INTERNSHIP REPORT

ON

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

By

PINTU DAS (2008-1-80-046)
TAHSIN AHMED (2008-1-80-073)
BISHUDDHANANDA PURABRAMMHAN (2008-1-80-008)

Submitted to the

Department of Electrical and Electronic Engineering
Faculty of Sciences and Engineering
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)

Summer, 2011

Approved By

29/9/2011 — Academic Advisor, Dr. Khairul Alam

29.09.2011 — Academic Advisor, S. M. Shahriar Rashid

01.10.2011 — Department Chairperson, Dr. Anisul Haque

Approval Letter

ASHUGANJ POWER STATION COMPANY LTD.
(An Enterprise of Bangladesh Power Development Board)
Ashuganj, B.Baria-3402, Bangladesh
Fax: +88-08528-74014, 74044
E-mail: apscl@apscl.com, apsclbd@yahoo.com, Website: www.apscl.com

Approval Letter

To whom it may concern

This is to certify that Pintu Das, student ID 2008-1-80-046, Tahsin Ahmed, student ID 2008-1-80-073 and Md. Mahfuzul Hassan student ID 2008-1-80-017 have successfully completed the project work that was assigned to them as part of the internship program. They have completed 100 hours of their internship on Power Generation, Transmission, Distribution and Protection system equipment of APSCL. During the tenure of their training with us all the students put their best effort to comprehend the overall system of POWER STATION.

The undersigned on behalf of Ashuganj Power Station Company Limited (APSCL), recommending this work as the fulfillment for the requirement of EEE 499(Industrial Training) of the East West University, Dhaka.

I wish their success in life

Engr. Md. Nurul Alam
Managing Director
APSCL

Approval Letter

ASHUGANJ POWER STATION COMPANY LTD.
(An Enterprise of Bangladesh Power Development Board)
Ashuganj, B.Baria-3402, Bangladesh
Fax: +88-08528-74014, 74044
E-mail: apscl@apscl.com, apsclbd@yahoo.com, Website: www.apscl.com

Approval Letter

To whom it may concern

This is to certify that Anika Sharmin, student ID 2008-1-80-003, Bishuddhananda Purabrammhan, student ID 2008-1-80-008 and Mirza Rishad Hasan, student ID 2008-1-80-018 have successfully completed the project work that was assigned to them as part of the internship program. They have completed 100 hours of their internship on Power Generation, Transmission, Distribution and Protection system equipment of APSCL. During the tenure of their training with us all the students put their best effort to comprehend the overall system of POWER STATION.

The undersigned on behalf of Ashuganj Power Station Company Limited (APSCL), recommending this work as the fulfillment for the requirement of EEE 499(Industrial Training) of the East West University, Dhaka.

I wish their success in life.

Engr. Md. Nurul Alam
Managing Director
APSCL

Acknowledgment

First of all we would like to thank Engr. Md. Nurul Alam, Managing Director APSCL, Engr. Md. A.K.M Yaqub, our Superintendent Engineer and the Manager (Generator) of APSCL Ltd. for allowing us to do the internship and work in their team.

We would also like to thank our advisor Dr. Khairul Alam, Associate Professor, S. M. Shahriar Rashid, Research Lecturer and Shamim Ahmed, Research Lecturer, Department of Electrical & Electronic Engineering, East West University, Bangladesh.

We would also like to mention the name of Dr. Anisul Haque, Chairperson & Professor of the Department of Electrical & Electronic Engineering and Dr. Khairul Alam, Associate 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. We also would like to thank Engr. Md. Rokan Mia, Senior Engineer (Generator & Switchgear Protection); Engr. Md. Kamrujjaman, Senior Engineer(Generator & Switchgear Protection.), Engr. Nur Mohammed, Manager, Sub-Station, Engr. Md. Sahid Ullah, Assistant Engineer(Sub Station), Engr. Md. Azizur Rahman, Senior Engineer(Combine Cycle Power Plant), Engr. Bakiur Rahman, Junior Engineer, Control Room, Engr. Nur Mohammed, Manager, Sub-Station who had given us appointment from their precious time to collect related data of our report and also helped us to understand many related matters .

Last but not least we would like to thank the almighty Allah for giving us the chance to complete our internship and preparing the internship report.

Executive Summary

The power sector in Bangladesh faced numerous problems characterized by lack of supply capacity, frequent power cuts, unacceptable quality of supply, and poor financial and operational performance of the sector entities. There have been a number of reforms in the power sector in Bangladesh since her independence, but most of these reforms failed to bring desired improvements in the power sector. Among the three main components of the power system, recent reform activities were centered on generation and transmission. The most pressing problem in the power sector has been with the distribution system, which is characterized by heavy system loss and poor collection performance; however, the distribution system seldom got the priority in reform initiatives.

Ashuganj Power Station Company Ltd. (APSCL) owns the second largest power station in Bangladesh. The installed capacity by its 8 units is 724 MW and present de-rated capacity is 642 MW. Ashuganj Power Station fulfills about 15% of power requirements of the country. To face the growing requirements for power in the country Government of Bangladesh decided to setup another units of 1000 MW capacities in Ashuganj.

Our internship in APSCL (Ashuganj Power Station Company Limited), found on the planning and distribute on the practical field of power sector. Through this internship we got the opportunity to work as a member of a team which was involved in Generator section, transformer section, steam turbine, Gas turbine and combine cycle power plant. In this power station company, various types of work done by us. The superintendent engineer showed us the protection and switchgear section of generator, transformer and turbine. We mainly worked for a long term in the substation section. Control unit of this whole power station is very enormous. The main aim to set up a power plant, one have to give three things. Protection, Monitoring and Vision. The generation of electricity is one of the most complex processes in the world. After a lot of steps completion we generate it and distribute to the consumers. We gathered some experience in generator protection. We also had some experience to control a largest power plant working in the control room with the help of our superintendent engineer. On the completation of this internship we can relate the practical experience with the theoritical experience in power sector. Overall in our internship, we have gathered lots of knowledge about many real life problems.

Training Schedule

Day	Starting time -- Ending time	Topic	Superintendent Engineer	Total Hour
Saturday 30.04.2011	9 AM to 5 PM	Backup System/Generator and Turbine Introduction/Breaker/Megar testing of transformer.	Engg. Md.Rokan Mia Senior Engineer (Generator & Switchgear protection)	8 hours
Monday 02.05.2011	9 AM to 5 PM	Generator Excitation & Protection/Transformer protection/Control System of unit 3, 4.	Engg. Md.Kamruzzaman Senior Engineer (Generator & Switchgear protection)	8 hours
Tuesday 03.05.2011	9 AM to 5 PM	Auxiliary Electrical System/Bus bar Connection/Boiler Sub-Distribution Board /Rectifier and Main-Distribution Board.	Engg. Md.Rokan Mia Senior Engineer (Generator & Switchgear protection)	8 hours
Wednesday 04.05.2011	9 AM to 5 PM	Generator Protection (continue)/Transmission Line Protection/Shunt Reactor/Transformer Maintenance (Testing).	Engg. Md.Kamruzzaman Senior Engineer (Generator & Switchgear protection)	8 hours
Thursday 05.05.2011	9 AM to 5 PM	Generator Cooling System/ Control System of unit 5(Digital)/Motor Winding/Excitation & Synchronization.	Engg. Md.Rokan Mia Senior Engineer (Generator & Switchgear protection)	8 hours
Saturday 07.05.2011	9 AM to 5 PM	Control System of Unit 1,2 /Boiler Drum/Feed water drum/Electrical Relay/CW Pump/LP,HP,IP turbine/Condenser	Engg. Md.Kamruzzaman Senior Engineer (Generator & Switchgear protection)	8 hours

Day	Starting time -- Ending time	Topic	Superintendent Engineer	Total Hour
Sunday 08.05.2011	9 AM to 5 PM	Introduction of Sub-Station/Protection System/Single Line Diagram/Bus Bar System	Engg. Md.Shahid Ullah Assistant Engineer (Sub Station)	8 hours
Monday 09.05.2011	9 AM to 5 PM	Gas Turbine 1,2/control System of Gas turbine/Motor Testing/Motor Protection/Turning Gear/Turbine & Generator Protection	Engg. Md Azizur Rahman Senior Engineer (Combine Cycle PP)	8 hours
Tuesday 10.05.2011	9 AM to 5 PM	Combine cycle Plant/GT1,GT2,ST/Motor Valve/Condenser/Single Line Diagram of Combine Cycle Plant	Engg. Md Azizur Rahman Senior Engineer (Combine Cycle PP)	8 hours
Wednesday 11.05.2011	9 AM to 5 PM	CB rating/ relay setup/over currrent earth fault relay/transformer relay/erc extinction procedure/mechanism of SF6 circuit breaker	Engg. Md.Shahid Ullah Assistant Engineer (Sub Station)	8 hours
Thursday 12.05.2011	9 AM to 5 PM	PLC protection of sub-station/Batterytypes/High voltage breaker rating/Underground cable/cooling fan connection	Engg. Md.Shahid Ullah Assistant Engineer (Sub Station)	8 hours
Saturday 14.05.2011	9 AM to 5 PM	Protection of underground cables/Bulk oil circuit breaker/transmission process of 132KV, 230KV line	Engg. Md.Shahid Ullah Assistant Engineer (Sub Station)	8 hours
Sunday 15.05.2011	9 AM to 5 PM	Control unit of combine gas cycle power plant/ working principle of relay/mechanism of relay/maintenance of cooling process of combine cycle	Engg. Md Azizur Rahman Senior Engineer (Combine Cycle PP)	8 hours

Lunch break for 01.00 PM to 01.30 PM.

TABLE OF CONTENTS

Page Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER – 01

Introduction

Ashuganj Power Station Company Ltd. (APSCL) owns the second largest power station in Bangladesh. The installed capacity by its 8 units is 724 MW and present de-rated capacity is 642 MW. Ashuganj Power Station fulfills about 15% of power requirements of the country.

In 1966 the then government decided to setup a power station in Ashuganj. Ashuganj is situated near Titas Gas Field and at the bank of the river Meghna. So it was the most favorable place for power station because of availability of natural resources for power generation. For this purpose about 311 acre land at the 1 kilometer north-east away from the Meghna Railway Bridge was acquired.

In the same year with the financial assistance of German Government the establishment work of two units each of 64 MW (Unit 1 & Unit 2) started. These two units were commissioned in July 1970. M/S BBC (Germany) and M/S Babcock & Wilcox (Germany) supplied the turbo-generator and boiler equipment. These two units played an important role in post-liberation war economic development in Bangladesh.

To face the growing requirements for power in the country- Government of Bangladesh decided to setup another two units (Unit 3 & Unit 4) each of 150 MW capacities in Ashuganj. IDA, KfW (Germany), ADB, Kuwait and OPEC provided the financial assistance for this project. Contracts had been made for supplying and installation of turbo-generator, boiler and other main equipments for these two units with M/S BBC (Germany), M/S IHI (Japan), M/S KDC (Korea) and M/S PCC (Korea)

After the agreements signing with the contractors, government found that another unit of 150 MW can be established from the left over funds by the donors. With the consent from the donors, Government decided to setup another 150 MW unit (Unit 5).

The work for installation of Unit 3 & 4 was started in 1984 and Unit 5 in 1985. Unit 3, Unit 4 and Unit 5 were commissioned in December 1986, May 1987 and March 1988 respectively.

During the planning of installation of Unit 3 & 4 it was decided to install a Combined Cycle Power Plant by financial assistance of British Government. According to that decision, works of two gas turbine units (GT1 & GT2) of 56 MW each and one steam turbine unit **(ST1)** of capacity 34 MW (with waste heat recovery Boiler) had been started. GT1, GT2 and CCST were commissioned in 1982, 1984 and 1986 respectively.

1.1 Company Profile:

Name of the Company : Ashuganj Power Station Company Ltd.

- Date of Incorporation: 28 June 2000.
- Registration No: C-40630 (2328)/2000 dt. 28.06.2000.
- Location: 90 km North-East of Dhaka on the left bank of the river Meghna.
- Land : 311.22 Acres
- Installed Capacity: 724 MW.
- Total number of plants : 3
- Total Number of Units : 8

Plant 1: Thermal Power Plant (TPP)

Two Steam Units of 64MW- Unit # 1 & 2 each-commissioned in 1970.

Plant 2: Combined Cycle Power Plant (CCPP)

Gas Turbine Units-GT1 and GT2 of capacity 56MW each-commissioned in 1982 and 1986 respectively.

One Steam Turbine (ST) of capacity 34MW with waste heat recovery Boiler commissioned in 1984.

Plant 3: Thermal Power Plant (TPP)

Unit # 3 of 150MW capacity was commissioned in 1986.

Unit # 4 of 150MW capacity was commissioned in 1987.

Unit # 5 of 150MW capacity was commissioned in 1988.

Fuel used: Natural Gas Supplied by Titas Gas Transmission & Distribution Co. Ltd., Bangladesh

1.1.1 Present Facilities of APSCL

Ashuganj Power Station Company Limited is the second largest power station in Bangladesh. It's installed capacity was 724 MW. APSCL this year has added 53 MW to the system by its own fund. The present total power (electricity) generation capacity of its 9(nine) units considering de-rated capacity is [illegible]MW. Fuel of its all units is Natural gas. APSCL contributes about 15% of power to national grid of the country.

1.12 Availability and efficiency of APSCL Units

In Ashuganj Power Station Company Limited, there are some data of availability and efficiency of APSCL units. To maintenance this company the data will be collected in every one year.

Table 1: Yearly data of availability and efficiency of APSCL Units

SL No.	PARTICULARS	GT# 1	GT# 2	ST(cc)	UNIT # 1	UNIT # 2	UNIT # 3	UNIT # 4	UNIT # 5
1	Model & Capacity of Turbo-Generator	GEC, 69.6Mva 13.8 Kv	GEC , 69.6 Mva 13.8 Kv	GEC, 43 Mva 13.8 kv	BBC Germany 80 Mva 11.0 kv	BBC Germany 80 Mva 11.0 kv	ABB Germany 190 Mva 15.75 kv	ABB Germany 190 Mva 15.75 kv	ABB Germany 190 Mva 15.75 kv
2	Installed Capacity (Mw)	56	56	34	64	64	150	150	150
3	Present De-rated Capacity, MW	40	40	18	64	64	105	140	140
4	Date of Commissioning	15/11/82	23/03/86	28/03/84	17/08/70	8/7/1970	17/12/86	4/5/1987	21/03/88
5	Total hours run since Installation	150,516	114,768	87,034	231,011	204,371	186,821	183,865	164,933
6	Total Energy Generation to date , Gwh	5,936.68	6,607.73	1,734.07	10,575.44	9,744.33	22,328.50	21,306.43	29,767.39
7	Plant Factor %, 2010	71.77	85.52	31.05	56.15	86.03	81.74	53.45	83.77
8	Availability Factor %, 2010	82.69	96.03	29.54	68.10	95.65	94.75	64.06	95.54
9	Station Thermal Efficiency %	20	20	28	30	31	31	36	36

Table 2: Yearly data of Cost of production of existing units

SL No.	PARTICULARS	GT# 1	GT# 2	ST(cc)	UNIT #1	UNIT #2	UNIT #3	UNIT # 4	UNIT # 5
1	Installed Capacity (Mw)	56	56	34	64	64	150	150	150
2	Present Contracted Capacity MW	40	40	0	64	64	102	140	140
3	Date of Commissioning	15/11/82	23/03/86	28/03/84	17/08/70	8/7/1970	17-12-86	4/5/1987	21/03/88
4	Cost of fuel per unit Gen. TK.	1.30	1.30	0.00	0.93	0.87	0.90	[illegible]	0.79

1.1.3 Gas availability and usage

Ashuganj is strategic location of gas transmission system. There are several piping system has been tied up at Ashuganj specially Titas and GTCL installation. A good Gas pressure is maintaining at Ashuganj and Existing and ongoing power projects together there would be 864 MW at Ashuganj including units of under maintenance. So far APSCL is satisfied with the supplied pressure for its 9 units along with a 50 MW rental power plant against the gas allotment of 160 MMSCFD.

1.1.4 Near future projects of APSCL

Considering the age of the plant and thermal efficiency of outlived plant, APSCL has started to undertake some projects in order to decommission the old and inefficient plant after the implementing the new projects. APSCL has already been floated a tender of 150MW CCPP project through their own arrangement of funding. According to schedule the 150 MW project is expected to be implemented last quarter of 2013. This will finally replace existing combined cycle of GT1 & GT 2 of APSCL. Recently APSCL has implemented a 50MW gas engine project by its won fund within 8 months.

The following are near future power project of APSCL:

- Ashuganj 150 MW CCPP Project, Tender launched on 4 April.
- Ashuganj 450MW CCPP (North)
- Ashuganj 450MW CCPP (South)

APSCL has made a plan to increase station capacity 1550 MW as reliable and efficient plant by 2014 after implementation of these aforementioned projects and retiring of its outlived as well as inefficient plants such as unit 1, 2 & GT 1, 2 and ST.

1.1.5 Power evacuation Facility at APSCL

Strategically APSCL is very important for power system and a bigger size of substation. This substation has 3 systems of 33KV, 132KV and 230 KV. It has made APSCL very complicated. Due to age of substation and its complexity of design, power evacuation becomes difficult. Substation overloading is a regular issue at APSCL. Although there are a scope of further expansion of substation capacity by shifting 33 kv substation to another nearby location. At present, there is no more free bay for further expansion or new connection to 132 Kv substation.

APSCL 230 Kv substation has 2x3 feeder lines namely Sirajgonj, Comilla and Ghorasal. Though inter connection presents but over loaded. APSCL 3x150 MW generators are connected to 230 Kv bus and currently 2 generation line are being connected 230 Kv substation which are Rental power Aggreco and United Power. A free bay is booked for another 50 MW rental. Scope of further expansion of 230Kv substation is not present until demolition of APSCL Officer's quarter adjacent to substation. In view of these, APSCL would like to construct new substation with its 450 MW CCPP (North and South) project. A new GIS 230 kV sub-station will also be constructed on the same land.

1.1.6 Available land at APSCL Premises

APSCL is owned by 263.64 acres of land including a portion of river basin. By the time 3 rental plants have occupied available 3 places of land at different location. Those places are adjacent of residential area. APSCL have a plan to enhance its capacity by 1550 MW and accordingly floated a tender for 150 MW CCPP project in order to construct the plant by December 2013. This project is based on energy efficient it will finally replace the existing outlived GT1 and GT2 of APSCL.

Another piece of land has prepared for Ashuganj 450MW CCPP (North) and Ashuganj 450MW CCPP (South) project. ADB and IDB will finance the Ashuganj 450 MW CCPP (North) and ECA finance from [illegible] for Ashuganj 450MW CCPP (South).

ADB finance especially for energy efficient plant and the study has been completed. In order to build Ashuganj most reliable and efficient on fuel gas plant of 1550MW by 2014, there are no alternative of bigger size of plant. Bangladesh Railway has already been requested to handover 16.43 acres of land to APSCL to build power plant. This land of ditch is adjacent to APSCL premises.

1.1.7 Gas Scenario of APSCL

APSCL is operating 9 units and one 3 years 55MW Rental plant also is being operating from last year. At present APSCL unit 4 of 150MW and unit 1 of 64MW are under major overhauling. APSCL has constructed a 50MW Gas Engine Power Plant by its own fund and has put into operation on 30 April. In this month 80MW & 53MW two 3 years Rental Power Plants will also come into operation. All these machines together may consume approximately 200 mmscfd gas daily, if these run together. The present gas allocation for APSCL is 160 mmscfd. Considering present activities of increasing power generation there should be a revised gas allocation in order to operate the plant with full load.

1.1.8 Board of Directors APSCL:

To generate electric power and dispatch same through transmission line of PGCB Ltd and ultimately to BPDB and to utilize available resources and capacity so that it can contribute towards the national economy through increasing generation of power aiming at maximization of net worth of the Company, Ashuganj Power Station Company Limited(APSCL) have managing committee. The managing policy was created by the chairman of board of directors. The name list of the board of directors is given below:

1. Mr. Khan Md. Belayet Hossain, Chairman, Addl Secretary (Rtd.).
2. Mr. Ahmed Ullah, Director, Join Secretary (Development).
3. Dr. Md. Quamrul Ahsan, Director, Professor of Electrical and Electronic Engineering, BUET.
4. Mr. Md. Mostafa Kamal, Director, Member (Generation), BPDB.
5. Mr. Md. Anwar Hosain, Director, Deputy Secretary (Development), Power Division.
6. Mr. Md. Harunur Rashid, Director, Director-12, Prime Miinister Office.
7. Mr. Mamtaz Uddin Ahmed, Director, Past President & Council Member.
8. Mr. Md. Zakir Hossain Nayon, Director, General Committee Member, FBCCI.
9. Mr. Masum Al- Beruni, Member, BPDB.
10. Mr. Md. Gias Uddin, Director, Chief Engineer, BPDB.
11. Mr. Md. Nurul Alam P. Engg, Director, APSCL.

01.

Mr. Khan Md. Belayet Hossain
Chairman
Addl. Secretary (Rtd.)

02.

Mr. Ahmed Ullah
Director
Joint Secretary (Development)
Energy & Mineral Resources
Division, MOPEMR

03.

Dr. Md. Quamrul Ahsan
Director
Professor, Dept. of Electrical &
Electronic Engineering
Bangladesh University of
Engineering & Technology, Dhaka

04.

Mr. Md. Mostafa Kamal
Director
Member (Generation), BPDB
WAPDA Building, Motijheel C/A,
Dhaka

05.

Mr. Md. Anwar Hosain
Director
Deputy Secretary (Development)
Power Division, MOPEMR

06.

Mr. Md. Harunur Rashid
Director
Director-12, Prime Minister's Office,
Dhaka

07.

Mr. Mamtaz Uddin Ahmed
Director
Past President & Council Member
Institute of Cost & Management
Accountants of Bangladesh

08.

Mr. Md. Zakir Hossain Nayon
Director
General Committee Member,
Federation of Bangladesh
Chambers of Commerce &
Industries (FBCCI), Dhaka

09.

Mr. Masum-Al-Beruni
Director
Member (Planning &
Development), BPDB

10.

Mr. Md. Giasuddin
Director
Chief Engineer, Power Station
Construction, BPDB

11.

Mr. Md. Nurul Alam P.Engg.
Director
Managing Director, APSCL

Figure 1.1: Flow diagram of board of directors APSCL

1.2 Objective of the Internship:

The first objective of the internship is fulfilling the partial requirement of EEE program. In this intern report, we have attempted to give an overview of Ashuganj Power Station Company Ltd in power processing, substation and protection schemes. The study aims at some objectives, which are as follows

- Understanding Company management
- Understanding Generation process
- Understanding protection techniques
- Understanding how to control power generation unit
- Understanding maintenance process
- Finding out the every risk related to APSCL Ltd
- Recommending how it can be improved to fulfill the loads of the country
- Idea about sub-station equipments and maintenance

1.3 Scope And Methodology:

The scope of organization part covers the organizational structure, background, and objectives, functional departmentalization, generation process, design strategy of Ashuganj Power Station Company and as a whole and especially this report focuses on generation process, protection strategy, maintenance of individual section and control unit of Ashuganj Power Station Company Ltd. This report has been prepared on the basis of:

- Information collected from primary sources (primary information has been procured through personal interview as well as discussion with senior engineer of APSCL).
- Information from secondary sources (secondary data has been gathered by using company website).

1.4 Internship Group Members:

In our Acceptance Letter of industrial attachment from Md. Lutfar Rahman, Deputy Manager (HRD & Admin), Ashuganj Power Station Company Ltd. On that latter he told us to contract with Engg. A.K.M Yaqub, Manager, Generator unit. At 30th April, 2010 our first day of training Engg. A.K.M Yaqub gave us our training Schedule. Our group members are: Pintu Das, Tahsin Ahmed & Bisuddhananda ...hamman.

CHAPTER – 02

Power Generation

Electricity generation is the process of generating electric energy from other forms of energy.The fundamental principles of electricity generation were discovered during the 1820s and early 1830s by the British scientist Michael Faraday. His basic method is still used today: electricity is generated by the movement of a loop of wire, or disc of copper between the poles of a magnet.

For electric utilities, it is the first process in the delivery of electricity to consumers. The other processes, electricity transmission, distribution, and electrical power storage and recovery using pumped storage methods are normally carried out by the electric power industry.

Electricity is most often generated at a power station by electromechanical generators, primarily driven by heat engines fueled by chemical combustion or nuclear fission but also by other means such as the kinetic energy of flowing water and wind. There are many other technologies that can be and are used to generate electricity such as solar photovoltaics and geothermal power.

Centralised power generation became possible when it was recognised that alternating current power lines can transport electricity at very low costs across great distances by taking advantage of the ability to raise and lower the voltage using power transformers.

2.1 Generator:

A generator is a machine that converts mechanical energy into electricity to serve as a power source for other machines. Electrical generators found in power plants use water turbines, combustion engines, windmills, steam pressure or other sources of mechanical energy to spin wire coils in strong magnetic fields, inducing an electric potential in the coils. A generator that provides alternating current power is called an alternator.

There are two types of generator:

1. **AC Generator:** It generates alternative current
2. **DC generator:** It generates direct current

Figure 2.1: Picture of AC generator (64MW) of unit 2

In Ashuganj Power Station Company Ltd (APSCL), there are five generators in steam power plant section and three generators in combined cycle power plant section. Al the generators produce AC current. So these are AC Generators.

Table 3: Important information about the generators of (APSCL)

Category	Steam power plant section		Combined cycle power plant section	
	Unit 1,2	Unit 3,4,5	Gas turbine 1 & 2	Steam turbine
Name of the maker company	BBC,Germany	ABB,Germany	GEC,UK	GEC,UK
Rated terminal output	64 MW	150 MW	55.67 MW	34.33 MW
Rated terminal voltage	11 KV	15.75 KV	38.8 KV	13.8 KV
Rated power factor	0.8	0.8	0.8	0.8
Rated current	4200/4690 A	6965 A	2911 A	1799 A
Rated frequency	50 Hz	50 Hz	50 Hz	50 Hz
Number of poles	2	2	2	2

2.1.1 AC Generator:

The turning of a coil in a magnetic field produces motional emfs in both sides of the coil which add. Since the component of the velocity perpendicular to the magnetic field changes sinusoidally with the rotation, the generated voltage is sinusoidal or AC. This process can be described in terms of Faraday's law when you see that the rotation of the coil continually changes the magnetic flux through the coil and therefore generates a voltage. There are some descriptions of AC generator major parts:

1. **Field:**

The field in an AC generator consists of coils of conductors within the generator that receive a voltage from a source (called excitation) and produce a magnetic flux. The magnetic flux in the field cuts the armature to produce a voltage. This voltage is ultimately the output voltage of the AC generator.

2. **Armature:**

The armature is the part of an AC generator in which voltage is produced. This component consists of many coils of wire that are large enough to carry the full-load current of the generator.

3. **Rotor:**

The rotor of an AC generator is the rotating component of the generators. The rotor is driven by the generator's prime mover, which may be a steam turbine, gas turbine, or diesel engine. Depending on the type of generator, this component may be the armature or the field. The rotor will be the armature if the voltage output is generated there; the rotor will be the field if the field excitation is applied there.

In the generators of Ashuganj Power Station Company Ltd (APSCL) the rotor is used as the field exciter. The weight of the rotor of BBC generator used in unit 1,2 of steam turbine is 423 ton. It rotates at 3600 rpm.

4. **Stator:**

The stator of an AC generator is the part that is stationary. Like the rotor, this component may be the armature or the field, depending on the type of generator. The stator will be the armature if the voltage output is generated there; the stator will be the field if the field excitation is applied there. In the generators of Ashuganj Power Station Company Ltd (APSCL) the stator is used as the output voltage generator. The weight of the stator of BBC generator used in unit 1,2 of steam turbine is 1760 ton.

5. **Collector Slip Rings:**

Slip rings are circular rings, similar to a tube, that are connected to the armature and rotate with it, if it is rotating. Slip rings are usually made of nonferrous metal (brass, bronze or copper): iron or steel is sometimes used. Slip rings usually do not require much servicing. The wearing of grooves or ridges in the slip rings is should be bright and smooth, polishing can be performed with fine sandpaper and honing stone.

6. **Brushes:**

Brushes are in contact with the slip rings and the resistive load. Their job is to conduct the electricity from the slip rings to the load.

Figure 2.2: Brush of DC exciter of unit 3.

7. **Armature Windings:**

The armature windings are usually former-wound. These are first wound in the form of flat rectangular coils and are then pulled into their proper shape in a coil puller. Various conductors of the coil are insulated from each other. The conductors are placed in the armature slots which are lined with tough insulating material. This slot insulation is folded over above the armature conductors placed in the slot and is secured in place by special hard wood or fiber wedges.

8. **Frame, End Bells, Shaft, and Bearings:**

The frame and end bells are usually steel, aluminum or magnesium castings used to enclose and support the basic machine parts. The armature is mounted on a steel shaft, which is supported between two bearings. The bearings are either of sleeve, ball or roller type. They are normally lubricated by grease or oil.

9. **Field Poles:**

The pole cores can be made from solid steel castings or from laminations. At the air gap, the pole usually fans out into what is known as a pole head or pole shoe. This is done to reduce the reluctance of the air gap. Normally the field coils are formed and placed on the pole cores and then the whole assembly is mounted to the yoke.

iii. Yoke:

The yoke is a circular steel ring, which supports the field, poles mechanically and provides the necessary magnetic path between the poles. The yoke can be solid or laminated. The above mentioned components are present in the generators of Ashuganj Power Station Company Ltd (APSCL). When we were at the station for internship the unit-1 & 4 were under overhauling work. So we had the chance to observe the inside part of the generators and the above mentioned parts of the generators.

2.1.2 Excitation system of the Generator:

The exciter or excitation system is the "backbone" of the generator control system. It is the power source that supplies the dc magnetizing current to the field windings of a synchronous generator thereby ultimately inducing ac voltage and current in the generator armature.

There are four types of generator excitation system. These are:

1. AC Excitation System
2. DC Excitation System
3. Brushless Thyristor Excitation System
4. Static Excitation System

1. AC Excitation System:

This excitation system is used in the generator of unit 1 and 2 of steam turbine in Ashuganj Power Station Company Ltd.

Figure 2.3: Outlook picture of AC excitation system of 64MW (Unit 2)

The ac system of excitation shown consists of a sub-pilot exciter of permanent magnet type, pilot exciter and the main ac exciter all coupled to the main generator on the same shaft. The permanent magnet type generator is a single phase generator whose field is provided by permanent magnet. The single phase supply from the armature is converted to dc by means of rectifiers and dc supplies the field of the pilot exciter and main ac exciter. The pilot exciter and main exciter are ac three phase machines. The voltage transformer supplies voltage proportional to the generator voltage to magnetic amplifier.

2. **DC Excitation System:**

This excitation system is not used widely. There is no generator in Ashuganj Power Station Company Ltd (APSCL) where this system is used. In this excitation system the pilot exciter is a dc shunt wound machine. The main exciter is a dc shunt machine with a number of control field windings. The main exciter and pilot exciter are coupled to the main generator shaft. A dc motor drives a rotating amplifier which is a cross field dc machine. It has a number of control windings. The voltage transformer secondary supply is connected with automatic voltage regulator (AVR) and magnetic amplifier circuits. The magnetic amplifier, after due correction of voltage through AVR, supplies signal to one of the control windings (2) of the rotating amplifier. The pilot exciter supplies one of the control windings (3) of the rotating amplifier. The rotating amplifier then rectifies the current and supplies the field of the main exciter. The main exciter then supplies the field of the generator with required excitation to maintain load on the generator at rated voltage.

2.1.4 Synchronization of generators:

Synchronization is the process of connecting a 3-phase synchronous (ac) generator to another generator or to a power grid

There are four conditions must be met before the generator can be connected to the grid. These are:

1. Frequency
2. Voltage
3. Phase sequence
4. Phase angle

1. Frequency:

The generator must be driven by the prime mover at a speed such that the generated power frequency is equal to the grid's frequency.

Voltage:

The stator line voltage must be equal to the line voltage of power grid. This is achieved by controlling rotor current.

Phase sequence:

The phase sequence of the generator must be the same as the phase sequence of the grid. If the grid sequence is R-Y-B, then the generator's sequence must be also R-Y-B.

Phase angle:

The phase angle of the generator must be equal to the phase angle of the grid. The stator angke can be adjusted by adjusting the field current.

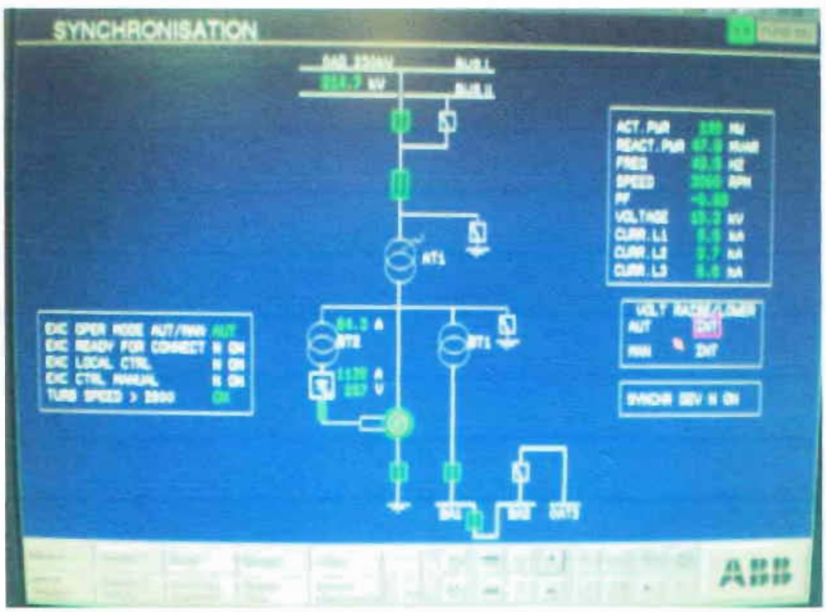


Figure 2.4: Synchronization of unit-5 of steam power plant of APSCL

2.2 Turbine:

Turbines are devices that spin in the presence of a moving fluid. It is a kind of machine in which the kinetic energy of a moving fluid is converted to mechanical power by the impulse or reaction of the fluid with a series of buckets, paddles, or blades arrayed about the circumference of a wheel or cylinder. There are various types of turbine. These are:

1. Steam turbine
2. Gas turbine

3. Water turbine
4. Wind turbine
5. Transonic turbine
6. Stator less turbine
7. Ceramic turbine
8. Sound less turbine
9. Blade less turbine

In Ashuganj Power Station Company Ltd (APSCL) there are only two types of turbine. These are:

1. Steam turbine
2. Gas turbine

2.2.1 Steam Turbine Power Plant:

The generating plant which converts heat energy from coal or natural gas into electrical energy is known as steam power plant. In Ashuganj Power Station Company Ltd (APSCL) there are three steam turbine power plants which run five generators.

Table 4: Important information about steam turbines of (APSCL)

Chracteristics	Steam power plant section	
	Unit 1,2	Unit 3,4,5
Name of the maker company	BBC,Germany	ABB,Germany
Rated terminal output	64 MW	150 MW
Live steam pressure(Pabs)	890 bar	135 bar
Live steam temperature	520°C	520°C
Exhaust pressure	0.0742 bar abs	0.08 bar abs
Number of stages	30/12/5	21/16/5
Rated speed	3000rpm	3000rpm
Direction of rotation	Clockwise	Clockwise

2.2.1.1 Types of steam turbine:

There are two types of steam turbine. These are:

1. Impulse turbine.
2. Reaction turbine.

1. **Impulse Turbine:**

In impulse turbine the steam at a high pressure and temperature but at low velocity expands through the nozzles to exhaust pressure, thereby gaining a high velocity. The nozzles are stationary and secured either in a diaphragm or directly in the casing. The high velocity jet issuing from the nozzle impinges on the blades fixed on the periphery of a rotor. The blade changes direction of steam without changing pressure. The resulting change of phenomenon gives the motive free force to the turbine shaft.

In Ashuganj Power Station Company Ltd (APSCL) this type of turbine is used in steam turbine unit:1-5.

Figure 2.5: Picture of Impulse Turbine of APSCL unit 3 (150MW)

2. **Reaction Turbine:**

In reaction turbine 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 these 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.

2.2.1.2. Sections 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 of these sections are different from each other. These are:

1. High pressure turbine (HP)
2. Intermediate pressure turbine (IP)
3. Low pressure turbine (LP)

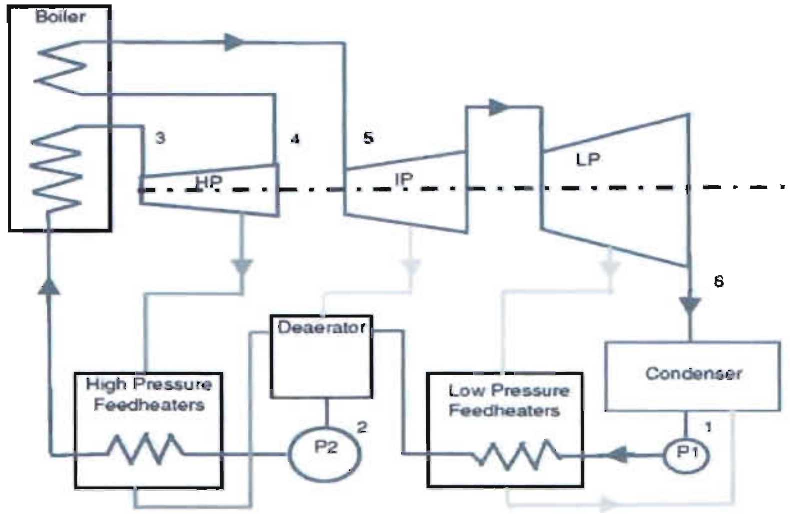


Figure 2.6: Arrangements of three turbine section

1. **High Pressure Turbine (HP):**

From the super heater the high speed steam first enter 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:**

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:**

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.

2.2.1.3. Losses in the steam turbines:

1. Losses in regulating valves.
2. Friction in the nozzles.

3. Friction in the blades.
4. Residual velocity loss.
5. Winding friction.
6. Leakage loss.
7. Friction in the bearings.
8. Losses due to the wetness of the steam.
9. Radiational loss.

2.2.2 Steam generation:

A boiler or steam generator is a device used to create steam by applying heat energy to water. Although the definitions are somewhat flexible, it can be said that older steam generators were commonly termed boilers and worked at low to medium pressure but, at pressures above this, it is more usual to speak of a steam generator. A boiler or steam generator is used wherever a source of steam is required. The form and size depends on the application: mobile steam engines such as steam locomotives, portable engines and steam-powered road vehicles typically use a smaller boiler that forms an integral part of the vehicle; stationary steam engines, industrial installations and power stations will usually have a larger separate steam generating facility connected to the point of use by piping.

2.2.2.1. Boiler:

The equipment used for producing steam is called steam generator or boiler.

Table 5: Information about the boilers used in steam power plant of APSCL

Chracteristics	Steam power plant section	
	Unit 1,2	Unit 3,4,5
Type	Natural circulation, Radiant boiler(pressurized)	IHI-FWSR-504 Single drum, Natural circulation, single re-heat
Make	Babcock, Germany	IHI, Japan
Maximum evaporation capacity	270 t/hr	500.4 t/hr
Efficiency(MCR)	90%	86.8%

Classification of Boiler:

According to the relative position of hot gases and water boiler is of two types. These are:

1. Fire tube boiler.

2. Water tube boiler.

1. **Fire tube boiler:**

In this type of boiler hot gases passes through the tubes that are surrounded by water. The products of combustion leaving the furnace are passed through fire (smoke) tubes which are arranged within the water space. The energy of the gas is transferred to water which is converted into steam. The spent gases are then discharged to atmosphere through chimney.

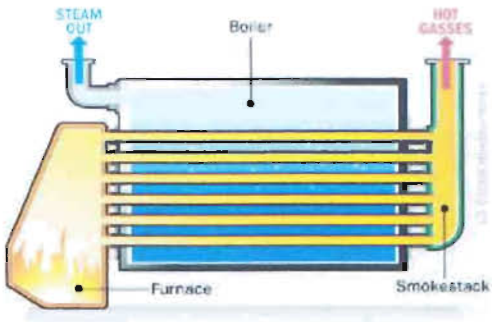


Figure 2.7: Diagram of Fire tube boiler

2. **Water tube boiler:**

In this type of boiler the tubes contain the water and the hot gases produced by the combustion of fuel flow outside. A bank of water tubes (tubes containing water) 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 discharged to the stack. The steam formed separates from water in the drum and gets accumulated in the steam space.

In Ashuganj Power Station Company Ltd (APSCL) water tube boilers are used for steam power plant.

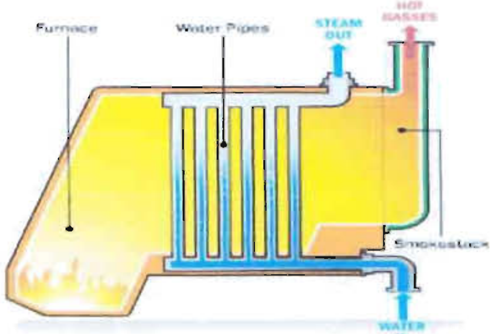


Figure 1.8: Diagram of Water tube boiler

2.2.2.1.1 Furnace/Burner:

Furnace or 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 1200-1300°C. The treated water from the feed water tank through economizer enters into the furnace through tubes and the flue gas produced inside the furnace passes through the tubes. By this way flue gas releases heat to the water and water becomes saturated steam. Temperature of this saturated steam is about 260°C.

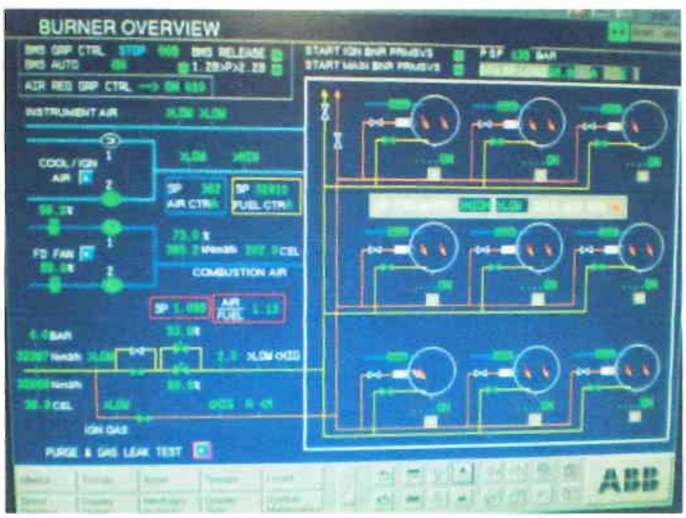


Figure 2.9: Arrangement of the burner in unit-5 of APSCL

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. By forced draft fan the air is supplied to the furnace. From the furnace the saturated steam goes to boiler drum.

2.2.2.1.2 Boiler Drum:

It is the place where the saturated steam is reserved which comes from the furnace. Inside the drum upper and lower level of amount of steam is controlled so as the pressure of the steam. 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 saturated steam. This is done by an automatic system. From the boiler drum the saturated steam is transferred into super heater.

2.2.1.3 Super heater (SH):

Super heater is a part inside the furnace where saturated steam is converted into a super heated steam. There will be no water particles in the super heated steam. So the super heater converts the wet saturated steam into dry high temperature steam.

In each steam power plant of Ashuganj Power Station Company Ltd (APSCL), the temperature of the super heated steam inside the super heater is about 523°C. This super heated steam is then supplied to the high pressure turbine at a pressure of 135 Bar.

Table 6: Information about super heater used in the boiler of steam power plant of APSCL

Chracteristics	Steam power plant section	
	Unit 1,2	Unit 3,4,5
Max allowable steam pressure,SH/RH	110 bar abs	171/50 bar abs
Normal working pressure, SH/RH	93 bar abs	138.5/36.6 bar abs
Normal working temperature, SH/RH	525°C	523°C

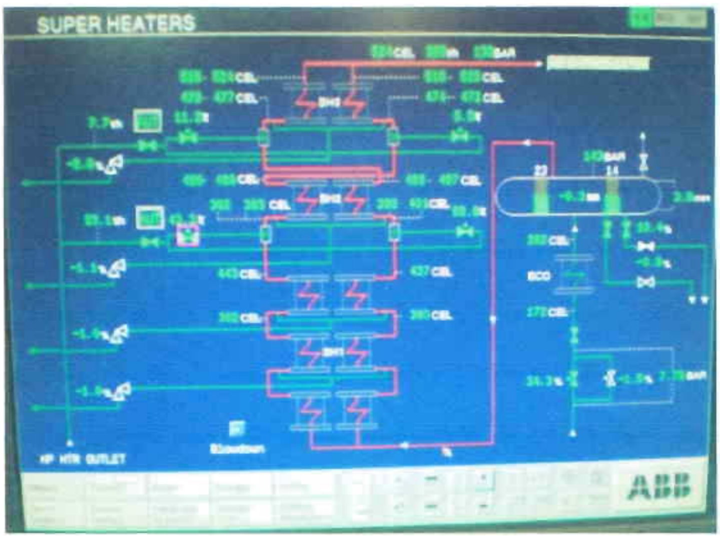


Figure 2.10: Arrangement of super heater in steam power plant unit-5 of APSCL

There are three super heaters inside the boiler section of every steam power plant of APSCL. SH3 produces the highest heat. There are bundle of tubes inside the super heater which carries the saturated and the flue gas passes through these tubes. While passing the tubes the flue gas releases heat and the saturated steam receives the heat and becomes dry and super heated.

2.2.2.1.4 Flue Gas:

Flue gas is the heated gas which is produced inside the burner or furnace of the boiler by burning coal or natural gas with the presence of air. It is very important gas for steam production.

In steam power plant of Ashuganj Power Station Company Ltd (APSCL) the flue gas is produced by burning natural gas which comes from the Titas Gas Transmission and Distribution Company Ltd (TGTDCL).The flue gas is needed to create the steam from the treated water in a steam power plant. Flue gas may contain oxide, carbon, sulfur. So it is a harmful gas for human health.

2.2.2.1.5 Re-heater (RH):

It is the part of a boiler which is needed to re-heat the steam comes from the high pressure turbine. At this stage the steam is known as exhaust gas.

In each steam power plant of Ashuganj Power Station Company Ltd (APSCL) there are two re-heaters inside the boiler. RH2 provides steam of about 522°C temperature and 29.4 Bar pressure. From the re-heater the exhaust gas6 goes inside the intermediate turbine. From the intermediate turbine the steam directly goes into the low pressure heater.

Table 7: Information about Re- heater used in the boiler of steam power plant of APSCL

Chracteristics	Steam power plant section	
	Unit 1,2	Unit 3,4,5
Max allowable steam pressure,SH/RH	110 bar abs	171/50 bar abs
Normal working pressure, SH/RH	93 bar abs	138.5/36.6 bar abs
Normal working temperature, SH/RH	525°C	523°C

The difference between super heater and re-heater is super heater can increase the temperature and pressure of the steam but re-heater can only raise the temperature of the steam it cannot increase the pressure.

2.2.1.6 Condenser:

A condenser is a device which condenses the steam at the exhaust of turbine. It serves two important functions. Firstly, it creates a very low pressure at the exhaust of turbine, thus permitting expansion of the steam in the prime mover to a very low pressure. This helps in converting heat energy of steam into mechanical energy in the prime mover. Secondly, the condensed steam can be used as feed water to the boiler. There are two types of condenser. These are:

1. Jet condenser.
2. Surface condenser.

1. Jet condenser:

In a jet condenser, cooling water and exhaust steam are mixed together. Therefore, the temperature of cooling water and condensate is the same when leaving the condenser.

Advantages of this type of condenser are:

1. Low initial cost.
2. Less floor area required.
3. Less cooling water required.
4. Low maintenance charge.

Disadvantages are:

1. Condensate is wasted.
2. High power is required for pumping water.

2. Surface condenser:

In a surface condenser, there is no direct contact between cooling water and exhaust steam. It consists of a bank of horizontal tubes in a cast iron shell. The cooling water flows through the tubes and exhaust steam over the surface of the tubes. The steam gives up its heat to the water and is itself condensed.

Advantages:

1. Condensed can be used as feed water.
2. Less pumping power required.

Disadvantages:

1. High initial cost.
2. Requires large floor area and high maintenance charges.

In steam power plant of Ashuganj Power Station Company Ltd (APSCL) surface condenser is used.

2.2.2.1.7 Feed water heater:

A feed-water heater is a power plant component used to pre-heat water delivered to a steam generating boiler. Preheating the feed-water reduces the irreversibility involved in steam generation and therefore improves the thermodynamic efficiency of the system. This reduces plant operating costs and also helps to avoid thermal shock to the boiler metal when the feed-water is introduced back into the steam cycle.

The heating of feed water is done by using steam which comes from high, intermediate and low pressure turbine through steam extraction line. The steam is flowed over the surface of the tubes containing feed water. Steam releases heat and the feed water receives heat.

In steam and combined cycle power plant of Ashuganj Power Station Company Ltd (APSCL) two types of feed water heater is present. These are:

1. Low pressure heater (LP heater)
2. High pressure heater (HP heater)

Table 8: Feed water temp of LP and HP heater of the steam power plant of APSCL

Characteristics	Steam power plant section	
	Unit 1,2	Unit 3,4,5
Feed water temperature	229°C	246°C

1. Low pressure heater (LP heater):

Low pressure heater heats feed water by the steam which comes from low and intermediate pressure turbine through extraction lines or tubes.

Feed water is pumped from the hot well by condensate extension pump (CEP) into the LP heater. In unit-5 of steam power plant of Ashuganj Power Station Company Ltd (APSCL), the temperature of feed water raises about 127°C when it passes through the LP heater.

Figure 2.11: LP heater of steam power plant of APSCL

Steam of 222°C and 91.2°C from LP and IP turbine respectively is extracted by extraction line and flowed over the tubes which carry feed water. The steam releases heat and feed water receives heat. There are two LP heaters in the steam power plant of APSCL. Steam from IP turbine flows through LP heater2 and steam from LP turbine flows through LP heater1.

From the LP heater feed water goes to HP heater through feed water tank.

2. High pressure heater (HP heater):

High pressure heater heats feed water by the steam which comes from high and intermediate pressure turbines through extraction lines or tubes.

Feed water is pumped from the feed water tank by boiler feed pump (BFP) into the HP heater. Steam from HP and IP turbines is extracted by extraction line and flowed over the tubes which carry feed water. The steam releases heat and feed water receives heat.

There are two HP heaters in the steam power plant of APSCL. Steam from HP turbine flows through HP heater2 and steam from IP turbine flows through HP heater1. The HP heaters of unit-5 are out of service so a bypass line is installed in the boiler to bypass the feed water from feed water tank to economizer. Because of this faulty HP heater the production of unit-5 becomes 140 MW instead of 150 MW. 10 MW power is enough to meet the total power demand of a district in Bangladesh. So it is a huge fault.

2.2.2.1.8 Feed water tank:

The feed water is reserved inside this feed water tank which comes from LP heater. From feed water tank feed water is transferred to the HP heater. Boiler feed pump (BFP) is used to transfer feed water to the HP heater.

2.2.2.1.9 Economiser:

The economizer is a device which serves to recover some of the heat being carrying by exhaust flue gases. The heat thus recovered is utilized in raising the temperature of feed water being supplied to the boiler. If the feed water at raised temperature is supplied to the boiler, it needs less heat for its conversion into steam and thus there is saving in the consumption of fuel.

The advantages claimed by installing an economizer are:

1. .improvement in the thermal efficiency of the steam plant. It has been estimated that for each 5.5 to 6°C rise in the temperature of feed water, there is a gain of about 10% in the plant efficiency.
2. Reduction in the losses of heat with flue gases.
3. Increase in the steaming capacity of the boiler.
4. Less thermal stresses in the boiler parts and consequently long life of the boiler.

The economizer used in Ashuganj Power Station Company Ltd (APSCL) is also used for the same reason.

2.2.2.1.10 Deaerator:

A deaerator is a device that is widely used for the removal of air and other dissolved gases from the feed water to steam-generating boilers.

Dissolved oxygen in boiler feed waters will cause serious corrosion damage in steam systems by attaching to the walls of metal piping and other metallic equipment and forming oxides (rust). Water also combines with any dissolved carbon dioxide to form carbonic acid that causes further corrosion. Most deaerators are designed to remove oxygen down to levels of 7 ppb by weight (0.005cm³/L) or less.

There are two basic types of deaerators. These are:

1. tray-type
2. spray-type:

1. Tray-type:

It includes a vertical domed deaeration section mounted on top of a horizontal cylindrical vessel which serves as the deaerated boiler feed water storage tank.

2. Spray-type:

It consists only of a horizontal (or vertical) cylindrical vessel which serves as both the deaeration section and the boiler feed water storage tank.

In Ashuganj Power Station Company Ltd (APSCL) spray type deaerator is used.

2.2.2.1.12 Air pre-heater:

The function of an air pre heater is to extract heat from the flue gases and give it to the air being supplied to the furnace for natural gas or coal combustion.

Super heater and economizer generally cannot fully extract the heat from flue gases. Therefore, pre-heaters are employed which recover some of the heat in the escaping gases. Because of this technique the furnace temperature increases which increases the efficiency of the plant.

There are two types of air pre-heater. These are:

1. Recuperative type.
2. Regenerative type.

2.2.2.1.13 Stack/Chimney:

Stack or chimney is a passage through which smoke and gases 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.

2.2.2.2 Water treatment plant:

Boiler requires clean and soft water for longer life and better efficiency. The source of boiler feed water is generally a river or lake which may contain suspended and dissolved gases etc. Therefore, it is very important that water is first purified and softened by chemical treatment and then delivered to the boiler. The water from the source of supply is stored in storage tanks. The suspended impurities are removed through sedimentation, coagulation and filtration. Dissolved gases are removed by aeration and degasification. The water is then softened by removing temporary and permanent hardness through different chemical process. The pure and soft water is fed to the boiler for steam generation.

2.2.2.3 Pumps and fans used in the steam generation process:

There are various types of pumps and fans are used in the process of steam production. These pumps and fans are run by the auxiliary supply of the power station. Most of these pumps are run at 6.6KV voltage. In Ashuganj Power Station Company Ltd (APSCL) the following pumps and fans are used for steam generation.

2.2.2.3.1 Condensate extension pumps (CEP):

This pump is used for transferring condensed water of hot well to the low pressure heater. In steam power plant of Ashuganj Power Station Company Ltd (APSCL) there are two condensates extension pumps in each boiler one is standby and another is working.

2.2.2.3.2 Boiler feed pump (BFP):

Boiler feed pump is used for pumping feed water from feed water tank to high pressure heater. In steam power plant of Ashuganj Power Station Company Ltd (APSCL) there are two boiler feed pumps in each boiler one is standby and another is working. In unit-5 of steam power plant the BFP transfers feed water to the economizer through by-pass line because the high pressure heater is out of work.

2.2.2.3.3 Forced draft fan (FD fan):

Forced draft fan is connected with the furnace. This fan is used for feeding air from the nature in to the furnace for the burning of natural gas.

2.2.2.3.4 Circulating water pump (CW pump):

This is the pump to send cooling water to the condenser. Depending upon the water intake source, the vertical type is usually used when taking water directly from sea or river, and the horizontal type is commonly used when taking water from the cooling tower. The type having the controllable movable impeller is called the variable pitch vane type.

In Ashuganj Power Station Company Ltd (APSCL) CW pump is used for cooling and condensing purpose. The water is pumped from the Meghna River.

2.2.3 Combined cycle power plant:

Combined Cycle power plants are those which have both gas and steam turbines supplying power to the network. Combined cycle power plants employ more than one thermodynamic cycle – Rankine (steam) and Brayton (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.

So combined cycle power plant consists of two sections. These are:

1. Gas turbine section.

2. Steam turbine section.

Table 9: Information of combined cycle power plant of APSCL

Category	Combined cycle power plant section	
	Gas turbine 1 & 2	Steam turbine
Name of the maker company	GEC,UK	GEC,UK
Rated terminal output	55.67 MW	34.33 MW
Live steam pressure(Pabs)	Flue gas	39 bar
Live steam temperature	1010°C	490°C
Exhaust pressure	-	-0.8 bar-g
Number of stages	-	17
Rated speed	3000rpm	3000rpm
Direction of rotation	Clockwise	Clockwise

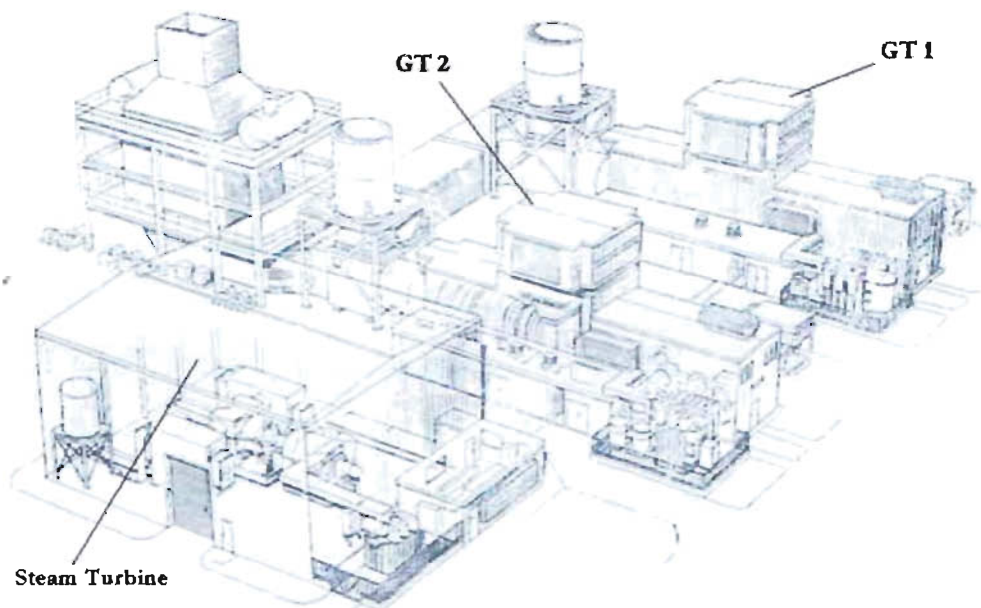


Figure 2.12: Top View Combined cycle power plant of APSCL

2.2.3.1 Gas turbine section:

In APSCL, there is a gas turbine to generate the power. In this chapter, working principle of gas turbine, compressor, combustion chamber and diesel engine has been discussed. The engineer of gas turbine section showed the generating process of the power and the whole power distribution process has been discussed. Now the whole process has been given below:

2.2.3.1.1 Working principal of gas turbine section:

A gas turbine plant consists of compressor, combustion chamber and a turbine. The compressor draws air from the atmosphere and supplies is under pressure to the combustion chamber. The fuel which can be natural gas is injected into the combustion chamber in atomized form and burnt. Once the combustion is started by an igniter, it is self-sustained. The hot gas formed in the combustion chamber expands through the turbine, producing mechanical power. The compressor is also connected to the same shaft and the turbine supplies power to drive the compressor, as well as the output shaft for driving generator.

2.2.3.1.2 Compressor:

Compressor is a device in the gas turbine section which is used to compress the air which is needed to expand by the help of combustion of fuel to create mechanical energy to rotate the turbine.
The compressor used in the plant is generally rotator type. The air at atmospheric pressure is drawn by the compressor via the filter which removes the dust from air. The rotator blades of the compressor push the air between stationary blades to raise its pressure. Thus air at high pressure is available at the output of the compressor.
There are two types of compressor. These are:

1. Centrifugal compressor.
2. Axial compressor.

2.2.3.1.3 Combustion chamber:

The combustion chamber consists of a vessel into which pressurized air and pressurized fuel (oil, natural gas) are fed in appropriate proportions, finally mixed, ignited and fed into the turbine at correct turbine entry temperature. The pressure in the combustion chamber is decided by the outlet pressure of the compressor, which feeds air directly to the chamber. About 30% of the main flow of air passes into the burner area as primary air. The air fuel ratio in the area is maintained at about 15:1.

2.2.3.1.4 Gas turbine:

It is the most important part of the gas turbine section. The products of combustion consisting of a mixture of gases at high temperature and pressure are passed to the gas turbine. These gases in passing over the turbine blades expand and thus do the mechanical work.
There are two types of gas turbine. These are:

1. Shaft power gas turbine.
2. Jet engine gas turbine.

2.2.3.1.5 Diesel Engine:

It is a very essential part in gas turbine power plant. 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 a rated speed which makes the compressor to suck air by itself then the diesel engine is turned off.

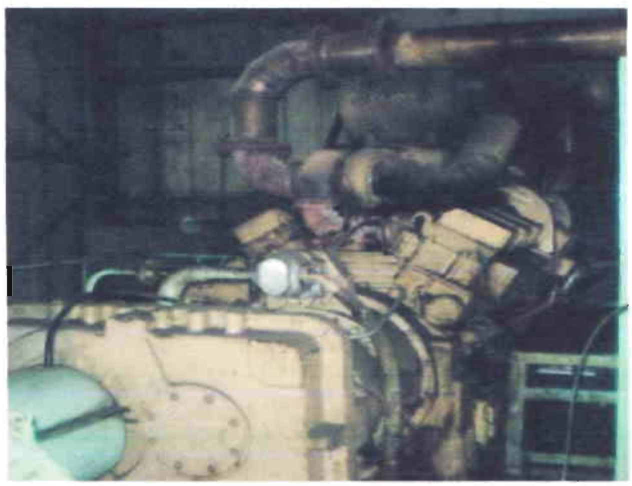


Figure 2.13: Diesel engine used in the gas turbine

Table 10: Situation of the gas turbine with respect to the turbine speed.

rpm of turbine	Situation
0 rpm	Diesel start
750 rpm	Fire or ignition inside combustion chamber
1800 rpm	Diesel off
2300 rpm	Excitation on
3000 rpm	At no load condition

2.2.3.2 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 which can be used to create steam by using several equipments.

The main difference between the steam turbine sections of combined cycle power plant to the steam turbine section of steam power plant is in the steam power plant there is a furnace which produces the heat or flue gas but in the combined cycle there is no furnace, steam is produced by the heat of exhaust gas.

In combined cycle power plant of Ashuganj Power Station Company Ltd (APSCL) there is one steam turbine section which runs by the exhaust gas of gas turbine-1 & 2.

2.2.3.2.1 Steam generation process:

In steam generation process there are several equipments are used. In combined cycle power plant of Ashuganj Power Station Company Ltd (APSCL) following equipments are used.

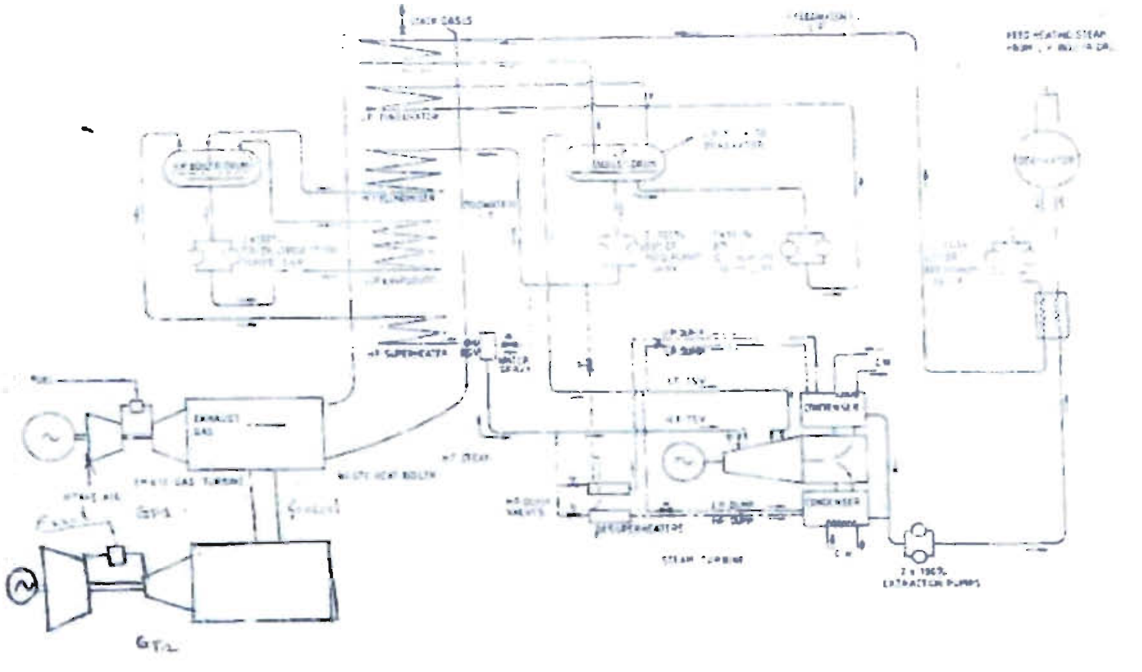


Figure 2.14: Single line diagram of steam generation system of combined cycle power plant of APSCL

2.2.3.2.2 Deaerator:

A deaerator is a device that is widely used for the removal of air and other dissolved gases from the feed water to steam-generating boilers.

In this case it is also 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 to the low pressure boiler drum through low pressure economiser. From the LP boiler the feed heating steam is flowed inside the deaerator which has 100°C temperature.

2.2.3.2.3 Low pressure economizer (LP economiser):

The feed water is heated in this section before it goes to the low pressure boiler at low pressure. Boiler feed pump is used to circulate feed water to the low pressure economiser. 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 economiser the feed water goes to the LP boiler drum.

2.2.3.2.4 Low pressure boiler drum:

The feed water is reserved into this drum after it passes through the LP economiser. The feed water is pumped from the LP boiler drum to the low pressure evaporator.

At the top of the low pressure boiler drum steam gathers. This steam is then transferred to the low pressure turbine.

2.2.3.2.5 Low pressure evaporator:

At the low pressure evaporator the feed water is heated at low pressure. It is placed below the LP economiser. Feed water flows through the tubes and exhaust gas is flowed over the tubes.

From the low pressure evaporator the evaporated feed water is again transferred to LP boiler drum. From the LP boiler drum, evaporated feed water is then flowed to the high pressure economiser

2.2.3.2.6 High pressure economiser:

At high pressure economiser 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 HP economiser the temperature raises up to 220°C.

2.2.3.2.7 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.

2.2.3.2.8 Super heater:

This part is at the bottom of the boiler where the temperature of the exhaust gas is hughest. 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 bar.

2.2.3.2.9 Condenser:

A condenser is a device which condenses the steam at the exhaust of turbine. It serves two important functions. Firstly, it creates a very low pressure at the exhaust of turbine, thus permitting expansion of the steam in the prime mover to a very low pressure. This helps in

Figure 2.15: Condenser used in steam turbine section of combined cycle power plant

converting heat energy of steam into mechanical energy in the prime mover. Secondly, the condensed steam can be used as feed water to the boiler.

In combined cycle power plant of Ashuganj Power Station Company Ltd (APSCL) there are two condensers is used.

2.2.3.2.10 Steam turbine:

The steam turbine used in the combined cycle power plant is almost same as steam turbine used in the steam power plant.

In combined cycle power plant of Ashuganj Power Station Company Ltd (APSCL) there is one steam turbine. This steam turbine has two section or chamber. These are:

1. High pressure turbine chamber.
2. Low pressure turbine chamber.

The characteristics of these turbine chambers are as same as the steam power plant turbine chamber which is discussed in the earlier segments of this report.

2.2.3.3. Valves used in combined cycle power plant

A valve is a mechanical or electromechanical device by which the flow of a gas, liquid, slurry, or loose dry material can be started, stopped, diverted, and/or regulated.

Valves are of two kinds. These are:

1. **Isolation valve:**
   It is an on/off valve that typically operates in two positions; the fully open and fully closed position.
2. **Control valve:**
   It can be controlled. This valve can regulate the fluid flow in a piping system.In combined cycle power plant there are various types of vales are used. These are:
   1) Manual Valve
   2) Pneumatic Valve
   3) Hydrolic Valve
   4) Motorized Valve
   5) Electro-hydrolic Valve
   6) Servo Valve

In this chapter, the whole power generation processes of APSCL have discussed. The different types of generator, synchronization and excitation, various types of turbine, boiler, heater, condenser, combine cycle power plant and operations of valves are briefly explained.

CHAPTER – 03

Protection & Switchgear

Power system protection of APSCL is a branch of electrical power engineering that deals with the protection of electrical power systems from faults through the isolation of faulted parts from the rest of the electrical network. The objective of a protection scheme is to keep the power system stable by isolating only the components that are under fault, whilst leaving as much of the network as possible still in operation. Thus, protection schemes must apply a very pragmatic and pessimistic approach to clearing system faults. For this reason, the technology and philosophies utilized in protection schemes can often be old and well-established because they must be very reliable.

The apparatus used for switching, controlling and protecting the electrical circuits equipments is known as switchgear. This is used in association with the electric power system, or grid, refers to the combination of electrical disconnects, fuses or circuit breakers used to 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 important because it is directly linked to the reliability of the electricity supply.

In the Ashuganj Power Station of Company Limited (APSCL) at switchgear section there are many circuit breakers, relays, control panels etc.

3.1 Generator Protection

The generating units especially the larger ones, are relatively few in number and higher in individual cost than most other equipments. Therefore it is desirable and necessary to provide protection to cover the wide range of faults whish may occur in the modern generating plant. Some protection of generator is given below which is used at APSCL.

3.1.1. Over Current Under Voltage Protection

In generation process of APSCL, the over current under voltage protection give to protect the over current through the generator. If more than one generator supply the load and due to some reason one generator is suddenly trip, then another generator try to supply the load. Each of these generators will experience a sudden increase in current and thus decreases the terminal voltage. Automatic voltage regulator connected to the system try to restore the voltage.

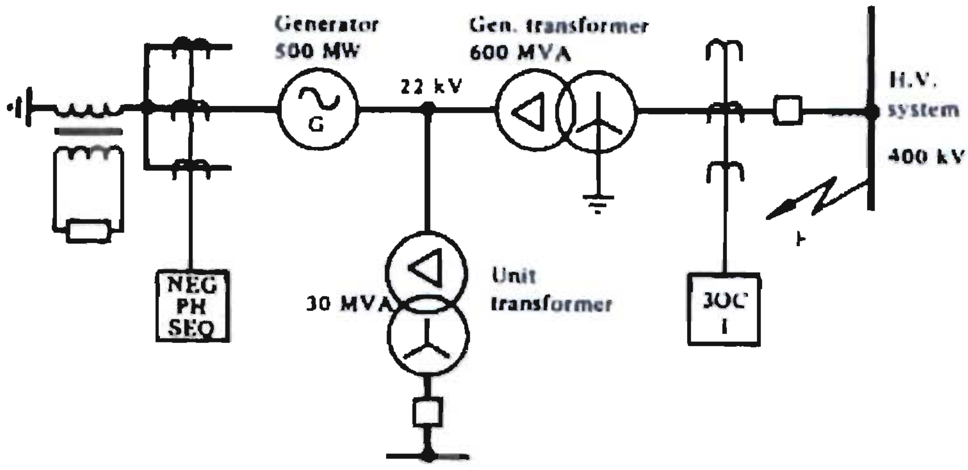


Figure 3.1: Figure for over current under voltage protection.

Overcurrent protection normally uses circuits in the high voltage circuit breaker which in the case of a transformer connected generator is on the star connected side of the generator transformer.

1. Direct connection to star-connected current transformer. Where the relay is supplied with the phase currents.
2. Connection to star-delta current transformer where the relay is supplied with phase difference currents to avoiding zero sequence currents in the primary fault current.

3.1.2. Static Earth Fault Protection

Stator faults involve the main current carrying conductors and must therefore be cleared quickly to complete shutdown of the generator. They may be faults between phases or turns of a phase in single combination. The great danger of all faults is the possibility to damage the stator core and stator windings due to the heat generator at the point of fault. If the damaged is other than superficial, the stator would have to dismantled and the damaged windings replaced and the stator rebuilt. It is a lengthy and costly process. Limitation of generator stator earth fault current is to minimize the core burning.

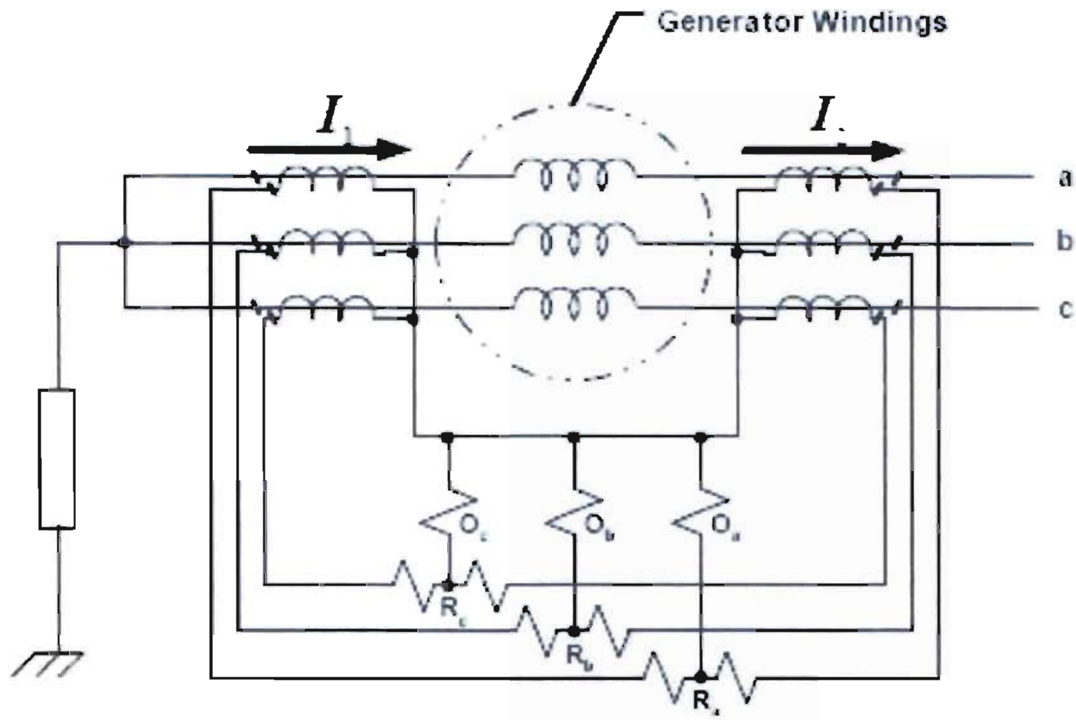


Figure 3.2: Figure for static earth fault protection.

3.1.3. Rotor Earth Fault Protection

In APSCL, AC generator has some major protection. Rotor earth fault protection in one of the major protection of generator. The method of grounding effect the degree of protection which is employed by the differential protection. High impedance reduces the fault current and thus it is very difficult to detect the high impedance faults. So the differential protection does not work for the high impedance grounding. The separate relay to the ground neutral provides the sensitive protection. But ground relay can also detect the fault beyond the generator, it the time co-ordination is necessary to overcome this difficulty. If we use the star- delta transformer bank, then it will block the flow of ground currents, thus preventing the occurrence of the fault on other side of the bank from operating ground relays. In unit protection scheme the transformer bank limits the operation of the fault relay to the generator.

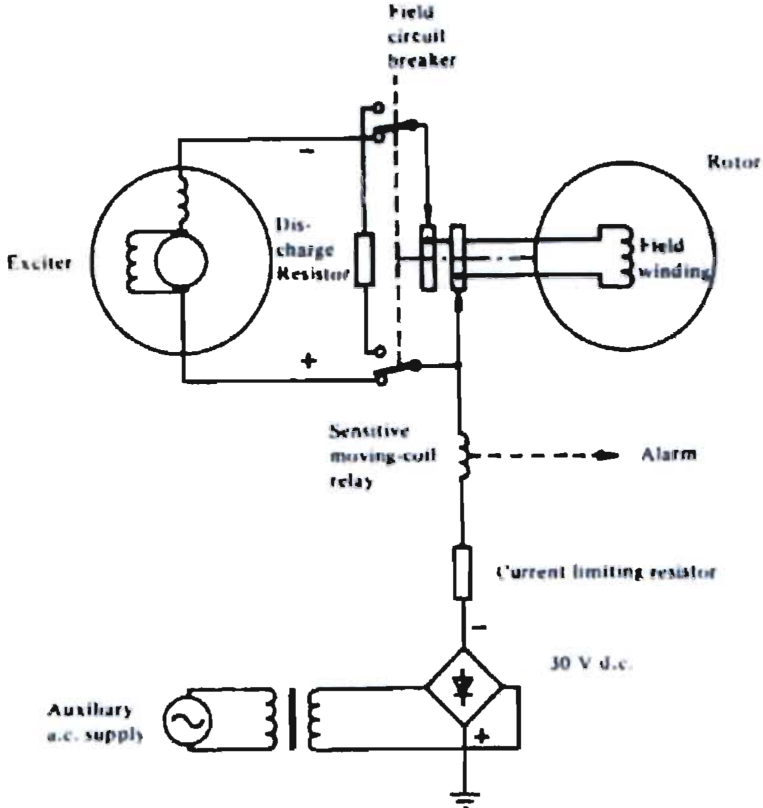


Figure 3.3: Figure for rotor earth fault protection.

3.1.4 Back-up Earth Fault Protection

Back-up earth fault protection is given to protect the power transformer. In APSCL, they used Inverse, definite minimum time (DMT) relays are generally fitted to provide back-up overcurrent and earth-fault protection of a generator. The minimum permissible relay setting is determined by the requirement that tripping must not occur for external HV system faults which may be more discriminatively cleared by other forms of protection. The relay setting should be chosen to provide adequate grading margins with negative phase sequence back-up protection.

3.1.5 Generator Differential Protection

Differential protection is used for protection of the generator against phase to earth and phase to phase fault. Differential protection is based on the circulating current principle.

In this type of protection scheme currents at two ends of the protection system are compared. Under normal conditions, currents at two ends will be same. But when the fault occurs, current at one end will be different from the current at the end and this difference of current is made to flow through relay operating coils. The relays then closes its contacts and makes the circuit breaker to trip, thus isolate the faulty section. This type of protection is called the merz price circulating current system.

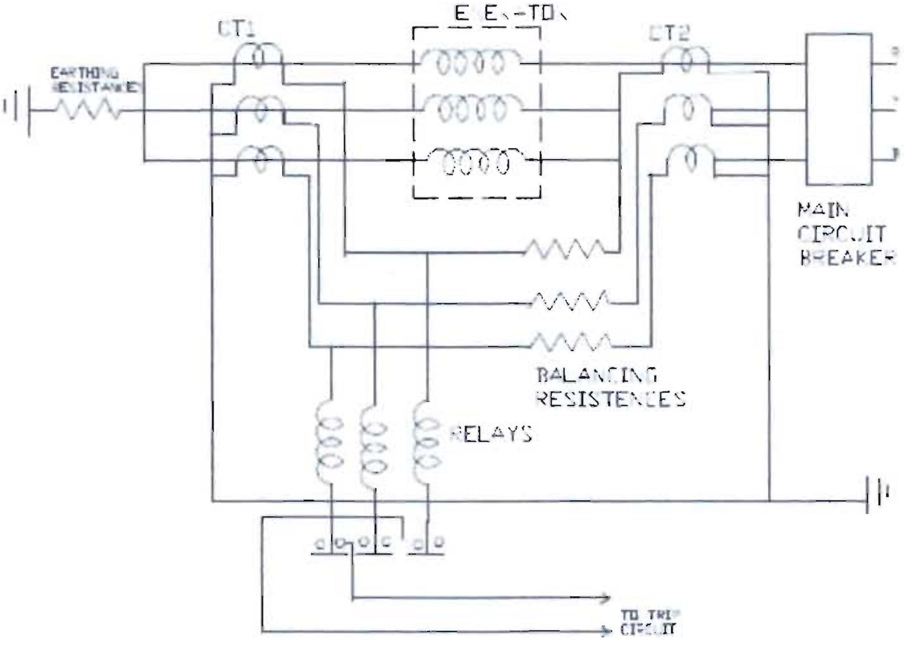


Figure 3.4: Figure for generator differential protection.

3.1.6. Loss of Field Excitation Protection

When a generator loses synchronism, the quantity which changes most is its impedance as measured at the stator terminals. Loss of field will cause the terminal voltage of the generator to begin to fall, while the current begins to increase. The apparent impedance of the machine will therefore be seen to decrease and its power factor to change. A relay designed to detect the change of impedance from the normal load value may therefore be used to provide protection against asynchronous operation resulting from the loss of excitation. Loss of excitation results in a generator losing synchronism and running above synchronous speed. Operating as an induction generator, it would produce its main flux from wattless stator current drawn from the power system to which it was still connected. Excitation under these conditions requires components of reactive current which may well exceed the rating of the generator and so overload the stator winding. Additionally the slip frequency currents induced in the damper windings of the rotor would cause abnormal heating of the rotor.

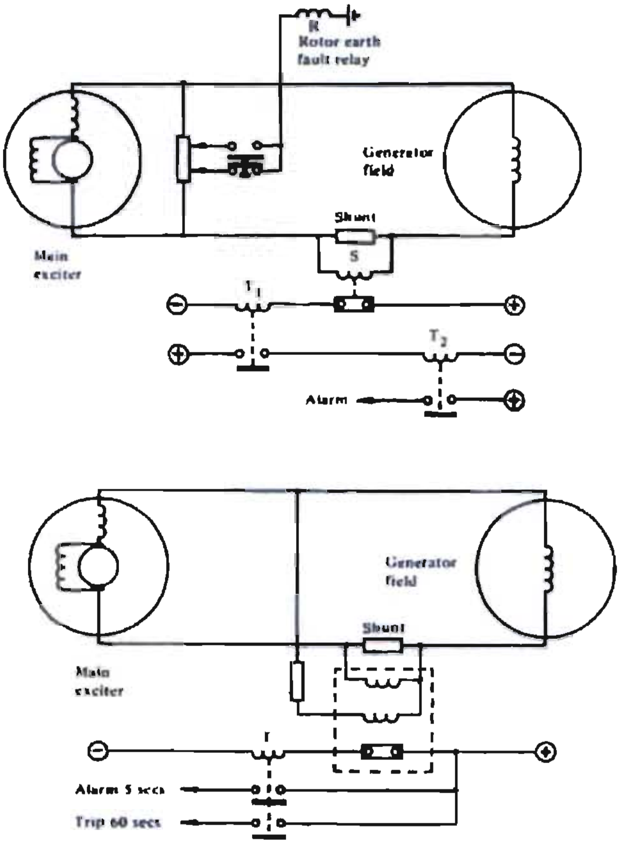


Figure 3.5: Figure for loss of field excitation protection

3.1.7. Negative Phase Sequence Protection

This type of protection is very important for a generator. Negative phase sequence protects generator from excessive heating in the rotor due to unbalanced stator currents. Negative sequence component of stator current induces double frequency current in rotor because of heating. Rotor temperature rise proportion to I^2t. Negative sequence relays provide settings for this relationship in the form of a constant, $k = I^2t$. Minimum permissible continuous unbalance currents are specified by IEEE.

Negative sequence current interacts with normal positive sequence current to induce a double frequency current (120 Hz). Current (120 Hz) is induced into rotor causing surface heating.

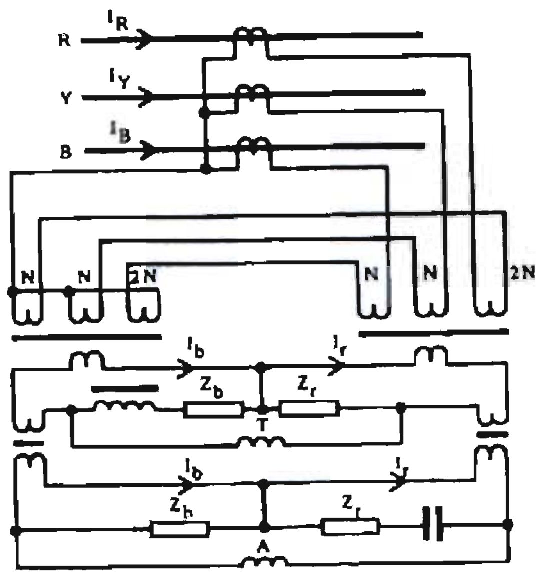


Figure 3.6: Figure for negetive phase sequence protection and phase angle.

3.1.8. Under Frequency Protection

Under frequency occurs due to the excess of overload. Generation capability of the generator increases and reduction in frequency occurs in under frequency condition. The power system survives only if we drop the load, the generator output becomes equal or greater than the connected load. If the load increases the generation, then frequency will drop and load need to shed down to create the balance between the generator and the connected load. The rate at which frequency drops depend on the time, amount of overload and also on the load and generator varies the frequency changing. Frequency decay occurs within the seconds so we cannot correct it manually. Therefore automatic load shedding facility needs to be applied. These schemes drops load in steps as the frequency decays. Generally load shedding drops 20% to 50% of load in four to six frequency steps. Load shedding scheme works by tripping the substation feeders to decrease the system load.

Generally automatic load shedding schemes are designed to maintain the balance between the load connected and the generator. The present practice is to use the under frequency relays at various load points so as to drop the load in steps until the declined frequency return to normal. Nonessential load is removed first when decline in frequency occurs. The setting of the under frequency relays based on the most probable condition occurs and also depend upon the worst case possibilities. During the overload conditions, load shedding must occur before the operation of the under frequency relays. In other words load must be shed before the generators are tripped.

3.1.9. Over Voltage Protection

In APSCL generator protection and switchgear room, there are over voltage protection. Over voltage occurs because of the increase in the speed of the prime mover due to sudden loss in the load on the generator. Generator over voltage does not occur in the turbo generator because the control governors of the turbo generators are very sensitive to the speed variation. But the over voltage protection is required for the hydro generator or gas turbine generators. The over voltage protection is provided by two over voltage relays have two units – one is the instantaneous relays which is set to pick up at 130 to 150% of the rated voltage and another unit is IDMT which is set to pick up at 110% of rated voltage. Over voltage may occur due to the defective voltage regulator and also due to manual control errors. For this protection each and every generator are being protected.

3.1.10. Rotor Overload Protection

Overload devices are designed to allow high currents to flow briefly in the motor to allow for:

- Typical motor starting currents of 6 to 8 times normal running current when starting.
- Short duration overloads such as a slug of product going through a system.

If the motor inlets and outlets are covered by a blanket of lint or if a bearing should begin to lock, excessive heating of the motor windings will “overload” the motors insulation which could damage the motor.

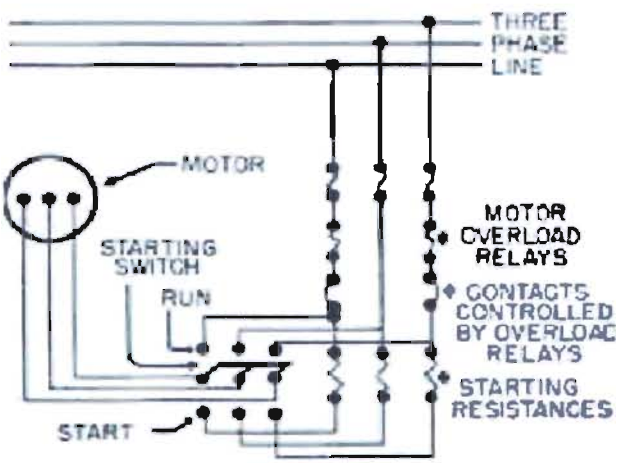


Figure 3.7: Figure for Rotor overload protection.

3.1.11. Winding Temperature Protection

Continuous overloading may increase the winding temperature. If winding temperature extent that the insulation will be damaged and its useful life reduced. Temperature rise can also be caused by failure of cooling system. In large machines thermal elements are embedded in the stator slots and cooling system. The electrical overcurrent protection is generally set at higher value for responding the excessive overloads. Winding temperature protection senses the failure of cooling system. In APSCL, the winding temperature protection needed to increase the efficiency of the generator.

3.1.12. Cooling Air Temperature Protection

Two axial fans supply the self ventilated generator with cooling air. There are two parallel cooling air circuits, each fed by one of the axial fans. These cooling air circuits are symmetrical about the mid-plane of the generator. The cooling air enters the rotor between the end-bell plate and the shaft, and flows into the end-winding chamber. At the inlet to the slots, the air runs into the hollow conductors. There it splits up into two portions. One portion flows through the hollow conductors in the slots. It reaches the center of the rotor, where it comes out into the air gap through radial holes in the hollow conductors and the slot wedges.

The other portion flows through the hollow conductors in the end winding. It reaches the polar axis, where it leaves the hollow conductors, ultimately emerging into the air gap through short slots in the end of the rotor body. APSCL used this cooling air temperature protection scheme to cool the generator internal heat and this protection increase the efficiency of the generator.

3.1.13. Rotor Temperature Protection

This protection is employed only to large sets and indicates the level of temperature and not the actual hot spot temperature. The rotor voltage and current are compared by a moving coil relay. The voltage coil of the relay is connected across the slip ring brushes. The current coil is connected across the shunt in the field circuit.

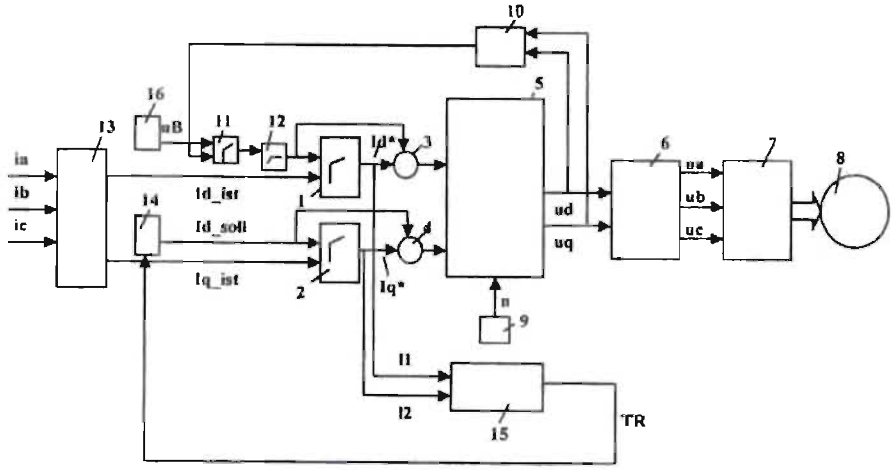


Figure 3.8: Figure for Rotor temperature protection.

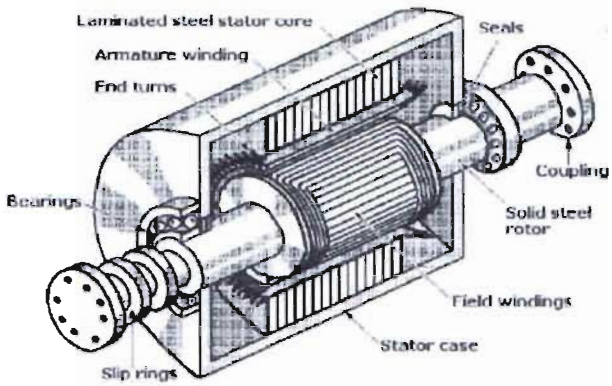
3.1.14. Stator Heating Protection

Generator overheating can be caused by failure cooling system or by sustained overloads. Embededresistance detectors are provided in the slots among with the stator coils for large generators. The protection is provided for generators above 1MW. It is not practicable to provide overload protection by back up stator fault over current protection. Because backup overcurrent protection is generally set for sensing fault currents and should not trip for overloads. Electrical overcurrent relays cannot sense the winding temperature acurately because temperature rise depends oncooling. Electrical protection cannot detect a cooling system failure.

3.1.15. Reverse Power Protection

When the input to the turbine is stopped the generator to rotate as a synchronous motor and taking from the

bus bars, this reverse power protection needed. That time the motor rotates as synchronous motor and turbine acts as a load. This protection is mainly benefited for the prime mover. Load coming on generator bus and reverse power protection measures the power flow from the bus-bars to the generatorwhen the generator running as a motor.



Cutaway view of a synchronous AC generator with a solid cylindrical rotor capable of high-speed rotation.

Figure 3.9: Figure for Reverse power protection.

During the monitoring action of the generator, the power flows from the bus-bars to the machineand the conditions in the three phases are balanced. The current transformers for reverse power protection may be either at the neutral point, the bus-bar and the generator winding.the setting depends on the type of prime mover. The reverse power protection does not operate during system disturbance and power swings.

3.1.16. Over Speed Protection

It is essential to incorporate safety device in turbine governing system to prevent overspeeding. Overspeeding can occur due to sudden loss of electrical load on generator due to tripping of generator circuit-breaker, before disconnection of prime mover. The speed should be maintained by the governor.By this overspeeding we get over voltages and increase in frequency. For steam turbine, the generator responds to the overspeed caused by load rejection. The steam beyond governor should be bypassed by some other path quickly. So the input to steam turbine is bypassed quickly and increased speed. For this the emergency valve is closed to stop the steam supply more rapidly. The valve opens again automatically. Then the governor responds to changed conditions and regulates the speed.

3.2 Turbine Protection

In APSCL, they are used two types of turbine, steam turbine and gas turbine. To check the efficiency and increase the life cycle of the turbine, they give the turbine protection. The Turbine Protection

System (TPS) is an electrical control and field sensor modernization package designed to replace the existing legacy protection system on steam turbines. The TPS can enhance turbine availability with features of 2-out-of-3 voting for pressure and speed sensors. Different option combinations can be incorporated within the core design providing a customized solution built around the specific units requirements. The Redundant Testable Trip Device combines vacuum, thrust, low bearing oil pressure, and trip block configuration in one freestanding unit. The TPS system is available for high pressure hydraulic systems and low pressure hydraulic systems. The TPS system can be used in both power and industrial applications. To give protection of a turbine has given below:

- Reduce downtime – on-line testing
- Reduce human error – automated testing
- Extend service life – minimize stress during testing
- Improve turbine availability – simplified on-line maintenance
- Eliminate single point failures
- Built-in first out trip indication

Figure 3.10: Figure for Turbine protection (Unit 3& 4).

3.3 Transformer Protection

The type of protection for the transformers of APSCL varies depending on the application and the importance of the transformer. In APSCL, Transformers are protected primarily against faults and overloads. The type of protection used should minimize the time of disconnection for faults within the transformer and to reduce the risk of catastrophic failure to simplify eventual repair. Any extended operation of the transformer under abnormal condition such as faults or overloads compromises the life of the transformer, which means adequate protection should be provided for quicker isolation of the transformer under such conditions.

3.3.1 Unit Transformer Protection

The scheme of generator transformer unit protection compromises the primary protection and back-up protection of generator, primary and back-up protection of main transformer, primary and back-up protection of unit auxiliary transformer and combined protection for generator and main transformer. The protection of unit transformer can be divided into three groups:

- Protective relays to detect faults or abnormal conditions external to the unit.
- Protective relays to detect faults internal to the unit.
- Devices associated with the overspeed safeguards, temperature measuring devices for bearings, windings etc. some of these wound an alarm and some cause tripping.

Figure 3.11: Picture of Unit Transformer.

3.3.2 Unit Auxiliary Transformer Protection

The unit auxiliary transformer supply internal power of the APSCL. In APSCL, they used 0.4KV and 6KV unit auxiliary power transformer. So the unit auxiliary transformer protection can be divided into such groups:

- Differential protection.
- Buckholz relay to protect the transformer.

- Restricted earth fault protection, than trip generator circuit breaker. Throttle valves closed, opened field circuit breaker and one auxiliary circuit breaker.
- Overcurrent protection and overvoltage protection.
- Winding and oil temperature sensors.

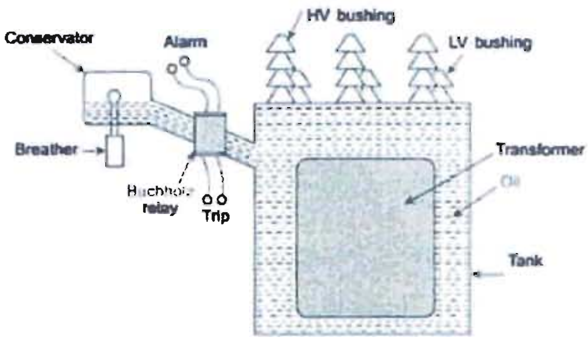


Figure 3.12: Figure for unit protection for auxiliary transformer.

3.3.3 Earth Fault Protection

In APSCL, earth fault protection gives when the current flows through earth return path. Other faults which do not involve earth are called phase faults. Since earth faults are relatively frequent, earth fault protection is necessary in most cases. When separate earth fault protection is not economical, the phase relays sense the earth fault currents. Hence separate earth fault protection is generally provided. Earth fault protection senses earth fault current. Following forms of earth fault protection such as

- Restricted earth fault protection by differential protection.
- Additional restrictedd earth fault protection.
- Leakage to frame protection.
- Neutral current relays.

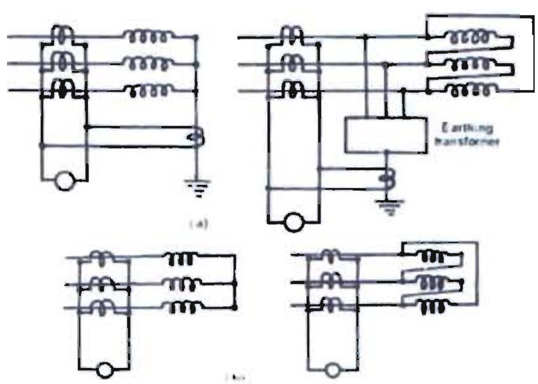


Figure 3.13: Figure for Earth fault protection for transformer.

3.3.4 Over current Protection

The over current protection is needed to protect the transformer from sustained overloads and short circuits. Induction type over current relays are used which in addition to providing overload protection acts as back up relays for protection of transformer winding fault. Overcurrent protection is employed as main protection against phase faults. For transformers above about 5 MVA, if differential protection is used as a main protection, overcurrent protection is used in addition for sustained through faults. Earth fault protection is provided in addition to phase fault protection.

For small distribution transformers below 500 KVA, overcurrent protection may be provided on fuse on high voltage side, as such transformers are installed in unattended sub-stations, circuit breakers and relays are not provided.

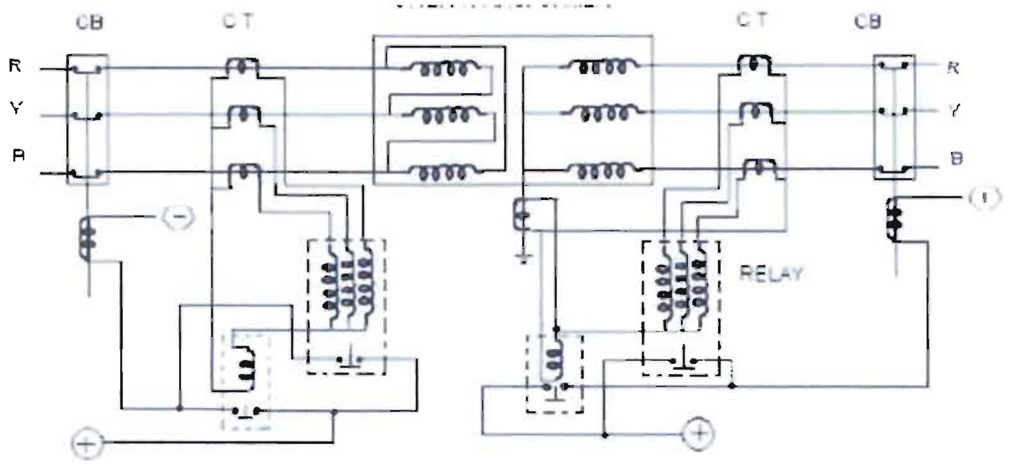


Figure 3.14: Figure for overcurrent protection for transformer.

3.3.5 Differential Protection for Auto Transformer

There are many auto transformers in Ashuganj power station Company limited. They used many types of protection for auto transformer. The application of the differential protection to auto-transformers can be applied to three phase auto transformers. The connections of current transformer secondaries differ for earth fault protection alone and combined phase fault and earth fault protection. Thus the current transformer secondaries can be so connected that during normal condition and exernal faults, the vector sum of currents in relay operating coil is zero.during internal faults, this balance is disturbed and relay operates.

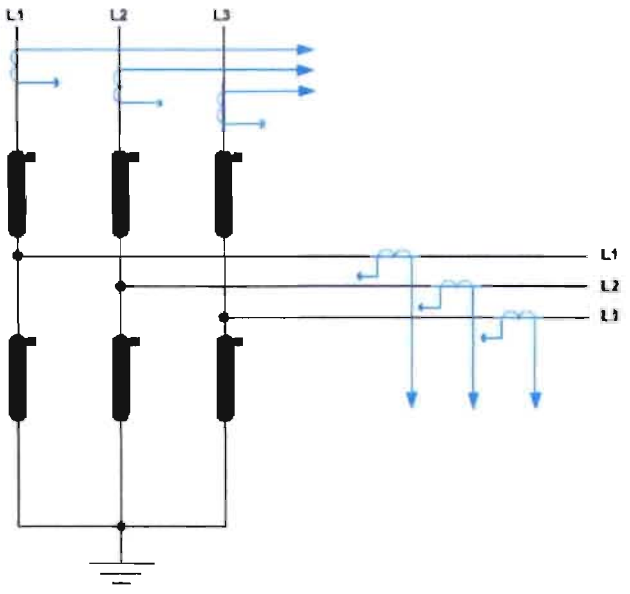


Figure 3.15: Figure for differential protection for auto transformer.

Differntial protection is generally unit protection. The protected zone is exactly determined by location of current transformers or voltage transformers. The vector differnces is achieved by suitable connection of current transformer or voltage transformer secondaries.

Each and every transformer protection is checked by the senior engineer and assistant engineer weekly. The switchgear and protection room always air cooled. Because a lot of heat produced in this room and it is cooled by air conditioning. Few accidents occur in this protection room during testing. The senior engineer of swicthgear and generator section described the working principle of transformer protection. For safety and security they don't show this.

3.4 Transmission Line Protection

In APSCL, transmission lines mostly use three-phase alternating current (AC). High-voltage direct-current (HVDC) technology is used only for very long distances (typically greater than 400 miles, or 600 km); submarine power cables (typically longer than 30 miles, or 50 km); or for connecting two AC networks that are not synchronized in APSCL.

Electricity is transmitted at high voltages (110 kV or above) to reduce the energy lost in long distance transmission. Power is usually transmitted through overhead power lines. Underground power transmission has a significantly higher cost and greater operational limitations but is sometimes used in urban areas or sensitive locations. In APSCL, there is transmision line protection to protect and save the urban areas people.

3.4.1 Earth Fault Protection of Lines

In Ashuganj power station, the earth fault protection need to separate overcurrent relay for single line to ground fault. Separate ground fault relays are generally preffered because they can be adjusted to provide faster and more sensitive protection for single line to ground faults than that provided by the phase. An Earth fault current depends on type of natural earthing. Where no natural point is available, grounding transformer is used. The setting of earth fault relays may be made less than rated full load current of the line. The earth fault elements are with inverse characteristics and time grading is preferred for earth fault protection of radial feeders.

3.4.2 Over Current Time Graded Protection

APSCL used the over current time graded protection to protect the transmission line. Definite time overcurrent relays have adjustable overcurrent elements. When an element is energizes a built in time element, a tripping signal elapse the preste time. The tripping times are so graded that the relay beyond the remote section at a shorter time. Than the relays nearer to the power source. This form of time grading is satisfactory for simple line configurations with single end in feed provided that the tripping times at the power source do not become excessively long. This overcurrent protection is also employed as back up protection for generator and transformers.

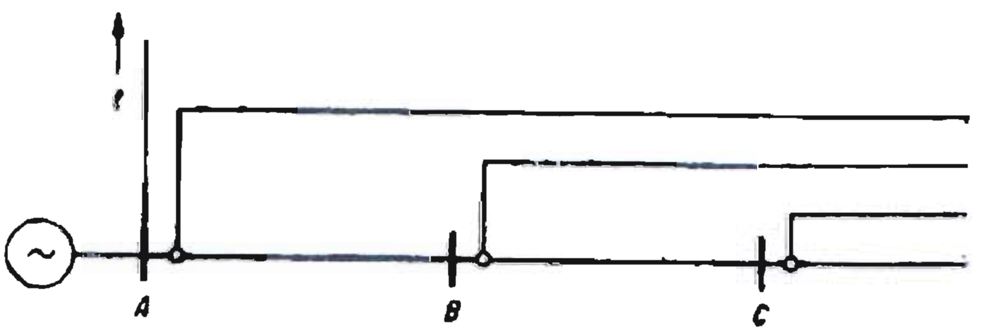


Figure 3.16: Figure for time graded overcurrent protection with definite time relays.

3.4.3 Distance Protection

This protection is one of the main protecion schemes for transmission line protection in APSCL. Distance relaying is considered for protection of transmission lines where the time lag cannot be permitted and selectivity cannot be obtained by overcurrent relaying. Distance protection is used for secondary lines and main lines. A distance relay measures the ratio V/I at relay location which give the measures of distance between the relay and fault location. The impedence of a fault loop is proportional to the distance between the relay location and the fault point. For a given setting, the distance relay picks up when impedence measured by its set value. Hence it protects a certain length of line.

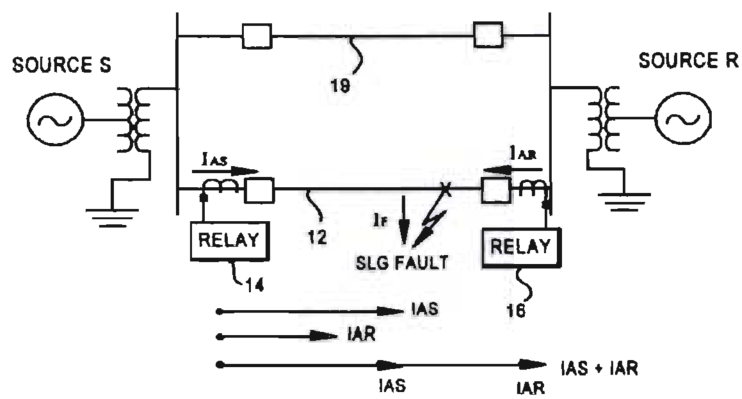


Figure 3.17: Figure for Distance protection of transmission line.

3.4.4 Over Current Protection of Lines

APSCL used Overcurrent protection of lines falls into following catagoies:

- Graded time lag or graded that differential protection.
- Protection by instantaneous overcurrent relays.
- Protection by definite time overcurrent relays.
- This overcurrent is employed where power flow can be form either sides and simple overcurrent protection does not provide selectivity.
- Separate relays are provided for phase fault protection and earth fault protection. The relays for phase fault protection are co-ordinated independently of relays for earth fault.

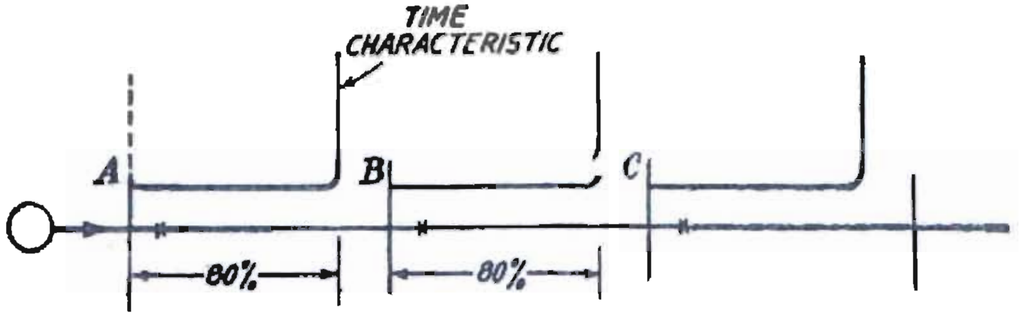


Figure 3.18: Figure for Instantaneous Overcurrent protection of line.

In this chapter different types of transformer protection are discussed. In APSCL, the manager and the senior engineer visits the generator and transformer protection room with security. If the plant tripped, they recover it rapidly and set the protection scheme errorless. Generator protection, transformer protection, transmission line protection and turbine protection is the main task to run a power station safely. There are many circuit breakers and relays to give the protection of this eqiupments. In APSCL, the switchgear and protection room has been secured. Because one small fault make a big trouble to the whole power plant.

CHAPTER – 04

Testing and Maintenance

In APSCL different types of tests are performed. To maintain the quality & performance of equipment there are various types of test and maintenance. The maintenance of power station is very important for power generation. In Ashuganj Power Station Company Ltd (APSCL), there is a testing section to test transformer, generator and motor. For motor testing, there is motor winding shop or section. This repairs the damaged motors.

4.1 Transformer Testing

To maintain the well performace of transformer APSCL usually takes different types of tests. By doing these tests they can understand about the present condition of the transformer. In APSCL various types of transformer testing are performed,some of them are given below:

4.1.1 Oil Test

For transformers Oil test, a sample of the transformer oil is taken. Then the break down voltage of the oil is measured. Oil is then filled in the vessel of the testing device. Two standard complaint test electrodes with a typical clearance of 2.5mm are surrounded by the dielectric oil. A test voltage is applied to the electrodes and increased up to break down voltage. At a certain voltage level breakdown occurs in an electric arc, leading to a collapse of the test voltage. An instant after ignition of the arc, the test voltage is switched off automatically by the testing device. The transformer oil testing device measures and reports the root mean square value of the breakdown voltage. This oil test has many parts. At APSCL Engr Md Rokon mia gave us a brief description of this test but didn't showed us all the parts of this test. In the next part at section no 4.1.6,4.1.7,4.1.8,4.1.10,4.1.11,4.1.12 & 4.1.13 a brief description & different data's of this test that we have taken at APSCL will be discussed.

4.1.2 Megar Test

The senior engineer Md.Rokan Mia showed the megar test of unit transformer (A step up transformer which is connected to the unit of a generating house) in switchgear and protection room. In megar test, the quality of insulation within the transformers is measured. Some variations will be obtained depending on the moisture; cleanliness and the temperature of the insulation. To perform this test, we have seen that they first connect the tank and the core with the ground. After that each booshing of the winding side are short circuited. Then resistance are measured between each winding and all windings and ground. For a particular power transformer at APSCL we get 500Mohm by doing megar test. So its resistance is good. During this testing, for safety and security we everyone stand beside the technitian.

4.1.4 Winding resistance measurement

This test can be done after the current has not passed through the transformer for several hours. Here winding resistance is calculated by measuring the voltage and current simultaneously. This ratio of voltage and current gives the value of the resistance of the winding. In APSCL this test is usually performed when a new transformer is brought to a station or after repairing a transformer. They didn't showed us how they perform this test. They just gave us a description of this test.

4.1.5 tanδ Test

This test is performed by applying a very low frequency AC voltage. It is used to test the level of degradation in insulation materials of electrical machine and transformers.

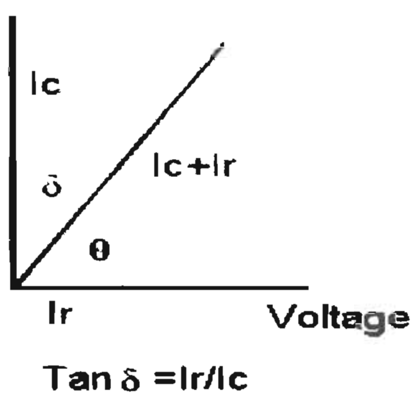


Figure 4.1: Figure for tanδ Test of transformer.

Tan δ test is actually a ratio of currents that are flowing through the winding of transformers that is, $\tan\delta = Ic/Ir = \propto_c/R$. Here Ic is the capacitive current & Ir is the resistive current. For a particular transformer, if the value of the tanδ test is less than 0.005 then we can say that the insulation materials of this transformer are ok (according to IEC (International Electro-technical Commission) 60247). At APSCL for 60 VA transformer we get tanδ =0.00605.So this transformer has some insulation problem. In APSCL this test is performed frequently.

4.1.6 Dielectric break down voltage Test

This test is a part of oil testing. Similar procedure is following here. This test is performed to know the condition of Oil. If the oil is moisture free and pure then we will get 60kv voltage for new oil and 25-30 kv voltage for older oil. At APSCL this test is performed with the oil test. At APSCL we get 26 kv breakdown voltage for a particular power transformer

4.1.7 Moisture contact particle Test

Moisture entering in oil-paper insulations of transformers can cause dangerous effects such as it can decreases the dielectric withstand strength and can accelerates cellulose aging (the so-called de-polymerization). It also can causes the emission of gas bubbles at high temperatures and may lead to a sudden electrical breakdown.

To prevent this problem it is needed to know that how much moisture is present in the oil. To know the moisture level this test is performed. This test measures the water ppm (parts per million) within the transformer oil. At APSCL Engr MD kamruzzaman gave us a description of this test but didn't showed us how they perform this test.

4.1.8 Dielectric Dissipation factor Test

Dielectric dissipation factor test measures the leakage current through an oil, which is the measure of the contamination or deterioration i.e. reveals the presence of moisture resin, varnishes or other products of oxidation oil or of foreign contaminants such as motor oil or fuel oil. At APSCL this test is also performed when they do the oil test. For the particular power transformer at APSCL we get dielectric dissipation factor=0.11. According to IEC (International Electro-technical Commission) 60422 the range for the dielectric dissipation factor is = very good <0.1 ~ 0.2< poor.

. The value we got at the test is in the range so we can say that the dielectric dissipation factor of the transformer is ok.

4.1.9 Dissolve Gas analyzer Test

Dissolved Gas Analysis or DGA is the study of dissolved gases in transformer oil.It is the most sensitive and reliable technique which gives an early indication of abnormal behavior of a transformer. DGA is advanced tool to diagnose the health of a transformer under preventive maintenance program. APSCL performs this DGA test by following the three steps. They are,

1. Sampling of transformer oil in an airtight glass tube
2. Complete extraction of gases from the sample
3. Subsequent analysis of the extracted gases for their quantity and Combination.

At APSCL Engr MD Rokon mia told us about this test but didn't showed us how they actually perform this test.

4.1.10 Neutralizations value Test

Insulating materials and acidity level of transformers are checked here. Acids in the oil originate from oil decomposition/oxidation products. Acids can also come from external sources such as atmospheric contamination. As per IEC296 class IA, standard neutralization value is 0.50 mg KOH/g. At APSCL they showed us a data that has taken on the day 27/02/11, there we have seen that for a particular transformer they got neutralization value=0.3 mg KOH/g.

4.1.11 Suspended particle in oil Test

The amount of dust, rust, scales and colloidal carbon oxidization sludge's present in the oil are checked in this test. At APSCL they usually perform this test when they do the full oil test of the transformer. So we didn't get the opportunity to see how they actually perform this test.

4.1.12 Interfacial Tension Test

The Interfacial Tension (IFT) measures the tension at the interface between two liquid (oil and water) which do not mix and is expressed in dyne/cm. The test is sensitive to the presence of oil decay products and soluble polar contaminants from solid insulating materials. Good oil will have an interfacial tension of between 40 and 50 dynes/cm. Oil oxidation products lower the interfacial tension and have an affinity for both water (hydrophilic) and oil. This affinity for both substances lowers the IFT. The greater the concentration of contaminants, the lower the IFT, with a badly deteriorated oil having an IFT of 18 dynes/cm or less. At APSCL they didn't showed us this test. They just gave us a chart that shows standard values for this test and some description about this test.

4.1.13 Sediments / sludge Test

This test determines the amount of sediment & sludge presents in the transformer oil. The test in IEC 296 distinguishes between sediment and sludge. Sediment is insoluble material present in the oil. Sediment may consist of insoluble oxidation or degradation products of solid or liquid materials, solid products such as carbon or metallic oxides and fibers etc. Sludge is polymerized oxidation products of solid and liquid insulating material.

The presence of sludge and sediment may change the electrical properties of the oil and hinder heat exchange, thus encouraging deterioration of the insulating materials. At APSCL they didn't showed us this test, they just gave a brief description of this test.

4.1.14 Viscosity Test

In this test the viscosity of the oil is measured. Low viscosity is preferred. At APSCL for the particular transformer we get 15 CST viscosity.

4.2 Motor Testing

To check 3φ motor winding, megar test is usually used.To ensure the good condition of motor,two types of megar tests are used:

(1) Phase to phase resistance measurement of the motor: Idealy this test is only possible when all of the windings of the motor are brought out.

(2) Phase to body resistance measurement of the motor: this test is performed by applying a voltage across the phase to body of the motor.

Megar test is a kind of insulation test to see is the insulation has been injured in any way to cause a short circuit when normal power is applied to it. On megger there can be 3 ranges 300V, 750V, and 1000 volts. Applying the proper voltage is essential to not damaging the device. Working voltages up to 240 volts should use the 300 range. Working voltages up to 600 volts use the 750 volt range and working voltages above 600 uses the 1000 volt range. Any reading below 20 megohms or above 30 megohms (phase to phase) indicates a problem with the insulation and the circuit. A megar test of the motor was performed at APSCL.

A 75 kW motor was used to perform this test. All the readings taken are given below:

For phase to phase:

Phase	Value (mega ohms)
U-V	21.8
U-W	21.8
V-W	21.8

For phase to body:

Phase to body	infinite

Test result says that this motor is faulty because its phase to body resistance is very high

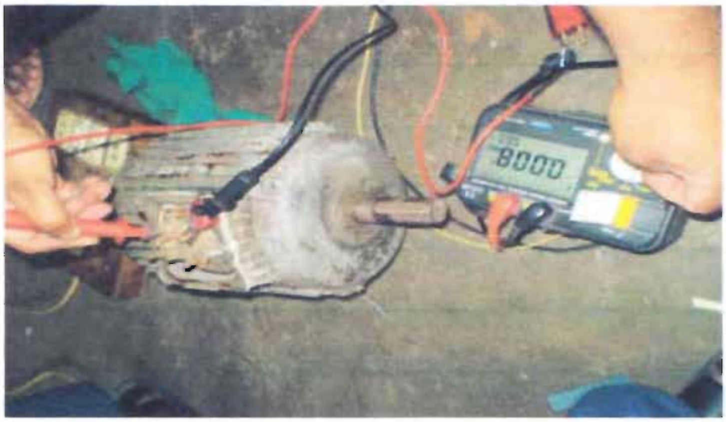


Figure 4.2: Figure for motor testing.

4.3 Generator Cooling System

Cooling system of a generator is a major part of power station. If a generator runs continuously then it becomes very heated. This heat can cause several damage to the generator as well as power generation. If the generator becomes highly heated then it will stops working and it can be burn out. In APSCL three types of cooling system are used to cool the genearator to get high efficiency. These three type of cooling system are :

1. Air cooling
2. Water cooling
3. Hydrogen cooling

4.3.1 Air Cooling

Air can be used to cool a generator, by circulating it through the generator to absorb heat and then exhausting the air to another area outside the generator. A continuous flow of air will cool the outside area of generator and rotor. The presumption is that the air entering the generator is cooler than the generator.

Figure 4.3: Air Cooling of generator transformer.

4.3.2 Water Cooling

The stator winding of the turbo generator is cooled by circulating demineralized water through hollow conductors of stator winding bars in a closed loop. The D.M. water is feed to the feed header mounted inside the generator casing on the turbine end. From the feed header water flows through Teflon hoses which connect feed header to the individual lower bar. Water passes through lower along the length to the other end and returns through the upper bars of another slot and drains in to the drain headers, also mounted on turbine side and connected with Teflon houses to the upper bars. The water flowing through the terminal bar circulates through the corresponding terminal booshing and cools it also. The pump drives the D.M. water through the coolers filters and windings and discharge it to a separate compartment of the harmonically sealed expansion tank mounted 5 M higher from the center line of generator and maintained at vaccum of 250-300 mm of Hg. The water from center of the expansion tank is again drawn by the pump. If the pressure of the D.M. water falls in the system below the particular value then other pump starts automatically.

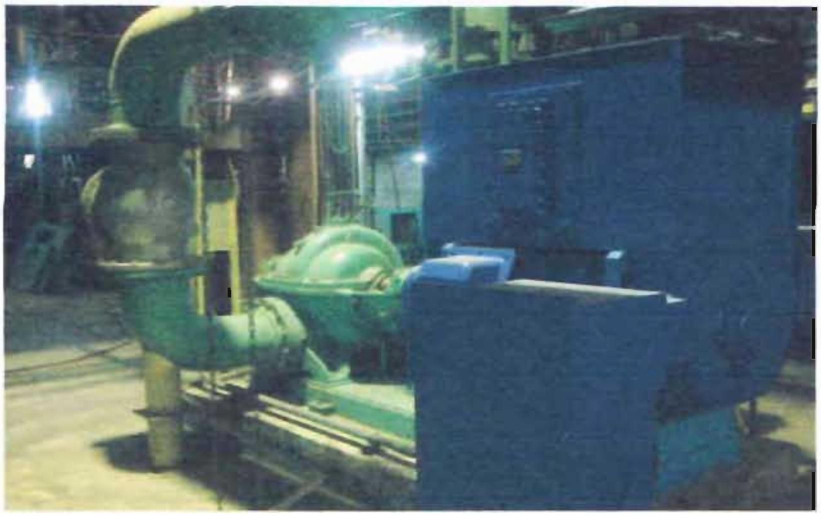


Figure 4.3: Cooling water pump of APSCL

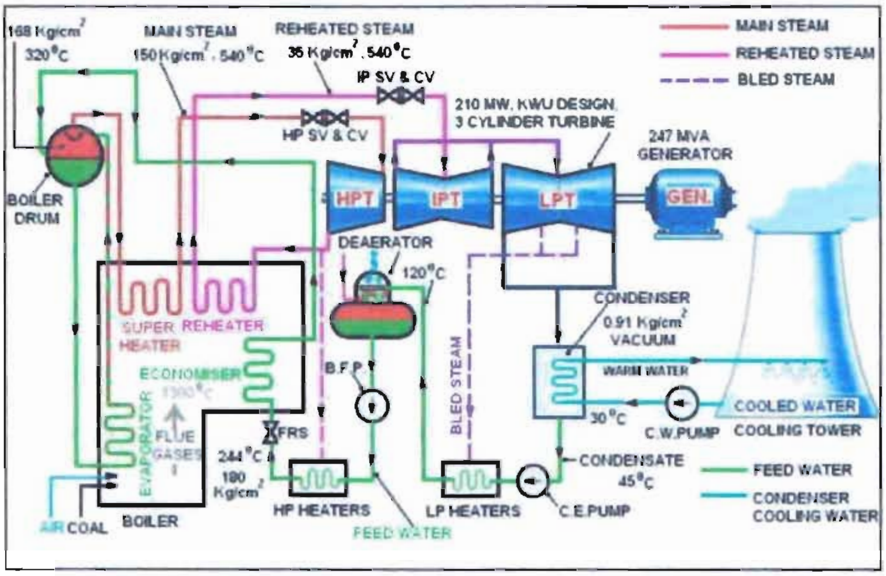


Figure 4.4: Figure for water cooling process of power station.

4.3.3 Hydrogen Cooling

Another way to cool the generator is to use hydrogen gas circulated through the generator and around the rotor to cool things. Hydrogen is seven to ten times better at transferring heat than air. Hydrogen is much better at absorbing heat and giving up that heat to another medium/area than air. This means that for the same size generator, if it is cooled with hydrogen then more current can flow in the stator and rotor windings of the generator than air cooled generator. This means that more power can be produced. The same amount of power can be produced with a smaller generator cooled with hydrogen than one cooled with air, which is the typical reason for using hydrogen cooling to reduce the physical size and cost of the generator

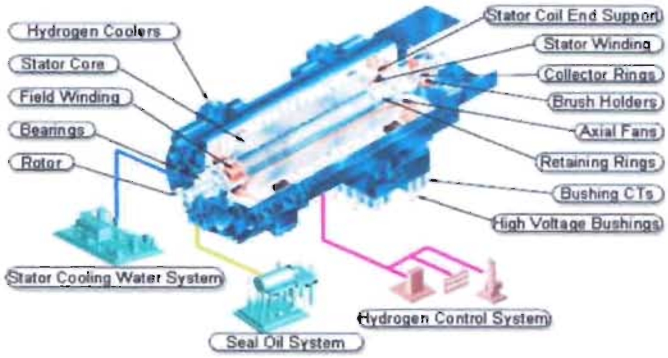


Figure 4.5 : Figure for hydrogen cooling process of a generator.

CHAPTER – 05

Substation

A substation is a part of an electrical generation, transmission, and distribution system. Substations transform voltage from high to low, or the reverse, or perform any of several other important functions. Electric power may flow through several substations between generating plant and consumer, and its voltage may change in several steps.

A substation that has a step-up transformer increases the voltage while decreasing the current, and a step-down transformer decreases the voltage while increasing the current for domestic and commercial distribution. The word substation comes from the days before the distribution system became a grid. The first substations were connected to only one power station, where the generators were housed, and were subsidiaries of that power station.

Substations generally have switching, protection and control equipment, and transformers. In a large substation, circuit breakers are used to interrupt any short circuits or overload currents that may occur on the network. Smaller distribution stations may use recloser circuit breakers or fuses for protection of distribution circuits. Substations themselves do not usually have generators, although a power plant may have a substation nearby. Other devices such as capacitors and voltage regulators may also be located at a substation.

APSCL substation transfers about one third powers to the country. The feeder of this substation is become urban and rural areas. At APSCL, Engr MD. Shahidullah, assistant engineer of substation showed different types of equipment and explained the working principle of these equipments. Detailed working principle and capacity of these equipments are given below:

5.1 Transformer

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

(1) Power transformers &

(2) Instrument transformers

5.1.1 Power Transformer

A power transformer is used in a substation to step up or step down the voltage. The modern practice is to use 3 phase transformers in substations. Although 3 single phase bank of transformers can also be used. The use of 3 phase transformer permits two advantages. Firstly, only one 3 phase load tap changing mechanism can be used. Secondly, its installation is much simpler than the three single phase transformers. The power transformers are generally installed upon lengths of rails fixed on concrete slabs having foundations 1 to 1.5 m deep. For rating up to 10 MVA, naturally cooled, oil immersed transformers are used. Most of the power transformers at the substation of APSCL rated up to 100MVA.At APSCL they use both single phase & 3 phase power transformers.

Figure 5.1: Picture of a Power Transformer of 132 KV line

5.1.2 Instrument Transformer

Instrument transformers are used in APSCL for measuring voltage and current in electrical power systems, and for power system protection and control. Where a voltage or current is too large to be conveniently used by an instrument, it can be scaled down to a standardized, low value. Instrument transformers isolate measurement, protection and control circuitry from the high currents or voltages present on the circuits being measured or controlled. There are two types of instrument transformer. These are:

1. Current transformer (CT).
2. Potential Transformer (PT).

5.1.2.1 Current Transformer

In electrical engineering a current transformer (CT) is used for measurement of electric currents. Current transformers, together with voltage transformers (VT) (potential transformers (PT)), are known as instrument transformers. 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. APSCL used current transformer in sub-station and auxiliary transformer section. Current transformer ratings in APSCL are from 5A to 133A.

Figure 5.2: Picture of a Current Transformer of 132 KV line

5.1.2.2 Potential Transformer

The instrument potential transformer (PT) steps down voltage of a circuit to a low value that can be effectively and safely used for operation of instruments such as ammeters, voltmeters, watt meters, and relays used for various protective purposes. In APSCL, there are many potential transformers with various ratings. Such as 6KV, 132KV, 230KV.

Figure 5.3: Conceptual Picture of a Voltage Transformer of 132KV line.

5.2 Bus Bar

In electrical power distribution, a busbar is a strip of copper or aluminium that conducts electricity within a switchboard, distribution board, substation or other electrical apparatus. The size of the busbar determines the maximum amount of current that can be safely carried. Busbars can have a cross-sectional area of as little as 10 mm^2 but electrical substations may use metal tubes of 50 mm in diameter (1,963 mm^2) or more as busbars, and an aluminum smelter will have very large busbars used to carry tens of thousands of amperes to the electrochemical cells that produce aluminum from molten salts.

5.2.1 Introduction of Bus-bar and Bus-bar equipment

The Buses concerned with switchgear. These Buses only transports electricity. Conductors to which a number of circuits are connected are called Buses. And Bar means rod or metals which help current to flow. The bus-bar rating of APSCL is given below:

Rating of Bus-bar:

The standard rms value of current and voltage which the bus-bar can carry continuously with temperature rise within specified limits are given bellow.

Voltage (KV rms)	Current (Amperes)
0.415	220

11	800
33	1600
132	2000
220	2400
400	3000

5.2.2 Bus-Bar arrangement

Bus-Bar arrangement of APSCL is the important component in substation. There are several ways in which the switching equipments can be connected in electrical layout of generating station, receiving station or a distribution station. The selection of scheme is in general affected by following aspects:

1. Degree of flexibility of operations desired.
2. Importance of load and local conditions. Freedom from total shut down and its period desired.
3. Economic consideration, availability and cost.
4. Technical consideration.
5. Maintenance, safety of personnel.
6. Simplicity.
7. Provision of extension.

There are several Bus-bar arrangements that can be used in APCSL substation. Like

- Single Bus-bar
- Double Bus-bar
- Sectionalization of Bus
- Ring Bus.
- One and half scam Bus-bar.

Figure 5.4: 230KV Busbar arrangement system of APSCL

5.2.3 Double Bus-bar or Main and reserved Bus-bar

In APSCL double bus-bar arrangement is used. A Double Bus-bar configuration consists of two independent buses, one of which, the main bus, is normally energized. Under normal operating conditions, all incoming and outgoing circuits are fed from the main bus through their associated circuit breakers and switches. If it becomes necessary to remove a circuit breaker from service for maintenance or repairs, the integrity of circuit operation can be maintained through use of the bypass and bus tie equipment. The bypass switch for the circuit breaker to be isolated is closed, the bus tie breaker and its isolation switches are closed, and the bypassed breaker and its isolation switches are opened to remove the breaker from service. The circuit is then protected by the bus tie breaker.

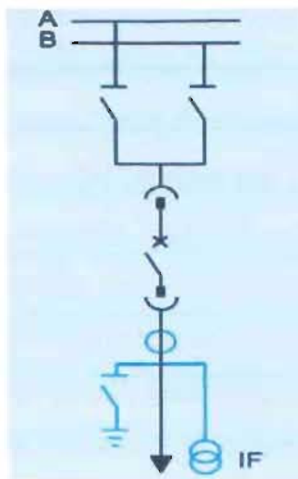


Figure 5.5: Conteptual diagram of Double Busbar arrangement system

Advantages:

1. Accommodation of circuit breaker maintenance while maintaining service and line protection.
2. Reasonable in cost
3. Fairly small land area
4. Easily expandable

Disadvantages:

1. An additional circuit breaker is required for bus tie.
2. Since the bus tie breaker have to be able to be substituted for any line breaker, its associated relaying may be somewhat complicated.
3. Failure of a circuit breaker or a bus fault causes loss of the entire substation.

4. Somewhat complicated switching is required to remove a circuit breaker from service for maintenance.

5.2.4 Circuit Breaker:

In APSCL, Engg. Md.Shahid Ullah, Assistant Engineer (Sub Station) visits the switchyard. There are various types of switchyard equipment. The most important part of the switchyard is Circuit Breaker (CB). A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and, by interrupting continuity, to immediately discontinue electrical flow. Unlike a fuse, which operates once and then has to be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation. Circuit breakers are made in varying sizes, from small devices that protect an individual household appliance up to large switchgear designed to protect high voltage circuits feeding an entire city. It is a protective device which protects electric load devices and electric power cables from a large fault current caused by an electrical shortage and a ground fault that can be generated on an electrical circuit. It also performs the breaking operation automatically when such fault current is generated. When the fault current occurs, then electric circuits detect the leakage current and give a trip signal. Circuit breaker may include an electronic trip unit that senses the over rated current. If it sense that the over current is flowing through the circuit, then in response of trip signal, it will separate breaker contacts. Circuit breaker can be of many types. It is mainly divided on the basis of voltage level, construction type, interruption type and their structures. They are Low Voltage Circuit Breaker, High Voltage Circuit Breaker, Magnetic Circuit Breaker, and Thermal Circuit Breaker. In Ashugonj Power Station, there are three types of Circuit Breaker.
We have seen the following types of circuit breaker at the substation

1. Oil circuit breaker
2. SF6 circuit breaker

Now the description of these types of circuit breaker is given below.

5.2.4.1 Oil Circuit Breaker

In Ashugonj Power Station Company Substation, they use Oil Circuit Breaker. The oil in OCBs serves two purposes. It insulates between the phases and between the phases and the ground, and it provides the medium for the extinguishing of the arc. When electric arc is drawn under oil, the arc vaporizes the oil and creates a large bubble that surrounds the arc. The gas inside the bubble is around 80% hydrogen, which impairs ionization. The decomposition of oil into gas requires energy that comes from the heat generated by the arc. The oil surrounding the bubble conducts the heat away from the arc and thus also contributes to deionization of the arc. Main disadvantage of the oil circuit breakers is the flammability of the oil, and the maintenance necessary to keep the oil in good condition.

Figure 5.6: Picture of oil circuit breaker.

5.2.4.2 SF6 Circuit Breaker

In APSCL they used many SF6 circuit breakers at substation.In such circuit breakers, sulpher hexafluoride (SF_6) gas is used as the arc quenching medium. The SF_6 is an electro-negative gas and has a strong tendency to absorb free electrons. The contacts of the breaker are opened in a high pressure flow of SF_6 gas and an arc is stuck between them. The conducting free electrons in the arc are rapidly captured by the gas to form relatively immobile negative ions. The loss of conducting electrons in the arc quickly builds up enough insulation strength to extinguish the arc. The SF_6 circuit breakers have been found to be very effective for high power and high voltage service. Some of the outstanding properties of SF6 making it desirable to use in power applications are:

1. High dielectric strength.
2. Unique arc-quenching ability.
3. Excellent thermal stability.

4. Good thermal conductivity.

Figure 5.7: Picture of SF6 Circuit Breaker

5.2.4.3 Relays that are used in APSCL substation:

- **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.

- **Over current relay**

  An "over current relay" is a type of protective relay which operates when the load current exceeds a preset value. In a typical application the over current relay is connected to a current transformer and calibrated to operate at or above a specific current level. When the relay operates, one or more contacts will operate and energize to trip (open) a circuit breaker.

- **Distance relay**

  The most common form of protection on high voltage transmission systems is distance relay protection. Power lines have set impedance per kilometer and using this value and comparing voltage and current the distance to a fault can be determined

- **Percentage differential relay**

  This type of relay is capable to identify internal fault only. There are two current transformers (CT) connected to the two end points of the protection part. The difference between two CTs current passes through the operating coil of the percentage differential relay. If difference is greater than zero then relay will operate.

- **Pilot relay**

  Pilot relay is used for sending signal to the fault part. If any kind of fault occurs in any zone of transmission line, immediately the fault should be cleared by using a signal, which comes from pilot relay. At APSCL, microwave type pilot relay and power line carrier type pilot relay are used for protecting the transmission line.

- **Classical relay**

  Classical relay is the first protection device. It is the most guaranteed relay. There are several types of classical relays in power system, but at APSCL substation they use electromagnetic attraction type double quantity classical relay. This relay has instantaneous operation, means operation time is constant. The construction of this relay is very simple and operating current can be adjusted easily.

5.2.4.4 Desirable quality of protective relay

Protective relay should have certain qualities. Without these qualities we cannot say a protective relay is a really good relay. So those qualities are [4]-

- **Selectivity:** Selectivity is a quality being selective, selective in protecting equipment. The protective relay should select the faulty part from the system and should isolate as soon as possible.
- **Speed and time:** As soon as possible relay will select the faulty part; damage would be that much minor.
- **Stability:** Stability is defined as the quality of protective system by the virtue of which the protective system remains inoperative and stable under specified condition such as system disturbance, faults etc.
- **Reliability:** Reliability means trustworthiness. It should not fail to operate during the fault in the protected zone.

5.2.5 Lightning Arrester

Lightning is a huge spark and takes place when clouds are charged to such a high potential with respect to ground or earth. A lightning arrester is a device used on electrical power system to protect the insulation system and other equipment from the damaging effect of lightning. Lightning arrester is also known as surge arrester. It has a high voltage terminal and a ground terminal. One end of the arrester is connected to the terminal of equipment to be protected and the other end is grounded. It has also a non linear resistance with spark gap. Under the normal condition lightning arrester does not work but when the high voltage or thunder strike occur then air insulation of the gap breaks and arc is formed for providing a low resistance path to surge the ground. In this way the excess charges that falls on the line because of the surge or thunder passes through this lightning arrester and causes no harms to the line. When the surge or thunder is over then the non linear resistance of the arrester becomes high and makes the path non-conducting. There are three types of lightning arrester used at APSCL. These are (1) Expulsion type (2)Non linear resistor type (3) Gapless metal oxide type

Figure 5.8: Picture of Lightning arrester.

5.2.6 Transmission & Distribution:

Transmission line is a material medium or structure that forms a path for directing the transmission of energy from one place to another, such as electromagnetic waves or acoustic waves, as well as electric power transmission. Overhead lines are used for transmission. Over head lines has some components, these are:

1) Conductors.
2) Line Supporters.
3) Insulators

(1)Conductor: Conductor carries electrical power from sending end to receiving end. Conductor cost is the most vital cost of the total transmission cost. Therefore proper choice of the material and size of the conductor is considerable importance. So, the conductor used for transmission and distributions of electrical power have the following properties:

i) High electrical conductivity.

ii) High tensile strength in order to withstand mechanical stress.

iii) Low cost so that it can be used for long distances.

(2)Line supporters: The supporting structures for overhead line conductors are various types of poles and towers called line supporters. Line supporters should have the following properties:

i) High mechanical strength to withstand the weight of conductors and wind loads etc.

ii) Light in weight without the loss of mechanical strength.

iii) Cheap in cost and Economical to maintain.

iv) Longer life.

v) Easy accessibility of conductors for maintainance.

There are many types of line supporters or towers that are used in transmission line. Most commonly used supporters used in transmission lines are wooden poles, steel poles, and RCC poles.

1. **Wooden poles:**

These are made of seasoned wood and are suitable for lines of moderate cross-sectional area and of relatively shorter spans say up to 50 meters. Such supporters are cheap easily available, provide insulating properties and therefore are widely used for distribution purposes in rural areas as an economical proposition.

But these types of supporters are not suitable all cases because of many reasons. Reasons are:

i) Smaller life.

ii) Cannot be used for voltage Higher than 20kv.

iii) Less mechanical strength.

iv) Tendency to root below the ground level.

v) Require periodical Inspection.

2. **Steel poles:**

The steel poles are often used as a substitute for wooden poles. They posses greater mechanical strength, longer life and permit longer span to be used. Such poles are generally used for distribution purposes for cities. This type of supports need to be galvanized or pained in order to prolong its life.

3. **RCC (reinforced concrete poles) poles:**

These types of poles are very popular and widely used as line supports in recent year. They have greater mechanical strength, longer life and permit longer spans than steel poles. Moreover, they give good outlook; require little maintenance and have good insulating properties. The holes in the poles facilate the climbing of poles and at the same time reduce the weight of line supports.

The main difficulty with the use of these poles is the high cost of transport owing to their heavy weight. Therefore, such poles are often manufactured at the site in order to avoid heavy cost of transportation.

4. **Steel tower:**

In practice, wooden poles, steel poles and RCC (reinforced concrete poles) poles are used for distribution purposes at low voltages say up to 11kv. However, for long distance transmission at higher voltage, steel towers are invariably employed. Steel tower have greater mechanical strength, longer life, can withstand most severe climate condition and permit the use of longer span.

(3) Insulators: The overhead line conductors should be supported on the poles or towers in such way that current from conductor do not flow to the earth through supports that is line conductor must be properly insulated from supports. This is achieved by securing line conductor to supports with the help of the insulator.

There are many types of insulators. Most common insulators are discussed below:

1. **Pin type insulator:** Pin type insulators are used for transmission and distribution of electrical power at voltages up to 33kv. Beyond operation of 33kv, the pin type insulators become too bulky and hence uneconomical.
2. **Suspension type insulators:** The cost of pin type insulator increases rapidly as the working voltage is increased. Therefore, this type of insulator is not economical beyond 33kv. For voltages above 33kv, it is a usual practice to use suspension type insulator. They consist of a number of porcelain discs connected in series by metal links in the form of string. The conductor is suspended at the bottom end of this string while the other end of the string is secured to the cross-arm of the tower. Each unit or disc is designed for low voltage; say 11kv. The number of disc in series would obviously depend upon the working voltage.
3. **Strain Insulators:** When there is a dead end of the line or there is corner or sharp curve, the line is subjected to greater tension. In order to relieve the line of excessive tension, strain insulators are used. For low voltage lines, shakle insulators are used as strain insulators. However, for high voltage transmission lines, strain insulators consist of an assembly of

suspension insulators. The disc of strain insulators are used in the vertical plane. When the tension in lines is exceedingly high, as at long river spans, two or more strings are used in parallel.

Figure 5.9: Distribution line (11KV) of APSCL

This substation is feed by some incoming feeders. These incoming feeders came from the generators of generating units. These feeders feed the substation through a 6.6 KV bus. All the incoming feeders of this substation are given below:

Incoming feeder:

6.6 KV Bus is present for incoming feeder from GT 1,2,3,4 &5. Then at the substation the voltage is step up by using different instrument that are discussed in the previous sections. After that the electric power transmitted by using different cables, poles, towers etc are also discussed in the previous section. Then this power is distributed to the different areas. These areas are called outgoing feeders. All the outgoing feeders of this substation are given below:

Outgoing feeder:

For outgoing feeder double bus are used .These are,

(1)132 KV bus feeds:

1) Shajibazar-1
2) Shajibazar-2

3) Shajibazar-3
4) Ghorashal-1
5) Ghorashal-2
6) Kishoregonj-1
7) Kishoregonj-2

(2)230 KV bus feeds :

1) United 50 MW rental
2)AGREKO 80 MW rental
3)Comilla -1
4)Comilla-2

5.2.7 Power line carrier communication (PLCC)

PLCC means Power Line Carrier Communication. It is mainly used for Telecommunication, Tele-protection and Tele-monitoring between electrical substations through the power lines at high voltage. Through the power line, the PLCC system is established. PLCC integrates the transmission of communication signal and 60 Hz power signal through the same power cable. So it is a real benefit that two important application, power transmission and telecommunication are occurring in a single system. Here, in this system, audio frequency carried by carrier frequency and the modulation system is amplitude modulation. Carrier frequency range is set according to the distance of sub stations. This carrier frequency is distributed to include the audio signal, protection and pilot frequency. We got to know from the substation of APSCL that they use this PLCC for their substation to substation communication.

We have seen following contents of PLCC-

- **Wave trap:** Wave trap is also known as Line trap. It is connected with the power line and blocks the high carrier frequency and let 60 Hz power waves to pass through.
- **Coupling capacitor:** Coupling capacitor provides low impedance path for carrier frequency and provides high impedance for power frequency, so that it cannot pass through.

5.3 AC and DC AUXILIARY SYSTEM for substation:

In Ashuganj power station there are AC and DC auxiliary system for substation. AC auxiliary system of substation supplies the typical loads which is very important for a substation. DC auxiliary system supply the backup loads which is primarily needed to run and maintenance the power station and substation bothly. So the AC and DC auxiliary system are given briefly:

5.3.1 AC Auxiliary System:

Typical Loads Supplied:

Substation ac auxiliary systems are typically used to supply loads such as:

1. Transformer cooling, oil pumps, and load tap changers
2. Circuit breaker air compressors and charging motors
3. Outdoor device heaters
4. Outdoor lighting and receptacles
5. Control house
    a. Lighting and receptacles
    b. Heating, ventilating, and air conditioning
    c. Battery charger input
    d. Water well pump
6. Motor-operated disconnecting switches.

Design Requirements:

Critical Loads: Some low-voltage loads have to be maintained at all times:

4. Battery chargers which, through the batteries, supply breaker trip and close circuits as well as communication circuits
5. Transformer cooling.
6. Power circuit breaker compressors and motors.
7. Trouble light receptacles in the station yard.
8. Security lighting.
9. Breaker control circuits.
10. Fire alarm circuits.
11. Electric heating.
12. Substation automation circuitry

5.3.2 DC Auxiliary System:

DC power supply is the heart of the substation. Without a DC supply the substation is fully unprotected. DC auxiliary system is also called Back-up system. In the backup system DC supply is used. It is needed to run the Relay, Circuit breakers and control System when Fault occurs. Here Nichel Cadmium batteries are used because its efficiency is very high. Each cell is 1.2 volt and 750 amp-h. Total battery section output is 220 volt. To get 22o volt, the batteries are connected in series. These batteries are cleaned regularly to prevent it from flashing. To check the performance of the batteries, some tests are also done twice in a month. These tests are: Date: 27/02/11; 220v DC

Battery No	Cell voltage (V)	Gravity test
61	1.37	1160
62	1.37	1160
63	1.36	1160
64	1.41	1160
65	1.36	1160
66	1.37	1160
67	1.38	1160
68	1.34	1160
69	1.38	1160
70	1.36	1160
71	1.37	1160
72	1.35	1160
73	1.40	1160
74	1.34	1160
75	1.36	1160
76	1.36	1160
77	1.36	1160
78	1.38	1160
79	1.37	1160
80	1.40	1160

Table 11: testing of battery cells.

1. Acid leveling test: This test is performed visually.
2. Cell voltage Test: Here voltage level of each batteries are checked
3. Total Output: Here total output of back up section is checked whether it is 220V or not.

4. Gravity test: This test is performed by using a testing tube.

All these tests results of some batteries taken in a day are given below:

These batteries are initially charged with constant currents. After that it is charged with floating voltage/current. Characteristics curve of the battery when fully charged is given below:

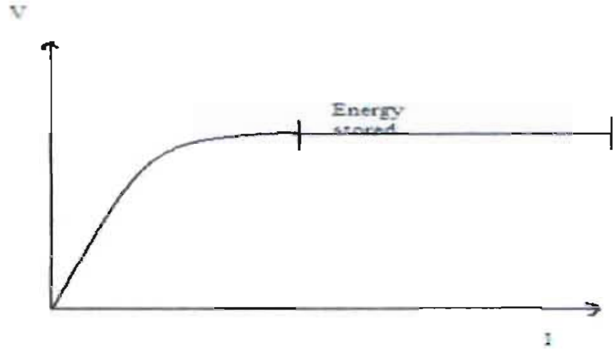


Figure 5.10: Characteristics curve of Battery charging

Batteries are charging and discharging continuously. As a result after passing many days the characteristics curve of the battery changes. As a result it cannot store enough energy. Then "Energy Boost" is applied to solve this problem. Here batteries are charged at a very high voltage.

Figure 5.11: Battery arrangement of back up system

This backup system will only be used when the plant trips and power generation stops.

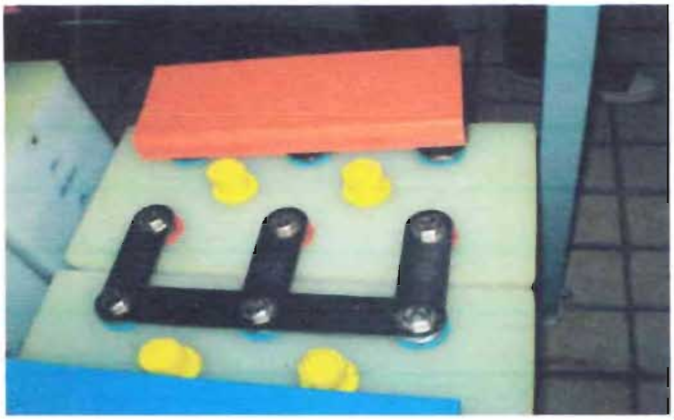


Figure 5.12: Series connection of battery in backup system

5.4 Underground cables:

APSCL used underground cables for the connection of equipments at substation. An underground cable essentially consists of one or more conductors covered with suitable insulation and surrounded by a protecting cover.Underground cable should have the following properties:

(i) Copper or aluminum conductor for good conduction.
(ii) Economical cross-section.
(iii) Proper insulation thickness.
(iv) Armoring may be required for better mechanical strength.
(v) Should not be corrosive.

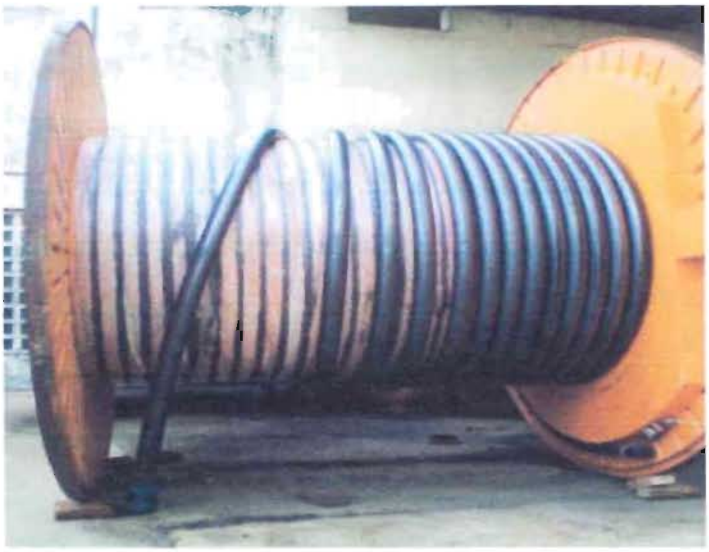


Figure 5.13: Underground cables at APSCL for 132KV line.

5.4.1 Construction of cable:

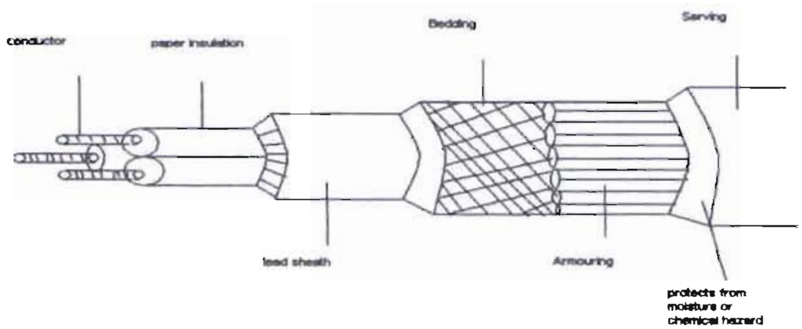


Figure 5.14: Construction of Cable

Conductor:

Conductor may be one core or multi core depending upon the types of service for which it is intend.

Insulation:

Each core or conductor is provided with a suitable thickness of insulation. The thickness of the layer depends upon the voltage to be withstood by the cable.

Bedding:

Jute or hessian type for the placement of the metallic armoring.

Armoring:

Metal for better mechanical strength.

Serving:

Protects armoring from atmospheric condition.

5.4.2 Properties of insulating Cable:

i) High insulation resistance to avoid the leakage current.

ii) High dielectric strength to avoid the electrical breakdown of cable.

iii) High mechanical strength to withstand the mechanical handling of cables

iv) Non-hygroscopic that means it should not absorb moisture from air and soil. In case of insulating material is hygroscopic, it must be enclosed in a waterproof covering like lead sheath.

v) Non-inflammable.

vi) Unaffected by acid or alkalis to avoid any chemical action.

Insulating material those satisfy the requirements:

1. **Rubber:**

Relative permittivity-varying between 2 and 3. Dielectric strength is about 3kv/mm. Receptivity of insulation10^17Ωcm.

But the major drawbacks are that it absorbs moisture and maximum safe temperature is low (about 38 deg Celsius).

2. **Vulcanized India rubber (V.I.R):**

Pure rubber cannot be used as insulating material that's why mineral material such as zinc oxide, red lead and 3 to 5% of sulphur is mixed with the pure rubber. The whole process is called vulcanization. Vulcanized India rubber has greater mechanical strength, durability and wears resistive proper than India rubber.

Its main drawback is that sulphur reacts very quickly with the copper.VIR is generally used for low and moderate voltage cable.

3. **Impregnated paper:**

Impregnated paper has high insulation resistance, high dielectric strength, low cost and low capacitance. The only disadvantage is that paper is hygroscopic. It absorbs moisture and decrease the insulation resistance.

4. **Varnished cambric:**

It is a cotton cloth impregnated and coated with varnish. This type of Insulation is also known as empire tape. Varnished cambric is hygroscopic .Its dielectric strength is about 4kv/mm and permittivity is 2.5 to 3.8.

5. **PVC (polyvinyl chloride):**

PVC (polyvinyl chloride) has high insulation resistance, good dielectric strength and mechanical toughness over a wide range of temperature. This type of insulation is preferred over VIR in extreme environmental condition such chemical factory, cement. As the mechanical property of the PVC are not as good as rubber. Therefore, PVC insulated cables are generally used for low and medium domestic lights and power installations

5.4.3 Classification of cable:

i) Low tension(LT) – up to 1kv

ii) High tension(HT) – up to 11kv

iii) Super tension (ST) – 22-33kv.

iv) Extra high tension (EHT) – 33-66kv.

v) Extra super high tension (ESHT) – beyond 132kv.

Figure 5.15: Cross section of High Tension Cable

CHAPTER – 06

Operation & Maintenance of Substation

There are three major parts in the Ashuganj power station. These are generation, transmission and distribution. For the lossless and minimum errorless distribution of power is the main purpose of power distribution. For this reason power station operation and maintenance is required. Line maintenance also required for distribution power. The substation authority of APSCL maintains their substation in regularly routine. In the certain months the station is maintains. When they maintains they announced to the consumer. General Equipments of substation is power transformer, switchgear or circuit Breaker, current transformer, potential transformer, Isolator, lightening arrester, auxiliary transformer, Bus bar, Battery and Battery Charger and Control Relay Panel. These eqipments are maintained regularly to keep the power distribution line of substation properly.

6.1 Line Construction

The line construction operates by the lineman of APSCL. They tide the conductor strongly for that there is no occurred surge or leakage current. If the line conductor is the loose connection there is produce leakage current and for this reason their produce excessive heat and that's very harmful for substation.

6.2 Maintenance & Inspection of Substation Equipments

Proper installation and preventive maintenance of substation will assure continued electrical power supply, it is very important to the consumers specially, for industrial sector where the curtail of electrical power supply is costly. Maintenance of Substation Equipment of APSCL is Preventive and Schedule Maintenance and Emergency or Break-down maintenance. Inspection of Substation Equipment of APSCL is daily Inspection, weekly Inspection, monthly Inspection, quarterly Inspection, half-yearly Inspection and annual Inspection.

6.3 Operation of Power Transformer

APSCL used many power transformers at various ratings. Such as 130KV, 230KV, 0.4KV power transformer. A transformer is a passive device which transfers alternating (AC) electric energy from one circuit into another through electromagnetic induction. A power transformer in SMPS is designed to change amplitude of high-frequency pulses by the turns ratio and to provide isolation between circuits. The technicians of APSCL check the operation of Tap Changer, operation of cooling control system and operation of breaking system to increase the efficiancy of a power transformer.

6.4 Maintenance of a Power Transformer

To maintain the power transformer of APSCL, the technician do some test. They took those types of test to see the efficiency and life cycle of a power transformer. There are some tests to maintain the transformer oil. The test oil sample of transformer main tank & tap changer tank is to check condition of oil gauges and oil level. The technician of APSCL check for oil leakage & integrity of gasket joints, check the tightness of nuts & bolts, check the insulation resistance of bushing and check that silica gel crystals are blue. He also checks the re-greasing of bearings; check the performance of oil temperature & winding temperature meter changing the oil of OLTC, check the control system and driving mechanism of OLTC and check insulation resistance between each winding and ground. Calculation of Dielectric Absorption Ratio- DAR = (I.R. of 60 sec)/(I.R. of 15 sec).

Test of Insulating Oil:

Table 12: Testing of insulating oil.

Test	Assumptions
Dielectric strength test	Min. 30kV at 2.5 mm gap (12.5mm sphere)
Acidity test	Acid value less than 0.02 mg KOH/g
Moisture content in oil	50-60 ppm
Neutralization number	0.03 mg KOH/gm
Viscosity at 20°C	40 cst
Pour point maximum	-10°c
Flash point	140°c
Dissipation factor or Power Factor	0.5% (at 90°c), 0.1% (at 20°c)
Volume resistivity	5.7×10^{14} Ω-cm
Interfacial tension at 27°C	minimum 0.04 N/m
Dielectric constant	2 to 2.5
Specific gravity	0.895 (at 20 °C)

6.5 Operation and Maintenance of some other equipments

In the sub-station of APSCL, there are many eqipments which is maintained every week by the technitian. Breakers, insulator, transformer, lightning arrester, bus-bar, relay panel of 133KV and 33KV side, feeder protection, Different testing instruments and equipments of Grid Substation and back up protection of bus. Assistant engineer Md. Sahidullah showed the relay operation to open a relay. Transmission line set up also shown by the technician khokan mia and the connection of a cooling fan to the power transformer also done by the students.

6.5.1 Breakers:

A breaker plays an important role in sub-station. Oil circuit breaker, SF6 circuit breaker are used in APSCL at various ratings. There are many testing of breakers done by the students. These types testing are done by students. These are timing and Insulation resistance test, measurement of contact resistance, check SF6 gas pressure and the charging Mechanism, check security of couplings and pipes, measurement condensation temperature (Dew point) of gas, check operation of pressure gauges, hydraulic pressure and check accumulator pre-charge pressure and check for oil leaks and low pressure oil tank oil level.

Before this testing, the connection of breakers is being disconnected. Few days ago, one technitian become affected during testing. So it is very important that to check the connection of all eqipments carefully.

6.5.2 Transformer

In APSCL, there are two types of transformer. Current transformer and potential transformer. To maintenance this transformer, the senior engineer check the physical condition and the insulation resistance of a transformer. They also check the tightness of primary side & secondary terminals, the ratio and Justify the accuracy of the transformer, check for oil leakage for oil immerged CT and PT and check the dielectric strength of oil. To give the protection of this transformer APSCL used some relay. This has lower price and long life cycle. The relay which is used in APSCL is Buchholz relay, differential relay, pressure relief relay, Oil surge relay for OLTC, directional over current, high set over current, earth fault protection: Stand by earth fault or restricted earth fault and thermal over heating protection. These types of relay are low price in the local market. The efficiency of this relay is high. If APSCL want, they used another types of relay to give the protection of sub-station equipments. From all kinds of relay they choose these types of relay to protect the transformer.

6.5.3 Insulator:

There are various types of insulator in APSCL. For 133KV line, there are one types of insulator. For 230KV line, there is another type of insulator. The sub-station manager showed the students, the connection of insulator disk at transmission line. So the testing of insulator is very important factor for APSCL. To testing the insulator, the technician check security of nuts bolts and clamps securing drive parts. He also clean and inspect porcelain insulators, check split pins in clevis and oil all clevis pins and clean and lubricate auxiliary switch contacts. To check the physical strength of an insulator, the testing process is continued in every week. If any insulator is broken, the technician of APSCL replaced it rapidly. Either there will be problems in transmission line. Insulator plays an important role in the power transmission line. So it should be checked in every week by the technician.

6.5.4 Lightening Arrester

APSCL used three types of lightning arrester. Every types of lightning arrester should be checked by the technician of APSCL. The senior engineer, Nur Mohammed showed the maintenance process of lightning arrester. There are such types of maintenance process of lightning arrester. Wash Diverter housing and the check for damage to porcelain housing and for deformation of corona or stress rings. Lightning arrester protects the transmission line and the bus-bar arrangement of APSCL substation. So the maintenance of lightning arrester is very important in the whole substation of APSCL.

6.6 Relay operation

APSCL used three types of relay to maintenance the sub-station. They are electro-mechanical relay, static relay and digital or numerical relay. Electromechanical relay and digital relay used largely in this sub-station. The efficiency and the operational side are very high. In other sub-station, many types of relay are used.

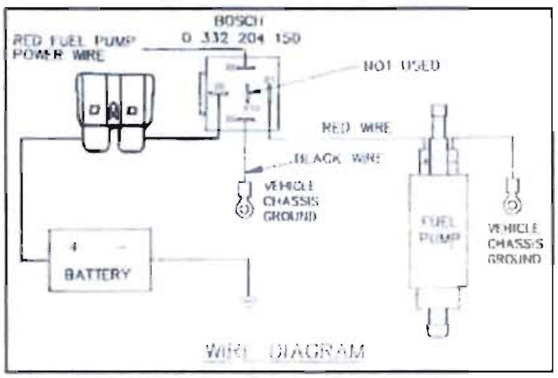


Figure 6.1: Wire diagram of Relay Operation.

6.7 Faults of power system

The conceptual design of network protection schemes determines the secure and reliable supply of the consumers with electricity. The APSCL network protection schemes must recognize incorrect and inadmissible operating conditions clearly and separate the faulty equipment rapidly, safely and selectively from the power system. An expansion of the fault onto other equipment and system operation has to be avoided. Classification of faults of power system in APSCL: Short Circuit fault, Three phase fault (with or without earth), Two phase fault (with or without earth), Single line to ground fault, Open circuit fault, Simultaneous fault. These types of fault are rapidly separated and solved. The power generation process may be delayed for these types of power system faults.

6.8 Feeder protection

Feeder means a connection between two circuits. Feeder can be in the form of overhead transmission lines or cable. APSCL has two types of feeder. One is incoming feeder and another is outgoing feeder. If there are no feeder protections, the supply of electricity will stop in the maximum areas. So it is very important to give the feeder protection in the APSCL sub-station. These types of feeder protection give the APSCL:

1. Non directional Over current and Earth fault protection
2. Directional Over current and Earth fault protection

By this feeder protection, the generation of electricity and the supply of the electricity both are useful for the consumers. Every power station company gives this protection to maintain the power supply nicely.

6.9 Bus bar Protection

In any sub-station, bus bar is one of the main equipment. To protect the bus bar APSCL gives the busbar protection in many protection schemes. Bus bar protection is required when the system protection does not cover the busbars, or when, in order to maintain power system stability, high-speed fault clearance is necessary. APSCL gives bus bar protection by differential protection, over current relay and the frame leakage earth protection. The backup bus bar protection also given by APSCL. Distance protection from remote end and by over current protection from far end.

Bus bar protection is necessary for all types of substation. In APSCL, there are two types of bus bar. One is single bus bar and another is double bus bar. Double bus bar protection is very important from all types of bus bar protection.

In this chapter operation and maintenance of sub-station are briefly discussed. The line construction of sub-station, maintenance and inspection of sub-station equipments, maintenance of a power transformer, relay operation, feeder protection, busbar protection and the different testing instruments and equipments of grid substation are discussed. There are several types of maintenance and protection in APSCL substation. The operation process is maintained by the technicians and junior assistant engineer. Testing instruments and management of sub-station has to be done carefully by APSCL sub-station engineers.

CHAPTER – 07

Control Unit

Mainly there are two ways of monitoring and operating all the individual parts of a power generation system. One is directly from the equipment control system and another one is from control unit. In normal condition most of the monitoring and operations are done from the control unit of the power station. There are two major objective of the control unit.

1. Monitoring
2. Operation

So, control unit is an essential and key section of power station from where a combined controlling operation of both manual and automatic, is done to control most of the system from a master controlling system.

7.1 Monitoring

All the states of individual parts and the metering of different phenomenon of the whole power generation system can be monitored directly from the control unit. There are some indicators which indicate if an individual part is on or off or on some other state. And there are also lots of meters which show the metering values such as pressure, temperature, frequency etc.

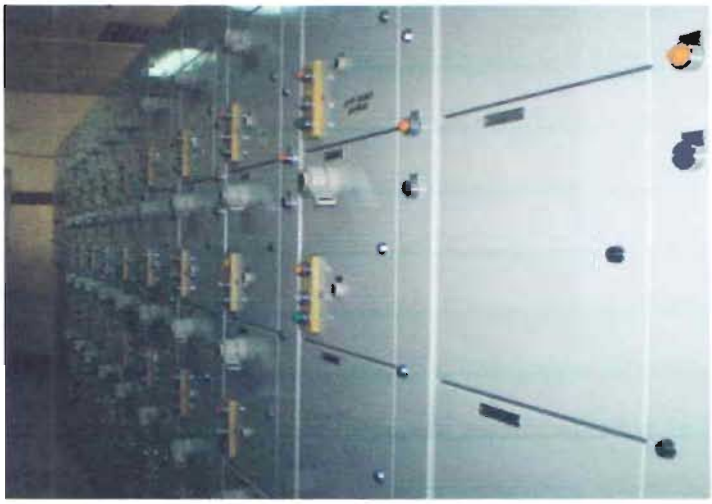


Figure 7.1: Switchgear room of control unit 3

In this room, switchgear protection, motor protection, turbine protection and various types of pump protection are monitoring. In any types of accident occurs, the plant are tripped and the engineers and the senior technitians are solved this immediately.

Figure 7.2: Various Parameters monitoring room of control unit 3

Frequency, temperature, voltages, currents and the capacity of this unit monitored in this room. Here the engineers maintain it very carefully.

7.2 Operation

As the whole power generation system is spread in a wide range area and also as it is not possible to reach to all individual operating parts for operation, an effective and strong operating system is developed in control unit. Several operations can be done at a time instantly from this unit.

Figure 7.3: Operation unit of control unit 3

Mainly two way operating system is developed for most machines or devices. One is directly from the machine control and another one is from the control unit. The local control system can be restricted from the control unit. If it is needed to operate it locally, the local restriction also can be removed from this unit.

Synchronizing different machines and devices cannot be done locally. This is totally done from the control unit.

7.3 Control Units of APSCL

At Ashuganj Power Station and Company Limited (APSCL) there are four control rooms for different unit.

1. control room of unit 1&2
2. control room of unit 3&4
3. control room of unit 5
4. control room of combine cycle

7.3.1 Unit 1 & 2 Control

Unit 1 & 2 of APSCL was developed in 1970. Capacity of each unit is 64MW. Control system of these two units is analog. All the metering and operations are analog.

Figure 7.4: Operation unit of control unit 1 & 2

Due to analog control system some problems are faced by the managers and operators as now a day's digital control system is used widely. If any equipment get damaged, sometimes it becomes difficult to find a duplicate part or to repair it as it is from backdated technology.

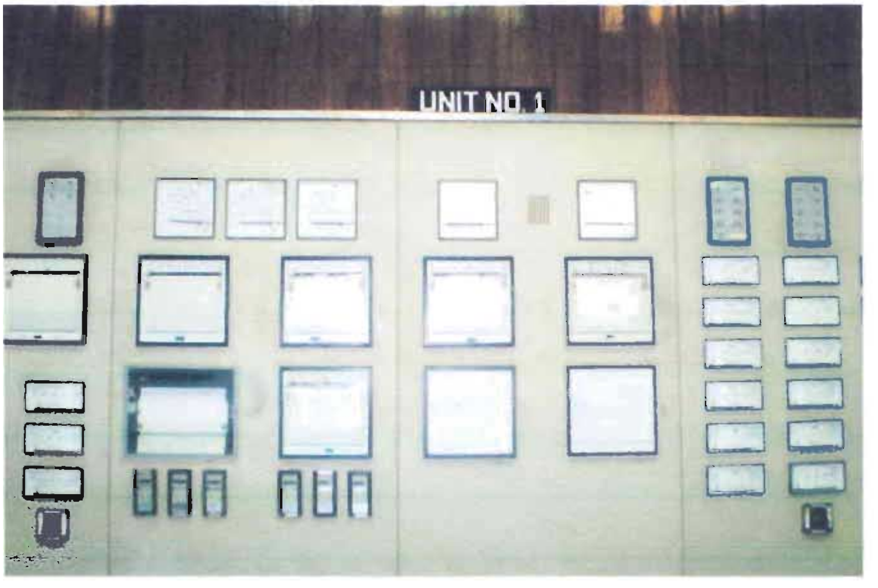


Figure 7.5: Figure of control unit 1

Figure 7.6: Figure of control unit 2

Unit 1 and 2 operated by seniar civil engineer of APSCL and one of the unit was turned off. By this the power generation is quite low because of older technology.

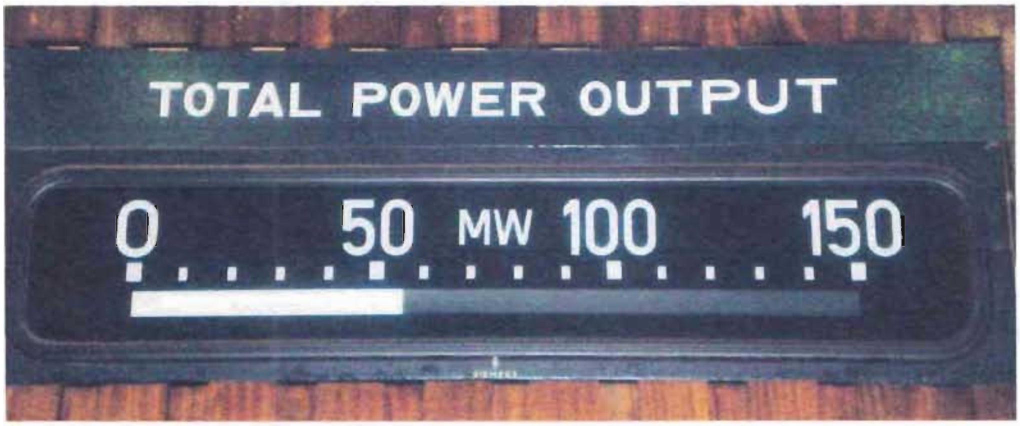


Figure 7.7: Figure of total power output (Unit 1& 2)

7.3.2 Unit 3, 4 & 5 Control

Unit 3, 4 & 5 of APSCL was developed from 1986 to 1988. Capacity of each unit is 150MW. Control system of these two units is digital. All the metering and operations are done by using digital technology.

Figure 7.8: Control unit of 3 and 4

Figure 7.9: Auxiliary Electrical system of unit 3 & 4

Digital metering is more accurate than analog. And operations are also flawless. So due to its advance technology and availability of devices, less problems are faced to operate this unit. And in digital control system, it is easy to upgrade the system according to requirements.

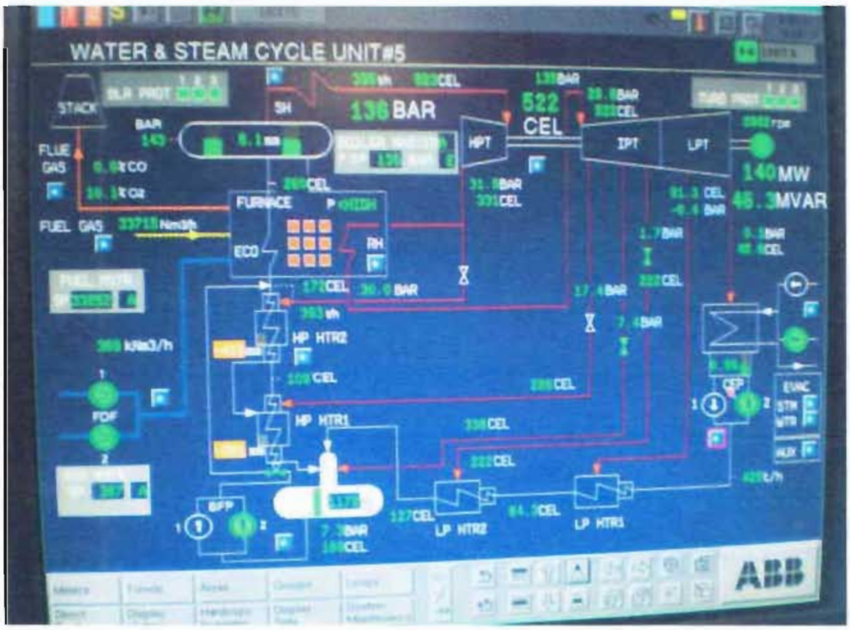


Figure 7.10: Control unit of 5 (Digital)

7.3.3 Combine Cycle Control

Combined cycle is consisting of both gas and steam turbines. It was developed from 1982 to 1986. Its control system is analog. And due to having a very backdated controlling technology its efficiency started going down. And now a day it is very difficult to maintain and repair it.

Figure 7.11: Control unit of combine cycle plant.

Figure 7.12: Switchgear unit of combine cycle plant.

7.4 Control Unit of Sub-Station

Sub-station's control system is analog. Due to having a very backdated controlling technology its efficiency started going down. Now a day it is very difficult to maintain and repair it. Many parts of this control room being damaged. For high costing, APSCL do not maintain it.

Figure 7.13: Control unit of sub-station.

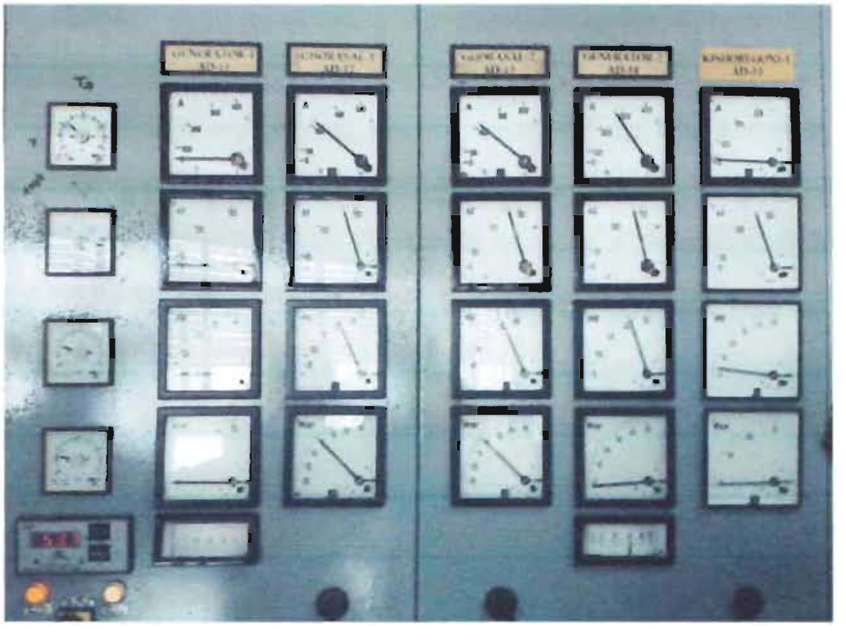


Figure 7.14: Monitoring unit of Sub-station.

7.4 In charge officers

Each Control unit is mainly under a senior mechanical engineer. As only the power generation and some basic objectives are directly related to electrical engineering, but the rest of the system is basically mechanical. That is why a mechanical engineer is in charge of an individual unit to monitor and operate that particular unit. But in case of taking major decisions and faulty situations electrical engineers are immediately called from the official section. Some junior engineers are always there to assist the senior engineer. In this section of power plant 24 hours observation is need, that is why engineers work in different shifts.

Providing a stable source of electrical power, the APSCL must also be highly efficient, provide good operability and have minimal adverse effects on the environment. Meeting these demanding requirements calls for plant supervision and operations that are more advanced and at the same time more intuitive and easy to use. And considering the ongoing trend toward liberalization of the energy market, it is also essential to hold down APSCL construction costs and reduce plant construction schedules.

Control unit one of the most important part of any power plant. A control room is necessary to operate the switchgear, generator, motor, relay, turbine etc. At Ashuganj Power Station Company Limited (APSCL) there are four control room for different unit which is discussed above. The latest control unit - 5 is software base control room. This control room is fully modified in digital system in 2005. Here all equipments are operated by software. In this control room we can observe everything of unit 5 on computer. Operation system of Control units 1,2,3,4 are still analogue. As result monitoring operator and in charge engineers faces many problems to operate it. So APSCL will be shifting all control units in digital system. It is very easy to control the whole units of APSCL in software. It may be helpful for the maintenance system of APSCL engineers.

CHAPTER – 08

Conclusion

8.1 Observation

1. The internship program should be scheduled in such a way so that it does not clash with the university classes.
2. Practical participation in different works of Ashuganj Power Station Company Limited would give us more experience, but unfortunately it was not within the policy of APSCL. We were just observer.
3. Because of the company confidentiality, we could not achieve some important information through we were much interested to know these things.
4. We faced some problems during internship as we had not completed one pre-requisite course (EEE 447), which were related to the internship program.
5. The authority of APSCL could not give us sufficient time as that was the time of closing of the year's activity book. This is critical and very busy time for them.

8.2 Recommendation

1. Students must complete the courses related to their internship before beginning the programme. Taking the courses before the internship helps the students understand the topic much better.
2. The tenure of our internship program with APSCL was only for two weeks. Even these duration gave was exposure to the practical aspects of theoretical issues. Considering the benefits of practical exposure, the following recommendations have been put forward for the consideration of the management of Electrical and Electronics Engineering department of East West University.
3. The EEE Department should sign MoU (Memorandum of Understanding) with prospective companies like Energypac for ensuring internship program for the students.

8.3 Conclusion:

We passed some remarkable days at APSCL during our internship program. APSCL could be regarded as the practical ground of the Electrical and Electronic Engineering Department of East West University. The theories that we have learned at the University could be observed at the APSCL. We consider ourselves very much lucky to have our internship program with a reputed power station company like APSCL. It gave us an opportunity to apply our theoretical knowledge in practice. Our achievements from APSCL are:

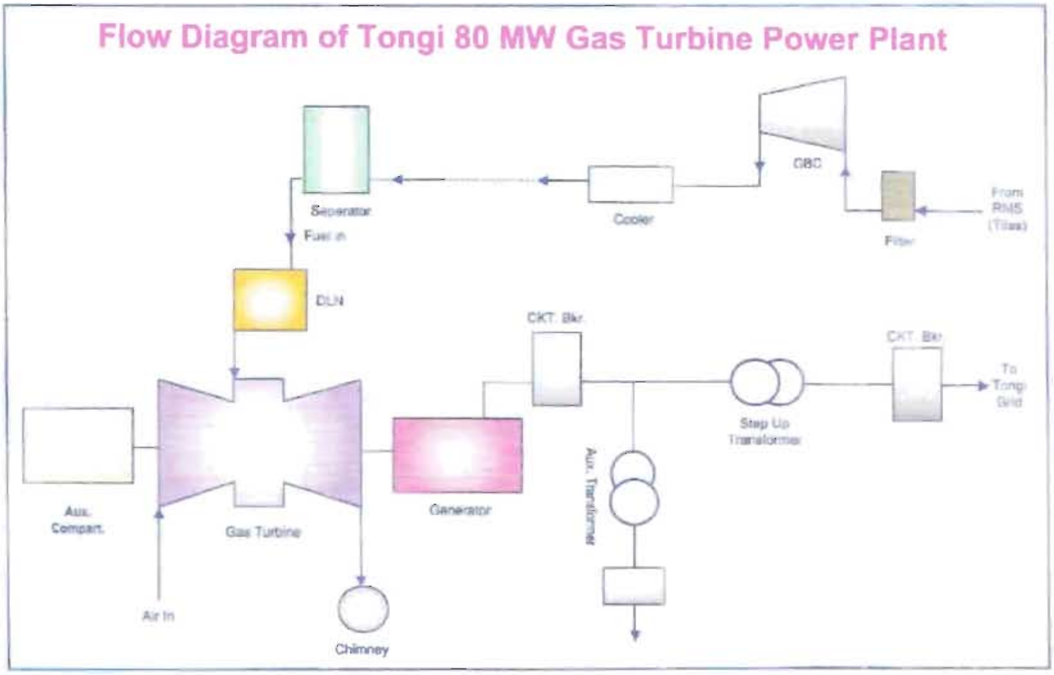
- Industrial training provided by APSCL has enriched our practical knowledge.
- It has opened our eyes about practical operation of different equipments.
- It has increased our confidence to face interview in future.
- APSCL gave us the unique experience of observing the equipment

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.

APSCL is the second leading company in Bangladesh. Its strategic aim is to strengthen the leading position and to ensure continued growth which leads it to be the leading power station company in Bangladesh and start to introduce themselves not only in Bangladesh, all over the world.

Appendix A

To make the similarities of APSCL flow diagram, there are some important flow diagram of Tongi power station, Siddhirganj power station and Barapukuria power station.



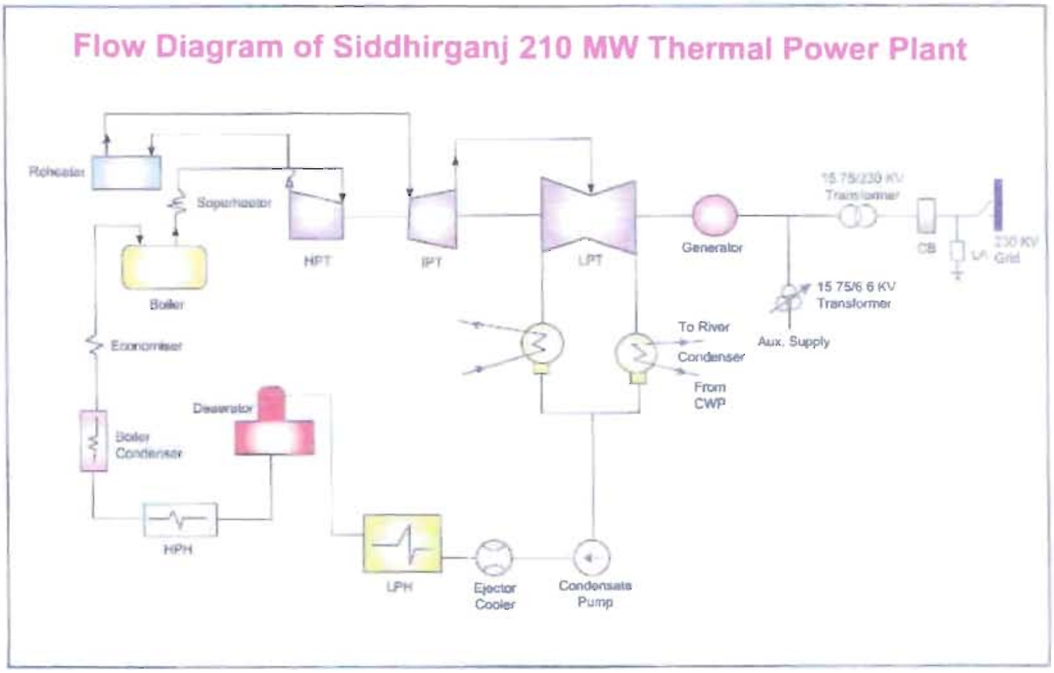


Figure A.1: Tongi and Siddhirganj Power Plant Flow diagram.

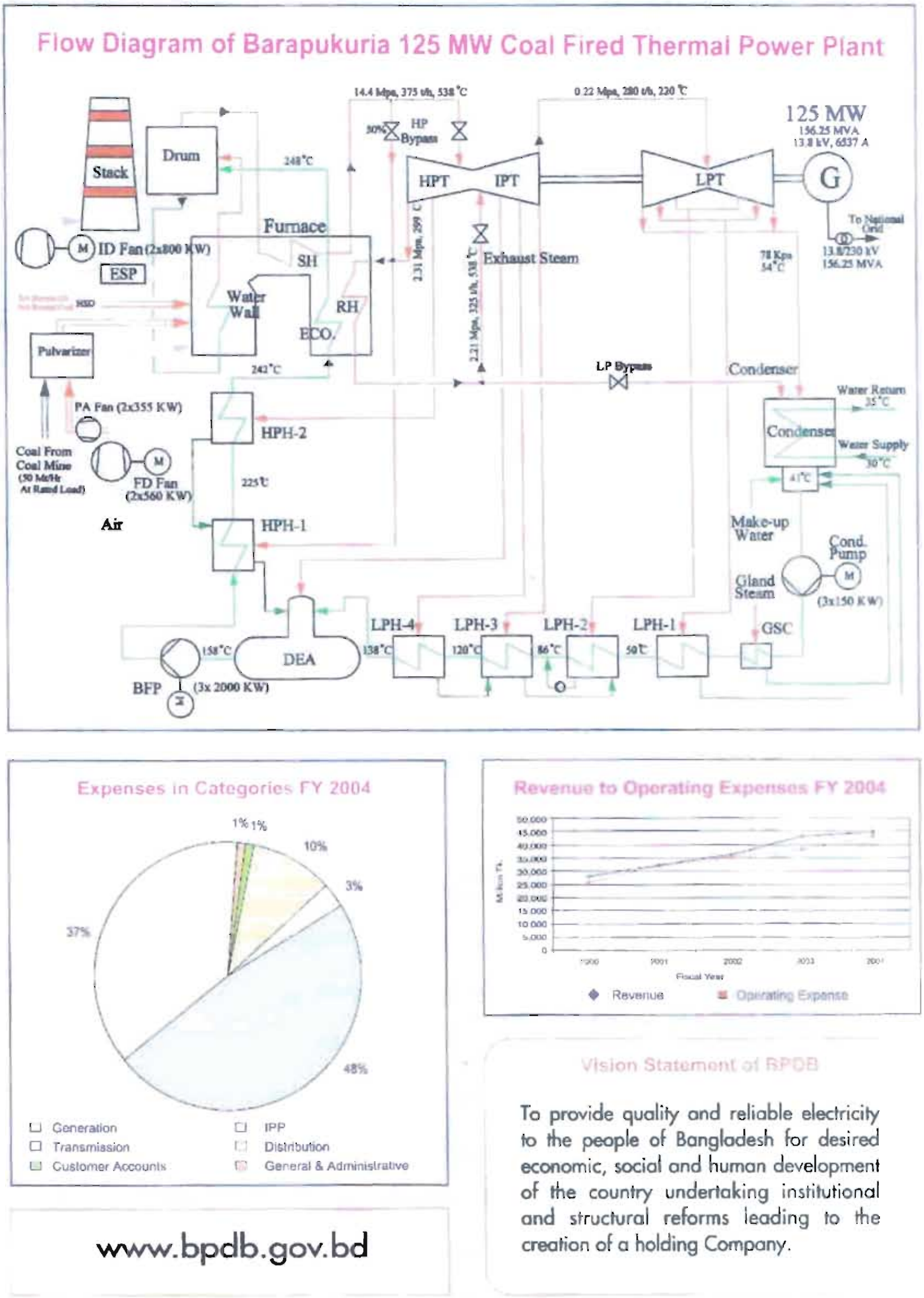


Figure A.2: Barapukuria Power Plant Flow diagram.

Appendix B

Some Snapshot of Ashuganj Power Station Company Limited:

Figure B.1: At Ashuganj Power Station Company Limited as team.

References

1. http://www.gers.com.co/pdf/Generator_Protection_gers.pdf
2. http://www.basler.com/downloads/genprotguidC.pdf
3. http://www.ceerelays.co.uk/brochures/CEE%20PRAG.pdf
4. http://canteach.candu.org/library/20030805.pdf
5. http://itee.uq.edu.au/~elec4302/Document%20Folder/Lecture%20PDF%20files/Generator%20Protection%206%20slide%20per%20page.pdf
6. http://www05.abb.com/global/scot/scot296.nsf/veritydisplay/c1256d32004634bac1256e0f006bf54f/$file/1mrk509042-ben_en_reverse_power_relay_and_protection_assemblies_rxppk_2h__rappk.pdf
7. http://books.google.com/books?id=e0kdmbuWB0gC&pg=PA1&dq=generator+protectio#v=onepage&q&f=false
8. http://en.wikipedia.org/wiki/Thermal_power_station
9. http://www.electricneutron.com/motor-control/motor-overload-protection
10. http://books.google.com/books?id=mowX6Mi-C20C&printsec=frontcover#v=onepage&q&f=false
11. http://itee.uq.edu.au/~elec4302/Document%20Folder/Lecture%20PDF%20files/Generator%20Protection%206%20slide%20per%20page.pdf
12. http://www.gers.com.co/pdf/Generator_Protection_gers.pdf
13. V.K. Mehta & Pohit Mehta, "Principles of Power system", 4th Revised Edition, 2009, S.Chand & Company Ltd, 2009.
14. M.V. Deshpande, "Elements of Electrical Power Station Design", 3rd Edition, 1986, A.H.Wheeler & Company Private Ltd.
15. V.P. Vasandani & D.S.Kumar, " Heat Engineering", 4th Revised Edition, 1995, Metropolitoan Book Co. Pvt. Ltd.
16. http://www.thefreedictionary.com
17. http://powerelectrical.blogspot.com
18. http://www.engineersedge.com
19. http://www.dieselserviceandsupply.com