INTERNSHIP REPORT

ON

ASHUGANJ POWER STATION COMPANY LTD.

APSCL

By

Md. Maidul Islam: 2008-1-80-030

Submitted to the
Department of Electrical and Electronic Engineering
Faculty of Sciences and Engineering
East West University
In partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering
(B.Sc in EEE)

[Summer, 2011]
Approved By

04·10·2011
Academic Advisor
S. M. Shahriar Rashid

04.10.2011
Department Chairperson
Dr. Anisul Haque

APPROVAL LETTER

ASHUGANJ POWER STATION COMPANY LTD.
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Memo no. APSCL/MD/Trg.-10/2011/৭১৭ Date-14/05/2011

TO WHOM IT MAY CONCERN

This is to certify that Anik Das , SID 2008-1-80-028, Md. Maidul Islam, 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 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.

14.5.2011

Engr. Md. Nurul Alam
Managing Director
APSCL

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Deputy General Manager
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14/5/11

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

ACKNOWLEDGEMENT

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

I would also like to thank S. M. Shahriar Rashid, Research Lecturer, Department of Electrical & Electronic Engineering, East West University, Bangladesh for his important direction on preparing this report.

I would also like to mention the name of Dr. Anisul Haque, respected Chairperson & Professor of the Department of Electrical & Electronic Engineering for giving me the chance to submit the report.

I would like to thank Engr. Md. Rokon Mia, Senior Engineer (Generator & Switchgear Protection), Engr. Md. Kamruzzaman, Senior Engineer (Generator & Switchgear Protection), Engr. Nur Mohammed, Manager, Sub-Station, Engr. Md. Shahidullah, Assistant Engineer (Sub Station), Engr. Md. Azizur Rahman, Senior Engineer(Combine Cycle Power Plant), Engr. Nur Mohammed, Manager, Sub-Station who had given us their precious time to collect related data of the report.

EXECUTIVE SUMMARY

Development of sources of energy to accomplish useful work is the key to the industrial progress which is essential to the continual improvement in the standard of living of people everywhere. In Bangladesh the demand of power is approximately 5800 MW. Public and private sector produces 63% and 37% of electricity respectively. Public sector produces electricity through Bangladesh Power Development Board (BPDB), Ashuganj Power Station Company LTD (APSCL) and Electricity Generation Company of Bangladesh (EGCB). On the other hand, private sector produces power through small independent power producers and rental that government buys at a constant price. BPDB individually produces 46% of the total production. To fulfill this large demand there are many power stations that are being setup throughout the country. This will reduce the load shedding in the long run. It is expected that this step will also put a contribution to the national economy.

To fulfill the large demand of electric power in Bangladesh, the Ashuganj Power Station Company Ltd. (APSCL) plays a vital role in power generation being the second power station in Bangladesh. The APSCL produces 724 MW of electric power and supplies to the national grid. Its contribution to the country is 15% of the total national power generation sector. It has total 8 units. In near future to contribute more in the power system they have plan to setup more units in the power station. It is expected that the power generation in APSCL will be increased by its own property. The mission of this company is to ensure long-term uninterrupted supply of quality power to the consumers in future.

The internship in Ashuganj Power Station Company Ltd. (APSCL) covers all the process of power generation, transmission and distribution system of APSCL. During our internship in APSCL, we were taught about the power plant management system in the power station. This large power station (APSCL) has a large number of equipments which was observed by us during the internship period. This report is the attachment of that industrial training.

The systems or the devices those were observed during the internship includes generator, boiler, control room, water treatment plant, steam turbine, gas turbine, compressor, backup system, cooling system, transmission system, distribution system, substation equipments like- power transformer, current transformer, potential transformer, protective relays, circuit breakers, underground cable connection, isolator, insulator, lightning arrester and other essential equipments of the APSCL. In this report the main emphasize is given on the explanation of those things along with the acquired knowledge about power generation, transmission, maintenance and distribution system in Ashuganj Power Station Company Ltd. (APSCL).

Training Schedule

Day	Topic	Mentor	Time Duration	Training Hour
02.05.2011	Generator Introduction, Excitation and Control System	Engr. Md.Rokon Mia Senior Engineer (Generator & Switchgear protection)	8 am – 1 pm	5
			2 pm – 5 pm	3
03.05.2011	Generator Protection, Auxiliary Electrical system, Boiler sub distribution board	Engr. Md. Kamruzzaman Senior Engineer (Generator & Switchgear protection)	8 am – 1 pm	5
			2 pm – 5 pm	3
04.05.2011	Generator cooling system, Maintenance, Testing, Control system, Boiler drum, Feed water drum	Engr. Md.Rokon Mia Senior Engineer	8 am – 1 pm	5
			2 pm – 5 pm	3
05.05.2011	Generator and switchgear protection, Excitation and Synchronization	Engr. Md. Kamruzzaman Senior Engineer	8 am – 1 pm	5
			2 pm – 5 pm	3
06.05.2011	Electrical Relay, CW Pump, Steam Turbine Introduction, Condenser	Engr. Md.Rokon Mia Senior Engineer	8 am – 1 pm	5
07.05.2011	Backup System, Turbine, control panel of unit 1,2 and unit 3,4 and 5.	Engr. Md.Rokon Mia Senior Engineer	8 am – 1 pm	5
			2 pm – 5 pm	3
08.05.2011	Introduction to substation, Transformer, Bus bar Connection, Transmission Line Protection	Engr. Md. Shahidullah Assistant Engineer (Substation)	8 am – 1 pm	5
			2 pm – 5 pm	3

Day	Topic	Mentor	Time Duration	Training Hour
09.05.2011	Single Line Diagram, Bus Bar System, Protection system of the substation, Circuit breaker, CT, PT	Engr. Md. Shahidullah Assistant Engineer (Substation)	8 am – 1 pm	5
			2 pm – 5 pm	3
10.05.2011	Control room of substation, transformer maintenance, Transformer protection , wye delta conversion, transmission system	Engr. Nur Mohammad Manager (Substation)	8 am – 1 pm	5
			2 pm – 5 pm	3
11.05.2011	Gas Turbine-1, Gas Turbine-2, control System of Gas turbine plant	Engr. Md. FazleHasan Assistant Engineer (Combined Cycle)	8 am – 1 pm	5
			2 pm – 5 pm	3
12.05.2011	Turning Gear, Combined Cycle introduction, Gas Turbine and steam turbine	Engr. Md. Azizur Rahman Senior Engineer (Combined Cycle)	8 am – 1 pm	5
			2 pm – 5 pm	3
13.05.2011	Motor Winding, Motor test, Sensors for protection of Gas Turbine vibration	Engr. Md. Azizur Rahman Senior Engineer	8 am – 1 pm	5
			2 pm – 5 pm	3
14.05.2011	Layout diagram of combined cycle, Generator Protection, Condenser, Turbine protection	Engr. Md. Azizur Rahman Senior Engineer	8 am – 1 pm	5
			2 pm – 5 pm	3
			Total	101 Hour

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CHAPTER 01

1. INTRODUCTION :

Power sector plays a very vital role in overall economic growth of any country. The internship in APSCL (Ashuganj Power Station Company Limited) enriched the knowledge of practical field of power sector. Through this internship I got the opportunity to work as a member of a team of in Generator section, transformer section, steam turbine, Gas turbine and combine cycle power plant. The overall findings show that there is a strong relationship between electricity consumption and Industrial development. So the APSCL plays a vital role to the national power grid as well as to the national economy producing the 15 % power of total national grid. The APSCL has its plan to produce more power and contribute to the country's development. This chapter concludes the total overview of APSCL and its 8 power production unit. The units under thermal power plant and the combined cycle power plant are also described in this chapter and their production capabilities are also shown in this chapter.

1.1. Vision

The APSCL has a vision to use the available resources to produce more power. This company aims to play a significant role in the power system of Bangladesh. It has a longer vision to contribute to the national economy also. The vision of APSCL can be described as below-

"To generate electric power and dispatch same through transmission line of PGCB Ltd. and ultimately to BPDB and to utilize available resources and capacity so that it can contribute towards the national economy through increasing generation of power aiming at maximization of net worth of the Company".

1.2. Mission

The company has a plan to contribute more to the power grid. If there is no continuous supply of power in the grid, the grid will be unable to achieve and supply the quality power. The mission of APSCL is - "To ensure long-term uninterrupted supply of quality power to the consumers in future".

1.3. The Objective

To meet the power demand in our country APSCL are contributing much. To enhance this contribution to the national grid they have set the objective of the company. This contribution will be carried out in future and through this process the company will continue its business. Thus the objective of APSCL -

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

1.4. COMPANY PROFILE :

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

Figure 1.1: Logo of Ashuganj Power Station Company Ltd. (ASPCL)

1. Name of the Company: Ashuganj Power Station Company Ltd. (ASPCL).
2. Date of Incorporation: 28 June 2000.
3. Registration No: C-40630 (2328)/2000 date. 28.06.2000.
4. Location: 90 km North-East of Dhaka on the left bank of the river Meghan.
5. Land : 311.22 Acres
6. Installed Capacity : 724 MW
7. Total number of plants : 3
8. Total Number of Units : 8
9. Website : www.apscl.com

1.5. Power Generation

The APSCL has total 3 plants. There are two thermal power plant and a combined cycle power plant. The fuel used in APSCL is the natural Gas Supplied by TITAS Gas Transmission & Distribution Co. Ltd.

1.5.1. Plant 1: Thermal Power Plant (TPP)

There are two steam units in thermal power plant which use the Meghna river water after purification. These two steam power unit, Unit-1 and Unit-2 are under Plant 1. These two units produce total 128 MW power.

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

1.5.2. Plant 2: Combined Cycle Power Plant (CCPP)

There are two gas turbine units in the combined cycle power plant. These two gas turbine power unit (GT-1 and GT-2) and a Steam power unit are under Plant-2. The total capacity of this combined cycle power plant is 146 MW.

a. Gas Turbine Units-GT1 and GT2 of capacity 56MW each-commissioned in 1982 and 1986 respectively.
b. One Steam Turbine (ST) of capacity 34MW with waste heat recovery Boiler commissioned in 1984.

1.5.3. Plant 3: Thermal Power Plant (TPP)

There are three steam power units (Unit-3, 4 and 5) in thermal power plant under Plant-3. The total installed capacity of this plant is 450 MW. But presently the Unit-4 is out of the production due to the overhauling purpose. The three units are -

a. Unit # 3 of 150MW capacity was commissioned in 1986.
b. Unit # 4 of 150MW capacity was commissioned in 1987.
c. Unit # 5 of 150MW capacity was commissioned in 1988.

Fuel used:

The fuel used in APSCL is the natural gas supplied by TITAS Gas Transmission & Distribution Co. Ltd., Bangladesh.

1.6. Future Plan of APSCL

The APSCL has a vision to ensure long-term uninterrupted supply of quality power to the consumers in future. They have planned to increase the total power supply to the national grid. To fulfill these requirements they have taken some steps. To produce more power the future power they have plan to setup three combined cycle power plants. These projects will be funded by the own property of APSCL. The future projects of APSCL which will be setup in the power station are -

1. Ashuganj 150 MW Combined Cycle Power Plant Project
2. Ashuganj 450MW Combined Cycle Power Plant (North)
3. Ashuganj 450MW Combined Cycle Power Plant (South)

1.7. Scope and Methodology:

At present, 48.5% of the total population of Bangladesh is enjoying the electric facilities. As of April 2010, the total numbers of transmission and distribution lines are recorded to 8,359 km and 266,460 km respectively. In Bangladesh per capita generation is 220 KW hr which is comparatively lower than other developed countries in the world. A recent Status about Bangladesh power generation is stated below:

Table 1.1: A recent status about Bangladesh power generation and consumption

Installed capacity (Feb 2011)	6,658 MW
Derated generation capacity	5,480 MW
Generation	3,900 - 4,300 MW
Maximum generation (Feb 2011)	4,699 MW
Peak demand	5,800 MW
Access to electricity	47%
Per capita generation	220 KW-hr

This report focuses on generation process which includes generator, water treatment plant, steam management, cooling system and protection systems. The protection and maintenance of the equipments of the generator section and the substation section of APSCL are also mentioned in the report. The backup and auxiliary systems, the control room with the control system are also discussed here.

Primarily the data is collected during the internship period. The discussions with the superintendent engineer was effective and this report is based on these informations. Some informations are also taken from the company website (www.apscl.com) as a secondary source of information.

1.8. Conclusion

The overview of power plants of APSCL and their production capabilities are discussed in this chapter. There have been a number of improvements in the power sector in Bangladesh since her independence, but most of these improvements failed to bring desired progresses in the power sector. The mission, vision and objective of the company is described in this chapter which concludes that APSCL has a long term plan to contribute to the national power grid by increasing power generation and supplying the uninterrupted quality power . It is expected that the three combined cycle power plants which will be setup in near future will be able to contribute not only to the national grid but also in the national economy. However the APSCL will be looking forward to getting the governmental assistance in every field of the power station.

CHAPTER 2

STEAM TURBINE PLANT

2.1 Introduction

There are six steam turbine plants in APSCL. Among them the unit 1 and 2 has the capability of producing 64 MW power each. These two steam units commissioned in 1970. The unit 3, 4 and 5 has installed capacity of 150 MW each. A combined cycle plant steam turbine produces 34 MW with the waste heat recovery of gas turbine. The total steam turbine power generation is given in a tabular form -

Table 0.1: Total power generation in steam turbine generation unit

Steam Turbine unit	Plant	Installed Capacity
Unit - 1	1	64 MW
Unit – 2	1	64 MW
Unit – 3	3	150 MW
Unit – 4	3	150 MW
Unit – 5	3	150 MW
Steam turbine of Combined cycle unit	2	34 MW

The total generation process in steam turbine power point is been discussed in this section. The unit 1 and 2 are under the steam turbine plant-1. These two units have a combined control room. Similarly the unit 3,4 and 5 are also under steam turbine unit and have a common control room for these units. There is also a steam turbine unit which is combined with the gas turbine. Its capacity is 34 MW and it has a control room combined with the gas turbine unit. During the internship period, the unit 4 was out of service due to the overhauling purpose.

2.2 Water Treatment Plant

In APSCL water of Meghna River is used to generate steam which is then used to rotate the steam turbine. In APSCL the impulse turbine is used to produce electricity. The river water is not pure. This impure water is purified (demineralized) through some chemical steps and stored in a tank. Finally the demineralized water is supplied to the boiler. It is known as Demi Water to the people of APSCL.

Figure 2.1: Impure river water processing through water treatment plant

Beside the water treatment plant there is a control room where all the control equipment of water treatment plant is kept. There is a store room where a number of chemicals are stored which are needed to mix up with the water to purify. The reservoir tank contains the demi water and continuously supplies water.

2.3. Boiler

After the water treatment plant we were introduced with the boiler which takes the demineralized water from the water reservoir tank. In APSCL water tube boiler is used to produce the steam in which water circulates in tubes heated externally by the fire. The heated water then rises into the steam drum. Here, saturated steam is drawn off the top of the drum. The steam is made superheated and then used to drive the steam turbine as we know water drops can severely damage turbine blades. The steam temperature at the inlet is 535°c.

Figure 2.2: A boiler of APSCL in steam turbine

2.4. Boiler steam purity

In APSCL it is important that the steam leaving the boiler drum should be free from impurities which could be deposited in the super heater or the turbine. Such impurities may arise from the cause that the property which steam at high temperature and pressure has of dissolving significant amounts of certain substances, notably SILICA & CAUSTIC SODA. Impurities caused by steam solubility is controlled by careful regulation of the boiler water analysis, particularly with regard to alkalinity and silica, and it is accepted that if the silica in steam doesn't exceed 0.02ppm , it will cause no trouble by deposition in the superheater or the turbine.

2.5. Condenser

The steam is then reused as water by a condenser. A condenser is a device which condenses the steam at the exhaust of turbine. The condensed water is supplied to the feed water. The condenser receives exhaust steam from the low pressure turbine. Circulating water flows through the condenser tubes to remove heat from the condenser, which causes the exhaust steam to condense. The condensate steam is collected in the hot well which is located in the bottom of the condenser. The hot well stores the condensate for re-use and recirculation in the water/steam cycle. The condenser is located directly beneath the low pressure turbine. As the steam exits the LP turbine, it flows over the condenser tube bundles which are oriented horizontally and perpendicular to the axis of the turbine. This is how the use of the water from the reservoir water tank is lessened.

2.6. Lubricating oil system

The lubrication oil for the turbine bearings and control oil for the actuator positioning is supplied by Control and Lubricating oil system. During normal operation, main oil pump driven by AC motor supplies the lubrication oil. A standby pump auxiliary oil pump driven by AC motor supplies lubricating oil at the failure of main oil pump. When main oil pump and auxiliary oil pump do not work or can't provide lubricating oil with adequate pressure, an Emergency oil pump driven by DC motor supplies the lubricating oil. The oil discharged to supply lubrication oil for the Turbine Bearings.

Figure 2.3: Lube Oil pump in the generator of steam turbine

2.7 Pressure Measurement

In APSCL the major concern in process control applications is the measurement of fluid pressure. The term fluid means a substance that can flow. So the term applies to both liquid and gas. Both will occupy the container in which they are placed. In APSCL the pressure is measured in gauge pressure. Gauge pressure is the pressure measured above atmospheric or barometric pressure.

Figure 2.4: Pressure measurement and control panel beside the generator

2.8 Steam Turbine

In APSCL the impulse turbine is used to produce electricity. A steam turbine is a mechanical device that extracts thermal energy from pressurized steam, and converts it into rotary motion.

Figure 2.5: An Impulse turbine of unit 4 in APSCL removed for overhauling

2.9. Governing and protection system of turbine

The turbine is equipped with hydro-mechanical system of automatic governing which ensures smooth and stable operation under all conditions of operation. The system is capable of sustaining full load from the generator without the operation of protection system and thus enables quick reloading of the turbo set. Speed governor-the principal sensing organ is directly coupled to the turbine rotor through a gear coupling and has been so designed to maintain automatically the speed of the turbo set within the static speed regulation.

2.10. Generator

The generator in APSCL has the output of 190 MVA. The generator has two poles, so it runs at 3000 rpm to produce 50 Hz. The rotor is mechanically coupled with the turbine. Here 3600 rpm is the maximum rated speed of the generator. For safety purpose it is needed to lift up the system when the system is started. So for lifting up, there is a hydroelectric system. The oil is pumped to the hydroelectric system. This is known as jagging oil pump.

2.10.1 The nameplate data of the generator

The generator used in steam power plant is capable of producing 150 MW power each. The name plate data of a generator of unit 3 which was taken during the internship period is given below.

Table 2.2: Generator Nameplate Data of unit 3 in APSCL

Rated speed	3000 rpm
Frequency	50 Hz
Voltage	15750 V ±5%
Y- armature current	6965 A
Rotor weight	42.31 ton
Stator weight	176.0 ton
Excitation voltage	323 V(at full load) 210 V (at no load)
Field current	1500 A
Over speed	3600 rpm
Power factor	0.8
Output	190000 KVA
Cooling air inlet	43°c
Number of pole	2
Direction of rotation clock wise from driven and energy constant= 1.5 KWs/KVA	

2.11 Excitation with brush gear

In APSCL using the carbon brush gear they give the dc excitation in the rotor. The current capacity is almost 30%. The excitation voltage is 220 V. The carbon conductor is checked every two days to check whether they are shortened (due to friction and carbon decay) or not. The carbon brush bar is pressured to the rotor by the spring. There are 14 carbon brushes in parallel which supplies the dc to the field winding.

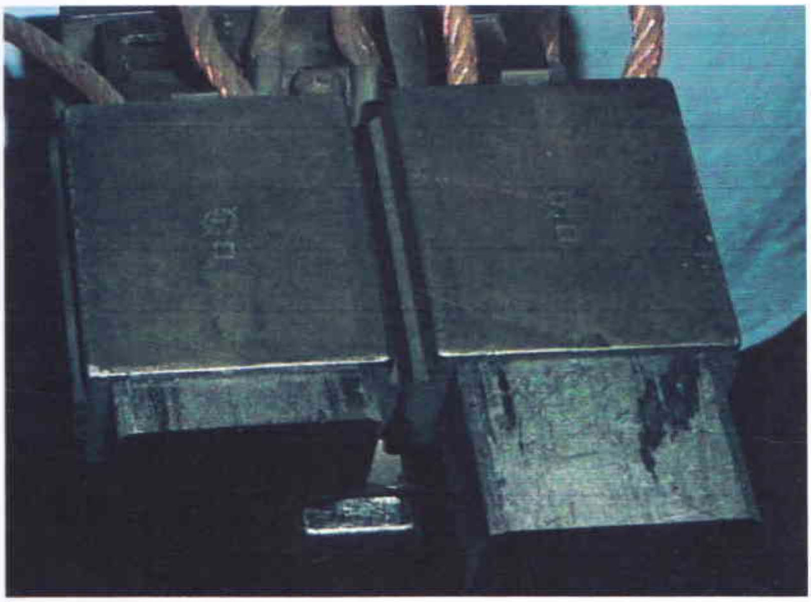

Figure 2.6: Carbon Brush gear and decayed carbon due to friction

2.12 Generator Cooling System

We were introduced with the generator cooling system. As current flows in a conductor, heat is generated. A generator has a lot of conductors and a lot of current flowing through the conductors, generating a lot of heat. If that heat is not removed then the windings will be damaged (insulation breakdown, conductors extend causing clearance and balance issues). In addition, in a synchronous generator (alternator), there are high currents flowing in the rotor winding which also generates heat which must be removed.

In APSCL there are three ways of generator cooling system.

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

2.12.1 Water cooling

The stator winding of the generator is cooled by circulating demineralized water through hollow conductors of stator winding bars in a closed loop. The pump drives the water through the water filters and windings and discharge into a separate compartment of the sealed expansion tank. The water from center the expansion tank is again drawn by the pump cooled and re-circulates. If the pressure of demineralized water falls in the system below particular value, the other pump automatically starts. The closed circuit demineralized water is in turn cooled by demineralized water supplied from the station demineralization plant. The use of demineralized water on secondary side eliminates any accidental contamination of the closed circuit demineralized water which calls for tripping and shut down of the machine. The mechanical filters remove foreign particle in the water. These filters are periodically cleaned one by one.

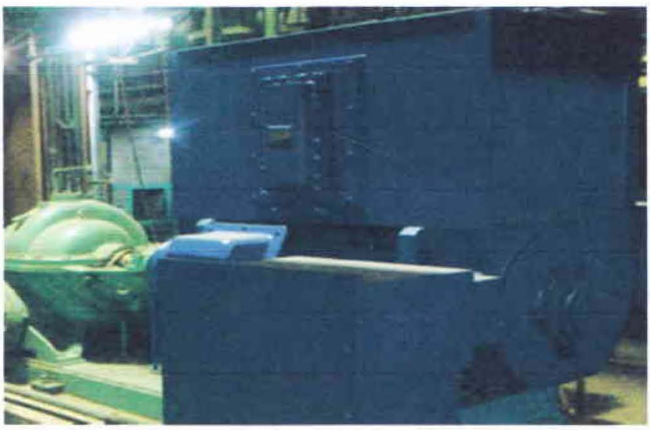

Figure 2.7: Cooling water pump used in water cooling in APSCL

2.12.2 Air cooling

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

Figure 2.8: Air cooling system in APSCL using external fan

2.2.2.3 Hydrogen Cooling

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

2.2.3 Mechanical Speed Checking

Figure 2.9: Speed of rotor checking (Tachometer)

The frequency of the generator depends on the prime mover speed. The speed is kept 3000 rpm. So using this meter (Tachometer) the speed is always monitored. This meter is set beside the generator. The operator always checks this meter and if any abnormal reading is found, he informs it to the respective engineer.

2.3.4 Generator Protection of APSCL

In APSCL, there are 15 types of generator protection included. They are –

1. Over current under voltage protection
2. Earth fault
    a. Stator earth fault
    b. Rotor earth fault
3. Loss of Field Excitation Protection
4. Under frequency protection
5. Over frequency protection
6. Reverse power protection
7. Negative phase sequence protection
8. Generator differential protection
9. Winding temperature protection
10. Over voltage protection
11. Backup earth fault protection
12. Rotor overload protection
13. Rotor temperature protection
14. Stator temperature Protection
15. Cooling air temperature protection

2.3.4.1 Over Voltage Protection

In the generator of APSCL the maximum allowable voltage is 16 KV. If the voltage level higher than the allowed voltage, the relay will sense the abnormalities and it will be tripped. In this scenario the generator will be isolated from the supplying power to the grid.

2.3.4.2 Over frequency and under frequency protection

Generator frequency is 50 Hz. The frequency is always monitored. If the frequency decreases rapidly then the protection system will isolate the generator and trip it down. If initially the frequency decreases up to 48.5 Hz then the warning alarm will ring after that if this condition continues and frequency decreases up to 47.5 Hz, then the generator will trip. Similarly when the frequency starts to increase then the generator will be isolated from the grid.

2.3.4.3 Stator Ground fault:

A stator ground fault is a single-phase to ground fault. A stator ground fault is the most common type of fault to which generators are subjected. Stator ground faults could be caused by the insulation degradation in the windings as well as environmental influences such us moisture or oil in combination with dirt which settles on the coil surfaces outside the stator slots. This often leads to electrical tracking discharges in the end winding which eventually punctures the ground wall. This may cause to a phase-to-phase fault or another single-phase to ground fault.

2.9.4.4 Protection of Stator Ground fault: (High-resistance grounded system)

The high resistance is connected between the neutral point of the generator and the ground. In this system a low resistor is connected at the secondary winding of a single phase transformer called the neutral grounding transformer. This method of grounding limits the ground fault currents to the order of 5 to 10 A, and then there is no danger of damage in case one ground fault occurs.

2.9.4.5 Loss of excitation

When partial or complete loss of Excitation occurs on a synchronous generator, Reactive power flows from the other generator into the generator. The real power is controlled by the Prime-Mover input, while the reactive power output is controlled by the Field Excitation. A loss of excitation will cause the generator to start drawing more and more reactive power over time. Over the first few seconds active power will stay relatively constant, but reactive power will continue to be absorbed from the rest of the system, and voltage levels will drop. Eventually, the magnetic field between the stator and rotor degrades too much so the loss of synchronism will occur.

2.9.4.6 Reverse Power Protection

Generator reverse power (motoring) protection is designed for the prime mover or the system, rather than for the generator. With steam turbines, Turbines will overheat on low steam flow, motoring results from a low input to the ac Generator. When this input can't meet all the losses, the deficiency is supplied by absorbing real power from the system. Since field excitation should remain the same, the same reactive power would flow as before motoring. So on motoring the real power will be into the generator but the reactive power may either flowing out or into the generator. This can cause insulation breakdown of the windings, flashover at the brushes, and violent shaking of the generator. If a generator loses DC excitation to the rotor it will not generate power, the prime mover power will still turn the rotor. Using the reverse power relay the reverse power protection is given in the generator of APSCL.

2.9.4.7 Unit Transformer Protection

The transformer has its own protection system. When the protection system of the transformer has any internal fault, the unit transformer protections relay will work and trip down the circuit breaker.

2.14.8 Backup earth fault protection

In this protection scheme the restricted earth fault relay is used. In any case if this relay does not work, then the backup earth fault relay is there to support the protection system.

2.14.9 Generator Differential protection

In APSCL differential protection is a very reliable method of protecting generators from the effects of internal faults.

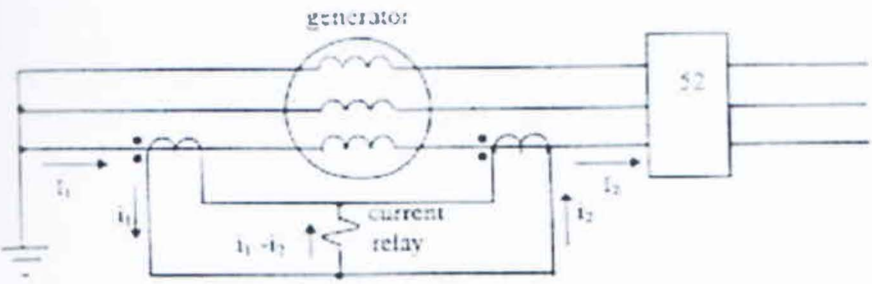

Figure 2.10: Generator differential Protection Relay Setting

In a differential protection scheme in the figure, currents on both sides of the equipment are compared. Under normal conditions current I_1 is equal to current I_2. Therefore the currents in the current transformers secondaries are also equal ($i1 = i_2$) and no current flows through the current relay. If a fault develops inside of the protected zone, currents I_1 and I_2 are no longer equal, therefore i_1 and i_2 are not equal and there is a current flowing through the current relay.

2.15 Conclusion:

In this chapter the steam turbine power plant of APSCL is been described which includes five steam turbine power plants. Starting from the water purification system in water treatment plant in APSCL, the supply to the boiler and reuse of steam with the condenser is also described in this chapter. The generators which are used in producing power are also described along with the protection systems of the generator. The generator cooling system is always monitored as this is the most important part of the power generation system. The other protection schemes are introduced to save the generator from any physical hazard. Due to the overhauling purpose the unit 4 was isolated from the power generation. A few numbers of local and foreign engineers are continuing the overhauling of this unit which is expected to be more efficient than the previous time.

Chapter 03

GAS TURBINE AND COMBINED CYCLE

3.1 Introduction:

A Gas-turbine power station uses gas turbine as prime mover for generating electrical energy. In APSCL there are two gas turbine unit and a steam turbine plant. Gas turbine-1 (GT-1), Gas turbine-2 (GT-2) and steam turbine plant are under Plant-2 (Combined Cycle Power Plant). This kind of power stations is used to produce limited amounts of electrical energy. The production capacity of the Plant-2 (Combined cycle power plant) is as below-

Table3.1: Total generation of combined cycle power plant in APSCL

PLANT 2 (Combined Cycle Power Plant)
Gas Turbine Units-GT1 and GT2 of capacity 56MW each
One Steam Turbine (ST) of capacity 34MW

Each gas turbine of the combined cycle has the production capability of 56 MW. In this chapter the total overview of the combined cycle power plant in APSCL will be described. The overview of gas turbine, its operation, protection will be discussed elaborately.

3.2 Operation:

This power station is run with natural gas as fuel. The turbines draw in air at the front of the unit and then compress; mix with fuel and ignite the mixture at high pressure. The hot gas released expands through the turbine blades connected to the turbine shaft. The shaft turns thus developing mechanical energy which is converted into electrical energy by the generator. Compared to the steam turbine power plant in APSCL, the area of the gas turbine power plant is less. This gas turbine produces a huge noise compared to the steam turbine plant. The gas turbine plant has an advantage that it starts faster than steam turbine plant.

The gas turbine is consisting of three main components: a compressor, a combustor, and a turbine.

3.2.1 Combustion Chamber

The combustion chamber in gas turbines is called the combustor. The combustor is fed high pressure air by the compression system, adds fuel and burns the mix and feeds the hot, high pressure exhaust into the turbine components of the engine or out the exhaust nozzle. The oil is injected through the burner into the chamber at high pressure. Here the temperature is also very high.

3.2.2 Compressor:

The gas turbine has a second turbine acting as an air compressor mounted on the same shaft. The compressor draws in air, compresses it and feeds it at high pressure into the combustion chamber increasing the intensity of the burning flame. It is a positive feedback mechanism. As the gas turbine speeds up, it also causes the compressor to speed up forcing more air through the combustion chamber. It increases the burn rate of the fuel sending more high pressure hot gases into the gas turbine increasing its speed even more. The control on the fuel supply line limit the amount of fuel fed to the turbine. This controlling limits its speed.

3.3 Gas Turbine:

In APSCL combined cycle power plant, the impulse turbine is used which is discussed in the earlier chapter. The protections in gas turbine are:

1. Bearing vibration protection
2. Temperature Protection
3. Over speed protection

3.4 Jacking oil pump:

A jacking oil or lift pump is used on rotor shafts of steam driven Turbine Generators earlier to startup or after shutdown to provide even cooling of the shaft and eliminate rotor distortion. The jacking oil pump uses high pressure oil supplied at the bearing journals to initiate an oil film and lift the shaft off its bearings. The rotor can then be put on a turning gear.

3.5 Turning Gear:

Turning gears are used to rotate slowly to create even cooling and or roll out any distortions caused by the weight of the shaft while at rest. It also helps to maintain the oil between shaft and the bearing till the rotor speed is adequate enough to maintain the thickness and protects the shaft and bearing.

3.6 Brushless Exciter:

In APSCL combined cycle power plant, the generator exciters are brushless. The exciter has stationary field coils and a rotating armature (power coils). The main alternator uses the opposite configuration with a rotating field and stationary armature. A bridge rectifier, called the rotating rectifier assembly, is mounted on a plate attached to the rotor. The main alternator has a rotating field and a stationary armature (power generation windings). Varying the amount of current through the stationary exciter field coils varies the 3-phase output from the exciter. This output is rectified by a rotating rectifier assembly, mounted on the rotor, and the resultant DC supplies the rotating field of the main alternator and hence alternator output. The result of all this is that a small DC exciter current indirectly controls the output of the main alternator.

3.7 Combined Cycle Layout Diagram:

The combined cycle power plant is consisted of two gas turbine power plant and a steam turbine power plant. The Layout diagram of the combined cycle power plant is given below-

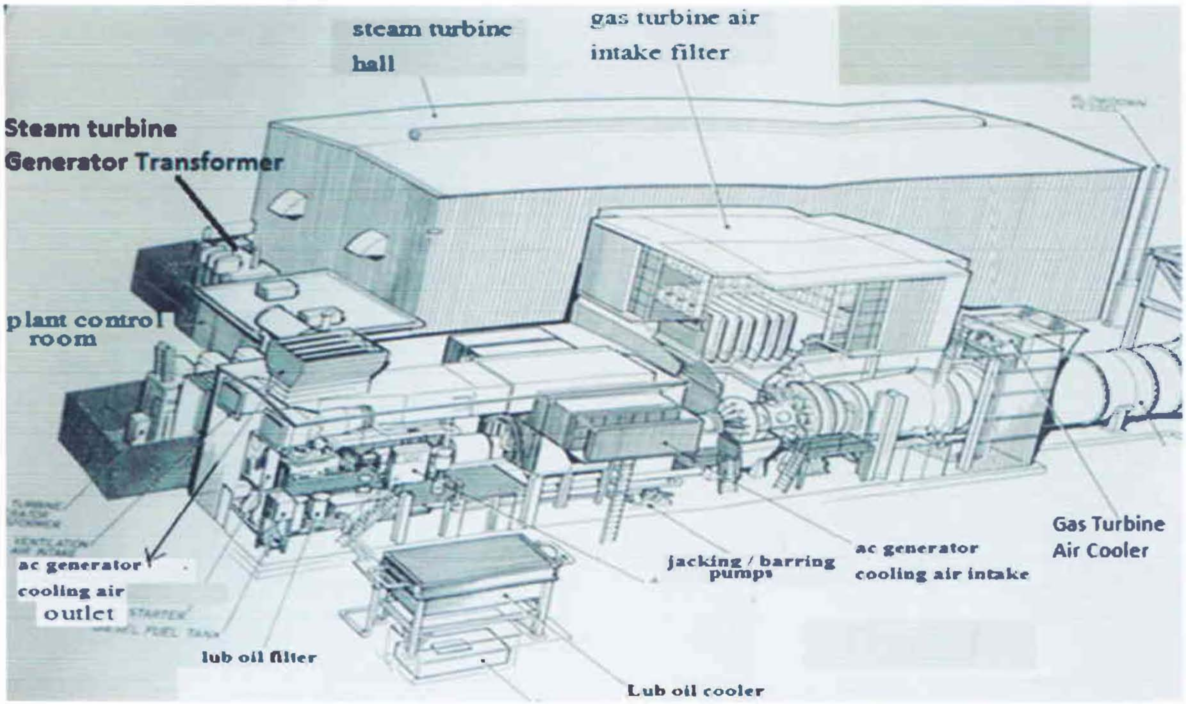

Figure 3.1: Layout diagram of the combined cycle power plant in APSCL

There are different sections in this diagram which includes the gas turbine air cooler, ac generator cooling air intake, ac generator cooling air outlet, Lub oil filter, Lub oil cooler, plant control room, steam turbine hall, gas turbine air intake filter etc. which will be discussed in the following sections.

3.8 Cooling air intake:

For cooling purpose of the bearing lubrication oil, generator and turbine the air intake system is setup at the gas turbine power plant. This air intake system takes the air. Then this air is used in air cooling process which was described in the previous chapter.

3.8.1 Air intake filter

To ensure high efficient filtration of dust and other contaminants even in the most polluted environments, air intake filters are used. Depending on the dust absorption they change these filters in every 3-4 days.

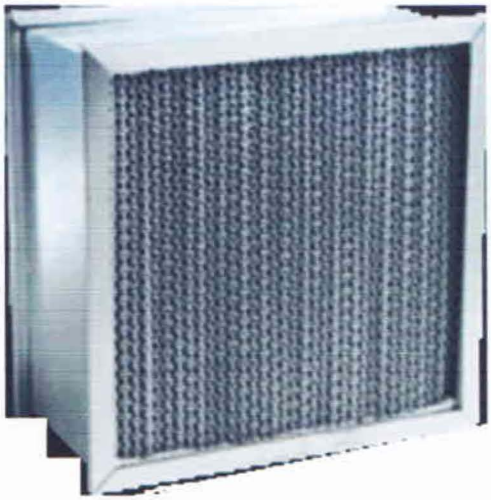

Figure 3.2: Air Intake Filter of APSCL

3.9 Lubrication:

There is a lubrication system. In case of bearing lubrication is very necessary to minimize the bearing resistance, frictions and power losses. The lubricants used in APSCL are –

1. Oil
2. Grease

3.9.1 Oil lubrication Applications:

1. Antifriction bearings
2. Generators
3. Machine tools
4. Power transmission equipments
5. Pumps

3.9.2 Grease Lubrication application:

1. Motor bearings
2. Power transmission devices

3.10 Waste Heat Recovery Unit:

After combustion some flue gases are produced having temperature about 500^0C which exits through the chimney. To use the flue gas properly a combine cycle plant is there which use the flue gas as working fluid. Here damper is used to recover the waste heat. Damper blocks the chimney and passes the flue gas to boiler and produce steam. This steam is used to generate electricity at steam turbine.

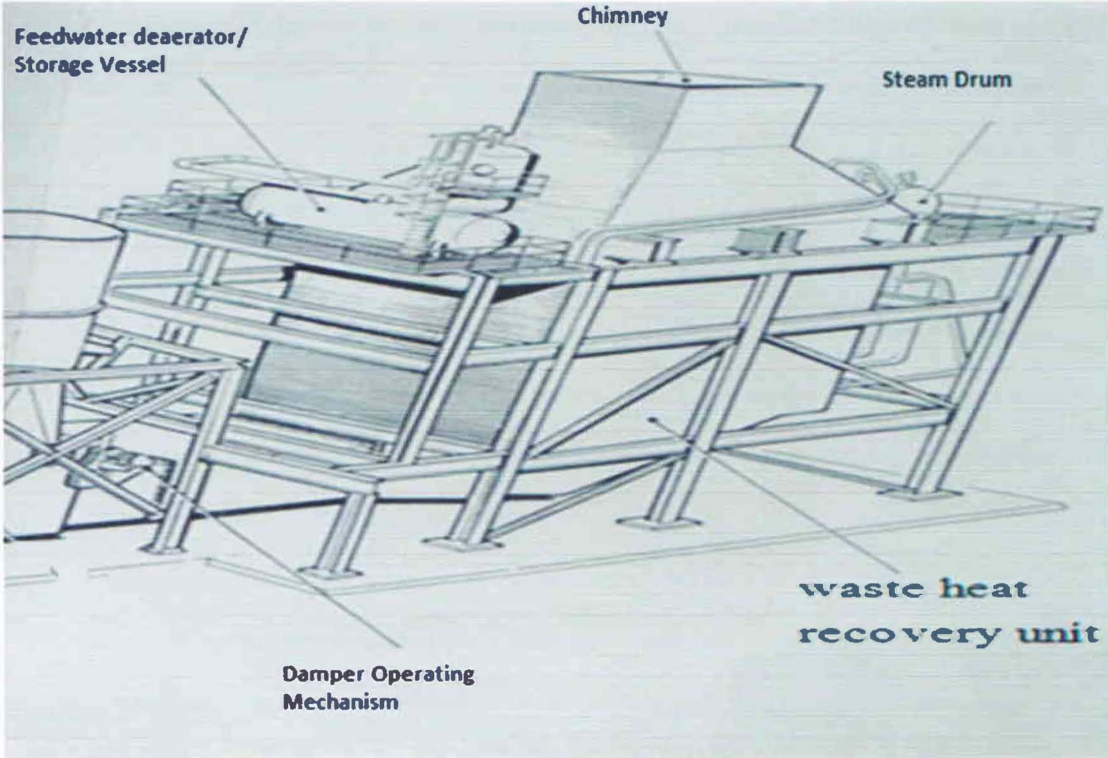

Figure 3.3: Layout of Waste Heat Recovery unit in combined cycle power plant

3.10.1 Benefits of Waste Heat Recovery:

The waste heat recovery unit has a direct effect on the efficiency of the process. The heat which is wasted in the gas turbine power plant is reused through the waste recovery unit. Through this process the efficiency of the total power plant is increased. The benefits are as below-

1. Reduction in the utility consumption, costs and process cost.
2. Reduction in pollution
3. Reduction in equipment sizes
4. Reduction in auxiliary energy consumption

3.10.2 Feedwater Deaerator:

At first, water is pumped into the deaerator to remove all kind of dissolved gases such as O_2, CO_2 etc. From deaerator water is pumped by LP pump to LP evaporator to take some heat from exhaust gas and then again sent to the deaerator. Next water is pumped to the forced flow section by feed pump to take more heat from exhaust gas and sent to the HP steam drum. To reuse the condensed steam (condensate), this condensate is again passed to the deaerator by condensate pumps. If there is any shortage in condensate then some make up water is pumped by makeup pump to compensate the loss.

Figure 3.4: Feedwater Deaerator

3.10.3 Chimney:

The waste gases from the boiler are first passed through precipitators to separate the solid dust particles. The fly ash is collected at these precipitators. The gases are then thrown out with the se of Chimneys.

Figure 3.5: Chimney of Waste heat recovery unit in combined cycle plant

3.11 Piping system:

Piping system is the essential part of the combined cycle power plant. It is employed to transmit water, steam, air, oil and vapor from one position to others.

1. **Water piping:** Raw water, feed water, condensate and condenser cooling water.
2. **Steam piping:** Main, reheat, bleed exhaust steam.
3. **Blow of piping:** Boiler, evaporator, feed treatment.
4. **Miscellaneous piping:** Water treatment, service water, lubricating oil, drains compressed air etc.

Figure 3.6: Piping System of the combined cycle power plant

3.12 Test and protection:

Different types of tests are being conducted to ensure the device is active and some protection measurements are taken for the protection purpose of the machines. The tests and protection system can be stated as below-

1. Bearing test
2. Winding temperature excessiveness test
3. Protection against vibration
4. Cooling air protection
5. Pressure level test of gas, liquid and steam

3.13 Conclusion

This chapter includes the power generation process of combined cycle power plant of APSCL. The operation of the gas turbine generator, excitation system, and cooling system is described through a sequential form. Different parts of the combined cycle power plant are also described presenting the layout diagram of the combined cycle plant of APSCL. This combined cycle power plant has total installed capacity of producing 146 MW but presently it is producing 100 MW. In this combined cycle (mainly in gas turbine) the noise is a great problem compared to the steam turbine. The pipelining system in the combined cycle power plant is the main thing that is discussed in the respective section as the recovered heat is transferred through this. This is how using the waste heat the combined cycle power plant runs.

Chapter 04

SUBSTATION

4.1 Introduction

An electrical sub-station is an assemblage of electrical components including busbars, switchgear, power transformers, auxiliaries etc. This chapter describes about the substation of APSCL. In APSCL, we spent three days to observe the substation equipments. There our instructors were Md. Shahidullah (Assistant Engineer, substation) and Nur Mohammad (Manager and senior engineer, substation). In this chapter the substation equipments, their operation and maintenance are described. The transmission lines along with the outgoing feeder of different voltage level of APSCL are also described. The control room of the substation, from where the substation equipments are monitored and controlled is also introduced here. The protection system and the communication system of the substation are mentioned in this chapter which gives a better idea about the whole substation of APSCL.

4.2 Substation parts and equipments

In APSCL the sub-station has the following parts and equipment.

1. **Outdoor Switchyard**

The substation yard in APSCL is filled up with granite to protect the yard from water. The outdoor switchyard in substation contains all the necessary equipments like transformers, busbar, circuit breakers, relays, lightning arrester etc. The equipments in the APSCL substation yard are as below-

a) Incoming Lines
b) Outgoing Lines
c) Bus bar
d) Transformers
e) Bus post insulator & string insulators
f) Substation Equipment such as Circuit-breakers, Isolators, Earthing Switches, Surge Arresters, CTs, VTs, Neutral Grounding equipment.
g) Station Earthing system comprising ground mat, risers, auxiliary mat, earthing strips, earthing spikes & earth electrodes.
h) Overhead earth wire shielding against lightening strokes.
i) Galvanized steel structures for towers, gantries, equipment supports.
j) PLCC equipment including line trap, tuning unit, coupling capacitor, etc.
k) Power cables
l) Control cables for protection and control
m) Roads, Railway track, cable trenches
n) Station illumination system

2. **Main Office Building**

In APSCL, substation main office building is situated beside the substation. It is divided into two parts-

a) Administrative building
b) Conference room etc.

3. **Switchgear and Control Panel**

The switchgear and control panel are setup in the control room of the substation. From this control room the substation equipments can be remotely controlled. It can be divided into two parts-

a) Low voltage a.c. Switchgear
b) Control Panels, Protection Panels

4. **Battery Room and D.C. Distribution System**

Some equipments need uninterrupted power supply for the protection and function. For the backup system the NiCd batteries are used. These batteries are used when there is no power supply. This system can be subdivided into two parts-

a) D.C. Battery system and charging equipment
b) D.C. distribution system

5. **Mechanical, Electrical and Other Auxiliaries**

For the regular maintenance purpose some mechanical and electrical auxiliaries are needed.

a) Firefighting system
b) Oil purification system

4.3 Transformers

In APSCL different types of transformers like- power transformer and instrument transformers are used for stepping up or stepping down and measurement purpose respectively. The instrument transformer is divided into two parts (CT and PT) which are discussed in this section. Different types of transformers were shown to us by Md. Shahidullah (Assistant Engineer, substation) and Nur Mohammad (Manager and senior engineer, substation),

4.3.1 Power Transformer

The power transformer is used in the substation to step up or step down the voltage. The generated voltage at the generator is stepped up at the substation through the power transformers and then it is supplied to the grid. In the APSCL substation yard, there are three phase power transformers which steps up the generated voltage and supply power to the grid. There are also single phase transformers.

Figure 4.1: A Step up Power Transformer of APSCL

4.3.2 Transformer heating and cooling

Engr. Md. Shahidullah told us about the transformer heating and cooling which is very necessary to take into account. In a real transformer, some power is dissipated in the form of heat. A portion of these power losses occur in the conductor windings due to electrical resistance and are referred to as copper losses. However iron losses from the transformer core are also important. Taking account of both iron and copper losses, the efficiency (or ratio of electrical power out to electrical power in) of real transformers can be in the high 90% range.

Under extreme heat, the oil can break down, sustain an electric arc, or even burn, and a transformer may explode. Heat from core losses and copper losses must be dissipated to the environment. In dry type transformers, cooling is accomplished simply by circulating air around and through the coil and core assembly, either by natural convection or by forced air flow from fans.

One day in APSCL a power transformer was isolated from the grid (tripped) due to the overheating of the transformer. Then it was repaired by Engr. Nur Mohammad. We were present at the venue. Adding external fans to the radiators the air was forced. Then again the transformer was connected to the grid. He told us that the external fan will increase the efficiency of the transformer.

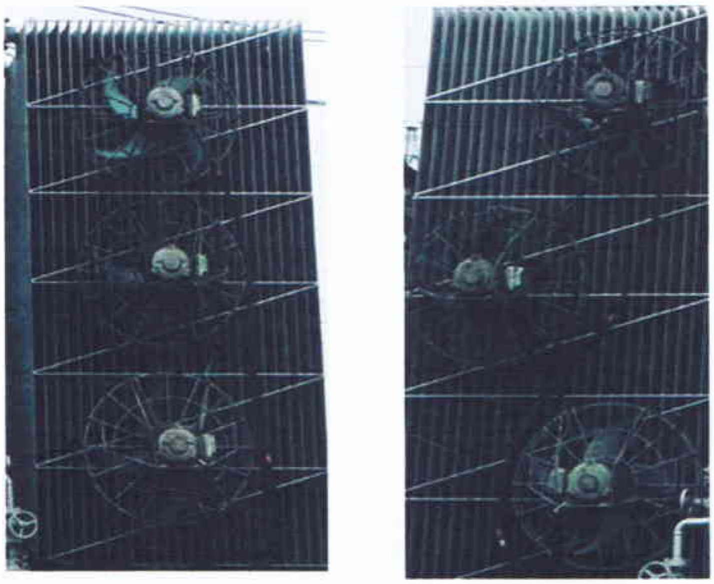

Figure 4.2: Additional cooling fan in power transformer radiator

4.3.3 Maintenance of a Power Transformer:

The transformer is a sophisticated device which needs to be checked regularly to get the better performance. The regular maintenance of a power transformer includes the following

1. Check condition of oil level
2. Check that silica gel crystals are blue
3. Check for oil leakage
4. Check the tightness of nuts & bolts
5. Check the insulation resistance of bushing
6. Check the performance of oil temperature & winding temperature meter
7. Check insulation resistance between each winding and ground.

4.4 Instrument Transformers

Combined instrument transformers, sometimes called metering units, include a voltage transformer and current transformer in a single free-standing unit. These units are used primarily in metering applications where a dedicated voltage transformer and current transformer are used for revenue metering.

4.4.1 Current Transformers

A current transformer is an instrument transformer intended to have its primary winding connected in series with the conductor carrying the current to be measured or controlled. The ratio of primary to secondary current is roughly inversely proportional to the ratio of primary to secondary turns and is usually arranged to produce either five amperes or one ampere (IEC Standard) in the full tap of the secondary winding when rated current is flowing in the primary.
Current transformers can be included in two general categories: metering service and relay service. As a rule, current transformers designed for metering service should not be used for relay applications or system protection. Likewise, current transformers designed for relay service should not be used for high accuracy metering applications.

Figure 4.3: A single phase, oil immersed 132 KV current transformer of APSCL

The nameplate rating of a single phase current transformer in the APSCL substation is given below-

Table 4.1: A current transformer nameplate data

Usage	Current
Phase	Single
Coil Structure	Winding Type
Insulation Method	Oil-immersed Type
Installation Method	Outdoor
Rated Voltage	132KV
Highest Voltage	145KV
Rated Frequency	50HZ
Rated Secondary Output	20~50VA

4.4.2 Potential transformer

After Current transformer, we were told about potential transformers which are used to step down the high voltage to low standard value accurately in proportion to their ratio. Potential transformers are used for measurement and protection. It is either measuring type or protective type. PT may be single phase or three phase units.

Figure 4.4: Single Phase, 132 KV outdoor Potential Transformer of APSCL

A single phase potential transformer rating is given below –

Table 4.2: A potential transformer nameplate rating

RATED VOLTAGE	132 kV
CONSTRUCTION	OUTDOOR
NO. OF PHASE	SINGLE
RATIO	$\frac{132000}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
RATED FREQUENCY	50 Hz
TOTAL WEIGHT	600 KG
HIGHEST SYSTEM VOLTAGE	145 kV

4.5 Bus bar

Various factors affect the reliability of a substation, one of which is the arrangement of the switching devices. Arrangement of the switching devices will impact maintenance, protection, initial substation development, and cost. There are three types of substation bus switching arrangements commonly used in APSCL substation. They are –

a. Single Bus configuration
b. Double Bus, Single Breaker Configuration
c. Main and Transfer Bus Configuration

4.5.1 Single Bus Configuration

This arrangement involves one main bus with all circuits connected directly to the bus. The reliability of this type of an arrangement is very low. When properly protected by relaying, a single failure to the main bus or any circuit section between its circuit breaker and the main bus will cause an outage of the entire system. In addition, maintenance of devices on this system requires the de-energizing of the line connected to the device.

Figure 4.5: Single Bus Configuration

4.5.2 Double Bus, Single Breaker Configuration

This scheme has two main buses connected to each line circuit breaker and a bus tie breaker. Utilizing the bus tie breaker in the closed position allows the transfer of line circuits from bus to bus by means of the switches. This arrangement allows the operation of the circuits from either bus. In this arrangement, a failure on one bus will not affect the other bus. However, a bus tie breaker failure will cause the outage of the entire system. Operating the bus tie breaker in the normally open position defeats the advantages of the two main buses. It arranges the system into two single bus systems.

Figure 4.6: Double bus, single breaker configuration

4.5.3 Main and Transfer Bus Configuration

This scheme is arranged with all circuits connected between a main (operating) bus and a transfer bus (also referred to as an inspection bus). Some arrangements include a bus tie breaker that is connected between both buses with no circuits connected to it. Since all circuits are connected to the single, main bus, reliability of this system is not very high. However, with the transfer bus available during maintenance, de-energizing of the circuit can be avoided. Some systems are operated with the transfer bus normally de-energized. When maintenance work is necessary, the transfer bus is energized by either closing the tie breaker, or when a tie breaker is not installed, closing the switches connected to the transfer bus.

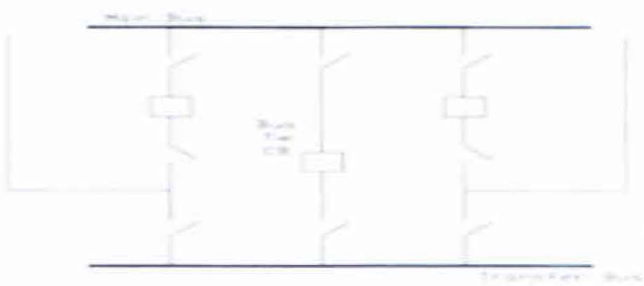

Figure 4.7: Main and transfer bus configuration

4.6 Circuit Breaker

While visiting the substation in APSCL, Engr. Md. Shahidullah showed us different types of circuit breaker. A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and, by interrupting continuity, to immediately discontinue electrical flow. Unlike a fuse, which operates once and then has to be replaced, a circuit breaker can be reset to resume normal operation. The circuit breakers are –

1. Oil circuit breaker
2. SF6 circuit breaker

4.6.1 Oil circuit breaker:

The oil in OCBs serves two purposes. It insulates between the phases and between the phases and the ground, and it provides the medium for the extinguishing of the arc. When electric arc is drawn under oil, the arc vaporizes the oil and creates a large bubble that surrounds the arc. The gas inside the bubble is around 80% hydrogen, which impairs ionization. The decomposition of oil into gas requires energy that comes from the heat generated by the arc. The oil surrounding the bubble conducts the heat away from the arc and thus also contributes to deionization of the arc.

Figure 4.8: Oil Circuit Breaker in substation rated voltage of 132 KV and Current 1250 A

The rating of an oil circuit breaker in APSCL is given below –

Table 4.3: Nameplate data of an oil circuit breaker of APSCL

Rated Voltage = 132 KV	Making current 55/45 KA
Maximum service voltage =170 KV	Operating duty = 0-0-3s-CO-3min-CO
Rated Current = 1250A	Operating mechanism = 220 VDC
Frequency = 50 HZ	Weight including oil = 3280 Kg
Breaking capacity = 5000 MVA	Oil filling of breaker poles = 330 Kg
Neutral frequency =1.5 KHz	

4.6.2 Bulk oil Circuit breaker:

The oil serves as both arcs extinguishing medium and main insulation in the bulk oil breakers

4.6.3 Minimum oil circuit breaker:

The minimum oil breakers reduce the oil volume only to amount needed for extinguishing of the arc

4.7 Sulpher hexafluoride (SF_6) high-voltage circuit-breakers

In the substation we also see the sulpher hexafluoride circuit breaker. A sulfur hexafluoride circuit breaker uses contacts surrounded by sulfur hexafluoride gas to quench the arc. They are most often used for transmission-level voltages and may be incorporated into compact gas-insulated switchgear.

The rating of a SF6 circuit breaker is given below –

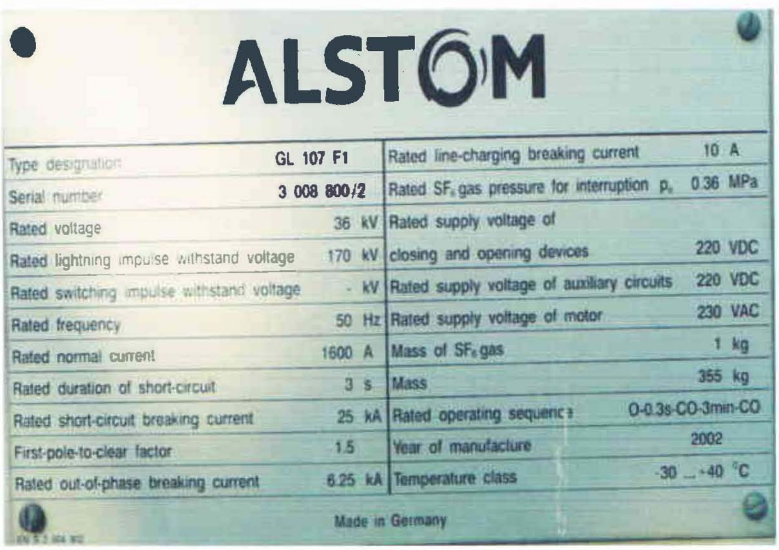

Figure 4.9: A nameplate rating of a SF6 Circuit Breaker whose rated normal current 1600A

4.7.1 Advantages of SF6 CB:

a. Noiseless operation
b. The closed gas keeps the interior dry
c. Low maintenance cost

4.8 Circuit breaker in switchgear and protection system

There are some low/medium voltage circuit breakers to protect the switchgear and the protection system. These circuit breakers can be described as below –

1. Miniature Circuit Breaker: Rated current 100A
2. Molded Case Circuit Breaker : Rated current 2500A
3. Air Circuit Breaker: Rated current 400-6400A
4. Vacuum circuit breaker:
    a. Rated voltage 22-66kV
    b. Rated current 2500-3100A

4.9 Relays that are used in APSCL substation

Different types of relays are used in the substations. Among them some are being described in this section.

4.9.1 Over current relay

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

4.9.2 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. It detects faults and minimizes the propagation of any damage which might occur within oil-filled transformers.

Figure 4.10: A typical Buchholz Relay used in 132 KV substations

4.9.3 Distance relay

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

4.10 Transmission and Distribution:

A substation receives electrical power from generating station via incoming transmission lines and delivers electrical power via the outgoing transmission lines. Overhead lines are used for transmission. Overhead lines has some components, these are

4.10.1 Conductors

The underground cables are used to connect the devices of the substation of the APSCL to the control room. The underground cables are highly insulated. The underground cables are put under the pathway of the substation. They always check the condition if there is any water or not. To transmit the electric power ACSR (Aluminum Conductor Steel Reinforced) conductors are used in APSCL.

4.10.2 Line Supporters

The supporting structures for overhead line conductors are various types of poles and towers called line supporters. They have high mechanical strength to endure the weight of conductors and wind loads.

4.10.3 Insulators

Engr. Shahidullah showed me different types of insulators in the store room which are used in power lines. There are three types of different types of insulators. They are-

1. Suspension type insulator,
2. Pin type insulator and
3. Strain insulator

4.10.4 Isolators

Isolators are used as a disconnecting switch. For the confirmation of the complete de-energization of the electric circuit during maintenance, isolators are used.

Figure 4.11: Isolators used in APSCL (Rated voltage 252KV, rated current maximum 2500 A)

4.11 Wye to Delta conversion

In APSCL Three single phase transformers are used to transform the wye connected generator output into delta connection. There is a three phase transformer which is used as the backup for these three transformers. If any of the transformers fails, then the three phase transformer will transform the wye connection to delta. This is how the wyeconnected generator output is converted into delta and then it is transmittedto the grid.

Figure 4.12: Wye to delta conversion (3-single phase and a three phase transformer) and transmission

4.12 Outgoing feeder:

APSCL transmit power to the different regions of the country.

Outgoing feeders of APSCL are:

4.12.1 The 132 KV outgoing feeders

The regions which are covered by the 132 KV transmission line are Ghorashal, Kishoreganj and Shajibazar. These are divided into outgoing feeders. The outgoing 132 KV feeders are -

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

4.12.2 The 230 KV outgoing feeders

The regions which are covered by the 230 KV transmission line are Ghorashal and Comilla. These are divided into outgoing feeders. The outgoing 230 KV feeders are -

1. Ghorashal-1
2. Ghorashal-2
3. Comilla -1
4. Comilla-2
5. AGREKO 80 MW rental
6. United 50 MW rental
7. OAT-11 & OAT-12 (230 kv)

4.13 Auxiliary Systems

Initially the power station takes the power from the power grid. Then they produce power in the plant and transmit it to the grid. They also use their own generated power for their own use. The auxiliary systems in APSCL, are used to supply the following loads –

1. Oil pumps
2. Outdoor device heaters
3. Outdoor lighting and receptacles
4. Control house
5. Heating and ventilation
6. Air conditioning
7. Battery charger input
8. Water well pump
9. Motor-operated switches.

4.14 PLCC (Power line carrier communication) equipment:

PLCC means Power Line Carrier Communication. It is mainly used for Telecommunication, Tele-protection and Tele-monitoring between electrical substations through the power lines at high voltage. It is a real benefit that two important applications (power transmission and telecommunication) are occurring in a single system. In this system, audio frequency carried by carrier frequency and the modulation system is amplitude modulation. It includes -

1. Wave Trap
2. Coupling Capacitor

4.14.1 Wave Trap:

It is known as Line trap. It is connected in series with the power (transmission) line. From the APSCL substation, they communicate with the other substation connected to the power grid. Wave trap is used to arrest the PLCC signals.

Figure 4.13: Wave Trap

4.15 Lightning Arrester

Lightning arrester is also known as surge arrester. It has also a nonlinear resistance with spark gap. Under the normal condition lightning arrester does not work but when the high voltage or thunder strike occur then air insulation of the gap breaks and arc is formed for providing a low resistance path for surge the ground.

Figure 4.14: Lightning Arrester arrangement in the substation

4.16 Conclusion

Substation is the gateway to transmit the power to the grid. This chapter gives an overview about the substation equipments like- Transformer, circuit-breakers, isolators, earthing switches, surge arresters, CT, VT, neutral grounding equipment, substation yard etc. The proper maintenance in the substation equipments in APSCL has made it possible to supply power to the national grid uninterruptedly. During any emergency condition the substation isolates the total power station from the grid. The precaution is that peoples in the substation are restricted to walk in some predefined path as there underground cables are installed.

CHAPTER 05

CONTROL AND BACKUP

5.1 Introduction:

The control system is the most important part of the power station. Each and every device in APSCL is needed to be controlled somehow. So the control room operators are there to serve this duty. From the control room they control or maintain auxiliary equipment, such as pumps, fans, compressors, condensers, feed water heaters, filters to supply water, fuel, lubricants, air, or auxiliary power etc.

The APSCL is totally grid dependent power plant. When there is no power in the grid, generator and other equipments of the power station cannot be run. But the control equipments need always power to run. For this reason, there is a backup system in APSCL, which is provided by the NiCd batteries. Where the ac source is needed, inverter is used to supply the ac power. So the backup system is also important for APSCL when there is no power supply.

5.2 Substation Control room:

From substation control room the equipment of the substation is monitored and controlled. In the control room there are-

5.2.1 Metering panel:

The supplied power to the grid is monitored through this panel. The total supplied power is recorded here and from this panel they calculate the total unit.

5.2.2 Announcement panel:

If there is any announcement regarding the control room or substation, the respective people announce it from this panel.

5.2.3 Control panel:

This is the most important part of this control room. They control the substation equipments remotely with this panel. There are motor operated switches in the substation. They are controlled by this panel.

5.2.4 Relay panel

All the relay panels are automated in APSCL. This relay panel includes protective relays, control switches, temperature sensor, energy meters and auxiliary relays.

5.3 SCADA Control:

Previously the control room of APSCL was not under the SCADA control. But now the equipments of the control room are under SCADA control. There is an interface in every panel which is the SCADA interface. To be controlled remotely this interface is needed to be turn on into SCADA mode. If the engineers fail to control any equipment or fault, then this SCADA terminal is turned on to be controlled it by other experts from Rampura, Dhaka.

5.4 Combined Cycle Power Plant Control Room:

In the corner of the combined cycle power plant, there is a control room. Here all the metering and controlling systems of this plant are maintained. They always monitor the panel board. If they find any abnormalities in the machines they trip them remotely from the control room.

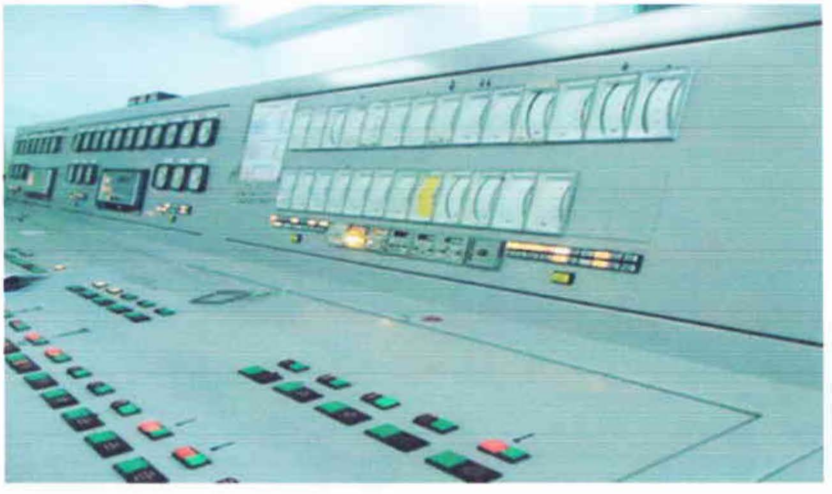

Figure 4.15: Control room of combined cycle power plant(meters and control board)

5.5 Steam turbine Control Panel

In steam turbine plant there are five units. Control room of unit 1 and 2 is in the same room. Similarly the control room of unit 3,4 and 5 is in a room.

5.5.1 UNIT 1 & 2 CONTROL

The control room of unit 1 and 2 are arranged in a room. It is the main part of APSCL as this control room is arranged with the meters, relays and other control equipments of the generators of Plant 1. In this control room all the data (related to the power generation, frequency, speed, temperature, current, voltage, gas control) are recorded in a graph automatically. From the graph they can identify the problems.

Figure 4.16: Data (frequency, speed, temperature, current, voltage) record in graphical form in unit 1 and 2 control room

5.5.2 UNIT 3, 4 & 5 CONTROL

The unit 3, 4 and 5 control room is in a same room. The operation of this control room is similar to the unit 1 and 2 control room. During my internship program the unit four was out of service due to the overhauling purpose of the equipments. So in the panel of unit 4, I observed there were zero values in the meters.

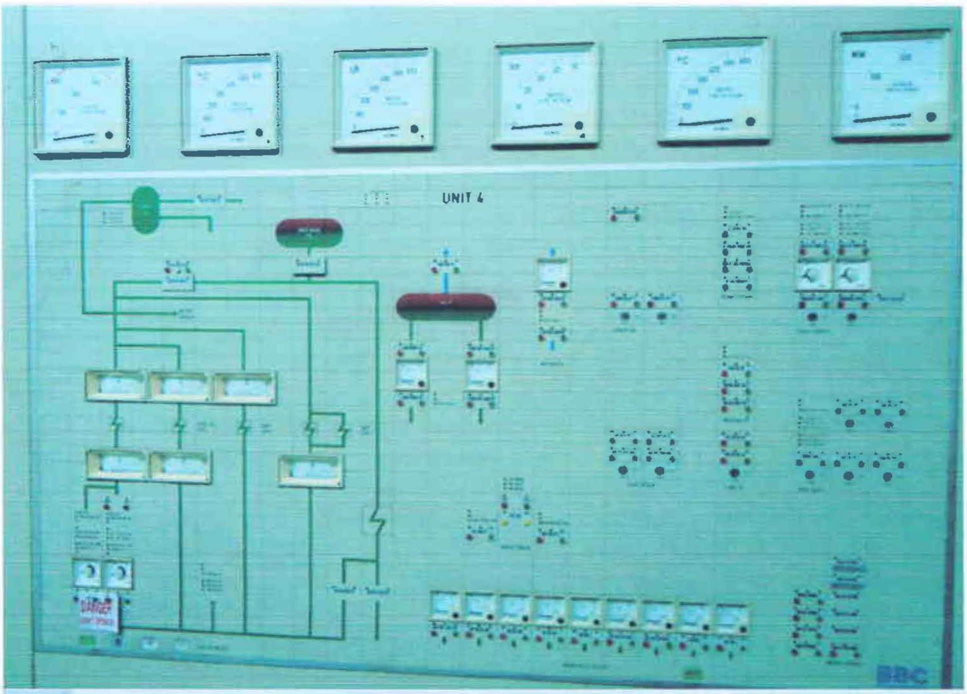

Figure 4.17: Meters of unit four showing values zero in the control room as unit 4 is out from service

5.6 Responsibilities of the control room operators

In APSCL, the responsibilities of different control room (Substation, Gas turbine plant, Steam turbine plant) are little bit different. But all of them have to do some regular duties they are -

1. Monitor power plant equipment and indicators to detect evidence of operating problems.
2. Take regulatory action, based on readings from charts, meters and gauges, at established intervals.
3. Open and close valves and switches in sequence to start or shut down auxiliary units.
4. Record and compile operational data by completing and maintaining forms, logs, or reports.
5. Make adjustments or minor repairs, such as tightening leaking gland and pipe joints.

6. Regulate equipment operations and conditions, such as water levels, based on instrument data or from computers.
7. Inspect records or log book entries or communicate with plant personnel to assess equipment operating status.
8. Start or stop generators, auxiliary pumping equipment, turbines, or other power plant equipment as necessary.
9. Control power generating equipment, including boilers, turbines, generators, or reactors, using control boards or semi-automatic equipment.
10. Clean, lubricate, or maintain equipment, such as generators, turbines, pumps, or compressors, to prevent failure or deterioration.
11. Communicate with systems operators to regulate and coordinate line voltages and transmission loads and frequencies.
12. Adjust controls to generate specified electrical power or to regulate the flow of power between generating stations and substations.
13. Place standby emergency electrical generators on line in emergencies and monitor the temperature, output, and lubrication of the system.
14. Examine and test electrical power distribution machinery and equipment, using testing devices.
15. Receive outage calls and request necessary personnel during power outages or emergencies.

5.7 BACKUP SYSTEM

The backup system provides uninterrupted power supply to the control equipments. This backup system is provided by the NiCd batteries. In this section the auxiliary power supply using the dc batteries and its maintenance is going to be discussed. Different types of tests of batteries are also discussed here.

5.7.1 Auxiliary DC power supply

We have seen the auxiliary power supply which is provided by the DC supply. The inverter is used to convert the dc supply to the AC. In the battery backup panel the batteries are interconnected. Battery ensures an uninterrupted power supply. In APSCL Nickel cadmium batteries are used to get 220V dc supply. In the control room there are two rectifiers. One is for supplying the dc to the control panel from the input AC source and the other rectifier (Rectifier-2) is used for the backup rectifier of Rectifier-1.

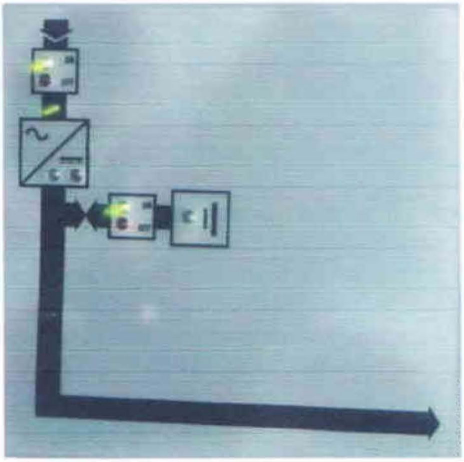

Figure 4.18: Rectifier diagram in the rectifier indicating ac to dc supply &battery charging

The batteries are charging and discharging continuously. When charge is needed, the batteries are being charged, but when there is AC power supply, the batteries are in floating condition. In this state neither they get charged nor the supply power. The rectifier itself supplies the DC to the control board from the input AC.

Figure 4.19: Series Connection of NiCd battery in battery backup room

5.7.2 Battery Voltage Level

In the battery backup room we have seen NiCd batteries are connected in series to add the voltage. The voltage level of all the batteries is same (1.2V). The battery capacity is denoted by the Ampere-Hour (A-H). These batteries are also connected to the system. The batteries are charging continuously and when needed, these batteries will behave like a backup system. The steady condition when the constant voltage will be given this condition is called the floating position. These batteries are charged once a month in a higher voltage (1.6V) to enhance the battery performance.

The voltages can be categorized as below-

Nominal voltage ------ 1.2V

Floating Voltage ------- 1.4 V

Boost Voltage --------- 1.6 V

5.7.3 Battery Test

Some tests are continuously done for the backup system. The data is stored in a notebook. If there are any abnormalities in the test value, then the data is shown to the respective engineer (Engr. Rokon Mia).

The tests are –

1) The cell voltage test
2) Specific gravity test (1180-1220)
3) The tightness capacity test of the connection
4) Breathing test to identify that any chemical reaction is occurred or not
5) Liquid level test

5.8 Quick transfer device

Initially before the starting of the generator, the APSCL take the power from the power grid. When using the power the generator is started and the generator of APSCL start producing power, they do not take power from the grid anymore. They use their own generated power. To change the connection from the power grid to their own system, they use a device which is known as quick transfer or quick changeover device.

5.9 Black out plant

All the power plants are grid dependent. When any abnormality in the national grid, all the power stations are unable to transmit power to the grid, it is known as National Grid Failure. In this situation the power stations require minimum power to start producing the power and transmit to the grid. This minimum power is supplied by generator of any plant. It is known as blackout plant. Then one by one the other power plants of the country start to supply power. The blackout plant is mainly diesel generator. In APSCL, there is no blackout plant. This power plant is Grid dependent.

5.10 CONCLUSION

This chapter highlights about the control system which is a very important part in the plants of APSCL. The equipments in the control system are automated. They can also be operated manually. The equipments which need the constant power supply are provided with the constant dc power supply as backup system. Through different sequential steps the control room of the substation, combined cycle plant and steam turbine plant is described. The battery testing part is the most important part as described before. The regular testing ensures the best performance of the batteries.

CHAPTER- 6

CONCLUSION

This chapter is designed to give an overview about the problems and findings in APSCL during the internship period. These will be discussed briefly and then there are some recommendations which could be regarded as a suggestion from my point of view. During my internship I was able to observe the applications of the theory in APSCL that I have learnt in the university. The instructors at APSCL showed us all the equipments and explained their working principle. So the best practice would always be preparing oneself before going for an internship.

6.1 Problems and Findings

Some problems that I had to face during my internship are stated below -

1. Sometimes it was very hard to understand the matters as they were unable to show the internal configurations properly.
2. In the power station all the equipments are running system, so I could not get chance to learn practically about all kinds of faults although the instructor there helped me a lot to make me understand about different types of faults of the equipments in APSCL.
3. During the internship they asked me to provide a detailed working list that we are expected to complete during my internship, but I was unable to provide it to the mentor.

6.2 Recommendation

From my point of view the internship program is very effective to learn something practically applying the theoretical knowledge. To get the best from the internship program, some necessary steps could be followed by the interns. The recommendations can be summarized as below-

1. It could be suggested to take all the notes from the instructor about what he is doing as well as learn it practically.
2. Taking some suggestions before the internship program from relevant teacher would be very effective to learn the matters and
3. Get a total outline of what to learn during the internship program discussing with the subject relevant teachers.
4. Before going for an internship in a power station, completion of the power related course is mandatory.

6.3 Conclusion

In a large power station like Ashuganj Power Station Company Ltd. (APSCL), maintenance of the equipment is the main challenge in a power station. They check their each and every equipment on a regular basis to keep them fully running. It is hoped that some constructional changes of equipments will be made in APSCL which will increase the total power generation.

In the long run the APSCL will improve its distribution, transmission and contribution to the country. I was lucky enough to work with a group of enthusiastic and communicative people in APSCL. It has been a unique opportunity and one that I will not soon forget.

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