Undergraduate Internship

INTERNSHIP REPORT

ON

ASHUGANJ POWER STATION COMPANY LTD.

An Enterprise of Bangladesh Power Development Board

By

Md. Abed Hossain (2008-1-80-050)

Sheikh Sakil Ahmed (2008-1-80-025)

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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.S.C in EEE)

[Summer, 2011]

Approved By

04.10.2011	04.10.2011
Academic Advisor	Department Chairperson
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Approval letters

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Memo no. APSCL/MD/Trg.-10/2011/718 Date-14/05/2011

TO WHOM IT MAY CONCERN

This is to certify that Biddut Ranjan Sarker, SID 2007-2-80-016, Raktim Debnath, SID 2007-2-80-035 , Sharmin Kader, SID 2007-3-80-010, Sheikh Sakil Ahmed, SID 2008-1-80-025, Md. Abed Hossain , SID 2008-1-80-050 have successfully completed their internship from Ashuganj Power Station Company Ltd. (APSCL) from 2nd May to 14th May 2011. They have completed 100 hours of their internship on Power Generation, Transmission, Distribution and protection system of the equipments 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 Ltd. (APSCL), recommending this work as the fulfillment of the requirements of EEE 499 (Industrial Training) of The East West University, Dhaka.

I wish their success in life.

14/5/11

Engr. A.K.M Yaqub
Manager (generator division)
APSCL

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14.5.2011

Engr. Md. Nurul Alam
Managing Director
APSCL

Acknowledgement

The days we had during the internship were indeed memorable and we had an experience of a life time while trying to comprehend the overall system of Ashuganj power station. We are honored and grateful to the power company for giving us the opportunity to work there as interns. The power station workers were very much eager to help us regarding all aspects and they made us feel comfortable to stay there for 14 days and learn the topics of our interest.

We especially want to thank our mentors, who showed us the practical field works in the power station, Md Rokon Mia (senior engineer), Md. Kamruzzaman (senior engineer), Md Shahidullah (assistant engineer), Nur Mohammad (senior engineer), Md. Fazle Hasan (assistant engineer) and last but not the least Md. Azizur Rahman (senior engineer).

We express our gratitude to the instructors of our university who gave us the foundation of engineering. We especially want to mention the name of Dr. Anisul Haque, Dr . Khairul Alam, Dr. I Raza, Kazi Mazibur Rahman (visiting Professor), Dr. Abdul Malekh Mia (visiting Professor) and S.M. Shahriar Rashid, Research lecturer Department of Electrical & Electronic Engineering.

Finally we would like to thank our Department head Dr Anisul Haque for granting our internship in Ashuganj Power station and encouraging us to work hard in order to fulfill the partial requirements for graduating from the university.

We deeply thank our academic advisors for assisting us to write the report Sharmin Rowshan Ara, Senior lecturer and Shamim Ahmed, Research lecturer Department of Electrical & Electronic Engineering, who managed their precious time.

Executive Summary

To fulfill the requirements of graduation in Electrical and Electronics Engineering at East West University we chose the industrial attachment interne. We successfully completed our internship on power production from the Ashuganj Power Station Company Ltd (APSCL). It is situated near Meghna River in Ashuganj. As our major is in power sector so we chose to go for interne in a power company where we can actually learn the practical knowledge of producing electricity and distribute it in an efficient way.

On completion of this internship we gathered practical knowledge about production of electricity, major equipments e.g. Generator, Transformer and Switchgear equipments required for distribution and protection of the system.

We learned about the operation of a power station and also the maintenance of it. We learned the responsibilities of being an Engineer and responding to it as efficiently as possible.

A power station has lots of equipments connected in synchronized manner (where it is necessary) in order to produce power and distribute it. A power station can be divided into three basic sections.

- Backup and control section (it runs on DC power).
- Generation section (it generates electrical energy and conditions it for grid supply).
- Distribution and transmission section (known as substation and grid).

Our duration of stay was divided equally to work in this three major section.

During the internee we have seen a plant getting tripped and the necessary actions that the engineers take in order to make it back to work in normal conditions. We have seen how a transformer is started and the conditions necessary for the transformer to start. We have seen the substation and understood the necessity of each and every equipments used there.

Table of Internship work

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Memo no. APSCL/MD/Trg./2011/ 753 Date-24/05/2011

This is certify that the students of EEE department of East West University, Anik Das, SID: 2008-1-80-028; Md. Maidul Ialam, SID: 2008-1-80-030; Rajesh Mondal, SID: 2008-1-80-065; Kazi Shihab Hossain, SID: 2008-1-80-062; Tanvir Ahmed, SID: 2008-1-80-071; Faisal Md. Jiaur Rahman, SID:2007-2-80-031; Biddut Ranjan Sarker, SID: 2007-2-80-016; Raktim Debnath, SID: 2007-2-80-035; Sharmin Kader, SID: 2007-3-80-010; Sheikh Sakil Ahmed, SID: 2008-1-80-025; Md. Abed Hossain, SID: 2008-1-80-050 have successfully completed their internship in from Ashugonj Power Station Company Ltd.(APSCL) from 2nd May to 14th May,2011 according to the following time table:

Date	Division	Time	Mentor	Signature
02/05/2011	Generator	08.00 AM to 05.00 PM	Md. Rokon Mia Senior Engineer	02/5/11
03/05/2011		08.00 AM to 05.00 PM	Md. Kamruzzaman Senior Engineer	03-05-11
04/05/2011		08.00 AM to 05.00 PM	Md. Rokon Mia Senior Engineer	04/5
05/05/2011		08.00 AM to 05.00 PM	Md. Kamruzzaman Senior Engineer	05-05-11
06/05/2011	Steam turbine and Control Panel	08.00 AM to 01.00 PM	Md. Rokon Mia Senior Engineer	07/5
07/05/2011		08.00 AM to 05.00 PM	Md. Rokon Mia Senior Engineer	
08/05/2011	Substation	08.00 AM to 05.00 PM	Md. Shahidullah Assistant Engineer	08/05/11
09/05/2011		08.00 AM to 05.00 PM	Md. Shahidullah Assistant Engineer	09/05/11
10/05/2011		08.00 AM to 05.00 PM	Nur Mohammad Manager	10/5/2011
11/05/2011	Gas turbine	08.00 AM to 01.00 PM	Md. Fazle Hassan Assistant Engineer	11/5/11
		02.00 PM to 05.00 PM	Md. ~~Ajijur~~ Azizur Rahaman Senior Engineer	11/5/11
12/05/2011	Combined cycle	08.00 AM to 01.00 PM	Md. Fazle Hassan Assistant Engineer	12/5/11
		02.00 PM to 05.00 PM	Md. Ajijur Rahaman Senior Engineer	14/5/11
14/05/2011		08.00 AM to 05.00 PM	Md. Ajijur Rahaman Senior Engineer	

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1.1 Mission of the Company

To ensure uninterrupted and quality power supply to the consumers

1.2 Vision of the Company

To generate electricity and dispatch same through national transmission line to BPDB and to utilize available resources and capacity so that it can contribute towards the national economy through increasing power generation with an aim to maximize the net worth of the company.[5]

1.3 Company Information

Ashuganj Power Station is the second largest power station in Bangladesh, the total power (electricity) generation capacity of its 8 units is 611MW. As a part of the Power Sector Development and reform Program of the Government of Bangladesh, Ashuganj Power Station Company ltd, has been incorporated under the companies Act 1994 on 28 June 2000.

All the activities of the company started formally on 01 June 2003. From that day the overall activities of the company along with the operation, maintenance and development are vested upon a Management Team consisting of the Managing Director, the Director (technical) and the Director (Finance).

Electricity generated in this power station is supplied to the national grid and distributed to the consumers throughout the whole country. This power station plays a significant role in the national economic development by generating more than 15% of the total demand of electricity in the country. In this power station Natural Gas is used as fuel. Water from Meghna is used through in-take channels for steam generation and cooling of generated steam. Used water (for cooling) is again thrown into the Meghna through discharge channels. Huge water from the discharge channels is used for irrigation in the dry season. Approximately 36,000 acres of land of Ashuganj are irrigated by this water. [4]

1.4 Main Objective of the Company

- To carry out the business of electric power generation.
- To supply and sell electricity to Bangladesh Power Development Board through National Grid.
- To undertake projects to increase the power generation of APSCL to meet the growing demand of electric power in the country.
- To increase the net worth of the company. [5]

1.5 Business Risk and Uncertainty

The Directors consider risk factors and uncertainty as follows:
(The following points are taken from the website of APSCL www.apscl.com)

- APSCL took over 8 number of old power Generating Units from BPDP in 2003 which were 20 to 35 years old. 5units are now outlived and operating at lower efficiency and reliability. Overall lower thermal efficiency and scarcity of spare parts are the major threat to operate the company economically and commercial viably.
- In order to up keep old power plants need more time and money this is not favorable to grow competitively in power sector.
- Time replacement with new power plants is the uncertainty of APSCL business growth and prosperity.
- De-rating of APSCL's facility is real threat and risk for steady business.
- APSCL's primary responsibility is to generate electricity. A large overloaded grid substation within APSCL's premises is also a business risk because of different nature workmanship. [5]

1.6 Future Development Plan

Electricity is the driving force of modern civilization as well as the backbone of all development activities of the country as a whole. But the present generation capacity of the country is not sufficient enough to meet the prevailing load demand of the country and causes hindrance to the development activities in industrial, commercial, agricultural and social sectors. So, main objective of APSCL as Generation Company are:

- To narrow the ever increasing gap between demand and supply of electricity through gas based high efficient plant in the country.
- To increase the power generation through optimized utilization of country's natural gas resources.
- To accelerate the economic development of the country by adequate and reliable power generation and to support the planned target of power demand.
- To overcome the present generation shortage through replacement of outlived machine. [5]

1.7 Production Report of the Company

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

Table 1: Present production [7]

1.8 Availability and Efficiency of APSCL Units

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

Table 2: Availability and Efficiency of APSCL Unit [6]

1.9 Cost of Production of Existing Units

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

Table 3: Cost of production of the units [6]

1.10 Company Profile (keynotes)

> Name of the Company : Ashuganj Power Station Company Ltd.

> Date of Incorporation : 28 June 2000

> Registration No: C-40630 (2328)/2000 date. 28.06.2000

> Location : 90 km North-East of Dhaka on the left bank of the river Meghna

> Land : 311.22 Acres

> Installed Capacity : 724 MW

> Total number of plants : 3

➤ Total Number of Units : 8

➤ **Plant 1: Thermal Power Plant (TPP)**

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

➤ **Plant 2: Combined Cycle Power Plant (CCPP)**

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

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

➤ **Plant 3: Thermal Power Plant (TPP)**

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

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

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

➤ Fuel used: Natural Gas Supplied by Titas Gas Transmission & Distribution Co. Ltd. Bangladesh. [3]

1.11 Current Power Sector Structure

Till date in Bangladesh the power sector has been under the authority of government directly or indirectly. The power sector in Bangladesh has been managed, facilitated and regularized by the government in such a way that delivers the flourished outcome. Overview of Bangladesh power sector has been given below:

Owner & Regulator:

- Power Division, Ministry of Power, Energy & Mineral Resources.

Generation:

- Bangladesh Power Development Board (BPDB).
- Rural Electrification Board (REB).
- Ashuganj Power station co. Ltd (APSCL).
- Electricity Generation Company of Bangladesh Ltd. (EGCBL).
- Independent Power Producer (IPP).
- Small Power Producer (SPP).

Transmission:

- Power Grid Company of Bangladesh Ltd. (PGCB).

Distribution:

- Bangladesh Power Development Board.
- Dhaka Electricity Supply Authority (DESA).
- Dhaka Electric Supply Company Ltd. (DESCO).
- Rural Electrification Board through Rural Electric Co-operatives, Palli Biddyut Samities (PBS).
- West Zone Power Distribution Co. Ltd (WZPDCL). [8]

1.12 Bangladesh's Power Sector at a Glance

In FY 2010-11 total generation capacity was 6727MW (upto June 15, 2011) including 3534 MW in public sector and 3193 MW in private sector including (REB)

Sl. No.	Items	FY 2010-11 (Up to 15 June'11)
1.	Generation Capacity, MW	6,727
2.	Maximum Generation, MW (June 13, 2011)	4,890
3.	Net Generation, MkWh (FY2009-10)	29,247
4.	Transmission Line, km	8,500
5.	Grid Substation Capacity, MVA	
	(a) 400 KV & 230 KV	6,850
	(b) 132 KV	9,899
6.	Distribution Line, km	2,70,000
7.	Number of Consumers (million)	12.00
8.	Number of Village Electrified	53,281
9.	Per Capita Generation, kWh	236
10.	Access to Electricity	49%

Table 4: Power sector at a glance [9]

1.13 Generation Capacity and Present Generation

In the public sector, a good number of generation units have become very old and has been operating at a much-reduced capacity. As a result, their reliability and productivity are also poor. For the last few years, actual demand could not be supplied due to shortage of available generation capacity. Besides, due to shortage of gas supply some power plants are unable to reach their usual generation capability. But now it has been seen that lots of private company are much interested to set up power plant and this scenario is increasing day by day. That's why the present situation of power generation is much developed than past time. Maximum generation **was (4936.00 MW as on 18/07/2011)** supplied till to-date. Here below the table shows the present situation of generation of different sector of Power Company (public, private and rental). [9]

Owner Name	Derated Capacity (MW)	Day Peak (MW)	Eve. Peak (MW)
Daily Generation of 27/07/2011			
PDB	2593.00	980.50	1181.00
SBU,PDB	267.00	192.00	191.00
EGCB	255.00	60.00	62.00
APSCL	759.00	466.00	506.00
IPP	1271.00	1033.00	1077.00
SIPP,PDB	325.00	221.00	235.00
RENTAL(3 yrs)	453.00	274.00	332.00
SIPP,REB	25.00	12.00	12.00
Q.Rental 3 Years	764.00	600.00	627.00
Rental 15 Years	168.00	147.00	146.00
QRPP(5yrs)	50.00	15.00	13.00
QRPP(5yrs)	236.00	302.00	336.00
Total	7166.00	4302.50	4718.00

Table 5: Demand at peak hours of different company [9]

The installed capacity by owner basis for FY 2010-11 (up to 15 June'11) is shown in chart

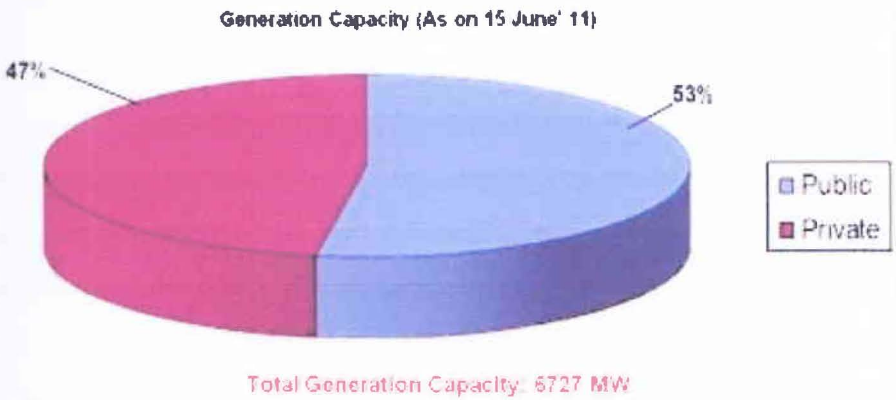


Figure 1.1: Installed capacity by owner basis [8]

1.14 Power Generation Future Rolling Plan

Power is the pre condition for social and economic development. But currently consumers cannot be provided with uninterrupted and quality power supply due to inadequate generation compared to the national demand. To resolve the present shortfall and to meet the increasing demand for electricity, the government has taken an initiative to add additional power 14773 MW by 2016. For this reason installation of new power plants and the maintenance of the old power plants has been given highest priority. [10]

2. Power Generation

2.1 Introduction of Steam Power Plant

Generally a steam power plant is a power generating station in which the prime mover is steam driven. Steam generated from heated water, spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and converted to water again. This process of recycling is known as a Rankine cycle. [11]

There are three power plants in Ashuganj Power Station Company Ltd (APSCL) and among that three plants unit 1,2,3,4 and unit 5 is steam power plant. During our internship we visited unit 2 which is 64 MW, 3 and 5 which produce 150MW each. Unit 2 were commissioned in July 1970 and the turbo generator and boiler equipment were supplied by M/S BBC (Germany), and M/S Babcock and Wilcox (Germany).Unit 3 was started in 1986 and unit 5 was 1987. Present generation of unit 2 is 64MW and unit 3 is 105MW and unit 5 is 140 MW. We saw the overall generation system of steam power plant of APSCL during our internship in 02.05.2011 to 07.05.2011 by the guidance of Md Rokon Mia (senior engineer) and Md. Kamruzzaman (senior engineer).

2.2 Choice of Location of Steam Power Station

It is very much important to select a suitable location for a steam power plant. Ashuganj is situated at the bank of the river Meghna. So it was the most favorable place for a power station because of availability of natural resources for power generation. That's why in 1966 the government decided to set up a power station in Ashuganj The following is a list of factors that influence the selection of site for constructing a Steam power station:

Supply of fuel:

- The station must be located close to any gas field to reduce the transportation cost of fuel.

Availability of water:

- The station must be located near a river bank or canal for continuous water supply.

Transportation facilities:

- The station must be well connected to major transport routes (e.g. Rail or Road).

Cost & type of land:

- The land must have a good bearing capacity for heavy equipment and yet be cheap enough to purchase.

Distance from populated areas:

- The station must be located as far away from populated areas as possible due to air pollution. [11]

2.3 Efficiency

Efficiency of power plant is a very significant factor. Different power plants have different rates of efficiency. The overall efficiency of a power station is quite low (about 33% to 48%) due to some reasons. A huge amount of heat is lost in the condenser and secondly, heat losses occur at various stages of the plant. The heat lost in the condenser cannot be avoided. It is because the heat energy cannot be converted into mechanical energy without a temperature difference. The greater the temperature difference, the greater the heat energy is converted into mechanical energy. These necessities keeping the steam in the condenser at the lowest temperature. But we know that the greater the temperature difference, the greater is the amount of heat lost.

In APSCL among the five units three units are now running and the efficiency of unit 2, 3 and 5 is respectively 31%, 31% and 36%. [11]

2.4 Equipment of Steam Power Station

A modern steam power plant is highly complex and has numerous equipments and auxiliary. At the time of internship we have learnt about the equipment and auxiliaries which are part of the steam power plant. During that time we were familiar with many terms which were related with steam power plant such as turbine introduction, Backup System of Generator, Generator Excitation & Protection and Control System of unit 3, 4. Transformer Maintenance (Testing), Generator Cooling System, Control System of unit 5(Digital), Motor Winding/Excitation & Synchronization, Control System of Unit 1,2 , Boiler Drum, Feed water drum, LP,HP,IP turbine and Condenser. Now we will discuss some of these apparatus, their working principle and their types.

2.4.1 Boiler

A boiler is a closed vessel in which water is converted into steam by utilizing the heat of fuel combustion. In APSCL natural gas from Titas is being used as fuel. There are 3 boilers (present time), running in APSCL and these boilers are water tube boiler.

Water Tube Steam Boiler

When hot combustion gases circulate around the outside of a large number of water-filled tubes then it is called water tube steam boiler. The tubes extend between an upper header, called a steam drum, and one lower header or drum. In older designs, the tubes are either straight or bent into simple shapes. Newer boilers have tubes with complex and diverse bends. Because the pressure is confined inside the tubes, Water Tube Steam Boilers can be fabricated in larger sizes and used for higher-pressure applications and for large capacity of power station.

Figure 2.1: Water Tube Steam Boiler of APSCL

Advantages of Water Tube Steam Boiler:

- Available in larger capacities.
- Able to handle higher pressures.
- Faster response to changing loads.
- Able to reach very high temperatures.
- Provide an adequate furnace to ensure complete combustion.

Disadvantages of Water Tube Steam Boiler:

- High initial capital cost.
- Cleaning is difficult due to design structure.
- No commonality between tubes.
- Bigger in physical size. [11]

2.4.2 Super Heater

A super heater is a device which superheats the steam. It raises the temperature of steam above boiling point of water. This increases the overall efficiency of the plant. A super heater consists of a group of tubes made of special alloy steels such as chromium-molybdenum. These tubes are heated by the heat of flue gases during their journey from the furnace to the chimney. The steam produced in the boiler is led through the super heater where it is superheated by the heat of flue gases. [12]

2.4.3 Economizer

It is a device which heats the feed water with the exhausted heat from the flue gas. This results in raising boiler efficiency, saving in fuel and reduced stresses in the boiler due to higher temperature of feed water. An economizer consists of a large number of closely spaced parallel small tubes connected by header of drums. The feed water flows through these tube and the flue gases flow outside. A part of heat of a flue gases is transferred to feed water, thus raising the temperature of the latter. [12]

2.4.4 Air Pre-Heater

Super heater and economizer generally cannot fully extract the heat from flue gases. Therefore pre-heaters are employed which recover some of the heat in the escaping gases. The function of an air pre-heater is to extract heat from the flue gases and give it to the air being supplied to furnace for combustion. This raises the furnace temperature, which increases the thermal efficiency of the plant. [13]

2.4.5 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 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. We saw large size of condenser in steam power plant of APSCL during our internship.

2.4.6 Prime Mover

The prime mover converts steam energy into mechanical energy. There are two types of steam prime movers, one is steam engine and other is steam turbine. A steam turbine has several advantages over a steam engine as a prime mover such as high efficiency, simple construction, higher speed, less floor area requirement and low maintenance cost. Therefore like all modern steam power station, APSCL employ steam turbine as prime mover.

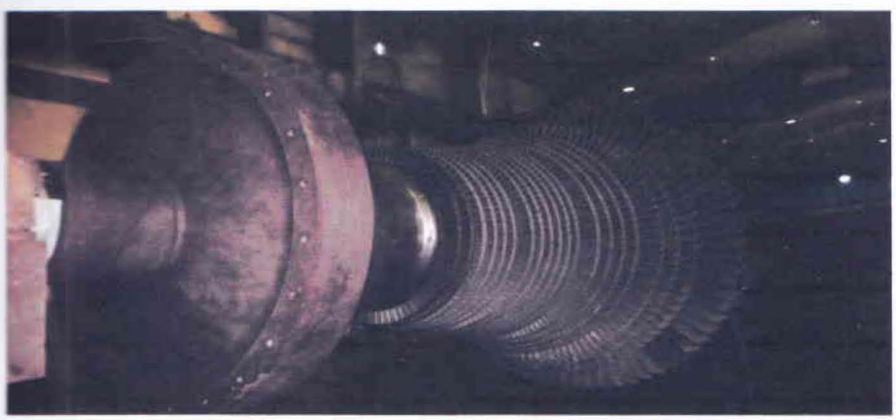


Figure 2.2: Turbine Rotor & Blades

2.4.7 Water treatment Plant

Boilers require clean and soft water for longer life and better efficiency. In APSCL the source of boiler feed water is river Meghna. But this river water may contain suspended and dissolved impurities, dissolved gases etc. Therefore, it is very important that the water is first purified and softened by chemical treatment and then delivered to the boiler.

In APSCL first a huge amount of river water is stored in storage tanks known as large filtering house. Then 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 thus available is fed to the boiler for steam generation. We also saw a control room which controls the overall system of filter house.

Figure 2.3: Storage Tank

Figure 2.4: Control room of filter house

2.4.8 Alternator

An alternator is a mechanical device which is coupled to a steam turbine and converts mechanical energy to electrical energy in the form of alternating current. The alternator may be hydrogen or air cooled. Most alternators use a rotating magnetic field. Any AC electrical generator can be called an alternator. Alternators generates electricity by the same principle of DC generators, namely when the magnetic field around a conductor changes, current is induced in the conductor. Typically the rotating magnet known as rotor turns within a stationary set of conductors wound in coils on an iron core, called the stator. As the mechanical input causes the rotor to turn, the field cuts across the conductors, generates an induced emf. [11]

2.4.9 Turbo Generator

A turbo generator is a turbine directly connected to an electric generator for the generation of electric power. Large steam powered turbo generators (steam turbine generators) provide the majority of the world's electricity. Smaller turbo-generators with gas turbines are often used as auxiliary power units. For base loads diesel generators are usually preferred, because of better fuel efficiency and reliable operation, but on the other hand they are much heavier and need more space. The efficiency of larger gas turbine plants can be enhanced by using a combined cycle, where the hot exhaust gases are used to generate steam which drives another turbo generator. In APSCL unit 1 and 2 Brown Boveri (BBC) generator is using and it was supplied by Germany. Following diagram shows figure of BBC:

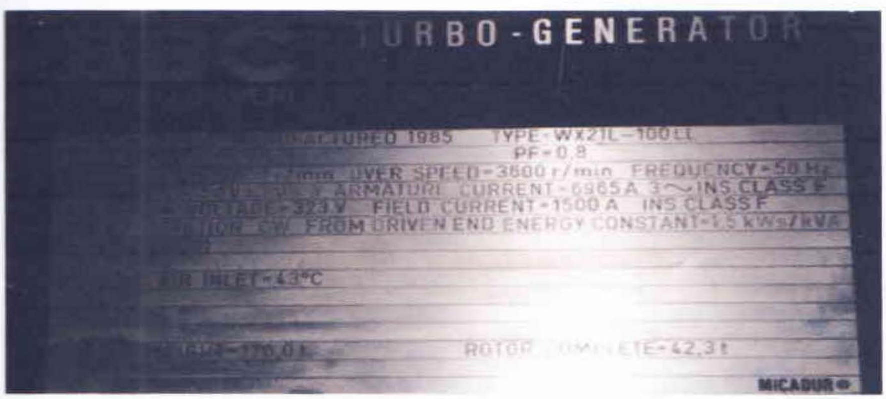


Figure 2.5: Nameplate of BBC

Figure 2.6: BBC Turbo Generator

2.4.10 Transformer

A transformer is an energy transfer device. There are two main purposes for using transformers. The first is to convert the energy on the primary side to a different voltage level on the secondary side. The second purpose is to isolate the energy source from the destination. Transformers are generally divided into two main types. Power transformers are used to convert voltages and provide operating power for electrical devices, while signal transformers are used to transfer some type of useful information. In APSCL we saw the use of transformer and these transformers are used to step up or step down the voltage in substation. Here a picture of a transformer of APSCL is given which is a step-up transformer. The rating of step up transformer is unit 1and 2: 11/132 kV and unit 3 and 4: 15.7/230 kV.

Figure 2.7: Step-up Transformer

2.4.11 Excitation system

Excitation systems have a powerful impact on generator dynamic performance and availability, it ensures quality of generator voltage and reactive power, i.e. quality of delivered energy to consumers. Following types of excitation system are common:

- Brushless excitation systems, with rotating exciter machines and Automatic Voltage Regulator (AVR), or
- Static excitation systems (SES), feeding rotor directly from thyristor bridges via brushes.

Main functions of excitation system are to provide variable DC current with short time overload capability, controlling terminal voltage with suitable accuracy, ensure stable operation with network and or other machines, contribute to transient stability subsequent to a fault, communicate with the power plant control system and to keep machine within permissible operating range.

Figure 2.8: Batteries of Ashuganj Power Plant for back-up System

2.4.12 Cooling Arrangement

Cooling system is very much imperative for a power plant. In order to improve the efficiency of the plant, the steam exhausted from the turbine is condensed with the help of a condenser. Water is drawn from a natural source e.g. river (APSCL), canal or lake and circulated through the condenser. The circulating water absorbs the heat of the exhausted steam. The hot water coming out from the condenser is discharged at a suitable location, down to the river. As the availability of water from the source of supply is not assured throughout the year, recycled water is used to produce steam. During the scarcity of water in the river, hot water from the condenser is passed on to the cooling towers where it is cooled. We saw different types of cooling systems during our internship.

Generator cooling

While small generators may be cooled by natural air circulated through filters at the inlet, larger units generally require special cooling arrangements. Hydrogen gas cooling, in an oil-sealed casing, is used because of its highest heat transfer coefficient and low viscosity which reduces windage losses. This system requires special handling during start-up. The air inside the generator enclosure is first replaced by carbon dioxide before filling with hydrogen. This ensures that the highly flammable hydrogen does not mix with oxygen in the air.

The hydrogen pressure inside the casing is maintained slightly higher than atmospheric pressure to avoid outside air ingress. The hydrogen must be sealed against outward leakage where the shaft emerges from the casing. Mechanical seals around the shaft are installed with a very small angular gap to avoid rubbing between the shaft and the seals. Seal oil is used to prevent the hydrogen gas leakage to the atmosphere.

The generator also uses water cooling. Since the generator coils are at a potential of about 22 kV and water is conductive, an insulating barrier such as Teflon is used to interconnect the water line and the generator high voltage windings. Deminaralized water of low conductivity is used.

Transformer Cooling

The cooling of transformers differs from that of rotary machinery in that there is no inherent relative rotation to assist in the circulation of ventilating air. The losses are comparatively small, and the problem of cooling in most cases can be solved by reliance on natural self-ventilation.

Figure 2.9: External Cooling System of transformer

Internal Cooling

The heating of the coils depends on their thermal conductivity, which itself is a function of thickness of the winding and external insulation. A coil design, which allows the copper heat to flow radially outwards with little cross insulation in the path of the flow, leads to economical rating in that a high current density can be employed for a given temperature rise without sacrifice of efficiency.

2.4.13 Control Room

Control room is very important part of a power station. Power plant operators control and monitor boilers, turbines, generators, and auxiliary equipment in power-generating plants. They distribute power among generators, regulate the output from several generators, and monitor instruments to maintain voltage and regulate electricity flows from the plant. When demand changes, power plant operators communicate with dispatchers at distribution centers to match production with system load. On the basis of this communication, they start and stop generators, altering the amount of electricity output. They also go on rounds to assure that everything in the plant operates correctly and keep records of switching operations and loads on generators, lines, and transformers. In all of these tasks, they use computers to report unusual incidents, malfunctioning equipment, or maintenance performed during their shifts.

The control room of steam power plant of Ashuganj power station use automatic control system and programmable logic control (PLC) unit in their operating system. Programmable logic control (PLC) unit can be operated in two different ways, one is automatic and the other is manual. APSCL use automatic PLC unit. PLC unit is essential for the protection purpose and PLC automatically controls most of the electrical equipments. We visited different types of control rooms in APSCL, picture is given below:

Figure 2.10: Control Room of unit 2 & 5

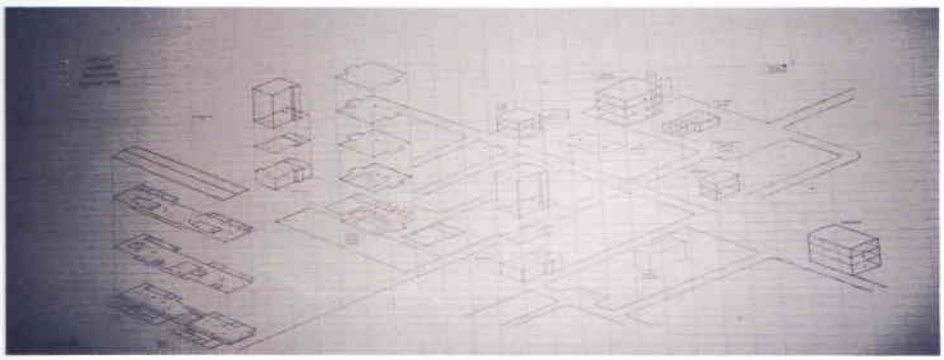


Figure 2.11: Overall diagram of steam power plant of APSCL

Above picture shows the overall picture of steam power plant of APSCL. Here we can see that fire alarm represents by red color, fire detector is orange color, sprinkler is green and water system represents by yellow color. So if any problem occurs in any place of power station then those lights turn on and then engineers take necessary steps to solve the problem.

2.4.14 Switchgear

Basically the apparatus used for switching, controlling and protection of the electrical circuits and equipments is known as switchgear. The switchgear equipment is essentially concerned with switching and interrupting currents either under normal or abnormal operating conditions.

During normal operation, switchgear permits to switch on or off generators, transmission lines, distributors and other electrical equipment. On the other hand, when a failure (e.g. short circuit) occurs on any part of power system, a heavy current flow through the equipment, threatening damage to the equipment and interruption of service to the customers. However, the switchgear detects the fault and disconnects the unhealthy section from the system. In this way switchgear protects the system from the damage and ensures continuity of supply. During our internship we saw different types of switchgear equipments such as:

- **Isolator**

These are used to disconnect transmission line under no-load condition for isolation and maintenance purpose.

Figure 2.12: Isolators used in APSCL

- **Circuit breakers**

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. Circuit breakers are available in various ranges, from small devices that protect an individual household appliance up to large switchgear designed to protect high voltage circuits.

High Voltage Circuit Breakers

Electrical power transmission networks are protected and controlled by high-voltage breakers. The definition of high voltage varies but in power transmission usually 72.5 kV or higher is considered as high voltage, according to a recent definition by the International Electro technical Commission (IEC). High-voltage breakers are nearly always solenoid-operated, with current sensing protective relays operated through current transformer. In substations the protective relay scheme can be complex, protecting equipment and buses from various types of overload or ground/earth fault.

High-voltage breakers are broadly classified by the medium used to extinguish the arc.

- Bulk oil
- Minimum oil
- Air blast
- Vacuum
- SF_6

Sulfur Hexafluoride (SF_6) Circuit Breakers

A sulfur hexafluoride circuit breaker uses contacts surrounded by sulfur hexafluoride gas to quench the arc. They are mostly 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 SF_6 gas.

Figure 2.13: SF_6 used in APSCL

Medium-Voltage Circuit Breakers

Medium-voltage circuit breakers rated between 1 and 72 kV may be assembled into metal-enclosed switchgear line ups for indoor use, or may be individual components installed outdoors in a substation. Air-break circuit breakers replaced oil-filled units for indoor applications, but are now themselves being replaced by vacuum circuit breakers (up to about 35 kV). Like the high voltage circuit breakers described below, these are also operated by current sensing protective relays operated through current transformers. The characteristics of MV breakers are given by international standards such as IEC 62271. Medium-voltage circuit breakers always use separate current sensors and protective relays, instead of relying on built-in thermal or magnetic over current sensors. Medium-voltage circuit breakers can be classified by the medium used to extinguish the arc:

Vacuum circuit breakers

With rated current up to 3000 A, these breakers interrupt the current by creating and extinguishing the arc in a vacuum container. These are generally applied for voltages up to about 35,000 V, which corresponds roughly to the medium-voltage range of power systems. Vacuum circuit breakers tend to have longer life expectancies between overhaul than do air circuit breakers.

Air circuit breakers

Rated current up to 10,000 A. Trip characteristics are often fully adjustable including configurable trip thresholds and delays. Usually electronically controlled, though some models are microprocessor controlled via an integral electronic trip unit. Often used for main power distribution in large industrial plant, where the breakers are arranged in draw-out enclosures for ease of maintenance. [14]

Low Voltage Circuit Breakers

Low voltage (less than 1000 V_{AC}) types are common in domestic, commercial and industrial application, and include:

MCB (Miniature Circuit Breaker)

Rated current is not more than 100 A. Trip characteristics are normally not adjustable. MCB is operated by thermal or thermal-magnetic operation. Breakers illustrated above are in this category.

MCCB (Molded Case Circuit Breaker)

Rated current is up to 2500 A. MCCB is operated by thermal or thermal-magnetic operation. Trip current may be adjustable in larger ratings. [14]

Relay

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. Relay does not have arc extinction facility whereas circuit breaker has it. Relays are used to sense the abnormalities and to send the trip signal to the circuit breaker. [14]

Buchholz relay

A Buchholz relay is a safety device sensing the accumulation of gas in large oil-filled transformers, which will alarm on slow accumulation of gas or shut down the transformer if gas is produced rapidly in the transformer oil.

These are used to break the circuit in case of any abnormalities in the transmission lines. [14]

- **Bus-bar**

In electrical power distribution, a bus bar is a strip of copper or aluminum that conducts electricity within a switchboard, distribution board, substation or other electrical apparatus.

Figure 2.14: Bus bars used in APSCL

The size of the bus bar determines the maximum amount of current that can be safely carried. Bus bars can have a cross-sectional area of as little as 10 mm^2 but electrical substations may use metal tubes of 50 mm in diameter (1,963 mm^2) or more as bus bars. [14]

The protections that APSCL uses are illustrated in chapter 4.

3. Combined Cycle Power Plant

3.1 Introduction

We want to introduce the combined cycle power plant of Ashuganj Power Station Co. Ltd. in this chapter. In this combined cycle power plant, gas turbine generator (GT-1 and GT-2) generates electricity and the exhaust heat of GT-1 is used to make steam to generate additional electricity using a steam turbine (ST-1); the final step enhances the efficiency of electricity generation of APSCL.

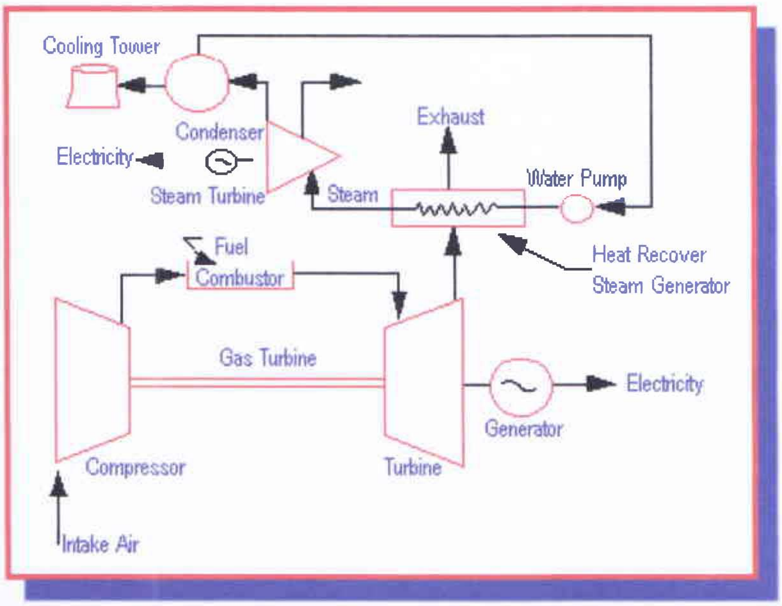


Figure 3.1: A Combined Cycle Power Plant [20]

In APSCL, combined cycle plant uses two gas turbine units-GT1 and GT2 of capacity 56MW, commissioned in 1982 and 1986 respectively. There is also a steam turbine (ST-1) of capacity 34MW with waste heat recovery boiler commissioned in 1984. Though the capacity of GT-1 and GT-2 is 56MW each but these two plants actually produce 35MW and 40MW respectively. The ST-1 produces 16MW actually. The Natural Gas is used as fuel to run this plant which is supplied by Titas Gas Transmission & Distribution Co. Ltd., Bangladesh.

3.2 Working Principle of Combined Cycle Power Plant (CCPP)

In APSCL's combined cycle power plant, compressed air is mixed with natural gas in the combustion chamber at 1000°C. Here diesel engine is used to start the compressor. The exhaust gas expands through a turbine. The turbine drives the compressor, typically the ratio of natural gas and compressed air is (1:8).

The hot exhaust gas of about 480 to 500°C expands through a Waste Heat Recovery Unit (WHRU). Generating steam at about 550°C and high pressure (40 bars), is expanded through ST-1.

3.3 Components of Combined Cycle Power Plant

In Combined Cycle Power Pant of APSCL consist of one gas turbine (GT-1) and one steam turbine (ST-1).

The following sections will describe the gas turbine units of APSCL.

3.3.1 Gas Turbine

A generating station which employs gas turbine as the prime mover for the generation of electrical energy is known as a gas turbine power plant. A gas turbine, also called a combustion turbine, is a type of internal combustion engine. It has an upstream rotating compressor coupled to a downstream turbine, and a combustion chamber in-between.

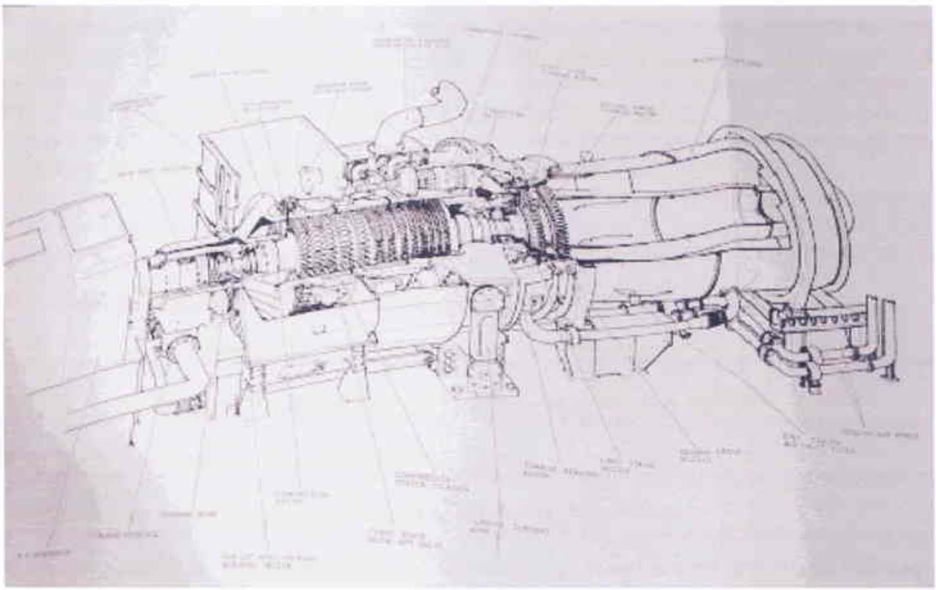


Figure 3.2: Sectional View of Gas Turbine

Energy is added to the gas stream in the combustor, where fuel is finely sprayed with air and ignited. In the high pressure environment of the combustion chamber, combustion of the fuel increases the temperature. The products of the combustion are forced into the turbine section. There, the high velocity and volume of the gas flow is directed through a nozzle over the turbine's blades, spinning the turbine which energizes the compressor and drives their mechanical output. [11]

3.3.2 Gas Turbine Generator

There are three main chambers of APSCL's gas turbine generator. These are compressor, the combustion area and the turbines. The compressor is an open cylinder at one end which contains a series of fan blades attached around a central spindle. The combustion area has a ring of fuel injectors surrounding it, which leads into an inverted cone-shaped device called a candle holder. The candle holder is filled with perforations, like a colander. The turbines are almost identical to the compressor turbine. The turbine blades of GT is larger compared to that of ST.

Gas turbine generators have the following types of operation cycles,

- Simple cycle.
- Combined cycle.
- Simplified combined cycle.

A combined cycle is a power producing engine or plant that employs more than one thermodynamic cycle. Gas turbine engines are only able to use a portion of the energy generated by fuel. The remaining heat is normally wasted. By incorporating two thermodynamic cycles such as Brayton and Rankine, the wastage is minimized. [11]

3.3.3 Gas Turbine Engine

A gas turbine engine ejects air at a high velocity through a nozzle to generate thrust. To obtain that high velocity, the air is typically passed through a compressor, combustion chamber and a turbine. This adds up energy to the flow of gas before entering the nozzle.

Gas turbine engine's major parts are highlighted below.

- A compressor to compress the incoming air to high pressure.
- A combustion area to burn the fuel and produce high pressure and high velocity gas.
- A turbine to extract the energy from the gas which is at high velocity and pressure. [11]

3.3.3.1 Compressor

In APSCL they use multistage axial compressor, where the blades of the compressor rotate around a central axis. Some of the compressor uses a centrifugal compression. Compression efficiency is an important part of gas turbine because the compressor requires a lot of energy to operate. The compressor of APSCL is given below:

Figure 3.3: The Compressor of GT-1

3.3.3.2 Combustion Chamber

After the air is compressed, the combustion chamber raises the total pressure by raising the temperature of the flow drastically. According to the pressure law, pressure is proportional to temperature. Fuel flows into the airflow and ignites, which raises the temperature to 1000°C. [18]

3.3.3.3 Nozzle

As the flowing gas reaches the outlet, the cross sectional area decreases, which creates an increase in velocity thus results a thrust in the engine.

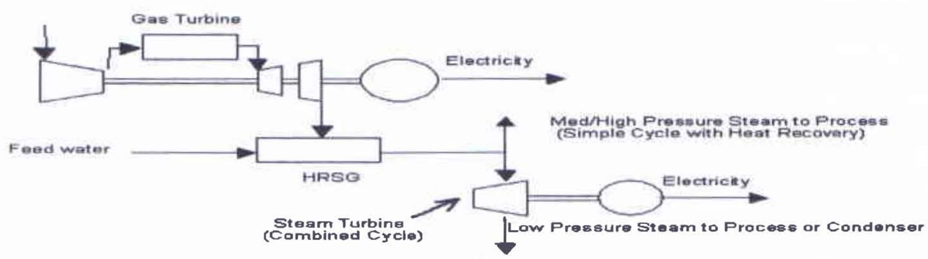


Figure 3.4: Heat Recovery from Gas Turbine

3.4 Steam Turbine

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

In combined cycle power plant of APSCL, gas turbine (GT-1) and the steam turbine (ST-1), both are present. In chapter two, the steam turbine is discussed in detail. The difference between CCPP's steam turbine and general steam turbine is fuel. In CCPP, exhaust gas of GT-1 is used as fuel for ST-1 and usually water is used as fuel in others ST plant.

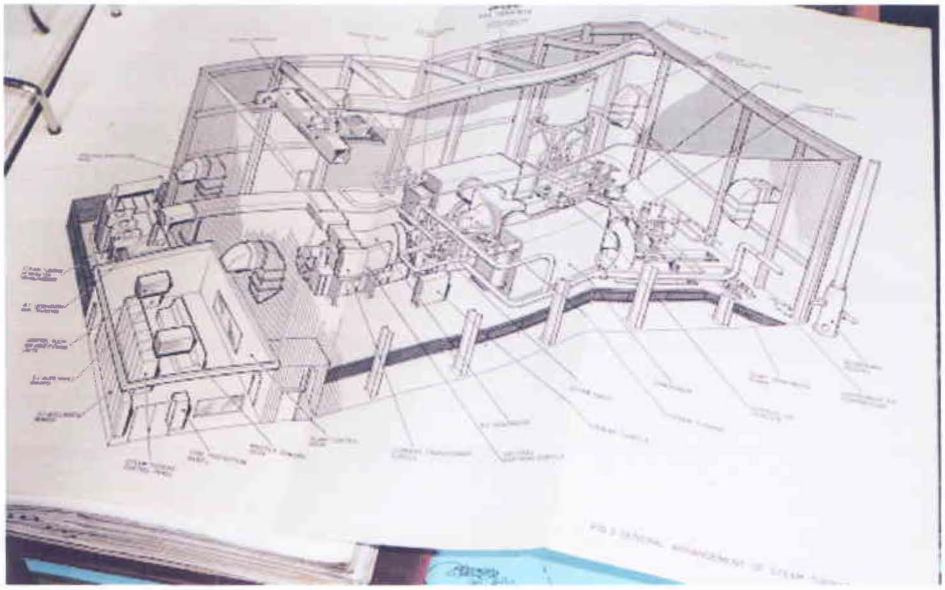


Figure 3.5: Steam Turbine-1 of CCPP in APSCL

3.4.1 Operation and Maintenance

When warming up a steam turbine for use, the main stream stop valves (after the boiler) have a bypass line to allow superheated steam to slowly bypass the valve and proceed to heat up the lines in the system along with the steam turbine. When there is no steam to the turbine, a turning gear is engaged to slowly rotate the turbine to ensure even heating to prevent uneven expansion. At first, rotating the turbine by the turning gear, allowing time for the rotor to assume a straight plane (no bowing) and the turning gear is disengaged and steam is admitted to the turbine, first to the astern blades then to the ahead blades slowly rotating the turbine at 10 to 15 RPM to slowly warm the turbine.

Like gas turbine, the steam turbine requires maintenance equipments. There are some relays, control systems, monitoring systems etc.

3.4.2 Speed Regulation

The control of a turbine with a governor is essential; as turbines need to be run up slowly, to prevent damage (such as the generation of alternating current electricity) require precise speed control is necessary. Uncontrolled acceleration of the turbine rotor can lead to an over speed trip, which causes the nozzle valves to close. If this fails then the turbine may continue accelerating until it breaks apart, often spectacularly. Turbines are expensive to make, requiring precision manufacture and special quality materials. During normal operation, in synchronization with the electricity network, power plants are governed with a five percent droop speed control. This means that the full load speed is 100% and the no-load speed is 105%. This is required for the stable operation of the network without hunting and drop-outs of power plants. Normally the changes in speed are minor. Adjustments in power output are made by slowly raising the droop curve by increasing the spring pressure on a centrifugal governor. Generally this is a basic system requirement for all power plants because the older and newer plants have to be compatible in response to the instantaneous changes in frequency without depending on outside communication. [17]

3.5 Systems of Combined Cycle Power Plant

There are various types of system in combined cycle plant.

3.5.1 Starting System

Starting system provides the initial momentum for the Gas Turbine to reach the operating speed. This is similar to the starter motor of a car. The gas turbine in a power plant runs at 3000 RPM (for the 50 Hz grid). When the minimum speed is 1700-1800 RPM then turbine runs. During starting the speed has to reach at least 60 % for the turbine to work on its inertia. The simple method is to have a starter motor with a torque converter to bring the heavy mass of the turbine to the required speed. For large turbines this means a big capacity motor. The latest trend is to use the generator itself as the starter motor with suitable electrics.

A Combined Cycle Power Plant contains the following systems.

- Fuel System.
- Air Intake System.
- Cooling System.
- Lubrication System.
- Instrument System.
- Protection & Control System.
- Auxiliary Power Supply.
- Excitation System.
- Governor System.

There are some other small units like filter system, compression system and combustion chamber etc.

3.5.2 Fuel System

The Fuel system prepares a clean fuel for burning in the combustor. In Ashugonj Power Plant, natural gas is used as fuel which is supplied by Titas Gas Co. Ltd. The fuel consumption of GT-1 is $0.4684m^3$/KWh, GT-2 is $0.4684m^3$/KWh and ST-1 is $0.3180m^3$/KWh respectively.
A burner system and ignition system with the necessary safety interlocks are the most important items. There are nine burners. A control valve regulates the amount of fuel burned. A filter prevents entry of any particles that may clog the burners. Natural gas directly from the wells is scrubbed and cleaned prior to admission into the turbine. External heaters heat the gas for better combustion. For liquid fuels high pressure pumps pump fuel to the pressure required for fine atomization of the fuel for burning.
These are the main Auxiliary systems in APSCL. Other systems and subsystems are also part of the complex system required for the operation of the Gas Turbine Power Plant. The fuel control is the heart of the gas turbine engine fuel system. This complex device schedules fuel flow to the engine combustion chamber. It automatically provides fuel flow as dictated by the operating conditions of the engine (temperature, pressures, altitude, throttle position, etc.). The fuel control combines the inputs of throttle position, compressor discharge pressure, compressor inlet temperature, and engine speed to produce the fuel flow to operate the engine. The fuel control governs the engine speed by controlling fuel flow. Fuel flow variations are limited to ensure fast stall-free acceleration and deceleration. During throttle bursts, the fuel control also postpones the initiation of the afterburner operation (if installed) to achieve the fastest possible acceleration.
Typical system includes:

- Fuel Conditioning.
- Fuel Metering.
- Performance Monitoring.
- Fuel Flexibility.

3.5.3 Air Intake System

Air Intake System provides clean air into the compressor. During continuous operation the impurities and dust in the air deposits on the compressor blades. This reduces the efficiency and output of the plant. The Air Filter in the Air Intake system prevents this.

A blade cleaning system comprising of a high pressure pump provides on line cleaning facility for the compressor blades. There are two layers of blades. One layer is with 59 blades and another one is with 79 blades. The flow of the large amount of air into the compressor creates high noise levels. A Silencer in the intake duct reduces the noise to acceptable levels.

To purify water filter system is used. This filter system is a three stage filter.

- Metallic.
- Permanent.
- Disposal.

3.5.4 Cooling System

The generator and especially the induction coil need water for cooling. Selection of cooler depends on amount of power's production time.

There are mainly two types of cooling system in APSCL.

- Air Cooling.
- Water Cooling.

Air Cooling: There are several types of air cooling

- Turbine overall cooling.
- Valve cooling.
- Oil cooling.

Water Cooling: There are different kinds of water cooling also

- Condenser Cooling (for large portion).
- Lube Oil Cooling (from main line for other side).
- Generator Cooling.
- Gland Water Heat Exchange (cool by demi water).

3.5.5 Lubrication System:

The oil lubrication systems of modern gas turbine engines vary in design and plumbing. The APSCL is one of them. However, most systems have units that perform similar functions. In a majority of cases, a pressure pump or system furnishes oil to lubricate and cool several parts of the engine. A scavenging system returns the oil to the tank for reuse. Overheating is a problem in gas turbine engines. Overheating is more severe after the engine stops than it is running. Oil flow, which normally cools the bearings, stops. The heat stored in the turbine wheel now raises the temperature of the bearings much higher than the running condition. The oil moves heat away from these bearings to prevent overheating. Most systems include a heat exchanger to cool the oil. Many systems have pressurized sumps and a pressurized oil tank. This equipment ensures a constant head pressure to the pressure lubrication pump to prevent pump cavitations at high altitudes. Oil consumption is relatively low in a gas turbine engine compared to a piston-type engine. Oil consumption in the turbine engine primarily depends upon the efficiency of the seals. However, oil can be lost through internal leakage, and, in some engines, by malfunctioning of the pressurizing or venting system. The main parts of the turbine requiring lubrication and cooling are the main bearings and accessory drive gears. Therefore, lubrication of the gas turbine engine is simple. In some engines the oil operates the servomechanism of fuel controls and controls the position of the variable-area exhaust nozzle vanes. Because each engine bearing gets its oil from a metered or calibrated opening, the lubrication system is known as the calibrated type. With few exceptions, the lubricating system is of the dry sump design. This design carries the bulk of the oil in an airframe or engine-supplied separate tank. In the wet sump system, the oil is carried in the engine itself. All gas turbine engine lubrication systems normally use synthetic oil.

Lubrication system includes:

- pumps
- reservoir
- filters
- low pressure protection
- high temperature protection
- air to oil & water to oil cooler

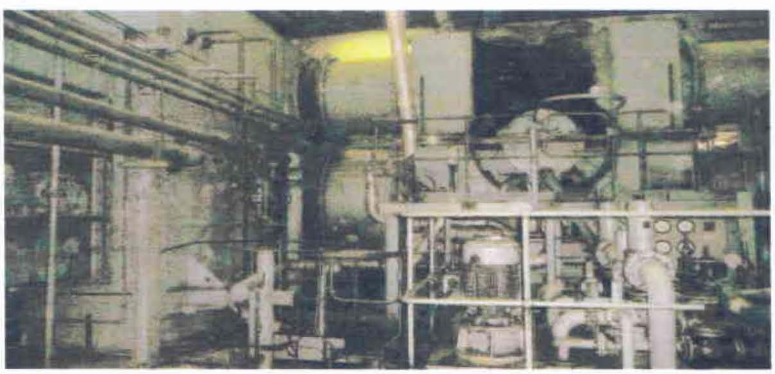


Figure 3.6: Lubrication System in GT-1 of APSCL

3.5.6 Instrument System:

The instrument system contains.

- Flame Detectors and Analysis Unit.
- Flame Monitoring and Configuration Tool
- Carbon in Ash Load Instrument
- Engineering and Commissioning Services
- Gas Igniters and Electrical Lighters

3.5.7 Protection and Control System:

APSCL can supply turbine control and monitoring solutions for a full range of gas turbines, including heavy-duty machinery. Our turbine control solutions comprise the turbine governor, sequence control, drives control and turbine protection. Operation of the gas turbine can be fully automated; the various systems of the plant are automatically controlled in a sequential manner. Minimal operator intervention is required to start a complete CCPP unit.

All the control systems are same as steam turbines control system which is described in chapter 2. To control and protect the plant many types of system are in use. The sensor is used in different areas for temperature detection. If the temperature crosses 625°C, the system will trip.

Other components of Control System include:

- PLC.
- Fixed and Variable Speed Motor Control.
- Heat Trace.
- Trip Relay and Alarm.
- Generator/Transformer Protective Relay.
- Process Control & Machine Control.
- Flow Metering.
- Performance Monitoring.
- Gas Analyzers.
- Instrument.

Figure 3.7: Protection & Control System of APSCL

For gas turbine controls include:

Ignition and startup control with Soft start

- Acceleration limiter.
- Temperature rise limiter.
- Temperature control.

Exhaust

- Gas Generator exit.
- Blade path.
- Combustion monitor.
- Individual monitoring.
- True software correction for inlet air temperature.

Turbine Speed Control

- Single shaft.
- Multi shaft.

3.5.8 Auxiliary Power Supply

Auxiliary power unit is used to start the system. It is a DC power system. When AC power is failed DC is on orderly.

3.5.9 Excitation System

In excitation system DC input is applied to the rotor, outside field and armature. The pilot exciter consists of permanent magnet.

3.5.10 Governing System

The governing system controls gas to flow up to combustion chamber. The following system controls the gas quantity also.

Governor system includes:

- Power Turbine Speed Control.
- Gas Generator Speed limit.
- Gas Generator Exhaust Temperature Control.
- Gas Generator Compressor Discharge Pressure Limit Control.
- Acceleration and deceleration schedules.
- Light off to Idle Control.
- Idle to Minimum Governor Speed Control.

Governing – Fuel control Sequencing

- Fuel System.
- Lube Oil System.
- Starter.
- Pumps, Fans, Ventilation.
- Bleed Valves.
- Auxiliaries, Water Wash.
- Dual fuel.
- Generator Control.

3.5.11 Exhaust System

Exhaust system discharges the hot gases to a level which is safe for the people and the environment. The exhaust gas that leaves the turbine is around 550 °C. This includes an outlet stack high enough for the safe discharge of the gases. [13]

4. Substation transmission and distribution

4.1 Introduction

A substation is a part of an electrical generation, transmission, and distribution system. Substations transform voltage from high to low, or the reverse and perform several other important functions. Electric power flows through several substations between generating plant and consumer unit. The voltage level is changed in several steps to ensure satisfactory electric supply.

4.2 Requirements of Satisfactory Electric Supply

Criterions needed to meet to provide satisfactory power supply are described below:

- Voltage regulation – constant voltage is to maintain so that the electrical equipments work properly.
- Dependability – uninterrupted supply is very important for industries hospitals etc.
- Balanced Voltage – unbalanced voltage may harm 3Φ machines.
- Efficiency – it is vital for minimization of wastage.
- Frequency – it should be constant so that the appliances are safe.
- Sinusoidal waveform – pure sinusoidal wave form is necessary because non-sinusoidal waveform causes harmonics problems in the equipments.
- Inductive Interference – it causes electromagnetic interference to the common signals creating problems so it should be not occur.

Figure4.1: Substation of APSCL

)uring the internship work we have seen that APSCL employees try heart and soul to naintain these satisfactory requirements in order to excel in power business and meet their ision.

A substation that has a step-up transformer increases the voltage while decreasing the current, nd with a step-down transformer decreases the voltage while increasing the current for omestic and commercial distribution. Electric power distribution is the main purpose of APSCL and substation is a necessary part of distribution.

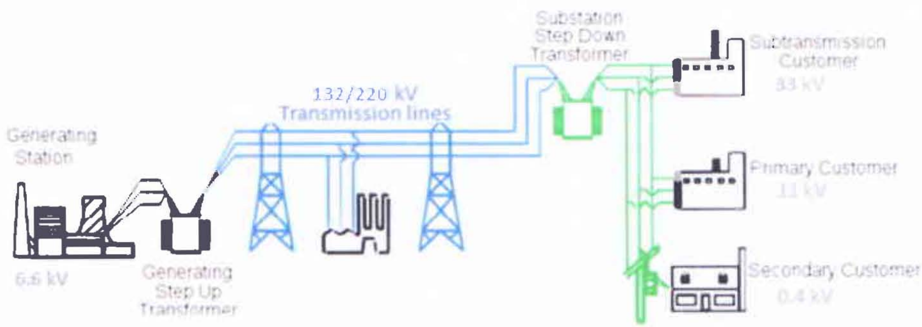
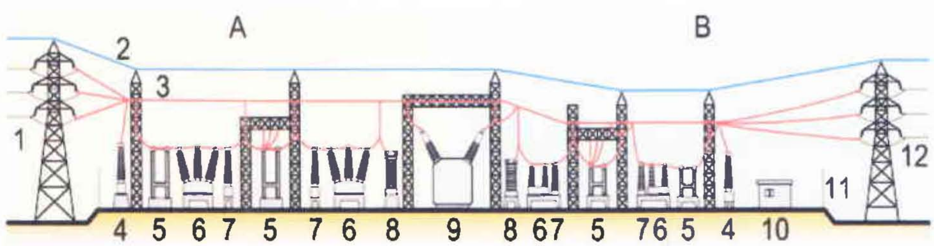


Figure 4.2: An overall power system diagram

Meters measuring electrical quantities differ depending on the form of electrical service. Since he service differs from meter to meter, the number of conductors and sensors in the meters also vary.



Figur4.3: Elements of a substation [19]

n figure 4.3 different elements of substation are diagrammatically identified; these are A: Primary power lines' side B: Secondary power lines' side 1.Primary power lines 2.Ground wire 3.Overhead lines 4.Transformer for measurement of electric voltage 5.Disconnect switch 6.Circuit breaker 7.Current transformer 8.Lightning arrester 9.Main transformer 10.Control building 11.Security fence 12.Secondary power lines.

4.3 Switching Function

An important function performed by a substation is switching. The connection and disconnection of transmission lines or other components to and from the system is known as switching. Switching events can be planned or unplanned.

A transmission line or other component needs to be de-energized for maintenance or for new construction, as an example, adding or removing a transmission line or a transformer.

To maintain reliability of supply, no company ever brings down its whole system for maintenance. From routine testing to adding entirely new substations, all work to be performed while keeping the whole system running.

A fault may develop in a transmission line or any other component. As an example: a line is hit by lightning and develops an arc, or a tower is blown down by high wind. The function of the substation is to isolate the faulty portion of the system in the shortest possible time.

There are two main reasons: a fault tends to cause equipment damage; and it tends to destabilize the whole system. For example, a transmission line left in a faulty condition will eventually burn down; similarly, a transformer left in a faulted condition will eventually blow up. While these are happening, the power drain makes the system more unstable. Disconnecting the faulted component, quickly, tends to minimize both of these problems.

4.4 Types of substation

Depending on service substations can be categorized according to the following types:

- Transmission Substation
- Distribution Substation
- Substation with Change of Current Type
- Switching Substation

4.4.1 Transmission Substation

A transmission substation connects two or more transmission lines. The simplest case is where all transmission lines have the same voltage. In such cases, the substation contains high-voltage switches that allow lines to be connected or isolated for fault clearance or maintenance. A transmission station may have transformers to adjust transmission voltages, voltage control or power factor correction devices such as capacitors, reactors or static VAR compensators and equipment phase shifting transformers to control power flow between two adjacent power systems.

Transmission substations can range from simple to complex. A small "switching station" may be little more than a bus plus some circuit breakers. The largest transmission substations can cover a large area (several acres/hectares) with multiple voltage levels, many circuit breakers and a large amount of protection and control equipments (voltage and current transformers, relays and SCADA systems).

4.4.2 Distribution Substation

A distribution substation transfers power from the transmission system to the distribution system of an area. It is uneconomical to directly connect electricity consumers to the main transmission network, unless they use large amounts of power. The distribution substation reduces voltage to a value suitable for local distribution. The input for a distribution substation is typically at least two transmission or sub transmission lines. Input voltage is 11 kV in our country. The output is a number of transmission lines covering the electrical supply of the area. Distribution voltages are typically medium voltage, between 11 and 33 kV depending on the size of the area served and the practices of the local utility.

In addition to transforming voltage, distribution substations also isolate faults in either the transmission or distribution systems. Voltages are regulated mainly in distribution substation, although on long distribution circuits (of several miles/kilometers), voltage regulation equipment may also be installed along the line. [11]

4.4.3 Substations with Change of Current Type (AC to DC or vice versa)

Substations may be associated with HVDC (high voltage direct current) converter plants, traction current, or interconnected non-synchronous networks; formerly where rotary converters changed frequency.

4.4.4 Switching Substation

A switching substation is a substation which does not contain transformers and operates only at a single voltage level. Switching substations are sometimes used as collector and distribution stations. Sometimes they are used for switching the current to back-up lines or for parallelizing circuits in case of failure.

4.5 Protections Used in Substations

Substations use varieties of equipments. Typically the substation of (APSCL) is assembled for high voltage transmission to the national grid and it has lots of current transformers, potential transformers, instrument transformers, isolators and different types of synchronizers and circuit breakers and relays and many other electrical equipments.

Protection is necessary in order to transmit power smoothly and in real life all these equipments work in conjunction to make that happen. The voltage produced in the generating section has to be treated and conditioned for grid supply.

The generators of the voltage producing sections are protected using the following schemes, which include stator protection thoroughly.

4.5.1 Introduction of the Stator Winding Faults

These types of faults occur due to the insulation breakdown of the stator coils. Some types of stator windings faults are:

- Phase to earth fault
- Phase to phase fault
- Inter turn fault

Phase to earth fault are limited by resistance of the neutral grounding resistor. There are fewer chances for the occurrence of the phase to phase and inter turn faults. The insulation between the two phases is at least twice as thick as the insulation between one coil and the iron core, so phase to phase fault is less likely to occur. [1]

4.5.2 Stator Protection

Differential protection for generator

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

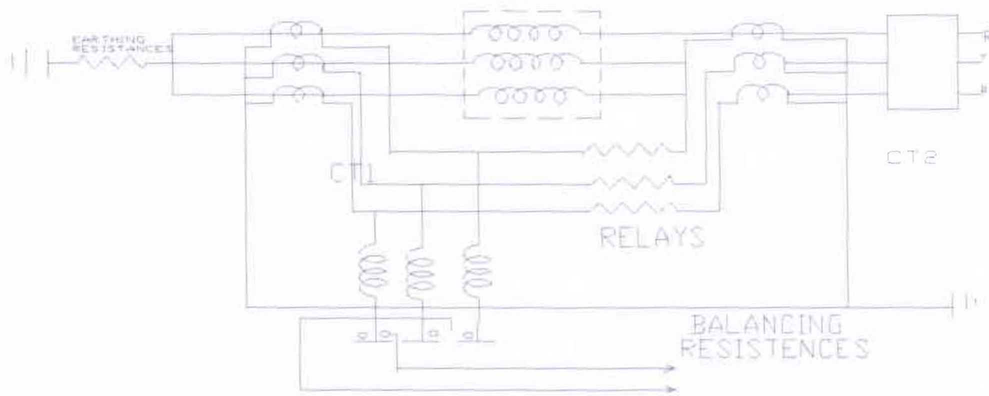


Figure4.4: Differential protection for generator [1]

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

Limitations of this method:

The earth fault is limited by the resistance of the neutral earthing. When the fault occurs near the neutral point, this causes a small current to flow through the operating coil and it is further reduced by the neutral resistance. Thus this current is not sufficient to trip the circuit breaker. By this protection scheme, one can protect only 80 to 85 percent of the stator winding. If the relays with low settings are used then it will not provide desired stability. This difficulty is overcome by using the modified differential protection.

4.5.3 Biased circulating current protection

Percentage differential relay protection: With the differential protection relaying, the CTs at both end of the stator windings must be same. If there is any difference in the accuracy of the CTs, the mal-operation of the relay will occur. To overcome this difficulty, biased circulating current protection is used. In this protection system we can automatically increase the relay setting in proportion to the fault current. This is done by suitable proportioning of the ratio of the relay restraining coil to the relay operating coil. [11]

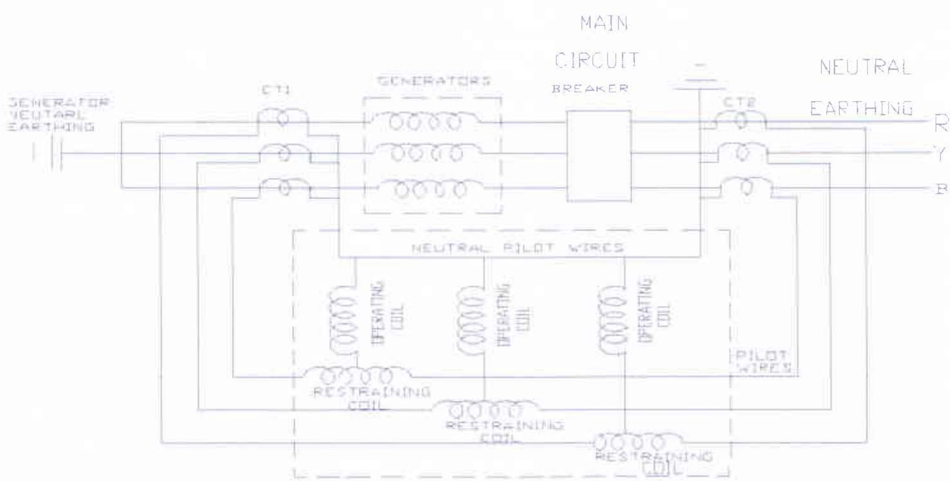


Figure 4.5: Biased protection of the stator winding [1]

Under normal operating condition current in secondary of the line CTs will be same as the current in the secondary of the CTs at the neutral end. Hence there are balanced current flows in the restraining coils and no current flows in the operating coil. If there is any phase to phase or phase to earth fault occurs then it causes the differences in the secondary current of the two CTs. Thus the current flows through the operating coil and make the circuit breaker to trip.

Advantages of this method:

a) It does not require the CTs with balancing features.

b) It also permit the low fault setting of the relay, thus protects the greater percentage of the stator winding.

4.5.4 Self balance protection system

This type of protection is employed for earth fault and also for the phase to phase fault.

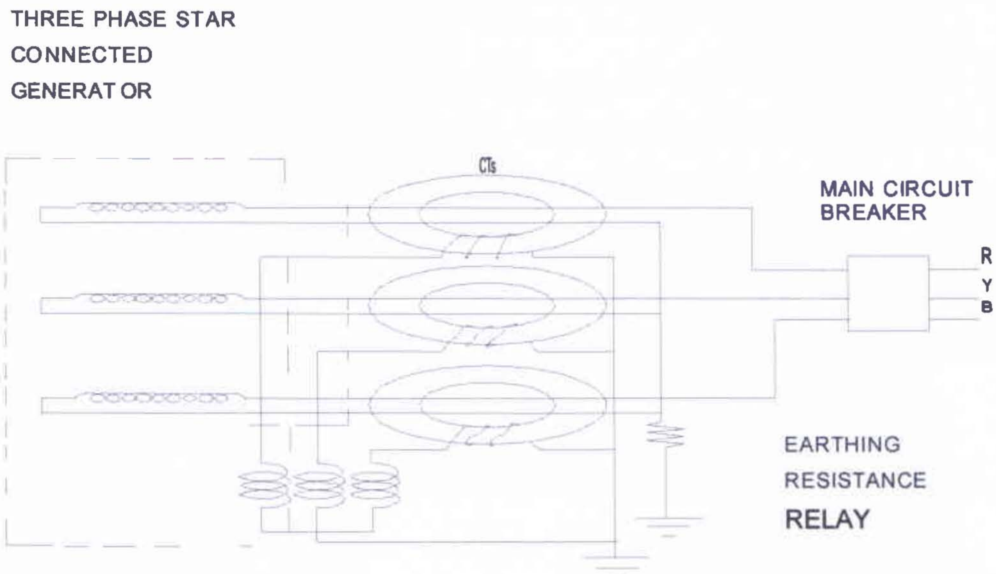


Figure4.6: Self biasing protections of the stator windings [1]

In this type of protection two cables are required which is connected to the two ends of each phase. These two cables are passed through the circular aperture of the ring type CTs. Under normal conditions the current flowing in the two leads of the cable will be in the same direction and no magnetization occurs in the ring type CTs. When the earth fault occurs in any phase, the fault current flows only once through the CTs, inducing magnetic flux. As a result emf is induced in the relay circuit which causes the circuit breaker to trip.

Though earth fault protection system is sensitive enough it also has some limitations:

a) A different design of the cable lead is required in this scheme.

b) Large electromagnetic forces develop in the CT ring under the condition of heavy short circuit. [19]

4.5.5 Stator ground fault protection

The method of grounding affects the degree of protection which is employed by the differential protection. High impedance reduces the fault current and thus it is very difficult to detect the high impedance faults. So the differential protection does not work for the high impedance grounding. A separate relay to the ground neutral provides a better protection. Ground relays operation is not limited within the generator. It can detect faults outside the generator circuit as well. The time co-ordination is necessary to overcome this difficulty. If we use the star- delta transformer bank, then it will block the flow of ground currents, thus preventing the occurrence of the fault on other side of the bank from operating ground relays.

In unit protection scheme the transformer bank limits the operation of the fault relay to the generator.

Unit protection schemes:

In this scheme high resistance grounding is used and system is grounded through the transformer bank and through the resistors.

95% scheme: Relay which is used in the unit connected schemes must be insensitive to the third harmonics voltage which may be present between the neutral and the ground, and it must be sensitive to the fundamental harmonic voltage which causes the fault. And the general choice of the relay sensitivity and distribution transformer voltage provides 95% protection of the winding so this scheme is called 95% scheme.

100% scheme: This scheme provides complete protection of the stator winding by injecting a signal (pulse of a voltage) between the stator winding and the change in signal indicates a fault. 95% scheme provides protection only at rated speed and rated voltage but in 100% scheme it also provides protection at standstill. [1]

4.5.6 Stator inter turn fault protection

Differential protection for stator does not provide protection against the inter-turn faults on the same phase winding of the stator. The reason is that the current produced by the turn to turn fault flows in the local circuit between the turns involved and thus it does not create any difference between the current entering and leaving the windings at its two ends where the CTs are mounted.

The coils of the modern turbo generator are single- turn, so there is no need to provide inters–turn fault protection for the turbo generator. But the inter turn protection is necessary for the multi turn generator like hydro electric generator. Sometimes stator windings are duplicated to carry heavy current. In this case stator winding have two different paths.

In this type of protection, primaries of the CTs are inserted in the parallel paths and secondaries are inter-connected. Under the normal condition current flowing through the two parallel paths of the stator winding will be same and no current flowing through the relay operating coil. Under the inter turn fault, current flowing through the two parallel path will be different and this difference in current flowing through the operating coil causes the circuit breaker to trip and disconnect the faulty section. This type of protection is very effective.

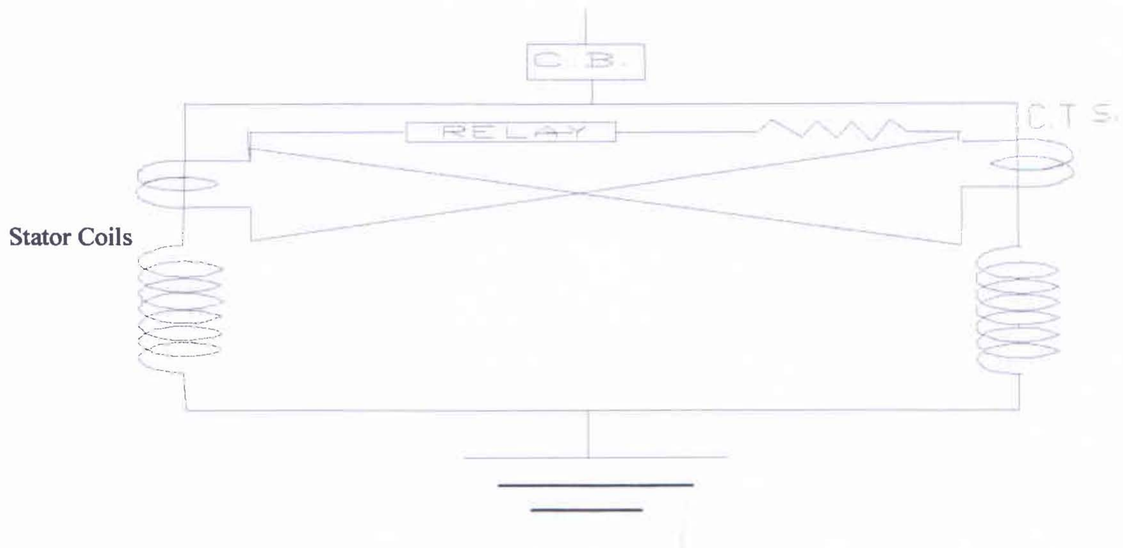


Figure4.7: Inter turn protection of the stator winding [1]

4.5.7 Stator over heating protection

Stator over heating is caused due to the overloads and failure in cooling system. It is very difficult to detect the overheating due to the short circuiting of the lamination before any serious damage is caused. Temperature rise depend upon I^2Rt and also on the cooling. Over current relays cannot detect the winding temperature because electrical protection cannot detect the failure of the cooling system. So to protect the stator against overheating, embed resistance temperature detector or thermocouples are used in the slots below the stator coils. These detectors are located on the different places in the windings so that detectors can detect the temperature throughout the stator. Detectors which provide the indication of temperature change are arranged to operate the temperature relay to sound an alarm. [1]

4.5.8 Under and Over frequency protection

This is an important protection used in APSCL.

1. Over frequency operation: Over frequency results from the excess generation and it can easily be corrected by reducing in the power outputs with the help of the governor or manual control.

2. Under frequency operation: Under frequency occurs due to the excess loading. During an overload, generation capability of the generator increases and reduction in frequency occurs. The power system survives only if we drop the load so that the generator output becomes equal or greater than the connected load. If the load increases the generation, then frequency will drop and load need to shed down to create the balance between the generator and the connected load. The rate at which frequency drops depends on the time, amount of overload and also on the load and generator variations. Frequency decay occurs within seconds so we cannot correct it manually. Therefore automatic load shedding facility needs to be applied.

These automatic load shedding schemes drops load in steps as the frequency decays. Generally load shedding drops 20 to 50% of load in four to six frequency steps. Load shedding scheme works by tripping the substation feeders to decrease the system load. Generally automatic load shedding schemes are designed to maintain the balance between the load connected and the generator.

The present practice is to use the under frequency relays at various load points so as to drop the load in steps until the declined frequency returns to normal. Non essential load is removed first when decline in frequency occurs. The setting of the under frequency relays based on the most probable condition occurs and also depend upon the worst case possibilities. During the overload conditions, load shedding must occur before the operation of the under frequency relays. In other words load must be shed before the generators are tripped. [19]

4.5.9 Over Voltage and Under Voltage Protection

APSCL uses this protection to keep its equipments safe from voltage fluctuations which can hamper the system and equipments badly.

1. Over VoltageProtection: Over voltage occurs because of the increase in the speed of the prime mover due to sudden loss in the load on the generator. Generator over voltage does not occur in the turbo generator because the control governors of the turbo generators are very sensitive to the speed variation. But the over voltage protection is required for the hydro generator or gas turbine generators. The over voltage protection is provided by two over voltage relays that have two units – one is the instantaneous relays which is set to pick up at 130 to 150% of the rated voltage and another unit is IDMT (inverse definite mean time) which is set to pick up at 110% of rated voltage. Over voltage may occur due to the defective voltage regulator and also due to manual control errors.

2. UnderVoltageProtection: If more than one generator supplies the load and due to some reason one generator suddenly trips, then the other generators try to supply the load. Each of these generators will experience a sudden increase in current and thus the terminal voltage will decrease. Automatic voltage regulator connected to the system try to restore the voltage. And under voltage relay type-27 is also used for the under voltage protection. [19]

4.5.10 Protection of the Generator due to Unbalance Loading

Due to fault there is an imbalance in the three phase stator currents and due to these imbalanced currents, double frequency currents are induced in the rotor core. This causes the overheating of the rotor and thus the rotor is damaged. Unbalanced stator currents also damage the stator. Negative sequence filter provided with the over current relay is used for the protection against unbalanced loading. From the theory of the symmetrical components, we know that an unbalanced three phase currents contain the negative sequence component. This negative phase sequence current causes heating of the stator. The heating time constant usually depend upon the cooling system used and is defined as $I^2t=k$ where I is the negative sequence current and t is the current duration in seconds and k is the constant.

It is general practice to use negative current relays which matches with the above heating characteristics of the generator. In this type of protection three CTs are connected to three phases and the output from the secondaries of the CTs is fed to the coil of over current relay through negative sequence filter. Negative sequence circuit consists of the resistors and capacitors and these are connected in such way that negative sequence currents flows through the relay coil. The relay can be set to operate at any particular value of the unbalanced currents or the negative sequence component current.

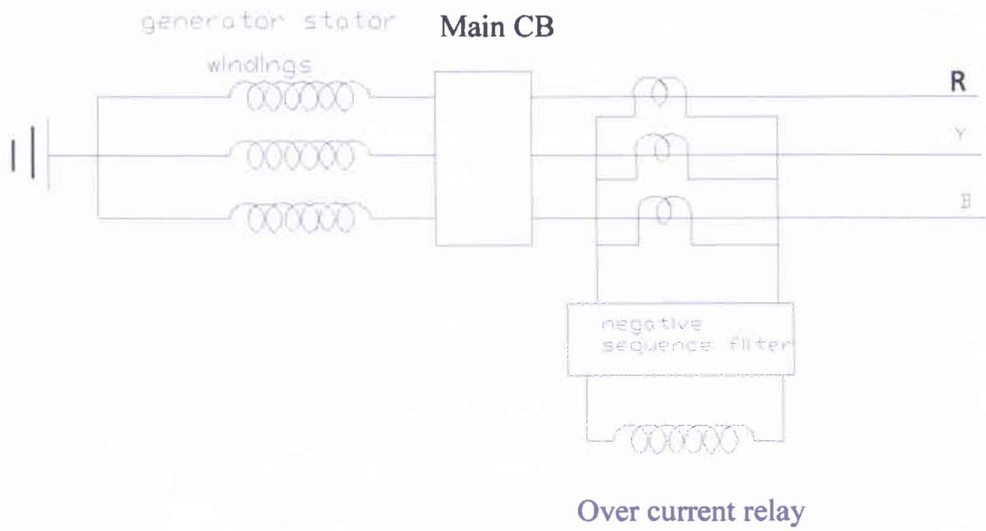


Figure4.8: Protection against unbalanced loading [1]

4.6 Transformer Protection Principles

Transformers are a critical and expensive component of the power system. To save the time consumed in repairing and replacement of transformers, a major goal of transformer protection is limiting the damage to a faulted transformer. Some protection functions, such as over excitation protection and temperature-based protection may aid this goal by identifying operating conditions that may cause transformer failure. The comprehensive transformer protection provided by multiple function protective relays is appropriate for critical transformers of all applications. [19]

4.7 Transformer Protection Overview

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

- Abnormal operating conditions can be identified when there is over fluxing, overloading and overvoltage.

Conditions	Protection Philosophy
Internal	
Winding Phase-Phase, Phase-Ground faults	Differential (87T), over current (51, 51N) Restricted ground fault protection (87RGF)
Winding inter-turn faults	Differential (87T), Buchholz relay,
Core insulation failure, shorted laminations	Differential (87T), Buchholz relay, sudden pressure relay
Tank faults	Differential (87T), Buchholz relay and tank-ground protection
Over fluxing	Volts/Hz (24)
External	
Overloads	Thermal (49)
Overvoltage	Overvoltage (59)
Over fluxing	Volts/Hz (24)
External system short Circuits	Time over-current (51, 51G), Instantaneous over-current (50, 50G)

Table 6: protection philosophy with respect to the conditions

4.8 Transformer Failures

Failures in transformers can be classified into:

- Winding failures due to short circuits (turn-turn faults, phase-phase faults, phase-ground, open winding).
- Core faults (core insulation failure, shorted laminations).
- Terminal failures (open leads, loose connections, short circuits).
- On-load tap changer failures (mechanical, electrical, short circuit,overheating).

4.9 Differential Characteristic of Relaying

The major operating challenge to transformer differential protection is maintaining security of life during CT saturation for external faults while maintaining sensitivity to detect low magnitude internal faults. CT saturation reduces the secondary output current from the CT, and causes a false differential current to appear to the relay. GE Multilin differential relays meet this challenge in the following ways:

- The restraint current is based on the maximum measured winding current, as opposed to the traditional magnitude sum of the currents. This ensures ideal restraint for the actual fault condition, balancing sensitivity and security from hazards.
- The differential element uses a dual slope-dual breakpoint characteristic. The differential element can be set to account for both DC and AC saturation of the CTs, while maintaining sensitivity for fault detection.

An alternative method for inrush inhibit is also available, where current, voltage, or breaker status is used to indicate a de-energized transformer. The threshold can be lowered during energization of the transformer as indicated either by breaker contact, current or voltage sensing, and will last for a settable time delay. This allows settings of less than 20% for inrush inhibit during transformer energization. [19]

4.10 Inrush current during Transformer Energization

The transformer energization resembles the condition of an internal fault. If no inhibiting mechanism is provided, the differential element will trip. The magnetizing inrush current has significant 2nd harmonic content in it. The level of 2nd harmonic current can be used to differentiate between inrush and a fault condition. The UR T60 and T35 GE Multilin transformer relays use two different 2nd harmonic modes to inhibit the differential element for inrush.

Traditional 2nd harmonic blocking – The traditional 2nd harmonic restraint responds to the ratio of the magnitudes of the 2nd harmonic and the fundamental frequency currents.

Adaptive 2nd harmonic blocking– The adaptive 2nd harmonic blocking responds to both magnitudes and phase angles of the 2nd harmonic and the fundamental frequency currents. The differential element correctly distinguishes between faults and transformer energization, when the 2^{nd} harmonic current is less than the entered 2^{nd} harmonic setting. The levels of 2^{nd} harmonic during inrush often do not go below 20%, many transformers are susceptible of generating lower 2^{nd} harmonic current during energization. Setting the 2^{nd} harmonic restraint below 20% may result in incorrect inhibit of the differential element during some internal faults. The adaptive 2^{nd} harmonic blocking allows settings in the traditional 20% range, while maintaining security of differential element against inrush current. [1]

4.11 Ground Fault Protection to limit Transformer Damage

Differential and over-current protection do not provide adequate protection for wye-connected windings with grounded neutrals. Fault close to the neutral produces lesser fault current as shown by the current distribution curve. The restricted ground fault function can be used to provide differential protection for such ground faults, down to faults at 5% of the transformer winding. Restricted ground fault protection can be a low impedance differential function or a high impedance differential function. The low impedance function has the advantage to being able to precisely set the sensitivity to meet the application requirement. This sensitive protection limits the damage to the transformer and allows quicker repair. The restricted ground fault element uses adaptive restraint based on symmetrical components to provide security during external phase faults with significant CT error. This permits the function to maximize sensitivity without any time delay. [1]

4.12 Over Flux Protection

Transformer over fluxing can be a result of

- Over voltage
- Low system frequency

A transformer is designed to operate at or below a maximum magnetic flux density in the transformer core. The design also limits the eddy currents in the core. The magnetic flux in the core is proportional to the voltage applied to the winding divided by the impedance of the winding, the flux in the core increases with increasing voltage or decreasing frequency. During startup or shutdown of generator-connected transformers, or following a load rejection, the transformer may experience an excessive ratio of volts to hertz and become overexcited. When a transformer core is overexcited, the core is operating in a non-linear magnetic region, which creates harmonic components in the exciting current. A significant amount of current at the 5th harmonic is a characteristic of over-excitation.

The transformer winding hot-spot temperature is another quantity that should be kept minimized for protection of transformers. Protection based on winding hot-spot temperature can potentially prevent short circuits and catastrophic transformer failure, as excessive winding hot-spot temperature causes degradation and an eventual failure of the winding insulation. The ambient temperature, transformer loading, and transformer design determine the winding temperature. Temperature based protection functions alarm or trip when certain temperature conditions are met.

GE Multilin relays use IEEE C57.91 compliant thermal models to calculate the winding hot-spot temperature and the loss of life of the winding insulation. The top-oil temperature may be directly measured, or calculated from the ambient temperature, load current, and transformer characteristics. The calculations may use a monthly model of ambient temperature, eliminating the need for external connections to the transformer and relay. This winding hot-spot temperature is used in thermal overload protection to provide alarm or tripping when unacceptable degradation of the transformer winding insulation is occurs.

There are more protection schemes but we are not going to discuss about the others in this report. The types of protection we discussed is used in APSCL and there maybe some more protection schemes that APSCL uses but we could not grab those concepts in practice due to insufficient time.

The power system of APSCL comprises of numerous electrical equipments and the time limit we had to comprehend those individually was not enough. But accomplishing the interne we walk out with uncountable experience and off course an enriched knowledge regarding power equipments.

Conclusion

The power sector of Bangladesh has to go for a long way in future. For achieving the production target government has taken some initiatives to increase the generation capacity of electricity. As power sector is a capital-intensive industry, huge investment will be required to increase generation capacity. Public sector is not in a position to secure this huge investment for power generation. Recognizing these trends, Government of Bangladesh modified its industrial policy to enable private investment in the power sector and Private Sector Power Generation Policy was framed in 1996 for promoting private sector participation in power generation

One of the major problems of power sector was shortage of fund. BPDB generates and also purchases electricity for IPP (Independent Power Producer), sales them to the distribution organization and some consumers directly. But they could not sale of standard amount due to high system loss and not to collect sale revenue which they could sale because of poor management.

After ten years of its commencement, in the year 2011 APSCL is the most profitable utility service provider of Bangladesh with net profit of Taka 2140 million (2010-11). By managing its operations in efficient and effective manner, incorporating new ideas in providing better consumer service, APSCL has become the role model for all the electricity utility service providers of Bangladesh. But the service quality is far behind the world standard. A change in the Management's view, employee mindset, MIS structure etc. is required to build a world class company.

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