INTERNSHIP REPORT

ON

THE POWER GENERATION, TRANSMISSION, DISTRIBUTION OF ASHUGANJ POWER STATION COMPANY LTD.

APSCL

By

ANIK DAS (2008-1-80-028)
RAJESH MONDAL (2008-1-80-065)

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

Sohana Tanzeem 13.10.11 | AHaque 13.10.2011
Academic Advisor | Department Chairperson
Sohana Tanzeem | Dr. Anisul Haque

Date of Report Submission: 13th October, 2011

Training certificate

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E-mail: apscl@apscl.com, apsclbd@yahoo.com, Website: www.apscl.com

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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Memo no. APSCL/MD/Trg-10/2011/719 Date-14/05/2011

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Engr. A.M.M Sazzadur Rahman
Deputy General Manager
APSCL

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14/5/11

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

Training schedules

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

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

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

Acknowledgement

First of all we would like to thank Engr. Nurul Alam, Managing Director APSCL, Engr. Md. A.M.M Sazzadur Rahman, and the manager (generator Division) of APSCL Ltd. for allowing us to do the internship and work in their team.

We would also like to thank our advisor Dr. Khandokar Zakir, Senior Lecturer and Sohana Tanzeem, Lecturer, Department of Electrical & Electronic Engineering, East West University, Bangladesh.

We would also like to mention the name of Dr. Anisul Haque, Chairperson & Professor of the Department of Electrical & Electronic Engineering and Dr. Khandokar Zakir, Senior Lecturer, Department of Electrical & Electronic Engineering, East west University for being so kind during the period of our internship. We are also grateful to all of our teachers and friends for their cooperation and encouragement throughout our whole academic life in EWU. We also would like to thank Engr. Md. Rokon Mia, Senior Engineer(APSCL, Ashugonjho power station company Ltd) production unit); Engr. Md. Kamrizzaman, Senior Engineer(APSCL, Ashugonjho power station company Ltd),Engr. Md. Nur Mohamod, Manager , Substation (APSCL, Ashugonjho power station company Ltd), Engr. Md. Shahidullah, Senior Engineer ,substation (APSCL, Ashugonjho power station company Ltd),Engr. Md. Aziz, Senior Engineer, Gas turbine (APSCL, Ashugonjho power station company Ltd), who had given us appointment from their precious time to collect related data for our report and also helped us to understand many related matters .At last but not the least we would like to thank the Almighty for giving us the chance to complete our internship and preparing the internship report.

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1.1 COMPANY PROFILE:

1)Name of the Company: Ashuganj Power Station Company Ltd.

Date of Incorporation: 02 May 2011.

Registration No: C-40630 (2328)/2000 dt. 02.07.2000.

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

Land : 311.22 Acres

Installed Capacity : 724 MW

Total number of plants : 3

Total Number of Units : 8

Plant 1: Thermal Power Plant (TPP)

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

Plant 2: Combined Cycle Power Plant (CCPP)

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

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

Plant 3: Thermal Power Plant (TPP)

Unit 3 of 150MW capacity was commissioned in 1986.

Unit 4 of 150MW capacity was commissioned in 1987.

Unit 5 of 150MW capacity was commissioned in 1988.

Besides this there are also other plants which are already running or will be next future.

50 MW (Thermal Power Plant)	APSCL	Already running
150 MW	APSCL	Tender cell
450 MW	APSCL	proposed
450 MW	APSCL	proposed
55 MW	Precision	Ready to launch
80 MW	Aggreko	Ready to launch
	United hospital	Ready to launch

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

1.1.1 Present Facilities of APSCL

Ashuganj Power Station Company Limited is the second largest power station in Bangladesh. Its installed capacity was 724 MW. APSCL this year has added 53 MW to the system by its own fund. The present total power (electricity) generation capacity of its 9(nine) units considering de-rated capacity is 731MW. Fuel of its all units is Natural gas. APSCL contributes about 15% of power to national grid of the country.

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

1.1.2 Existing unit's Cost

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

1.1.3 Gas Scenario of APSCL

APSC is operating 8 units and one 3 years 55MW Rental plant also is being operating from last year. At present APSCL unit 4 of 150MW and unit 1 of 64MW are under major overhauling. APSCL has constructed a 50MW Gas Engine Power Plant by its own fund and has put into operation on 30 April. In this month 80MW & 53MW two 3 years Rental Power Plants will also come into operation. All these machines together may consume approximately 200 mmscfd gas daily, if these run together. The present gas allocation for APSCL is 160 mmscfd. Considering present activities of increasing power generation there should be a revised gas allocation in order to operate the plant with full load.

1.1.4 Board of Directors APSCL

01

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

02.

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

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

03.

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

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

06.

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

07

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

08.

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

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

10.

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

11.

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

1.2 Objectives :

The first objective of the internship is to fulfill the partial program of EEE program. In this intern report, we want to give an overview of Ashuganj Power Station Company Ltd where we finished our internship and our emphasis was on:

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

Chapter: 02

In power generation section we worked four days (02-05-2011 to 05-05-2011). In generator section our supervisors were Engr. ***Md. Rokon Mia, senior Engineer, APSCL*** & Engr. ***Md. Kamruzzaman, senior Engineer, APSCL*** who instructed us uniformly from their daily routine circle. We know that APSCL is the second largest power station in Bangladesh. In our introductory part we are representing or giving a short discussion on generator.

2.1 Power generation

In the earlier section we have known the principle of Generator. By this principle we can generate electricity and by utilizing it how the power will be generated that will be discussed in this section. Here, first we have to know about which are the parts are liable for generating power. The fundamentals parts are: rotor, shaft, winding, brush gear, jagging oil, dehumidifier etc. To run this rotor, we have to need prime mover. We can rotate this prime mover by electrically or mechanically. In this section we rotate prime mover mechanically by water or stem and we take fuel as gas. Now, for rotating rotor two things are very important one of this is boiler and second is turbine.

2.1.1 Boiler

This is discussed in the gas turbine section.

2.1.2 Feed water pump

In APSCL water comes from river and this water is first come into the basin and there it filter in two stages. After filtering water, it is taken to the filter house for another two times filtering process and then in reserve tank, water is reserved, then water is cleaned by the different chemicals which are used in water treatment tank and this water is converted into distil water (DH_2O) and its goes to the feed water pump.

Figure 1: Feed water pump

At last the main purpose of the feed water pump is to deliver the distil water (DH_2O) to the boiler so that at a random process the steam will become heated by using the condenser to the feed water pump and again to the boiler.

2.1.3 Condenser

Boiler, which can have an increased efficiency over the more traditional boiler. The efficiency of a typical non-condensing boiler is around 75%, whereas with condensing boilers it can be over 87%. This increased efficiency is due to the extraction of heat from the otherwise wasted flue gases. Most boilers have a single combustion chamber enclosed by the waterways of the heat exchanger through which the hot gases can pass. These gases are eventually expelled through the flue, located at the top of the boiler, at a temperature of around 180°C.

Figure 2: Condenser

Here in APSCL two condensers is used condenser A and condenser B. So the condenser A is used to condense the total 440° c steam in to two stages to give the desired energy of the steam to the turbine to rotate the generator.

2.2 Turbine

A turbine is a rotary engine that extracts energy from a fluid flow and converts it into useful work.

The simplest turbines have one moving part, a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades, or the blades react to the flow, so that they move and impart rotational energy to the rotor. Early turbine examples are windmills and water wheels.

2.2.1 Intermediate pressure system turbine

On leaving the boiler reheater (After expanding through the high pressure turbine the exhaust steam is returned to the boiler at 360°C and 42 bar pressure for reheating before being used in the intermediate pressure turbine.), steam enters the intermediate pressure turbine at 565°C and 40.2 bar pressure. From here the steam goes straight to the next section of the turbine set. The steam has expanded and has less energy when it enters this section, so here the turbine blades are bigger than those in the high pressure turbine. The blades are fixed to a shaft and as the steam hits the blades it causes the shaft to rotate.

2.2.2 Low pressure system turbine

From the intermediate pressure turbines, the steam continues its expansion in the three low pressure turbines. The steam entering the turbines is at 306°C and 6.32bar. To get the most work out of the steam, the exhaust pressure is kept very low, just 50 mill bar above a complete vacuum. The tip speed of the largest blades with the shaft spinning at 3000 revolutions per minute is 1,285 miles per hour, or 1.6 times the speed of sound.

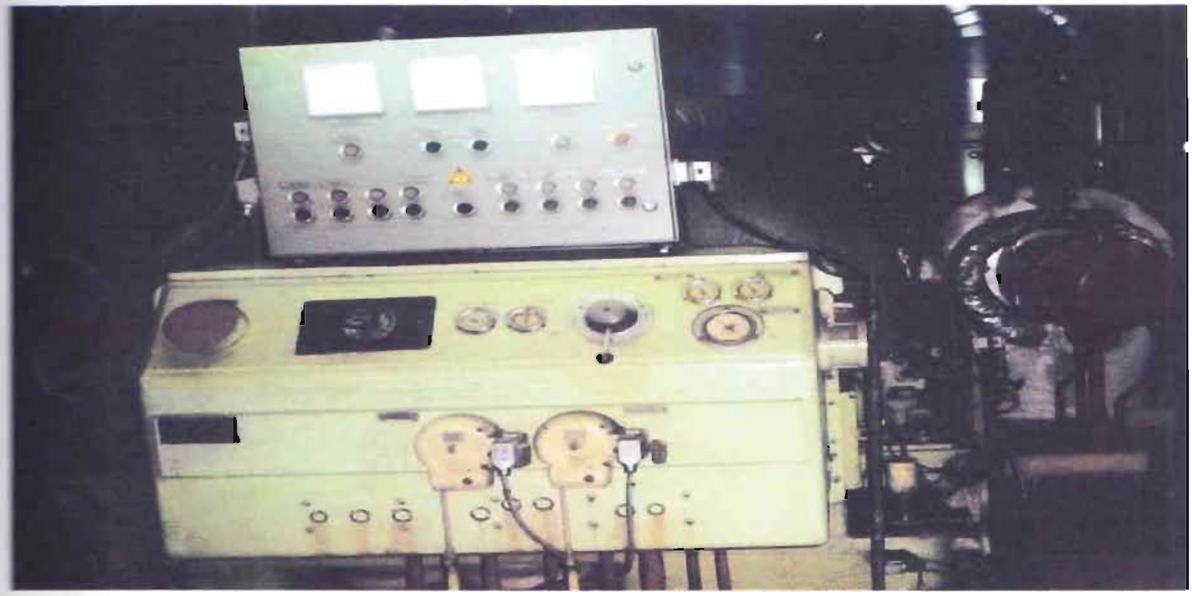

Figure 3: low pressure turbine control

2.2.3 High pressure system turbine

High pressure steam at 565°C and 156 bar pressure passes through the high pressure turbine. The exhaust steam from this section is returned to the boiler for reheating before being used in the next section of the turbine set. The blades in the high pressure turbine are the smallest of all the turbine blades, this is because the incoming steam has very high energy and occupies a low volume. The blades are fixed to a shaft and as the steam hits the blades it causes the shaft to rotate.

Figure 4: High pressure turbine

2.3 Generator

An electrical generator is a device that converts mechanical energy to electrical energy, generally using electromagnetic induction. The source of mechanical energy may be a reciprocating or turbine steam engine, water falling through a turbine or waterwheel, an internal combustion engine, a wind turbine, a hand crank, or any other source of mechanical energy. The energy conversion in generator is based on the principle of the production of dynamically induced e.m.f. whenever a conductor cuts magnetic flux, dynamically induced e.m.f is produced in it according to Faraday's Laws of Electromagnetic induction. This e.m.f causes a current to flow if the conductor circuit is closed. Hence, two basic essential parts of an electrical generator are (i) a magnetic field and (ii) a conductor or conductors which can so move as to cut the flux

2.3.1 KVA rating

The nameplate data of the generator that has been used in APSCL:

Rated speed	3000 rpm
Frequency	50 Hz
Voltage	15750 V 5
Armature current	6965 A 3~ INS.class F [class F- 165°c]
Rotor weight	42.31 ton
Stator weight	176.0 ton
Excitation voltage	323 V(at full load) 210 V (at no load)
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	

2.3.2 Stator

The stator, also known as the armature, of a synchronous machine is made of thin lamination of highly permeable steel in order to reduce the core losses. The stator laminations are held together by a stator frame. The frame may be of cast iron or fabricated from mild steel plates. The frame is designed not to carry the flux but to provide mechanical support to the synchronous generator. The inside of the stator has a plurality of slots that's intendment to accommodate thick armature conductors. The armature conductors are symmetrically arranged to form a balanced polyphase winding. To this end, the number of slots per pole per phase must be an integer. The induced emf per phase in large synchronous generator in kilovolt (KV) with a power handling capacity in megavolt-amperes (MVA).

The axial length of the stator core is comparatively short for slow-speed, large diameter generators. These generators have many poles and are left open on both ends for self cooling. They are installed at locations where hydroelectric power generation is possible.

The axial length of high speed generations having 2 or 4 poles can be many times its diameter. These generators require forced air circulation for cooling and are totally enclosed. They are used when the rotors are driven by gas or steam turbines.

2.3.3 Rotor

Two types of rotors are used in the design of synchronous generators, the cylindrical rotor and a salient pole rotor. The rotor is rotated at the synchronous speed by a prime mover such as a steam turbine. The rotor has as many poles as the stator, and the rotor winding carries dc current so as to produce constant flux per pole. The field winding usually receives its power from a 115- or 230V dc generator. The dc generator may be driven either by the same prime mover driving the synchronous generator or by a separate electric motor.

The salient pole rotor is used is low and medium speed generators because the windage loss is loss is small at these speeds. It consists of an even set of outward projecting laminated poles. Each pole is dovetailed so that it fits into a wedge-shaped recess or is bolted onto a magnetic wheel called the spider. The field winding is placed around each pole. The pole must alternate in polarity.

The cylindrical rotor is employed in a 2 or 4 pole, high –speed turbo generator. It is made of a smooth solid forged steel cylinder with a number of slots on its outer periphery. These slots are designed to accommodate the field coils. The cylindrical construction offers the following benefits:

It results in a quite operation at high speed.

It provides better balance than the salient pole rotor.

It reduces the windage loss.

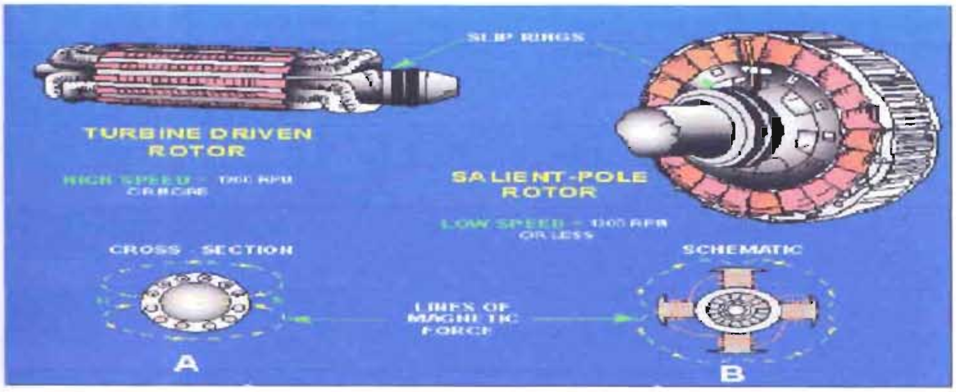

Figure 5: internal view of Rotor

2.3.4 Excitation

An electric generator or electric motor consists of a rotor spinning in a magnetic field. The magnetic field may be produced by permanent magnets or by field coils. In the case of a machine with field coils, a current must flow in the coils to generate the field; otherwise no power is transferred to or from the rotor. The process of generating a magnetic field by means of an electric current is called excitation.

2.3.5 Brush gear

We know that the magnetic flux, conductor and magnetic flux change is needed in the generator to induce the voltage. The main working principle is that the relative motion will be done between these. Turbine is used for rotation motion. The stator is used as the conductor. The electromagnetic rotor will be given power for excitation. The excitation will be given by the bus gear. Here when the rotor is rotated then the friction will be occurred with the brush gear so the rotor will get the field excitation voltage. It will be decayed due to friction. Actually the carbon brush will be decayed. There are 14 carbon brushes in parallel. Current capacity is almost 30% increased capacity of the requirement. Carbon brush layer will be decayed because the spring force will push forward. So we need to change the brush gear while it is in an indicated position.

2.3.6 Jagging oil pump

Here the generator is used which is 55 tons (approximately). To create the torque while running by the generator it will be needed to lift to reduce the friction. So for lifting/jagging purpose there is a hydroelectric system. Here oil is pumped to the hydroelectric system for lifting purpose. This is called jagging oil pump.

Figure 6: Jagging oil pump

2.3.7 Dehumidify fire

A dehumidifier is typically a household appliance that reduces the level of humidity in the air, usually for health reasons. Humid air can cause mold and mildew to grow inside, which pose various risks. Very humid climates or air make some extremely problem, causing excessive sweating that can't evaporate in the already-moisture-saturated air.

For generator, it is used for the absorbing of moisture when generator will be off. If moisture is inside the generator then the generator will be faulted. The absorb body of dehumidifier will absorbed the moisture. Here automation technique has been given inside the dehumidifier to absorb the moisture. The steam is going inside to the dehumidifier and the moisture is absorbed. The outside steam also goes inside and it will go outside after absorbing the moisture. The dehumidifier is rotated slowly

Figure 7: Dehumidify fire

2.3.8 Type of fault of generator

The Core of an electrical power system is the Generator. The conversion of the fundamental energy into its electrical equivalent requires a prime mover to develop mechanical power as an intermediate stage. The nature of this machine depends upon the source of energy and in turn this has some bearing on the design of the generator. There are power units based on steam, gas, water power and Diesel engine Drives. The modern generating unit is a complex system comprising the generator stator winding and associated transformer and unit transformer, the rotor with its field winding and exciters and the turbine and its associated condensers and boiler complete with auxiliary fans and pumps. Faults of many kinds can occur within the system for which diverse protective means are needed. The amount of protection applied will be governed by economic considerations taking in to account the value of the machine and its importance to the power system as a whole. There are 15-20 generator protections. If there is any abnormal condition then the generator will be disconnected from the grid.

1. Stator insulation faults
2. Overload.
3. Over voltage
4. Unbalanced loading

5. Rotor faults
6. Loss of Excitation
7. Loss of synchronism
8. Failure of Prime Mover
9. Low vacuum
10. Lubrication oil failure
11. Loss of boiler firing
12. Over Speeding
13. Rotor distortion
14. Difference in expansion between rotating and stationary parts
15. Excessive vibration

The main protections are:

Over current with under voltage: if there is any over current is flowed through the line. This over current will be passed through the current transformer and it will be given to the amplifier. If the amplifier negative input is become higher than the positive input then the negative output will be occurred at the amplifier. If the amplifier positive input is become higher than the negative input then the negative output will be occurred at the amplifier. The relay will sense the over current then the CB will be tripped.

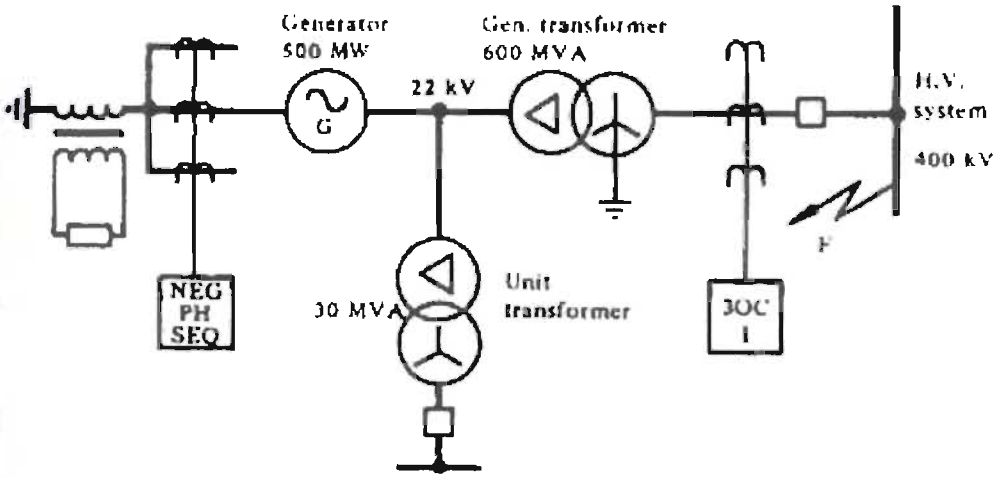

Figure 8: Over current with under voltage

Over voltage: if the bus voltage is higher than the 15 75 KV (16KV) then the relay will operate. This overvoltage will be given to the potential transformer and the power transformer output will be given to the amplifier input 110V. Before giving the input a relay is used if the input voltage is become over 110V then the relay will be tripped.

Generator differential: suppose 7000 A is the rated current and if the fault current is occurred then the fault current will flow in the rotor. Imagine 3500 A current is passing to the rotor so 3500 A current will pass through the line. This difference of current will sense the current transformer then the relay will trip. Here we need to multiply by the constant then we get the exact ratio. Here the multiplying factor is the current transformer ratio. In one zone there are 2 CB and one generator.

$$I_G = I_V + I_A$$

Negative phase sequence: The negative phase sequence is occurred when the fault is phase to ground. Then the current will increased but the voltage will be decreased if we analysis it we get

(1) Positive sequence
(2) Negative sequence
(3) Zero sequence

This is only possible when there is only line to earth fault.

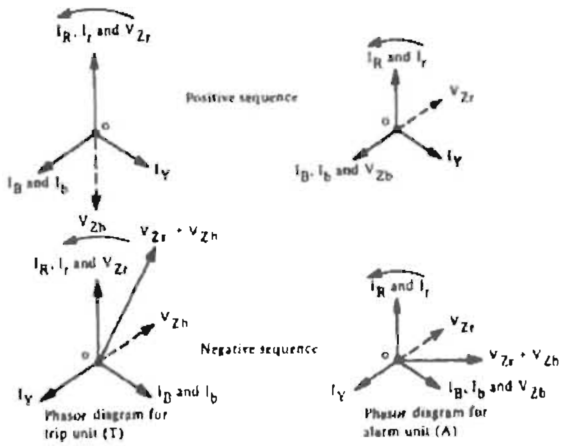

Figure 9: Negative, positive and zero phase sequence

When there is over current in one line then the negative phase sequence is occurred negative phase sequence is occurred due to over current. Main reason is that if the one phase current is higher than the negative phase sequences will occur.

Stator earth fault:

1) Restricted earth fault
2) Backup earth fault

Winding voltage is 10% high then the relay will not operate because adequate relay sensing current will not pass through the relay. If current is 10% high then the relay will sense. In the period of less than 10% of the winding voltage the winding differential will operate.
If the restricted earth does not sense the backup earth fault will be sensed. If there is any unbalanced in the three line phase sequence then the back earth fault will occurred. If the winding has become grounded then there will be high current will flow through the winding and result is that there will be huge amount of mechanical force will create in the stator. So it will burn out and fell down.

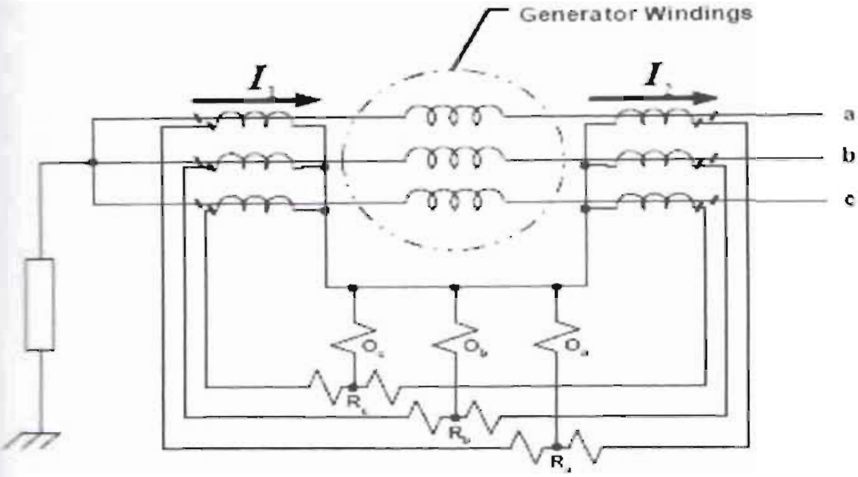

Figure 10: stator earth fault

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

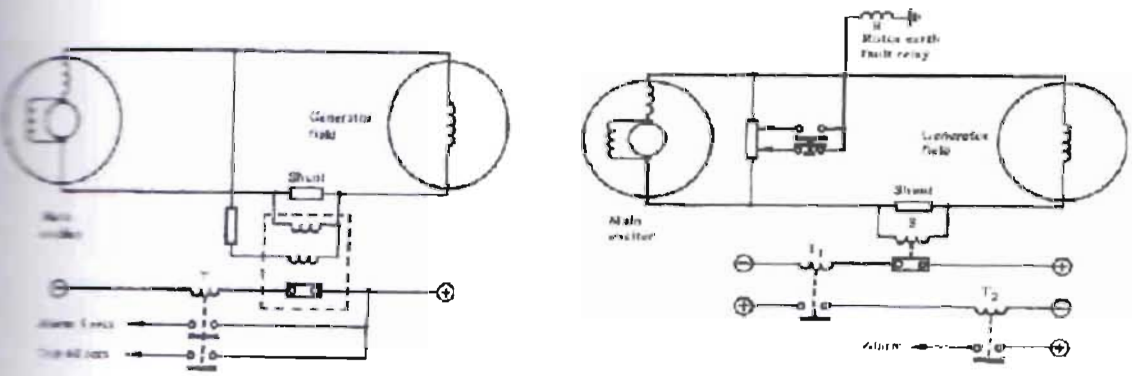

Figure 11: Loss of Excitation

Rotor earth fault: The flux will go inside of the rotor then flux will go outside at the middle point of the rotor. If the winding is slightly shorted to the rotor then the fault current will pass through the relay so the CB will trip

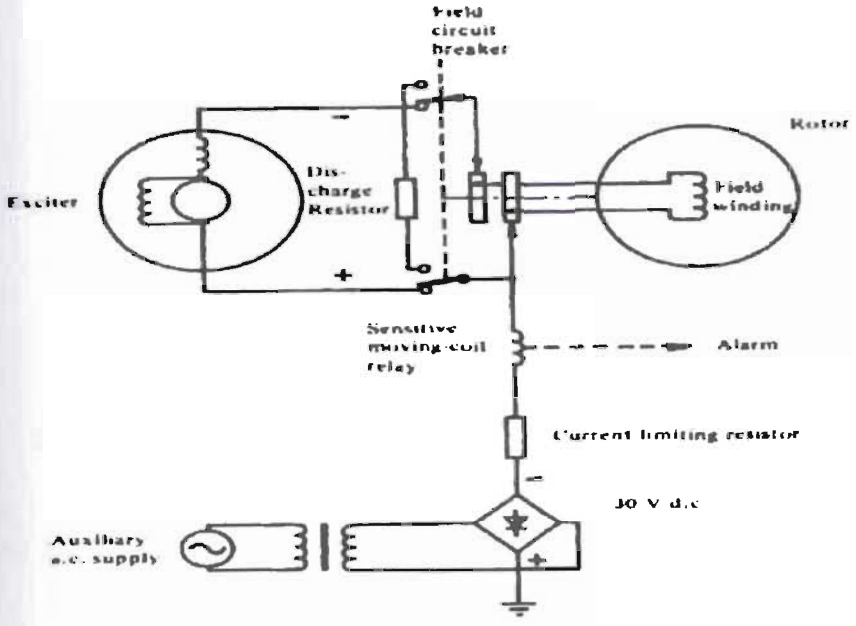

Figure 12: Rotor earth fault

Unit transformer protection
Unit auxiliary transformer protection

2.4 Protection

2.4.1 Circuit Breaker

The circuit breakers are automatic switches which can interrupt fault currents. In some application like single phase traction system, single pole circuit breakers are used. The part of the circuit breakers connected in one phase is called the pole. A circuit breaker suitable for three phase system is called a "triple pole circuit breakers". Each pole of the circuit breaker comprises one or more interrupters or arc extinguishing chambers.

The interrupts are mounted on supported insulators. The interrupts encloses a set of fixed and moving contacts. The moving contacts can be drawn apart by mans of the operating links of the operating mechanism. The operating mechanism of the circuit breaker gives the necessary energy for opening and closing of contacts' of the circuit breakers.

The arc produce by the separation of current carrying contacts is interrupted by a suitable medium and by adopting suitable techniques for arc extinction. The circuit breaker can be classified on the basis of the arc extinction medium.

There are three types of circuit breaker are used for protection in APECL

MCB (miniature circuit breaker)

MCCB (moulded case circuit breaker)

VCB (vacuum circuit breaker)

MCB (miniature circuit breaker): Miniature circuit breakers are only use at low voltage, mainly in domestic or light-industrial or commercial applications. In general they are used in same applications as semi enclosed or cartridges fuses and offer an alternative for protracting radial or ring circuits. They are usually use in single phase devices and have a typical rated load current rang up to 100A with maximum short circuit rating of 16kA at 240V. All MCB operate on a air break principle where an arc formed between the main contacts is forced by effects of the magnetic effects of the short circuit currents.

MCCB (moulded case circuit breaker): MCCB are also only used for low voltage applications. They are basically an upgraded version of the MCB and are invariable three phase devices. They have typical current rating 100A to 2500A and must have short circuit rating p to 50KA at 415V. MCCB are generally used in similar applications to the fuse switches, i.e. protection of large three phase low voltage loads and for motor starting application. They do not have the facility for frequent operation and cannot replace the contractor.

VCB (vacuum circuit breaker): It has been said that there are three contacts which are called upper source bushing and there are another three contacts for lower load bushing. The porcelain vacuum chamber is at the middle position of the source bushing and the load bushing. Here vacuum is used because the arc extinction capability of vacuum is higher than the air.

Nameplate data of vacuum CB:

Rated voltage	7.2KV
Normal current	1250 A
Light impulse withstand capability voltage	50KV
Rated short circuit breaking current	31.5 KA
Rated frequency	50Hz
Rated duration of short circuit	31.5 KA for 1 sec
Rated supply voltage of closing device	220 V (DC)
Rated supply voltage for opening device	220 V (DC)
Rated operating sequence	0-3M-CO-3M-CO
Total	170 kg

2.4.2 Hydrostat

Hydrostatic pressure is the pressure exerted by a fluid at equilibrium due to the force of gravity. A fluid in this condition is known as a hydrostatic fluid. The hydrostatic pressure can be determined from a control volume analysis of an infinitesimally small cube of fluid. Since pressure is defined as the force exerted on a test area and the only force acting on any such small cube of fluid is the weight of the fluid column.

2.4.3 Generator cooling

When the generator is producing the power 100Mw which means that 10000Kw then there will some loss will be occurs in the generator which makes the generator hot. So the loss has converted into heat energy. If we do not remove the heat, the generator will be hot.

There are three types of cooling system in APSCL:

Air cooling = cooled by the air

Water cooling = 300MVA purpose we use water cooling & H_2 cooling all together.

H_2 cooling = 200MVA purpose we use H_2 cooling.

If the cooler is stopped then the generator will stop immediately.

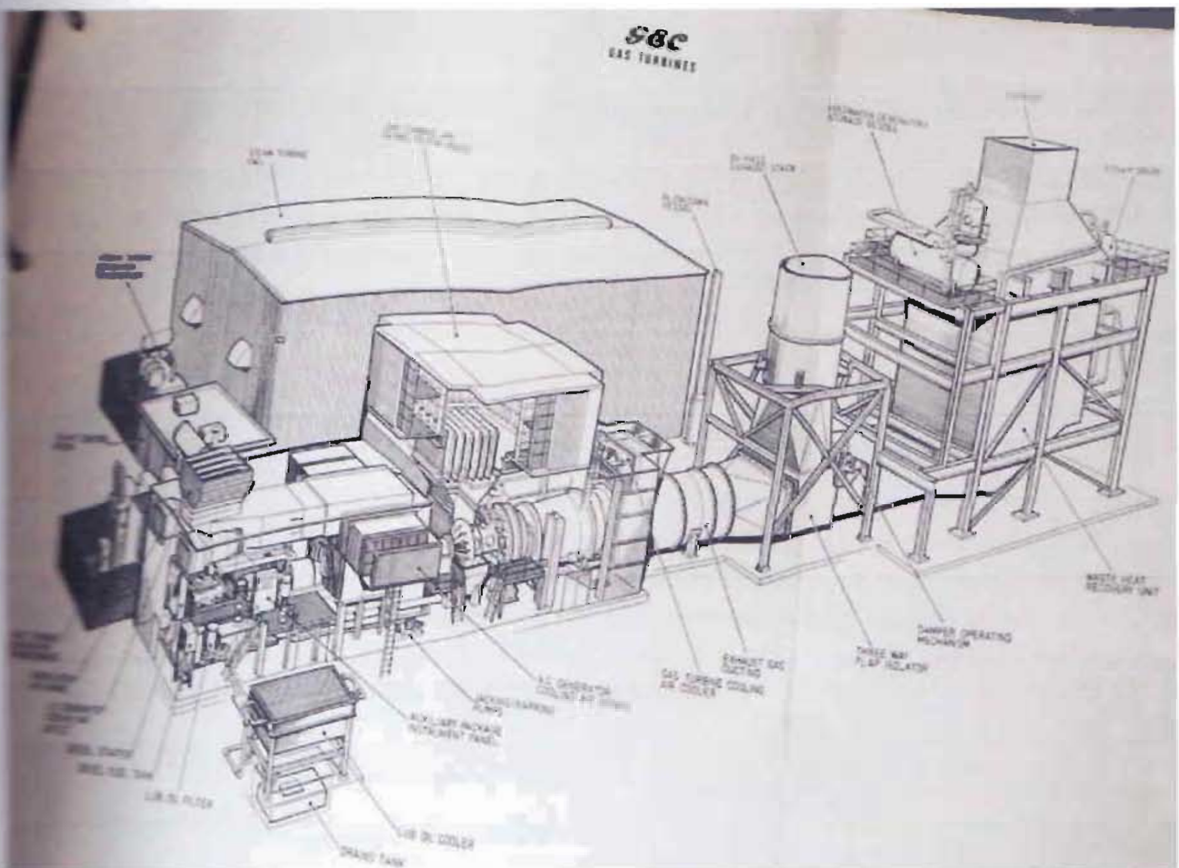

Figure 13: Overall circuit diagram of gas turbine

2.4.4 Battery backup system

The DC power is used in control system always. If the control system fails the control power must not fail. The electricity that is coming from the battery is produced due to the chemical energy is converted into electrical energy. For the backup purpose we use the battery. In this power plant they use two kinds of battery: Led acid &NICD battery

NICD battery is costly. The difference is that in led acid the sulfuric acid is used and in NICD battery the potassium hydrochloric acid is used. The rectifier is used to convert the DC to AC. The rectifier is nothing but a battery charger from the technical point of view. The voltage of NICD is 1.2 V. for battery capacity we use AH (amp hour). If we connect the battery in parallel we are adding the capacity and if we connect the battery in series we are reducing the capacity. For example 10 hours the capacity is 50 AH. It means that 50A current will run the battery through 10 hours. A performance curve is given by the manufacturer which indicates the points of operation of the battery. Initially high amp of current flows afterwards it becomes steady. After that it will be discharged. Then current will be constant to the battery to charge initially. The steady condition when the constant voltage will be given this condition is called the floating position for energy gaining. This floating condition can be changed if the product is same and the same material is used but the chemical reaction is changed. It charged in high voltage which is called booster. It will equalize the charge. In the control room there are some mechanical works which are done for testing the battery:

The tightness capacity: This test is done for the loose connection in the battery. If there is any loose connection then the then it will be removed.

Breathing test: If there is any chemical reaction occurred inside then this test is done to remove the chemical reaction.

Liquid level test: The nickel cadmium is emerged in to the potassium hydrochloric acid. There is a maximum point and a minimum point inside the battery. It means that the nickel cadmium is emerged in between two points. If acid level is higher than the maximum level the breathing test will be needed. But the acid level cannot go under the minimum level. For this reason the specific cell is kept on observation.

Specific gravity test: The range is 1180-1220kg/m^3

1220 cc or 1.2 liter (compared to 1 liter water)

The specific gravity is tested by the hand hydrometer of the acid. The specific gravity is in the range of 1180-1220.

The cell voltage test: Here the rectifier is used which is 220 V. There one rectifier is redundant. It is the subordinate rectifier if one fails then the other rectifier will be operated. The battery is energized and discharged. When the constant voltage will be supplied then the floating condition will be occurred. If we want to boost the battery then the data will be stored and it has been charged by the automation inside the rectifier.

For NICD Battery

The nominal voltage: 1.2V

Floating voltage: 1.4V

Boost voltage: 1.6V

Figure 14: Rectifier circuit diagram

2.4.5 Black out plant

If there is not any power in the grid the plant cannot be run. There are some blackout plants to give the power in the plant. They are dependent on grid. So there will be needed a source. The plant will be run by taking maximum 6.6 KV from the grid. The 2 current transformers will be used as source. There are OAT1 and OAT2 are the two transformers. They substitute with each other.

2.5 Control & Maintenance

Generally the control and maintenance in every power plant is very important. In APSCL for the generator division the control and maintenance purpose is very important because, there are several engineers have to monitor the total environment of the generator division as a whole. So the controlling and maintains part is done in an automation control system room by monitoring all the parts of this division simultaneously. So this job has to done very carefully that if there is any fault occurred in this division the fault display board will indicate the fault and the engineers will do their works on the basis of the faults to remove these. Otherwise this will hamper the total the generator division.

The control & maintenance is done in two ways. It is divided into two parts

Leakage air filter

Close circuit cooling

2.5.1 Leakage air filter

The total control & maintains system is surrounded by the air cooling system. It is such kind of room where proper ventilation of the air is maintained randomly, which means that the air passed out and in a certain process so that the control & maintains system room will be cooled throughout the process. Here leakage air system is that the air that makes cool to the control & maintains room will be go out to the environment & fresh air will be taken from the atmosphere to the control room which makes the room all times air cooled. It is very important room that we have mentioned earlier because there are several machines which will become hot while running for the control operation. So in this respect leakage air system plays very important role to make cooling the control unit.

2.5.2 Close circuit cooling

In the close circuit cooling system is where same air is circulating so some loss has occurred so it has backup by the LAF (Leakage air filter). It is such kind of system which makes cool inside the environment inside the generator. When the hot gas is formed inside the generator there are two rotor shaft fans is running one by one at the left side and at the right side. This cooling fan passed the hot air in a turbulent flow of several sides by a self process. Self means that when the breaker is open then we are generating the power & when we take the power from the grid for starting the transformer BT1 (mentioned in the following picture) then the breaker one will be closed and also breaker 2 will be closed.

2.5.3 Thyristor

Thyristors are a family of power semiconductor devices. Thyristors are used extensively in power electronics circuit they are operated at bitable switches operating from non conducting stage to conducting state. Thyristors can be assumed as ideal switches for many application but the practical thyristors exhibit certain characteristics and limitation. Conventional thyristors are designed without gate controlled turn off capability, in which case the thyristors can recover from its conducting state to a non conducting state only when the current is brought to zero by other means. Gate turn off thyristors (GTOs) is designed to have both controlled turn on & turn off capability. Compared to transistors, thyristors have lower on state conduction losses and higher power handling capability. On the other hand transistors generally have superior switching performances. In terms of faster switching speed and lower switching losses. Advances are continuously made to achieve devices with the best of both (i.e. low on state and switching losses, while increasing their power handling capability).

Figure 15: Thyristor

Generally in APSCL the thyristors are used to give the field excitation to the generator by the brush gear. Here the three connections from the transformer will come first to the power thyristor. Then the power thyristor will take the AC current and it will make it DC. There then field breaker which will take the DC current to the generator brush gear. Brush gear will take it and give the field excitation to the generator. In front of the thyristor there are thyristor controlling systems which will control the thyristor and there are fault display boards which will detect the fault in the excitation. The three connection from the generator will come to the transformer and the transformer is use to make the excitation voltage with the generator voltage.

Generator Dc excitation purpose we saw that there was a fault pannel board where if any fault occur in the generator or any fault occur in the Dc excitation then the light will glow in this pannel. So the engineer who is for monitoring purpose in that control room will be known about the idia that which fault is occured and take necessary actions to remove the fault.

Figure 16: generator control system for fault analysis board

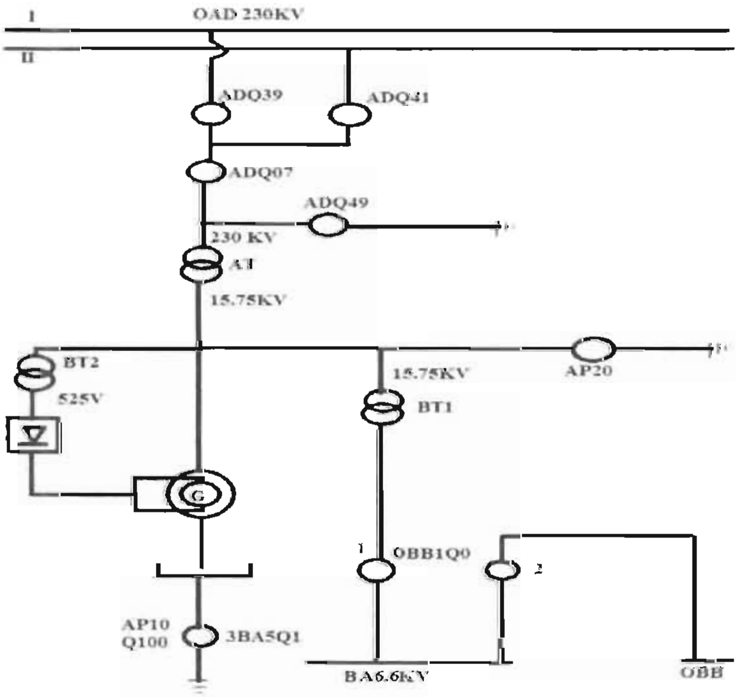

Figure 17: Using thyristor for giving the excitation

2.5.4 Current transducer

A transducer is a device that alters or transforms energy from one form into another. There are three types: power, voltage and current transducers. They can be found in products such as probes that convert ph into electrical signals, microphones (that convert sound into electricity), photoelectric cells (that convert sunlight into electricity), or Geiger counters (which turn radioactivity into measurable metered quantities). Pressure transducers, for instance, transform pressures into an electrical signal that can be measured or used for other applications. There are even biological converters with the body such as the hair cells of the ear.

The current transducer is the application we're interested in. The term current transducer, as we normally take the meaning, is a device that converts alternating current (AC) or direct current (DC) electrical signals into analog instrument signals (think meters or LED displays) for some type of automatic or human control system. They allow computers to automatically monitor and control processes because some type of signal can be turned into an electrical equivalent.

Chapter: 03

3.1 Gas turbine

The gas turbine is the turbine that is used to rotate the rotor of the generator. Main equipment is the gas that is used to rotate the turbine. So mechanical power will be developed which will used to rotate the rotor. Gasses passing through an ideal gas turbine undergo three thermodynamic processes. These are isentropic compression, isobaric (constant pressure) combustion and isentropic expansion. In a practical gas turbine, gasses are first accelerated in either a centrifugal or radial compressor. These gasses are then slowed using a diverging nozzle known as a diffuser; these processes increase the pressure and temperature of the flow. In an ideal system this is called isentropic here this isentropic compression has been used. Here main mechanism is air. So the operating temperature is high than steam turbine. Air and fuel is burnt and it will be given to the turbine. When foe gas is out there will be high temperature will be created. This temperature is used to heat the water from which the steam will be created. This stem will be given to another turbine to run the generator. This is called combined cycle plant.

Output temperature: 1050-1250 ^{o}c

Steam temperature: 540 ^{o}c

Steam turbine auxiliary cost is higher than the gas turbine. Efficiency of gas turbine is higher than the steam turbine.

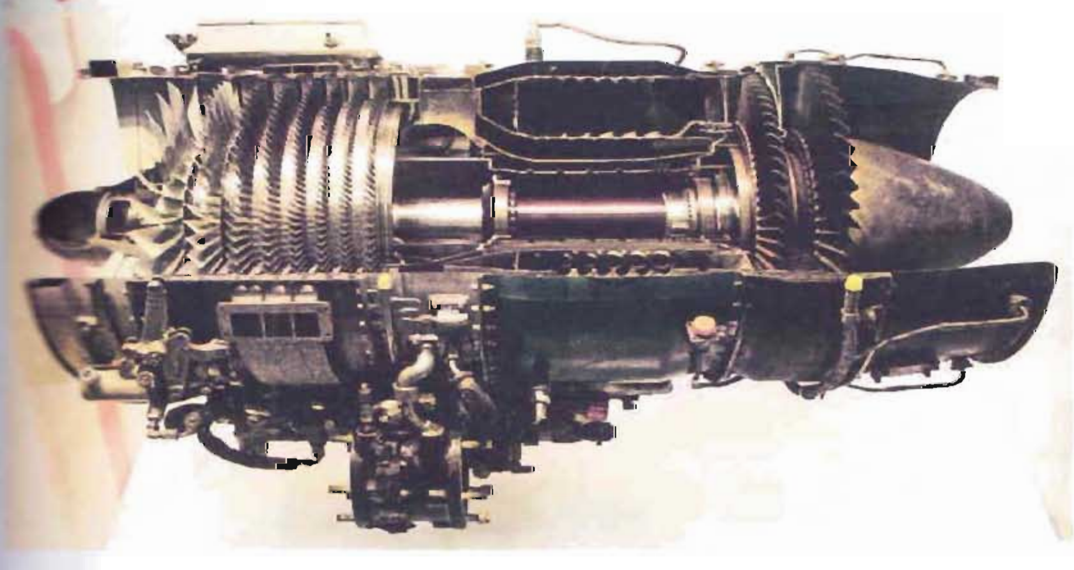

Figure 18: inside clear view of the gas turbine

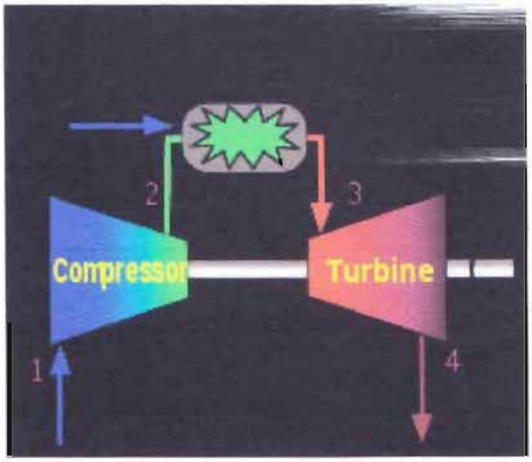

Figure 19: total process of the compressor through the gas turbine

3.1.1 Boiler

A boiler is also called a steam generator. A boiler is a device used to create steam by applying heat energy to water. The steam generator or boiler is considered as a prime mover. A boiler incorporates a furnace in order to burn the fuel and generate heat; the heat is initially transferred to water to make steam; this produces saturated steam which can vary according to the pressure above the boiling water. The higher the furnace temperature, the faster the steam production. The saturated steam thus produced is used to rotate the turbine and alternator. Any remaining heat in the combustion gases can then either be evacuated or made to pass through an economizer, the role of which is to warm the feed water before it reaches the boiler.

There is a boiler is commonly use in APSCL, that is Babcock & Wilcox boiler.

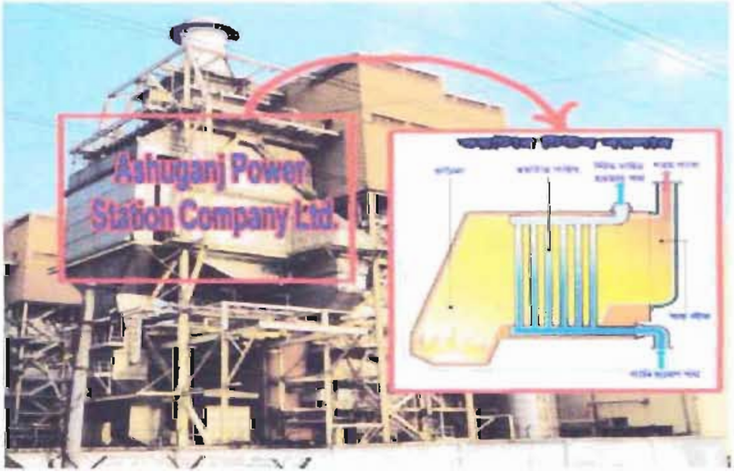

Figure 20: water tulbe boiler

This type has a single drum, with feed water drawn from the bottom of the drum into a header that supplies inclined water-tubes. The water tubes supply steam back into the top of the drum. Furnaces are located below the tubes and drum.

The superheat temperature of the Y160 was controlled manually by the Boiler Room Petty Officer of the Watch between 750°F and 850°F and the steam supplied to the main turbines was at a pressure of 550 psi.

3.1.1.1 Safety tank

A boiler that has a loss of feed water and is permitted to boil dry can be extremely dangerous. If feed water is then sent into the empty boiler, the small cascade of incoming water instantly boils on contact with the superheated metal shell and leads to a violent explosion that cannot be controlled even by safety steam valves. Draining of the boiler could also occur if a leak occurred in the steam supply lines that were larger than the make-up water supply could replace. Most boilers produce steam to be used at saturation temperature; that is, saturated steam. Superheated steam boilers vaporize the water and then further heat the steam in a super heater. This provides steam at much higher temperature, but can decrease the overall thermal efficiency of the steam generating plant because the higher steam temperature requires a higher flue gas exhaust temperature. There are several ways to circumvent this problem, typically by providing an economizer that heats the feed water, a combustion air heater in the hot flue gas exhaust path, or both.

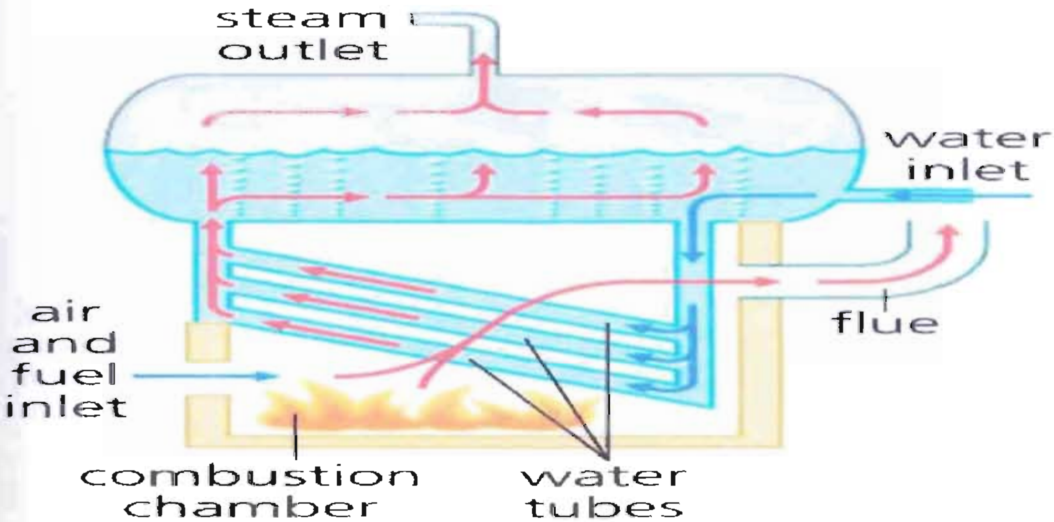

Figure 21: Safety tank

There are advantages to superheated steam that may, and often will, increase overall efficiency of both steam generation and its utilization: gains in input temperature to a turbine should outweigh any cost in additional boiler complication and expense. There may also be practical limitations in using *wet* steam, as entrained condensation droplets will damage turbine blades.

3.1.1.2 Stem Super heater & Pressure gauge

The circulation of water is maintained by convection currents. The hottest water and steam rise from the tubes to uptake header and then through rise inter the boiler drum. The steam vapor escape through water to the upper half of the drum. The cold water flows from the drum to the rear header and thus the cycle is complicated. For getting superheated steam, the steam accumulated in the steam space is sent to superheated tubes which are arranged above the water tubes. The superheated steam is finally supplied to the user through a steam pipe and steam stop valve. When the steam is being raised from the cold boiler, the super heater is filled with water to the drum water level. The super heater remains flooded until the steam reaches the working pressure. The super heater is then drained and steam is fed to it for superheating purpose.

At the bottom of the rear header is a mud box. The foreign matter held in suspension in water gets collected in it and can be blown off from time to time. The access to the interior of the boiler is provided by the door. This is necessary to clean the tubes to remove the soot. The draught is regulated by a damper which in the back chamber (Evaporates capacity for such boiler rate is 20,000-40,000 Kg/hour & operating pressures of 11.5-17.5Kg/ cm^2).

Here, Pressure gauge is used for the measure of pressure of the steam produce tank. It is also called vacuum gauge. If the pressure is higher of the tank then the safety valve is used for removing purpose of the excessive exhaust gas.

Figure 22: Pressure gauge

3.1.1.3 Furnaces

A **water tube boiler** is a type of boiler in which water circulates in tubes heated externally by the fire. Fuel is burned inside the furnace, creating hot gas which heats water in the steam-generating tubes. In smaller boilers, additional generating tubes are separate in the furnace, while larger utility boilers rely on the water-filled tubes that make up the walls of the furnace to generate steam.

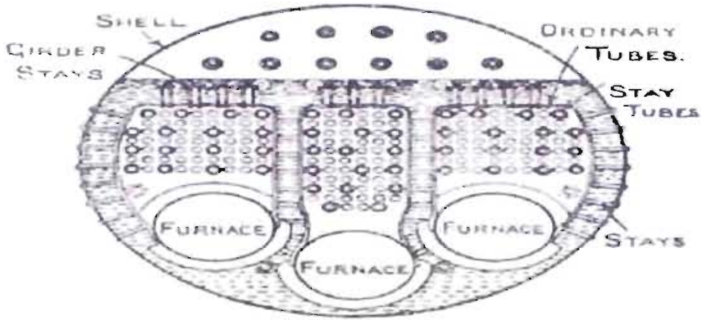

Figure 23: furnace

The heated water then rises into the steam drum. Here, saturated steam is drawn off the top of the drum. In some services, the steam will reenter the furnace through a super heater to become superheated. Superheated steam is defined as steam that is heated above the boiling point at a given pressure. Superheated steam is a dry gas and therefore used to drive turbines, since water droplets can severely damage turbine blades.

Cool water at the bottom of the steam drum returns to the feed water drum via large-bore down comer tubes, where it pre-heats the feed water supply. To increase economy of the boiler, exhaust gases are also used to pre-heat the air blown into the furnace and warm the feed water supply. Such water tube boilers in thermal power station are also called *steam generating units*. Furnaces are located below the tubes and drum.

3.1.1.4 Ash pit

When gas is burn in furnace there are lot of carbon-di-oxide (CO_2) and Hydrogen (H_2) produced. For producing of lot of carbon-di-oxide (CO_2) which is gathered as the resultant at the bottom of the boiler in a chamber which is called ass pit.

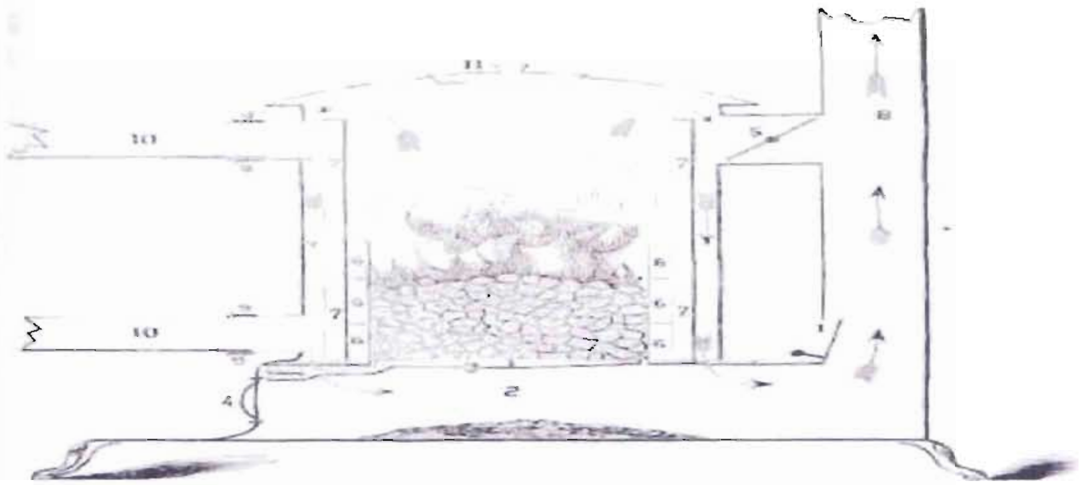

Figure 24: Ash pit

We have to clean it & for cleaning purpose there is a tray is used in the ass pit. On the other hand for the separate of heat from the other areas inside the boiler we use baffles.

3.1.1.5 Feed water pump

In APSCL water comes from river and this water first comes into the basin and there it is filtered in two stages. After filtering water, it is taken to the filter house for two more times and then in reserve tank. Then water is cleaned by the different chemicals which are used in water treatment tank and this water is converted into distilled water (DH_2O) and it goes to feed water pump.

Figure 25: feed water pump

At last the main purpose of the feed water pump is to deliver the distil water (DH_2O) to the boiler so that at a random process the steam will become heated by using the condenser to the feed water pump and again to the boiler.

3.1.2 Compressor

A gas compressor is a mechanical device that increases the pressure of a gas by reducing its volume. Compressors are similar to pumps: both increase the pressure on a fluid and both can transport the fluid through a pipe. As gases are compressible, the compressor also reduces the volume of a gas. Liquids are relatively incompressible, while some can be compressed, the main action of a pump is to pressurize and transport liquids. We need run the compressor with constant pressure. If it is in definite pressure then the compressor will be run. There is a diesel engine which is running at 1700 rpm. When it is running at 1800 rpm then the internal ignition is occurred then it is suitable for delivering the speed to the compressor. In APSCL the generator that is used which is run at 3000 rpm when the speed is 1700 rpm then it is used to run the compressor.

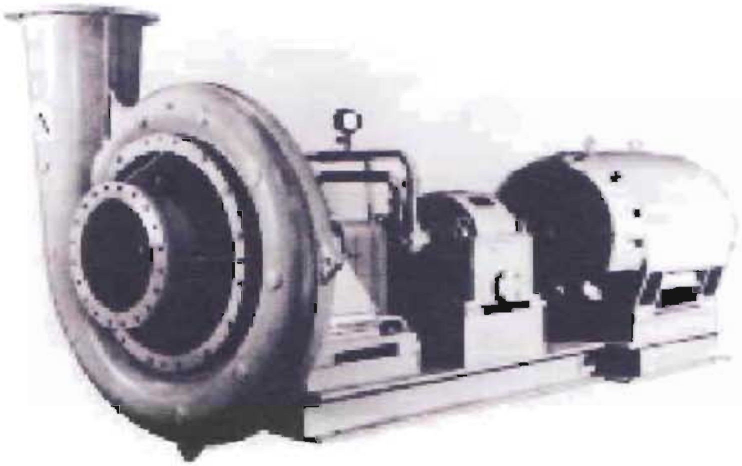

Figure 26 centrifugal compressor

3.1.3 Combustion chamber

A combustion chamber is the part of an engine in which fuel is burned. The hot gasses that produced from the combustion occupy a far greater volume than the original fuel, thus creating an increase in pressure within the limited volume of the chamber. This pressure can be used to do work, for example, to move a piston on a crankshaft or a turbine disc in a gas turbine. The combustion ratio is 1:8 times. If input is 1 then the output is 8 times higher. First the gas will go to the knockout plant then it goes to the filter then it goes to the constant pressure chamber. To give the certain amount of gas to the compressor and for speed controlling purpose the governor is used. The combustion chamber has spark plug that is used to fire the gas. Before fire there has the ignition if the ignition has been occurred then it has been given to the combustion chamber. The again need to be filter out the gas. There is metallic system for filtering purpose the metallic system is used. There is also disposal system, this disposal system is permanent. For reusing purpose we can use the metallic system.

3.1.4 Fuel system

The modern combustion gas turbine is one of the most reliable machines in use and a workhorse of the electric power generating industry. They can be run because of quick running capability which is only possible by delivering the quick additional power. So fuel system is the very important part on that respect. The most common fuels for these machines are natural gas and distillate fuel oil. Many industrial machines are delivered suitable to burn either gaseous fuel or liquid fuels. Thus, a liquid fuel system is frequently a part of the installation.

Even if natural gas is the primary fuel, liquid fuel as a backup is very common to provide for interruptions in gas supplies. Some fuels are relatively inexpensive if they are an excess product from a refinery. Naphtha is currently a very popular gas turbine fuel in India due to government regulation. Many of these fuels require special treatment and/or handling to be both safe to use and to minimize excessive erosion or corrosion to the hot gas parts of the machine. For example, naphtha is an extremely volatile liquid and some purchasers of pumps for this fuel specify a barrier system for the pump shaft seals. Figure 1 shows a twin screw naphtha fuel injection pump that includes a lube oil barrier system to insure that any shaft seal leakage is lube oil into the fuel. Such leakage can be readily detected so that an orderly shutdown can be initiated to investigate a possible seal leak.

Figure 27: Fuel system

3.1.5 Air intake system

Air is intake of a gas turbine plant for cooling purpose, here this air is cool the heat of the bearing lubrication oil, generator and turbine. Bearing oil has been cooled by 2 fans. Full turbine hall can be cooled by the ventilation air system .There are also fans in the generator by passing the air too cool the generator. This turbine can produce temperature from 100-1200°C.When temperature will increase 1000 °C then the gas will be fired. For this reason air will become so heated. This heat can band the turbine or bearing. For overcome this problem they make a circulating air blowing path to protect this parameter.

3.1.6 Cooling system

Here bearing oil has been cooled by 2 fans. Full turbine hall can be cooled by the ventilation air system. There are also fans in the generator by passing the air to cool the generator.1000° C temperature will increase when the gas will be fired. Then the air will become so heated so this air will be cooled and circulates to cool the turbine.

3.1.7 Lubrication system

When compressor is running in constant speed then turbine becomes hot so lubrication system is helpful here to move the shaft at 3000 rpm by reducing the load. The works of the lubrication system are:

Less friction in the bearing
Making the turbine smooth.
Making the turbine blade heat less.
Reducing the load

There are AC pumps and DC pumps. Each one is standby for each other. Gas is moved through the pump with constant pressure. In the lubrication system the oil is used to control the system. Here bearing will be used which is less than 1rpm for lifting purpose it is not a continuous process. By this pressure it will be reduce and the handle will go backward.

Figure 28: jagging oil pump

3.1.8 Instrument air

There is a compressor which will supply the instrument air to the various types of machines of the system.

3.1.9 CONDENSER:

The main purposes of the condenser are to condense the exhaust steam from the turbine for reuse in the cycle and to maximize turbine efficiency by maintaining proper vacuum. As the operating pressure of the condenser is lowered (vacuum is increased), the enthalpy drop of the expanding steam in the turbine will also increase. This will increase the amount of available work from the turbine (electrical output). by lowering the condenser operating pressure, the following will occur:

Increased turbine output.
Increased plant efficiency.
Reduced steam flow (for a given plant output

3.2 Protection & Control system

There are several sensor systems which will indicate the logic to give the alarm. There are 10 thermocouples when the temperature will become higher than the 625°C then these will give the signal for tripping. For ± 40°C the alarm will blow and for ± 60°C tripped will be occurred. Here lube oil test will be done for the safety.

The protection system will be given by the following ways:

3.2.1 Trip coil:

1) First command to the circuit breaker
2) Second command to the fuel valve. So the fuel flow will be shut down.

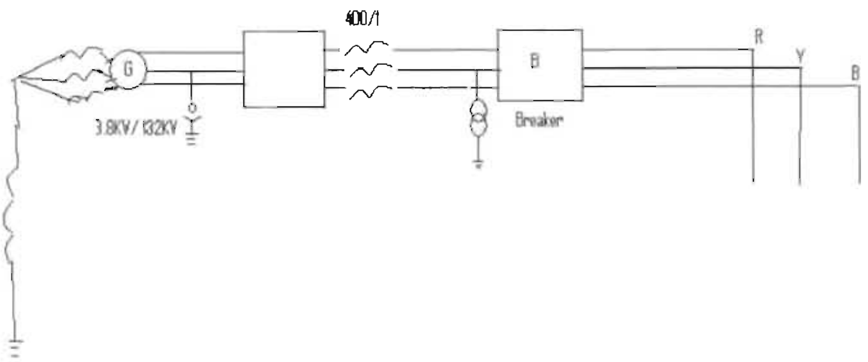

Figure 29: indicating the trip coil for balanced Y connected sources

Here Y connected balanced current will be flow. Synchronization has been occurred so that it will open the circuit breaker.

3.2.2 Generator:

1) Winding temperature excessiveness test.
2) Bearing test

Vibration high.[cooling fan is used if distance between the shaft and the bearing is increased then the steam will go in to the gap and it will push the shaft upward]
Temperature high.

3) Cooling air temperature high test.[2],[3]

3.2.3 Turbine

1) Bearing vibration will be high.
2) Bearing temperature will be high
3) Deviation ±60°C
4) Over speed test=3300 rpm

3.2.4 Lube oil test

Bearing temperature will be high because the lube oil will become less so the friction will be occurred. There are 10 burners. If there are any temperature of any burner will become less then the turbine blade will become compressed and decompressed so the turbine blade will be broken down. If load will become less so fuel will flow so the turbine speed will be high. Over speed acceptable till 3300rpm. Here when the turbine is moving faster than the bearing which makes a distance between the shaft and the bearing. It has been measured by a scale unit

$miles = \frac{1}{1000}\ inch$ => If it is 4 miles then an alarm will be blown.
If it is 6 miles then it will give the trip signal.

3.2.5 Compressor protection

1) Air intake differential pressure excessiveness test.

Two filters namely disposable filter and metallic filter are used for compressor protection. Metallic filter is used for less micron gap and disposable filter is for how much gap is there in the filter. The disposable filter will not be reused. Bearing and shaft gap has been filled by the lube oil which will take the heat. There are also lube oil cooler which will the cool the lube oil. Jacking oil supply should be ensured must. Safety of the power plant is given the DC or AC system. If one system is off then the other system will be running. But the DC system must not be off. AC system is used for ac supply to the equipment. For power failure purpose we use DC supply.

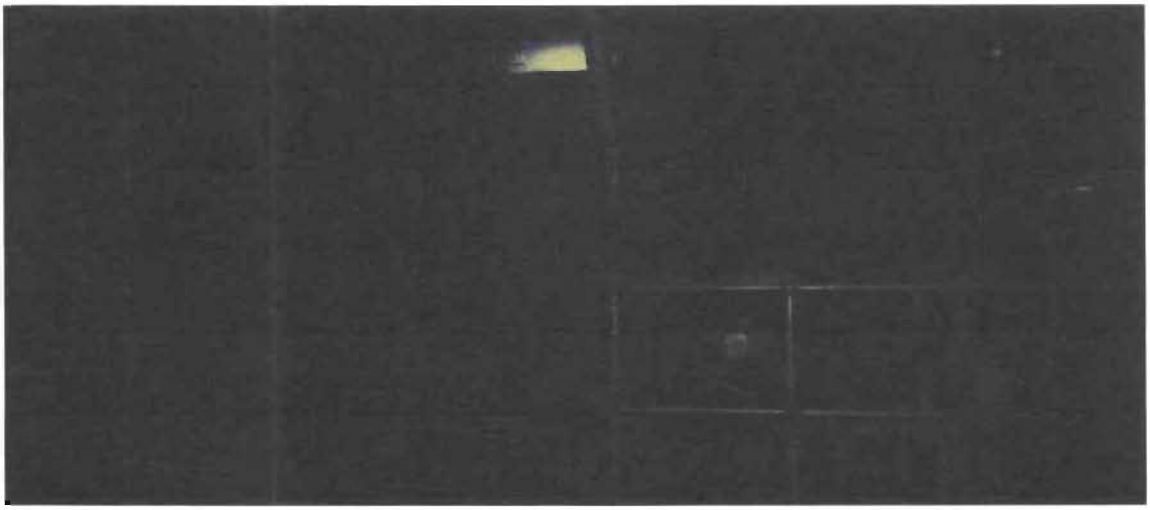

Figure 30: water treatment tank with feed water pump

3.3 Auxiliary power supply

The DC power is used in control system always. If the control system fails the control power must not fail. The electricity that is coming from the battery is produced due to the chemical energy is converted into electrical energy. For the backup purpose we use the battery. In this power plant they use two kinds of battery: Led acid &NICD battery

NICD battery is costly. The difference is that in led acid the sulfuric acid is used and in NICD battery the potassium hydrochloric acid is used. The rectifier is used to convert the DC to AC. The rectifier is nothing but a battery charger from the technical point of view. The voltage of NICD is 1.2 V. for battery capacity we use AH (amp hour). If we connect the battery in parallel we are adding the capacity and if we connect the battery in series we are reducing the capacity. For example 10 hours the capacity is 50 AH. It means that 50A current will run the battery through 10 hours. A performance curve is given by the manufacturer which indicates the points of operation of the battery. Initially high amp of current flows afterwards it becomes steady. After that it will be discharged. Then current will be constant to the battery to charge initially. The steady condition when the constant voltage will be given this condition is called the floating position for energy gaining. This floating condition can be changed if the product is same and the same material is used but the chemical reaction is changed. It charged in high voltage which is called booster. It will equalize the charge. In the control room there are some mechanical works which are done for testing the battery:

The tightness capacity: This test is done for the loose connection in the battery. If there is any loose connection then the then it will be removed.

Breathing test: If there is any chemical reaction occurred inside then this test is done to remove the chemical reaction.

Liquid level test: The nickel cadmium is emerged in to the potassium hydrochloric acid. There is a maximum point and a minimum point inside the battery. It means that the nickel cadmium is emerged in between two points. If acid level is higher than the maximum level the breathing test will be needed. But the acid level cannot go under the minimum level. For this reason the specific cell is kept on observation.

Specific gravity test: The range is 1180-1220kg/m^3

1220 cc or 1.2 liter (compared to 1 liter water)

The specific gravity is tested by the hand hydrometer of the acid. The specific gravity is in the range of 1180-1220.

The cell voltage test: Here the rectifier is used which is 220 V. There one rectifier is redundant. It is the subordinate rectifier if one fails then the other rectifier will be operated. The battery is energized and discharged. When the constant voltage will be supplied then the floating condition will be occurred. If we want to boost the battery then the data will be stored and it has been charged by the automation inside the rectifier.

For NICD Battery

The nominal voltage: 1.2V

Floating voltage: 1.4V

Boost voltage: 1.6V

3.4 Excitation and governor system

An electric generator or electric motor consists of a rotor spinning in a magnetic field. The magnetic field may be produced by permanent magnets or by field coils. In the case of a machine with field coils, a current must flow in the coils to generate the field; otherwise no power is transferred to or from the rotor. The process of generating a magnetic field by means of an electric current is called excitation.

In APSCL the excitation has been given by the brush gear. We know that the magnetic flux, conductor and magnetic flux change is needed in the generator to induce the voltage. The main working principle is that the relative motion will be done between these. Turbine is used for rotation motion. The stator is used as the conductor. The electromagnetic rotor will be given power for excitation. The excitation will be given by the bus gear. Here when the rotor is rotated then the friction will be occurred with the brush gear so the rotor will get the field excitation voltage. It will be decayed due to friction. Actually the carbon brush will be decayed. There are 14 carbon brushes in parallel. Current capacity is almost 30% increased capacity of the requirement. Carbon brush layer will be decayed because the spring force will push forward. So we need to change the brush gear while it is in an indicated position. Governor is used to adjust the speed of the engine by adjusting the fuel input.

3.5 Turbine analogy

There are two types of turbine.

1) Impulse turbine
2) Reaction turbine

Impulse turbine:

These turbines change the direction of flow of a high velocity fluid or gas jet. The resulting impulse spins the turbine and leaves the fluid flow with diminished kinetic energy. There is no pressure change of the fluid or gas in the turbine blades (the moving blades), as in the case of a steam or gas turbine, all the pressure drop takes place in the stationary blades (the nozzles).Before reaching the turbine, the fluid's pressure head is changed to velocity head by accelerating the fluid with a nozzle. Pelton wheels and de Laval turbines use this process exclusively. Impulse turbines do not require a pressure casement around the rotor since the fluid jet is created by the nozzle prior to reaching the balding on the rotor. Newton's second law describes the transfer of energy for impulse turbines.

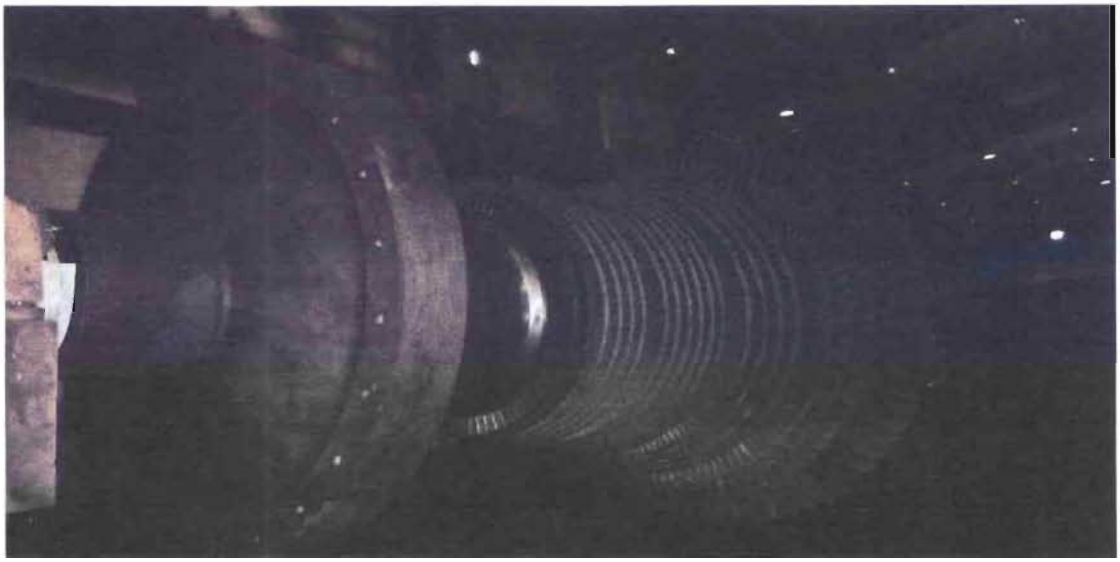

Figure 31: turbine blade

Reaction turbine

These turbines develop torque by reacting to the gas or fluid's pressure or mass. The pressure of the gas or fluid changes as it passes through the turbine rotor blades. A pressure casement is needed to contain the working fluid as it acts on the turbine stage(s) or the turbine must be fully immersed in the fluid flow (such as with wind turbines). The casing contains and directs the working fluid and, for water turbines, maintains the suction imparted by the draft tube. Francis turbines and most steam turbines use this concept. For compressible working fluids, multiple turbine stages are usually used to harness the expanding gas efficiently. Newton's third law describes the transfer of energy for reaction turbines.

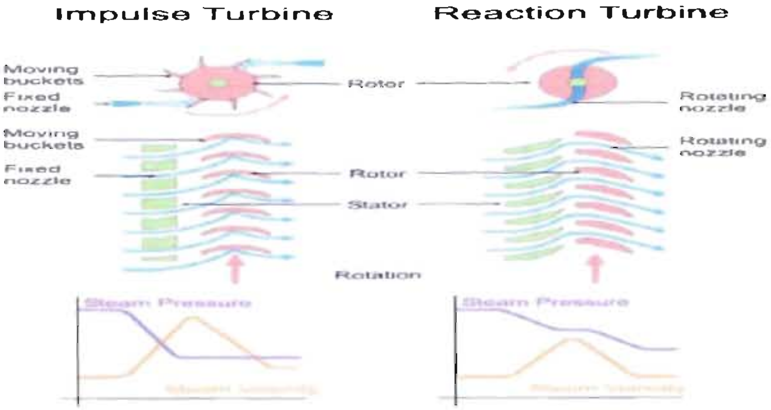

Figure 32: Impulse turbine & Reaction turbine

3.6 Different types of tests

There are different types of test in the Gas turbine. They are

Temperature:

Thermometer: the temperature of the power station is tested by the thermometer. The temperature is displayed in a display board.

Thermocouple: Two different metals are used. Their heads are joined with each other. Then the temperature is measured. There is a chart which indicates the voltages corresponding to the measured temperature. Here K- type thermocouple is used. Its range is 1200°C-1300°C. Here RTD (Resistor thermocouple detector) is used to give the measured values. Here we use thermostat.

Pressure: Naturally pressure gauge is used for the measurement of the pressure. Another device pressure transmitter is used where an electrical transducer (stain gauge) is used which generates electrical signal against the pressure.

Side glass: It is also a meter which indicates the pressure.

Dip stick: There is level indicator in the stick. It tests the level of oil.

RPM test: Tachometer is used to measure the rpm. Laser is used as the indicator of RPM.

Controller: It has some saved data. Here transducer converts the physical signal to electrical signal. Sensor senses the physical signal.

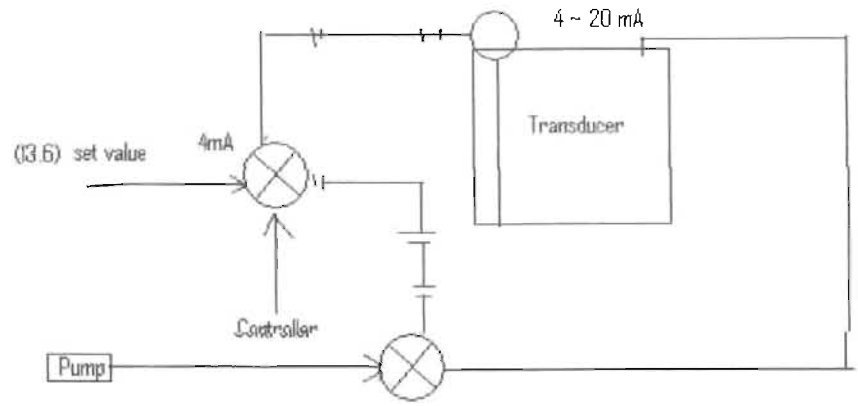

Figure 33: Controller

3.7 steam turbine

A steam turbine is a mechanical device that extracts thermal energy from pressurized steam, and converts it into rotary motion. Its modern manifestation was invented by Sir Charles Parsons in 1884. It has almost completely replaced the reciprocating piston steam engine primarily because of its greater thermal efficiency and higher power-to-weight ratio. Because the turbine generates rotary motion, it is particularly suited to be used to drive an electrical generator – about 80% of all electricity generation in the world is by use of steam turbines. The steam turbine is a form of heat engine that derives much of its improvement in thermodynamic efficiency through the use of multiple stages in the expansion of the steam, which results in a closer approach to the ideal reversible process.

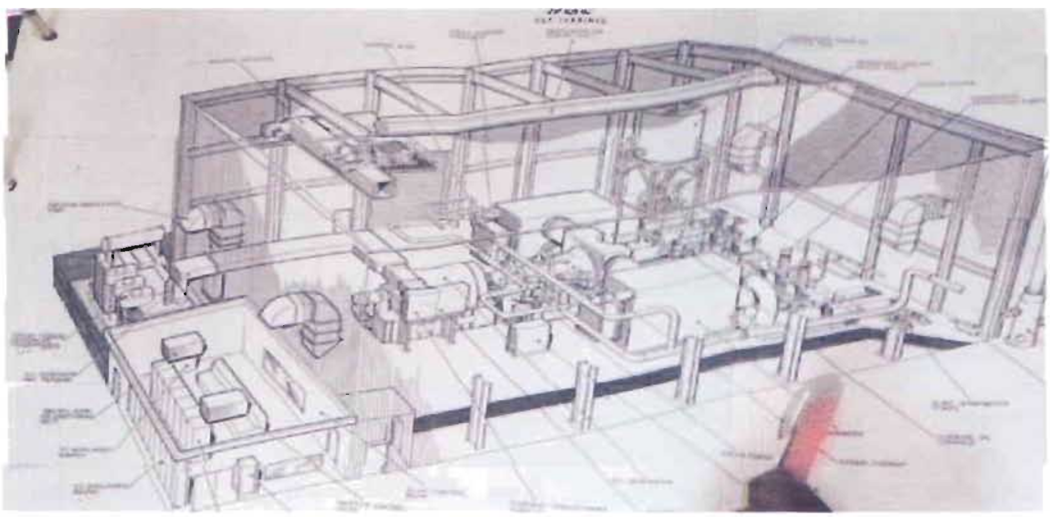

Figure 34: Steam turbine

3.7.1 Spray water boost pump

Spray water boost pump is the pump which is used to spray the water stem to the condenser and condenser will take this stem which will be reheated in a process to the boiler. There is an auxiliary contact and main contact. The main contact is used to supply the mainly total part of the steam and the other part of the steam which flows through the auxiliary contact. When there is excessive stem is passing through the main contact then the auxiliary contact will take some short of steam of the main contact. Then this stem will be passed to the condenser.

Figure 35: Spray water boost pump

3.7.2 Vacuum chamber

A vacuum chamber is a rigid enclosure from which air and other gases are removed by a vacuum pump. Chambers are typically made of metals which may or may not shield applied external magnetic fields depending on wall thickness, frequency, resistivity, and permeability of the material used. Chambers often have multiple ports, covered with vacuum flanges, to allow instruments or windows to be installed in the walls of the chamber. In low to medium-vacuum applications, these are sealed with rubber o-rings. In higher vacuum applications, the flanges have hardened steel knives welded onto them, which cut into a copper gasket when the flange is bolted on.

3.7.3 Low pressure steam (LPS)

The low pressure steam is the process which is connected to the steam stop valve so that the steam is not well equipped to generate to the steam turbine by this steam. So there will be another mechanism is used when the back flow of the steam will come this valve will be closed and that's why the steam cannot go through the steam stop valve finally this steam will be gathered in a process to the chamber where this gas will be flown through low pressure steam chamber.

3.7.4 Condenser A and Condenser B

In systems involving heat transfer, a condenser is a device or unit used to condense a substance from its gaseous to its liquid state, typically by cooling it. In so doing, the latent heat is given up by the substance, and will transfer to the condenser coolant. Condensers are typically heat exchangers which have various designs and come in many sizes ranging from rather small (hand-held) to very large industrial-scale units used in plant processes. For example, a refrigerator uses a condenser to get rid of heat extracted from the interior of the unit to the outside air. Condensers are used in air conditioning, industrial chemical processes such as distillation, steam power plants and other heat-exchange systems. Use of cooling water or surrounding air as the coolant is common in many condensers.

Here in APSCL two condensers is used condenser A and condenser B. So the condenser A is used to condense the total 440° c steam in to two stages to give the desired energy of the steam to the turbine to rotate the generator. First here the 40°C temperature steam will come to the dilator. Then on the other hand the 100° C temperature steam from the low pressure evaporator comes to the dilator. So the output 100°C temperature water will come which will go through the forced flow having the temperature of 230° C to the high pressure chamber. On the other hand high pressure evaporator will flow 240 ° C temperature steams to the high pressure chamber. The output of 440° C temperature steam will come through the super heater which is 40 bar super heated steam which will go to the steam turbine.

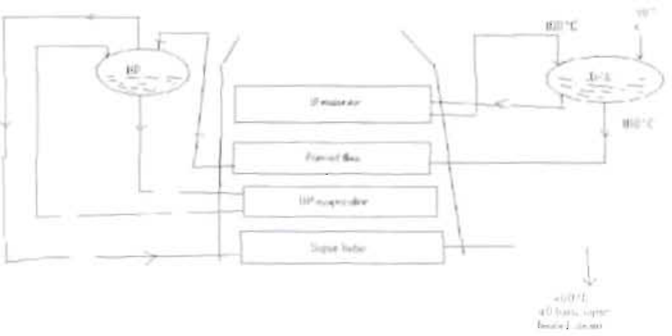

Figure 36: super heating process

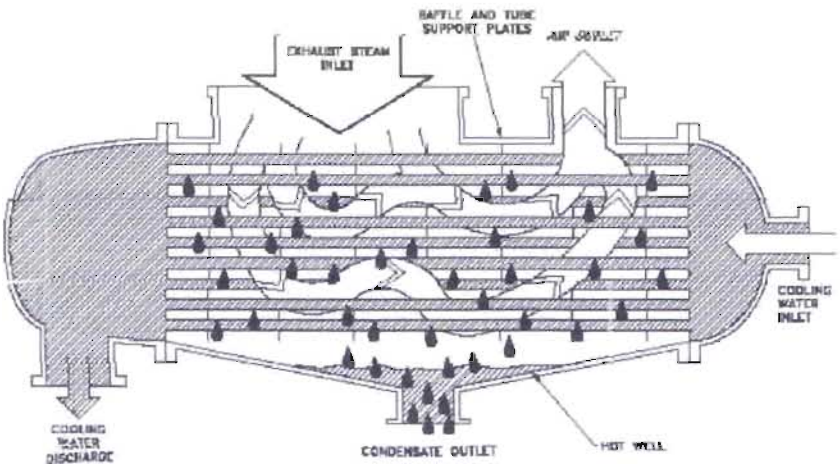

Figure 37: Condenser A and condenser B

3.7.5 Governor 1 & Governor 2

Governor is used to adjust the speed of the engine by adjusting the fuel input. So that the frequency of the generated voltage will remain constant in different loading condition.

Here in steam turbine the governor 1 and the governor 2 are used. When the cues valve is opened then the 440°c temperature steam is gone to the hp turbine to rotate the shaft of the 34.3KVA generator to rotate the steam turbine. The total process is done into two ways first the governor 1 is operated to control the speed of the turbine then after wards the governor 2 is operated to control the second step of constant speed supply. Otherwise the steam turbine will not run in the constant speed and vacuum chamber is also used to extract the gas from the chamber.

3.7.6 Pump steam valve

Pump steam valve are designed to transfer when a modulating valve controls the flow of steam to a heat exchanger. It is valve which will flow the steam to the heat exchange where these steam will be burned and is given to the generator through the condenser. When reverse steam will flow then the steam will be stopped by this valve.

3.7.7 Air extraction pump

The air extraction valve is to extract the hot gas from the steam turbine area so that the turbine will not become over heated. So that it will extract the gas and these gas will be exhausted in the atmosphere. Otherwise the turbine will become so heated; to remove the excessive heat we use the air extraction pump.

3.7.8 Protection and maintenance

The protection and maintenance of the steam turbine is same as the protection and maintenance of the gas turbine. So this section is described previously. The main deference is that there are two compressors and two governors and other steam controlling mechanism which is protected as the same as the procedure in gas turbine.

3.8 Combined cycle

In the combined cycle the combination of the gas turbine and steam turbine are used to produce to form the power generation and usually this power will be dissipated to the generator to form the electricity. In a thermal power station water is the working medium. High pressure steam requires strong, bulky components. High temperatures require expensive alloys made from nickel or cobalt, rather than inexpensive steel. These alloys limit practical steam temperatures to 655 °C while the lower temperature of a steam plant is fixed by the boiling point of water. With these limits, a steam plant has a fixed upper efficiency of 35 to 42%. In APSCL the gas turbine plant, steam turbine plant and combined cycle plant is used to produce the electricity. Mainly there are 2 gas turbines and 1 steam turbine. The exhaust gas from the gas turbine and the steam turbine is used to run the combined cycle plant.

Chapter: 04

Substation:

A substation is a component of an electricity transmission or distribution system where voltage is transformed from high to low, or the reverse, using transformers. A transmission substation transforms the voltage to a level suitable for transporting electric power over long distances. This is to minimize capital and operating costs of the system. Once it is transported close to where it is needed, a distribution substation transforms the voltage to a level suitable for the distribution system. In APSCL we visited the substation for three days and learnt about different types of Transformer, Circuit Breaker, Relay, Transmission Lines, Substation control system and transmission systems of APSCL. The instructors in substation division.

4.1 Transformer:

Figure 38: Transformer

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors -the transformer's coils. If a load is connected to the secondary, an electric current will flow in the secondary winding and electrical energy will be transferred from the primary circuit through the transformer to the load. Relation between induced voltage and number of turns is given below –

$$\frac{Vs}{Vp} = \frac{Ns}{Np}$$

Here,

Induced voltage in the secondary winding = V_S

Primary voltage =V_P

Number of turns in the secondary =N_S

Number of turns in the secondary =N_P

AC voltage is stepped up when N_s is greater than N_P and stepped down when N_S is less than N_P

4.1.1 Types of Transformer

The transformer can be categorized into General purpose and usage purpose transformer.

4.1.1.1 General Purpose Transformers

Current transformer

Potential transformer

Current Transformer (CT):

Figure 39: Current Transformer

The current transformer is used to measure the electric current. Current transformers are used extensively for measuring current and monitoring the operation of the power grid. To measure very high current which is not possible to directly apply to measuring instruments, we use a current transformer which produces a reduced current accurately proportional to the current.

Potential Transformer (PT):

They have a large number of primary turns and a few numbers of secondary turns. It is used to measure the voltage and control the high voltage. The potential transformer (used in APSCL) rating is given below –

Rated Voltage =132 KV	Highest system voltage = 145 KV
Construction = Outdoor	Insulation level = 275/650 KV
No. of phase = single	Rated frequency = 50 Hz
Ratio= 76.5KV/63.5V	Total weight = 600 Kg
Burden 60 VA	Class of accuracy = 0.2

Figure 40: Potential Transformer

Connection of PT

Ratio	Primary Connection	Secondary Connection
	A-N	a-n

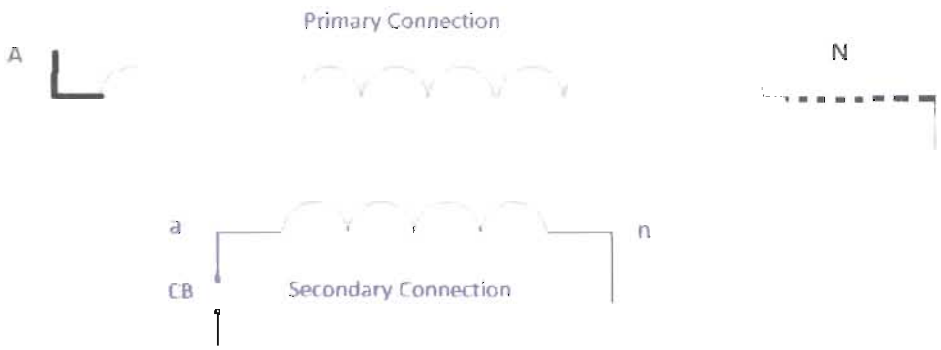

Figure 41: Connection diagram of PT

4.1.1.2 Usage purpose Transformer

Step up Transformer:

A transformer that increases voltage from primary to secondary is called a *step-up* transformer. This transformer steps up the ac voltage and steps down the current for reduced wire resistance power losses along power lines connecting generating stations with loads. Here secondary winding turns is greater than the primary winding ($N_S > N_P$).

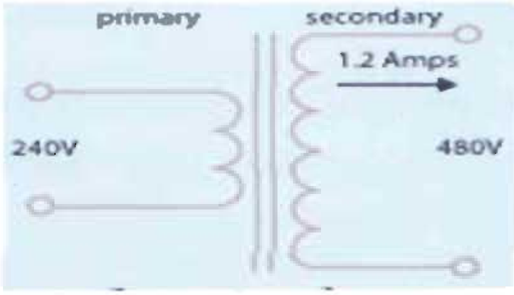

Figure 42: step up transformer

Step down Transformer:

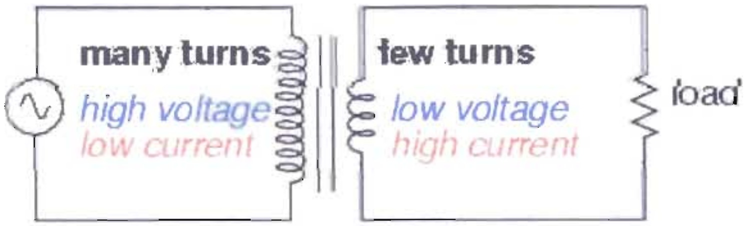

Figure 43: step down transformer

A transformer that decreases voltage from primary to secondary is called a *step-down* transformer. Here secondary winding turns is less than the primary winding ($N_S < N_P$).

Autotransformer:

Auto transformer is known as variable voltage transformer. In an autotransformer same winding act as both the primary and secondary but the winding is needed to be divided into portions known as tap.

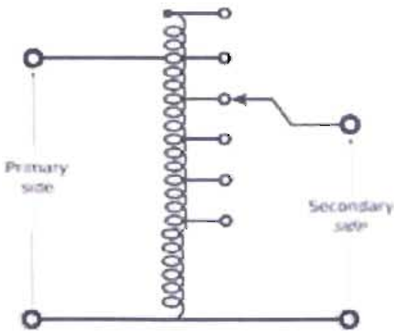

Figure 44: Autotransformer

The winding has at least three taps where electrical connections are made. An ordinary transformer provides electrical isolation between its winding but the autotransformer does not provide electrical isolation between its winding. Like multiple-winding transformers, autotransformers operate on time-varying magnetic fields and so cannot be used directly on DC. If the insulation fails in an autotransformer, the applied full input voltage will be found in the output terminal.

Applications of autotransformer:

1. Interconnect systems operating at different voltage level.
2. In industry, to get different voltage levels from a fixed supply voltage.

4.1.1.3 Regular Maintenance of a Transformer:

In APSCL, the regular maintenance checkup of transformer is pursued. This includes –

Color of silica gel crystal to make sure it is blue.

The nuts and bolts of the different parts of the transformers

Transformer cooling fan

The On load taps changer (OLTC) oil checking

Oil leakage checking

4.1.2 Condenser

An insulation which is made up of alternate layers of insulating material and metal foil. It is placed between the conductor and outer casing in terminals of transformers and other high-voltage equipment such as switchgears.

4.1.2.1 Lube Oil

Transformer Oil is highly refined electrical insulating oil developed for use in oil-immersed transformers, capacitors, tap changers and circuit breakers.

Applications

1. Oil-immersed transformers
2. Circuit breakers
3. Switches
4. Tap changers
5. Oil-immersed electrical equipment

Features and Benefits:

1. Excellent insulating properties
2. High dielectric strength
3. Low power factor
4. Resists oxidation
5. Excellent low-temperature properties
6. Compatible with materials used in transformers

4.1.2.2 Purpose of condenser

The main purposes of the condenser are to condense the exhaust steam from the turbine for reuse in the cycle and to maximize turbine efficiency by maintaining proper vacuum. As the operating pressure of the condenser is lowered (vacuum is increased), the enthalpy drop of the expanding steam in the turbine will also increase. This will increase the amount of available work from the turbine (electrical output). by lowering the condenser operating pressure, the following will occur:

1. Increased turbine output.

2. Increased plant efficiency.
3. Reduced steam flow (for a given plant output)

4.1.3 Breather

Breathers are used to absorb the moisture content from the sucked air, while the transformer oil gets expanded due to heating. Breathers make use of silica gel colored with brown used extensively in power transformers. This is an important part of the transformer as it provides an economic and efficient means of controlling the level of moisture entering into the electrical equipment like transformers. So in the transformers of the APSCL we checked the breather while visiting the substation.

Figure 45: Breather

4.1.4 Transformer Protection:

Transformers are a critical and expensive component of the power system.

In transformer some common failures are -

a. Winding failures due to short circuits
b. core faults (core insulation failure, shorted laminations)
c. Terminal failures (open leads, loose connections, short circuits)
d. On-load tap changer failures (mechanical, overheating)

So the protection schemes are very important. The protection includes –

1. Over fluctuation protection
2. Differential relay protection
3. Oil surge relay for OLTC (On load tap changer)
4. Buchholz relay protection.

4.2 Bus bar

In electrical power distribution, a busbar is a strip of copper or aluminum that conducts electricity within a switchboard, distribution board, substation or other electrical apparatus. The maintenance includes

1. Checking the clamps (sometimes it needs to be changed or tightened)
2. Checking the Insulation (resistance)

The bus bar arrangements are

1. Single Bus-bar
2. Double Bus-bar
3. Ring Bus.

Double Busbar is also known as Main and reserved Bus-bar.
The use for double busbar may be necessary when some of the following features are required:

1. Operation of incoming circuit breakers from non-synchronized systems
2. Load shedding of feeder circuits with a different level of importance during emergency conditions
3. Flexibility during inspection and maintenance procedures without load interruption
4. Extension without switchgear shutdown

Advantages and disadvantages of Double Bus bar

Advantages	Disadvantages
Flexibility of operations is increased	Cost of equipment is more
Extension of the switchgear without de-energizing is possible	Extension of the switchgear without de-energizing is possible
On load transfer is possible with certain double busbar designs	Cost of maintenance and spares holding is more
Non-synchronized systems can be used, to supply outgoing circuits	Cost of installation is more

Advantages and disadvantages of Single Bus-bar

Advantages	Disadvantages
Cost of equipment is less	Flexibility of operations is reduced
Requires less space	Extension of the switchgear without de-energizing is not possible
Ease of use	Load shedding is more complex

4.2.1 Synchronization:

When the generated power needs to be connected to the grid some conditions are required to be satisfied. They are-

a. Voltage magnitude is same.
b. The phase sequence of system must be compared to the phase sequence of the grid.
c. Frequency of the incoming generator is adjusted to be slightly higher than the running system.
d. Phase angle is equal. To keep the system in phase, we use the synchroscope.

In APSCL, before connecting to the power grid these conditions were checked first by the engineers. When they found all the conditions were satisfied, they connected the bus to the grid.

Over current relay protection

To protect a circuit against overloads and short circuit currents, a protective device must determine when a fault condition develops and automatically disconnect the electrical equipment from the voltage source. Slight overcurrent can be allowed to continue for a short time, but as the current magnitude increases, the protection device must open faster. Short circuits must be interrupted instantly.

Differential Protection

Differential protection is used to protect the windings of a transformer by comparing the current in the power supply's neutral wire with the current in the phase wire. The differential protection relay never operates when the currents are equal. But if there is a current inequality then the differential protection relay operates.

4.2.2 Isolation

The isolators consist of separate poles which can be arranged for single pole operation or linked together by operating rods.

Three types of isolators are

1. Center break isolator
2. Pantograph isolator
3. Double break isolator

Center break isolator:

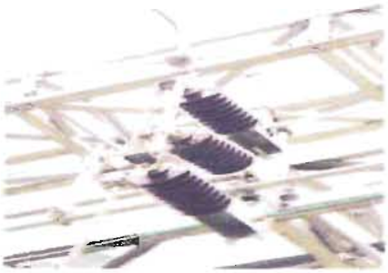

Figure 46: Center breaks isolator

1. Robust in construction
2. Good electrical & thermal conductivity
3. High long & short time current carrying capacity
4. Low contact resistance due to multi-point contact
5. Suitable for use at high continuous and short time temperature

Pantograph isolator:

Figure 47: pantograph isolator

While closing, the linkages of pantograph are brought nearer by rotating the insulator column. It is used in outdoor high voltage Sub-stations. It requires less area. The operating mechanism is manual as below:

1. Electrical motor operation
2. Pneumatic mechanism

Double break isolator:

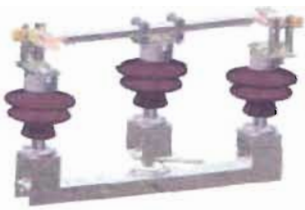

Figure 48: Double break isolator

1. Motor/Manual operating mechanisms.
2. Turn & twist mechanism with self-wiping contacts.
3. Fixed& moving blades are made out of hard drawn electrolytic copper
4. Simultaneous operation of three poles

4.2.3 Circuit Breaker:

A circuit breaker in a substation is a form of protection, designed to break fault current when fault is detected on the system. It also has secondary function allowing the system operator to switch circuits in and out. A circuit breaker allows a circuit to be reactivated after a short circuit or overload is cleared. The main difference with the fuse is fuses must be replaced when they are opened.

4.2.3.1 Vacuum Circuit Breaker (VCB)

In a Vacuum circuit breaker, vacuum interrupters are used for breaking and making load and fault currents. These circuit breakers are used to protect medium and high voltage circuits from dangerous electrical situations. In a vacuum circuit breaker two electrical contacts are enclosed in a vacuum. One of the contacts is fixed, and one of the contacts is movable. When the circuit breaker detects a dangerous situation, the movable contact pulls away from the fixed contact, interrupting the current. Because the contacts are in a vacuum, arcing between the contacts is suppressed, ensuring that the circuit remains open.

Figure 49: Vacuum Circuit Breaker

Advantages:

a. They are compact, reliable and have longer life.
b. There are no fire hazards
c. There is no generation of gas during and after operation
e. They require little maintenance and are quiet in operation
f. Can withstand lightning surges
g. Low arc energy
h. Low inertia and hence require smaller power for control mechanism.

4.2.3.2 Sulpher Hexafluoride (SF_6) circuit breakers:

In an SF6 circuit-breaker, the current continues to flow after contact separation through the arc whose plasma consists of ionized SF6 gas. The sulpher hexafluoride (SF_6) absorbs the free electron. The SF6 gas is non-inflammable so there is no risk of fire. Insulation problems are reduced as there are no carbon deposits. But these SF_6 breakers are costly due to the complicated nature of the enclosed system, and the high price of obtaining the SF6 gas. Moreover faulted SF6 gas must be carefully removed and can be toxic. The gas insulated transmission lines and power distributions are included in the applications of SF6. Due to the low energy the contact erosion is small.

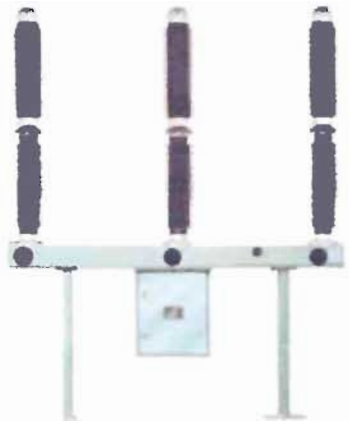

Figure 50: SF6 circuit breaker

Construction:

It consists of fixed and moving contacts which are enclosed in a chamber called arc interruption chamber.SF_6 gas reservoir is connected with this chamber. When the contacts of breaker are opened the valve mechanism permits a high pressure SF_6 gas from the reservoir to flow towards the arc interruption chamber. The fixed contact is a hollow cylindrical current carrying contact fitted with an arc horn. The moving contact is also a hollow cylinder with rectangular holes in the sides to permit the SF_6 gas to let out through these holes after flowing along the arc. The tips of fixed contact, moving contact and arcing horn are coated with copper-tungsten arc resistant material. Since SF_6 gas is costly, it's reconditioned and reclaimed by a suitable auxiliary system after each operation of the breaker.

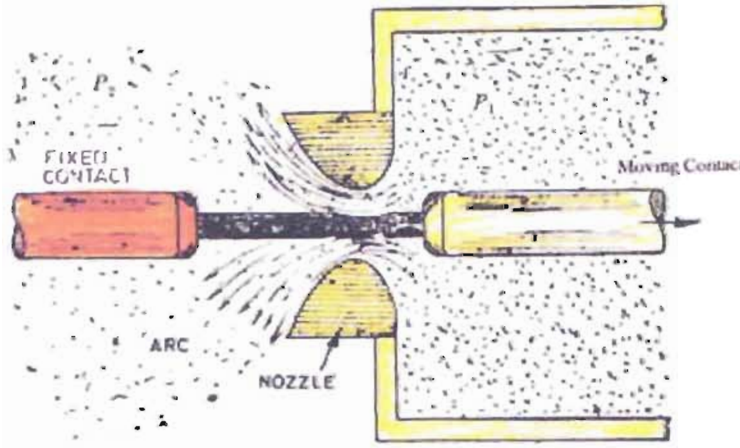

Figure 51: Constriction of SF6 Circuit breaker

Function:

SF6 circuit breakers work through arc interruption. When electrical current exceeds a certain level (called a rating), the breaker will trip and contacts within the circuit breaker will open to interrupt the circuit. When the current is interrupted, an electrical arc is created. An arc contains heat and voltage, so it must be contained and extinguished. The SF6 circuit breaker uses compressed sulfur hexafluoride (SF6) gas to cool the arc and absorb free conducting electrons. The electrons captured by the gas form mostly steady negative ions, creating dielectric insulation and extinguishing the arc.

4.2.3.3 Oil Circuit Breaker (OCB)

The oil in the circuit breakers used for

1. It insulates between the phases and between the phases and the ground
2. It provides the medium for the extinguishing of the arc.

The flammability of the oil and the regular maintenance of the oil (changing and purifying the oil) is the main disadvantage of the Oil Circuit breakers. Throughout the interruption of

heavy fault current the breakers are likely to move so the oil circuit breakers are usually fixed on concrete bases at the ground level.
The OCB nameplate data is given below:

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	

a. Bulk oil circuit breaker :

Figure 52: Bulk Oil Circuit Breaker

Bulk oil circuit breakers are enclosed in metal-grounded weatherproof tanks that are referred to as dead tanks. In bulk oil circuit breakers the arc extinction takes place in a tank. During interruption of heavy fault currents the breakers tend to move. To minimize the damage to the breakers, breakers with very high interrupting capacity have an impulse cushion is provided at the bottom of the breakers. The cushion is filled with an inert gas like nitrogen.

b. Minimum Oil Breakers

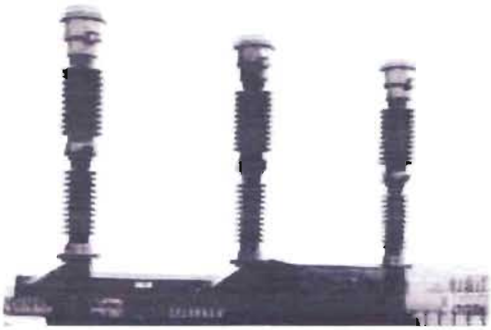

Figure 53: Minimum Oil Breakers

In minimum oil circuit breakers the arc extinction takes place in insulating housing enclosed in ceramic enclosures. The oil serves as both arcs extinguishing medium and main insulation in the bulk oil breakers whereas the minimum oil breakers reduce the oil volume only to amount needed for extinguishing of the arc about 10% of the bulk- oil amount. To improve breaker performance, oil is injected into the arc. For high voltages (above 132 kV), the interrupters are arranged in series. In minimum oil breakers the interrupter containers are made of insulating material which is insulated from the ground. This configuration is also known as live tank construction.

4.2.4 over Headed Line

Figure 54: Transmission Line (overhead line) in APSCL

Overhead power line means an overhead line for the transmission of electrical energy. Overhead power lines are generally the lowest-cost method of transmission for large quantities of electric energy. Considering the range of voltage the overhead power lines are classified as

a. Low voltage – less than 1000 volts
b. Medium Voltage (Distribution) - 1 kV to 33 kV
c. High Voltage (sub transmission) - less than 100 kV
d. Extra High Voltage (transmission) – 110 kV to 800 kV
e. Ultra High Voltage – higher than 800 kV

Conductors:

The commonly used conductor materials are Copper, Cadmium copper, Aluminum etc. Aluminum conductor steel reinforced (ACSR) are primarily used for medium and high voltage lines. The outer strands are aluminum which is a good conductor with low weight and cost. The center strand is of steel for the strength required to support the weight without stretching the aluminum due to its ductility (ability to deform under tensile stress). This gives the cable an overall high tensile strength. Though copper is a good conductor, it is rarely used due to its higher cost and less availability. The ACCC (Aluminum Conductor Composite Core) cable can double the current carrying capacity over existing transmission and distribution cable and can dramatically increase system reliability by virtually eliminating high-temperature drop.

4.3 Control Room:

In APSCL, the control room for substation is the place from where the equipment of the substation is monitored and controlled. There is motor operated disconnecting switch which are used to control the isolator of the substation. All the control equipment in APSCL is also under SCADA (supervisory control and data acquisition). They control the substation from the substation control room but if they fail or in any emergency the control equipment can be controlled remotely by SCADA. To control through SCADA system the equipment needs to be switched to SCADA mode or connect to the SCADA interface. The substation automation circuitries are also available in the control room. All the relays are automated. Previously they were needed to control manually. The meter is also available in the control room by which they regularly monitor the amount of power that is transferred to the grid. The control room includes-

1. Control panel
2. Relay panel
3. Announcement panel
4. Metering panel
5. Protection panel

4.3.1 over Current Relay

Lines are protected by overcurrent, distance-, or pilot-relaying equipment, depending on the requirements. Overcurrent relaying is the simplest and cheapest and the quickest to need readjustment or even replacement as a system changes. It is generally used for phase and ground fault protection on station-service and distribution circuits in electric utility and in industrial systems. An overcurrent relay is activated if the line current exceeds a certain value.

4.3.2 Impedance Relay

Impedance relays monitor the impedance between the relay location and the fault. When the overcurrent relays do not provide sufficient protection impedance relays are used. If the impedance falls within the relay setting, the relay will operate.

4.3.3 Earth fault relay

An earth fault relay is activated by the fault current flowing from line to earth. Normally these are combined to form what is known as a combined overcurrent and earth fault relay, which is widely used as back up protection if the main protection fails. When a fault occurs a current flow in the secondary winding of the current transformer. If the current is greater than the setting of the relay, the electromagnet is energized and attracts the armature. The action of the armature closes and opens the normally open and close contacts respectively. The shunt trip coil is energized or de-energized and the circuit breaker will trip.

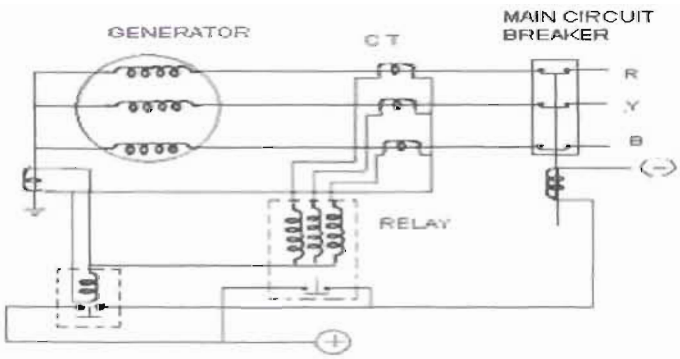

Figure 55: Over current and earth fault relay setup

4.3.4 Restricted earth fault relay

The restricted earth fault relays can be used to sense earth faults in a specified zone of the network. It is a type of unit protection that is applied to transformers or generators and is more sensitive than the method known as differential protection. An REF relay works by measuring the actual current flowing to earth from the frame of the unit. If that current exceeds a certain preset maximum value of milliamps (mA) then the relay will trip to cut off the power supply to the unit.

4.3.5 Buchholz relay

The gas and oil actuated relay is known as Buchholz relay. It is designed to detect faults and to minimize the propagation of any damage which might occur within oil-filled transformers, capacitors and reactors supplied with oil conservator.

Protection:

1. Broken-down core bolt insulation
2. Bad contacts
3. Overheating of some part of the winding
4. Short-circuits between phases
5. Leakage in the oil container or oil pipes

Figure 56: Buchholz relay connection

Construction:

The Buchholz relay takes the form of a domed vessel. It is placed in the connecting pipe between the main tank and the conservator. The device has two elements.

1. The upper element
   The upper element consists of mercury type switch. The upper element of the relay closes the alarm circuit during initial faults.

2. The lower element
   The lower element is located in the direct path of the flow of oil from the transformer to conservator. It is arranged to trip the circuit breaker in case of severe internal faults.

Advantages:

1. It detects the initial faults much earlier than any other forms of protection.
2. This is the simplest form to protect the transformer

Disadvantages:

1. The device can detect only faults below oil level in the transformer
2. It can only be used with oil immersed transformers which are equipped with conservator tanks

4.4 Description of 230 KV XPLE (Cross-linked polyethylene) Cable:

Figure 57: 230 kV XLPE Cable

1. Copper conductor, stranded, optionally with longitudinal water barrier
2. Inner semi conductive layer, firmly bonded to the XLPE insulation
3. XLPE main insulation, cross-linked
4. Outer semi conductive layer, firmly bonded to the XLPE insulation
5. Copper wire screen with semi-conductive swelling tapes as water barrier
6. Aluminum sheath
7. P.V.C (insulation purpose)

Chapter: 05

5.1 Problems

In APSCL we have introduced with the power generation, power distribution, and power maintenance and control operation. This is a huge power station. A short period of 100 credits hours is not enough to monitor all the details of this station. We had to make sure that we have utilized all the basic parts and concept of the power generation, power distribution, power maintenance and control operation within the short period we passed in this station. Here we face some problems which can be mentioned as:

a. Lack of time.

b. Lack of knowledge of the engineers.

c. Improper guidelines of the superior engineers.

d. Lack of accommodation problem.

e. Discontinuity of the engineers to give us the desired time.

f. Problems to get the important papers for preparing the report due to bureaucracy.

5.2 The future plan of (APSCL)

The future plan of APSCL is to develop few more plants which is discussed in the following table. By this the power plant will minimize the present problem of scarcity of electricity in future. The plants are:

50 MW (Thermal Power Plant)	APSCL	Already running
150 MW	APSCL	Tender cell
450 MW	APSCL	proposed
450 MW	APSCL	proposed
55 MW	Precision	Ready to launch
80 MW	Aggreko	Ready to launch
	United hospital	Ready to launch

5.3 Conclusion

APSCL is the second leading company in Bangladesh. Its strategic aim is to strengthen the leading position. We passed some remarkable days at APSCL during our internship program. By our internship program we have reached our expected practical experience. The completion of fifteen days industrial attachment at Ashuganj Power Station Company Ltd we have got the impression that this is one of the most important power stations in Bangladesh though it was established many years ago. The authorities in APSCL were very concerned about all kinds of safety. The friendly environment in APSCL encouraged us to co-operate with each other. Finally we learned a lot and obtained practical knowledge from our internship at APSCL, which will help us in our future life.

APSCL can be regarded as the practical ground for the students of the Electrical and Electronic Engineering Department of East West University. The theories that we have learned at the University can be observed at the APSCL. We consider ourselves very much lucky to have our internship program with a reputed power station company like APSCL. It gave us the opportunity to apply our theoretical knowledge in practice. The industrial training provided by APSCL has opened our eyes about practical operation of different equipments and increased our confidence to face interview in future as well.

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