INTERNSHIP REPORT

ON

BANGLADESH POWER DEVELOPMENT BOARD, RAJSHAHI

By

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Approved By

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Acknowledgement

First, we like to convey our heartfelt gratitude to Almighty Allah for His help to complete our internship successfully.

We would like to thank our supervisor Dr. Sharmin R. Ara, Assistant Professor, Department of Electrical & Electronic Engineering, East West University, Bangladesh, for giving us the opportunity to prepare this internship report under her supervision and guidance.

We would also like to mention the name of Dr. Mohammad Mojammel Al Hakim, respectable Chairperson and Professor of the Department of Electrical & Electronic Engineering, East West University, Bangladesh for his guidance.

We would also like to thank the management of Bangladesh Power Development Board for providing us with the opportunity to accomplish our industrial training at Bangladesh Power Development Board, Rajshahi. We also like to thank all the engineers and members of Bangladesh Power Development Board, Rajshahi for their guidance and suggestions and also for their precious time in answering our questionnaires. We also want to thank the deputy director of Bangladesh Power Development Board, Rajshahi, Engr. Md. Hasibul Huda, for providing us this opportunity.

Finally we want to thank all of our teachers, friends and family for their inspiration and cooperation throughout our whole academic life in EWU.

Executive Summary

To fulfill the large demand of electric power in Bangladesh, Bangladesh Power Development Board, Rajshahi is playing a vital role in power generation sector of Bangladesh. Bangladesh Power Development Board, Rajshahi (BPDB, Rajshahi) is a part of Bangladesh Power Development Board (BPDB) which is managing the Northern Zone.

We did our internship (first shift) at Bangladesh Power Development Board, Rajshahi (BPDB, Rajshahi) from 21th august to 29th august in 2017and then (second shift) from 6th September to 11septenber in 2017. During our internship we visited Katakhali 50MW Peaking Power Plant, Rajshahi, 132/33 kV Grid Project, PGCB, Amnura, Chapainababgang, Khulna Thermal Power Plant, BPDB, 33/11 kV substation, Horogram, Rajshahi, Baghabari Power Plant, BPDB, Baghabari, Sirajganj, Power Plant, BPDB, and gathered knowledge about diesel engine power plant, steam power plant, gas turbine power plant, grid substation and distribution substation. We have also learnt about power generation, transmission and distribution.

During our internship period we observed and gathered knowledge and experienced over the topics which we have learnt during our course of study. In this report we have focused on the operation of these power plants. We have also discussed about the power generation, transmission and distribution of these power plants, along with their protection mechanism.

Training Schedule

DATE	DIVISION	TIME	MENTOR
21/08/17 (Monday)	HFO plants and impact of IPP in Power sector	9 am to 6pm	Engr. Shoayeeb Muhammad Shaikh
22/08/17 (Tuesday)	Generator, HFO engine, cooling system of Katakhali 50MW peaking power plant	9 am to 6pm	Engr. Asique Rahman & Engr. Md. Tareq Mosarraf
23/08/17 (Wednesday)	Maintenance system of Katakhali 50MW peaking power plant	9 am to 6pm	Engr. Shoayeeb Muhammad Shaikh & Engr. Mahmudul Islam
24/08/17 (Thursday)	Amnura 1132/33 KV grid substation	9 am to 6pm	Engr. Md. Mostafizur Rahman
25/08/17 (Friday)	Auxiliary transformer, relays and circuit breaker of substation	9 am to 6pm	Engr. Md. Mostafizur Rahman
26/08/17 (Saturday)	Horogram 33/11 KV Substation	9 am to 6pm	Engr. Md. Hasibul Huda
27/04/17 (Sunday)	Gas turbine and its working principle at Baghabari Power Plant	9 am to 6pm	Engr. A.K.M. Tazedur Rahman
28/08/17 (Monday)	Maintenance Procedure of Startup and Shutdown process of Gas Turbine Power Plant	9 am to 6pm	Engr. Bozlurur Rahman
29/08/17 (Tuesday)	Boiler Management in Baghabari Gas Turbine Power Plant	9 am to 6pm	Engr. A.K.M. Tazedur Rahman
06/09/17 (Wednesday)	Metering System in power system at EAUD, Rajshahi.	9 am to 6pm	Engr. Md. Abdullah-AlMamun
07/09/17 (Thursday)	Working principle of thermal power plant	9 am to 6pm	Engr. Md. Mofazzal Hossain & Engr. Rezaul Karim
08/09/17 (Friday)	Maintenance procedure of turbine equipment and control system	9 am to 6pm	Engr. Nahid Rahman
09/09/17 (Saturday)	Boiler Management in in Khulna Thermal Power Plant	9 am to 6pm	Engr. Arif Reza Khan
10/09/17 (Sunday)	Different Stages of boiler SH/RH Panel/Tube at Khulna Power Plant	9 am to 6pm	Engr. Md. Mofazzal Hossain & Engr. Rezaul Karim
11/09/17 (Monday)	Risk factor of Power sector and future of power sector	9 am to 6pm	Engr. Hasina Dilruba

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Chapter One
Introduction

1 Introduction

This internship was an opportunity for us to gain some practical knowledge about the power sector of Bangladesh. We got this opportunity to do this internship in three different types of power plants under BPDB (Bangladesh Power Development Board). In this internship, we got the opportunity to learn about power generation, substation, transmission, operation and control system. In this chapter, we are going to give an overview about those power plants.

1.1 Objective of the Internship

The main goal of this internship is to achieve practical knowledge and experience about power station. In this internship report, we focused on generation process, various protection systems, control system, substation, and maintenance of the equipment such as generator, transformer and transmission of electricity at Katakhali,Baghabari and Khulna power plant.

1.2 Scope and Methodology

In BPDB, as an intern we got the opportunity to visit and learn practical knowledge about steam based power plant, HFO and Diesel fuel based power plant generation system, substation, control and maintenance of those plant.This internship report is based on the knowledge we have gathered during the internship period. We have experienced power generation of Katakhali, Baghabari and Khulna power plant. It covers the generation, operation, substation, instrumentation and control section of Katakhali, Baghabari and Khulna power plant. The data we have used here are collected during the internship period. The discussions with the superintendent engineer was very helpful.

1.3 Company Profile

Under BPDB, we have visited three different kinds of power plant. Those were, Katakhali Peaking Power Plant, Baghabari Gas Turbine Power Plant and Khulna Power Plant.

Table 1.1 Overview of Katakhali Peaking Power Plant

Name	Katakhali 50 MW peaking power plant
Year of establishment	2012
company Name	Bangladesh Power Development Board.
Location	Katakhali, Rajshahi
Capacity	50MW
Fuel type	HFO
Engine type	Diesel
Unit	6

Table 1.2 Overview of Baghabari Gas Turbine Power Plant

Specification	100 MW Unit	71 MW Unit
Date of commissioning	25th November, 2001	4th June 1991
Type	Gas turbine power plant	
Owner	Bangladesh power development board(BPDB)	
Generation	100 MW	71 MW
Builder company	Bharat Heavy Electricals Limited's (BHEL), India	Alstom, France
Type of fuel	Natural gas and fuel oil	
Shareholders	Government of Bangladesh	

1.3 OverviewofKhulna Power Plant

Project Location	Goalpara, Khalishpur ,Khulna
Owner	BPDB
Fuel Type	HFO
Manufacturer	SKODA(Czechoslovakia)
Inauguration	1973
Capacity	170 in total
Unit	2
Fuel Source	Bangladesh Government

1.4 Company's Mission and Vision

BPDB has mission to generate electricity for all over the country with a very reasonable and affordable price and has plan for increasing electricity according to the future demand. BPDB is working hard to provide reliable power supply to customer enabling socio-economic development. As part of the mission, BPDB, Rajshahi is playing a vital role in the development of the power sector in Bangladesh[2].These power plantsare increasing their capacity, based on recent and future demand of our country. Baghabari power plant has proposed a system for a combined cycle generation to increase the capacity.

Chapter Two

KatakhaliPeaking Power Plant

2.1 Introduction

Katakhali power plant is a 50 MW peaking power plant in Bangladesh. It is called peaking because this type of power plant supplies power during peak load hour.This is a diesel engine power plant and its fuel type is diesel and furnace oil. Diesel is called LFO (low fuel oil) and furnace is called HFO (heavy fuel oil). Use of LFO and HFO decreases the electricity production cost. The production capacity of the Katakhali power plant is 50 MW. This plant has 6 diesel engines and each engine's installed capacity is 8.73 MW. Though, present capacity of each engine is 8.33MW.

Table 2.1: Capacities of different units of Katakhali 50 MW peaking power plant

Power plant name	Unit	Installed Capacity(MW)	De-rated Capacity(MW)
Katakhali 50 MW peaking power plant	Unit-1	8.73	8.33
	Unit-2	8.73	8.33
	Unit-3	8.73	8.33
	Unit-4	8.73	8.33
	Unit-5	8.73	8.33
	Unit-6	8.73	8.33

2.2 Fuel Processing

In this type of power plants, diesel is used to start and stop the plants, and furnace oil (HFO) is used at during continuous running. The power plant startswith 25% load then the load gradually increases. After reaching 35% of the load, furnace oil replaces diesel. While stopping at the time of 35% load diesel is used to the power plant. There are two tanks of furnace oil tank (HFO). Each tank contains 50lakh litre HFO and also there are two diesel oil tank (LFO). Each tank contains 5 lakh litre LFO. For power generation the temperature of furnace oil should be kept 110^0–120^0 C. The storage temperature of furnace oil should be 40^0–45^0 C. This oil is transported into the buffer tank where its temperature is raised around 70^0-80^0 C. Then the oil is transferred to Day Tank through two pumps. There is a HFO separator. In HFO separator, the oil is purified and the pure oil goes to the day tank. The day tank maintainsat temperature at 100^0C.

Fig 2.1: HFO tank at Katakhali peaking power plant

Fig 2.2: LFO tank at Katakhali peaking power plant

2.3 Generator

In Katakhali power plant, AC generator is used for power generation. This type of generator is also called alternator which produces alternating current. For generating voltage, magnetic flux, conductor and relative motion between these two are needed. In a static magnetic field, if we rotate a conductor or the magnetic field by fixing one of them, then we get alternating current. So we can rotate the alternator field or keep static field to produce AC voltage [4]. In Katakhali power plant stator conductor is static and rotor's magnetic field is generated by DC excitation. When the rotor is rotating with dc excitation it creates magnetic flux which is cut by the stator coil. As a result induced voltage is created. In Katakhali power plant, there are 6 generators and each generator capacity is 8.7MW.

2.4 Generated Voltage and Supply Voltage

The generated voltage of Katakhali power plant is 11KV and the supply voltage is 132KV. This plant has 6 diesel engine generators and the plant takes 30-45 min to start. The generators start one by one. There is a step up transformer which raises the generated 11KV voltage to 132KV voltage.

Fig 2.3: 11/132KV Transformer at Katakhali power plant

Fig 2.4: Connection of the 132 KV line with national grid

2.5 Engine

There are six diesel engines at Katakhali 50 MW peaking power plant. The model of the engine is MAN 18V 32/40(Germany). It has 18V shape valve that's why it is called 18V MAN.The rotational speed of engine is 750 RPM. Each engine has air sucker for purifying the air from the environment and exhibit pure oxygen from purified air. There are four strokes in a diesel engine. The strokes are described next.

Suction

In this stroke the inlet valve is opened and the exhaust valve is closed. The piston moves from top dead centre to bottom dead centre. The inlet valve opens so that the air of the atmospheric pressure comes into the cylinder [6].

Compression

In this stroke both inlet and the exhaust valve are closed. The piston moves from bottom to top dead centre and the air which enters during the suction stroke, is now compressed and the pressure is high as well as the temperature [6].

Expansion

In this stroke both inlet and the exhaust valve are closed. The piston moves from top dead centre to bottom dead centre. But the time the piston reaches the bottom dead centre the exhaust valves start to open. At this time the fuel is injected into the cylinder. Then fuel is ignited by a spark plug. Then the fuel starts burning [6].

Exhaust

In this stroke the piston moves for bottom to top dead centre and the exhaust gases go out to the atmosphere through the exhaust valve. But when the piston reaches to the top dead centre the exhaust valve closes and gets ready for a new start [6].

Fig 2.5: Engines are coupled with the Generators at Katakhalipower plant

2.6 Cooling System

The generators ofKatakhali power plant run continuously for a long period of time and high current flows though the windings and the conductors of the generators. As a result a large amount of heat is produced. If this heat is not reduced it can damage the windings and other parts of the generator. For this reason cooling system is required to keep the temperature of the generator in control.

In Katakhali peaking power plant, there are two type of cooling system. One is water cooling system and the other is lube oil cooling system.

2.6.1 Water Cooling System

In this cooling system demineralized water is continuously pumped through the pipe slots of the stator and the shaft of the generator. As the demineralized water comes in contact with the hot parts, it absorbs heat. The water is then sent to the cooling chamber from where it is re-circulated after cooling. This demi water is used so that it does not cause corrosion of the pipes. There are two parts which is described next.

External Cooling System

For external cooling system the normal water is mixed with sodium chloride. Two pipes are attached to the each other, one contains normal water and the other contains the heated water. The normal water exchanges temperature with the heated water.

Internal Cooling System

Internal cooling system uses demi water. This de-mineralized water is filtered to get rid of impurities. As the de-mineralized water comes in contact with the hot parts, it absorbs the heat and then it is sent to the cooling chamber, from where it is re-circulated after cooling. De-mineralized water does not cause corrosion of the pipes,therefore it is safe for engines internal uses.

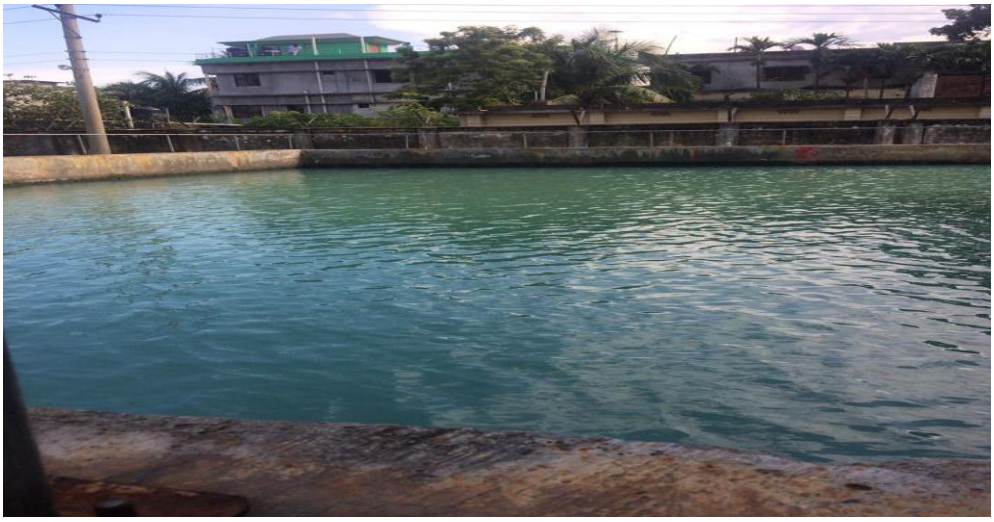

Fig 2.6: Demi water at Katakhalipeaking power plant

2.6.2 Lube Oil Cooling System

Now-a-days, the lubricating oil cooling system is preferred in power stations. Lube oil is used to protect the engine and the generator. Lube oil is used for internal cooling. The lube oil is stored in the bottom of the crankcase which is known as sump. The oil is taken by a pair of pumps through a filter. This oil has to pass through a cooler before it goes into the engine. It is then distributed to different branch pipes. The lube oil goes to the bearing and some oil will pass to the crankshaft end bearing and to the connecting rods. Filters are placed between the pipes. Mainly the lube oil is used to protect the parts, bearing from damage resulted by friction.

2.7 Protection System of Power Plant

Power system protection is one of the majortask, which deals with the protection from faults through the insulation of faulted parts from the rest of electrical network. The main purpose of protection is to keep the power system stable by insulating only the components that is under fault. So, protection schemes must apply for very strong fault. During emergency conditions, if any fault occurs in Katakhali Power Plant, the operators monitor the fault and trip the plant from control room.

2.8 Chimney

A chimney is a structure which provides ventilation for hot flue gases or smoke from a boiler to outside atmosphere.The flue gas passes through several numbers of equipment and finally goes into the nature through chimney. At Katakhali 50 MW power plant, they used six chimneys for six units.

Fig 2.7: Chimney of Katakhali peaking power plant

2.9 Auxiliary System

There are seven steam generators at Katakhali. Six of the steam generators are attached with six engines and another one is kept as backup. The steam generators generate steam and steams are used to raise the temperature of the HFO. There are different kinds of pumps. Fuel pumps, water circulation pumps etc. Here air is used for different purposes. Compressed air is used on thepiston to start the rotation. The pressure of the compressed air is around 25 bars. Air is usedfor different types of numeric valves. There is an emergency diesel generator in caseof emergency purpose.

2.10 Control Room

There are six IC engines and three transformersin one singlecontrolroom. Engineers are assigned to the control room and they control the whole system of this peaking power plant.

2.10.1 11KV Generation System

In Katakhali 50 MW peaking power plant there is a step up transformer raises the generated 11KV voltage to 132KV voltage. From the Fig 2.8 we can see that the operator can operate all of the fuel system of Katakhali power plant.

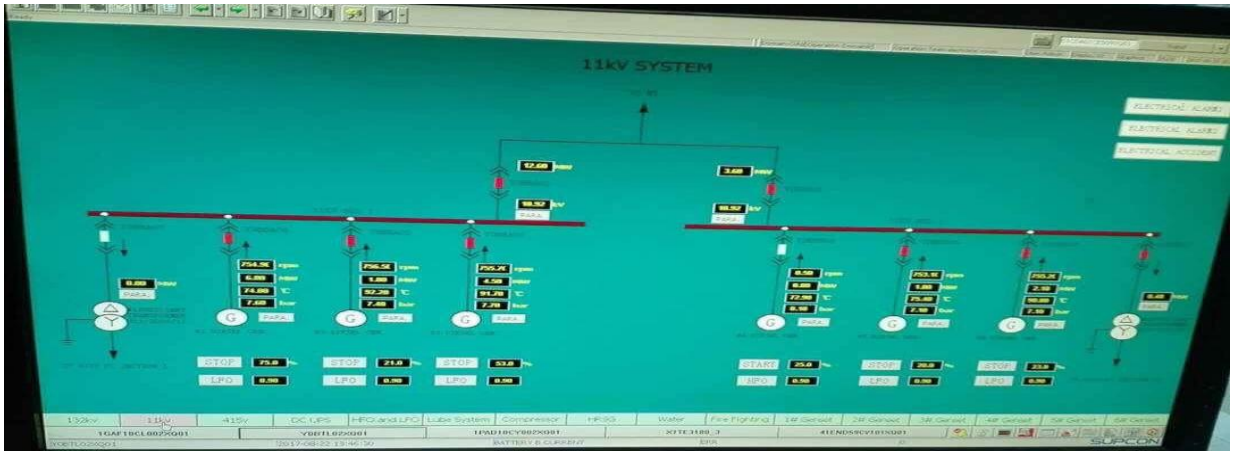

Fig 2.8: 11KV Generation system at Katakhalipeaking power plant

2.10.2 HFO and LFO Oil System

During start and stop time, LFO is used and the rest of the time, HFO is used. For HFO and LFO control system there is a software through which fuel system of the Katakhali power station is controlled. On thebelow Fig 2.9 shows this system diagrammatically.

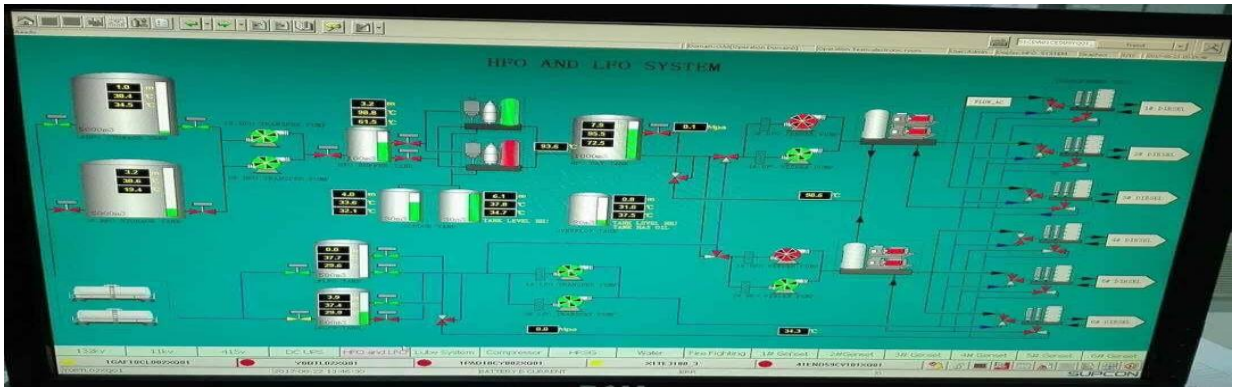

Fig 2.9: HFO and LFO system at Katakhalipeaking power plant

2.10.3 Water Supply System

In Katakhali power plant demi (de-mineralized) water is used. Water supply system is used for many purposes. For cooling system and other system, this system is controlled in control room. From Fig 2.10 we see the whole process of water supply system of Katakhali power plant.

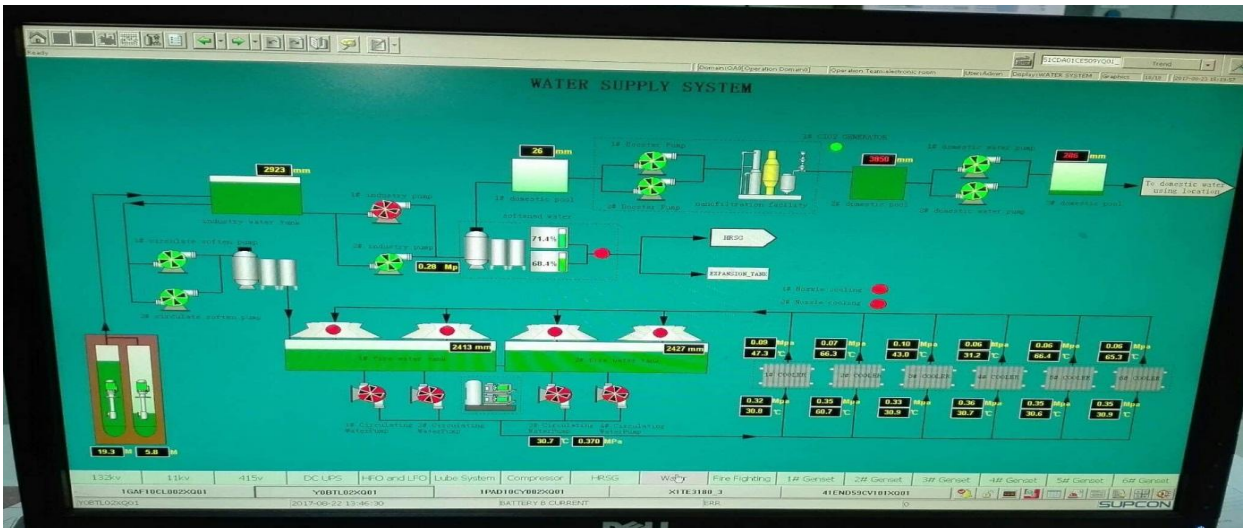

Fig 2.10: Water supply system at Katakhali peaking power plant

2.10.4 Heat Recovery Steam Generating System (HRSG)

HRSG system is used for water heating and raising the temperature of HFO oil in Katakhali power plant. Operator can control the whole process by monitoring the software. From the Fig 2.11 we see the whole process of HRSG system of Katakhali power plant.

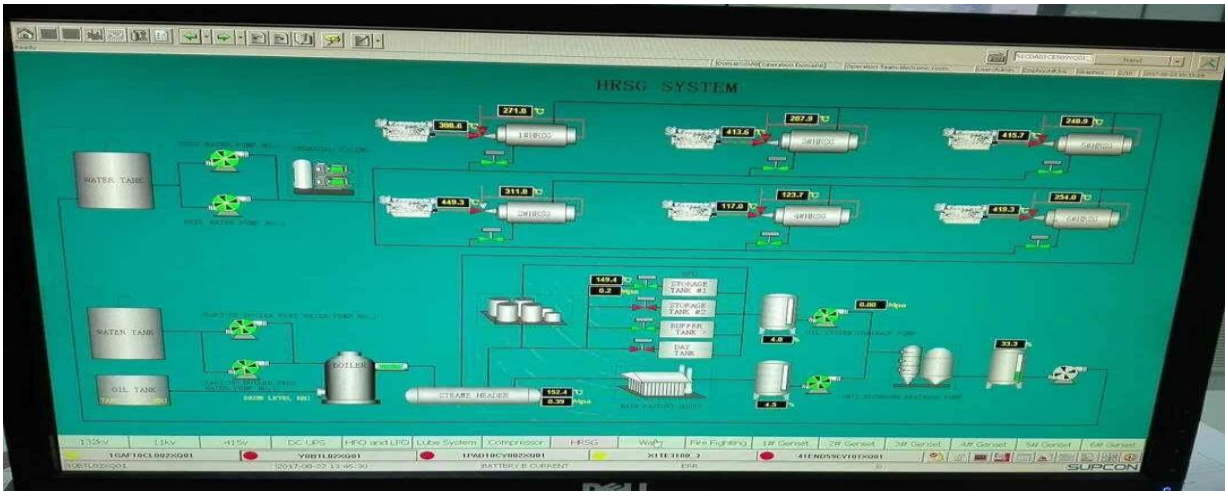

Fig 2.11: HRSG system at Katakhalipeaking power plant

Chapter Three

Baghabari Gas Turbine Power Plant

3.1 Introduction

Baghabari power station is one of the largest power station in Bangladesh. It is situated in Sirajganj district. It is a gas turbine power plant whose total generation capacity, 171 MW is generated by two units. Unit-1 generates 100 MW and unit-2 generates 71 MW. It is a base load power plant which is regulated by Bangladesh power development board (BPDB). The Alstom Company built 71 MW unit in 1991 and Bharat Heavy Electrical Ltd. built 100 MW in 2001.

3.2 Generation Process

A starting motor is used to start the compressor shaft and air enters the compressor. Then air is mixed with gas (natural gas) and goes to the combustion chamber. The mixture of air and gas ignites into the combustion chamber and goes to the turbine. A rotor is connected with turbine and rotates the generator. In Fig 3.1, the block diagram of gas turbine power plant is shown below:

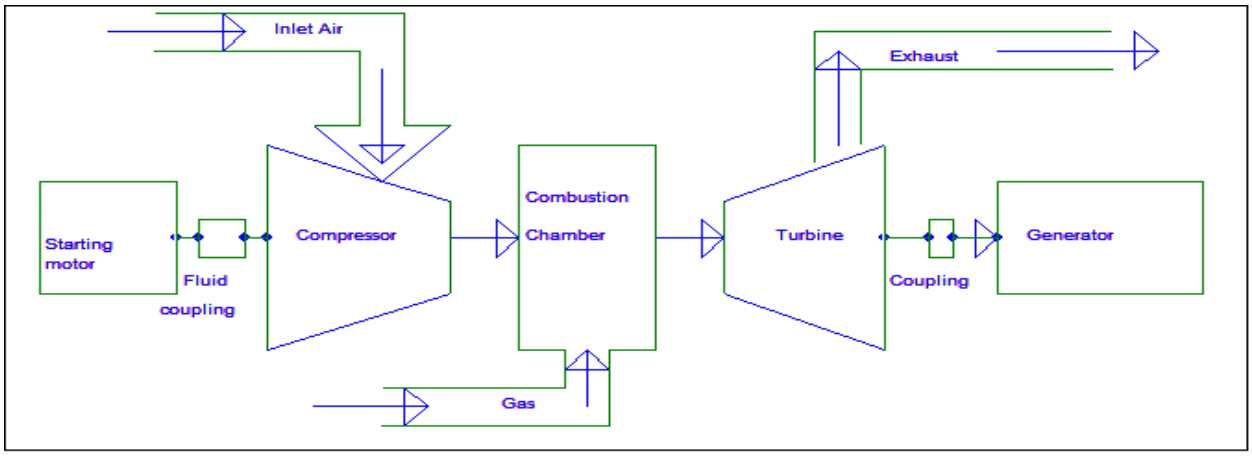

Fig 3.1: Brayton cycle for gas turbine power plant

3.3 Starting Motor

Starting motor is used to start the compressor. Starting motor and compressor are coupled through fluid coupling. Starting motor runs till 75% of rated speed and then it automatically gets disconnected.

Fig 3.2: Starting Motor

3.4 Compressor

Compressor is one of the major parts of Brayton cycle.At first, filters receive the air and refine it. Fresh atmospheric air flows through compressor. The pressure and temperature of inlet air is raised to 10 kg/m^2 and 300° C, respectively in the compressor. An additional gas booster is used here to maintain the gas pressure.

Fig 3.3: Inlet air filter receive the air

Compressor needs 60% of consumption power to operate itself. Compressor pressurizes the air and transfers that to the combustion chamber.

3.5 Combustion Chamber

When combustion chamber gets the compressed air, gas and air is started to burn in the combustion chamber. Here, the gas is natural gas. During this combustion, the ratio of air and gas is 10:1 and huge amount of heat is produced. In combustion chamber, there are 14 burners and each burner have an igniter. By spraying fuel into the air, igniter ignites it and generates a high-temperature flow.

Fig 3.4: Burner of combustion chamber

3.6 Turbine

Turbine is a mechanical device whose wheels or rotors are fitted with vanes. Turbine transfers rotational energy from a fluid medium. Turbine has a turbo machine that is connected with the rotor assembly. The turbine blades contain of moving fluid so that they move and impart rotational energy to the rotor.There are different types of turbines. Those are steam turbine (e.g.,impulse turbine, reaction turbine), gas turbine (e.g.,open cycle gas turbine, and closed cycle gas turbine), water turbine and wind turbine.

3.6.1 Gas Turbine

In Baghabari power plant, gas turbine is used. Turbine is coupled with upstream rotating compressor and downstream combustion chamber in a shaft. Gas turbine is known as combustion turbine. When high temperature and high pressure gas enters into the turbine, it expands and do the mechanical work. There are three stages in gas turbine, these are high pressure turbine, medium pressure turbine and low-pressure turbine.

Fig 3.5: Turbine and combustion chamber is coupled through a Shaft

To maintain the direction of flue gas, a nozzle is used. Flue gas is the main element of a gas turbine power plant. Maximum efficiency of gas turbine is 35%.

Open Cycle Gas Turbine(OCGT): In an OCGT, air enters through the compressor from atmosphere and burnt directly into the ignition compartment of burner. In the combustion chamber, a constant pressure and temperature of fuel is maintained. This high temperature and high air pressure will rotate turbine. Then exhaust is released to the environment.

3.7 Generator

Generator is a machine that converts mechanical energy into electrical energy. It is called synchronous generator because rotor rotates at synchronous speed (N_S), which is defined as

$$N_S=\frac{120f}{P}$$

Where,f= frequency

P=number of poles of stator

A synchronous generator can be either single phase or poly-phase. Due to many technical and economic advantages, 3-phase power is produced and therefore 3-phase alternator is used.

Fig 3.6: Generator of Baghabari gas turbine power plant

3.7.1 Specification

Table 3.2:Specification of the generator of Baghabari gas turbine power plant is given below:

Content	Unit 02	Unit 01
Capacity	100 MW	71 MW
Model	PG 9171E	PG 9111B
Frame size	9	9
Rated capacity	17×10^4 HP	11×10^4 HP
Shaft	Single	Single
Version	E	B
RPM	3000	3000
Control system	Mark V	Mark VI
Generated voltage	11 KV	11 KV

3.7.2 Construction of Generator

An alternator is coupled with downstream turbine and has two units. These are given below:

Rotor: The rotor is the rotating part of the generator. It has a DC source which is called the exciter. The weight of the rotor of this power plant is 30 ton. There are two types of rotor used in Baghabari power plant.

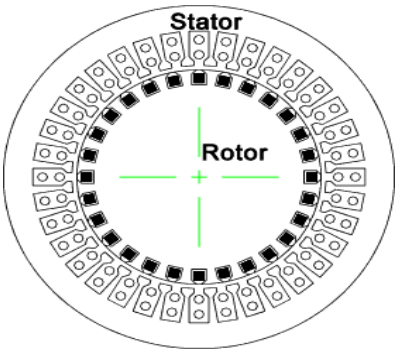

Fig 3.7: Rotor and stator winding of an alternator [3]

Stator: It is the stationary part of a machine. Stator winding is also known as the armature winding of the alternator. The armature winding is always connected in star and the neutral is connected to ground. The exciter contains permanent magnets that will supply auxiliary voltage to rotor [4].

3.8 Auxiliary Systems

The auxiliary system of a power plant is mainly used to maintain the plant. The auxiliary components of system are described next.

3.8.1 Auxiliary Transformer

An auxiliary transformer is used to supply power to auxiliary equipments of a power plant. It is a step down transformer. Power station always gets power from own system as well as from the grid. If the power plant is shut down, plant takes power from the grid to protect the whole system. In Baghabari power plant, a 3-phase 11/0.4 KV transformer is used to supply auxiliary power to system. There also two instrument transformers that are connected with its substation for protection. These are,current Transformer (CT) and potential Transformer (PT).

Fig 3.8: Auxiliary Transformer of Baghabari gas turbine power plant

3.8.2 Control System

Control system is the most essential part for any power plant. Faults and abnormalities are detected by control system. During the startup period of the power plant, it is monitored for avoiding any uncertain situation. Each system has two modes, one is auto and the other is manual. Automatic control system is mainly programmable logic (PLC) based system. When any kinds of fault occur, control system detects this fault automatically.

Fig 3.9: Control panel of Baghabari gas turbine power plant

3.8.3 Hydraulic Oil System

Hydraulic oil system is used to maintain the oil pressure. It contains inlet guide van (IGV), gas control valve (GCV), atomizing air system and trip circuit. If the hydraulic oil pressure decreases to the minimum limit then auxiliary hydraulic pump automatically operates.

3.8.4 Jacking Oil System

Jacking oil system is used in 71 MW unit which operates in turbine shaft. It consists of two pump, ac and dc. When ac pump fails then dc pump starts automatically. To avoid the thermal shock, rotor rotates slowly up to 24 hours even after the system shuts down.

3.8.5 Lube Oil System

Lubricating oil is another auxiliary system. Lubricating oil is supplied by three types of pumps, these are main lube oil pump, auxiliary lube oil pump and emergency lube oil pump.

Fig 3.10: Lubricating oil tank of Baghabari gas turbine power plant

Main lube oil pump operates in running condition. Emergency lube oil pump operates when pressure falls.

Fig 3.11: Front view of MIST ELIMINATOR

There is another device known as MIST ELIMINATOR which is utilized to release the lubricating oil pressure and filling every fluid medium before startup.

3.8.6 Turning GearSystem

It is used to rotate gas turbine during startup and works as a breakaway device. During cool down, turning gear system rotates the turbine rotor at specified cycles to prevent from the thermal damage. It consists with an electric motor which is connected with turbine shaft. This system includes a DC motor to prevent during AC power failure.

3.8.7 Gas Booster System

For burning fuel (gas), the system needs at least 20 kg/cm^2 pressure. When the pressure gets reduced to below this amount, gas booster system is started. When gas booster is needed, all the inlet and outlet gas valves are opened. Before running, main motor ensures that all the gas cooler fans and lubricating oil cooler fans are ready. Due to frequent variation of load, discharge pressure is maintained at 24 bars by slightly opening/closing the recycle valve. For shutting down the gas booster, the pressure is delivered to 22 bars and is opened recycle valve.

Fig 3.12: Gas booster units

Fig 3.13: Gas valve module

3.8.8 Cooling System

Cooling system is one of the most important part of a power station. Equipments may get damaged due to overheating only. So, cooling must be needed for protecting the system. The types of cooling systems of Baghabari gas turbine power plants are described next.

Water Cooling System

Water cooling system is used to cool down the lube oil pump. Demi (De mineralized) water is used in water cooling system. It consists of water circulating pump (AC), radiator and cooling fan. After absorbing heat from the lube oil, heated water is circulated through the radiator.

Fig 3.14: Water treatment plant of Baghabari gas turbine power plant

Air Cooling System:

In Baghabari gas turbine power plant, air cooling is used to cool down the generator and the turbine. Several fans are placed between turbine and generator, that carried out the heat away.

Fig 3.15: Air cooling fan of Baghabari gas turbine power plant

When air cooling mode is activated, in compressor cycle air carries out the heat and cools down the system. Air moves around turbine and generator, and heat is exchanged with air.

3.8.9 Protection System

System protection must be needed to maintain safety of all equipments of power plant. Any type of accident can create huge damage. Control room is used for monitoring the system, where protection of the system is also monitored by using relays and circuit breakers. If any fault is occurred in any equipment, the system trips immediately within a fraction of a second.

Fig 3.16: Different time relay

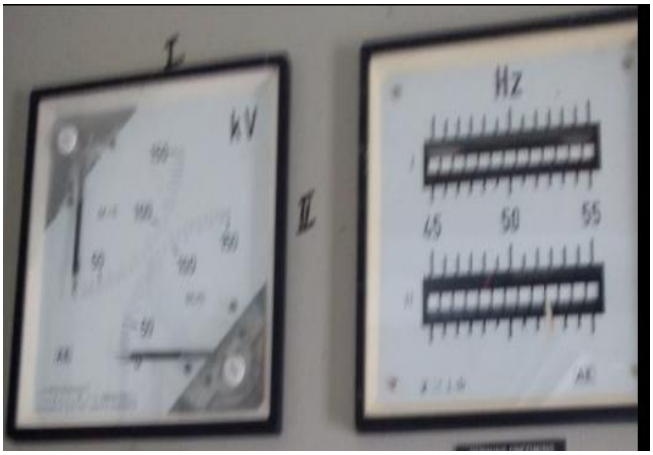

Fig 3.17: Voltmeter and frequency mete

Voltmeter, ammeter and frequency meter are also used for controlling the voltage drop, current flow and frequency of the system.

Chapter Four

Khulna Power Plant

4.1 Introduction

Khulna power station is a thermal power plant. The primary work was started in the period of Pakistan in 1968 but the construction was completed in 1973. There are two generation units, the first one is of capacity 60MW and the second unit is of capacity 110MW.

4.2 Generation Process

This is a thermal power plant, it generates thermal energy from hot steam. Here the generator is run by the turbine and turbine moves by the hot water steam. Generator, turbine, boiler and heater are the main components of the power plant.

4.3 Generator

A generator (electrical) is a device that converts mechanical energy into electrical energy. In Khulna power plant turbines are used as the source of mechanical energy. An AC generator is also known as alternator. The generator is designed and manufactured by SKODA (a Czech manufacturer company).

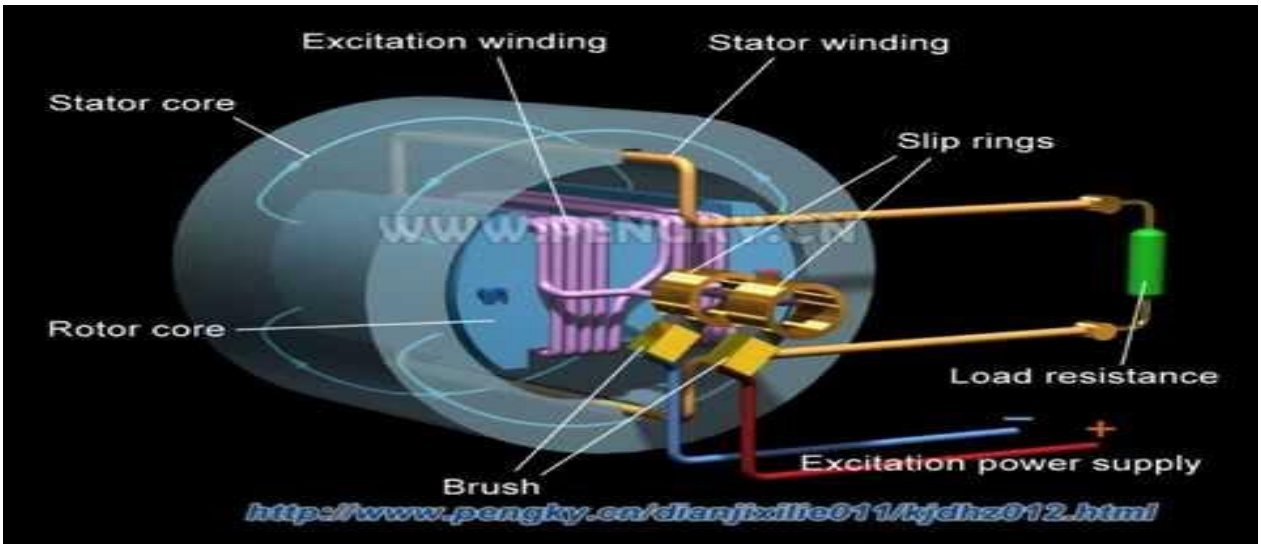

Fig 4.1: An internal view of generator[3]

Fig 4.2: A view of 110 Generator at Khulna power plant

Table 4.1: Specification of the generators in the Khulna Power Plant

Capacity	60MW	110MW
Type	H 632810 / 2 HH	HY. 644840/2HH
Design	TH2	TH32
Apparent power	75 MVA	137 MVA
Real Power	60 MW	110 MW
Stator Voltage	11 ± 7.5% kV	10.5 ± 5% kV
Stator Current	3940 A	7560 A
Rotor Voltage	75-240 V	20-100-346 V
Rotor Current	370-1000 A	80-468-1325 A
Speed	3000 rpm	3000 rpm
Frequency	50 Hz	50 Hz
Phase	Y	Y
Power Factor	0.8	0.8

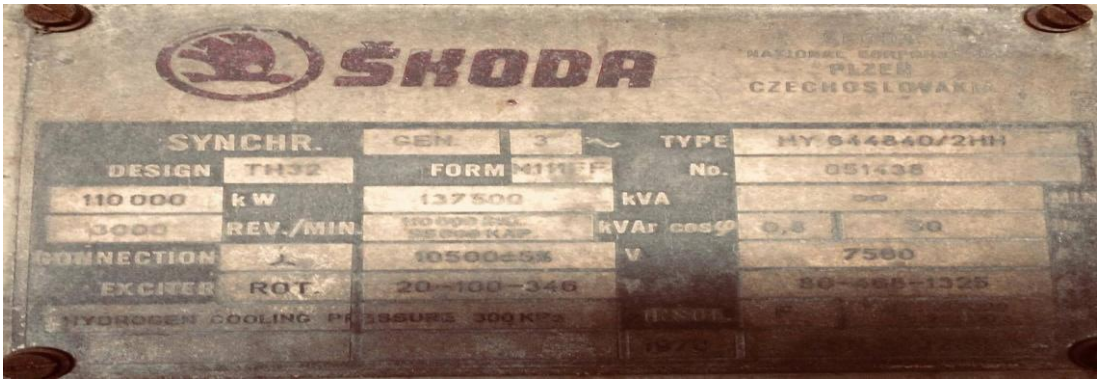

Fig 4.3: Nameplate of 110 MW Generator of Khulna power plant

4.4 Boiler

In any thermal power plant, boiler is one of the most important components. Boiler produces steam at a fixed temperature and pressure. In thermal power plant, steam is used to rotate the turbine blade. A water tube boiler is used in the Khulna power plant for each unit. The water tube boiler is designed in a way, such that the water is turn into the steam by the heat. Here, demi water is used for producing steam. The pressure and temperature of the boiler are always kept within the rated range to maintain the maximum utilization of heat and fuel. HFO (Heavy Fuel Oil) is used in the heater as fuel to heat the water to produce steam.

Table 4.2: Specifications of the boiler is given below:

Specification	Parameter
Feed water temperature	246^0 C
Normal working temperature	530 ^{0}C
Maximum Evaporation capacity	500 ton/hour
Heater type	Super heater
Maximum allowable steam pressure	161 kg/cm2

A boiler consists of several parts.These are, Boiler drum, Heater, Furnace and Economizer.

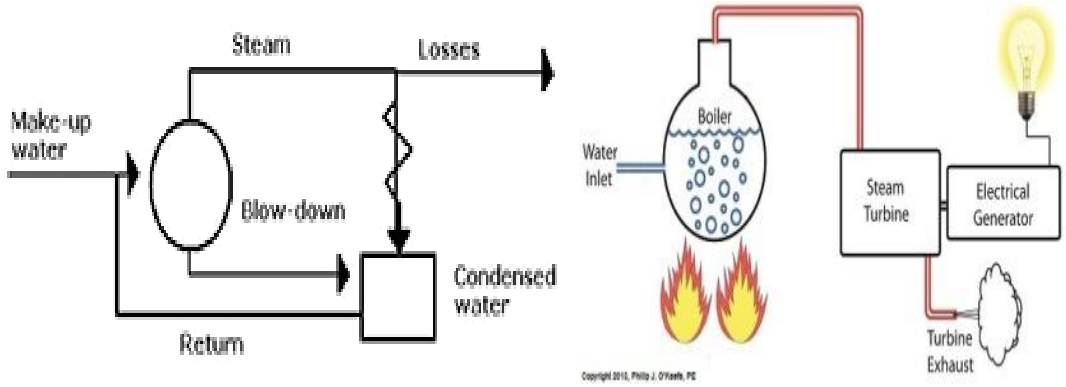

Fig 4.4: A view of Boiler [4]

Boiler Drum

To control the level of water in the boiler drum is very important. It controlled by automatic valve control system. Saturated steam is also reserved in the drum and from boiler drum, steam is transferred to the super heater.

Heater

In super heater (made of chromium- molybdenum), saturated steam temperature increases up to 538^0 C. The wet steam first gets dried and then raised to the temperature above the saturation temperature at constant pressure. Super heater and condenser cannot fully extract the heat from flue gases. Therefore, pre-heaters are employed to recover some of the heat from the escaping gases. The function of an air pre-heater is to extract heat from flue gases and transfer it to the air being supplied to furnace for coal combustion. This raises the furnace temperature and increases the thermal efficiency of the plant.

Furnace is a chamber where fuel is burned. The mixture of fuel and air in the furnace is burned by combustion. After the combustion the temperature rises up to 1200^0C. The furnace has 2 stages, upper header, from where the steam goes to the boiler drum and bottom header which stores the steam comes from Boiler Drum.

Fig 4.5: A view of Boiler Drum at Khulna power plant

An Economizer is used to increase the efficiency of the boiler. Generally, the boiler efficiency is around 30%. Economizer recovers the heat energy from exhaust fuel gas and transfers this energy to the feed water tank to use the heat energy. The feed water flows through some vertical tubes and the flue gases flows surrounding the tubes. The rest of exhaust goes to the chimney through some heat reducing process and then released to the environment.

4.5 Turbine

Turbine is a rotary mechanical device which runs by the flow of fluid. It produces mechanical energy and when the turbine shaft is directly coupled to an electric generator the mechanical energy its converted into the electrical energy. A turbine consists of shaft with blades. Moving fluid acts on the blades and blades start rotating.

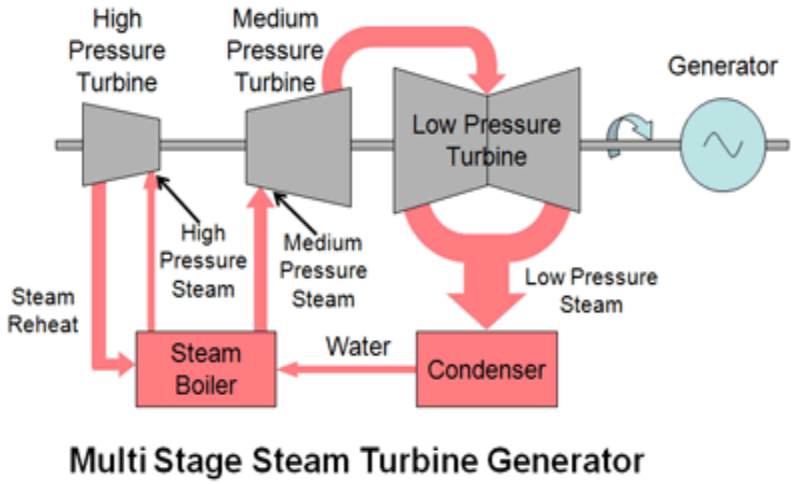

Fig 4.6: A Diagram of Steam Turbine[4]

In Khulna power plant, steam turbine is used to generate mechanical energy. In this type of turbine, pressurized steam is used to produce mechanical energy. It is a combination of reaction and impulse type turbine. Turbine's maximum efficiency is 30%. There are two units of turbine, one is for 60 MW and the other is for 110 MW units, respectively.

Fig 4.7: Name plate of Turbine at the Khulna power plant

Table 4.3:Specification of steam turbineis given below:

Specification	110 MW
Type No	Steam turbine K 110-130
Type	Condensing turbine/TPP
Rated Capacity	110MWe
Speed	3000 rpm
Manufacturer	Škoda Turbines
Efficiency	30%
Inlet steam temp	525℃
Inlet steam pressure	13 MPa
Reheat steam temp.	525 ℃

There are three stages of turbine in Khulna Power Plant. Those are:

4.5.1 High Pressure Turbine

In a high pressure turbine, a huge amount of steam is needed to rotate the shaft.The bladesof high pressure turbine is very small compare to low pressure turbine.It takes high pressure and high temperature within a low volume.

4.5.2 Intermediate Pressure Turbine

The intermediate pressure turbine is designed for lower pressure of steam. It is a medium pressure turbine. Steam released from the highpressure turbine, gets reheated and transferred to the intermediate pressure turbine. The Blades of intermediate pressure turbine is larger than the high pressure turbine. It takes less heated steam to expand. This stage of turbine is only usedin the 110 MW Plant.

4.5.3 Low Pressure Turbine

After the intermediate pressure turbine, the steam enters into the low pressure turbine and starts to expand with less energy. It has larger blades than the twoother turbines. This expended steam then enter into condenser. Here,more energy is extracted from the steam.

Fig 4.8: An unfastened view of low pressure turbine

4.6 Fuel System

In any kind ofpower plant**,** the cost of production of electrical power is based on the cost of fuel. Here, HFO (Heavy Fuel Oil) is used as fuelin heater to make the water into steam. HFO is high viscosity, tar-like mass. It is produced as a by productduringthe processing of crude oil. It is not costly as other purified oil.

Due to high viscosity and its semi fluid state, HFO needs to be preheated to make it combustible in engines. From the ship, HFO is first stored in a storage tank at 15-20^{0}C temp. Then it gets transferred to the service tank to make it usable for daily use by a transfer pump. A Low Pour Fuel Oil Pump sends the HFO to the filter.After filtering, HFO goes to the Burner through a fuel oil heater to the burner.

Table 4.4 Specifications of HFO of Khulna Power Plant (110 MW)

Content	Rating
Viscosity	55-60 cSt
Flash Point	150^{0}C
Air and Fuel Combination	12:1
Pour Quality	Low
Demand	450litre/min

Fig 4.9: Storage Tank for HFO.

4.7Auxiliary System

To run the main system of any power plant, an Auxiliary system is needed. Different components of the auxiliary system are described next.

4.7.1. Water Management:

It consists of water source, store, purification, water system flow. These are required for processing of water prior to producing steam. Water is used for cooling, producing steam and electrolysis for producing H_2. Water is a dangerous element for thermal power plant due to its heavy attraction tosulphur dioxide (SO_2), which is a major component of HFO. When it mixes with water vapor in the atmosphere, chemical reaction between these two, produces sulphuric acid (H_2SO_4), thereby produce corrosion on iron and make damages.There are two sources of Water in Khulna thermal power plant:

River: This source is only used during the dry season, i.e., November to April until the rainy season starts.

Deep Tube Well: Rest of the year, deep water is used for any purposes.

Purification

To make steam in the boiler, purification of water is a prior condition. The first step of purification is called clarifier. In clarification process, the raw water goes through a chemical treatment, where water gets mixed up with Al_2SO_4(Aluminum sulfate). The “Anthracite coal” of the filter removes any solid particles like sand, silt, etc. Clarifier removes 70% of un-dissolve solid from water. Then the water is passed through the filter. In this process the clean water is pumped to the filter. De-mineralization is the final task in water purification. Its done by ionizing the water, where cationic filter attracts the

cationand anionic filter attracts the anion. The resultant demineralized water is known as demineralized water. Now a days, reverse osmosis process is mostly used.

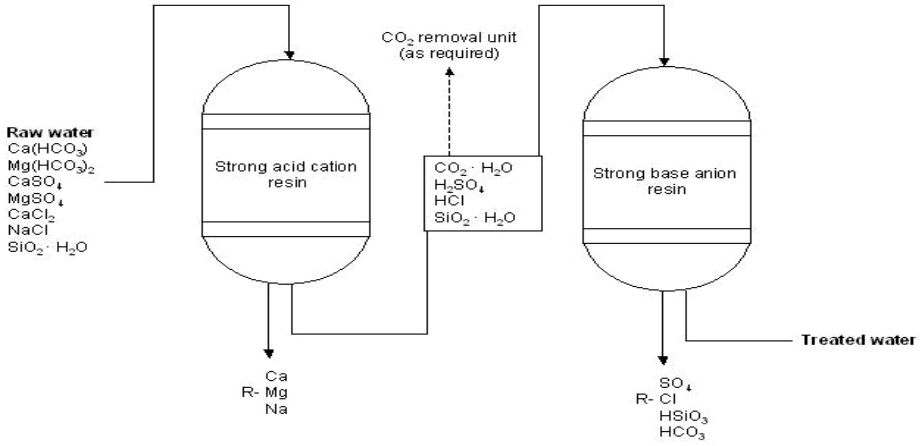

Fig 4.10: De-mineralization process of water

Table 4.5: Quality of the water used in this power plant is given below:

Conductivity	0.3% maximum
PH	9.5-11
Temperature	35^0C

4.7.2 Air System

In here, air is used for both cooler and burner. To make a plant cost effective air management has to be prefect or it can increase the cost of fuel, as well, of electricity.

Air Receivers

The air systems are known as vertical air receivers. The air receivers should be of welded construction. The receivers consist of manhole, drain connection, pressure gauges, relief valves and instrument connections.

Compressors

The total service air requirement for the station is supplied from control compressed air plant within the enclosure in air compressor. The delivered air to the compressor must be water cooled by intercooler with safety valve and moisture separator. An air intake filter and silencer are used to reduce noise. In compressor, the volume of the air is compressed to 60 times lesser than the received air.

4.7.3 Cooling System

The heat used to boil water gets produced from burning of fuel and air. Once steam passes through the turbines, it must be cooled back into water for the purpose of reused. Chilled water cools steam more effectively and increases the efficiency of the plant. Thisunwanted heat can lead to acceleration of wear and tear of the turbines. It can also compromise the efficiency of the power plant productivity. A working cooling system is therefore very important. In KPS, several cooling process are used based on device requirements. These are described next.

4.7.3.1 Water Cooling

Water carrying tubes surrounds the stator coils to cool the stator winding. Demi-water is supplied through the tubes to cool the stator coil. The water is supplied by the pump through hollow structured slots of the stator. The water in the tubes absorbs the heat of the stator and goes to the cooling chamber. The water is again re-circulated to the tubes for cooling. Water is also used to cool the hydrogen which is used to cool down the rotary part.

4.7.3.2 Hydrogen Cooling

Hydrogen cooling is used for the generator and for cooling the rotating part. In Khulna power station,an electrolyzer plant is used for cooling hydrogen. Between the gap of the stator and rotor, Hydrogen gas is inserted. As a result, Hydrogen gas absorbs the heat of the generator and transfers it to the water tube. A closed loop process is used for this cooling and a small fan is used to circulate the hydrogen gas.

4.7.3.3 Lube Oil Cooling

Lubricant oil is very important in every power plant.Lube oil is required to cool down the turbines. When the full system is about to shut down completely, the turbine keeps rotating with very low speed and supplied with lube oil for cooling process. The process continues until the total heat of the turbine is not absorbed by the lube oil. If the rotation of turbine gets stopped without cooling, the turbine may bend, resulting the requirement of the replacement of the turbine. Lube oil is also used for cooling different shafts, valves etc.

4.7.4 Pump

A pump is a device that raises, transfers, delivers or compresses fluids or that attenuates gases especially by suction or pressure or both [2]. The pumps are very essential to run any power plant. At KPS, various types of pumps are used for different purposes. Such as, feed water pump, circulating water pump, lube oil pump, jack oil pump, etc.

4.7.5 Transformer

It is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. A varying current in one coil of the transformer produces a varying magnetic field, which in turn induces a voltage in a second coil. Power can be transferred between the two coils through the magnetic field, without a metallic connection between the two circuits [4]. Transformers are used to increase or decrease the alternating voltages in electric power applications. At KPS, there is a unit transformer required to convert the generated voltage of 10.5KV into 132KV to supply produced power through 132KV Bus Bar for each unit individually. There is an auxiliary transformer to step down 10.5KV voltage to 6.6KV required for internal consumption of the plant.

Fig 4.11: Unit Transformer of Khulna Power Plant

4.8 Control System

Control system of a power plant performs various important tasks. To ensure the plant is workingoptimally, a monitoring system, either locally or in the control room is required. Transparency is a prerequisite for improving efficiency of the system. The SCADA system is required in control system. Every fault in any section of plant can be monitored from control room for quick assistance in case of failures. When any disturbance is found, it can be taken care of within fraction of second from control room. The control system of Khulna power plant is not so modern; all the monitoring tasks are done manual by using various switches which is time consuming.

Chapter Five

Amnura, Chapainawabgang 132/33 KV Grid Project, PGCB

5.1 Introduction

The generated electricity in any power plant is transmitted and distributed through substation. Substation is an important part of a power station. Generated powers are transferred to transmission and distribution lines through substations. In a substation, transformers are used to change the voltage and current level for measuring and protection purposes.

5.2 Amnura (Chapainawabgonj) 132/33 KV Grid Project

This is a double bus bar project under PGCB. 132 KV single pole line is connected from Rajshahi to Chapainawabgonj. National grid line incoming voltage 132 KV is stepped down to 33KV by transformer at this grid substation.

Fig 5.1: 132/33 KV transformer of Amnura grid substation

The main equipments of Amnura substation are

- Transformer
- CT
- PT
- Circuit Breaker
- Earthing switch
- Lightning Arrester

5.3 Bus Bar Arrangement

In Amnura, we have seen double bus bar arrangement. These bus bar lines are connected parallel. Bus bar is a copper wire which carries a large amount of current in a very high voltage. If any fault occurs in one line then another line is used as standby. Therefore,repairmentof the faulty line becomes easier. Incoming line 132 KV is connected to the bus bar system and outgoing line can be taken from identical bus.

Fig 5.2: double line bus bar at Amnura substation

5.4 Circuit Breaker

Circuit breaker isa necessary equipment for any substation. A circuit breaker is an electrical device which works as a switch and operates automatically when any abnormality is found. It is a protective device which protects the whole electrical system from abnormal condition, like overload, short circuit etc. If any abnormality occurs, the circuit breaker automatically disconnects the circuit from the system. In Amnura substation, there are two types of circuit breakers, these aredescribed next.

5.4.1 SF_6 Circuit Breaker

Sulphur hexafluoride (SF_6) gas is used as the arc quenching medium in SF_6 circuit breakers. SF_6 circuit breakers have very good arc quenching property.SF_6 is an electronegative gas and has a strong tendency to absorb free electrons. The contacts of the circuit breaker are opened in a high pressure flow of SF_6 gas and extinguish the arc from the contacts. SF_6 is very effective for high power and high voltage service [7].

Fig 5.3: SF_6 circuit breaker

5.4.2 Air Blast Circuit Breaker

Air blast circuit breakers work as an arc quenching medium in a high pressure air blast. At normal condition, the contacts are closed. When a fault occurs, contacts are opened. The opening of contacts is done by a flow of air blast established for the opening of blast valve. The air blast cools the arc and sweeps away the arching products to in the atmosphere. As a result the arc gets extinguished and the flow of current is interrupted [8].

5.5 Relays

Relay is an automatic device which senses the abnormal condition of any electrical circuit and closes its contacts. Relay operates a circuit breaker. Relay makes the circuit breaker tripped for disconnecting the faulty portion of the electrical circuit from rest of the healthy circuit. There are various types of protective relays in Amnura Substation. Some major types of relays are described next.

5.5.1 Differential Relay

The differential relay is used to compare primary current and secondary current of power transformer and if any fault finds, the relay trips both the primary and secondary circuit breaker of the transformer.

5.5.2 Distance Relay

Distance relay is very common on high voltage transmission systems. The operation of it depends on the value of voltage to current ratio. There is a predetermined value in this relay. When the ratio of voltage and current becomes less than its predetermined value then the distance relay operates. Another name of this relay is impedance relay.

5.6 Isolator

Isolator is a mechanical switch which is used to separate a circuit under no current or off load condition from the power system. Normally isolators are installed along with circuit breaker. If a circuit breaker trips then an isolator is used to separate circuit breaker from the system. If isolator opens under on load condition then arc creates and it could be hazardous for the system.

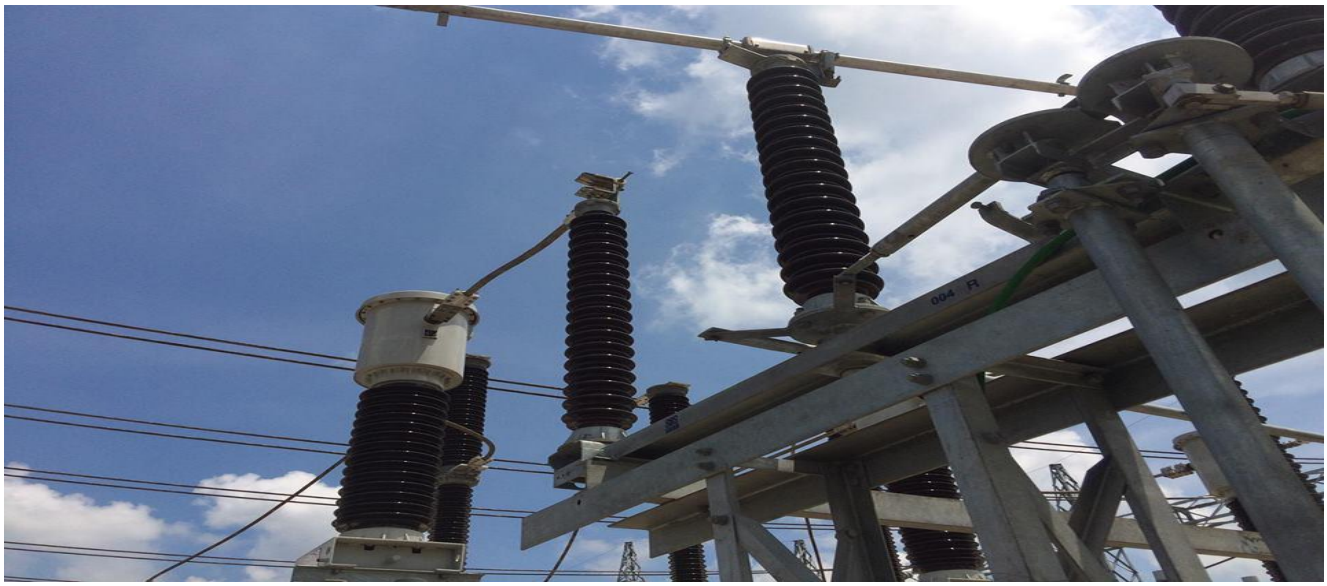

Fig 5.4: Isolator

5.7 Lightning Arrester

Lightning arrester is used at Amnura substation to protect the equipments of substation from the lightning surge. A lightning arrester is a device to protect the equipments of the system from the sky lightning or a surge voltage. Lightning occurs when clouds are highly charged with respect to ground. It has a high voltage terminal and a ground terminal. There are various types of lightning arrester. In Amnura substation, polymer metal oxide and zinc oxide arresters are mainly used. Lightning arrester is shown in Fig.5.5.

Fig 5.5: Lightning Arrester

5.8 Earthing Switch

Earthing switch is very essential for a substation. It is a switch between the line conductor and earth. Even when any line is off, there are still some charges which are trapped in the line. This trapped charge is very harmful for human. Before maintenance of that equipment the charge needs to be neutralized. Earthing switch discharges the trapped charge to earth and keep the equipment safe for human.

5.9 Cooling System

Cooling system is very important for a transformer to protect it from excessive heating. In Katakhali 50MW peaking power plant, oil natural air forced (ONAF) cooling system is used for transformer oil cooling. By applying forced air, it removes the heat from the radiator's surface.

Chapter Six

Horogram Substation

6.1 Introduction

Substation is an essential part of the power system. It converts high voltage level to low voltage level. Horogramn Substationis a distributing substation under Power Grid Company of Bangladesh (PGCB). It is mainly used for supplying power for locality. It has three feeders which are, 33KV incoming and two (11KV and 0.4KV) outgoing.

6.2 Transformer

In this substation, there are two step down transformers. One is converting 33KV into 11KV and other is converting 11KV into 0.4KV and transfer to the distribution line. There is also an auxiliary transformer which is used for substation's equipments.

Fig 6.1: Step down transformer

6.2.1 Classification of Transformer

There are two types of instrument transformers in this substation. These are:

Current Transformer: Current transformer is one kind of transformer that is used to measure AC current. Current transformers need close coupling between the primary and secondary to ensure that the secondary current is proportional to the primary current over a wide range of current. The rating of CT is 200/5A at 33KV and 800/5A at 11KV.

Potential Transformer: A potential transformer is a step down transformer. These transformers have a large number of primary turns and small number of secondary turns. Typically, PT rating is 33/0.11KV at 132KV line.

6.3 Battery Bank

Battery bank is one of the major equipment of a substation, because most of the protective equipments are supplied with DC. Battery bank is used for avoiding voltage drop, voltage rise, and earth fault. It is used to store DC voltage, controlling switchgear system and emergency motor, etc.

Fig 6.2: Battery Bank of Horogram substation

6.4 Protection Systems and Relays

Protection system is related to the total protection of a substation. The safety of the system is of prime importance and all the equipments are very costly and sensitive in a substation. The protection systems and protective devices are described next.

6.4.1 Lightning Arrester

Lightning arrester is a device that is used to protect the insulator and conductor against lightning surge. It has two terminals, one is high voltage terminal and the other is ground terminal. When a lightning surge travels along the power line to the arrester, the current from the surge is diverted through the arrestor. These prevent the flow of the normal power or signal current into the ground, as

well as, provide an alternate path over which high-voltage lightning current flows, bypassing the connected equipment. Their purpose is to limit the rise in voltage when communication or power line is struck by lightning or is near to a lightning strike[1].

Fig 6.3: Lightning arrester of Horogram substation

6.4.2 Earthing Switch

Earthingswitch is very important and essential part of a substation. It bypasses unwanted or over current through the bypass line to ground and thereby protecting the transmission line.

6.4.3 Disc Switch/Isolator

It is one type of manual switch that is used at front and behind the breaker. To on/off the isolator, power must be disconnected. It is used to ensure that an electrical circuit is completely de-energized for service or maintenance. If circuit breaker trips, isolator gets active automatically and isolates the circuit breaker from the system.

6.4.4 Circuit Breaker

Circuit breaker is an electric switch that is operated automatically to protect an electrical circuit from damage caused by over current, typically resulting from an overload or short circuit. The circuit breakers of this substation are given below:

SF_6 Circuit Breaker: In SF_6circuit breaker,SF_6 (sulfur hexafluoride)is used to separate two contacts for its excellent dielectric strength and arc-quenching properties. When the contact separation is done, current flows through the arc medium and arc is cooled by a SF_6 gas.

Fig 6.4: SF_6 circuit breaker of Horogram substation

Vacuum Circuit Breaker: Vacuum circuit breaker is another kind of circuit breaker where arc quenching is done in vacuum. The operation of switching on and closing off any current carrying contacts and interrelated arc interruption takes place in a vacuum chamber in the breaker which is called vacuum interrupter [2].

Oil Circuit Breaker: Oil circuit breaker contains two contacts, one is fixed contact and the other is a moving contact and both are submerged into the insulating oil. After separating the current carrying contact, the arc is initializing the circuit breaker. At this moment, the contact gets separated and oil is vaporized. The oil circuit breaker is very old type of circuit breaker.

Fig 6.5: Oil circuit breaker of Horogram substation

6.4.5 Differential Relay

The differential relays are those type of relays that are used when there is a difference between two or more electrical quantities that exceeds a predetermined value. It operates depending upon the

differences between two or more similar electrical quantities. Current cannot flow through the relay coil at normal operating conditions. If any abnormal condition is occurred, some current flows through the relay coil. At that time the circuit is tripped. There are two sets of current transformers, each connected to both side of the equipment protected by differential relay.

6.4.6 Overcurrent Relay

Overcurrent relay is a type of relay that operates when overcurrent flows through the power system due to short circuit or ground fault, etc. When any fault occurs inside the feeder, it trips. For the feeder protection, one or more overcurrent relays are connected with the feeder. It always operates automatically because relays observe and monitor the system continuously.

Fig 6.6: Overcurrent relay of Horogram substation

6.4.7 Overvoltage Relay

Overvoltage relay is similar to overcurrent relay but overvoltage relay is connected with line by a potential transformer that measures the voltage and check whether voltage limit is exceeded or not. If the voltage limit exceeds its predetermined value, then relay coil trips the circuit.

6.4.8 Control Room

Control room is a very important part of any substation. In Fig 6.7, three ammeters are shown. These are used for measuring load current and ensure that all the phases are connected appropriately. If any

phase is disconnected or doesn't supply current at this time, that particular phase ammeter shows zero reading of this meter. On the other hand, if any type of fault occurs in this substation, there is an alarm and also there is a manual switch to clear the fault. A control panel is shown Fig 6.8 that includes all the manual switch of substation. When any fault occurs, it is shown in the display and results in an alarm.

Fig 6.7: Three phase Current and voltage load measurement

Fig 6.8: Alarming system of control room

6.5 Bus Bar

In this distribution substation, a single line bus bar is connected where incoming and outgoing lines are connected. A 33KV incoming line from bus bar is connected with a step down transformer which converts it into 11KV.

Fig 6.9: Bus bar arrangement of Horogram substation

6.6 Cooling System

Cooling system is very necessary for protection of all equipments of a substation as overheating damages the system. A cooler fan is externally connected with each transformer to cool down.

Fig 6.10: Cooling fan

If the heat of the transformer is not dissipated properly, it damages the transformer. It is essential to control the temperature within permissible limit to ensure the long life of transformer by reducing thermal degradation of its insulation system. In electrical power transformer, external cooling system is used to accelerate the dissipation rate of heat from transformers.

Chapter Seven

Metering

7.1 Introduction

Metering system is one of the most vital arrangements in the power system. It is required for measuring the power as well as for controlling system and fault measurement. It is also used for other different purposes. It is the important system to observe the indication of any hazard. The metering system measures and records the several importantparameters of electricity.In the generation sector, metering is used to check the generation level. Metering system is extensively used in distribution sector. Energy meter are used to measure the amount of power consumed by a load.

7.2Working Principle

It is connected between two nodes, one is before entering the load and another point is the last point of the load to measures electricity. In the analog meters, there is a disc which rotates with the flow of current. One unit of power consumption is measured in terms of the rotation of the disc. In the digital meters, it similarly counts the consumption but the readings are shown in a digital format. The unit of power consumption is kilowatt hour (KWhr). Onekilowatt consumption for an hour is defined as one unit. When meter gets two different values then the meter will record the highest value between two consecutive months. The distributors take the difference between two consecutive months and calculatethe consumed energy of the most recent month.

7.3Classification of Meter

There are two types of meters which are mostly used in power sector. These are described next.

7.3.1. Single Phase Meter

Single phase meter is used widely for household purposes and also for commercial uses. To connect a singlephase meter, a single phase line is required. Generally single phase lines carry 230V voltage difference between the phase and neutral. The configuration of a single phase meter is very easy and can be mounted on the 230V single phase line, where one of two connections is for incoming 230V live line and other one is for neutral line. Therefore, they are called 1-Phase2-Wire meter. The measured values can be seen in analog or digital format. There are some differences between analog and digital metering. The current range is 10-40A for analog and 10-60A for digital and meter constant is 1600 imp/kWh for digital single phase meter. In every metering arrangement, accuracy is

very important to minimize the loss of supplier. There are two types of classes based on accuracy, these are Class 1.0 and Class 2.0. The accuracy of Class 1.0 is better than Class 2.0.

Fig 7.1: Single Phase EnergyMeter (Analog)

Fig 7.2: Single Phase Energy Meter (digital)

7.3.2 Three Phase Meter

Three phase connection is usually used in industrial purposes. Generally to run an induction motor or three phase load, the three phase metering is needed. In three phase connection each phase carries 230V,and the line to line voltage is 400V. The configuration of a three phase meter is not easy as of a single phase meter. There are total 4 points for input, where 3 points are for three phases and another one is for neutral. Therefore, these are called 3-Phase 4-Wire meter. For digital meter, the rated current is 10-60A and meter constants are 1000 imp/kWh and 1000 imp/kVARh. There are also two types of meter based on accuracy, and these areClass 1.0 and Class 2.0, where accuracy of Class 1.0 is better than Class 2.0.

Fig 7.3: A view of Digital Three Phase Meter

7.4 Meter Testing

Metering test is very important for the distribution sector. It is necessary to measure its consumption with an acceptable range of accuracy. Meter can be manipulated (bypass or tamper) to get the power without paying for it by the dishonest consumers. A common way of tampering is to tamper the mechanical disk is to attach magnets outside of the meter. It can lead a huge amount of loss. Therefore, regular meter testing is required to reduce the losses and prevent the energy theft. The smart and prepaid meters can stop energy theft.

Chapter Eight

Conclusion

8.1 Discussion

Before this internship, we had only theoretical knowledge about power system and power station equipments. After this internship, we can relate our theoretical knowledge with the practical equipments of power plants. We have learnt about steam turbine power plant, gas turbine power plant, diesel engine power plant, HFO based peaking power plant, grid substation, and distribution substation,etc. We have observed various protection schemes which are used for the protection of the equipments. We have also learnt about the excitation systems of the generators and motors. During our internship, we gathered practical knowledge which will be helpful in our professional career.

8.2 Problems

During this internship, we have faced some challenges. These are:

- The duration of the internship time was only 15 days which was not sufficient for gaining proper practical knowledge.
- As all the machines and equipments were in operational mode in Katakhali and Khulna power plant, it was difficult to learn about all the equipments practically.
- The safety equipments were not available in Khulna power plant.

8.3 Recommendations

On completion of this internship, we would like to recommend a few things for the future students:

- The duration of internship should be increased.
- Before doing internship, students should complete all the relevant courses, such as, power station and switchgear.
- Everyone should be aware of the precautions and safety rules of a power station.

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