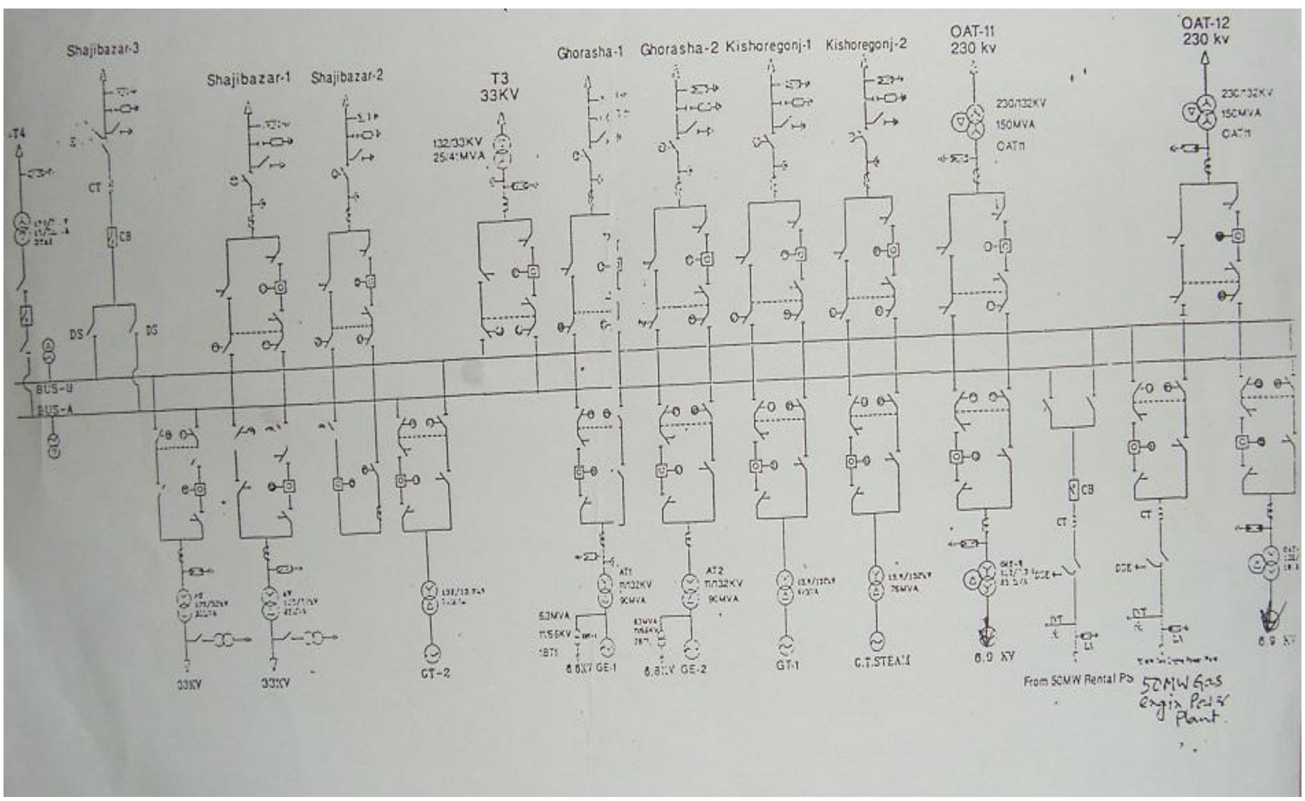


Figure 4.11: Connections of APSCL power station. [Source: Author]

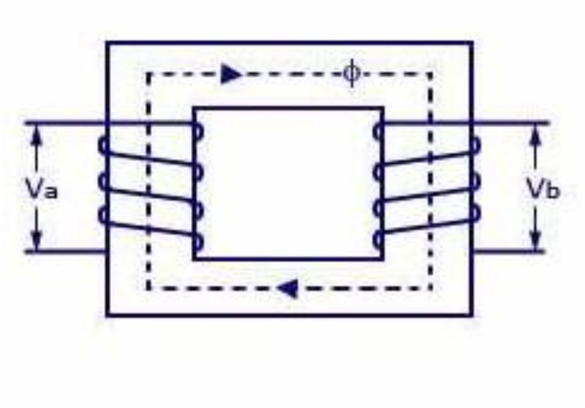
4.5 Types of a Transformer

There have several types of transformer depending on different aspects:

4.5.1 According to constructions

There are two types of transformer based on their winding arrangement.

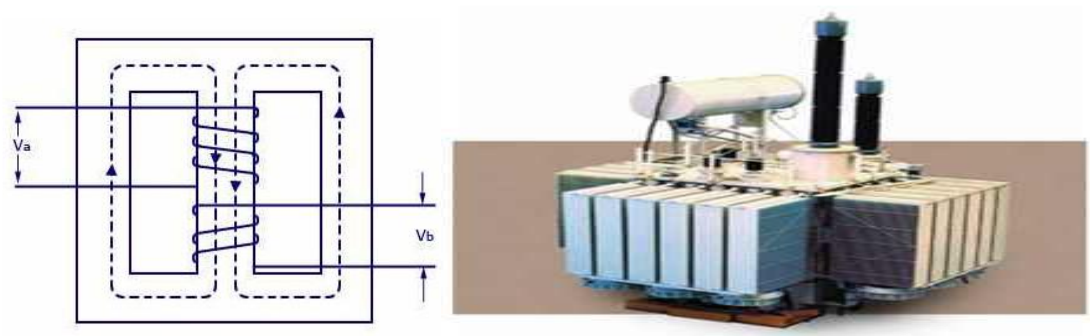
1. **Core type:**Here, windings are given to a considerable part of the core. The coils used for this transformer are cylindrical type. This type of transformer can be applicable for both small and large transformers. In the small transformer, the core is rectangular in shape and the coils are cylindrical. The cylindrical coils have many layers and each layer is insulated from the others paper, cloth, board etc.[10]



a **b**

Figure 4.12: a). Windings of a core type transformer. b). Structure of a core type transformer . [10]

2. Shell type: This type of transformer is more efficient than another type. Such transformers are used in transmitting commercial power. The core of the shell-type transformer is made of laminated silicon steel sheets and these sheets are placed over one another. The coils are wound around the central section of the core. Primary and secondary coils are wound close together around the core where windings are highly insulated. [10]



a b

Figure 4.13: a). Windings of a shell type transformer and b). Structures of a shell type transformer. [10]

4.5.2 According to connection:

1. **Delta to Delta:** Normally used for industrial applications. This type of connection provides the advantage that one of the transformers can be removed while the remaining two transformers can deliver three-phase power.

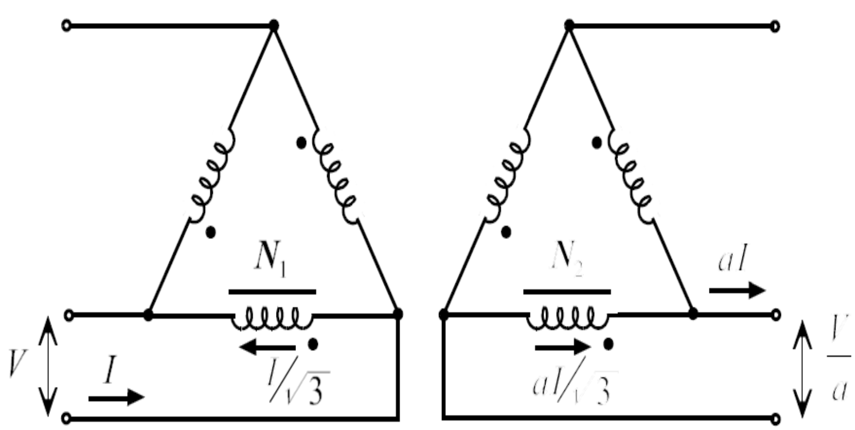


Figure 4.14: Delta to Delta connection. . [10]

2. **Delta to Wye:** Normally used in commercial and industrial area. Commonly used in a step-up transformer, WYE connection on the HV side reduces insulation costs; the neutral point on the HV side can be grounded, stable with respect to unbalanced loads.

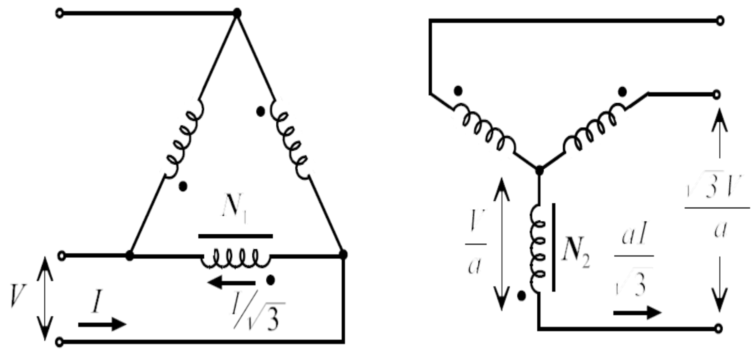


Figure 4.15: Delta to Wye connection. . [10]

3. **WYE to Delta:** Normally uses for high voltage transmissions. Commonly used in a step-down transformer, WYE connection on the HV side reduces insulation costs; the neutral point on the HV side can be grounded, stable with respect to unbalanced loads.

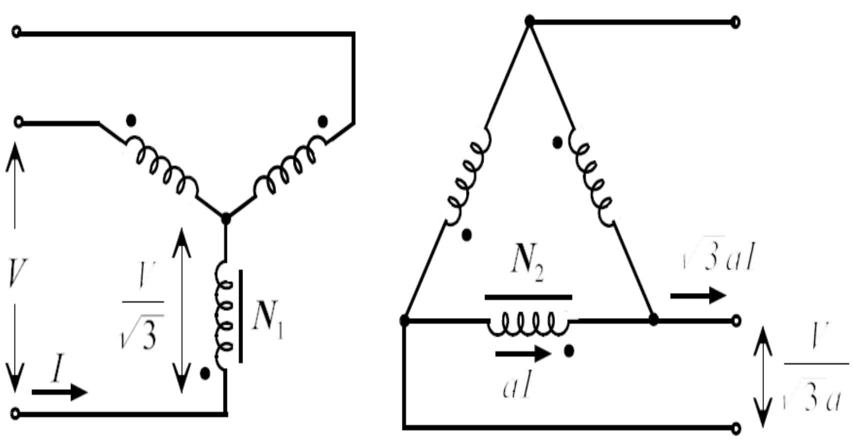


Figure 4.16: Wye to Delta connection. . [10]

4. **Wye to Wye:** This type of transformers are rarely used for the system where problems with unbalanced loads.

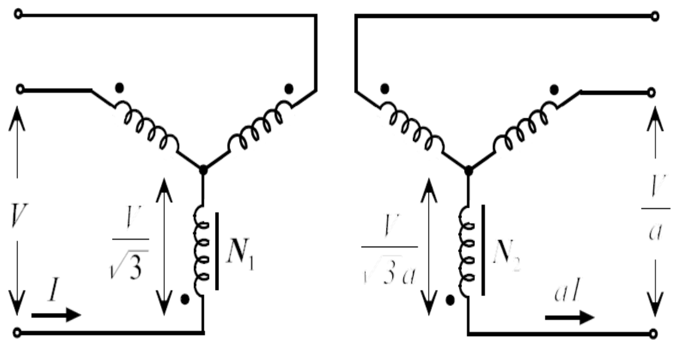


Figure 4.17: WYE to WYE connection. . [10]

4.5.3 According to operation:

1. **Step up transformer:** When a transformer designed to increase voltage from primary to secondary is called a step-up transformer. In this transformer there are more turns on the secondary coil than the primary coil. The induced voltage in the secondary coil is greater than the applied voltage in the primary coil hencewe can say voltage has been "stepped-up". That's why it's called step up transformer.

   The relationship between the voltage and the number of turns in each coil is given by:

   $$\frac{Voltage\ in\ Secondary\ Coil}{Voltage\ in\ Primary\ Coil} = \frac{Turns\ on\ Secondary\ Coil}{Turns\ on\ Primary\ Coil}$$

   Or, $\frac{Vs}{Vp} = \frac{Ns}{Np}$

2. **Step down transformer:** Step down transformers are designed to reduce electrical voltage. Their primary voltage is greater than their secondary voltage. This kind of transformer "steps down" the voltage applied to it.

Transformers are very efficient. If it is assumed that a transformer is 100% then the power in the primary coil is equal to the power in the secondary coil according to the law of conservation energy.

Power in primary coil = Power in secondary coil

Or, Primary coil p.d. x primary coil current = Secondary coil p.d. x secondary coil current

Or, $V_P \times I_P = V_S \times I_S$

So if the voltage is stepped up by a transformer then the current is stepped down by the same ratio. In the case of the voltage stepped down by the transformer then the current is stepped up by the same ratio.

4.5.4 According to phase connection:

1. **Single phase transformer:** This type of transformers are
2. **Three phase transformer**: This type of transformers are

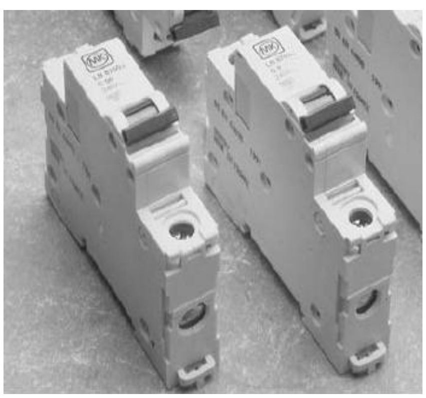
4.6 Circuit Breaker:

Circuit breakers are generally located so that each generator, transformer, bus, Transmission line, etc., can be completely disconnected from the rest of the system. These circuit breakers must have sufficient capacity so that they can carry momentarily the Maximum short-circuit current that can flow through them, and then interrupt this current; they must also withstand closing in on such a short circuit and then interrupting it according to certain prescribed standards.

In the Ashuganj Power Station of Company Limited (APSCL) use MCB(Miniature Circuit Breaker), MCCB (Molded Case Circuit Breaker), ACB (Air Circuit Breaker), Vacuum Circuit Breaker, SF6 Circuit Breaker, Oil Circuit Breaker, Air Blast Circuit Breaker and Air Blast Circuit Breaker hear all of these circuit breaker working principle are descried

4.6. 1 MCB (Miniature Circuit Breaker)

The miniature circuit breaker has a contact system and means of arc quenching, a mechanism and tripping and protection system to open the circuit breaker under fault conditions. The modern mcbs with breaking capacities of 10 kA to 16 kA now available, mcbs are used in all areas of commerce and industry as a reliable means of protection. Most mcbs are of single-pole construction for use in single-phase circuits. The contact system comprises a fixed and a moving contact, and attached to each is a contact tip which provides a low-resilience contact junction to resist welding. [4]



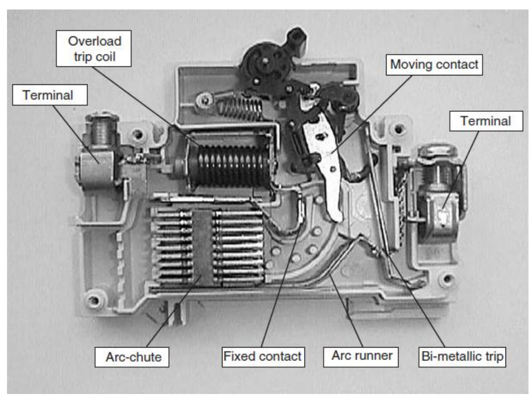


Figure 4.18: Miniature circuit breaker extern and internal view. [4]

4.6. 2. MCCB (Molded Case Circuit Breaker)

MCCBs are available in a wide range of ratings and are generally used for low-current, low-energy power circuits. The breakers have self-contained over current trip elements. Conventional MCCBs with thermal-magnetic trip elements depend on the total thermal mass for their proper tripping characteristics. Magnetic-trip-only breakers have no thermal element. Such breakers are principally used only for short-circuit protection The breaker provides the instantaneous protection and fault interruption, and other overload devices in the starter handle the long-time overload protection. No automatic circuit breakers have no overload or short-circuit protection. They are primarily used for manual switching and isolation.[5]

4.6.3 Vacuum Circuit Breaker

Vacuum circuit breakers are the most common type of circuit breaker used in new installations. Vacuum circuit breakers are being used to replace air circuit breakers. Vacuum breakers are smaller and can provide additional space if the plant needs to be expanded to meet new requirements. Before using vacuum circuit breakers, a transient analysis study should be performed to determine if there is a need for surge protection. If required, surge protection can be supplied by the installation of capacitors and/or surge suppressors can be used to eliminate voltage surge problems.[4]

Figure 4.19: Sectional view of a vacuum interrupter. [Source: Author]

4.6. 4 SF6 Circuit Breaker:

SF6 is inert gas the property of this gas the higher pressure and temperature its dielectric strength will be SF6has two gas chamber when contract is close the pressure is two chamber have the same pressure but when the contract is open then one of the chamber get totally close and other remain open ,there is a narrow channel between two chamber and when contract open the SF6 flow a plane of high pressure region to the low pressure region there will be turbulence of SF6.At zero current the turbulence of SF6 absorb all the ions and since it is flowing from a narrow region hence it provide high dielectric strength but there is problem that the pressure of SF6 is not always remain fixed due to leakage in the cylinder of SF6.so there is pressure gauge as well as alarm attached with it. Whenever pressure decreases the alarm ringing and the gas is refilled to increase pressure.

The advantage of SF6 is not harmful so whenever linkages there is no harmful in living creature.SF6 use in place which are not open And SF6 circuit breaker require maintenance.

Figure 4.20: SF6 circuit breaker used in APSCL. [Source: Author]

4.6. 5 Oil Circuit Breaker

Oil circuit breakers have been two designs exist bulk oil and oil minimum breaker technology. Bulk oil circuit breakers were designed as single-tank or three-tank mechanisms; generally, at higher voltages, three-tank designs were dominant. Oil circuit breakers were large and required significant foundations to support the weight and impact loads occurring during operation. The design of the interrupter employs the arc caused when the contacts are parted and the breaker starts to operate. The electrical arc generates hydrogen gas due to the decomposition of the insulating mineral oil. The interrupter is designed to use the gas as a cooling mechanism to cool the arc and to use the pressure to elongate the arc through a grid, allowing extinguishing of the arc when the current passes through zero.

Figure 4. 21:Oil circuit breaker use in APSCL. [Source: Author]

4.6. 6 Air Blast Circuit Breaker

The breaker employ high pressure air blast as an quenching medium .the contract are opened in a flow of air blast establish by the operating of blast valve .the air blast the cool the arc and sweeps away the arching product to the atmosphere .the rapidly increasing the dielectric strength of the medium between contracts and prevent from re establish the arc consequently arc is extinguish and flow of current is interrupt.

4.7 Relay:

A relay is a device used to control the operation of a magnetic contactor or other device .relay operate as a function of current ,voltage ,heat .and pressure and supply the “intelligence” that is necessary to provide automatic acceleration ,protect against overload ,under voltage, excessive speed, excessive torque, etc .At APSCL two types of relay is used. One is electrical relay and another is electronics relay.[5]

4.7.1 Electrical Relay:

Electrical relays Measuring and protection equipment These electrical relays trip to shut the system down until the problem can be addressed .An electrical relay is a switch which is under the control of another circuit., electrical relays were often made with electromagnets, They key difference between electromagnetic and solid state options is that electromagnetic relays have moving parts, and solid state relays do not. Electromagnets also conserve more energy than their solid state counterparts do.[5]

Figure 4. 22: Electrical Relay. [Source: Author]

4.7.2 Electronics Overload Relay:

Electronic overload relays are the alternative to thermal overload relays. An electronic overload relay offers reliable and fast protection for motors in the event of overload or phase failure. If a power phase is lost, motor windings can burn out very quickly. Electronic overload relays can detect a phase loss and disconnect the motor from the power source. Phase loss protection is not available on mechanical types of overload relays.

4.7.3 Buchholz relay

A Buchholz relay is a safety device sensing the accumulation of gas in large oil-filled Transformers, which will alarm on slow accumulation of gas or shut down the transformer if gas is produced rapidly in the transformer oil. These are used to break the circuit in case of any abnormalities in the transmission lines.[5]

Chapter 5 Generator

In this section we learned about Generator and different types of protection of generator.

5.1 Introduction to Generator

Generator is an electro mechanical device that converts mechanical energy into electrical energy. The operation of the electrical generators used depends upon the principle of electromagnetic conduction. When conductors move through a magnetic field or when a magnetic field in moved past conductors an induced current develops. The current that is induced into the conductors produces induced electromotive force or voltage. To produce electricity there are 8 generators in APSCL.

Figure 5.1: Generator in APSCL. [Source: Author]

Table 11: Generator information of APSCL.

Category	Steam power plant		Combine cycle power plant	
	Unit 1,2	Unit 3,4,5	Gas turbine 1,2	Steam turbine
Name of the Company	BBC, Germany	ABB, Germany	GEC,UK	GEC,UK
Rated voltage	11 KV	15.75 KV	13.8 KV	13.8 KV
Rated power	64 MW	150 MW	64 MW	34 MW
Rated current	4200 A	6965 A	2911 A	1799 A
Frequency	50Hz	50Hz	50Hz	50Hz
Number of pole	2	2	2	2

Essentially, there are two basic types of generator.

1. AC Generator
2. DC Generator

5.2 AC generator

Ac generator also called synchronous generators or alternators. Ac generator are the principal sources of electrical power throughout the world, and range in size from a fraction of a KVA to 1500 MVA. Alternating voltage may be generated by rotating a coil in the magnetic field or rotating by magnetic field within a stationary coil.

The value of voltage generated depends on

► The numbers of turn in the coil

►Strength of the field

►The speed at which the coil or magnetic fields rotate.

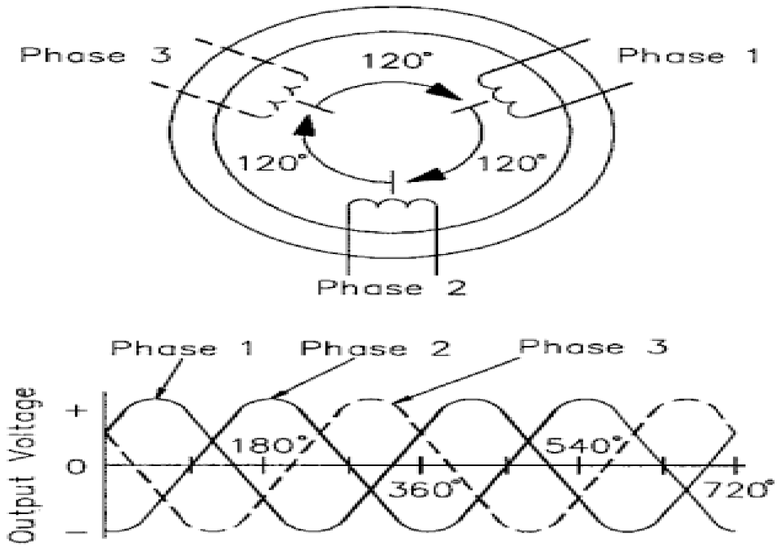


Figure 5.2: A three phase AC generator conductor and wave shape. [6]

5.3 Working principal of AC generator

Synchronous generators are used because they offers precise control of voltage, frequency, VARs and WATTs. This control is achieved through the use of voltage regulators and governors. A synchronous machine consists of a stationary armature winding (stator) with many wires connected in series or parallel to obtain the desired terminal voltage. The armature winding is placed into a slotted laminated steel core. A synchronous machine also consists of a revolving DC field - the rotor.

A mutual flux developed across the air gap between the rotor and stator causes the interaction necessary to produce an EMF. As the magnetic flux developed by the DC field poles crosses the air gap of the stator windings, a sinusoidal voltage is developed at the generator output terminals. This process is called electromagnetic induction .

The magnitude of the AC voltage generated is controlled by the amount of DC exciting current supplied to the field. If “FIXED” excitation were applied, the voltage magnitude would be controlled by the speed of the rotor (E=4.44fnBA), however, this would necessitate a changing frequency!

Since the frequency component of the power system is to be held constant, solid state voltage regulators or static exciters are commonly used to control the field current and thereby accurately control generator terminal voltage. The frequency of the voltage developed by the generator depends on the speed of the rotor and the number of field poles.

5.4 Generator Synchronization

The process of connecting an AC generator to other AC generators is known as synchronization and is crucial for the generation of AC electrical power. An AC machine must match both the amplitude and the timing of the network voltage, which requires both speed and excitation to be systematically and closely controlled for synchronization.

5.5 Generator Protection

A modern generating unit is a complex system comprising the generator stator winding, associated transformer and unit transformer ,the rotor with its field winding and excitation system, and the prime mover with its associated auxiliaries. Faults of many kinds can occur within this system for which diverse forms of electrical and mechanical protection are required. The amount of protection applied will be governed by economic consider rations, taking into account the value of the machine, and the value of its output to the APSCL OWNER. The following problems require consideration from the point of view of applying Generator Protection:

5.5.1 Over current protection

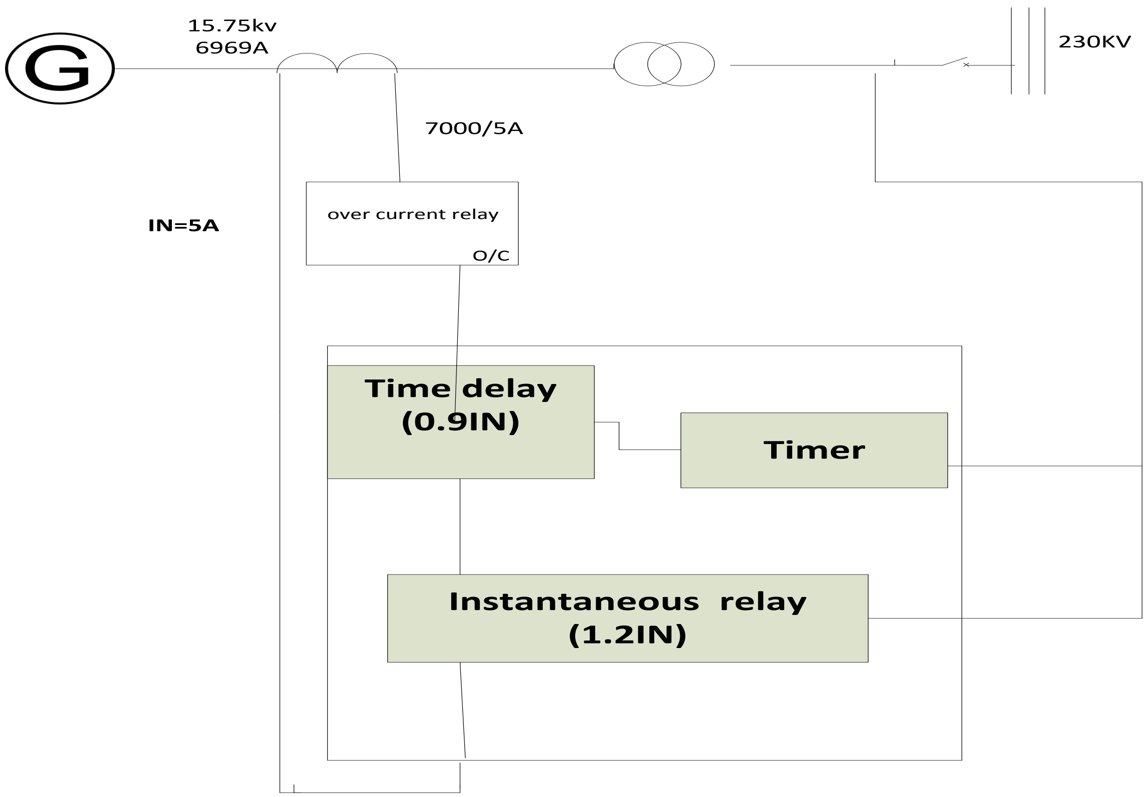


Figure 5.3: Over current protection. [Source: Author]

In APSCL generator unit 3,4 and 5 uses rated terminal voltages 15.75kv and rated current 6995A. Hear over current relay connect through the CT with the terminal and use CT ratio 70000V/5A. Inversely we can say if 5A current flow the voltages flow 7000V,Over current relay consists of two types of relay, one is time delay relay which is connect with timer another is instantaneous relay. In APSCL timer setting time is 0.5second. When time delay activated than start time counting and after 5second is breaks contract, on the other hand instantaneous relay operate instantaneously. Generally nominal current 5A. If 0.9 times of nominal current flow through the line then time delay activated or if 1.2 times of nominal current flow through the line then instantaneous relay activated. In these case time delay activated but it start time counting where as instantaneous relay operate instantaneously.

Suppose fault occurs in the terminal than high current (9000A) appear in the line time delay start time counting but instantaneous relay trip the breaker instantaneously. In the power r system time delay relay operate when load increase in the feeder line and instantaneous relay operate when fault in the line

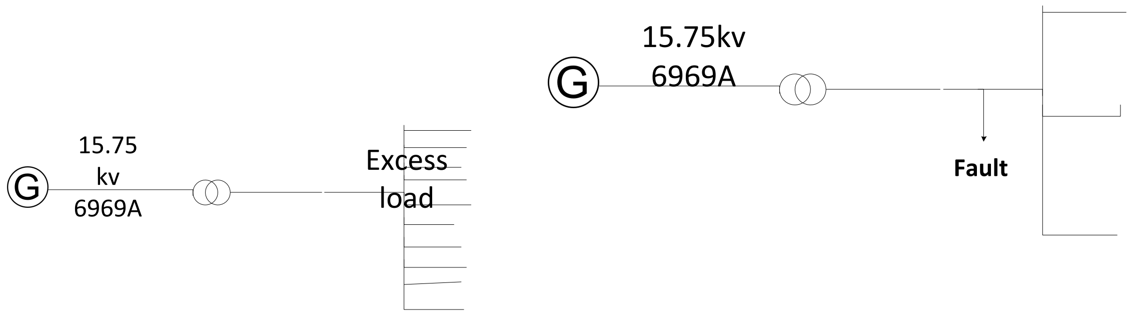


Figure 5.4: Time delay relay and instantaneous relay. [Source: Author]

5.5.2 Stator Winding Protection

To respond quickly to a phase fault with damaging heavy current, sensitive, high-speed differential protection is normally applied to generators rated in excess of 1MVA. For large generating units, fast fault clearance will also maintain stability of the main power system. The zone of differential protection can be extended to include an associated step-up transformer. For smaller generators, IDMT/instantaneous over current protection is usually the only phase fault protection applied.

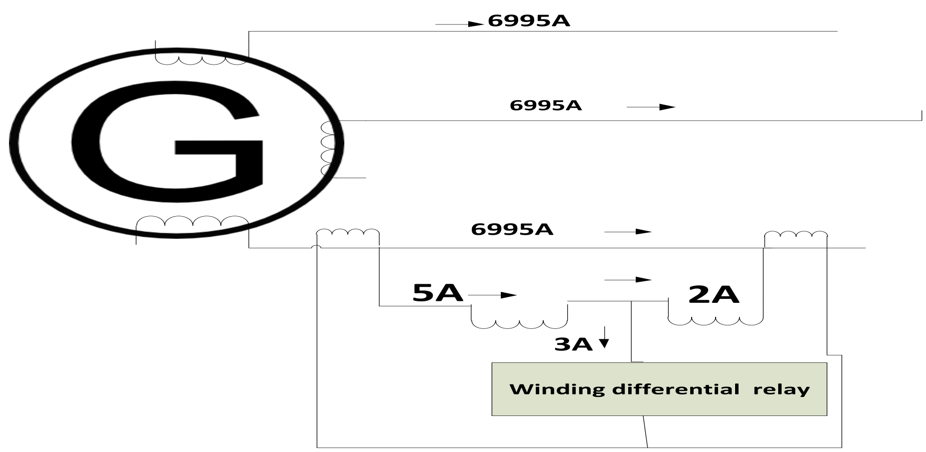


Figure 5.5: Stator Winding Protection. [Source: Author]

5.5.3 Over Current With Under Voltages

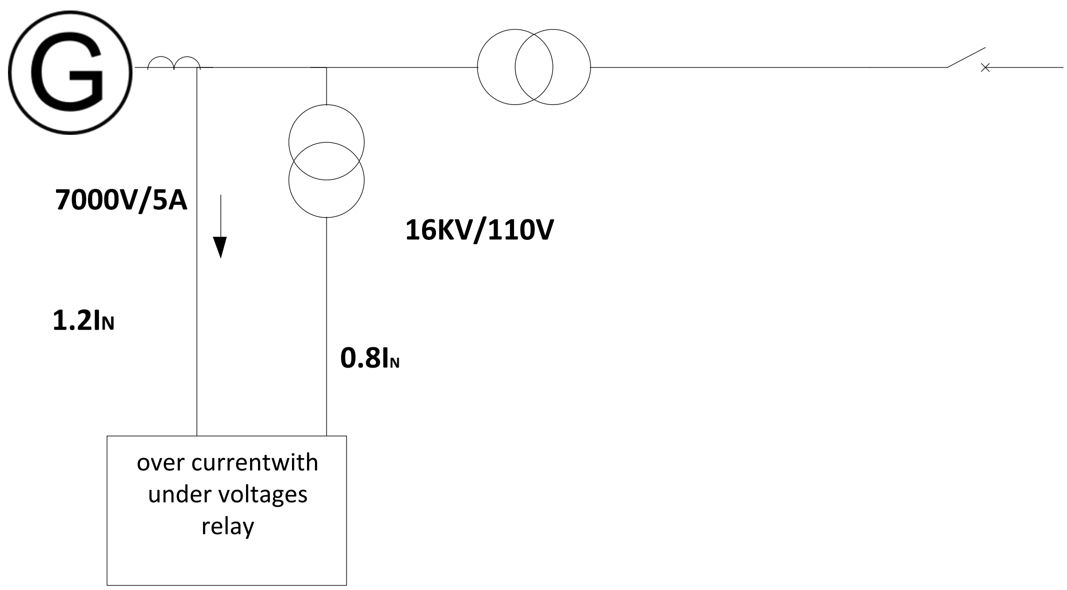


Figure 5.6: Over current with under voltages. [Source: Author]

Over current with under voltages consist of under voltages section and under voltages section ,if only over current activated the relay do not operate .when over current and under voltage operate then the over current with under voltages relay operate .in the over current section if current flow 1.2in than it does not effect on the terminal voltages ,if current flow more the 1.2times of in in than the terminal voltages reduces ,for these reasons power system appear over current and under voltages appear .when in the power system both condition appear then the under voltages with over current relay activated .if over current relay activated we understands that huge amount of fault in the system occurred ,if under voltage appear we can are confuse if it is fault or over load occurred or over voltages.

In the power system main causes of over voltages occur

1. Sudden load rejection
2. Lightening

3. Line fault

5.5.3.1 Sudden load Rejection

Operation under manual control with the voltage regulator out of service. A sudden variation of the load, in particular the reactive power component, will give rise to a substantial change in voltage because of the large voltage regulation inherent in a typical alternator.

5.5.3.2 Lightening

If thundering occurred in the power system then terminal voltages will increase. To protect terminal from over voltages we use lightning arrester to ground enter charge in the ground .

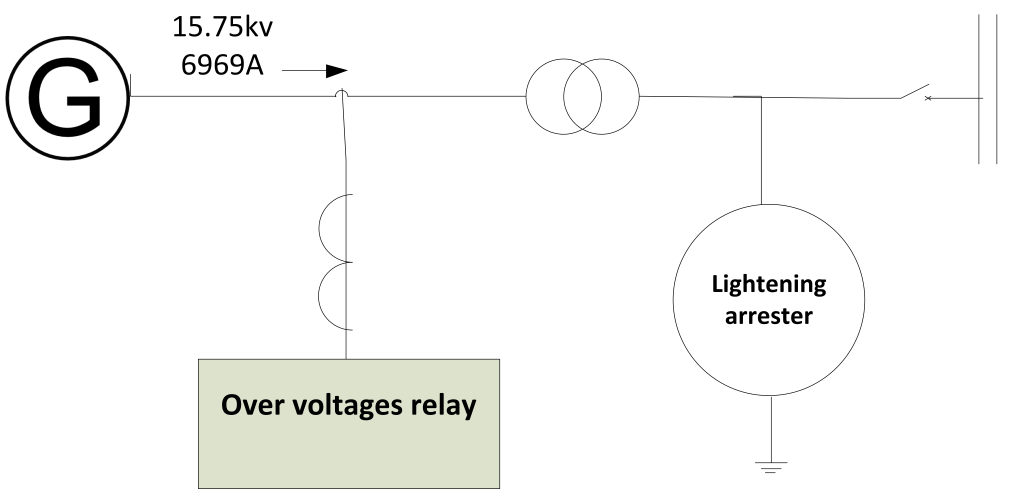


Figure 5.7: Lightening. [Source: Author]

5.5.3.3 Line Fault

Line fault is a common phenomenon in the power system, if line fault occurred then line voltages increase.

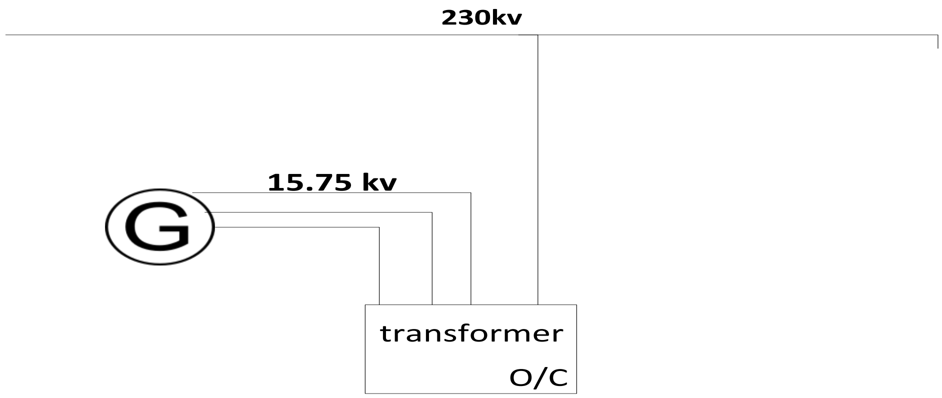


Figure 5.8: line fault. [Source: Author]

Figure 5.9: Duct use in APSCL. [Source: Author]

If any abnormal condition 230KV line the connect with 15.75 KV line then the generator and transformer primary winding will be burn .this abnormal situation may occurred before over voltages relay activated to reduces this problem APSCL use duct every individual connection.

5.5.4 Over Speed Protection

The speed of a turbo-generator set rises when the steam input is in excess of that required to drive the load at nominal frequency. The speed governor can normally control the speed, and, in any case, a set running in parallel with others in an interconnected system cannot accelerate much independently even if synchronism is lost. However, if load is suddenly lost when the HV circuit breaker is tripped, the set will begin to accelerate When a generator operating in parallel with others loses its power input, it remains in synchronism with the system and continues to run as a synchronous motor, drawing sufficient power to drive the prime mover. This condition may not appear to be dangerous and in some circumstances will not be so. However, there is a danger of further damage being caused.[3]

5.5.5 Negative Sequence Protection

Power system can be divided into three sequence such as positive phase sequence, negative phase sequence and zero phase sequence .

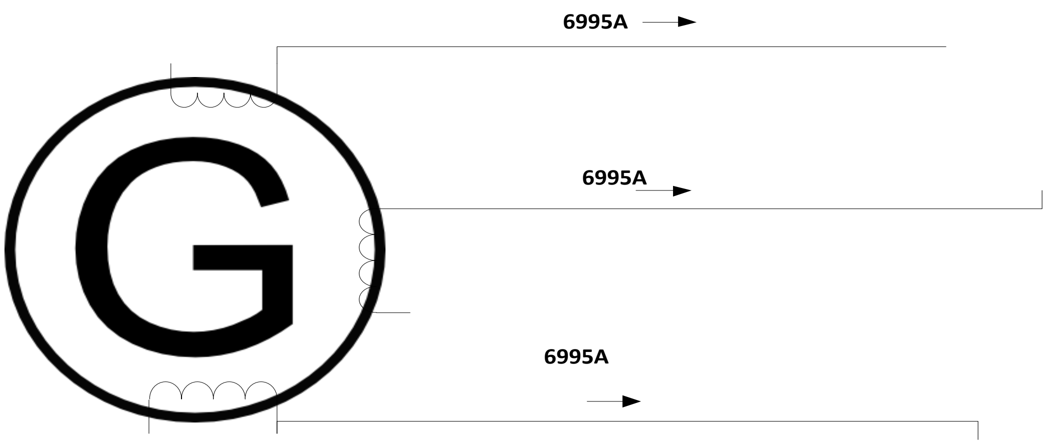


Figure 5.10 Negative sequence protection. [Source: Author]

4.2.5.1 Positive Phase Sequence

Normal and abnormal both case it activated .we can express positive sequence as impedance and voltages source.

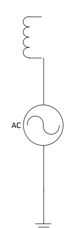


Figure 5.11: Positive phase sequence. [Source: Author]

5.5.5.2 Negative Phase Sequence

When fault occurred then negative sequence activated, it can be express as inductor .it can be phase to phase, phase to ground, phase to phase ground and three phase fault.

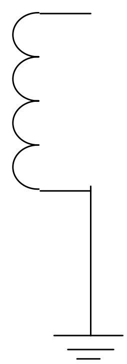


Figure 5.12 Negative phase sequence. [Source: Author]

5.5.5.3 Zero Sequence

Zero sequence appears when fault anything (phase /ground) to ground, phase to ground phase to phase to ground.

5.5.6 Reverse Power Protection

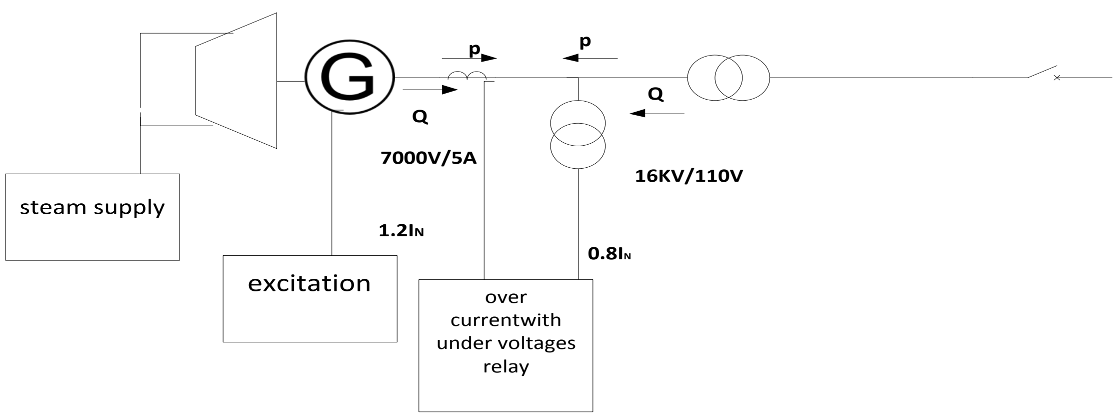


Figure 5.13: Reverse power Protection. [Source: Author]

Reverse power relay uses in APSCL for generator protection section .Its activated when real power and reactive power flows from grid to generator supply steam for rotor rotate 3000rpm and generate real power and supply field excitation to produces reactive power in the case if steam supply to the generator turn off the real power will be zero than grid supply real power to generator for rotation 3000rpm of rotor .in that case reverse power relay will trip the breaker .generator work as synchronous motor when real power is negative then grid supply real power. Synchronous motors are used in APSCL to supply reactive power in the grid and over excited motor work as a condenser and power factor improvement .generator work as asynchronous motor when real power and reactive power is negative. When both real power and reactive power is positive than generator work as synchronous generator .when both real power and reactive power negative than generator work as asynchronous Generator. Asynchronous Generator has not existed in real life.

Lastly when real power is positive the generator work as synchronous generator and when real power is negative generator work as motor .when reactive power is positive generator work as asynchronous motor.

Figure 5.14: Reverse power Protection use in APSCL. [Source: Author]

5.5.7 Under Frequency Protection

An under frequency relay is one which operates when the frequency of the system falls below a certain value. Overloading of a generator, perhaps due to loss of system generation and insufficient load shedding, can lead to prolonged operation of the generator at reduced frequencies. This can cause particular problems for gas or steam turbine generators, which are susceptible to damage from operation outside of their normal frequency band. The turbine is usually considered to be more restrictive than the generator at reduced frequencies because of possible mechanical resonance in the many stages of the turbine blades. If the generator speed is close to the natural frequency of any of the blades, there will be an increase in vibration. Cumulative damage to the blades due to this vibration can lead to cracking of the blade structure .While load-shedding is the primary protection against generator overloading, under frequency relays should be used to provide additional protection.

Alarm: 48 Hz,

5.5.8 Minimum impedance and Distance protection

Minimum impedance relay always deal with ratio of voltages and current .minimum impedance relay generally use in transmission line ,transformer, Grid, Generator .minimum impedance mean if voltages and current fluctuates then they always have ratio is call set point ,in APSCL use terminal voltages 110Vand current 5A then minimum impedance is

R=V/I

=110V/5

=22.

So In APSCL use set point 22,if below set point then the plant will trip .if in the powe system over load appear then current will increase in the terminal ,let current will increase 5Ato 18A then minimum impedance will be R=V/I=18

if in the power system short circuit occurred then current will increase in the terminal ,let voltages will decrease 5Ato 18A then minimum impedance will be R=V/I=80V/5A=16. In both case the plant will be trip

distance protection relay work same principle distance protection indicate the direction in which direction fault appear left or right side of generator .we ca set point in the case of distance protection .In APSCL use distance protection which sense 80%distance from the transformer winding and in the case of generator it sense 100%.the main difference between is distance relay is vector and minimum relay is scalar In the APSCL some synchronous generator has only minimum impedance relay And some generator use both minimum impedance and distance protection.

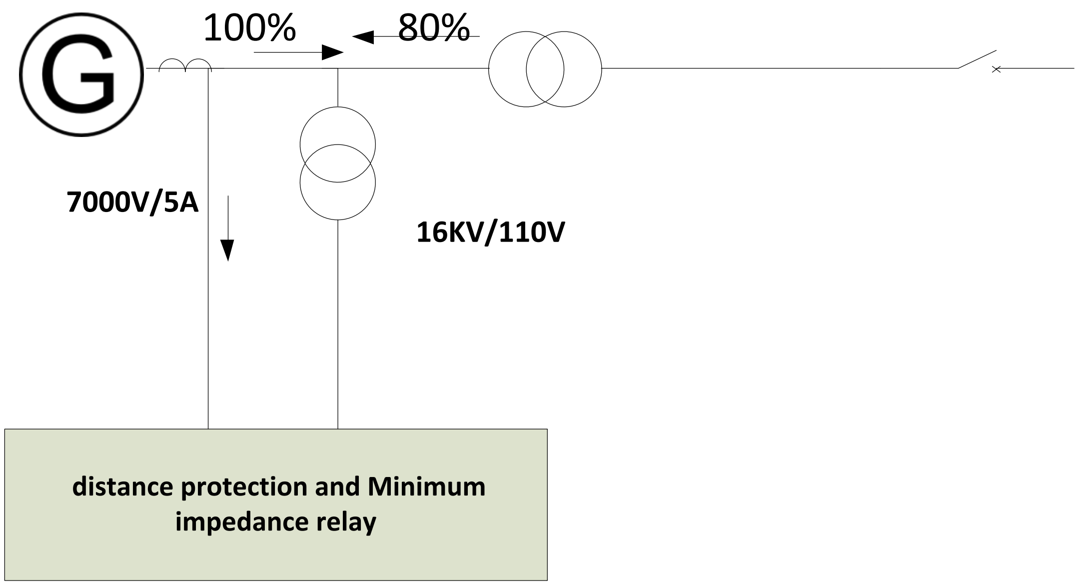


Figure 5.16: Minimum impedance and Distance protection. [Source: Author]

5.5.9 Stator Ground Fault Protection

Stator ground faults are short circuits between any of the stator windings and ground, via the iron core of the stator. Typically, when a single machine is connected to the power system through a step-up transformer, it is grounded through high impedance. As a result, the amount of the short circuit current during stator ground faults is driven by the amount of capacitive coupling in the machine and its step-up transformer. Therefore, when a ground fault occurs with some capacitive current flow, makes the short circuit difficult to detect. Ground faults can be detected throughout most of the winding through the use of an overvoltage relay responding to the fundamental component of the voltage across the grounding impedance. This stator ground fault is sometimes known as 100% stator ground fault protection. [3]

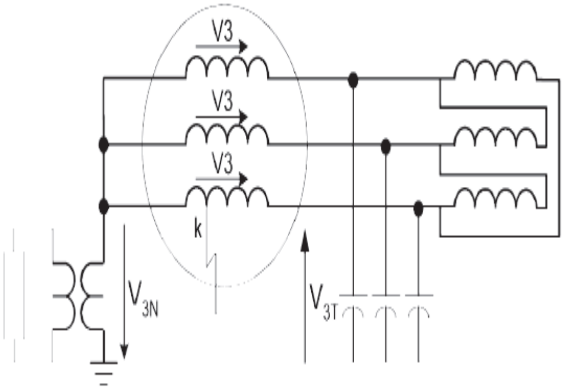


Figure 5.17: Stator Ground Fault Protection. [Source: Author]

5.5.10 Back Up Earth Fault Protection

This protection is provided as back-up earth-fault protection for the generator and downstream system. It must therefore have a setting that grades with the downstream protection. The protection is driven from the generator star-connected VT, while the downstream protection is current operated. It is therefore necessary to translate the current setting of the downstream setting of the current-operated earth-fault protection into the equivalent voltage for the NVD protection.

Figure 5.18: Picture of back up earth fault relay in APSCL. [Source: Author]

5.5.11 Rotor Earth Fault Protection

Two methods are available to detect this type of fault. The first method is suitable for generators that incorporate brushes in the main generator field winding. The second method requires at least a slip-ring connection to the field circuit

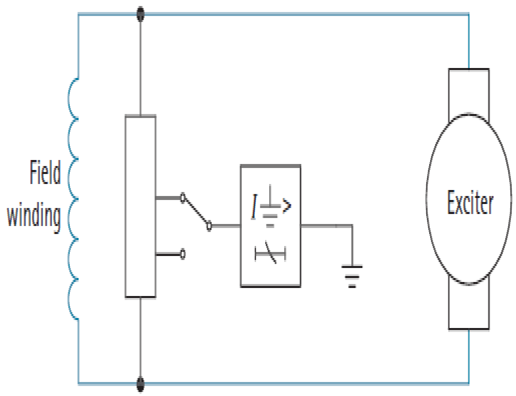


Figure 5.20 Earth fault protection of field circuit by potentiometer method & picture of the relay used in APSCL. [Source: Author]

5.5.12. Unit Transformer Protection

Unit transformer are usually applied to balance the generator differential protection and prevent the unit Transformer through current being seen as differential current. The location of the third set of current transformers is normally on the primary side of the unit transformer. If located on secondary side of the unit transformer, they would have to be of an exceptionally high ratio. One advantage is that unit transformer faults would be within the zone of protection of the generator. However, the sensitivity of the generator protection to unit transformer phase faults would be considered inadequate, due to the relatively low rating of the transformer in relation to that of the generator. Thus, the unit transformer should have its own differential protection scheme. [3]

Chapter 6 Operation and Control room

At the ending we visited operation and control room. Our instructor was Anwar Hossain. We spent three days here.

The entire power plant can be controlled and supervised from the centered console and the large display panel in the main control room. There are two ways of monitoring and operating all the individual parts of a power station. One is directly from the equipment control system and another one is from control unit. Power plant operators control and monitor the different parts and metering from the control room. They distribute power among generators, regulate the output from several generators, and monitor instruments to maintain voltage and regulate electricity flows from the plant.

6.1 Control Units of APSCL

There are four different types of control room in Ashuganj Power Station and company Limited(APSCL).

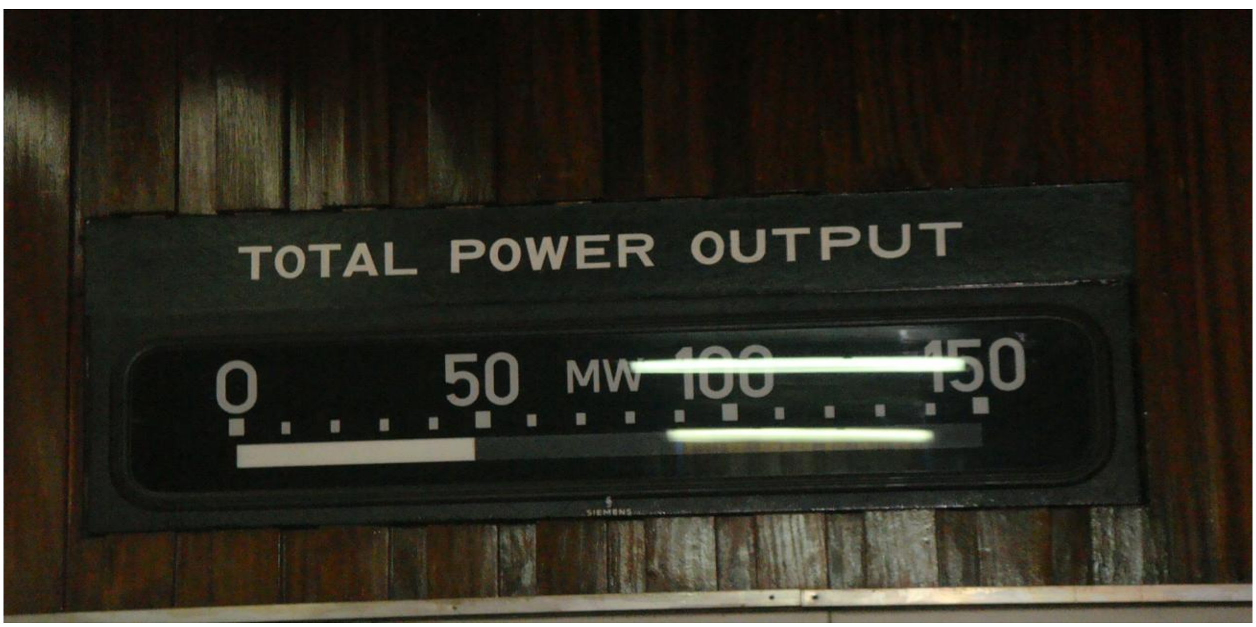


Figure 6.1 Total generation output. [Source: Author]

6.1.1 Control Room of Unit 1 & 2

Control system of unit 1 and 2 is analog in APSCL. Unit 1 and 2 of APSCL was developed in 1970. Power plant operators operate by pushing the button or changing the possion of switch on control broad in these two control rooms. As the oldest power plant it is operated by senior engineer of APSCL.

Figure 6.2   Control Room of Unit 1 & 2. [Source: Author]

6.1.2 Control Room of Unit 3 & 4

Control system of unit 3 and 4 is digital in APSCL. Unit 3 and 4 was developed from 1986 to 1988. All the metering and operation are done by using digital technology. Digital metering is more accurate than analog. So due to the advance technology and availability of devices less problems are faced to operate this unit.

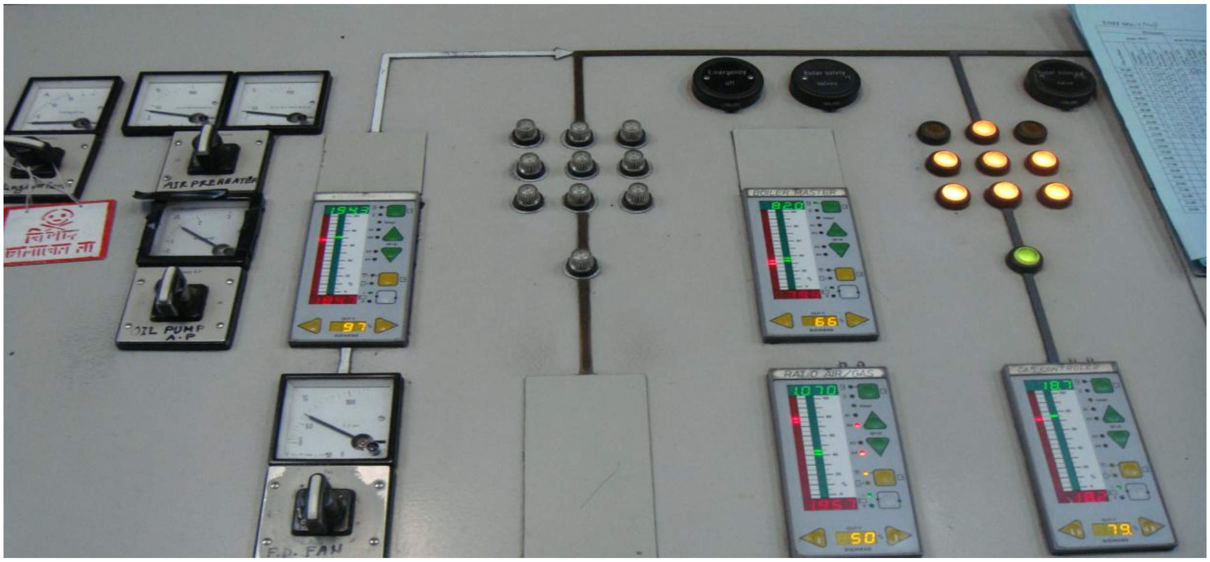


Figure 6.3 Control Room of Unit 3 & 4. [Source: Author]

6.1.3 Control Room of Unit 5

Control system of unit 5 is totally digitalized and controlled by pc. It needs less operators than other power plant unit. This unit is controlled by pla software.

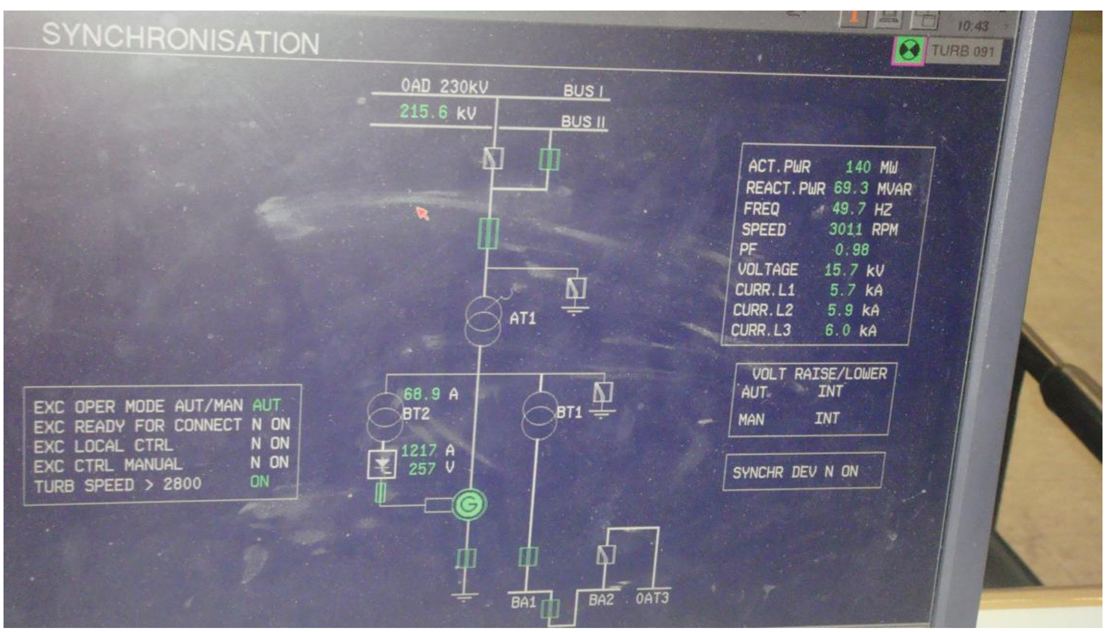


Figure 6.4 Control Room of Unit 5. [Source: Author]

6.1.4 Combine Cycle Control Unit

Gas turbine and steam turbine both combine consist of combine cycle .it was developed from 1982 to 1986 .in combine cycle use analog system .the efficiency of combine cycle day by day reduces because of backdated technology . in present situation the gas turbine unit 2 is totally unused .experts are require to repair and maintained combine cycle control unit .which has lack in APSCL.

Figure 10 Combine Cycle Control Unit [Source: Author]

Conclusion:

In case of power generation, APSCL is the combination of steam, gas and combined cycle plant. Last 26th December we went to Ashuganj Power Station Company ltd. for our internship program. At first we visited steam power plant, we observed how water is collected, purified and then boiled to produce steam. There are several switch gear and control rooms to control the overall system of producing steam and power generation. Various types of relays used for protective purposes that are also controlled in control room. Next we visited gas turbine of APSCL. There we have seen how fresh air and natural gas supplied by TITAS GAS are used as fuel to burn. After burning, produced hot gas used to rotate the turbine as well as power generation. For protective measures relays are also used and controlled in switch gear room. After gas turbine, we visited combined cycle power plant (CCPP). Here the exhausted hot gas is being used to boil water for producing steam. At last we visited the distribution section of APSCL. In sub-station, stepped up or down of voltages is being done using transformers and power is distributed. Different types of isolators are being used for maintenance purpose of transmission lines. Breakers are also used for transmission line protection. To meet the present demand there's no other option instead of increasing power generation.

The authorities in APSCL were very concerned about all kinds of safety. The friendly environment in APSCL encouraged us to co-operate with each other. We learned a lot and obtained practical knowledge from our internship at APSCL, which will help us in our future life.

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