INTRENSHIP REPORT
ON

Ashuganj Power Station Company Ltd (APSCL)

BY

Mirza Rishad Hasan (2008-1-80-018)

Md. Mahfuzul Hassan (2008-1-80-017)

Anika Sharmin (2008-1-80-003)

Submitted to the
Department of Electrical and Electronic Engineering
Faculty of Science 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

4.10.11
Academic Advisor
Sharmin Rowshan Ara

04.10.2011
Academic Advisor
Tahseen Kamal

04.10.2011
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
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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

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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

Intern Evaluation Form

Intern Evaluation Form

(To be filled up by the mentor)

Name and ID of mentored student: Mirza Rishad Hasan 2018-1-80-018

1) Punctuality
   - ☑ Excellent ☐ Good ☐ Poor
2) Sincerity
   - ☑ Excellent ☐ Good ☐ Poor
3) Interest in work
   - ☑ Excellent ☐ Good ☐ Poor
4) Follows instructions
   - ☑ Very well ☐ Well ☐ Not so well
5) Interpersonal skills
   - ☐ Excellent ☑ Good ☐ Poor
6) Communicating skills
   - ☑ Excellent ☐ Good ☐ Poor
7) Suitability for employment
   - ☑ Excellent ☐ Good ☐ Poor
8) Overall evaluation
   - ☑ Satisfactory ☐ Unsatisfactory

General feedback (if any):

I am very much satisfied by his work.

Information about mentor:

Name : Md. Azizur Rahman

Address : Ashuganj, B-Baria.

Position/Title : Senior Engineer. (E&IC).CCPP.

Phone : +8801712542318.

Company : APSCL

Email : shamim.rj@gmail.com.

Signature : ARahman 23/5/22

Date : __/__/____

Intern Evaluation Form

(To be filled up by the mentor)

Name and ID of mentored student	Md. Mahfuzul Hasan	2008-1-80-017

1) Punctuality

- [x] Excellent
- [ ] Good
- [ ] Poor

2) Sincerity

- [x] Excellent
- [ ] Good
- [ ] Poor

3) Interest in work

- [x] Excellent
- [ ] Good
- [ ] Poor

4) Follows instructions

- [x] Very well
- [ ] Well
- [ ] Not so well

5) Interpersonal skills

- [x] Excellent
- [ ] Good
- [ ] Poor

6) Communicating skills

- [ ] Excellent
- [x] Good
- [ ] Poor

7) Suitability for employment

- [x] Excellent
- [ ] Good
- [ ] Poor

8) Overall evaluation

- [x] Satisfactory
- [ ] Unsatisfactory

General feedback (if any):

I am satisfied by his work.

Information about mentor:

Name : Md. Azizur Rahman

Address : Ashuganj, B-Baria.

Position/Title : Senior Engineer. (E&IC), CCPP.

Phone : +8801712542318.

Company : APSCL

Email : shamim.pj@gmail.com.

Signature: ARahman

Date: 21/5/11

Intern Evaluation Form

(To be filled up by the mentor)

Name and ID of mentored student	Anika Sharmin	2008-1-80-003

1) Punctuality

☑ Excellent ☐ Good ☐ Poor

2) Sincerity

☑ Excellent ☐ Good ☐ Poor

3) Interest in work

☑ Excellent ☐ Good ☐ Poor

4) Follows instructions

☑ Very well ☐ Well ☐ Not so well

5) Interpersonal skills

☑ Excellent ☐ Good ☐ Poor

6) Communicating skills

☑ Excellent ☐ Good ☐ Poor

7) Suitability for employment

☐ Excellent ☑ Good ☐ Poor

8) Overall evaluation

☑ Satisfactory ☐ Unsatisfactory

General feedback (if any):

She satisfied me by her work.

Information about mentor:

Name : Md. Azizur Rahman
Address : Ashugonj, B Baria
Position / Title : Senior Engineer (E&IC), CCPP
Phone : +8801712549 2318.
Company : APSCL
Email : shamim.rj@gmail.com.

Signature: ARahman

Date: 21 / 5 / 11.

Acknowledgment

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

We want to thank all those people who helped to complete our internship report successfully. In this process our special thanks goes to Engr. A.K.M. Yaqub, Manager(Generator), APSCL and Engr. Lutfurrahman (Principal of Trainnig Center, APSCL) who coordinated our internship program and helped us to get acquainted with other engineers. We are very grateful to Engr. Md. Rokon Mia,senior engineer(Generator and switchgear protection), Engr. Md. Kamruzzaman, senior engineer (Generator and switchgear protection), Engr. Md. Azizyr Rahman, senior engineer (combine cycle power plant), Engr. Md. Sahid Ullah, senior engineer(Sub-station) for their supportive guidance. They helped us to learn the scheduled topic which was present in our internship training schedule. We also want to thank each and every employee of APSCL for their continual support.

We would also like to mention the name of Dr. Anisul Haque, Chairperson& Professor of the Department of Electrical & Electronic Engineering, and East West University (EWU) for his support and encouragement throughout the period of our internship.

We take this opportunity to extend our sincere thanks and gratitude to our honorable supervisors Sharmin Rowshan Ara, Senior Lecturer, Department of Electrical & Electronic Engineering, East West University (EWU) and Tahseen Kamal, Senior Lecturer, Department of Electrical & Electronic Engineering, East West University (EWU) for giving their valuable time for us to complete this report successfully.

Executive Summary

We did our internship at Ashuganj Power Station Company Ltd (APSCL) located at 90 km North-East of Dhaka on the left bank of the river Meghna from 30th of April to 14th of May and this internship report is the result of those 15 days attachment with the APSCL. During our internship period we gathered practical experiences over the topics related power generation, switchgear protection and power distribution which we have learned inside the class room or from books. In this report we have focused on the processes which are used in APSCL.

For power generation, steam and gas turbine power plants are used in APSCL. So we observed the process of power generation by steam and gas turbine power plant. During our internship period unit 1 and 4 of steam turbine power plant were under overhauling situation. So we had the opportunity to observe the inside part of the generator (rotor and stator) and turbine chamber which helped us to collect more knowledge about these topics.

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

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

There are various types of tests (megar test, motor test, transformer test) which are performed by the technicians and engineers of the APSCL. With the help of the technicians we performed these tests successfully during our internship period.

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ASHUGANJ POWER STATION COMPANY LTD.
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APSCL

Ashuganj Power Station Company Limited

Internship Programme

Day	Topic	Superintendent Engineer
Saturday 30.04.2011	Backup System/Generator and Turbine Introduction/Breaker/Megar testing of transformer.	Engg. Md.Rokan Mia Senior Engineer (Generator & Switchgear protection)
Monday 02.05.2011	Generator Excitation & Protection/Transformer protection/Control System of unit 3, 4.	Engg. Md.Kamruzzaman Senior Engineer (Generator & Switchgear protection)
Tuesday 03.05.2011	Auxiliary Electrical System/Bus bar Connection/Boiler Sub-Distribution Board /Rectifier and Main-Distribution Board.	Engg. Md.Rokan Mia Senior Engineer (Generator & Switchgear protection)
Wednesday 04.05.2011	Generator Protection(continue)/Transmission Line Protection/Shunt Reactor/Transformer Maintainance(Testing)	Engg. Md.Kamruzzaman Senior Engineer (Generator & Switchgear protection)
Thursday 05.05.2011	Generator Cooling System/ Control System of unit 5(Digital)/Motor Winding/Excitation & Synchronization.	Engg. Md Rokan Mia Senior Engineer (Generator & Switchgear protection)
Saturday 07.05.2011	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)

Day	Topic	Superintendent Engineer
Sunday 08.05.2011	Introduction of Sub-Station/Protection System/Single Line Diagram/Bus Bar System/High Voltage Transformer	Engg. Md.Shahid Ullah Assistant Engineer (Sub Station)
Monday 09.05.2011	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)
Tuesday 10.05.2011	Combine cycle Plant/CT1,CT2,ST/Motor Valve/Condenser/Single Line Diagram of Combine Cycle Plant	Engg. Md Azizur Rahman Senior Engineer (Combine Cycle PP)
Wednesday 11.05.2011	CB rating/ Relay setup/Over current Earth fault relay/Transformer Relay/Arc Extinction Procedure/Mechanism of SF6 circuit breaker	Engg. Md.Shahid Ullah Assistant Engineer (Sub Station)
Thursday 12.05.2011	PLC protection of Sub Station/Battery Types/High Voltage Breaker Rating/Underground Cables/Cooling Fan Connection	Engg. Md.Shahid Ullah Assistant Engineer (Sub Station)
Saturday 14.05.2011	Protection of Underground Cables/Bulk oil circuit Breaker/Transmission Process of 132 KV, 230 KV Line/	Engg. Md.Shahid Ullah Assistant Engineer (Sub Station)

21/5/11

Engr. A.K.M. Yaqub
Manager (Generator)
APSCL

1. Introduction:

In the Summer semester of 2011 we got the opportunity for doing internship in Ashuganj Power Station Company Ltd (APSCL). We started our internship on 30th of April and completed on 14th of May. From APSCL we have gathered practical experience over power generation process, power generating equipments protection and power distribution system. Before this internship we had only theoretical knowledge over these topics but on completion of internship in APSCL we had the opportunity to experience the process of power generation, switchgear protection and power distribution system and get the chance to observe the industrial environment. APSCL is the second largest power station in Bangladesh. The total capacity of APSCL is 724 MW which is generated by 8 units. Presently the available capacity is 642 MW. Ashuganj Power Station fulfills about 15% of power requirements of the country.

1.1. Company Profile:

- Name of the Company: Ashuganj Power Station Company Ltd (APSCL).
- Date of Incorporation: 28 June 2000.
- Registration No: C-40630 (2328)/2000 dt. 28.06.2000.
- 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)
    1. Two Steam Units of 64MW- Unit # 1 & 2 each-commissioned in 1970.
- Plant 2: Combined Cycle Power Plant (CCPP)
    1. Gas Turbine Units-GT1 and GT2 of capacity 56MW. Each unit was commissioned in 1982 and 1986 respectively.
    2. One Steam Turbine (ST) of capacity 34MW with waste heat recovery Boiler commissioned in 1984.
- Plant 3: Thermal Power Plant (TPP)
    1. Unit # 3 of 150MW capacity was commissioned in 1986.
    2. Unit # 4 of 150MW capacity was commissioned in 1987.
    3. Unit # 5 of 150MW capacity was commissioned in 1988.

1.1.1. Vision:

To generate electric power and dispatch same through transmission line of PGCB Ltd and ultimately to BPDB. 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.

1.1.2. Mission:

To ensure long-term uninterrupted supply of quality power to the consumers in future.

1.1.3. Objective:

To carry out the business of electric power generation. To supply and sell of electricity thus produced to Bangladesh Power Development Board through National Grid for the purposes of meeting the need of electric power, and for all other purposes for which electric energy can be utilized.

1.1.4. History:

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. [11]

1.1.5. Formation of the Company: Ashuganj Power Station Company Ltd. (APSCL):

As a part of the Power Sector Development & Reform Program of Government of Bangladesh (GOB), APSCL has been incorporated under the Companies Act 1994. APSCL has been registered in the office of the Register of the Joint Stock Companies & Firms of Bangladesh on 28 June 2000.

1.1.6. Management Team:

Since 09.02.2008

Engr. Mr. Md. Nurul Alam P.Engg.
Managing Director

Engr. Mr. Md. Nurul Alam P.Engg.
Director (Technical) Charge

Mr. Mohammed Shahid Ullah, FCMA
Director (Finance) Addl. Charge

Board of Directors:

Chairman
Addl. Secretary

Director
Joint Secretary
(Development)
Energy & Mineral
Resources Division,
MOPEMR

Director
Professor, Dept. of Electrical &
Electronic Engineering
Bangladesh University of Engineering
& Technology, Dhaka

Director
Deputy Secretary (Development)
Power Division, MOPEMR

Director
Director-12, Prime Minister's Office,
Dhaka

Director
Past President & Council
Member
Institute of Cost & Management
Accountants of Bangladesh

Director
Member (Planning &
Development), BPDB

Director
Director, FBCCI, Dhaka.
Nominated by Power Division

Director
GM, Commercial Operation
BPDB, Dhaka
Nominated by Chairman of BPDB

Director
Managing Director, APSCL

1.1.7. Plant Present Status:

DESCRIPTION	2 X 64 MW		3 X 150 MW			2 X 56 MW		1 X 34 MW
	UNIT –1	UNIT – 2	UNIT – 3	UNIT – 4	UNIT – 5	GT – 1	GT – 2	ST
Date of Commissioning	17-07-1970	08-07-1970	17-12-1986	04-05-1987	21-03-1988	15-11-1982	23-03-1986	28-03-1984
Installed Capacity (MW)	64	64	150	150	150	56	56	34
Present (De-rated) Capacity (MW)	64	64	102	140	150	40	40	20
Total Running Hrs. since installation	228,939.98	199,450.15	181,952.94	182,591.35	159,919.20	146,301.77	109,943.46	84,009.03
Total Generation since installation (GWh)	10,473.15	9,453.80	21,833.64	21,176.63	29,119.64	5,812.51	6,446.74	1,695.10
Auxiliary Consumption of the Station	4.4510	7.6053	6.9865	7.1468	6.1035	0.1653	0.1021	-
Gas Consumption per unit of Generation (M^3/KWh)	0.33043	0.33043	0.29261	0.29261	0.29261	046020	0.46022	CC=0.3336
Cost of Fuel per unit of Generation	0.93	0.93	0.83	0.83	0.83	1.30	1.30	CC=0.87
Net Efficiency of the Plant	28.06	28.06	31.68	31.68	31.68	20.14	20.14	CC=27.79

1.1.8. Unit wise Maximum Power Generation:

DESCRIPTION	2 X 64 MW		3 X 150 MW			2 X 56 MW		1 X 34 MW	Total
	UNIT –1	UNIT – 2	UNIT – 3	UNIT – 4	UNIT – 5	GT – 1	GT – 2	ST	
Installed Capacity (MW)	64	64	150	150	150	56	56	34	724
Present (De-rated) Capacity (MW)	64	64	102	140	150	40	40	20	620
Generation at Maximum Demand on (Date Wise)									
31 Dec, 2010	-	64	105	-	140	38	40	18	405

1.2 Objective of the Internship:

The objectives of the internship are summarized below:

- Understanding company management.
- Understanding industrial environment.
- Acquiring practical knowledge about power generation
- Acquiring practical knowledge about switchgear protection and substation.
- Developing practical skills and techniques relevant to our career.
- Indentifying the problems of APSCL.
- Recommending how it can be solved.

1.3. Scope and Methodology:

This report is based on the internship program where we reviewed the basic process of power generation, switchgear protection, power distribution and substation of APSCL. It also contains descriptions of various mechanical and electrical equipments which are used to generate and distribute power in APSCL. The report contains other relevant information about the APSCL which we observed during the internship program.

This report is written on the basic of two ways information collection. These are:

- **Primary information:** The information is gathered by personal observation and working with the plant engineers at APSCL
- **Secondary information:** The company website and various single line diagram provided by the engineers whom we worked with.

2. Power Generation:

2.1. Generation of Electrical Energy:

The conversion of energy available in different forms in nature into electrical energy is known as generation of electrical energy.

Energy is available in various forms from different natural sources such as pressure head of water, chemical energy of fuels, nuclear energy of radioactive substances etc. Al these forms of energy can be converted into electrical energy by the use of suitable arrangements. The arrangement essentially employs an Alternator or Generator is coupled to a prime mover. The prime mover is driven by the energy obtained from various sources such as burning the fuel, pressure of water, force of wind etc [1].

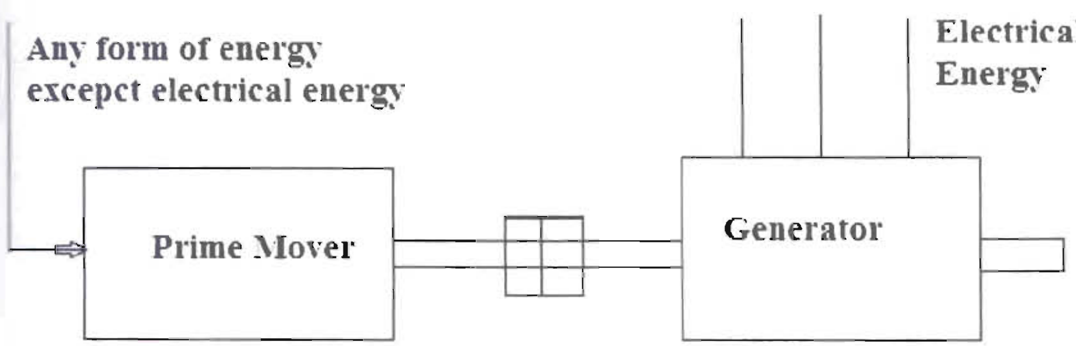

Figure 2.1 : Process of Generation of Electrical Energy

The chemical energy of fuel (e.g., Natural gas) can be used to produce steam at high temperature and pressure. The steam is fed to a prime mover which is a steam turbine. The turbine converts heat energy of steam into mechanical energy which is further converted into electrical energy by the generator. Similarly, the other forms of energy can be converted into electrical energy by employing suitable machinery and equipments.

In APSCL natural gas from Titas Gas Transmission and Distribution Company Ltd (TGTDCL) is used as a fuel to produce steam and the pressure of steam is used to rotate the steam turbine. There is also a gas turbine where pressure of natural gas is used to rotate the gas turbine.

2.2 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 [4].

There are two types of generator:

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

Figure 2.2: AC generator of ST-2 and GT-1 of APSCL

In APSCL there are five generators in steam power plant section and three generators in combined cycle power plant section. All the generators produce AC current. So these are AC Generators.

Table 2.1: 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

2.2.1. Construction and working principal of Generator:

Construction:

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 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 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.

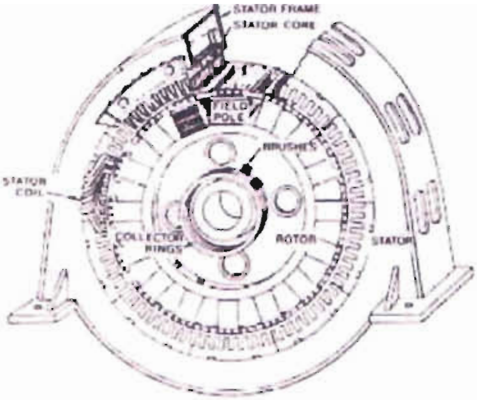

Figure 2.3: AC Generator [6]

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 [5].

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.

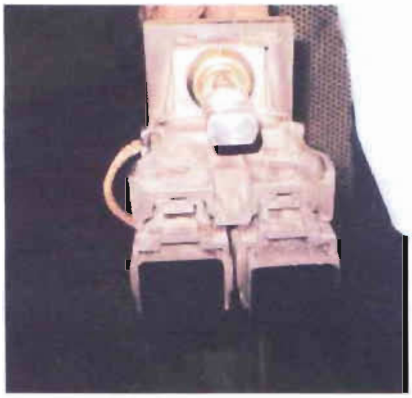

Figure 2.4: Brush

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.

5. 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 [5].

The above mentioned components are present in the generators of 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.

Working Principle:

From faraday's law of induction we know,

The induced electromotive force (EMF) in any closed circuit is equal to the time rate of change of the magnetic flux through the circuit.

If ● = Magnetic flux, N = Number of turns in the coil, t = Time

and ε = Induced electromotive force(EMF)

Then from the faraday's law we get,

$$\varepsilon = N \frac{\Delta \Phi}{\Delta t}$$

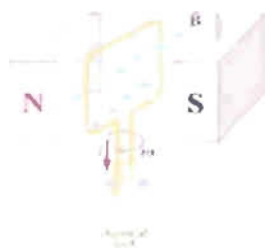

Figure 2.5: Faraday's Law of Induction

From the figure we can see that a coil of N turns is rotating inside a magnetic field. The magnetic flux varies with time, thereby inducing an EMF.

The operation of electric generators is based on the phenomenon of electromagnetic induction. Whenever a conductor moves relative to a magnetic field, voltage is induced in the conductor. If a magnet is spinning inside a coil, AC voltage is induced in the coil. The induced voltage which is known as electromagnetic force or EMF will create current through an external circuit connected to the coil, resulting in energy being delivered to the load. Thus the kinetic energy that spins the source of the magnetic field is converted into electricity. The current flowing through an external load in turn creates a magnetic field that oppose the change in the flux of the coil, so the coil opposes the motion, The higher the current, the larger the force that must be applied to the magnet to keep it from slowing down.

In most AC generators, the armature is the stator and the field structure is the rotor. This means that the electromagnets which make up the field structure rotate so the magnetic field sweeps past the armature coils. In these generators, the slip rings are used to carry the direct current from the exciter generator to the electromagnets in the field structure. Outside wires connected to the armature coils take the alternating current induced in the armature directly from the armature. Engineers have found that it is easier to conduct the relatively weak current from the exciter through the slip rings and to take the heavy current produced in the armature directly from the armature. This kind of AC generator is also called a synchronous generator because it generates a voltage that has a frequency proportional to, or synchronized with, the speed of the rotor [7].

2.2.2 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. Brushless Thyristor Excitation System
3. Static Excitation System
4. DC Excitation System

In APSCL AC, Brushless and Static excitation systems are used.

1. AC Excitation System:

This excitation system is used in the generator of unit 1 and 2 of steam turbine in APSCL.

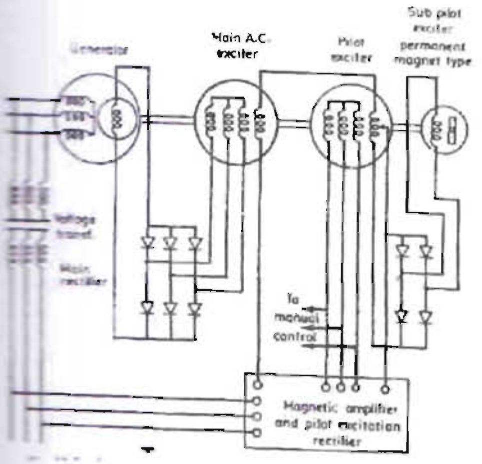

Figure 2.6: Schematic diagram [2] and outlook of AC excitation system

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].

Three phase voltage from the pilot exciter feeds into the magnetic amplifier. If an automatic voltage regulator is not in use, this can be supplied to manual control. The exciter stator generates required voltage which is rectified by the main rectifiers and the excitation is fed to the field winding of the generator.

2. Brushless Thyristor Excitation System:

The brushless thyristor excitation system is present in generator of gas turbine of APSCL.

A brushless diode excitation system consists of an exciter having stationary field system and a rotating armature diode rectifier assembly solidly coupled to the main generator rotor. The most

Figure 2.7 : Brushless Thyristor Excitater used in the combined cycle power plant of APSCL.

commonly used rectifier configuration is that of three phase bridge. If the silicon diodes are replaced by thyristors and suitable arrangements are made to apply firing pulses to their gates with the firing angle under control of the operator then it is possible to change the excitation voltage over the range in 10 milliseconds or less. The input voltage of thyristor converter has a constant value equivalent to the ceiling excitation voltage required by the generator. The thyristor converter performs dual functions. The functions are rectification and control of the mean voltage supplied to the generator field. This voltage can be varied from full positive ceiling to a substantial negative ceiling [2].

3. Static Excitation System:

This excitation system is used in the generator of unit 3, 4, 5 of APSCL.

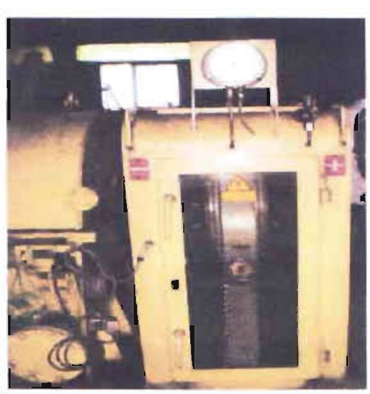

Figure 2.8: Static Exciter used in unit-3, 4, 5 of steam power plant of APSCL

In the static excitation system, the generator field is fed from a thyristor network shown in figure-2.9. It is just sufficient to adjust the thyristor firing angle to vary the excitation level. A major advantage of such a system is that, according to the requirement the field voltage can be varied through a full range of positive to negative values rapidly with the ultimate benefit of generator voltage regulation during transient disturbances. The thyristor network consists of either 3-phase fully controlled or semi controlled bridge rectifiers. Field suppression resistor dissipates energy in the field circuit while the field breaker ensures field isolation during generator faults [2].

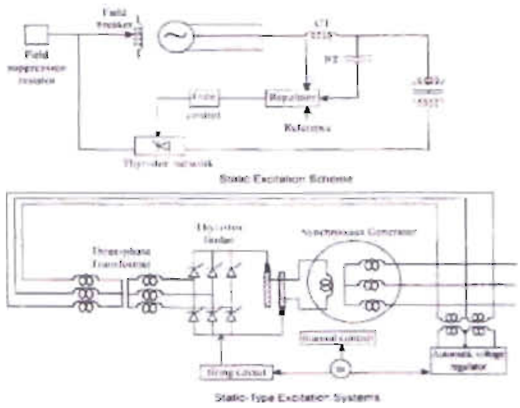

Figure 2.9: Static type excitation system [2]

2.2.3. 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. Synchronization of frequency
2. Synchronization of voltage
3. Synchronization of phase sequence
4. Synchronization of phase angle

1. Synchronization of 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.

2. Synchronization of Voltage:

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

3. Synchronization of 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.

4. Synchronization of Phase angle:

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

Figure 2.10: Synchronization of unite-5 of steam power plant of APSCL

4. Process of Synchronization of Generators of Combined Cycle Power Plant (Gas Turbine Unit - 1, 2 and Steam Turbine):

In combined cycle power plant of APSCL the generators are synchronized by synchroscope.

Synchroscope:

Synchroscope is an instrument used for indicating whether two alternating-current (ac) generators or other ac voltage sources are synchronized in time phase with each other. Its main use is in power supply networks where, if two generators are to be operated in parallel or an additional generator is to be coupled into the grid, it is essential that the generator voltages should be matched in amplitude, frequency, and phase.

Figure 2.11: Synchroscope

Method of using Synchroscope:

When operators of an electric generator wish to connect it to the grid, they first start the generator spinning at a rate approximately equal to the line frequency of the grid with which they plan to connect. The voltage of the generator is then matched with the grid by adjusting the field current. The synchroscope is connected to the power grid and to the generator being started.

If the generator is turning at a lower frequency than the grid, the synchroscope needle rotates continually in the direction (usually counterclockwise) marked "slow" or "lag" on the dial to indicate that the generator is running slower than, or lagging behind, the grid. If the generator is running faster than the grid, the needle rotates continually in the opposite direction, marked "fast" or "lead". Next, the plant operator adjusts the speed of the generator until it is running at precisely the same speed (frequency) as the grid. As the frequency of the generator nears that of the grid, the synchroscope needle slows down and when the frequencies match, the needle stops rotating.

At this point, there is one more task to perform before the generator can be connected to the grid. Although the generator and the grid are now operating at the same frequency, they are not necessarily at the same position in the rotational cycle as each other. If two electrical networks operating at two different phase angles were to be connected to each other, a fault similar to a short circuit would occur and most likely destroy the generator and damage the grid.

The position (as opposed to rotation) of the needle on a synchroscope indicates the phase angle between the two systems. The angle between the systems is zero when the synchroscope needle is pointing directly to the line in between the "slow" and "fast" markings on the dial

If the needle reads "fast," then the plant's generator is slowed down by a very small amount and the needle turns counterclockwise (toward the zero mark). Alternatively, if the needle reads slow," then the plant operator speeds the generator up slightly, and the needle turns clockwise. Slightly before the needle reaches the zero mark, the plant operator returns the generator to the grid frequency in order to stop the needle when it reaches the zero mark. When the needle is at zero and is not moving, the two systems are synchronized.Once the two systems are synchronized, they can be safely connected.

Depending on the application and the circuit design, the breaker is closed when the synchroscope is pointing at approximately 5 minutes to noon, while traveling slowly in the fast direction, to allow the incoming generator to come onto the grid as a source. The purpose of this action is to prevent the possibility of the oncoming generator paralleling onto the grid as a load. This has the potential to cause the generator to operate as a motor which can cause damage to the generator and the prime mover [8].

B. Synchronization Process of Generators of Steam Power Plant (unit: 1-5)

In steam power plant of Ashuganj Power Station Company Ltd (APSCL) the generators are synchronized by Synchrotact manufactured by ABB Company.

Synchrotact:

Synchrotact is an electronic device manufactured by Brown Boveri Company (BBC) for the synchronization of the generators with the power grid. The four conditions of synchronization are checked by this device while synchronizing generators.

Working Principal of Synchrotact:

Inside a synchrotact there is an auto-mode which has a comparator made by operational amplifier which compares the voltages of the national grid and the generator which will be synchronized. If the voltage is not same then it gives command to the exciter to change the field current.

If the generator is running at lower or higher frequency than the grid then from the synchrostack a command goes to the turbine to increase or decrease the rpm. Changing of turbine rpm is done by changing the amount of steam supply.

Phase angle of the voltage of the generator is also maintained same with the grid by the synchrostack.

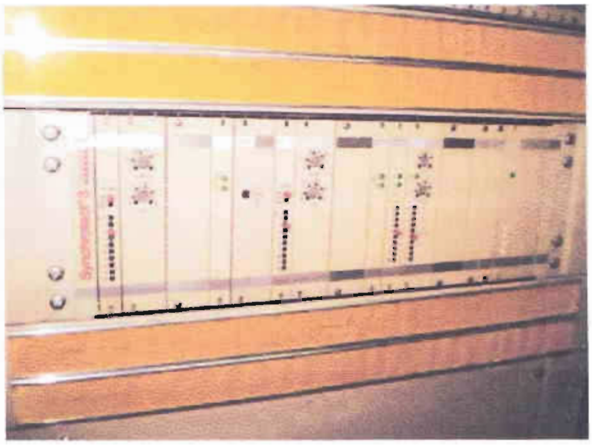

Figure 2.12: BBC made Synchrotack used in the steam turbine generator of unit: 1-5

These sequence is maintained same from the beginning of the installation of the generator by the operators or engineers of the power station.

When all the four conditions is fulfilled then from the synchronizing panel a command will be given to the relay of the connecting breaker which will connect the generator to the national grid [9].

2.2.4. Jack Oil Pump:

Jack oil pump is a hydraulic pump which is used in the generator of steam power plant of APSCL.

It is used to lift the heavy weight rotor of the generator at the time of starting of the generator.

Figure 2.13: Jack oil pump

2.3. 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.

In APSCL there are only two types of turbine. These are:

1. Steam turbine
2. Gas turbine

2.4. 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 APSCL there are three steam turbine power plants which run five generators.

Table 2.2: 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

2.4.1. Steam Turbine:

A steam turbine is a mechanical device that extracts thermal energy from pressurized steam, and converts it into rotary motion.

A. Types of Steam Turbine:

There are two types of steam turbine. These are:

1. Impulse turbine.

2. Reaction turbine.

In APSCL impulse type turbine is used in steam turbine unit: 1-5.

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.

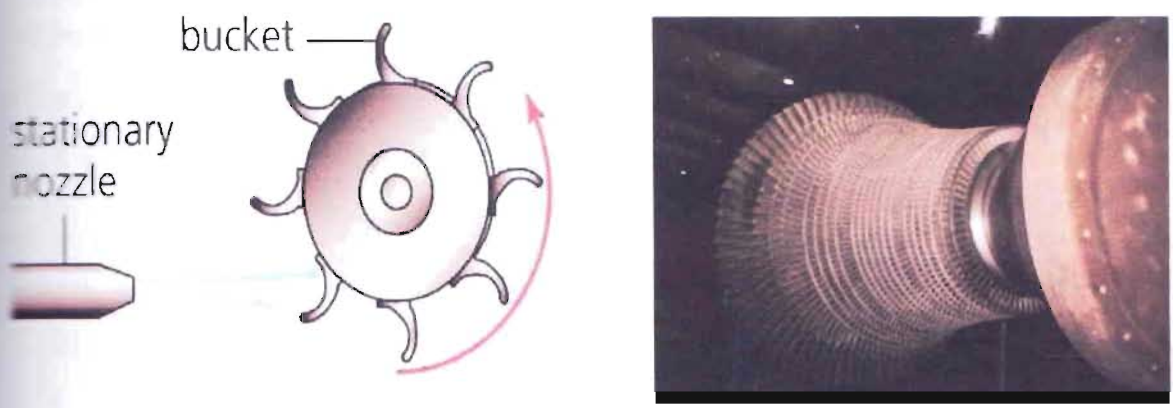

Figure 2.14: Schematic diagram of Impulse turbine and Impulse Turbine used in APSCL

B. Sections or Chambers of Steam Turbine in APSCL:

The steam turbines used in 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 2.15: 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 (IP):

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

3. Low Pressure Turbine (LP):

From the intermediate pressure turbine steam enters into the low pressure turbine and continues its expansion. The blades of the turbine of this section are larger than the previous two sections but the energy of steam is lesser than the previous two sections.

C. 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.

2.4.2. Steam Generation:

The process by which steam is produced is called steam generation process.

A. Boiler:

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

Table 2.3: 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.

In APSCL water tube boilers are used for steam power plant.

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 of the tube. 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 [2].

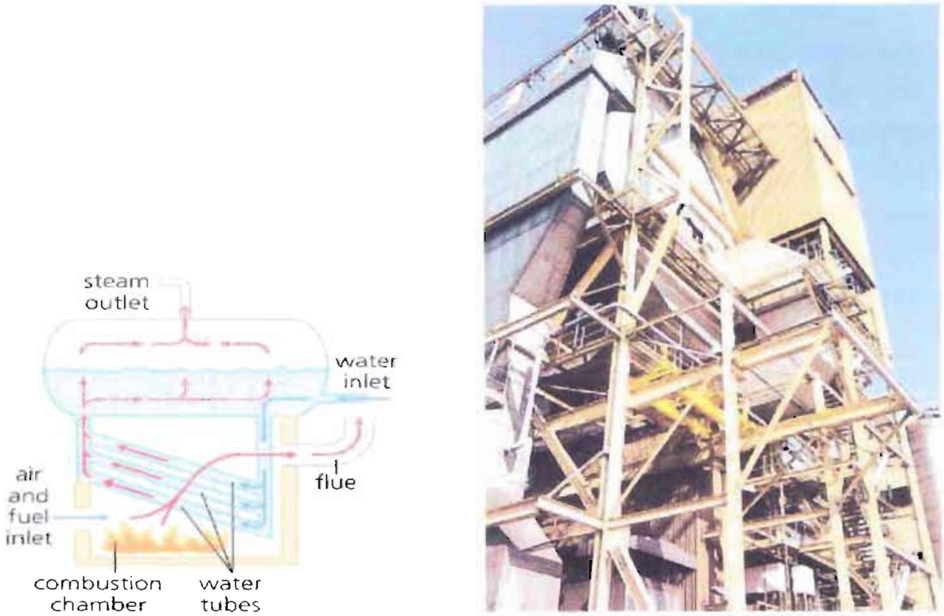

Figure 2.16: Water tube boiler used in APSCL

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 APSCL natural gas is burned with the presence of air for generating heat for making steam. In steam turbine power plant of APSCL each furnace chamber has nine furnaces. The temperature inside the furnace chamber is 1200-1500°C. The treated water from the feed water tank through economizer enters into the 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 2.17: Arrangement of the burner in unit-5 of APSCL steam power plant

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.

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 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 2.4: 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	525°C	523°C

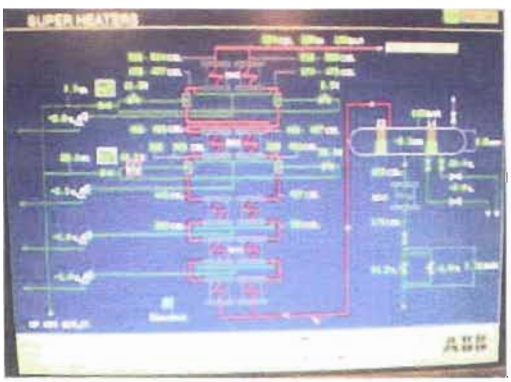

Figure 2.18: Arrangement of super heater in steam power plant unit-5 of APSCL.

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 steam 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.

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 APSCL the flue gas is produced by burning natural gas which comes from the Titas Gas Transmission and Distribution Company Ltd (TGTDCL).

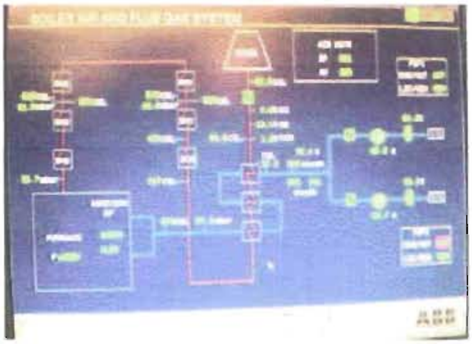

Figure 2.19: Path of flue gas is unite-5 of APSCL steam turbine section

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.

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 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 gas goes inside the intermediate turbine. From the intermediate turbine the steam directly goes into the low pressure heater.

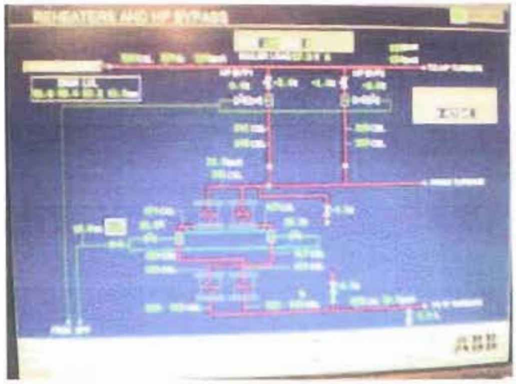

Figure 2.20: Re-heating system of unit-5 of steam turbine section

Table 2.5: 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

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. Surface condenser.
2. Jet condenser.

In steam power plant of APSCL surface condenser is used.

1. 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 steam can be used as feed water.

Disadvantages:

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

Hot-Well:

From the condenser the condensed water is reserved into hot-well. At this stage the steam becomes water. Make up water is supplied to the hot-well if the water level inside the hot-well decreases. Make up water is the treatment water from which the steam is produced. From the hot-well the water is supplied to the low pressure heater by condensate extension pump (CEP). There are two CEPs in every steam power plant of APSCL. One is standby and another is running.

Feed Water:

The condensate from the condenser is used as feed water to the boiler. Some water may be lost into the cycle which is suitably made up from external source and known as make-up water.

The feed water on its way to the boiler is heated by water heaters and economiser. This helps raising the overall efficiency of the plant.

Feed Water Heater:

A feed-water heater is a power plant component used to pre-heat the water that is 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. The heating of feed water is done by using steam which comes from high, intermediate and low pressure turbine through steam extraction line.

In steam and combined cycle power plant of APSCL two types of feed water heater is present. These are:

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

Table 2.6: Feed water temp of in 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 APSCL the temperature of feed water raises about 127°C when it passes through the LP heater.

Figure 2.21: 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. Presently 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.

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.

Economiser:

The economizer is a device which serves to recover some of the heat being carryied by exhaust flue gases. The heat thus recovered is utilized in raising the temperature of feed water being supplied to the boiler [1].

The advantages of using 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 APSCL is also used for the same reason.

Working Principal of Economiser:

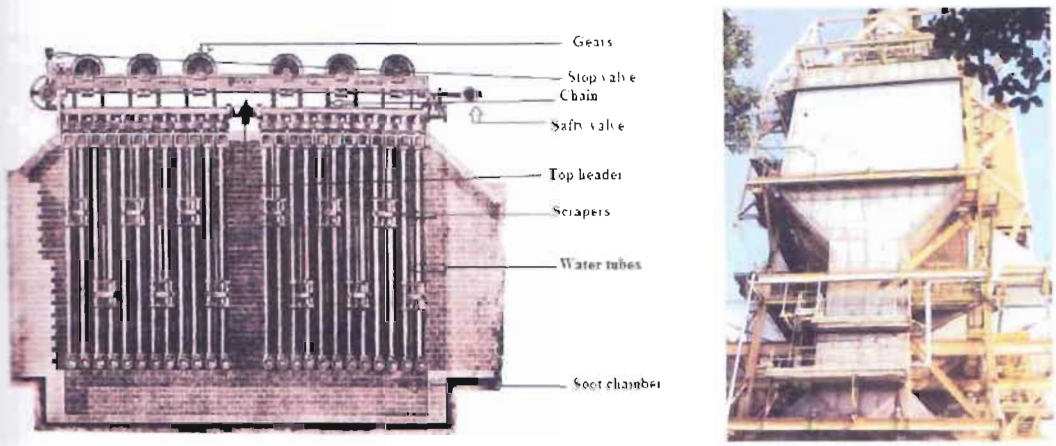

Figure 2.22: Economiser used in APSCL

The system comprises a number of vertical tubes which are passed hydraulically into the top and bottom header. The feed water from the feed pump on its way to the boiler enters the bottom header, passes through the vertical tubes and reaches the upper header. When the water flows upwards inside the tubes, it gains heat from the hot flue gases which are made to pass over the external surface of the tubes.

For efficient heat transfer, the surface of the tubes has to be kept clean from the soot and volatile ash deposits. This is achieved by scrapers which are kept slowly moving up and down to clean the surface. A pair of scrapers for adjacent tubes is coupled together by a chain which passes over pulley. The pulley is driven by mechanical drive.

The safety valve opens when the pressure of water becomes 10-15% higher than the boiler pressure.

Deaerator:

In APSCL deaerator is 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 (parts per billion) by weight (0.005 cm^3/L) or less.

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. Because of this technique the furnace temperature increases which increases the efficiency of the plant. In steam power plant of APSCL air pre heater is used.

Stack/Chimney:

Stack or chimney is a passage through which smoke and gases escape from a fire or furnace. The flue gas produced in the furnace and used to create steam passes through several equipments and finally goes into the nature through stack.

B. 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. So this 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.

C. Pumps and Fans used in the Steam Generation Process:

There are various types of pumps and fans 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 APSCL the following pumps and fans are used for steam generation.

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 APSCL there are two condensates extension pumps in each boiler one is standby and another is working.

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 APSCL there are two boilers 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.

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.

Circulating Water Pump (CW Pump):

This is the pump to send cooling water to the condenser. The vertical type CW pump is used when receiving water directly from sea or river. In APSCL CW pump is used for cooling and condensing purpose. The water is pumped from the Meghna River.

2.5. Combined Cycle Power Plant:

Combined Cycle power plants are those which have both gas and steam turbines supplying power to the network.

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 [3].

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

1. Gas turbine section.
2. Steam turbine section.

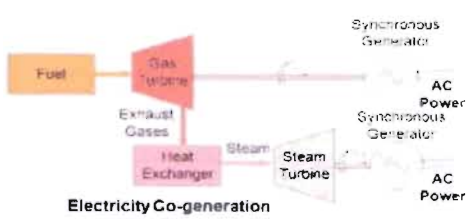

Figure 2.23: Combined cycle power station

Table 2.7: Information of combined cycle power plant of APSCL

Category	Combined cycle power plant section	
	Gas turbine 1 & 2	Steam turbine
Name of the manufacturer	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

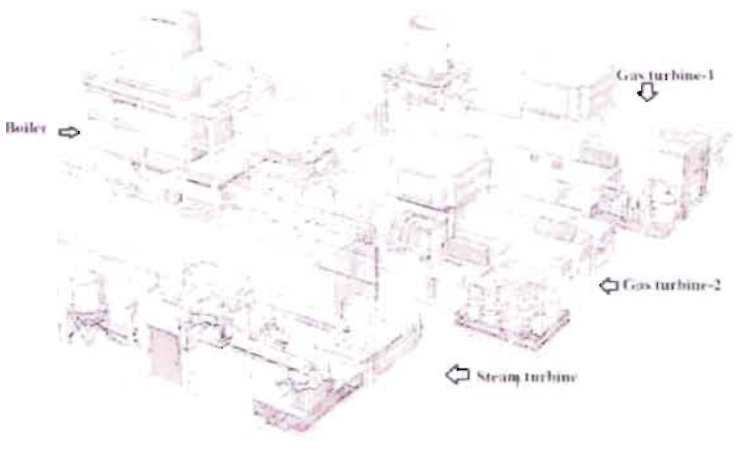

Figure 2.24: Top view of combined cycle power plant of APSCL

2.5.1. Gas Turbine Section:

A generating section of a combined cycle power plant which employs gas turbine as the prime mover for the generation of electrical energy is known as a gas turbine section of a combined cycle power plant.

There are three important parts in a gas turbine section. These are:

A. Compressor.
B. Combustion chamber.
C. Turbine.

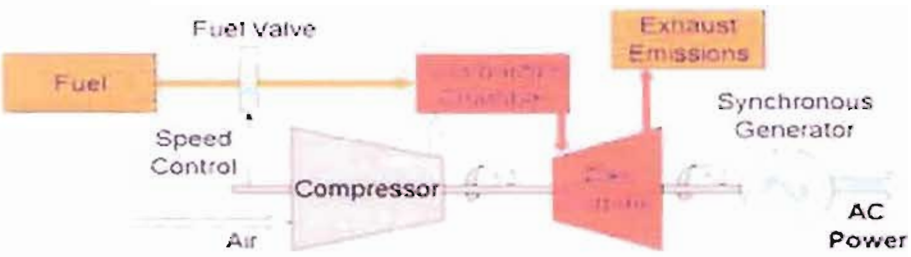

Figure 2.25: Gas turbine power generation system

Open cycle system is used in gas turbine section. Two gas turbines are present in gas turbine section of APSCL.

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.

A. 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.

In gas turbine section of APSCL, centrifugal compressor is used.

A. Centrifugal Compressor:

Inside the centrifugal compressor, the impeller which consists of large number of blades is mounted on the compressor shaft, inside the stationary casing. As the impeller rotates, the pressure in suction region falls and hence the air enters through the eye and flows radically outwards through impeller blades. As a result velocity and pressure of air increases.

Later this air enters and flows through the convergent passages formed by the diffuser blades. At this stage the velocity of air is decreases but the pressure increases still further. During this stage the kinetic energy is converted into mechanical energy.

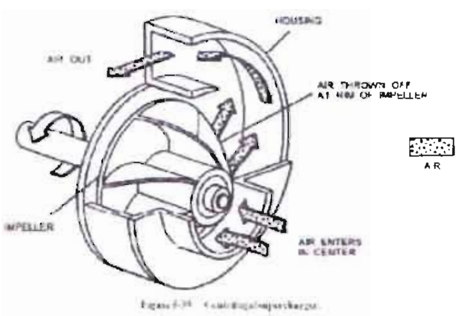

Figure 2.26: Centrifugal compressor used in APSCL [11]

Finally this high pressure air escapes from the compressor delivery portion. This is single stage compression and is suitable for small pressure ratios.

B. 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.

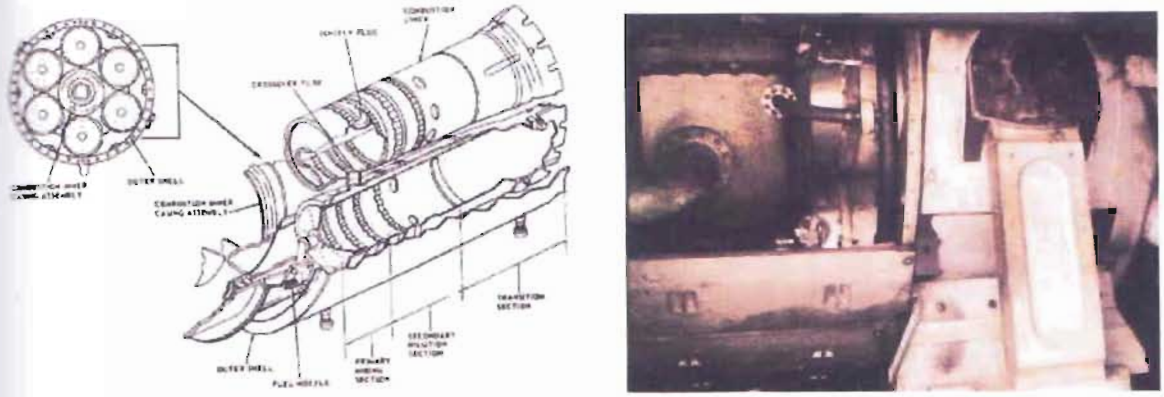

Figure 2.27: Combustion Chamber of Gas Turbine Plant of APSCL [10]

The secondary air is used to dilute the burnt gas to reduce its temperature to one which is acceptable and suitable for the turbine blades. The fuel burner contains an automiser, which uses the pressure of the fuel to divide it into an extremely fine spray which mixes with the primary air in the right proportion for complete combustion. A high energy igniter used is an electric spark plug to ignite the gas initially. Provision is made to detect the flame optically so that in the event of flame failure, the fuel supply to the burner can immediately be shut off automatically [2].

C. 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. While passing over the turbine blades the gases expand and thus do the mechanical work [1].

There are two types of gas turbine. These are:

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

In gas turbine section of APSCL shaft type gas turbine is used.

1. Shaft Power Gas Turbine:

A shaft power gas turbine is a gas turbine whose goal is to deliver shaft power. They are often also referred to as turbo-shaft engines.

These gas turbines are used in industrial applications. Gas turbines used for electricity production are of this type.

Figure 2.28: Gas turbine of APSCL

D. 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 to help compressor to suck air. The diesel engine is turned off when the turbine is at 1800 rpm.

Figure 2.29: Diesel engine use in the gas turbine

Table 2.8: 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

For the above reason any kind of engine can be used instead of diesel engine. But in gas turbine section of APSCL diesel engine is used.

2.5.2. 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 section 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 produce 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 APSCL there is one steam turbine section which runs by the exhaust gas of gas turbine-1 & 2.

A. Steam Generation Process:

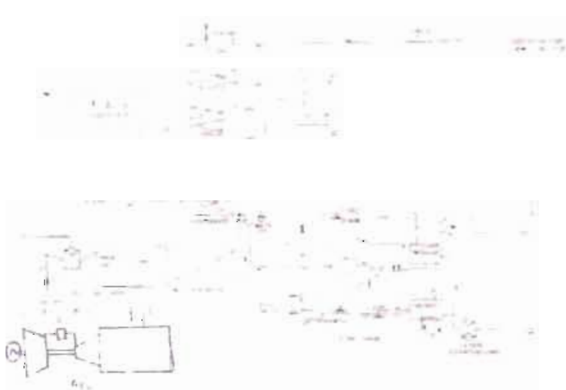

Figure 2.30: Single line diagram of steam generation system of combined cycle power plant

In combined cycle power plant of APSCL several equipments are used. These are:

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.

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 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.

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.

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 flowed to the high pressure economiser.

High Pressure Economiser (HP 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.

High Pressure Boiler Drum:

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

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 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 flowed to the super heater.

Super Heater:

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

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 2.31: 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 APSCL there are two condensers is used.

B. 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 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 2.4.1 section of this report.

2.5.3. 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 valves are used. These are:

A. Manual Valve:

Manual valves are those valves that operate through a manual operator (such as a hand wheel or hand lever), which are primarily used to stop and start flow (block or on-off valves), although some designs can be used for basic throttling.

Figure 2.32: Manual valve used in combined cycle power plant of APSCL

It is an isolation valve. Only on/off operation can be executed by manual valve.

B. Pneumatic Valve:

It is a valve in which the force of compressed air against a diaphragm is opposed by the force of a spring to control the area of the opening for a fluid stream.

Pneumatic process control valves are used in process industries to control the flow of fluid by using pneumatic actuators. It requires 4.5 to 6 Kg/sq. cm of pressure to operate the valve.

Figure 2.33: Pneumatic valve

Control room sends electrical signals of 4-20 mA to field where I/P converter convert these electrical signals into pneumatic signals. Actuators use these signals to operate the valve. Actuators move the steam up and down depending upon input signals and control the valve opening. It is a control type valve.

1. 4mA- 0% opening
2. 8mA- 25% opening
3. 12mA- 50% opening
4. 16mA- 75% opening
5. 20mA- 100% opening

C. Hydraulic Valve:

It is a valve which is used for regulating the distribution of water in the cylinders of hydraulic elevators, cranes, etc.

A hydraulic valve directs the flow of a liquid medium, usually oil, from its input ports to its output ports. The direction of the oil flow is determined by the position of a spool/coil, which is driven by a linear force motor.

Figure 2.34: Hydraulic valve

D. Motorized Valve:

Valves which are controlled by motor are called motorized valve. By running the motor clockwise and anti clockwise a motorized valve can be opened or closed. It is a control valve. The speed of the motor controls how fast or slow the valve is opening and closing. If it is an emergency opening or closing then the motor will run fast by increasing the field current with the help of electronic mechanism.

E. Electro-hydraulic Valve:

Electro-hydraulic valves use Electro-hydraulic actuators which convert fluid pressure into motion in response to a signal. They use an outside power source and receive signals that are measured in amperes, volts, or pressure.

Figure 2.35: Electro-hydraulic valve

Electro-hydraulic valve can perform rotary motion. It is a control valve.

F. Servo Valve:

The servo valve is a kind of valve that uses a torque motor type coil to control a small stream of fluid. Direction of the fluid stream is used to position a large spool. Therefore a low level power signal may provide precise spool position. Normally, the spool had mechanical feedback of spool position to the torque motor, creating a closed loop spool position system.

Figure 2.36: Servo valve

Servo valve can operate in a millimeter range.

2.6. Motor Winding and Testing:

There are various types of motors used in the power station for power generation purposes. The maintenance of these motor is very important for power generation purpose.

In APSCL there is a motor winding shop or section which repairs the damaged motors. Engr. Md. Rokon Mia showed us the motor winding shop of APSCL and gives us information about motor repairing and winding.

2.6.1. Motor Repairing:

A. Identifying the Damaged Portion of Motor:

The 1st and most important job of motor repairing is to identify the damaged part of the motor. For this purpose the following steps are taken:

1. **Observation:**
   Observation of the motor is very important to identify the damaged part.
   If the motor is burnt then by observing the internal and external part of the motor one can easily find that out the damage part.
2. **Megar test:**
   This is the most efficient test for identifying the damaged part of the motor in the motor winding shop of APSCL which is being told by head worker of the winding shop.

Figure 2.37: Megar testing

Megar is a measuring device which measures resistance of coil and other device. By using it one can measure the winding resistance of the stator and rotor of the motor. When the resistance is infinity or very large then it is assumed that there is a disconnection inside the coil which is a fault of the motor. If the resistance is not infinite or a reasonable value then motor winding is free from fault.

B. Sketching the Winding Configuration of the Motor's Stator:

In this stage the winding arrangement of the faulty motor is drawn by the Engineer of the winding shop. This is done because it will be needed at the rewinding time of the motor after the unwinding is done for repairing the motor.

Figure 2.38: Sketch of the winding diagram of motor

C. Unwind the Motor and Rewind it with New Coil:

While repairing the damaged winding of the stator or rotor the worker will unwind the winding coil and re-wind it with fresh new coil. This is carefully done by following the winding design which is sketched early.

Figure 2.39: A re-winded motor

After the winding is done the coil is again tested by megar. While re-winding is performed the delta-wye connection is carefully observed.

2.6.2. Opening and Megar Testing of Transformer Cooling Fan Motor:

Engr. Md. Azizur Rahman, a senior engr. of combined cycle power plant of APSCL had given us a faulty transformer cooling fan motor to observe the damaged part and megar test.

Figure 2.40: Opening and megar testing of motor stator

We had performed that work properly. There was winding damaged or burnt problem which was solved by re-winding the coil of the stator.

1. While opening the rotor we observed whether the rotor is jammed or not.
2. We tested the winding of stator with megar and found that the problem or damaged part is inside the winding of the motor.
3. We also checked the delta-wye connection of the motor.

3. Switchgear

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, fuses or circuit breakers are usually employed to protect the system during maintenance or faulty condition. Switchgear is used both to de-energize equipment to allow work to be done and to clear faults downstream. Importance of this protection is enormous because the reliability of the operation depends on this system.

In the Ashuganj Power Station of Company Limited (APSCL) at switch gear section we studied circuit breakers, relays, control panels etc. We also went to the back-up system of APSCL which is also a part of the switch gear. So we can divide the switch gear section in 3 parts on the perspective of APSCL:

3.1. Protection

A protection is a system which detects the fault and initiates the operation of the circuit breaker to isolate the defective element from the rest of the system. Protective relay is the main device to protect the electrical device.

3.1.1. Generator Protection:

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

A. Generator Differential Protection:

It is one of the important protections to protect generator winding against internal faults such as phase-to-phase and three phase-to-ground faults. This type of fault is very serious because very large current can flow and produce large amounts of damage to the winding.

In figure 3.1 (a) X is the winding of the protected machine. When there is no internal fault, the current entering in X is equal in phase and magnitude to current leaving X. The CT's are of such a ratio that during the normal conditions or for external faults (Through Faults) the secondary current of CT's are equal. These currents I1 and I2 circulate in the pilot wire. The polarity connections are such the current I1 and I2 are in the same direction of pilot wire during normal condition or external faults. Relay operation coil is connected at the middle of pilot wires.

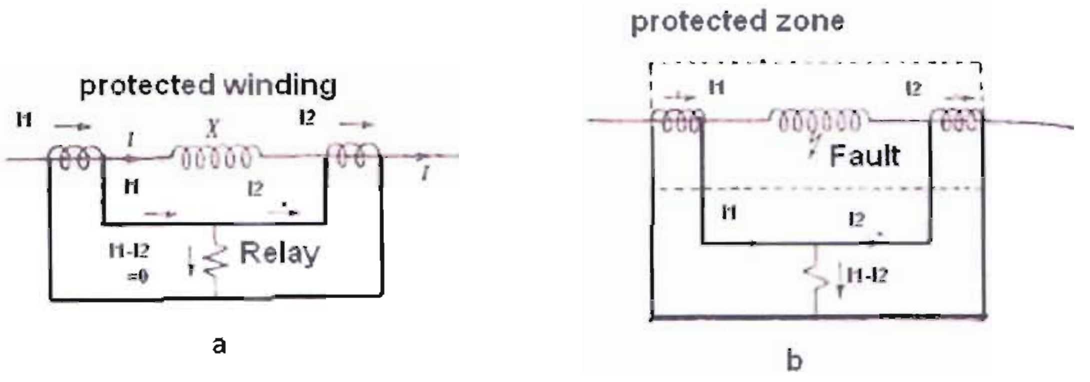

Figure 3.1: Differential protection mechanism

During normal condition and external fault, the protection system is balanced and the CT's ratios are such that secondary currents are equal. These current circulate in pilot wires. The vector differential current (I1- I2) which flow through the relay coil is zero.

This balance is disturbed for internal faults. When fault occurs in the protected zone, the current entering the protected winding is no more equal to the leaving the winding because some current flows to the fault. The differential (I1-I2) flows through the relay operation coil and the relay operates if the operating torque is more than the restraining torque.

The current I1 and I2 circulate in the secondary circuit. Hence CT's does not get damaged. Polarities of CT's are considered. CT's are connected such that the circulating currents I1 and I2 are as shown in Fig.3.1 (a) for normal condition.

B. Percentage Differential Protection:

This protection scheme is also called biased differential protection scheme. The Fig. 3.2 shows the connection of the percentage differential relay, in such protection scheme.

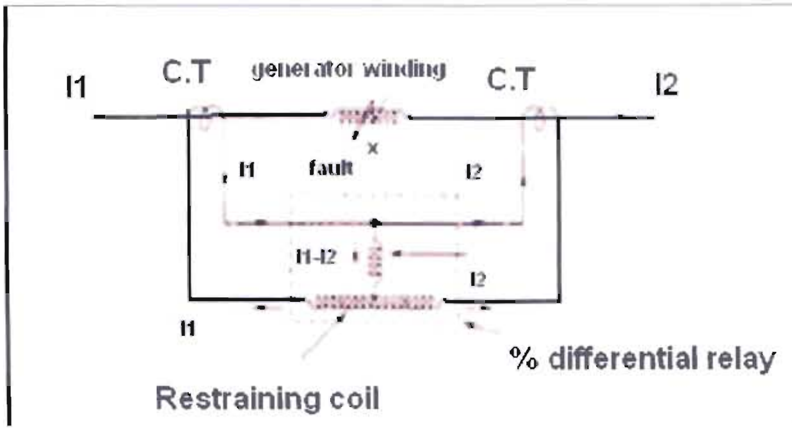

Figure 3.2: Percentage differential protection mechanism

The fault occurs at point X and the primary currents in the circuit are I1 and I2. The C.T. secondary currents are I1 and I2. The current flowing through the operation coil of the relay is (I1 + I2)/2. This is because the operating coil is connected to the midpoint of the restraining coil.

Thus if the number of turns of the restraining coil is N then I1 flows through N/2 and I2 flows through remaining N/2. The total ampere turns are I1N/2+ I2N/2 i.e N ((I1 + I2)/2.

This is as good as the flow of current ((I1 + I2)/2 through the entire restraining coil.

The operating characteristic of such a biased differential relay is shown in the Fig 3.3. The characteristics shows that except at low currents, ratio of differential operation current to average restraining current is a fixed percentage. Hence the relay is called the percentage differential relay.

Figure 3.3: Operation characteristic of percentage differential protection

This basic percentage differential protection scheme forms the basis of the very commonly used percentage differential protection scheme for alternator stator windings. This popular scheme is known as biased differential protection or Merz-Price protection.

C. Loss of Excitation or Field Excitation Protection:

The loss of excitation of the generator may result in the loss of synchronism and slight increment in the generator speed. The machine starts behaving as an induction generator. The loss of excitation may lead to the pole slipping condition. Hence protection against loss of excitation must be provided.

The protection is provided using directional distance type relay with the generator terminals. When there is loss of excitation, the equivalent generator impedance varies and traces a curve as shown in the Fig. 3.4. Fig. 3.4 shows the loss of excitation characteristics along with the relay operation characteristic, on R-X diagram.

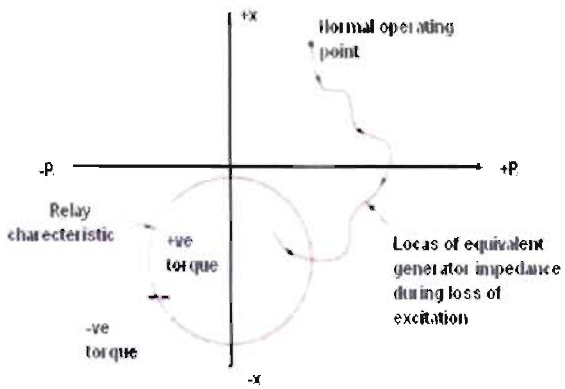

Figure 3.4: Mechanism of loss of excitation protection relay and picture of the relay

The equivalent generator impedance locus traces a path from first quadrant of R-X diagram to the fourth quadrant. The distance relay is used which covers the portion of the fourth quadrant where impedance locus path exists. Thus when the impedance takes value in the region covered by the relay characteristics, the relay operates. The relay operates when generator first starts to slip poles. Then relay trips the field circuit breaker. And it disconnects the generator from the system, too. When the excitation is regained and becomes normal, the generator can then be returned to service instantly [15].

D. Negative Phase Sequence Protection:

The negative relays are also called phase unbalance relays because these relays provide protection against negative sequence component of unbalanced currents due to unbalanced loads or phase-phase faults. The unbalanced currents are dangerous from generators and motors point of view as these currents can cause overheating.

A negative sequence relay has a filter circuit which is operative only for negative sequence components. Low order of over current also can cause dangerous situations hence a negative sequence relay has low current settings.

A negative sequence relay provides protection against phase to phase faults which are responsible to produce negative sequence components [14].

E. Stator Earth Fault Protection:

Normally the generator stator neutral operates at a potential close to ground. If a faulty phase winding connected to ground, the normal low neutral voltage could rise as high as line-to-neutral voltage depending on the fault location. Although a single ground fault will not necessarily cause immediate damage, the presence of one increases the probability of a second. A second fault even if detected by differential relay, may cause serious damage. The usual method of detection fault is by measuring the voltage across the secondary of neutral grounding transformer (NGT). Here are two over lapping zones to detect stator ground faults in a high impedance grounded generator system, the two zones are put together cover 100% stator winding for earth faults. A fundamental frequency neutral over voltage relay covers about 0-90% of the stator zonal winding for all faults except those near the neutral. [14]

Figure 3.5: stator earth fault relay

F. 100% Earth Fault Protection:

As seen uptill now, no protection scheme is in a position to give complete protection to the stator of generator against earth faults. The maximum protection achieved is upto 85 to 90% from the schemes discussed uptill now.

But in modern days it is possible to provide 100% earth fault protection to the stator of the generator. It uses a coupling transformer and the coded single current. The scheme is shown in the Fig. 3.6.

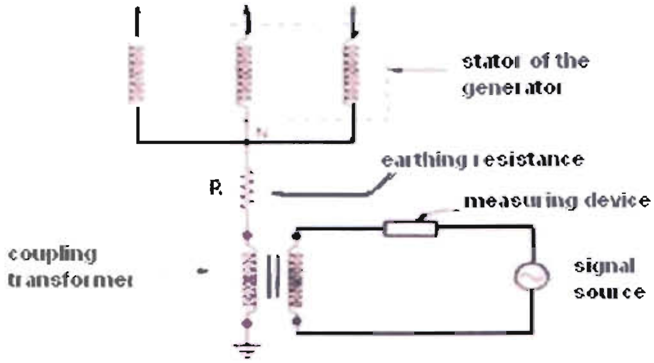

Figure 3.6: 100% Earth Fault Protection mechanism

A coupling transformer is connected between the earth and the earthing resistance R. The primary of the coupling transformer is excited by coded signal current source. This coded signal current has a frequency of 12.5 Hz. This current is continuously injected into the generator stator winding through the secondary of the coupling transformer.

During the normal condition the signal current injected into the stator flows through stray capacitance of the generator and directly connected system. But when earth fault occurs, the stray capacitance is bypassed. This increases the monitoring current. This increase is measured by a measuring device. Depending upon this measurement an immediate corrective action is taken.

This scheme gives the protection of 15 to 20% of stator winding from the neutral side. Overall 100% of stator winding gets protected against earth faults.

G. Rotor Earth Fault Protection:

The rotor circuit of the alternator is not earthed and d.c. voltage is imposed on it. Hence single ground fault in rotor does not cause circulating current to flow through the rotor circuit. Single ground fault in rotor does not cause any damage to it. But single ground fault causes an increase in the stress to ground at other points in the field winding when voltage is induced in the rotor due to transients. Thus the probability of single ground fault increases.

If the single ground fault occurs then part of the rotor winding is bypassed and the currents in the remaining portion increases abruptly. This causes the unbalance of rotor circuit and hence the mechanical and thermal stresses on the rotor. Due to this, rotor may get damaged. Sometimes damage of bearings and bending of rotor shaft take place due to the vibrations. Hence the rotor must be protected against earth fault.

In this method a high resistance is connected across the rotor circuit. It is provided with centre tap and the centre tap point is connected to the ground through a sensitive earth fault relay.

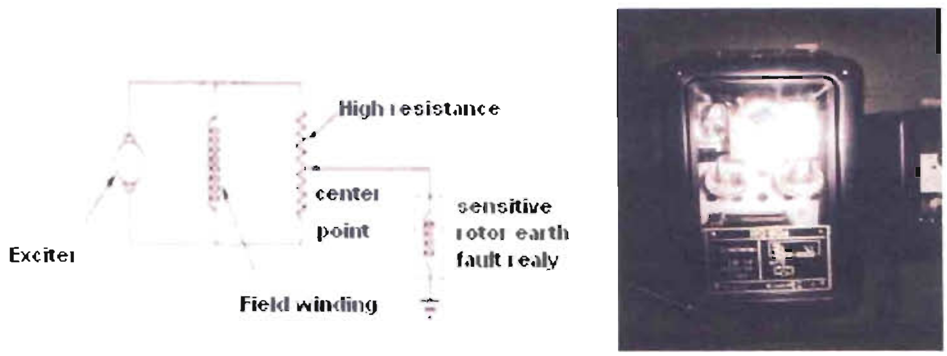

Figure 3.7: Rotor earth fault protection mechanism & picture of the relay used in APSCL

Except the centre point, the earth fault relay detects the earth faults for most of the rotor circuit. Thus most of the rotor winding part is protected against the earth faults [13].

H. Restricted Earth Fault Protection:

Generally Merz-Price protection based on circulating current principle provides the protection against internal earth faults. But for large generators, an additional protection scheme called restricted earth fault protection is provided.

When the neutral is solidly grounded then the generator gets completely protected against earth faults. But when neutral is grounded through earth resistance, then the stator windings gets partly protected against earth faults. The percentage of windings protected by this system depends on the value of earthing resistance and the relay setting.

In this scheme, the value of earth resistance, relay setting, current rating of earth resistance must be carefully selected. The earth faults are rare near the neutral point as the voltage of neutral point with respect to earth is very less. But when earth fault occurs near the neutral point then the insufficient voltage across the fault deliver very low fault current than the pickup current of relay coil. Hence the relay coil remains unprotected in this scheme. Hence it is called restricted earth fault protection. It is usual practice to protect 85% of the winding.

I. Protection against Turn-To-Turn (Inter-turn) Fault on Stator Winding:

The system gives protection against phase to phase faults and earth faults. It does not give protection against inter-turn faults. The inter-turn fault is a short circuit between the turns of the same phase winding. Thus the current produced due to such fault is a local circuit current and it does not affect the currents entering and leaving the winding at the two ends, where C.T.s are located.

In single turn generator, there is no question of inter-turn faults but in multi-turn generators, the inter-turn fault protection is necessary. So such inter-turn protection is provided for multi-turn generators such as hydroelectric generators. These generators have double winding armatures. This means, each phase winding is divided into two halves, due to the very heavy currents which they have to carry. This splitting of single phase winding into two is advantageous in providing inter-turn fault protection to such hydroelectric generators.

This protection follows cross differential principle. Each phase of the generator is doubly wound and split into two parts. The current transformers are connected in the two parallel paths of the each phase winding. The parts of secondary of the current transformers are cross connected. The current transformers work on circulating current principle. The relay is connected across the cross connected to the parts of secondary of the current transformers.

Under normal operation conditions, when the two paths are sound then currents in the two parallel paths are equal. Hence currents in the secondary of the current transformers are also equal. The secondary current flows round the loop and is same at all the points. Hence no current flows through the relay and the relay is inoperative.

If the short circuit is developed between the adjacent turns of the one part of the winding say then currents through these two no longer remain same. Thus unequal currents will be induced in the secondary of the current transformers. The difference of these currents flows through the relay. Relay then closes its contacts to trip the circuit breaker which isolates the generator from the system.

Such an inter-turn fault protection system is extremely sensitive but it can be applied to the generators having doubly wound armatures [14].

J. Reverse Power Protection:

It is backup protection to the low forward protection. Motoring of a generator will occur when turbine output is reduced such that it develops less than no-load losses while the generator is still on-line, the generator will operate as a synchronous motor and drive the turbine. The motoring of the turbine output can be detected by reverse power protection. The avoid false tripping due to power swings a time delay is incorporated before tripping signal is generated. The unit trips on the reverse power protection. Restart the machine and increase the input power to the turbine as quickly as possible within low forward power time setting. After repeated attempts, the machine is tripping on the same protection; probably the governor of turbine is faulty.

Figure 3.8: Reverse power relay

K. Over Frequency Protection:

For a generator connected to a system, abnormal frequency operation is a result of a severe system disturbance. The generator can tolerate moderate over frequency operation provided voltage is within an acceptable limits. The machine operated at higher speeds at which the rotor material no longer contain the centrifugal forces imposed on them result in serious damage to the turbine-generator set.

L. Under Frequency Protection:

For a generator connected to a system, under frequency operation is a result of a severe system disturbance. The generator can tolerate moderate under frequency operation provided voltage is within an acceptable limits. The machine operated at lower higher speeds causes severe over fluxing in the generator-transformer. The abnormal under frequency on the machine may be due to improper speed control adjustment or disoperation of the speed controller. We can change the frequency by changing the rotation speed. The governor is used to change the speed of rotor.

M. Over Voltage Protection:

In case of over frequency operation is also a result of a severe system disturbance. The generator can tolerate moderate over frequency operation provided voltage is within an acceptable limits. The machine operated at higher speeds at which the rotor material no longer contain the centrifugal forces imposed on them resulting in serious damage to the turbine-generator set. The abnormal over frequency on the machine may be due to improper speed control adjustment or disoperation of the speed controller or severe grid disturbance or sudden load through off [14].

N. Over Current and Earth-Fault Protection for Generator Back-up:

For generators above 1 MW, where primary protection of stator winding is provided by differential protection, the over current and earth-fault protection gives back-up protection for external phase-to-phase and earth fault.

Induction type inverse definite minimum time relays may be used for generator back-up protection for external fault.

Since the faults in stator winding are fed by stator winding itself, their influence on current in the outgoing terminals of generator depends upon the fault level of the main bus.

Figure 3.9: Picture of over current relay used in APSCL.

Hence over current and earth-fault relays do not provide satisfactory protection against internal fault.

However the over current and earth fault relays provide back-up protection to generator against external faults.

The setting is selected such that the generator over current and earth fault protection does not normally operated for external fault.

However, if fault continues for a longtime due to failure of the line protection, the fault will be fed by generator. Hence the over current and the earth fault protection of generator may be set to operate with due time lag for higher values of external fault currents. Hence high set, minimum time, induction type, inverse over current, earth fault relays are recommended for generator back up.

O. Rotor Temperature Protection:

This protection is employed only to large sets and indicates the level of temperature and not the actual hot spot temperature. It is not practical to embed thermocouples in rotor winding since the slip rings connections would be complicated. Resistance measurement is adopted. The rotor voltage and current are compared by a moving coil relay. The voltage coil of relay is connected across the slip ring brushes. The current coil is connected across the shunt in the field circuit. Double actuating quantity moving coil relay is used, the restraining coil being circuit coil and the operating coil is the voltage coil. Resistance increases with temperature. The relay measures the ratio V/I =R which gives a measures of rotor temperature [12].

P. Stator Heating Protection:

Generator over heating can be caused by failure cooling system or by sustained overloads. Embedded resistance detectors or thermocouples are provided in the slots along with the stator coil for large coils for large generators. These give an alarm if temperature rises above safe value. The protection is provided for generator above 1MW.

It is not practicable to provided over-load protection by back-up stator-fault over-current protection. Because back up over current protection is generally set for sensing fault current and should not trip for over-loads. Electrical over current relays cannot sense the winding temperature accurately temperature rise depends on I2Rt and also on cooling. Electrical protection cannot detect a cooling system failure [12].

Q. Over Speed Protection:

It is essential to incorporate safety device in turbine governing system to prevent over-speeding. Over-speeding 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 of the generator should be maintained by a governor. The over-speeding results in over voltages and increase in frequency.

3.1.2. Motor Protection:

Motor protection should be simple and economical. Cost of productive system should be within about 5% of motor cost. The motor protection should not operate during staring and permissible over loads. The choice of motor protection scheme depends upon the following:

- Size of motor, rated voltage, kW
- Type of squirrel-cage or wound rotor.
- Type of starter, switchgear and control gear
- Cost of motor and driven equipment
- Type of load, starting currents possible abnormal condition

A. Overload Protection of Motor:

Each continuous-duty motor must be protected against excessive overloads under running conditions by some approved protective device. This protective device except for motors rated at more than 600 volts, may consist of fuses, circuit breakers, or specific overload devices. Overload protection will protect the branch circuit, the motor, and the motor control apparatus against excessive heating caused by motor overloads. Overload protection does not include faults caused by shorts or grounds. A separate overload device that is responsive to motor current. This device is required to be rated or selected to trip at overload condition. And a thermal, protector, integral with the motor, is approved for use with the motor that it protects on the basis that it will prevent dangerous overheating of the motor caused by overload and failure to start.

B. Ground Fault Protection:

Damage to a phase conductor's insulation and internal shorts due to moisture within the motor are common causes of ground faults. A strategy that is typically used to limit the level of the ground fault current is to connect impedance between the neutral point of the motor and ground. This impedance can be in the form of a resistor or grounding transformer sized to ensure that the maximum ground fault current is limited to a level that will reduce the chances of damage to the motor.

There are several ways by which a ground fault can be detected. The most desirable method is to use the zero sequence CT approach, which is considered the best method of ground fault detection due to its sensitivity and inherent noise immunity. All phase conductors are passed through the window of a single CT referred to as a zero sequence CT. Under normal circumstances, the three phase currents will sum to zero resulting in an output of zero from the zero sequence CT's secondary. If one of the motor's phases were shorted to ground, the sum of the phase currents would no longer equal zero causing a current to flow in the secondary of the zero sequence CT. This current would be detected by the motor relay as a ground fault.

C. Unbalance Protection:

Unbalanced load in the case of AC motors is mainly the result of an unbalanced power supply voltages. The negative-sequence reactance of the three-phase motor is 5 to 7 times smaller than positive-sequence reactance, and even a small unbalance in the power supply will cause high negative sequence currents. For example for an induction motor with a staring current six times the full load current, a negative sequence voltage component of 1% corresponds to a negative sequence current component of 6%. The negative-sequence current induces a field in the rotor, which rotates in the opposite direction to the mechanical direction and causes additional temperature rise. Main causes of current unbalance are: system voltage distortion and unbalance, stator turn-to-turn faults, blown fuses, loose connections, as well as faults.

D. Under Voltage Protection:

If an induction motor operating at full load is subjected to an under voltage condition, full load speed and efficiency will decrease and the power factor, full load current and temperature will increase. The under-voltage element can be considered as backup protection for the thermal overload element. The under-voltage element can be considered as backup protection for the thermal overload element. If the voltage decreases, the current will increase, causing an overload trip. In some cases, if an under-voltage condition exists it may be desirable to trip the motor faster than the overload element. The overall result of an under-voltage condition is an increase in current and motor heating and a reduction in overall motor performance.

E. Over Voltage Protection:

When the motor is running in an over-voltage condition, slip will decrease as it is inversely proportional to the square of the voltage and efficiency will increase slightly. The power factor will decrease because the current being drawn by the motor will decrease and temperature rise will decrease because the current has decreased. As most new motors are designed close to the saturation point, increasing the V/HZ ratio could cause saturation of air gap flux causing heating. The overall result of an over-voltage condition is an increase in current and motor heating and a reduction in overall motor performance.

3.1.3. Turbine Protection:

Turbine is one of the most important parts of the power generation section. It rotates in very high speed constantly although this is heavy metal part. So protection for unexpected situation is a mandatory requirement.

A. Over speed protection:

This protection is used against over speed of a turbine. The normal speed of a turbine is 3000rpm and the maximum speed is 3300 rpm. Due to any kind of unexpected condition if the turbine speed crosses the maximum speed it would be dangerous for power plant. So to avoid this type of situation over speed protection is used in the power plant.

B. Turbine bearing temperature protection:

There is a requirement for protection against high temperature of turbine bearing. If the temperature of the bearing is increased, it is cooled by the lube oil. This lube oil is also use for avoiding the friction. This protection results in less power loss.

C. Turbine high vibration protection:

Turbine blades are situated very close to each other. So when the turbine starts running there will be a vibration in the blade. If the vibration is very high, it will be tripped by the protection device.

D. Deviation:

There are nine burners in the combustion chamber. The difference of the temperature of these burners is not much. But if there is a gas leak with burner, the temperature difference will be high. In that case system will be tripped.

E. Turning gear:

Turning gear is an extra mechanism to maintain the turbine blade. During the running condition if suddenly the system is turned off and turbine is stopped, the blade of turbine will be bending as it has high temperature. So in that case we use turning gear to rotate the turbine when generator is turned off.

3.2. Circuit Breaker:

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.

3.2.1. MCB (Miniature Circuit Breaker):

Rated current of MCB is not more than 100 A. It can be used for both single phase and three phase power system. The tripping characteristic is not adjustable normally. Thermal or thermal-magnetic mechanism is used in this circuit breaker. There is no fixed time for the thermal operation.

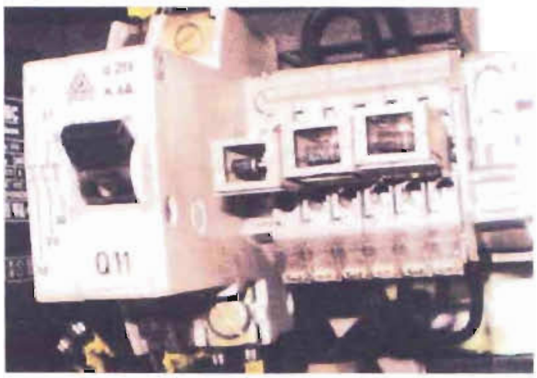

Figure 3.10: Miniature circuit breaker

3.2.2. MCCB (Molded Case Circuit Breaker):

Rated current of MCCB is up to 2500 A. It has also thermal or thermal-magnetic operation. Trip current may be adjustable in larger ratings using a knob. Normally it is used for three phase power system.

Figure 3.11: molded cage circuit breaker

3.2.3. ACB (Air Circuit Breaker):

Air circuit breakers can be used both as circuit-breakers for general protection and as protection circuit breakers of electrical machines. It is available from 400A to 6400A. "Under Voltage Release" mechanism is used in this circuit breaker. This mechanism will be active when there will be low voltage supply or zero voltage supply. Magnetic tripping mechanism applied for short circuit.

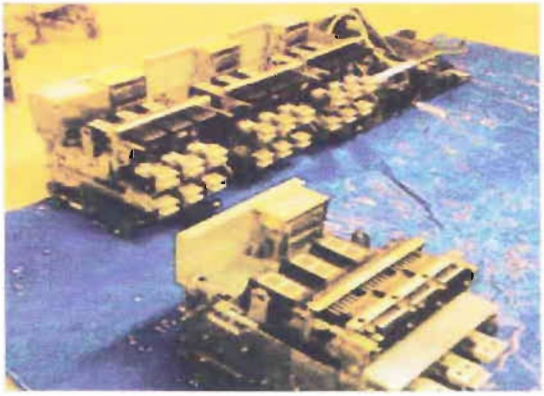

Figure 3.12: Air Circuit Breaker

3.2.4. Vacuum Circuit Breaker:

Vacuum circuit breakers are circuit breakers which are used to protect medium and high voltage circuits from dangerous electrical situations. Like other types of circuit breakers, vacuum circuit breakers literally break the circuit so that energy cannot continue flowing through it.

Figure 3.13: Internal part of vacuum circuit breaker

In a vacuum circuit breaker, two electrical contacts are enclosed in a vacuum. One of the contacts is fixed, and the other is movable. When the circuit breaker detects a fault, the movable contact pulls away from the fixed contact, interrupting the current. Because the contacts are in a vacuum, arcing between the contacts is suppressed, ensuring that the circuit remains open. As long as the circuit is open, it will not be energized. Rated voltage is 22kV -66kV and rated current is 2500A-3150A

3.2.5. SF6 Circuit Breaker:

In this circuit breaker, sulphur hexafluoride (SF6) gas is used as the arc quenching medium. The sf6 gas 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 sf6 gas and an arc is struck between them. The conducting free electrons in the arc are rapidly captured by the gas to form relatively immobile negative ions. This loss of conducting electrons in the arc quickly builds up enough insulation strength to extinguish the arc. This circuit breaker is very effective for high power and high voltage service.

Figure 3.14: SF6 circuit breaker

3.2.6. Oil Circuit Breaker:

In oil circuit breakers insulating oil is used as an arc quenching medium. The contacts are opened under oil and an arc is struck between them, heat of the arc evaporates the surrounding oil and produce hydrogen at high pressure. The oil is pushed away from the arc region and the gas bubble occupies adjacent portions of the contact. The arc extinction is facilitated mainly by two processes. Firstly the hydrogen gas has high heat conductivity and cools the arc, thus aiding the deionization of the medium between the contacts. Secondly the gas sets up turbulence in the oil and forces it into the space between contacts thus eliminating the arcing products from the arc path resulting in arc extinction and interruption of current.

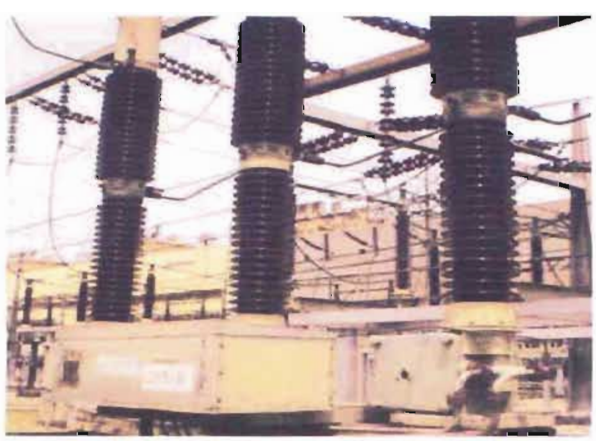

Figure 3.15: oil circuit breaker and rating of oil circuit breaker

3.2.7. Air Blast Circuit Breaker:

This type of breakers employs 'air blast' as the quenching medium. The contacts are opened by air blast produced by the opening of blast valve. The air blast cools the arc and sweeps away the arcing products to the atmosphere. This rapidly increases the dielectric strength of the medium between contacts and prevents from re-establishing the arc. Consequently the arc is extinguished and the flow of current is interrupted.

3.3 Relay:

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and disconnects the switch contacts. At APSCL two types of relay is used. One is electrical relay and another is electronics relay.

3.3.1. Electrical Relay:

At APSCL for the protection of unit 1 and 2 electrical relay is used. This is a large size relay according to electronics relay. This type of relay is now rarely used in the power plant. In this relay we need to adjust the tripping condition manually. Suppose we want to trip the system in 1 second at 5 ampere fault current. We have to adjust the time and current accordingly.

Figure 3.16: Electrical relay

3.3.2. Electronics Relay:

Now this type of relay is enormously used. There is used micro chip in this type of relay. So it is a small in a size. This relay is very fast and effective to trip the circuit. At APSCL this type of relay is used in unit 3, 4 and 5.

Figure 3.17: electronics relay

3.3.3. Fabricated Relay:

In this type of relay there will be relay board. In this board there will be different types of protecting device like fuel pump relay, main power relay, circuit breaker, fuse, injector ballast resistor etc. Connecting these all equipment form fabricated relay. At APSCL this type of relay is also used in unit 5.

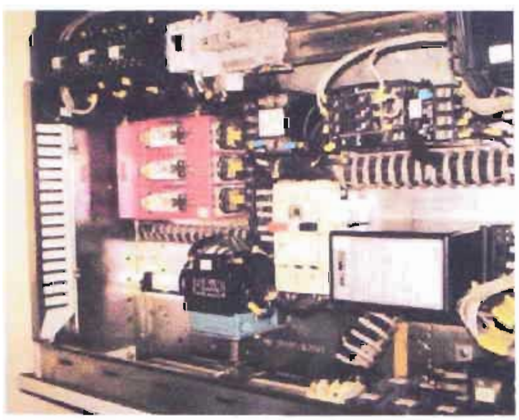

Figure 3.18: Fabricated relay

3.4. Generator cooling system:

Efficiency of a generator is strongly related to the cooling system of the generator. Basically there are three types of cooling system.

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

3.4.1. 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, through the generator, will cool the generator and rotor.

3.4.2. Hydrogen Cooling:

Another way to cool the generator is to use hydrogen gas. It is circulated through the generator and around the rotor to cool things. Hydrogen is seven to ten times better at transferring heat than air. This means that for the same size generator, if it is cooled with hydrogen the effecting of generator increases. The hydrogen is circulated by fans on the ends of the generator rotor, and as it's circulated around the generator it passes over coolers which have water circulating through them. The heat which is absorbed by the hydrogen gas as it passes through the generator and around the rotor is transferred to the water in the cooler. As the hydrogen exits the coolers, it's re-circulated back to the generator and rotor, in a continuous cycle.

3.4.3. Water Cooling:

The stator winding of the turbo generator is cooled by circulating de-mineralized water through hollow conductors of stator winding bars in a closed loop. The de-mineralized water is feed to the feed header mounted inside the generator casing on the turbine end. From the feed header water flows through hoses which connect feed header to the individual lower bar. Water passes through lower bar 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 boosting and cools it also. The pump drives the D.M. water through the coolers filters and windings and discharge in to a separate compartment of the hermetically sealed expansion tank mounted 5 M higher from the center line of generator and maintained at vacuum of 250-300 mm of Hg. The water from center the expansion tank is again drawn by the pump cooled and re-circulated. If the pressure of the D.M. water falls in the system below the particular value then the other pump starts automatically.

Figure 3.19: Cooling water pump

3.5. Back-up System:

In the back-up system, DC supply is used. It is needed to run the relay, circuit breakers and control system when Fault occurs. Here Nickel 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 220 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:

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.

The cell voltage of all the batteries is around 1.36V and the gravity test is 1160

Figure 3.20: Battery arrangement of back-up system and Series connection of the batteries

This back-up system will only be used when the plant trips and power generation stops.

3.6. Control Unit:

Control unit one of the most important part of the power plant. There will be a control room to operate the switchgear, generator, motor, relay, turbine etc. At Ashuganj Power Station and Company Limited (APSCL) there are five control room for different unit.

- control room of unit 1&2
- control room of unit 3&4
- control room of unit 5
- control room of GT1 & ST(combine cycle)
- control room of GT2

3.6.1. Control Room of Unit-1&2:

This control room analog system control room. Here all equipments are operated in manually. Electrical equipment are used is this unit. From staring moment of APSCL this control room is unchanged.

Figure 3.21: Control Room of unit 1&2

3.6.2. Control Room of Unit-3&4:

This control room is depended in electronics equipments. Here everything is controlled by electronics card system. In this electronics card we set the instruction as we want.

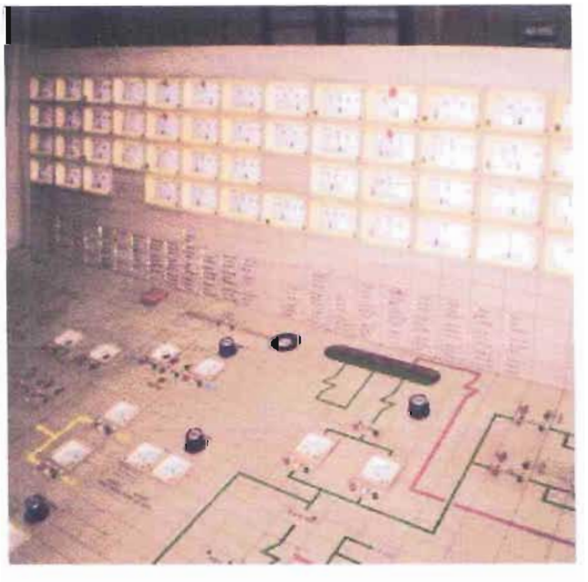

Figure 3.22: Control Room of unit 3&4

3.6.3. Control Room of Unit-5:

This 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.

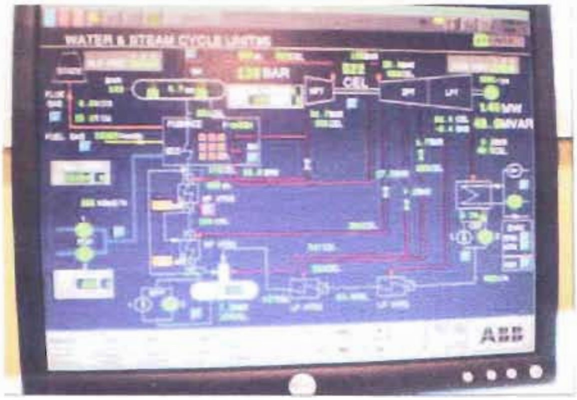

Figure 3.23: Control System of unit 5 (on computer)

3.6.4. Control Room of GT1 & ST(Combine Cycle):

This control room is also electronics card base control room. Combine cycle of gas turbine is controlled in this control room.

Figure 3.24: Control Room of combine cycle

4. SUBSTATION

The present day electrical power system is a.c. i.e. electric power is generated, transmitted and distributed in the form of alternating current. The electric power is produced at the power stations which are located at favorable locations generally quite away from the consumers. It is delivered to the consumers through a large network of transmission and distribution. At many places in line of the power system, it may be desirable and necessary to change some characteristic of electric supply. This is accomplished by suitable apparatus called substation. For example generation voltage (11KV or 6.6KV) at the power station is stepped up to high voltage (say 220KV or 132KV) for transmission of electric power. The assembly of apparatus used for this purpose is substation. Similarly near to the consumer localities, the voltage may be stepped down to utilization level. This job is again accomplished by a suitable apparatus called substation.

Figure 4.1: Substation

Substations usually contain transformers in order to change voltage levels; they are connected to a "bus" via a circuit breaker. Specifically, substations are used for some or all of the following purposes: connection of generators, transmission or distribution lines, and loads to each other; transformation of power from one voltage level to another; interconnection of alternate sources of power; switching for alternate connections and isolation of failed or overloaded lines and equipment; controlling system voltage and power flow; reactive power compensation; suppression of over voltage; and detection of faults, monitoring, recording of information, power measurements, and remote communications. Minor distribution or transmission equipment installation is not referred to as a substation.

Figure 4.2: Power generation and distribution network

At APSCL, Ashugonj substation, we were introduced with various equipment of substation during our internship. Our supervisor Engineer Md.Shahid Ullah, assistant Engineer (Sub Station) helped us to learn about them. We visited the grid station, 8th May, 2011 and from 11th May, 2011 to 14th May, 2011.

4.1 Equipment in a Transformer Sub-Station:

The equipment required for a transformer Sub-Station depends upon the type of Sub-Station, Service requirement and the degree of protection desired. Sub-Station has the following major equipments.

- Bus - bar
- Insulators
- Isolating Switches
- Circuit breaker
- Protective relay
- Instrument Transformer
- Lightning Arrester
- Transmission line
- Cable
- Tower
- Cooling system

In addition to above, there are following equipment in a Sub-Station.

- Fuses.
- Carrier-current equipment.
- Sub-Station auxiliary supplies.

4.1.1. Bus bar:

In electrical power distribution, bus bar is a thick strip of copper or aluminum that conducts electricity within a switch board, distribution board and other electrical elements. Bus bar is used to carry a very large current or to distribute current to multiple devices within switchgear or equipment. The size of bus bar is important in determining the maximum amount of current that can be safely carried.

There are several types of bus bar such as-

- Single bus bar
- Double bus bar
- Double bus bar with reserved bus bar
- Ring bus bar etc.

But during our internship, we got to know that Ashugonj grid station uses double bus bar arrangement. So we only discuss here about the double bus bar arrangement. They do not use single bus bar because it cannot carry large load.

4.1.1A. Double Bus bar arrangement:

Bus bar arrangement is very important issue in substation. But this arrangement depends on several issues like flexibility, technical consideration, economic consideration, safety, extension etc.

Figure 4.3: Bus Bar in APSCL

Advantages:

Double bus bar has several advantages. It has following advantages-

- Cost of equipment is less.
- Easy to use.
- Requires less space.
- Cost of installation is less.
- Cost of maintenance and spares holding is less.

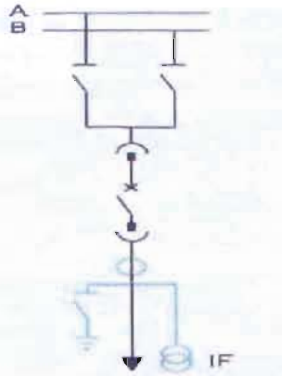

Figure 4.4: Double Bus bar arrangement system

4.1.2. Insulator:

An insulator, also called a dielectric, is a material that resists the flow of electric charge. In insulating materials valence electrons are tightly bonded to their atoms. These materials are used in electrical equipment as insulators or insulation. Their function is to support or separate electrical conductors without allowing current through themselves. The term also refers to insulating supports that attach electric power transmission wires to utility poles. There were several types of insulators Such as-

4.1.2A. Pin type Insulator:

This type of insulator only used for above 33 KV transmission line. Otherwise electricity transmission cost will rise.

4.1.2B. Shackle type Insulator:

At the beginning shackle insulators were used as strain insulator but later they are used in low voltage distribution line. This type of insulator can be used for both horizontal and vertical position and also directly fixed with a bolt.

4.1.2C. Suspension type Insulator:

This type of insulator is cheaper than pin type insulator beyond 33 KV voltages. The desired number of disc can be connected in series for suspension type insulator. The series disc arrangement provides more flexibility to the transmission line. The insulators string is free to swing in any direction. If the demand of supply voltage is being increased; we can manage this demand by using series disc.

Cause of Insulator failure:

Causes of insulator failure at APSCL substation are given below:

- The insulators have to withstand both mechanical and electrical stress.
- Due to flash over voltage.
- Due to undesired line voltage.
- Insulator may fail due to spark.
- Due to air gap.

4.1.3. Isolating Switches:

In electrical engineering, a disconnector or isolator switch is used to make sure that an electrical circuit can be completely de-energized for service or maintenance. Such switches are often found in electrical distribution and industrial applications where machinery must have its source of driving power removed for adjustment or repair. High-voltage isolation switches are used in electrical substations to allow isolation of apparatus such as circuit breakers and transformers, and transmission lines, for maintenance. Often the isolation switch is not intended for normal control of the circuit and is only used for isolation.

Isolator switches have provisions for a padlock so that inadvertent operation is not possible. In high voltage or complex systems, these padlocks may be part of a trapped-key interlock system to ensure proper sequence of operation. In some designs the isolator switch has the additional ability to earth the isolated circuit thereby providing additional safety. Such an arrangement would apply to circuits which inter-connect power distribution systems where both end of the circuit need to be isolated.

The major difference between an isolator and a circuit breaker is that an isolator is an off-load device intended to be opened only after current has been interrupted by some other control device. Safety regulations of the utility must prevent any attempt to open the disconnector while it supplies a circuit.

4.1.4. Circuit Breaker:

Engg. Md.Shahid Ullah, assistant Engineer (Sub Station) of the Ashugonj Power Station Company took us to visit the switchyard. There he introduced us with various types of switchyard equipment. The most important part of the switchyard is Circuit Breaker (CB). He told us about circuit breaker that, 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, we have seen two types of Circuit Breaker. A typical circuit breaker is shown in Figure 4.5.

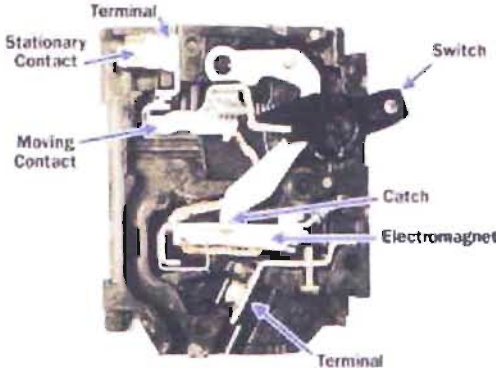

Figure 4.5: Inside of a typical Circuit Breaker

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:

4.1.4A. 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 (i.e. changing and purifying the oil) In Figure 4.6, we have shown Oil Circuit Breaker.

Figure 4.6: Oil Circuit Breaker at APSCL

The circuit breaker is made by SIEMENS. Rating of the circuit breaker is shown in figure 4.7 below.

Figure 4.7: Rating of Oil Circuit Breaker

4.1.4B. SF6 Circuit Breaker:

A sulfur hexafluoride circuit breaker uses contacts surrounded by sulfur hexafluoride gas to quench the arc. They are most often used for transmission-level voltages and may be incorporated into compact gas-insulated switchgear. In cold climates, supplemental heating or de-rating of the circuit breakers may be required due to liquefaction of the SF6 gas. In Figure 8, we have shown a SF6 circuit breaker.

Figure 4.8: SF6 Circuit Breaker

The circuit breaker is made by SIEMENS. Rating of the circuit breaker is shown by a figure 9 below.

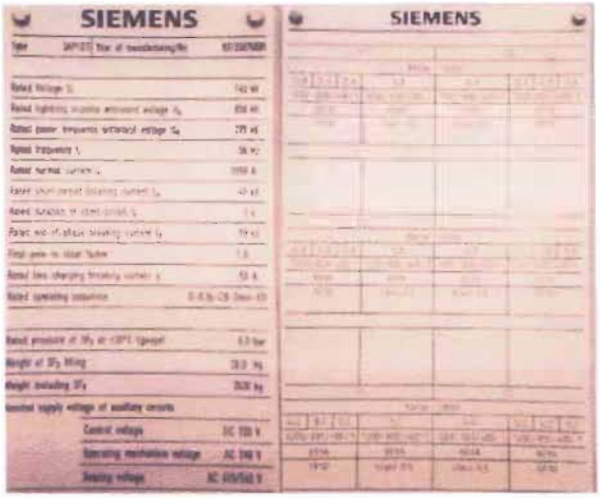

Figure 4.9: Rating of SF6 Circuit breaker

4.1.5 Protective relays:

In electrical engineering, a protective relay is a complex electromechanical apparatus, often with more than one coil, designed to calculate operating conditions on an electrical circuit and trip circuit breakers when a fault is detected. Unlike switching type relays with fixed and usually ill-defined operating voltage thresholds and operating times, protective relays have well-established, selectable, time/current (or other operating parameter) curves. Protection relays respond to such conditions as over-current, over-voltage, reverse power flow, over- and under- frequency. Distance relays trip for faults up to a certain distance away from a substation but not beyond that point. An important transmission line or generator unit will have cubicles dedicated to protection, with many individual electromechanical devices.

4.1.5A. Relays that are used in APSCL substation:

i. **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.

ii. **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.

iii. **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

iv. **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 point 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.

v. **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, they use microwave type pilot relay and power line carrier type pilot relay for protecting the transmission line.

vi. **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. This type of relay uses most of the cases.

4.1.5B. 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 -

i. **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.

ii. **Speed and time:**

As soon as possible relay will select the faulty part; damage would be that much minor.

iii. **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.

iv. Reliability:

Reliability means trustworthiness. It should not fail to operate during the fault in the protected zone.

4.1.5C. Function of the protective relay:

A relay's principal function is to protect service from interruption or to prevent or limit damage to apparatus of the grid station. Following functions are operated by a protective relay -

1. Close the trip circuit for opening the circuit breaker during the abnormal condition such as unbalanced load, reverse power, over current flow, short circuit etc.
2. Make sound or give alarm for opening the circuit breaker during the abnormal condition.
3. To disconnect the faulty part as soon as possible to minimize the damage.

To improve the system stability, service continuity and system performance, relay disconnects the faulty part quickly.

4.1.5D. Measurement in relay:

Relay could measure the voltage, current, frequency, temperature, impedance, power, pressure, velocity, difference between two currents, magnitude etc

4.1.6 Instrument transformers:

Instrument transformers are used 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.

4.1.6A. Step up Transformer:

A transformer is made from two or more coils of insulated wire wound around a core made of iron. The number of times the wires are wrapped around the core ("turns") is very important and determines how the transformer changes the voltage. If the primary has fewer turns than the secondary, you have a step-up transformer that increases the voltages. When voltage is applied to one coil (frequently called the Primary or input) it magnetizes the iron core, which induces a voltage in the other coil, (frequently called the secondary or output). The turns ratio of the two sets of windings determines the amount of voltage transformation. An example of this would be 100 turns on the primary and 50 turns on the secondary, a ratio of 2 to 1. Transformer is nothing more than a voltage ratio device with a step up transformer or step down transformer the voltage ratio between primary and secondary will mirror the "turn ratio" (except for single phase smaller than 1 KVA which have compensated secondaries). A practical application of this 2 to 1 turns ratio would be a 480 to 240 voltage step down. A transformer is made from two coils, one on each side of a soft iron core. Step-up transformer increases the voltage.

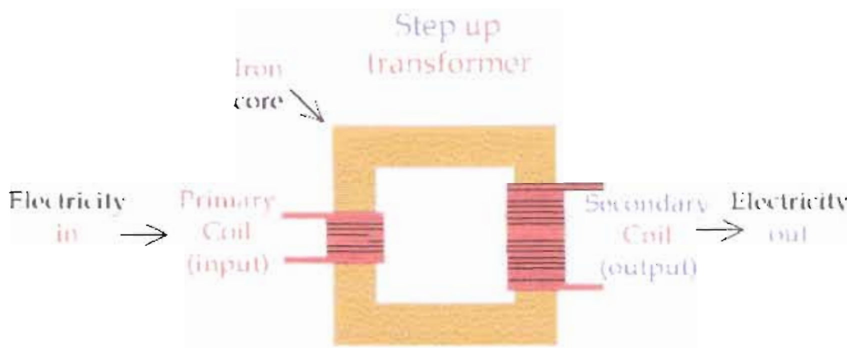

Figure 4.10: model of transformer

Figure 4.11: Step-up transformer

4.1.6B. Current Transformer (CT):

At Ashugonj Power Station Company Substation, we have seen various types of Current Transformers. The engineers of substation informed us about the usage of current transformer in series with equipment for the protection. Current transformer or CT is used for measuring the current of electric equipment. It is a step down transformer. When high current is applied to any measuring circuit and then it can be damaged. Current transformer then produces reduced current which is proportional to the applied current. Only then, this reduced current is safe for measuring circuits and measuring instruments. For that current transformer is often termed as Instrument Transformer. When we were doing internship at the power grid station, we were told that current transformer is excessively used in protective relays and measuring circuits. It is usually connected to the bus bar protection system and circuit breakers trip unit. For the safety of the system, current transformer's secondary winding should be checked regularly, because if it gets unloaded or open, then it can create arc, which is harmful. Sometimes current transformers step up the current in the transmission line that reduces the cost of transmission with less power loss. Without current transformer, the transmission of electricity would not be cost effective and our house hold equipment, which works on AC, would not be safe. So in the metering, monitoring, relaying and protection functions, current transformer is playing a vital role. A typical current transformer is shown in Figure 4.12.

Figure 4.12: Current Transformer

4.1.6C. Potential Transformer (PT):

Potential transformer can be also considered as Voltage Transformer. Potential transformer is a step down type transformer. This is mainly used for protective relaying purpose and operation of other instruments such as ammeter, voltmeter and watt meter etc. In Figure a typical potential transformer is shown. This transformer works for single and three phase system both. While doing internship, we learnt that if a potential transformer is not used then KV (Kilovolts) voltage cannot be measured because it is too high to damage any meter. This transformer's primary winding is connected to the transmission line and secondary winding is connected to the point that will be measured. Potential transformer keeps the instrument voltage at a safe level and isolates from the power system. So there is no direct connection between power lines and measuring instrument. Potential transformer is designed to provide as accurate a voltage step down ratio as possible. We have seen the Coupling Capacitor Voltage Transformer (CCVT) in APSCL Substation.

Figure 4.13: Potential Transformer

4.1.7 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 for surge the ground. In this way the excess charge on the line because of the surge harmlessly conducted through the arrester instead of being sent back in the line, because when the surge is over the resistance offers high resistance to make the gap non-conducting.

Figure 4.14: Lightning Arrester

4.1.7A. Types of Lightning Arrester:

A protective device designed primarily for connection between a conductor of an electrical system and ground to limit the magnitude of transient over voltages on equipment. It is also known as lightning arrester. Basically lightning arrester could be various types. They are-

i. **Rod gap arrester:**

It is very simple type of lightning arrester which consists of two rods and is bent at right angle with a very short gap. One rod is connected to the line and other is connected to the ground.

ii. **Horn gap arrester:**

Horn gap arrester is also another types of arrester which consists of a two horn shaped metal rods separated by a small gap. One end of the horn is connected with line circuit and other end is connected with the ground. The gap between of the horn is so adjusted that normal supply voltage is not enough to cause an arc across the gap.

iii. **Multi-gap arrester:**

Multi gap arrester consists of a series of metallic cylinders insulated from one another and separated by small intervals of air gaps. The first cylinder is connected to the line circuit and others are connected to the ground though a series resistance.

iv. **Overhead ground wires:**

The most effective method of protection to transmission line against lightning strokes is use of over head ground wires. Over head ground wires are mainly seen at the top of the transmission tower and also are grounded through a low resistance. Below it, there are conductors. For such positions of the over head ground wire, all the lightning strokes are intercepted by them, and ground wire will take up all the strokes instead of allowing them in the conductors.

4.1.8 Transmission Line:

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. During Internship we saw outgoing feeder.

4.1.8A. Outgoing feeder:

This data is taken from SINGLE LINE DIAGRAM of ASHUGANJ 132KV SUB-STATION

There are nine outgoing feeders, the outgoing feeders are:

- Shajibazar-3
- Shajibazar-1
- Shajibazar-2
- Ghorashal-1
- Ghorashal-2
- Kishoregonj-1
- Kishoregonj-2

Data collected from SLD of ASHUGANJ 230KV SYSTEM is given below

- United 50MW Rental
- AGRECO 80MW Rental
- Comilla-I
- Comilla-II

4.1.9 Cable:

At APSCL substation, following types of cable they are using as transmission line. The cables are-

4.1.9A. Twisted Pair:

The Twisted Pair transmission line consists of insulated wires twisted together to form a flexible line without the use of spacers.

4.1.9B. Shielded Pair:

The Shielded Pair consists of parallel conductors separated from each other and surrounded by a solid dielectric. The conductors are contained within braided copper tubing that acts as an electrical shield. The assembly is covered with a rubber or flexible composition coating that protects the line from moisture and mechanical damage.

4.1.9C. Coaxial cable:

It is an electrical cable with an inner conductor surrounded by a flexible, tubular insulating layer, surrounded by a tubular conducting shield.

Figure 4.15: Co-axial cable

4.1.9D. Underground cable:

An underground cable essentially consists of one or more conductors covered with suitable insulation and surrounded by a protecting cover.

Figure 4.16: Underground Cable

Cable should have the following properties:

- Cable should have steel, Copper or aluminum conductor for good conductivity.
- The maintenance cost should be reasonable for cable.
- It should have good insulation properties for protecting undesirable situation.
- It must have good mechanical strength.

4.1.9.1. Construction of cable:

Cable must have following conductor and insulation for the best performance.

Conductor in cable

A good conductor can provide efficient service for power transmission. Depending upon the service category, conductor's core may be one or multiple. Aluminum conductor is being used as a cable conductor at substation for minimizes the cost and efficient service. They mainly use following types of conductor.

- Copper conductor
- Steel conductor
- Aluminum conductor

4.1.9.2. Insulation in cable:

The suitable insulation is given for each core of conductor depends upon of the voltage transmission.

Insulating material for cable should have the following properties:

- To avoid leakage current, it's should have high resistivity.
- To prevent the electrical breakdown of cable, insulation should have high dielectric strength.
- It should have high mechanical strength.
- It has to be non inflammable.
- The insulation material has to be incapable to make any kind of chemical reaction.

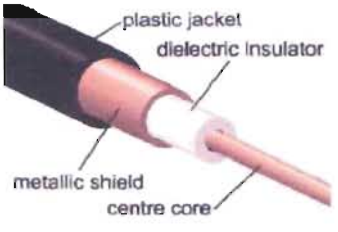

Figure 4.17: Co-axial cable model

4.1.10 Tower:

Tower is a tall structure, usually a steel lattice tower, used to support overhead electricity conductors for electric power transmission. There are various types of tower at APSCL substation. At the substation, there are following types of tower.

4.1.10A. Line Tower:

This type of tower is used for supporting the overhead line conductors. It has following properties.

- It has high mechanical strength to withstand the weight of conductors.
- It has long stability.
- Easy accessibility of conductors for maintaining.

It is low costly for maintaining.

4.1.10B.Wooden pole:

Wooden pole is made by seasoning wood. It is suitable for lines of moderate cross-sectional area and of relatively shorter spans. It has following properties.

- It has high availability.
- Providing insulating properties.
- It is very cheap for operating.

4.1.10C. Reinforced Concrete pole:

This is most popular and used as line supporters in recent year. It has following properties.

- It has greater mechanical strength compare to steel pole.
- It has good insulation properties.
- It has less weight.

4.1.10D. Steel tower:

This type of Tower is suitable for high power transformation with long distance. It is used most of the cases at substation due to following properties.

- Steel tower has more mechanical strength.
- It has longer life compare to other types of tower.
- It permits the use of longer span.
- This type of tower can minimize the lighting travel as each tower acts as a lightning conductor.
- It is suitable for bad climate condition.

Figure 4.18: Transmission line & Tower

4.1.11 Cooling system:

Cooling system is must at any substation. As the equipment of substation is working with high voltage and high current, so they always generate high temperature. If there is no good cooling system, then there are chances of fire and damage of the equipment. So for the cooling system

- Fan
- Various type of oil
- Water tank.
- Air conditioner

Figure 4.19: Transformer cooling fan

4.1.12 FUSE:

High voltage fuses are used to protect the electrical system in a substation from power transformer faults. They are switched for maintenance and safety.

Figure 4.20: Fuse

4.1.13 Carrier-current equipment:

4.1.13A. 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 50 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 station 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 50 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.

4.1.13B. Communication System:

Communication system is very important system in a substation. At APSCL station, they have-

- Telephone
- PLCC

4.1.14 Sub-Station auxiliary supplies:

All but the smallest substations include auxiliary power supplies. AC power is required for substation building small power, lighting, heating and ventilation, some communications equipment, switchgear operating mechanisms, anti-condensation heaters and motors. DC power is used to feed essential services such as circuit breaker trip coils and associated relays, supervisory control and data acquisition (SCADA) and communications equipment.

4.1.14A. DC Supplies:

DC Battery and Battery charger room:

Battery is the most important source in the grid station. It is the heart of the station because most the equipment is run on DC power. Battery is the only back up source of DC supply. Without DC power supply, the grid is unprotected, because security lighting, fire alarm circuit, breaker control circuit, heating equipment and relay get energized by the DC supply. In the station, they have a battery charger room and there were 84 nickel cadmium battery cell.

4.2 Transformer protection:

Transformer protection 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.

Protection systems usually comprise five components:

i. Current and voltage transformers to step down the high voltages and currents of the electrical power system to convenient levels for the relays to deal with;
ii. Protective relays to sense the fault and initiate a trip, or disconnection, order;
iii. Circuit breakers to open/close the system based on relay and autorecloser commands;
iv. Batteries to provide power in case of power disconnection in the system.
v. Communication channels to allow analysis of current and voltage at remote terminals of a line and to allow remote tripping of equipment.

For parts of a distribution system, fuses are capable of both sensing and disconnecting faults.

Failures may occur in each part, such as insulation failure, fallen or broken transmission lines, incorrect operation of circuit breakers, short circuits and open circuits. Protection devices are installed with the aims of protection of assets, and ensure continued supply of energy. The three classes of protective devices are:

1. Protective relays control the tripping of the circuit breakers surrounding the faulted part of the network
2. Automatic operation, such as auto-reclosing or system restart
3. Monitoring equipment which collects data on the system for post event analysis

While the operating quality of these devices, and especially of the protective relays, is always critical, different strategies are considered for protecting the different parts of the system. Very important equipment may have completely redundant and independent protective systems, while a minor branch distribution line may have very simple low-cost protection.

4.2.1. Types of protection

4.2.1A. Generator sets:

In a power plant, the protective relays are intended to prevent damage to alternators or of the transformers in case of abnormal conditions of operation, due to internal failures, as well as insulating failures or regulation malfunctions. Such failures are unusual, so the protective relays have to operate very rarely. If a protective relay fails to detect a fault, the damage to the alternator or to the transformer may have important financial consequences for the repair or replacement of equipment and the value of the energy that otherwise would have been sold.

4.2.1B. High voltage transmission network:

Protection on the transmission and distribution serves two functions: Protection of plant and protection of the public (including employees). At a basic level protection looks to disconnect equipment which experience an overload or a connection to earth. Some items in substations such as transformers may require additional protection based on temperature or gassing among others.

4.2.1C. Overload:

Overload protection requires a current transformer which simply measures the current in a circuit. If this current exceeds a pre-determined level, a circuit breaker or fuse should operate.

4.2.1D. Earth fault:

Earth fault protection again requires current transformers and senses an imbalance in a three-phase circuit. Normally a three-phase circuit is in balance, so if a single (or multiple) phases are connected to earth an imbalance in current is detected. If this imbalance exceeds a pre-determined value a circuit breaker should operate.

4.1.2E. Distance:

Distance protection detects both voltage and current. A fault on a circuit will generally create a sag in the voltage level. If this voltage falls below a pre-determined level and the current is above a certain level the circuit breaker should operate. This is useful on long lines where if a fault was experienced at the end of the line the impedance of the line itself may inhibit the rise in current. Since voltage sag is required to trigger the protection the current level can actually be set below the normal load on the line.

4.1.2F. Back-up:

At all times the objective of protection is to remove only the affected portion of plant and nothing else. Sometimes this does not occur for various reasons which can include:

- Mechanical failure of a circuit breaker to operate
- Incorrect protection setting
- Relay failures

A failure of primary protection will usually result in the operation of back-up protection which will generally remove both the affected and unaffected items of plant to remove the fault.

5. Conclusion:

It was a great opportunity to do the internship work in the 2nd largest power station of Bangladesh. From these 12 days internship in APSCL we have gathered lots of practical knowledge over power generation, switchgear protection and power distribution. Before this internship we had only theoretical knowledge over these topics. We are very pleased to get the opportunity to work at APSCL. We have learned and experienced the industrial environment by doing internship at APSCL. The authorities of APSCL were very concerned about our internship. The friendly environment at APSCL encouraged us to communicate with the engineers. The experience that we have got by doing internship will help us in future in our working life.

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