INTERNSHIP REPORT

ON

ASHUGANJ POWER STATION COMPANY LTD.

Submitted by

Shekh Shamim (2008-2-80-009)

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Submitted to the

Department of Electrical and Electronic 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)

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Approved By

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Date of Report Submission: 7th June, 2012

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

CIRIFICATION FOR INDUSTRIAL ATTACHMENT
TRAINING PROGRAMME

Certified that Shekh Shamim, Student. ID No- 2008-2-80-009 of Electrical & Electronic Engineering Départment of East- West University, Dhaka, has participated the Industrial Attachment Training Program from 26-12-2011 to 11-01-2012 and successfully completed the course.

11-01-2012

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

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

CIRIFICATION FOR INDUSTRIAL ATTACHMENT
TRAINING PROGRAMME

Certified that Shayam Arafat, Student. ID No- 2008-2-80-042 of Electrical & Electronic Engineering Départment of East- West University, Dhaka, has participated the Industrial Attachment Training Program from 26-12-2011 to 11-01-2012 and successfully completed the course.

11-01-2012

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ASHUGANJ POWER STATION COMPANY LTD. (APSCL)
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APSCL

CIRIFICATION FOR INDUSTRIAL ATTACHMENT
TRAINING PROGRAMME

Certified that Md. Saidul Islam, Student. ID No- 2008-2-80-035 of Electrical & Electronic Engineering Département of East- West University, Dhaka, has participated the Industrial Attachment Training Program from 26-12-2011 to 11-01-2012 and successfully completed the course.

11-01-2012

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Ashuganj, B-Baria.

ACKNOWLEDGEMENT

First of all we would like to thank the almighty Allah for giving us the chance to complete our internship and prepare the internship report.

We would like to acknowledge the advice and guidance of Mr. Md. Mahfuzul Haque, FCMA Finance Director of APSCL and Md Lutfar Rahman (HRM). We also thank the members of APSCL for their guidance and suggestions, especially Engr. Achinta Kumer Sarker, DGM (mm), Engr. Md. Shahabuddin, Manager (CCPP), Engr. Noor Mohammad, Manager (Sub-station), Engr. Md. A.K.M Yaqub, Manager (Generator), Engr. Md. Anwar Hossain, Manager (Operation), Engr. Bikash Ranjan Roy, Manager (Instrumentation & Control), without whose knowledge and assistance this report would not have been successful. We also thank the senior engineers for all their advices, encouragements and work in their team.

We would also like to thank our advisor Tahseen Kamal, Lecturer and Fakir Mashuque Alamgir Lecturer, Department of Electrical & Electronic Engineering, East West University, Bangladesh

We would also like to mention the name of Dr. Khairul Alam, respectable Chairperson & Professor of the Department of Electrical & Electronic Engineering.

We would also like to thank Engr. Md. Kamruzzaman, Senior Engineer (Generator & Switchgear Protection.), Engr. Md. Fazle Hassan Siddiqui, Assistant Engineer & Engr. Md. Nazmul Amin (Combine Cycle Power Plant), Engr. Sujol, Junior Engineer, (Operation), who had provided the associated data of our report and also careful us to understand related matters.

At last we want to give thanks all of our teachers and friends for their inspiration and co-operation throughout our whole academic life in EWU.

EXECUTIVE SUMMARY

Electricity has been the foundation of economic growth of a country, and constitutes one of the vital infra-structural inputs in socio- economic development. Bangladesh's energy infrastructure is quite small, insufficient and poorly managed. The per capita energy consumption in Bangladesh is one of the lowest (136 kWH) in the world. Bangladesh's installed electric generation capacity was 4.7 GW in 2009; three-fourth of which is considered to be available. 40% of the population has access to electricity with a per capita availability of 136 kWh per annum. The Ministry of Power and Energy has been mobilizing Tk 40,000 crore ($5.88 billion) to generate 5,000 MW of electricity to reduce load shading into a tolerable level within next four and half years during the term of the present government.

By arranging carefully understand the role of power sector in Bangladesh the general electricity production, distribution and transmission system in the country must also be taken into account. All these have been rightfully done in this report. The purpose of this report is to establish a brief description of electricity production, distribution and transmission system in Bangladesh. By following the collected data from APSCL (Ashuganj Power Station Company Ltd), APSCL has 9 units with installed capacity of 777MW. But its present de rated capacity is 677MW. Ashuganj Power Station fulfills about 15% of power requirements of the country. Unit 1&2 produce 64 MW each. Unit 3, 4&5 produce 150 MW each, unit 6&7 produce 56 MW each and unit 8 produce 34 MW. This is all about the power generation of APSCL.

Through our internship we have come to know how a power station runs and also know the practical field of power generation, distribution and transmission. On the completion of our internship we can relate theoritical knowledge with practical experience.

TRAINING SCHEDULE

Date	Division	Time(1st session)	Time (2nd session)	Mentor
26-12-2011	Total Plant Overview	08am to 01pm	02pm to 05pm	Engr.Achinta Kumer Sarker
27-12-2011	Generator	08am to 01pm	02pm to 05pm	Engr. Md. Kamruzzaman
28-12-2011	Generator	08am to 01pm	02pm to 05pm	Engr. Md. Kamruzzaman
29-12-2011	Operation	08am to 01pm	02pm to 05pm	EngrAnwar Hossain
31-12-2011	Operation	08am to 01pm	02pm to 05pm	EngrAnwar Hossain
01-01-2012	Operation	08am to 01pm	02pm to 05pm	EngrAnwar Hossain
02-01-2012	I&C	08am to 01pm	02pm to 05pm	Engr. Bikash Ranjan Roy
03-01-2012	I&C	08am to 01pm	02pm to 05pm	Engr. Bikash Ranjan Roy
04-01-2012	I&C	08am to 01pm	02pm to 05pm	Engr. Bikash Ranjan Roy
05-01-2012	CCPP	08am to 01pm	02pm to 05pm	Engr.Md. Mizanur Rahman
07-01-2012	CCPP	08am to 01pm	02pm to 05pm	Engr.Md. Mizanur Rahman
08-01-2012	CCPP	08am to 01pm	02pm to 05pm	Engr.Md. Mizanur Rahman
09-01-2012	Substation	08am to 01pm	02pm to 05pm	Engr.Noor Mohammad
10-01-2012	Substation	08am to 01pm	02pm to 05pm	Engr.Noor Mohammad
11-01-2012	Substation	08am to 01pm	02pm to 05pm	Engr.Noor Mohammad

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1. INTRODUCTION

1.1. Company profile

At APSCL Achinta Kumar Sarkar DGM (MM) of the APSCL provide us an elaborating description of the power station at 26th December, 2011. The main objective of the day's activities was to know the history and future plan of the APSCL and to visit the APSCL.

Ashuganj Power Station is the second largest power station in Bangladesh. Ashuganj Power Station fulfills about 15% of power requirements of the total country.

- Name of the Company: Ashuganj Power Station Company Ltd (ASPCL).
- 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 Meghan.
- Land : 311.22 Acres
- Installed Capacity : 777 MW
- Total number of plants: 4
- Total Number of Units: 9

1.2. Objective of internship

The objective of internship was to gather practical knowledge and experience the implementation of theoretical study in real world. To this regard, this report is contemplating the knowledge and experience accumulated from the internship program. Another objective of this internship is to know about power generation and distribution process of APSCL.

1.3. Scope and Methodology

The scope of organization part covers the organizational structure, background, objectives, functional departmentalization, generation process and design strategy of the whole Ashuganj Power Station Company Ltd and especially this report focuses on generation process, protection strategy, maintenance of individual section and control units of Ashuganj Power Station Company Ltd.

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.

Chapter 2

2. STEAM POWER PLANT (OPERATION & GENERATOR)

2.1. Introduction

At APSCL Mohammad Kamruzzam Senior Engr.(Generator) offered us an elaborating description of the generator and showed us the whole generator system of APSCL from 27th to 28th December, 2011. Introduction to the concepts of generator principle, construction and protection were the main purposes of these day's activities. On the days december 29 and 31, 2011 and january 1, 2012 Mr. Anwar Hossain manager of operation provided us a description of the operation and showed us the network control room.

2.2. Power producing process of steam power plant in APSCL

Ashuganj power station generates steam using water from the river Meghna. Firstly, water is collected from the Meghna river through a pump and is put into a basin. Naturally this water contains various types of various type of contaminations. For example different types of salt, like- sodium, carbonate, sulfur chloride and calcium etc. Water also contains silica and mud which is harmful for boiler. So, water treatment is needed. By using de-mineralization process, sedimentation of this basin water is done at first and then the chemical reaction is done to eliminate various types of chemicals from the water. After this process this water is called "demi water". It is highly purified for boiling and generating steam. This water is taken to the boiler using a pump. In APSCL the boiler is fueled by methane gas (CH_4) which is supplied by TITAS GAS company ltd. Through a force draft fan (FDF) air is blown to the burner to boil the demi water. As a result steam is produced and the temperature at this stage is 170-175°C and pressure is around 30 bars. This steam is taken to the Super Heater (SH) to increase the temperature to 520-525°C which also increases pressure to 135-138 bars. The following steps are then followed to generate electricity from this high temperature steam.

(i) The steam from the super heater (SH) is divided into two paths. The steam first one is sent through High Pressure Turbine (HPT) and this exhaust steam is taken back to Re-heater (RH). The temperature of this exhaust steam decreases to 330-332°C and pressure decreases to 32 bars. Using RH the temperature of this steam is increased again to 520-525°C and thus pressure becomes 135-138 bars.

(ii) On the other hand, the rest of the steam goes to Intermediate pressure turbine (IPT) and then to Low Pressure Turbine (LPT). At this time turbine starts to rotate the prime mover of generator and the rotation speed is 3000 rpm. Electricity is thus produced. The exhaust steam produced from the LPT is sent to a condenser through the low pressure heaters (LPH1) and (LPH2). At this stage the steam has very low temperature (44-45°C) very low pressure (around 0.1 bars). Finally this steam goes from condenser to boiler drum through high pressure heaters (HPH1) & (HPH2) and again in turbine.

The below figure demonstrate the working procedure of Unit 5 in Ashuganj Power Station.

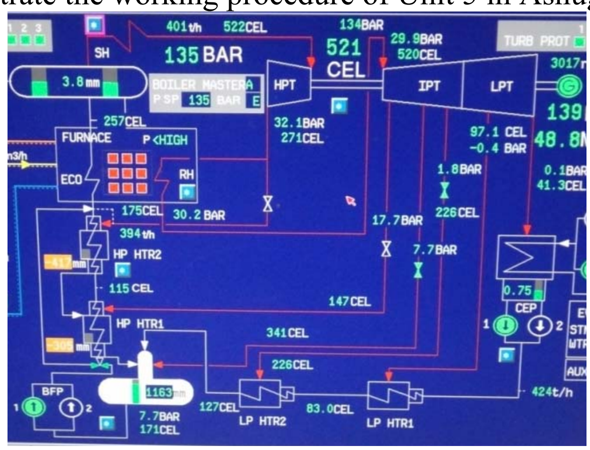

Figure 2:1: water & steam cycle unit-5.

2.3. Principle of generator

An electrical generator is a device that converts mechanical energy into electrical energy. The mechanical energy in turn is obtained from different renewable sources such as wind or water falling, gas turbines, steam turbines, electric motor etc. According to the Faradays Law, when a conductor moves relative to magnetic field a voltage is induced in the conductor by electromagnetic induction method. This is called e.m.f causes a current to flow if the conductor circuit is closed.

There are two types of generators depending on output:

i. AC Generator.

ii. DC generator**.**

Depending on Construction:

i. 1-phase generator.

ii. 3-phase generator.

Depending on Rotor:

i. Salient pole.

ii. Non- Salient pole.

Figure 2:2: AC Generator of unit-2 APSCL.

Table 2:1: Information about the generators of (APSCL)

Type	Revolving field, Brushless, cylindrical rotor	Revolving field, Brushless, cylindrical rotor	WT 572h self excited	WX 21L-100LL externally excited/self
Make	GEC, UK	GEC Turbine generator Co, UK	BBC, Germany	ABB,Germany

Description	Combined cycle power plant		Steam power plant	
	GT-1&2	ST	UNIT -1&2	Unit-3,4&5
Rated terminal output	55.67 MW	34.33 MW	64 MW	150 MW
Rated terminal voltage	31.8 KV	13.8 KV	11 KV±5%	15.75KV±5%
Rated power facto cosφ	0.8	0.8	0.8	0.8
Rated current	2911 A	1799 A	4200 A/4690 A	6965 A

Rated frequency	50 Hz	50Hz	50Hz	50Hz
Number of poles	2	2	2	2
Cooling system	Air cooled	Air cooled	Hydrogen cooled	Air cooled
Insulation class	F	F	F	F
Excitation voltage	-	-	249 V/267 A	323 V
Excitation current	-	-	1238 V/1327 A	1500 A

2.4. Construction of the Generator

The major parts of the generator are given below:

i. Stator
ii. Rotor
iii. Armature.
iv. Collector Slip Rings.
v. Carbon Brushes.
vi. Dehumidifier.

2.3.1. Stator

The stator of the generator consists of a cylindrical ring made of iron to provide an easy path for the magnetic flux. The stator contains only one coil, the two sides being accommodated in slots in the iron and the ends being connected together by curved conductors around the stator periphery.

2.3.2. Rotor

The central shaft of the rotor is coupled to the mechanical prime mover. The magnetic field is produced by conductors, or coils, wound into slots cut in the surface of the cylindrical iron rotor.

Figure 2:3: AC Generator Rotor in unit-5

2.3.3. Armature

Armature is a rotating part of an electromagnetic device consisting of copper wire wound around an iron core. It carries the current of the generators.

2.3.4. Collector Slip Rings

Slip ring is a metal ring, mounted on but insulated from the rotating shaft. It provides a continuous electrical connection through brushes on stationary contacts.

Figure 2:4: Generator slip rings of unit-5 in APSCL.

2.3.5. Carbon Brush

Carbon Brush is consisted with the small block of carbon. It is used to convey the current between the stationary and moving parts of the generator.

2.5. Excitation of the Generator

The process of creating a magnetic field is called excitation. A direct current is required for generators to energize its magnetic field. An exciter is a part of generator supplying direct current in the alternator field windings to magnetize the rotating poles. The output of the exciter is controlled by the voltage regulator.

Generator can work with two excitation principle.

i. Self-Excitation
ii. Static Excitation

Self excitation system is used in the generator of UNIT-3, 4 and 5 in steam turbine in Ashuganj Power Station Company Ltd.

2.6. Maintenance of the Generator

In APSCL different types of checking are received for generator maintenance.

i. Shaft voltage check.
ii. Carbon brush check.
iii. Slip ring check.
iv. Lube oil check.
v. Cooling system.

2.5.1 Cooling system

There are two types of cooling system is used to cool the generator in Ashuganj Power Station Company Ltd.

i. Air cooling.
ii. Hydrogen cooling, (H_2) .

2.5.1.1 Air cooling

Air can be used to cool a generator, by circulating it through the generator to absorb heat and then exhausting the air to another area outside the generator. In APSCL(Ashuganj Power Station Company Ltd.) air cooling is used in Unit -3,4 and 5.

2.5.1.2 Hydrogen cooling, (H_2)

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. Thus , hydrogen is much better at absorbing heat and then at giving up that heat to another medium/area than air. In APSCL(Ashuganj Power Station Company Ltd.) H_2 cooling is used in Unit -1 and 2.

2.7. Generator protection

Generators are to be protected against short-circuits and overloads by multipole circuit-breakers.

i. Overvoltage protection
ii. Negative phase sequence protection

iii. Reverse power protection
iv. Under frequency protection
v. Distance protection
vi. Stator earth-fault protection
vii. Loss of field excitation
viii. Bearing overheating protection
ix. Generator vibration protection
x. Back up earth-fault protection

2.6.1. Overcurrent under Voltage Protection

Overcurrent as any current in excess of the rated current of equipment of a conductor. It may result from overload, short circuit, or ground fault. Current flow in a conductor always generates heat. The greater the current flow, the hotter the conductor. Excess heat is damaging to electrical components. For that reason, conductors have a rated continuous current carrying capacity. Overcurrent protection devices are used to protect conductors from excessive current flow.

2.6.2. Winding Differential Protection

This type of protection is suitable for higher power rating transformers and limits the extent of the damage caused by an internal fault by instantaneously clearing faults between turns or between windings on the same phase or or different phases.

Differential protection is a unit scheme that compares the current on the primary side of a transformer with secondary side. Where a difference exists it is assumed that the transformer has developed a fault and the plant is automatically disconnected by tripping the relevant circuit breakers.

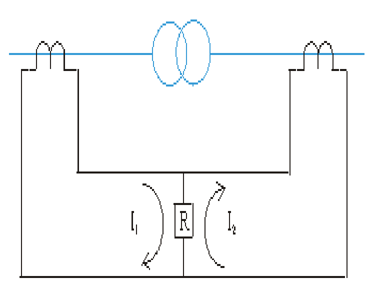

Figure 2:5: Differential protection relay

Under normal conditions $I_1$and I_2 are equal and opposite such that the resultant current through the relay is zero. An internal fault produces an unbalance or 'spill' current that is detected by the relay, leading to operation.

2.6.3. Stator earth fault protection

When generator neutral is earthed through high impedance, differential protection does not protect the complete alternator stator winding against with earth faults. Hence a separate sensitive earth faults protection is necessary.

The alternative methods are employed for neutral connection.

i. The neutral connection through resistor which limits the maximum earth fault current to much lower value than full load current (fig: a) this method is preferred for large units.

ii. The neutral connected through a voltage transformer. The earth fault current is limited to the magnetizing current of the voltage transformer plus the zero sequence current of generator (fig :b)

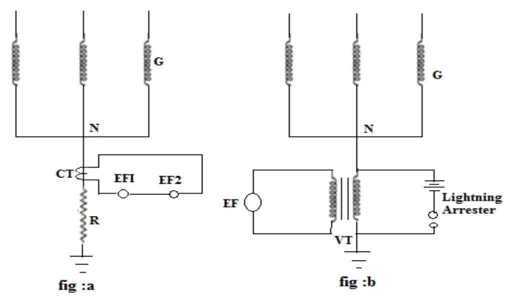

Figure 2:6: Sensitive stator Earth Fault Protection of Generator

2.6.4. Rotor earth fault protection

A single ground fault does not cause flow of current since the rotor circuit is undergrounded. When the second ground fault occurs part of the rotor winding is by passed and the currents in the remaining protection may increase. This causes unbalances in rotor and may cause mechanical as well as thermal stresses resulting in damage to the rotor.

Here a high resistance is connected across the rotor circuit. The center point of this is connected to the earth through a sensitive relay. The relay detects the earth faults for most of the rotor circuit except the center point of the rotor.

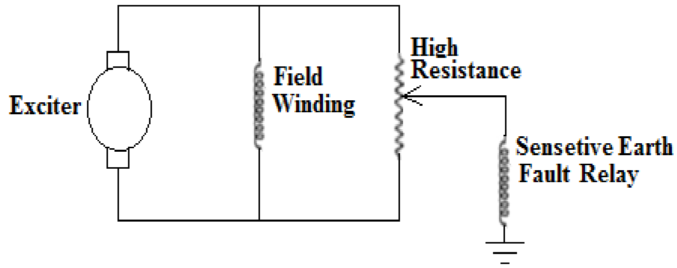

Figure 2:7: Scametic Diagram of a Rotor Earth Fault Protection.

2.6.5. Loss of field Excitation Protection

After excitation is lost the internal generator voltage will decay at the same as the rotor current decays determined by the field circuit time constant. Then the machine behaves as an asynchronous generator and draws a high quantity of reactive power. Thus this protection is needed to protect the generator.

2.6.6. Bearing-overheating protection

Bearing overheating can be detected by a relay actuated by a thermometer-type bulb inserted in a hole in the bearing, or by a resistance –temperature detector relay such as that described for stator overheating protection with the detector fixed in the bearing. Ro, where lubricating oil circulated through the bearing under pressure, the temperature of the oil may be monitored if the system has provision for giving an alarm if the oil stops flowing.

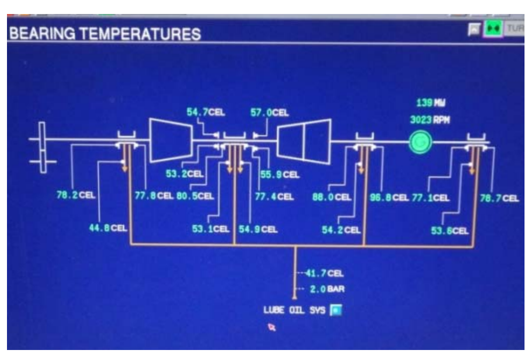

Figure 2:8: Bearing temperature control in unit-5.

Chapter-3

3. INSTRUMENTATION AND CONTROL

3.1. Introduction:

At APSCL Bikash Ranjan Roy, Manager (I & C) gave us an important description of the Instrumentation and control and showed us the whole system instrumentation and control of APSCL from 2 to 4 December, 2011. Daily activity report of Instrumentation and control is attached with this final report by Shayam Arafat. Instruments are used to occupy a power station smoothly as well as they give control information for maintaining the normal condition. In APSCL, mainly **POS** (Process Operation System) is used for operation system. POS which is a part of linux is supported by **EDS** (Engineering Documentation system), **CDS** (Central Diagnostic System) and **PDDS** (Program Diagnosis and Display System) for instrumentation control. PDDS is connected with EDS. EDS maintains the axial shaft pressure, thrust bearing and all the maintenance service.

Instruments that are used for controlling the power station:

3.2. Waste Drain valve:

Waste Drain valve is used to clean the debris and other wastage from the water before using the water for steam generation.

3.3. Controller:

Controller is used to control the drum water level. When the supply pressure of the drum is 1.4 bar it is in normal condition. Usually drum level is +350mm to -350mm. When drum level is +150mm, controller gives a high signal. When drum level is +300mm, controller gives high high signal. When drum level is -150mm, controller gives low and when it is -300mm, controller gives low low signal. Input path of water reacts with the controller signal.

3.4. Binary control:

When the controller gives high high or low low signal, binary control works with that signal to make the throttle fully closed or full open respectively.

3.5. Level switch:

When the controller gives high or low signal, level switch works with that signal to make the throttle closed or open respectively. Difference between level control and binary control is binary control can stand between 0 and 1. But level switch can give reading from 0 to 1.

3.6. Temperature control valve:

Temperature control valve detects winding temperature, bearing temperature and motor temperature. When this temperature is high high this valve gives a trip signal.

3.7. Voith gear control valve:

Voith gear control valve gives signal to boiler feed pump to boost up its speed or decrease the pump's speed.

3.8. Air header:

Air header controls air intake by forced draft fan. When the pressure of air is less than 0.4 bar, air header sends a signal to boiler to trip.

3.9. Shut off valve:

When there is any abnormal condition, emergency shut off valve can stop all the functions.

3.10. Condenser ventilation valve:

Condenser ventilation valve operates when there is any bubble in condenser water.

3.11. Control valve:

The control valve can open and close from 0 to 100. There are two control relays connected in 3-phase system that are used to operate the control valve. To open the control valve one relay rotates with RYB direction. To close the control valve another relay rotates with BYR direction. When the control valve is 100% open, a signal is sent to the control room and the limit switch disconnects the motor connection. If limit switch fails torque switch operates to stop the motor connection.

3.12. Junction box:

Junction box is an important element for instrumentation and control. Junction box links among the instrument, electronic room and the control room. When there is any abnormal situation for the instrument, it sends the signal to its certain cubicle and to the control room through the junction box.

3.13. Differential pressure transmitter:

Feed water control valve makes the difference between input and output pressure of water. Voith gear of feed pump would decrease the coupling so that the difference gets bigger or would do the vice versa. Differential pressure transmitter measures that pressure.

3.14. Air flow transmitter:

Air flow is proportional to the square root of differential pressure. Range of air flow transmitter is o to 8.1 mbar.

3.15. Live steam flow transmitter:

Live steam flow transmitter controls the flow of live steam. With high or low signal this transmitter decrease or increase live steam respectively. This transmitter works with 220AC voltage.

3.16. Photo receiver:

Photo receiver detects the flame in the burner and sends the signal to the control room.

3.17. Venge valve:

Venge valve moves the residue from the condenser. This valve is used for **Purging**. Purging is the process of removing unused gas from the condenser before starting the condenser. This process is very important for condenser maintenance.

Chapter-4

4. CCPP (COMBINED CYCLE POWER PLANT)

4.1. Introduction

At CCPP we were instructed by Mohammad Mizanur Rahman. This part of report is prepared by Shayam Arafat. Combined cycle power plant incorporating the latest turbine technology at Ashuganj Power Station Co. Ltd. was first put into commercial operation in 1984. In terms of thermal efficiency, this accomplishment was epoch-making for the period. Combined cycle power plants are consisted of two thermodynamic cycles- Rankin (steam) and Bray ton (gas).

Basic Information of combined cycle power plant of APSCL:

There are two gas turbines GT1 and GT2 and one steam turbine (ST) which is used for combined cycle with GT1. In APSCL only one gas turbine can be used for combining because of its structure and only GT1 can be used as damper of GT2 is not working properly now a days. Gas turbines and steam turbine are manufactured by GEC, UK. Rated terminal output for GT1 and GT2 are 55.67 MW at 35°c ambient temperature and for steam turbine is 34.33 MW. IOC standard for gas turbines are 70 MW at ambient 15°c and 60% relative humidity, ambient pressure at sea level.

But present condition is different from installed level. Terminal output of GT1 and GT2 are 42 MW and 37 MW respectively. ST terminal output is 16 MW. Gas Turbine inlet temperature is 1010°c and exhaust temperature is 569°c (old), presently 500°c. Live steam pressure of ST is 39 bars and exhaust pressure is -0.8 bars. 10 burners are used for each gas turbine. Compressor used for GT is axial flow type and the inserted mixture of fuel with air in compressor is 1:8 (optimum).

4.2. Working principle for Gas Turbine:

A diesel Engine with a prime mover is used for starting the gas turbine as the gas engine is not self excited. Diesel engine is used in APSCL is 1400 HP is coupled with torque converter. Torque converter is used for fluid coupling as the starting load of the system is very high. Torque converter is coupled with auxiliary gear box which is used for running lube oil and control oil box. Auxiliary gear box is coupled with brushless exciter which consists of a journal bearing. This brushless exciter runs the generator at the starting. This diesel engine gives starting power to the generator. This generator is coupled with compressor. 0.44-0.46m³/KWH fuel is needed in APSCL. This combustion chamber produces high pressure, high velocity gas. 17.2 bar of pressure is needed for combustion. Once the combustion is started by an igniter, it is self-sustained. The hot gas formed in the combustion chamber expands through the turbine, producing mechanical power. In gas turbine there are 2 stages of blades consisting 59 and 79 blades respectively. The compressor is also connected to the same shaft and the turbine supplies power to drive the compressor, which runs the output shaft for driving generator. There is a waste heat recovery unit (WHRU) in gas turbine. This is mainly a damper, which supplies the input energy for steam turbine.

4.3. Diesel Engine:

Diesel engine is a very essential part in gas turbine power plant. The gas turbine is not a self excited. The turbine only can be rotated if fuel and air is burned inside the combustion chamber. But before the turbine starts the air cannot be sucked by the compressor automatically because the compressor is coupled with the turbine. So a diesel engine is coupled with the turbine to rotate the turbine at the beginning for helping to suck air by the compressor. At first the diesel engine starts. When the turbine starts to move by the diesel engine at a rated speed which makes the compressor to suck air by itself then the diesel engine is turned off.

Table 4:1: Starting Procedure of Gas Turbine

RPM of Turbine (GT-1,2)	Situation
0 rpm	Diesel start
750 rpm	Fuel valve on, ignite air and fuel runs GT
1750 rpm	Diesel off
22500 rpm	Excitation on
2500 rpm	Self drive
3000 rpm	At no load condition

4.4. Compressor:

A gas compressor is a mechanical device that increases the pressure of a gas by reducing its volume. Compressor can increase the pressure of a fluid through a nozzle, and it is also can transport the fluid through a pipe. There are two types of compressor. These are centrifugal compressor and axial compressor. In APSCL axial compressor is used which has 13 stages.

4.5. Filter House:

Air intake filter ensures high efficient filtration of dust and other contaminants even in the most polluted environments. In APSCL air is filtered in 3 states with one big and two small filters. These filters mainly obtain three functions. Main function is to supply air to the compressor. Other two functions are to cool the generator and the turbine.

4.6. Combustion chamber:

The combustion chamber consists of a vessel into which pressurized air and pressurized fuel (oil, natural gas) are fed in an appropriate proportion. The air fuel ratio in the area is maintained at about 8:1

The main parts of combustion chamber are given below

1. Combustion casing
2. Primary fuel nozzle
3. Secondary fuel nozzle
4. Spark plug
5. Flame detector

4.7. Gas turbine:

In gas turbine there are two sets of turbine blades. The first set directly drives the compressor. The turbines, the shaft and the compressor all turn as a single unit. Other drives the output shaft. They spin freely without any connection to the rest of the engine. 59 and 79 number of blades is used in two stages respectively.

4.8. Knock out pot:

Knock out pot is a very important part of gas turbine. It removes condensate from gas.

4.9. Main systems of gas turbine:

4.9.1. Starting System:

Starting system is one of the most important auxiliary systems of gas generator. In APSCL normally generator starts by a diesel engine and turbine rotates. In 750rpm speed there is a firing and gas engine began operating. After 1700rpm speed compressor delivery pressure (CDP) will decide whether the gas engine will run as self or it will run in combined with diesel engine. Usually after 1750rpm speed diesel engine stops and gas engine begins working independently.

4.9.2. Fuel system:

Fuel of APSCL for gas turbine is natural gas which comes from Bakhrabad. This gas is taken in a gas treatment plant. Normally the pressure of the gas before treatment is 32 bar, but after treatment the pressure is reduced to 4.5 bar.

4.9.3. Air intake system:

Air is taken from the atmosphere through forced draft (FD) fan. This air is taken into the filter house. Three stages of filtration occur through 1 big and 2 small filter houses. Big filter supplies air to compressor and small filters are used for cooling down generator and turbines.

4.9.4. Air Injection System or Exhaust system:

An air injection system forces fresh air into the exhaust ports of the engine to reduce HC and CO emissions and cooling. The exhaust gases leaving an engine can contain unburned and partially burned fuel. Oxygen from the air injection system causes this fuel to continue to burn. The major parts of the system are the air pump, the diverter valve, the air distribution manifold, and the air check valve.

4.9.5. Baring system:

In Baring system there is a Baring pump which creates a high pressure around 40-50 bar and forcedly flow to the turbine. When turbine is shut off it is important to cool down the whole mechanism equally, otherwise there might be a friction problem. That's baring pump is used. It helps to reduce the friction of the turbine with shaft, reduces generated heat and provides the long liability to the turbine. Baring pump rolls the turning gear in 1 rpm for 45° angle. It cools a gas turbine in 36 hours and a steam turbine in 68 hours.

4.9.6. Lube oil system:

The engine lubrication system is designed to deliver clean oil at the correct temperature and pressure to every part of the engine. Lubricating oil system mainly does two major works. One is lubricating the bearing for moving the shaft smoothly. Other is to absorb heat from the machineries. The oil is sucked out into the pump, than forced through an oil filter and pressure feuded to the main bearings and to the oil pressure gauge. Three motors are used for lube oil system. One DC motor, one AC motor and other one runs with the shaft so it does not need any extra power. Basically lubricating system is done for reducing friction and heat of the turbine and for smoothing the rotation at 3000rpm. In lubricating system there are two major elements:

1. Baring Oil system
2. Jacking Oil system

4.9.7 Cooling system:

Gas turbines are usually air cooled system. As the generator runs in 3000 rpm it realizes high amount of heat so before running the whole system cooling system is checked. Beside the generator shaft two fan is set to cool down the generator.

4.10. Auxiliary Power system:

A black start is the process of restoring a power station to operation without relying on the external electric power transmission network. Normally, the electric power used within the plant is provided from the station's own generators. If all of the plant's main generators are shut down, station service power is provided by drawing power from the grid through the plant's transmission line. In the absence of grid power, a so-called black start needs to be performed to bootstrap the power grid into operation. So with AC power source DC source are kept stand by for black start. In APSCL battery is used as auxiliary power system. For making 110V DC supply 55 batteries are kept in series each of 2V. There are two sets of 55 batteries.

4.11. Governor System:

The governor system is the most important element of fuel system. The governor system is like a cruise control system. It keeps the engine running at the speed which would be selected, regardless of changes in the load. It controls the amount of fuel supply and the level of fuel in the combined cycle.

4.12. Steam turbine section:

In combined cycle power plant the exhaust gas which comes out from the gas turbine is used to produce steam and run a steam turbine. The exhaust gas has very high temperature about 500°c which can be used to create steam by using damper in gas turbine exhaust line. The main facility of the steam turbine sections of combined cycle power plant is that there is no furnace; steam is produced by the heat of exhaust gas. In APSCL there is one steam turbine section which runs by the exhaust gas of gas turbine-1.

4.12.1 Working procedure of steam turbine:

Gas turbine exhaust line is connected with the damper of steam producing section. There are four units in steam turbine section for absorbing this heat. They are Super heater (SH), High Pressure (HP) Evaporator, Forced flow section and Low pressure (LP) evaporator. Exhaust gas temperature is about 500°c.

4.12.2. Different Parts of steam generator:

Deaerator

Low pressure economizer

Low pressure boiler drum

Low pressure evaporator

High pressure economizer

High pressure evaporator

Super heater

Condenser

Steam turbine.

4.13. Manual Start-up:

There are three types of start-up used for steam turbine. They are,

1. Cold start-up
2. Warm start-up
3. Hot start-up

Figure 4:1: System of different start-up

4.14. Non Dwell Speeds:

For steam turbines in APSCL combined cycle power plant 1506 & 2665 rpm are not used. As there is a huge amount of natural vibration in 1506 &2665 rpm, so these two ratings are omitted.

4.15. Over Speed:

When turbine crosses 3300 rpm, it trips automatically for preventing over speed.

CHAPTER-5

5. SUBSTATION

5.1. Introduction

At APSCL Mr. Noor Mohammad manager of substation gave us an elaborating description of the substation and showed us the entire substation of APSCL from 26^{th} December to 28^{th} December of 2011. The electrical power is produced at the power station which is located at favorable place far away from the consumers; it delivers power to consumer by a long transmission line. Hence it requires accomplishment of many electrical equipments and set-up which is cumulatively known as Substation.

5.2. Transformer

Transformer is one of the most important and expensive part of a substation. We visited the substation of APSCL and watched different types of transformers on 28^{th} 2011. There are different types of transformer, such as:

- Power transformer
- Instrument transformer

5.2.1 Power Transformer

The power transformer is used in the substation to step up or step down the voltage. To supply the voltage to the grid, the generated voltage at the generator is stepped up at the substation through the power transformers. Most of the power transformers at the substation of APSCL are rated up to 100MVA. At APSCL they use both single phase & 3 phase power transformers.

5.2.2 Instrument Transformer

Instrument transformers are used for measuring and control purposes. They provide currents and voltages proportional to the primary, but there is less danger to instruments and personnel. There are two types of instrument transformers. Such as;

- Potential Transformer
- Current Transformer

5.2.2.1 Potential Transformer

Those transformers used to step voltage down are known as potential transformers (PTs). Potential transformers are usually rated from 50 to 200 volt-amperes at 120 secondary volts.

Figure 5:1: potential Transformer

5.2.2.2 Current Transformer

The instrument transformer that is used to step current down is known as current transformers (CTs). CT is used to measure current on the primary. The primary of a current transformer typically has only one turn.

Figure 5:2: Current Transformer

5.2.3 Transformer Construction

To describe the construction of a power transformer bushing, core and winding are main three parts of a power transformer. The core of each transformer is built with laminations made of the highest quality non-ageing grain orientated steel. The construction is of the core type. The core frame design provides a simple and effective means for re-clamping after dry-out e.g. jacking screws. The flux density within the core do not exceed 1.65 Tesla during normal operation; that is, with the rated primary voltage applied to the primary terminals at the principal tap and rated frequency.

The winding conductors and conductor connections are constructed from high conductivity copper and burr free and profiled. All electrical connections within windings are brazed or welded (not soldered) to withstand shocks of the type. That might occur through handling, vibration during transport, switching, earthquakes and other transient service conditions. In APSCL all the transformers are consist of following equipments.

5.2.4 Insulation and Transformer Cooling System

Insulation oil, oil preservation system, ONAF (Oil Natural Air Forced) cooling system, Breather etc are very important parts of a transformer. These parts are described briefly in the following sections.

5.2.4.1 Insulating Oil

The insulating oil has sufficient insulation strength, and is excellent in heat conductivity, low in viscosity and pour point, and high in flash point.

5.2.4.2 Oil Preservation System

Oil immersed transformers is provided with an oil preservation system in which the insulating oil is isolated from atmospheric air. The oil preservation system is of the diaphragm seal or air seal cell type conservator with silica-gel breather.

5.2.4.3 ONAF (Oil Natural Air Forced) Cooling System

An adequate number of unit coolers are fixed to the tank of oil immersed transformers, and the cooling capacity are sufficient to operate the transformer under the rated power. The transformer is able to deliver the required output with one cooling fan out of service. The coolers are of such structure that does not be affected by the vibration of transformer. A valve is provided with each pipe connecting a unit cooler to the tank

5.2.4.4 Breather

Dehydrating breathers are used to prevent the normal moisture in the air from coming in contact with the oil in electrical equipment as the load or temperature changes. This reduces the degeneration of the oil and helps maintain its insulation capability. When used with conservator system with a rubber air cell it reduces moisture accumulation in the cell.

Figure 5:3: Breather

5.2.5 Transformer Bushings

The two most common types of bushings used on transformers as main lead entrances are solid porcelain bushings on smaller transformers and oil-filled condenser bushings on larger transformers. Solid porcelain bushings consist of high-grade porcelain cylinders that conductors pass through. Outside surfaces have a series of skirts to increase the leakage path distance to the grounded metal case.

5.2.6 Transformer Taps

Most power transformers have taps on either primary or secondary windings to vary the number of turns and, thus, the output voltage. The percentage of voltage change, above or below normal, between different tap positions varies in different transformers.

5.2.7 Megger Test

In APSCL we observed the megger test on 27th December 2011. Measuring a transformer's DC resistance from one external terminal to another can reveal a great deal of information about the transformer. In addition to the obvious faulted winding (i.e., an open winding or shorted turn), more subtle problems can be detected. The DC current, in addition to flowing through the winding, must also flow through the off-load ratio adjusting switch (RA switch), the on-load ratio adjusting switch (load tap changer or LTC), as well as numerous welded and mechanical connections. Hence, the integrity of all these components can be verified.

Figure 5:4: Megger Test

5.2.8 GROUNDING TRANSFORMERS

Two types of grounding transformer are in general use: (1) the wye-delta transformer, and the zigzag transformer. The neutral of either type may be grounded directly or through current-limiting impedance. It is assumed here that neither load nor a source of generation is connected to the delta winding of the wye-delta transformer and that the zigzag transformer does not have another winding connected to load or generation; should either type have such connections, it would be treated as an ordinary power transformer.

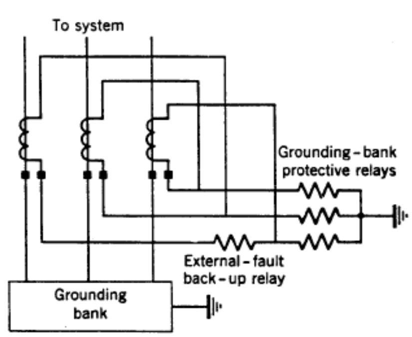

Figure 5:5: Grounding of 3 Phase Power Transformer

5.3. Bus-Bar

Bus-bar is a strip of copper or aluminum that conducts electricity within a switchboard, distribution board, substation or other electrical apparatus. In APSCL there are single bus, main and transfer bus, and ring bus configuration.

5.3.1 Single Bus

This is the simplest of the configurations, but is also the least reliable. It can be constructed in either of low profile or high-profile arrangement depending on the amount of space available. In the arrangement shown, the circuit must be de-energized to perform breaker maintenance, which can be overcome by the addition of breaker bypass switches, but this may then disable protection systems.

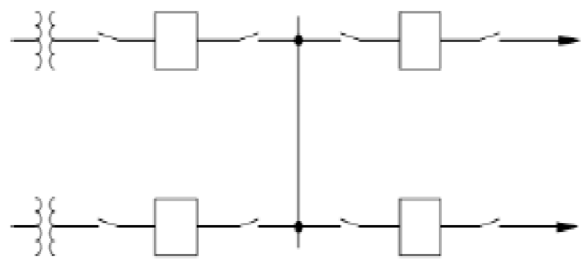

Figure 5:6: Single Bus

5.3.2 Main and Transfer Bus

There are two separate and independent buses; a main and a transfer. Normally, all circuits, incoming and outgoing, are connection the main bus. If maintenance or repair is required on a circuit breaker, the associated circuit can be then fed and protected from the transfer bus, while the original breaker is isolated from the system.

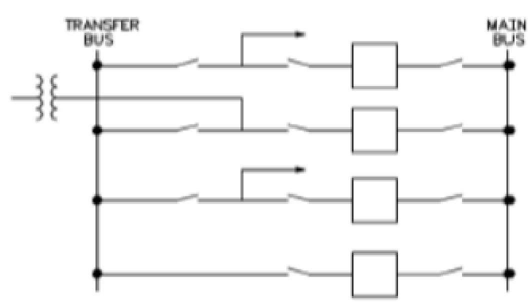

Figure 5:7: Main and Transfer Bus

5.3.3 Ring Bus

Ring bus configuration is an extension of the sectionalized bus. In the ring bus a sectionalizing breaker has been added between the two open bus ends. Now there is a closed loop on the bus with each section separated by a circuit breaker. This provides greater reliability and allows for flexible operation.

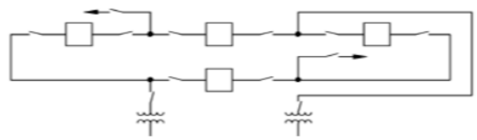

Figure 5:8: Ring Bus

5.4. Isolators

These are essentially off load devices although they are capable of dealing with small charging currents of bus-bars and connections. The design of isolators is closely related to the design of substations.

5.5. Circuit Breaker

Circuit breakers are critical to the safe operation of an electrical grid. A circuit breaker, irrespective of its position in a grid has two tasks: it is responsible for the daily switching of lines during normal operation, and for the disconnection of the power supply in case of overload or short circuit.

In APSCL there are mainly two types of circuit breakers are used:

- SF6 circuit breaker
- Oil type circuit breaker

5.5.1 SF6 circuit breaker

Sulfur Hexafluoride (SF6) is an excellent gaseous dielectric for high voltage power applications. It has been used extensively in high voltage circuit breakers and other switchgears employed by the power industry. Applications for SF6 include gas insulated transmission lines and gas insulated power distributions.

Figure 5:9: SF6 Circuit Breaker in APSCL

5.5.2 Oil type circuit breaker

The contacts in these breakers were embedded in a large tank, filled with the chosen medium. In the oil circuit breaker, when current arcs in oil, the medium vaporizes and a bubble forms around the arc. This high-pressure gas, which is almost 80 percent hydrogen, inhibits ionization and moves through the channels surrounding the arc. It enhances convection in the oil, which helps to cool the arc residuals around zero current. Minimum oil breakers work best on high currents that provoke a sharp rise in pressure and strong convection.

5.6. Relay

A relay is an electrically operated switch. 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.

5.7.1 Different types of Relay used in APSCL

There are different types of relay used in the substation of APSCL. We got a very brief description about relay from our mentors Mr. Noor Mohammod on 27th December.

5.7.1.1 Percentage Differential Relay

In a differential protection scheme currents on both sides of the equipment are compared. This relay is used for transformer and line protection in APSCL. The figure 5.20 shows the connection only for one phase, but a similar connection is usually used in each phase of the protected equipment. Under normal conditions, or for a fault outside of the protected zone, current I_1 is equal to current I_2 .

Therefore the currents in the current transformers secondary are also equal, i.e. $i_1 = i_2$ 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, for what the relay will operate. To provide protection of line and transformer this kinds of relay are used in APSCL.

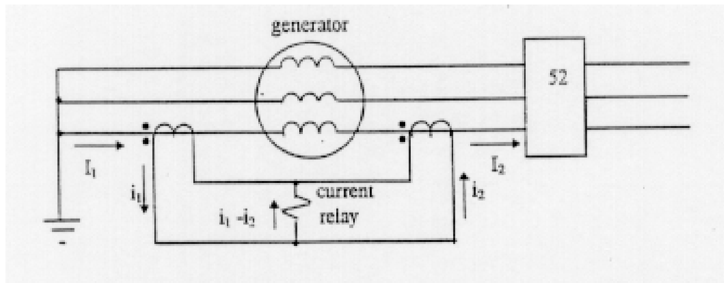

Figure 5:10: Differential Relay

5.7.2 Over current Relay

Over current than the rated current can be hazardous; for what over current protection of transformer is provided. There are two parameters for over current protection; one is the current and another is the current flow time. If a very high current higher than the rated current flow through the winding of the transformer then relay operate. On the other hand if the high current flows more than the rated time relay operates.

5.7.3 Pilot Relay

Pilot relaying is an adaptation of the principles of differential relaying for the protection of transmission-line sections. Pilot relaying provides primary protection only; back-up protection must be provided by supplementary relaying.

5.7.4. Buchholz Relay

A Buchholz relay is a gas and oil operated device installed in the pipe-work between the top of the transformer main tank and the conservator used for transformer protection in APSCL. The function of the relay is to detect an abnormal condition within the tank and send an alarm or trip signal.

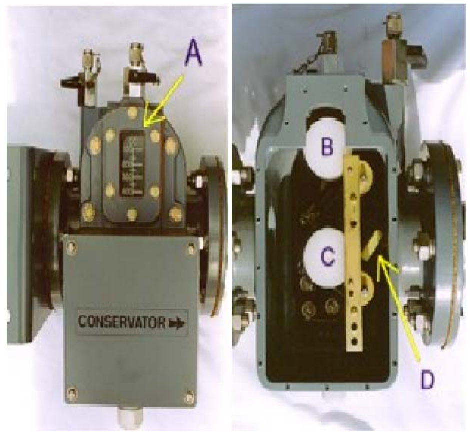

Figure 5:7: Buchholz Relay

5.7. Lightening Arrester

Lightening arrester is a protective device. In APSCL it is used for limiting surge voltages by discharging or bypassing surge current, and it also prevents the flow of follow current while remaining capable of repeating these function.

5.8. Wave Trap

Wave Trap is used for communication with other substation from APSCL substation, which is also used for communicate with SCADA from APSCL control room. We observed in APSCL, that lighting arrester is used surround of wave trap for giving protection from lighting surge.

5.9. DC Auxiliary System:

DC power supply is one of the most important part of the substation. DC auxiliary system is also called Back-up system. In the backup system DC supply is used, which is also needed to run the Relay, Circuit breakers and control System when Fault occurs. Here Nichel Cadmium batteries are used because its efficiency is very high. Each cell is 1.2 volt and 750 amp-h. Total battery section output is 220 volt. To get 22o volt, the batteries are connected in series.

5.10. Underground cable

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

Chapter 6

6. CONCLUSION

6.1. Introduction

The conclusion 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 our internship we were 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.

6.2. Problems and findings

Although it was a very good working experience, there were some problems and limitations as well. The problems and limitations are:

- Sometimes it was very hard to understand the matters as they were unable to show the internal configurations properly, because of insufficient time.
- In the power station all the equipments are running system, so it was quite difficult to learn ever single matter practically.
- Due to the overhauling of some equipments in APSCL, the total installed capacity was not produced.

6.3. Recommendations

- During training period if any fault occurred in the power station, we suggest the interns to be taken to the spot, so that they can learn how the fault is resolved.
- It is suggested that, one who is in the internship program should take all the notes from the instructor about what s/he is doing as well as learn it practically.
- A internship student must take instruction about the program from the academic advisor before going internship program.

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