STUDY ON MAINTENANCE SYSTEM OF SANTAHAR 50 MW PEAKING POWER PLANT

This field study submitted in partial fulfillment of the requirements for the Award of Degree of

Bachelor of Science in Electrical and Electronic Engineering

Submitted By

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Certification

This is to certify that this field study report entitled "**STUDY ON MAINTENANCE SYSTEM OF SANTAHAR 50 MW PEAKING POWER PLANT**" is done by the following students under my direct supervision and this work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held......

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The report entitled **"STUDY ON MAINTENANCE SYSTEM OF SANTAHAR 50 MW PEAKING POWER PLANT"** submitted by **Moslamin Sikder**, ID No: **152-33-2715, Mahmudul Hasan,** ID No: **152-33-2683,** Session: Summer 2015 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical and Electronic Engineering** on 25 May 2019.

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Dedicated to

Our Parents

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List of Abbreviations

AC	Alternating Current
DC	Direct Current
kVA	Kilo Volt Ampere
KW	Kilowatt
MW	Megawatt
EMI	Immune to Electromagnetic Interference
EMF	Electromagnetic Field
HRSG	Heat Recovery Steam Generator
BPDB	Bangladesh power Development Board
DPDC	Dhaka Power Distribution Company Ltd.
PGCB	Power Grid Company of Bangladesh Ltd.
LED	Light Emitting Diodes
REB	Rural Electricity Board
HFO	Heavy Foul Oil
LFO	Low Fuel Oil
CT	Current Transformer
PT	Potential Transformer
LV	Low Voltage
HV	High Voltage
SF6	Sulfur Hexafluoride
MCB	Miniature Circuit Breaker

MCCB	Molded Case Circuit Breaker
MCC	Main Combustion Chamber
O&M	Operation and Maintenance
LCP	Local Control Panel
T/C	Turbo Charger
ST	Steam Turbine
STG	Steam Turbine Generator
SLD	Single Line Diagram

List of Symbols

λ	Wavelength
λ_B	Bragg wavelength
n_{eff}	Effective index
Z	Position along the grating
N	Mode index
F	Fundamental Frequency
ω	Angular frequency
M	Modulation Index
T	Fundamental Time Period

ACKNOWLEDGEMENT

First of all, we give thanks to Allah for his divine blessing makes us possible to complete this Field study report successfully. Without his blessing, it was impossible for us to overcome the abstract to reach our desired destination.

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To our beloved family, we want to give them our deepest love and gratitude for being very supportive and also for their inspiration and encouragement during our studies in this University.

EXECUTIVE SUMMARY

The internship report titled “**STUDY ON MAINTENANCE SYSTEM OF SANTAHAR 50 MW PEAKING POWER PLANT”**. This is basically diesel engine base power plant. This type of power plant fuel source is diesel and furnishes oil. Diesel is called LFO (low fuel oil) and furnish is called HFO (heavy fuel oil). The main objective of the internship is to study the various equipment of the power plant and extrovert our theoretical knowledge to the practical field with adequate conceptualization and understanding the performance of parameters in case of Power generation, Operation, Maintenance and troubleshooting of Engine, Control Panel, Transformer, Circuit breakers.

This power plant have six diesel engine. Which used as the prime mover of the alternator. Each engine’s installed capacity is 8.73 MW.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The utility electricity sector in Bangladesh has one national grid with an installed capacity of 21,419 MW as of September 2019 and the total installed capacity is 20,000 MW (combining solar power). Bangladesh's energy sector is growing [1]. In recent times Bangladesh started construction of the 2.4-gigawatt (GW) Rooppur Nuclear Power Plant expected to go into operation in 2023[2]. According to the Bangladesh Power Development Board in July 2018, 90% of the population had access to electricity. However per capita energy consumption in Bangladesh is considered short.

Electricity is the most important source of power for most of the country's economic activities. Bangladesh's overall installed electricity generation capacity (including captive power) was 15,351 megawatts (MW) as of January 2017 and 20,000 megawatts in 2018.

The biggest energy consumers in Bangladesh are industries and the residential sector, followed by the commercial and agricultural sectors. As of 2015, 92% of the urban population and 67% of the rural population had contact to electricity. An average of 77.9% of the population had contact to electricity in Bangladesh. Bangladesh will need an estimated 34,000 MW of power by 2030 to sustain its economic growth of over 7 percent [3].

Problems in Bangladesh's electric power sector include high system losses, delays in completion of new plants, low plant efficiency, inconsistent power supply, electricity theft, blackouts, and shortages of funds for power plant maintenance. Overall, the country's generation plants have been unable to meet method demand over the past decade. On 2 November 2014, electricity was returned after a day-long nationwide blackout [4]. A transmission line from India had failed, which "led to a cataract of failures throughout the national power grid," and blame of "old grid infrastructure and poor management." However, in a recent root-cause analysis report the investigating team has simplified that the fault was actually due to absence of coordination and poor health of transmission and distribution infrastructure that caused the blackout [5].

1.2 Objective of the Internship

The main objective 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 Santahar 50 MW peaking power plant.

1.3 Scope

In Santahar, as an intern we got the opportunity to visit and learn practical knowledge about HFO and Diesel based power plant generation system, substation, control and maintenance of that plant. This was a great scope for all of us to relate all our theoretical knowledge with practical knowledge and to realize how a power plant runs by all these important sections.

1.4 Methodology

This internship report is based on the knowledge we have gathered during the internship period. We have experienced power generation of Santahar 50 MW Peaking power plant. It covers the generation, operation, substation, instrumentation and control section of this power plant. The data we have used here are collected during the internship period. The discussions with the superintendent engineer was very helpful.

CHAPTER 2

POWER PLANT DESCRIPTION

2.1 Information of Santahar power plant

Santahar power plant is a 50MW 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 Santahar power plant is 50MW [6]. 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 Overview of Santahar power plants

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

2.2 Install Capacity of Santahar Power Plant

The production capacity of the Santahar power plant is 50MW. 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 [6].

Table 2.2 Capacities of different units of Santahar 50MW peaking power plant

Power plant name	Unit	Installed Capacity(MW)	De-rated Capacity(MW)
Santahar 50MW 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

2.3 Mission and Vision

Santahar 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. Santahar is working hard to provide reliable power supply to customer enabling socio-economic development. As part of the mission, Santahar power plant is playing a vital role in the development of the power sector in Bangladesh. This power plants are increasing their capacity, based on recent and future demand of our country.

CHAPTER 3

GENERATION

3.1 Introduction of Generation

Power generation systems are simply the combination of a potential or stored energy converter providing kinetic energy. The power plant includes engines, generators and also the auxiliary equipment are required for power production. The engine and also the generator are mounted on a typical base frame, constituting a generating set [7]. The auxiliary equipment is especially mounted on modular units. The generating sets and part of the auxiliary apparatus are located in the power house. Every power plant has own procedure for operate the plant. Power plant produces electrical energy, which is most important factor for developing a country. Therefore, operational procedure of a power plant should be reliable and continuous process. Power plant generates electricity with continuous process. Before starting check, starting procedure and after start observation.

All procedures and the starting equipment are discussed in this chapter.

3.2 Basic Operation of HFO Power Plant

In HFO power station, an internal combustion engine that uses HFO as the main fuel (light fuel for starting and stopping engine), generators and also the auxiliary equipment required for power production. The engine and also the generator along represent a generating set. The engines have closed circuit cooling water systems with cooling radiators put in outside the power house. The thermal engine converts the thermal energy, made by the combustion of a mix of air and HFO/diesel provided in volumes, temperatures and pressures controlled by a semi-automated servo system, into mechanical power [8]. This power is transmitted by the engine's shaft then converted into electrical energy by a three-phase synchronous generator.

3.3 Working principle of Santahar Diesel engine power plant

Step1: Demineralized water pump.

Step 2: Start HRSG (Heat Recovery Steam System) power supply.

Step 3: Start up the boiler supply

Step 4: Start the compressor

Step 5: Open the compressor air valve after in engine room the air pressure raised 25 bars.

Step 6: Open the steam valve in HFO booster unit and when steam pressure raised at 4 bars.

Step 7: Start the LFO pump from the control room.

Step 8: Start the HFO pump from the control room.

Step 9: Start booster and viscosity pump.

Step 10: Run the engine and produce electricity.

3.4 Demineralized water pump

In the Santahar Power plant, demineralized water is often used for boiler feed water and steam generation. Boilers that generate steam to power turbines require high pressure boilers and therefore more complex feed water treatment method to remove as many impurities as possible. When steam is produced inside the boiler, the water little portion collect and condense, then are recycled and used as part of the boiler feed water. Technically, the condensate that the steam-making process produces is distilled, but dissolved gases such as oxygen and carbon dioxide are sometimes present. The chemical reactions due to the presence of these dissolved gases can cause strong corrosion on boiler pipes and parts. So, before the start Engine, all Water pump should be start [9].

3.5 Start Heat Recovery Steam Generator (HRSG) Power supply

The HRFG boiler uses the hot exhaust gases from the engine to produce steam. The boiler is a horizontal smoke tube boiler generating saturated steam. Manually operated steam soot blowers clean the boiler. Steam used by the soot blowers is taken from the steam outlet line of the boiler [10].

3.5.1 Specification of HRSG boiler

Table 3.1 Specification of HRSG boiler

Item	Specification
Steam capacity	1000kg/h
Rated work pressure	.8Mpa
Rate steam temperature	175 ˚C
Inlet air temperature	320 to 370˚C
Outlet air temperature	200 to290˚C
Dimension	3700×2650×2800mm
Air flow	18.5kg/s

Figure 3.1 HRSG boiler

3.6 Startup Boiler

The startup boiler is used for heating water in start-up of the power plant by burning light fuel oil. The boiler is also used for heat recovery system maintenance and as a back-up for the exhaust gas boilers. The LFO burner in the auxiliary boiler is controlled by temperature switches according to the temperature of the auxiliary boiler.

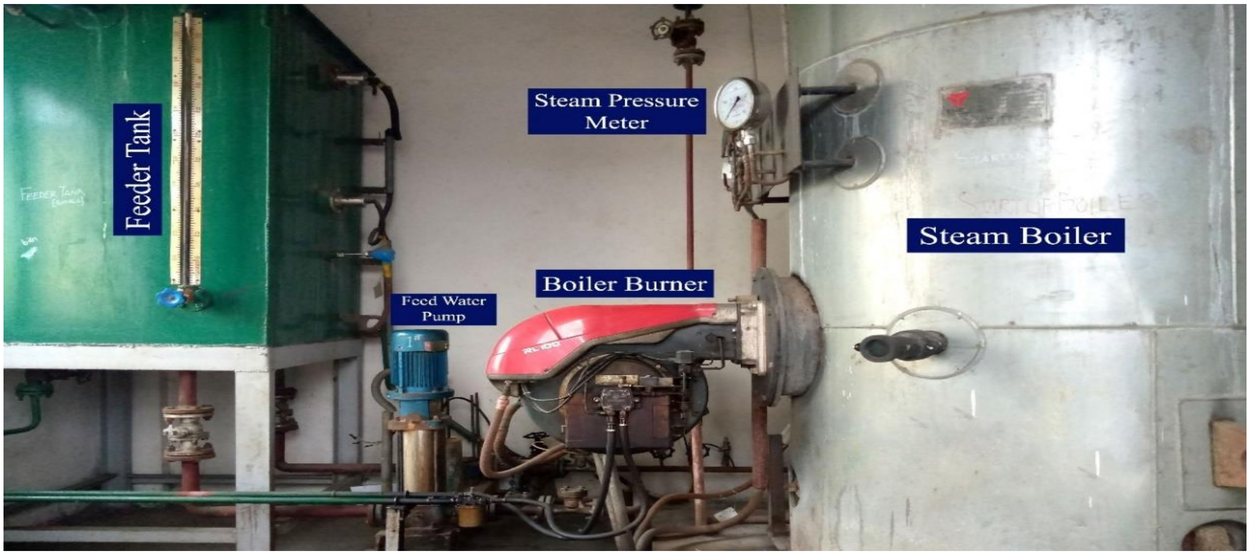

Figure 3.2 Startup Boiler

3.6.1 Typical startup process

- Check all valves and place in their startup position
- Open the sight gauge and water column high- and low-water shut-off valves. Make sure the water level safety controls are blown out.
- Close the bottom blow down valves, then open the upper drum vent valves.
- Start filling with soft water.
- Manually inject boiler water treatment chemicals including oxygen scavenger chemicals, so that the chemicals are added with the fill water.
- Once full to the operating level, open the fuel system and fire the boiler. Carefully bring the pressure up to 10-15 PSIG, with the vent valve open. The boiler's warm-up curve should be strictly followed. The standard warm-up curve for a typical boiler is not to increase the boiler water temperature over 100°F per hour.
- After the pressure reaches 10-15 PSIG, close the drum vent and slowly bring the boiler up to operating pressure.
- Collect a boiler water sample and test for the proper chemical concentrations. Adjust as needed.

3.7 Steam generation system

The steam is used for heating purposes in the HFO power plant. There are two-way, steam is produced in the power plant. Steam is generated from the startup boiler when exhaust gas is not available and on the on the other way, steam is produced in the HRFG boiler by recovering heat from the exhaust gas of the engines.

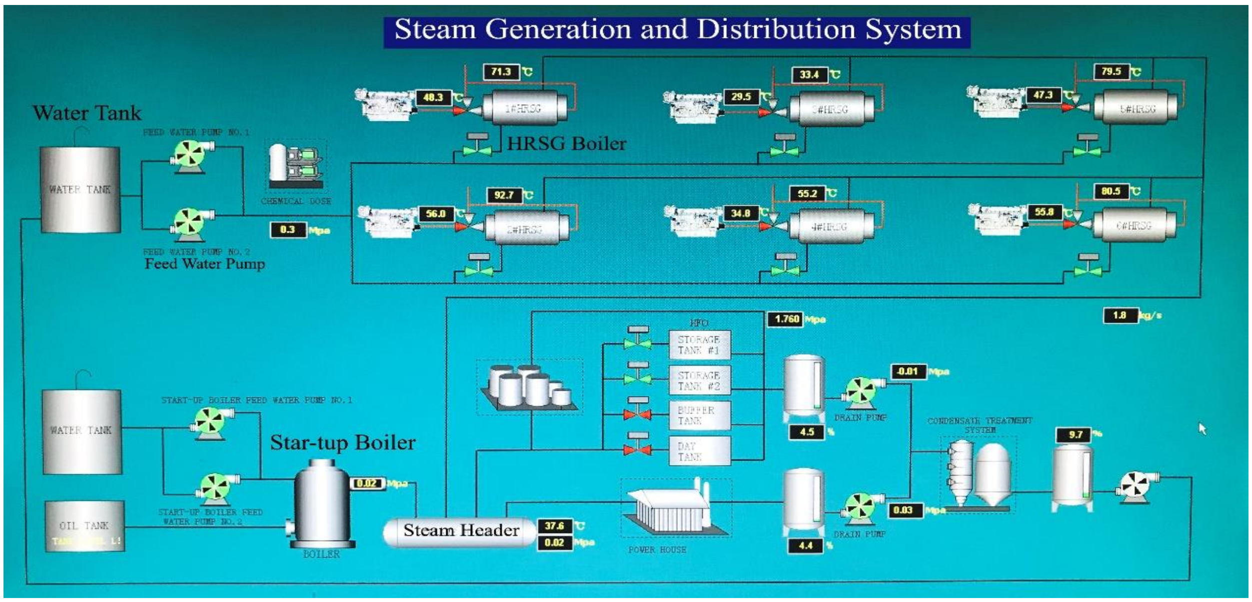

Figure 3.3 Steam Generation and Distribution System

3.7.1 Steam Distribution:

The steam produced is used for heating applications. Steam is used for heating purposes by various units in the power plant. For instance, the fuel circulation system and lubricating oil separator are equipped with steam heaters. Steam is also used for pipe trace heating.

Figure 3.4 Steam Header

3.8 Start Air Compressors

The diesel engine is mostly started with the help of compressed air, depending upon the size of the engine. The" main air" from the main air bottle reaches at the air starting valve. There is a tapping from the main air starting line, "pilot air" going to the starting air distributor. When the engine rotates, the camshaft also rotates which in turn rotates "the starting air distributor cam". This cam is designed as per the firing order of the engine such that, the distributor rotates and lets the pilot air to the specific unit. The pilot air reaches on top of the air starting valve, opening it, in turn making the long awaited main air to let inside the combustion chamber [11]. The main air which is at 30 bar, pushes the piston down making the crankshaft to rotate. This leads to continuous rotation of the crankshaft making the engine to achieve the minimum rpm at which firing of the injected fuel takes place. When the engine picks up on fuel, the air is take off and drained. Thus the auxiliary diesel engine is started with the help of compressed air [12].

Starting Air Pressure within Vessel/Pressure Regulating Valve Inlet are minimum 10.00 bar and maximum 30.00 bar

Figure 3.5 Compressed Air Tanks

3.9 System for Manual Start

After checking all parameters by the operation engineers, then operation engineers inform it to the shift engineers. Shift engineers check it again by the controlling computer monitor (for MAN18V32/40). After getting sure for all parameters, shift engineers commend start to the engine from control panel. Before taking star commend for Rolls-Royce engine pre-lube electric pump should be start. It will take 2 or 3 minutes. Then engineer will take further step for engine start commend.

Figure 3.6 Controller Unit

In the MAN18V32/40 engine, compressed air passes through the air-starting chamber and creates force to the engine cylinder. Then the engine cylinder starts turning. When rpm reaches over 700, the air-starting chamber automatically shut off the airflow to the engine cylinder. After create force on the cylinder the compressed air passes through the exhaust port.

3.10 Fuel Processing

In a power plant fuel processing is very important part. In Santahar power plant furnace oil is used as fuel though it is a diesel engine power plant to reduce the production cost. Diesel is only used when the power plant is starting and when it is stopping. Before using furnace oil as fuel of the generator it should remember that the temperature of the furnace oil can't be over 110^0 C. Then at first the furnace oil comes to the storage tank where the temperature must be $40\text{-}45^0$ C and then it goes to the buffer tank. In the buffer tank the temperature should maximum 85^0 C after this the oil then goes to Day tank through two pumps. There is a HFO separator where the temperature will be 90^0 C. In HFO separator purifies the oil and the pure oil goes to the day tank and the slush goes to the slush tank. Into the day tank temperature maintains at maximum 100^0C. To run this separation process it has to give some extra water outside of the separator bowl to open and close the bowl. At the beginning of this process there are three particle as pure oil, water and hard particle. When the bowl starting is starting rotate at

26000 rpm the strong particle goes far away than water and pure oil. So the water and the hard particle both go to the slush tank. The pure oil goes to day tank to booster unit where temperature controls at 110-115^{0}C. This pure oil then goes to engine through change over unit. Now the pure oil is ready for use. Diesel is again filtered before injecting into the engine by the fuel injection pump. The fuel is supplied to the engine according to the load of the plant.

Figure 3.7 HFO tank at Santahar power plant

Figure 3.8 LFO tank at Santahar power plant

3.10.1 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 software through which fuel system of the Santahar power station is controlled. On the below Fig 2.12 shows this system is diagrammatically [13].

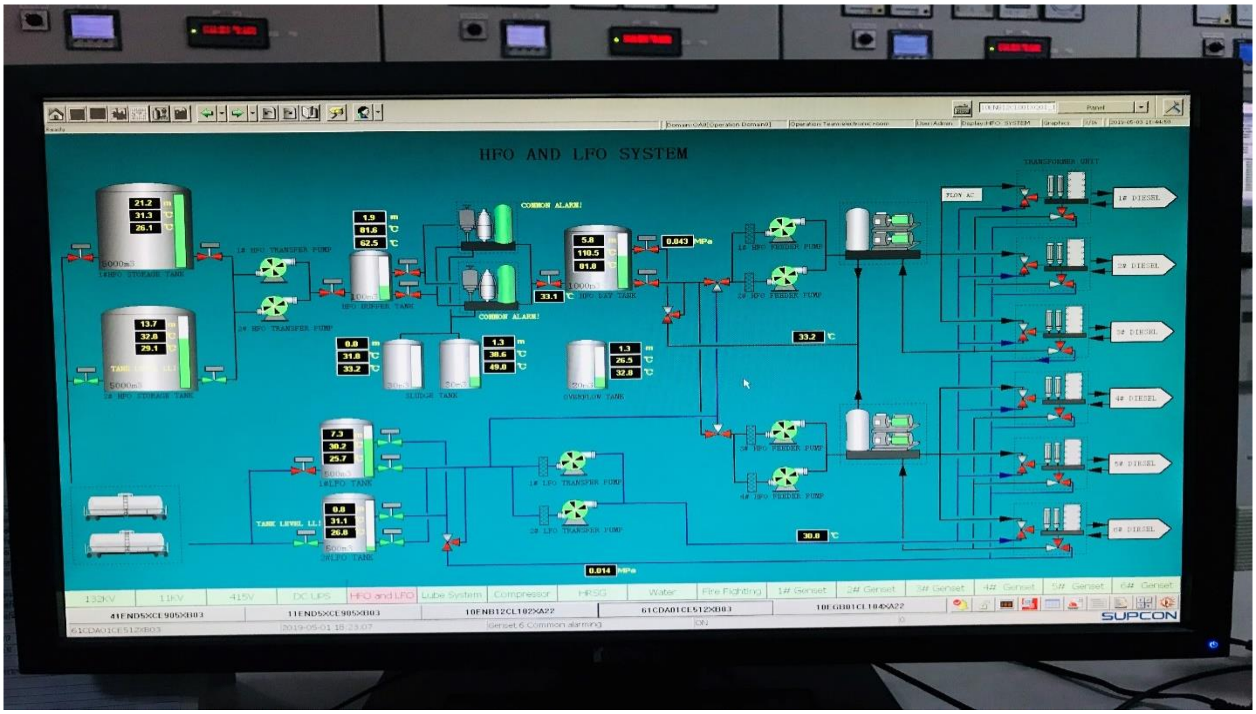

Figure 3.9 HFO and LFO system at Santahar peaking power plant

3.10.2 Lube Oil System

Lubricating oil for an engine is stored in the bottom of the crankcase, identified as the sump, or in a drain tank located beneath the engine. The oil is pulled from this tank through a strainer, one of a pair of pumps, into one of a pair of fine filters. It is then passed through a cooler before entering the engine and being distributed to the several branch pipes. The branch pipe for a specific cylinder may feed the main bearing, for instance. some of this oil will pass along a drilled passage in the crankshaft to the bottom end bearing and then up a drilled passage in the connecting rod to the gudgeon pin or crosshead bearing [14]. An alarm at the end of the distribution pipe ensures that enough pressure is maintained by the pump. Pumps and fine filters are prepared in duplicate with one as standby.

Figure 3.10 Lube oil filter

The fine filters will be prepared so that one can be cleaned while the other is operating. After usage in the engine the lubricating oil drains back to the sump or drain tank for re-use. A level gauge gives a local read-out of the drain tank contents. A centrifuge is arranged for cleaning the lubricating oil in the method and clean oil can be provided from a storage tank. The oil cooler is propagated by sea water, which is at a lower pressure than the oil. As a result any leak in the cooler will mean a loss of oil and not contamination of the oil by sea water. Where the engine has oil-cooled pistons they will be supplied from the lubricating oil system, probably at a higher pressure produced by booster pumps, e.g. Sulzer RTA engine. An appropriate type of lubricating oil must be used for oil-lubricated pistons in order to escape carbon deposits on the hotter parts of the system.

3.10.2.1 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 [15].

3.11 HFO Feeding and Boosting System

The engine fuel supply system is equipped with fuel feeder units which take suction from HFO day tanks or LFO day tank as selected by the changeover valve and delivers to fuel booster unit. Feeder units are fitted with an inter-connection valve which is used for crisis moment. The main function of Feeder and Booster unit is to provide the Engine with fuel oil of correct flow, pressure, viscosity and degree of purity [13]. Santahar power plant is designed for using Heavy Fuel Oil (HFO) as the main fuel. Light fuel oil (LFO) is used as back-up fuel.

The feeder unit feeds HFO and LFO from the fuel tanks to the fuel circulation method. The feeder unit has separate lines for HFO and LHO. The unit includes two feed pumps for HFO and two feed pump for LFO. One of the HFO pumps is normally is operation, while the other one is on standby. The feed pumps are electrically driven screw pumps equipped with suction strainers and built in safety valves. Each pump motor is equipped with a cooling fan. The pumps are controlled by frequency converters. The frequency converter regulates the speed of the feed pumps to maintain the pressure in the outlet line. To prevent under pressure or overpressure in the system at unexpected changes in the fuel consumption, the feeder unit is equipped with overflow valves. The feeder unit includes apparatus for monitoring the pressure in the system. A pressure switch at the outlet of the HFO pumps enables the standby pumps to be started automatically when required.

Figure 3.11 Booster Unit

3.12 Check list before Engine Start

Before starting the engine, the following safety checks must be carried out:

- Turning gear disengaged (if available).
- Lubricating oil sump level normal
- Turbocharger oil level (both turbine & blower) side normal
- Lubricating oil priming pump running.
- Fuel oil/diesel oil booster pump running.
- Lube oil, cooling fresh water, fuel oil pressure normal.
- Rocker arm tank level normal.
- All valves in compressed air line open to the engine.

3.13 Run MAN18V32/40 Engine & produce electricity

There are six diesel engines at Santahar 50 MW peaking power plant. MAN18V32/40 Type engine designed and manufactured by MAN Diesel & Turbo SE, Germany. A four strokes engine with direct fuel rejection, two stages cooling systems (with HT water pump and LT water pump), belt-lubrication pump and two turbochargers at free end. The engine supplies energy to the generator. The power of the engine determines how much electricity a generator can provide.

Figure 3.12 MAN18V32/40 Diesel engine at Santahar

3.13.1 MAN18V32/40 Engine Specification

Table 3.2 Engine Specification

Manufacturer Country	MAN Diesel & Turbo SE Germany
TYPE	18V32/40
Speed	750rpm
Rated power	8730Kw
Bore	320mm
Stroke	400mm
Pressure	24.87
Cylinder unit power	500Kw/cyl
Lubricating pump	Self-equipped
HT water pump	Self-equipped
LT water pump	Self-equipped

3.14 Check list after Engine start

- MAN18V32/40 Fuel Control status
- Radiator section status
- Bearing oil level status
- Abnormal sound
- Abnormal vibration
- Expansion vessel level
- Exhaust gas leakage
- Oil leakage
- Engine air receiver condensation discharge line status
- Water leakage
- Frequency converter module status
- 11KV switchgear panel status
- 128VDC charger panel status
- 24VDC charger panel status
- Neutral Grounding Resistor (NGR) panel status

- Condensation drain out from air compressor
- Relay control panel status
- 11KV protection panel status
- LV panel status
- Backup battery bank status
- Starting air unit status

3.15 Generator

In Santahar 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.

In Santahar 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 Santahar power plant, there are 6 generators and each generator capacity is 8.7MW.

Figure 3.13 Generator at Santahar power Plant

3.15.1 HAR7 185-08P Generator Specification

Table 3.3 Generator Specification

Manufacturer Country	Hyundai Korea
Type	HAR7 185-08P
KVA rating	10946.0 KVA
Power factor (0.80)	0.8 lagging
Max. leading & lagging KVAR capability	4370 leading 8975 lagging
Rated voltage between lines, KV	11
Connection of armature winding	Y type
Rated Current, A	574.5 A
Rated frequency, Hz	50
At pf 0.8, %	97.3
At pf 1.0, %	98
Stator overloading, %	110% for 1hr every 12hr
Critical speed, rpm	>900
Max. torque when the stator is short-circuited, Nm	940 kNm – 3 phase 1210 kNm – 2 phase
Pole	8 (750 rpm)

3.16 11KV Generation System

In Santahar 50 MW peaking power plant there is a step up transformer raises the generated 11KV voltage to 132KV voltage.

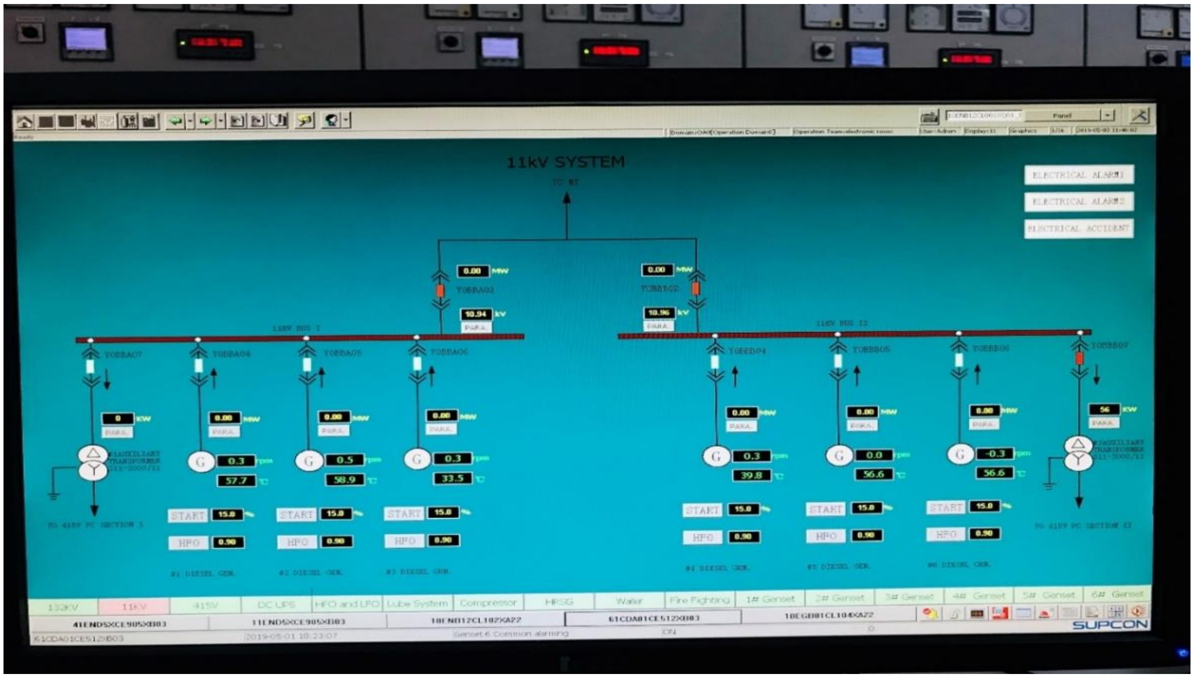

Figure 3.14 11KV Generation system at Santahar peaking power plant

3.17 Electricity Generation and Cost Calculation (For 31 days)**:**

Here,

Number of day =31

Hours of the month =744

Capacity:

Santahar Power Plant has six generating set, each capacity,

Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6
8730	8730	8730	8730	8730	8730

Total capacity =52,380 kW

Running Hours Reading							
	Engine 1 (hour)	Engine 2 (hour)	Engine 3 (hour)	Engine 4 (hour)	Engine 5 (hour)	Engine 6 (hour)	Total (hour)
Present	12530	12062	12524	11858	12036	12344	73354
Previous	12296	11742	12203	11533	11734	12030	71538
On Month	234	320	321	325	302	314	1816

Energy meter reading						
	Engine 1 (kWh)	Engine 2 (kWh)	Engine 3 (kWh)	Engine 4 (kWh)	Engine 5 (kWh)	Engine 6 (kWh)
Present	85397130	80946480	83122880	80391206	80295130	80503350
Previous	83817710	78697986	80890391	78144274	78470868	78521465
Gross Transferred	1579420	2248494	2232489	2246932	1824262	1981885

Total generation =12113482 kWh

Load factor:

Load factor is the ratio of average load to the maximum demand during a given period i.e,

Load factor = (Average load ÷ Maximum demand) ×100

And,

Average load = Gross generation ÷ Time of operation

For example,

Load factor of Engine 1:

Gross generation of engine 1= 1579420 kWh

Time of operation of engine 1= 234 hours

Average load = (1579420 kWh ÷234 hours) kW

= 6749.658 kW

So,

Load factor of engine 1 = (6749.658 kW÷8730 kW) ×100

= 77.32%

Load factor of Engine 2:

Gross generation of engine 2 = 2248494 kWh

Time of operation of engine 2 = 320 hours

Average load = (2248494 kWh ÷320 hours) kW

= 7026.544 kW

So,

Load factor of engine 2 = (7026.544 kW÷8730 kW) ×100

= 80.48%

Load factor of Engine 3:

Gross generation of engine 3 = 2232489 kWh

Time of operation of engine 3 = 321 hours

Average load = (2232489 kWh ÷321 hours) kW

= 6954.794 kW

So,

Load factor of engine 3 = (6954.794 kW÷8730 kW) ×100

= 79.66%

Load factor of Engine 4:

Gross generation of engine 4 = 2246932 kWh

Time of operation of engine 4 = 325 hours

Average load = (2246932 kWh ÷325 hours) kW

= 6913.637 kW

So,

Load factor of engine 4 = (6913.637 kWh÷8730 kW) ×100

=79.19%

Load factor of Engine 5:

Gross generation of engine 5 = 1824262 kWh

Time of operation of engine 5 = 302 hours

Average load = (1824262 kWh ÷302 hours) = 6040.603 kW

So,

Load factor of engine 5 = (6040.603 kW÷8730 kW) ×100

= 69.19%

Load factor of Engine 6:

Gross generation of engine 6 = 1981885 kWh

Time of operation of engine 6 = 314 hours

Average load = (1981885 kWh ÷314 hours) kW

= 6311.736 kW

So,

Load factor of engine 6 = (6311.736 kW÷8730 kW) ×100

=72.29%

Overall Load factor:

Plant maximum demand = 52380 kW

Plant average load = (6749.658 + 7026.544 + 6954.794 + 6913.637 + 6040.603 + 6311.736) kW

= 39996.972 kW

So,

Overall Load factor = (Plant average load ÷ Plant maximum demand) ×100

= (39996.974 kW ÷ 52380 kW) ×100

= 76.4%

Plant factor:

Plant factor is the ratio of actual generation to the maximum possible energy that could have been generated during a given period i.e,

Plant factor = (Actual generation ÷ Maximum possible energy that could have been generated) ×100

Plant factor of Engine 1:

Actual generation in the month of engine 1 = 1579420 kWh

Maximum possible energy that could have been generated of engine 1 = (Hours of the month =744 hours× Engine capacity 8730 kW) = 6495120 kWh

So,

Plant factor = (1579420 kWh ÷6495120 kWh) ×100

= 24.32%

Plant factor of Engine 2:

Actual generation in the month of engine 2 = 2248494 kWh

Maximum possible energy that could have been generated of engine 2 = (Hours of the month =744 hours× Engine capacity 8730 kW) = 6495120 kWh

So,

Plant factor = (2248494 kWh ÷ 6495120 kWh) ×100

= 34.62%

Plant factor of Engine 3:

Actual generation in the month of engine 3 = 2232489 kWh

Maximum possible energy that could have been generated of engine 3 = (Hours of the month =744 hours× Engine capacity 8730 kW) = 6495120 kWh

So,

Plant factor = (2232489 kWh ÷ 6495120 kWh) ×100

= 34.37 %

Plant factor of Engine 4:

Actual generation in the month of engine 4 = 2246932 kWh

Maximum possible energy that could have been generated of engine 4 = (Hours of the month =744 hours× Engine capacity 8730 kW) = 6495120 kWh

So,

Plant factor = (2246932 kWh ÷ 6495120 kWh) ×100

= 34.59%

Plant factor of Engine 5:

Actual generation in the month of engine 5 = 1824262 kWh

Maximum possible energy that could have been generated of engine 5 = (Hours of the month =744 hours× Engine capacity 8730 kW) = 6495120 kWh

So,

Plant factor = (1824262 kWh ÷ 6495120 kWh) ×100

= 28.09%

Plant factor of Engine 6:

Actual generation in the month of engine 6 = 1981885 kWh

Maximum possible energy that could have been generated of engine 6 = (Hours of the month =744 hours× Engine capacity 8730kW) = 6495120 kWh

So,

Plant factor = (1981885 kWh ÷ 6495120kWh) ×100

= 30.51%

Overall Plant factor:

Actual Overall generation in the month = 12113482 kWh

Maximum possible energy that could have been generated of Overall = (Hours of the month =744 hours× overall engine capacity 52380 kW) = 38970720 kWh

So,

Overall Plant factor = (12113482 kWh ÷ 38970720 kWh) ×100

= 31.08%

Efficiency:

Efficiency is the ratio of electrical output in the heat unit to the heat of combustion i.e,

Efficiency = (Electrical output in the heat unit ÷ Heat of combustion) ×100

And,

Engine efficiency = (Electrical output in the heat unit ÷ (Alternator efficiency ×Heat of combustion)) ×100

For example,

Electrical output in the heat unit = 860 kcal [1kWh=860 kcal]

Alternator efficiency = 0.94

Calorific value of fuel oil = 9729 kcal per ltr

Fuel combustion = 0.242 ltr per kWh

Heat of combustion = (.242×9729) kcal

= 2354.418 kcal

So, Engine efficiency = (860kcal÷ (0.94 × 2354.418kcal)) ×100

= 38.82%

According to this process we can find,

	Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6	Overall
Load Factor	77.32%	80.49%	79.67%	79.19%	69.19%	72.29%	76.4%
Plant Factor	24.32%	34.62%	34.37%	34.59%	28.09%	30.51%	31.08%
Efficiency	38.82%	38.82%	38.82%	38.82%	38.82%	38.82%	

Fuel Consumption

	Engine # 01(ltr)	Engine # 02(ltr)	Engine # 03(ltr)	Engine # 04(ltr)	Engine # 05(ltr)	Engine # 06(ltr)	Total(ltr)
HFO	374858.8	533656.5	529857.9	533285.8	432969.5	470379.6	2875008.1
LFO	7694.3	10953.8	10875.8	10946.1	8887.1	9654.9	59012
Lube Oil	416	1872	624	832	8736	832	13312

HFO per Ltr = 42.70 TK

LFO per Ltr = 63.15 TK

Lube Oil per Ltr = 320 TK

Total price of HFO = (2875008 × 42.70) TK

=122762845.9 TK

Total price of LFO = (59012 × 63.15) TK

= 3726607.8 TK

Lube oil = (13312 × 320) TK

= 4259840 TK

Total fuel cost (HFO+LFO+ Lube oil cost) = (122762845.9 + 3726607.8 + 4259840) TK

= 130749293.7 TK

So, per kWh generation cost = (Total fuel cost 130749293.7 TK ÷ Total generation 12113482 kWh)

= 10.79 TK (without O&M cost)

3.14 Exhaust System

This system conducts the engine exhaust gas outside the building and discharges it into atmosphere. A silencer is usually incorporated in the system to reduce the sound level. The exhaust system of a diesel engine performs three roles. First, the exhaust system routes the spent combustion gasses away from the engine, where they are diluted by the atmosphere. This keeps the area around the engine habitable. Second, the exhaust method confines and routes the gases to the turbocharger, if used. Third, the exhaust system allows mufflers to be used to reduce the engine noise.

Figure 3.15 Exhaust System

CHAPTER 4

POWER PLANT EQUIPMENT & ITS MAINTENANCE

4.1 Electrical System

The power system is a network which consists generation, distribution and transmission system. It uses the form of energy (like coal and diesel) and changes it into electrical energy. The power system includes the devices connected to the system like the synchronous generator, motor, transformer, circuit breaker, bus bar, conductor, etc. The power plant, transformer, transmission line, substations, distribution line, and distribution transformer are the six main elements of the power system. The power plant generates the power which is step-up or step-down through the transformer for transmission. The transmission line transfers the power to the various substations. Through substation, the power is transferred to the distribution transformer which step-down the power to the appropriate value which is proper for the consumers.

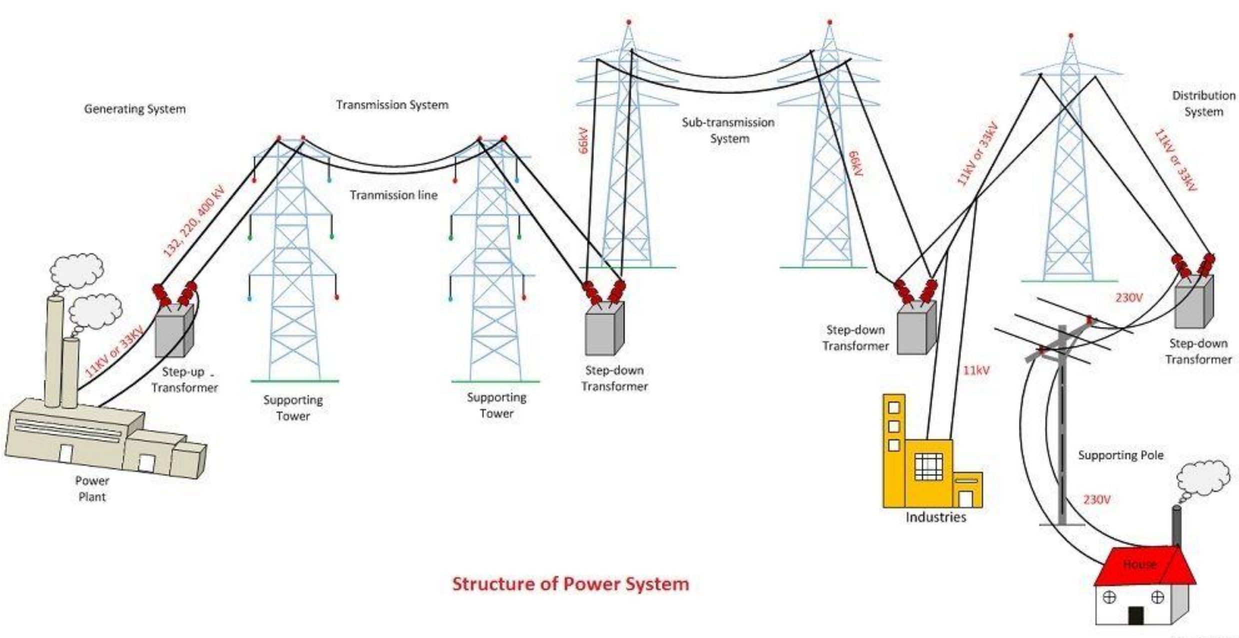

Figure 4.1 Electrical System

4.2 Generating Substation

Substation is an indispensable part of Power Plant. Substation is used for different purposes. Mainly substation is used for transmission of power. There are different kind of sub-stations which works at different purpose. Transmission substation transforms the voltage to a level suitable for transporting electric power over long distance. Distribution substation transforms the voltage to a level suitable for the distribution system. So, the assembly of apparatus to change some characteristic of electric supply is called a sub-station. Different kinds of apparatus like transformer, switchgear, PFI are used for sub-station. Transformer is the main component employed to change the voltage level of electric supply. Switchgear detects the fault and disconnects the unhealthy section from the system. PFI improves the earning capacity of a power station. Usually at Santahar, generator produces 11KV output voltage which is then increased up to 132KV by step-up transformer for transmitting and reducing I^2R loss purpose. Substation is also used for the maintenance of auxiliary equipment of the plant. In this chapter, we will discuss the main parts of a substation used in Santahar.

Figure 4.2 Substation of Santahar

Figure shows the partial part of the substation at Santahar where the Current Transformers (CT), Power Transformers (PT), Isolators, Insulators are connected and arranged. Below, different equipment of the substation is described from the collective perspective.

At Santahar we visited the substation; there we saw different types of equipment to obtain our desired voltage levels. Mainly substation is used for transmission of power. The equipment that is used in the substation of Santahar is as follows.

- Power Transformer
- Instrument Transformer
- Current Transformer (CT)
- Potential Transformer (PT)
- Bus bar
- Transmission and Distribution
- Insulators
- Isolators
- Auxiliary Systems
- Underground Cables

4.3 Transformers

In Santahar we saw two types of transformers. They are described below.

4.3.1 Power Transformer

The Power transformer is a one kind of transformer, which is used to transfer electrical energy in any part of the electrical or electronic circuit between the generator and the distribution primary circuits. These transformers are used in distribution systems to interface step up and step down voltage. The mutual type of power transformer is liquid immersed and the life span of these transformers is around 30 years. Power transformers can be classified into three types based on the ranges. They are small power transformers, medium power transformers and large power transformers. In Santahar, we closely observed power transformers and they are generally installed for step up or step down the voltage. For long line transmission high voltage in needed. In Santahar, there are total four power transformers in each unit.

Transformer-1 of the substation is a transformer which is used for stepping up the generated voltage from 11KV to 132 KV. This is a Δ-Y connected transformer.

Figure 4.3 Power Transformer-1 of Santahar

Transformer-2 is a transformer which is tapped from transformer 1. This is a step down transformer. Here, the voltage level is stepped down from 132KV to 11KV.

Figure 4.4 Power Transformer-2 of Santahar

The figure is showing both Transformer 3 and 4. They are also step down transformers tapped from transformer 2. Here, the voltage level is stepped down from 11KV to 6.6KV. Those transformers are used for auxiliary purpose of the plant. This 6.6KV high voltage is not directly used for auxiliary purpose but is made change as per demand to lowest nominal voltage need.

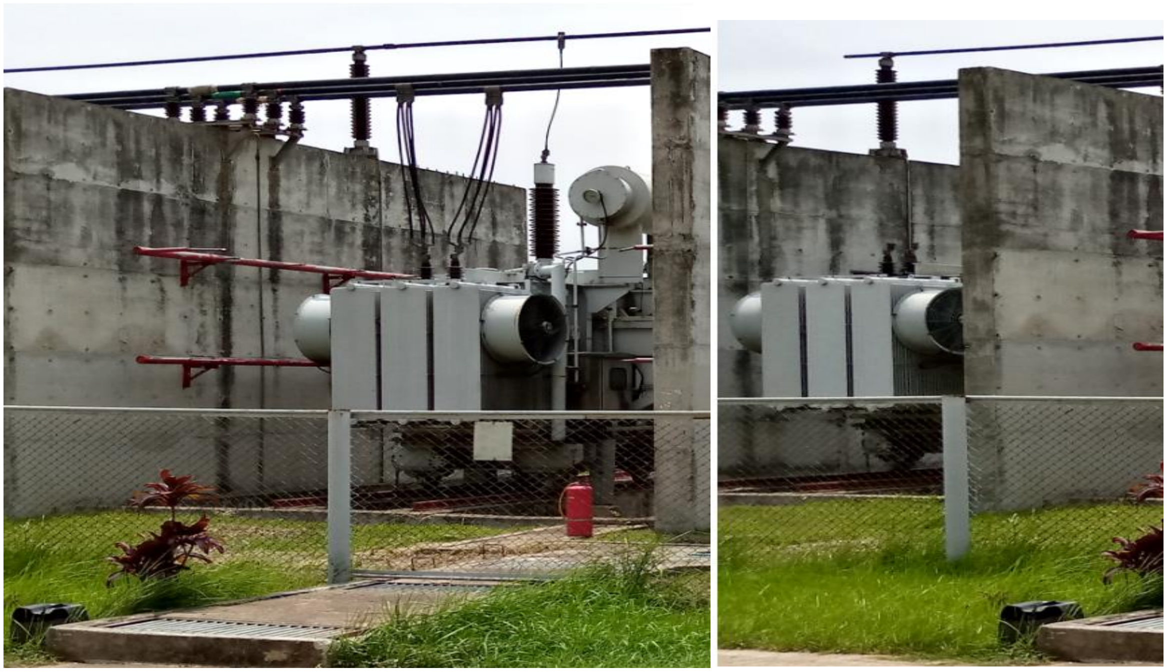

Figure 4.5 Power Transformer 3 and 4 of Santahar

4.3.1.1 Configuration of Transformer

Table 4.1 Transformer Configuration

Type	DFZ-25000/ (13/ $\sqrt{3}$)
Rate Voltage	132 KV
Peaking Voltage	145 KV
Rate Frequency	50 Hz
Style of the neutral point grounding	Larger ground current system
Service place	Outdoors
Cooling style	ONAF (Self-cooling capacity not less than 75% forced cooling)
Rate capacity	25 MVA (Winding temperature rise 55 k)
Rate Voltage at HV side	(132/ $\sqrt{3}$) ± 8×1.25% KV
Rate Voltage at HV side	11 KV
Rate currency at HV side	329 A

Rate currency at HV side	3937 A (out currency)
Transformer rate	$(132/\sqrt{3}) \pm 8\times1.25\%/11$ kV
Short-circuit impedance	15% (During main sub connection less than ±5%
Code of connects	YN, d11
Load loss	110 ≤kW
No-load loss	15 ≤kW

4.3.2 Instrument Transformer

During our internship we saw instrument transformers. There were two kinds of Instrument Transformers. They are Current Transformer and Potential Transformer. Instrument transformers are used for measuring and protection purposes. These transformers are discussed below.

4.3.3 Current Transformers (CT)

In Santahar during our intern period, we saw several current transformers. Current transformers are mainly used for metering and protection. Usually we cannot use high current for metering purpose. So we need to step down the current to a convenient value. Normally in CT, primary side current is very high and secondary side is low. At Santahar, the ratio is 800/1. Current Transformers are always connected in series with the 132 KV line. These transformers are made in India by BHEL (Bharat Heavy Electricals Ltd.). Figure shows the CT at Santahar substation. Apparently CT looks like wide circular cylinder and it is connected in series with the transmission line we observe carefully.

4.3.4 Potential Transformers (PT)

In Santahar, we saw several potential transformers. These transformers are used for measuring and protection purpose. Usually protective relays need low voltage to operate. So we need to convert the high voltage to low voltage. In fact, potential transformer is a step down transformer. It indicates primary side voltage is high and secondary side voltage is low. PT is used in parallel with the line. The ratio is 1200/1 of 132KV line. Potential transformers used in Santahar are made in India by BHEL.

4.4 Testing & Maintenance of Transformers

In every plant there are lots of elements that need to be tested in a routine basis. Moreover, electrical elements need to be maintenance properly in order to make lasted for a long time. So in BPDB, there are certain testing and maintenance procedures that we were told about. A brief discussion of them is in below.

4.4.1 Testing for Transformer

In practical it is very important to determine the transformer reaction for different loads. The performance depending on parameters can be obtained by solving the equivalent circuit for any load conditions. Although when a transformer is rewind with different primary and secondary windings the equivalent circuit also changes. In order to get the equivalent circuit parameters, test methods are first choice. From the analysis of the equivalent circuit one can determine the electrical parameters. On the other hand if the temperature rise of the transformer is required, then test method is the most dependable way. There are several tests that are done on the transformer in Santahar. A few common ones are discussed here.

4.4.2 Transformer Oil test

An oil sample will identify many things on a transformer. The following tests can be performed with the oil sample.

4.4.2.1 Moisture Content Test

Water decreases the power of insulation of oil. Moist can be formed from two sources. One of them is by the breathing process or from oil degradation. Now to absorb the moisture in the air sucked in by the transformer during the breathing process, silica gel breather is used. Now a question may rise that what is transformer breathing. Well when load on transformer increases the insulating oil of the transformer gets heated up, expands and gets expel out in to the conservator tank present at the top of the power transformer and subsequently pushes the arid air out of the conservator tank through the silica gel breather. This procedure is called breathing out of the transformer. Oil degradation also produces moisture. We can see the Mist Eliminator Pump which is an auxiliary appliance of the plant as it is run by auxiliary power supply.

Figure 4.6: Moist Eliminator Pump of Santahar

4.5 Bus Bars

During our internship in Santahar we observed Bus Bars. Bus bar is a bar or line where different types of lines such as transmission line, distribution line etc. operates at the same voltage level. Bus bar is used as the common electrical bar. The incoming and outgoing lines in a substation are linked to the bus bar. In Santahar they used single bus bar.

4.5.1 Single Bus Configuration

As the name suggests, it consist of a single bus bar and all the incoming and outgoing lines are connected to it. At Santahar, the reason why they have used Single Bus Configuration is due to the fact that it has low initial cost, less maintenance needed and simple operation. However, the disadvantage of single bus bar system is that if repair is to be done on the bus bar or a fault occurs on the bus, there is a complete interruption of the power supply as we were told.

4.6 Transmission and Distribution

During our internship we saw the transmission and distribution system of Santahar. A substation receives electrical power from generating station via incoming transmission lines and delivers electrical power via the outgoing transmission lines. Overhead lines are used for transmission and distribution. Some components are used in Santahar which are given below.

4.6.1 Insulators

We saw different types of insulators in the substation of Santahar which are used in power lines. There are three types of insulators. Figure shows these insulators which are pointed for identification purpose. And they are-

- Suspension type insulator.
- Pin type insulator.
- Strain Insulator.

Figure 4.7: Different types of Insulators used in Santahar substation

4.6.2 Isolators

In substation we also saw the Isolators. It is the extra protection part of the system. It is often desired to disconnect a part of the system for general maintenance and repairs. It is accomplished by an isolator. Isolator does not have the arc extinction capacity. It operates under no load condition. It does not have any indicated current breaking capacity or current making capacity. Isolator not even used for breaking load currents. While opening a circuit we have to open the circuit breaker first, and then we can open the isolator. While closing circuit, the isolator is closed first, then circuit breakers.

4.7 Auxiliary Systems

During our intern period we saw different types of auxiliary systems used in Santahar. The systems are Lube Oil pumps, Outdoor lighting and receptacles, Control house, Heating and ventilation, Chiller Air conditioning, Battery charger input and Motor-operated switches etc. For these auxiliary purposes, Santahar take power from Grid and Transformer 3, 4.

4.8 Protection System and Switchgear

Santahar is a HFO Power Plant with turbine, compressor, combustion chamber, water treatment plant and various pipes, valves, turbo charger, startup boiler and fans. And these are the major part of the electricity generation process. Hence, Santahar authority has the necessary and proper Protection System for the safety of this equipment and apparatus. In this chapter, a brief overview and discussion on the Protection system of Santahar will be made.

4.8.1 Differential Protection

From the collective perspective, we saw several differential protections for generator. It is actually a relay. It is used here in Santahar to protect generator winding against internal faults such as phase-to-phase and three phase-to-ground faults. We were told that the differential relay that has been used in the generator is actually current differential relay.

4.8.2 Over Current Protection

In Santahar, generator is designed to operate continuously at rated KVA, frequency and power factor over a range of 95% to 105% of rated value. Now, operating of the generator beyond rated KVA may result in unsafe stator over current. This leads to overheating of stator and failure of insulation. This is very a risky condition for people working in the unit. Hence, such a protection is taken in Santahar generator unit.

4.8.3 Restricted Earth Fault Protection

The working function of it is same to generator differential protection. It protects the high voltage winding of power transformer against interior faults. One set current transformer on neutral and phase side of the power transformer are exclusively used for this safety. The protection cannot detect turn-to-turn fault within one winding. Upon the detection of a phase to phase or phase to ground fault in the winding, the unit is tripped automatically from control unit in Santahar.

4.8.4 Reverse Power Protection

Our intern advisor introduced us to a new type of protection for generator called Reverse Power Protection. This is actually a protection for the Prime mover of the generator rather than for the whole generator. It describes a condition where the prime mover of a generator is not supplying sufficient torque to keep the generator rotor spinning at the same frequency as the grid to which the generator is connected. In other words, the generator will essentially become a motor and will draw current from the grid and will be supplying torque to the prime mover which is supposed to be supplying torque to the generator. Hence a protection relay is set up by Santahar within the generator prime mover.

4.8.5 Under Voltage Trip

In Santahar, there is also protection relay for under voltage occurrence. This system is used to prevent closing of the breaker by mistake. In this system tripping is generally delayed. This is done so that the voltage drop is caused by fault and time is allowed for the suitable fuse or breaker to operate and the voltage to be recovered without the loss of power supply.

4.9 Protection of Transformer

In Santahar just like any other plant, it has got different types of transformers like Power transformer, Current transformer, many Step-up and Step-down transformers for transmission of current to grid and others. And therefore, lots of protection has been taken care of for the safety purpose here in Santahar. Actually, the Santahar authority installed a protection scheme as a whole for the transformer protection ever since the plant was built for easy monitoring and protection purpose. And that protection scheme is described down here briefly based on the collective perspective.

4.9.1 Unit Transformer Protection Scheme

Santahar has a very advanced Transformer Protection Unit designed for use on 3-phase power transformers as we observed. It provides sensitive high-speed differential protection for internal phase and ground faults as well as time and instantaneous over current protection for auto, winded transformers. The user-selectable harmonic restraint setting prevents false tripping on magnetizing inrush and over excitation. So whenever any faults occur, protection unit trips down and take necessary steps to protect the transformers.

4.9.2 Transmission Line Protection

Transmission Line protection systems are designed to identify the location of faults on the transmission line and to isolate only the faulted section. The important challenge to the transmission line protection lies in reliably detecting and isolating faults compromising the security of the system.

4.10 Circuit Breakers

A circuit breaker is an automatically worked electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and to instantly discontinue electrical flow. Unlike a fuse, which operates once and then has to be replaced, a circuit breaker can be reset to resume usual operation. The circuit breakers that are commonly used in different sections of the plant are as follows,

● SF_6 circuit breaker

- Air Blast Circuit Breaker (ABCB)
- Air break Circuit Breaker (ACB)
- Miniature Circuit Breaker (MCB)
- Molded Case Circuit Breaker (MCCB)

4.10.1 Sulfur Hexafluoride (SF6) High-Voltage Circuit-Breakers

We were told about SF6 circuit breakers that were mentioned to be used in each of the three phases with rated voltage of 11KV. As it is very renowned for extinguishing arc in short times, hence it has been incorporated in three phase. So that while over voltage occurs, the breaker can trip to stop the system. But due to its high cost, it is not something that is used in many parts of the system.

4.10.1.1 Configuration of SF6

Table 4.2: Ratings of SF6 circuit breaker in Santahar

Model	HECS-100M
Rated voltage	132 Kv
Peak voltage of system	145 KV
Rate frequency	50 Hz
Style of the neutral point grounding	Directly earthing
Service place	Outdoors
Rate currency	1250 A effect value
Rate short-circuit breaking currency	40 kA effect value
Rate thermal currency	40 kA
Time-lasting of rate thermal currency	3 s

Rate short-circuit shut off currency	100 kA (peaking value)
Rate dynamic current	100 kA (peaking value)

4.10.2 Air Break Circuit Breaker and Air Blast Circuit Breaker

In Santahar we saw both Air Break Circuit Breaker and Air Blast Circuit Breaker that has been used in bus bar and motor feeders and its rated voltage is 400 Volt AC and 230 Volt AC respectively. It has been mainly used here for its fast operation essentially. These circuit breakers have panels that are installed in switchgear panel room of Santahar. So when these circuit breakers are tripped, light flickers in those panels which indicate that the breaker is tripped. Figure 4.2 is the apparent look of the breaker. It cannot be made work externally except just pulling up the lever as we can see in the figure to trigger down the breaker manually in case of any emergency need.

Figure 4.8: Air Circuit Breaker used in Santahar

4.10.3 Miniature Circuit Breaker and Molded Case Circuit Breaker

Both of these circuit breakers are rated at 230 Volt AC and have been used in each single phase of the three phase line. They are basically used to protect each phase individually rather than using fuse which needs to be replaced.

A table at a glance of the circuit breakers that are used in the plant with their rating is given below

Table 4.3: Complete information of different Circuit Breakers that are used in Santahar

Breaker's Name	Rating	Where used
SF_6 Circuit Breaker	11KV	Three Phase Line
Air Break Circuit Breaker	400VAC	Bus Bar and Motor Feeders
Air Blast Circuit Breaker	400VAC	Bus Bar and Motor Feeders
Miniature Circuit Breaker	230VAC	Each single phase of Three Phase Line
Molded Case Circuit Breaker	230VAC	Each single phase of Three Phase line

4.11 Different Relay Systems

Even though several protection relays for generators and transformers have already been discussed previously but there were certain completely new relays that were shown to us in Santahar. Actually these are very familiar to power plant engineers but for us as an intern, these are totally new.

4.11.1 Distance Relay

From the collective perspective, distances relay work on the basis that the impedance of a transmission line is proportional to its length. For distance measurement it is appropriate to use a relay capable of measuring the impedance of a line up to a fixed point. Such a relay is defined as a distance relay and is designed to operate only for faults occurring between the relay location and the selected reach point, thus giving protection for faults that may occur in different line sections

4.11.2 Buchholz Relay

An essential relay for transformer is a Buchholz relay which is found to be located in an inclined pipe between the transformer itself and its oil conservation tank (located above the transformer). It is a mechanical phenomenon. It is used to monitor big transformers for oil loss or insulation breakdown. Whenever there will be a minor internal fault in the transformer, the transformer insulating oil will be decomposed in dissimilar hydrocarbon gases, CO_2 and CO. The gases produced due to decomposition of transformer insulating oil will accumulate in the upper part of the transformer oil container which causes fall of oil level in it. Thus whenever the oil level will drop, the alarm circuit will be energized which means the relay will be tripped. Then by collecting the accumulated gases from the gas release pockets on the top of the relay and by investigating them, plant engineers can predict the type of fault in the transformer. Just like any other plants santahar have this relay used as well and our intern advisor for that day mentioned that it is a very necessary and important part of oil transformer.

4.12 Lightning Arrester

Lighting arrester is a protective device for electrical equipment which reduces excessive voltage resulting from lightning to a safe level by grounding the discharge. We have seen many lightning arresters to be used near power transformer section in Santahar power plant where they are used to bypass current to the ground when high voltage or thunder strike occurs. Generator, Transformer, Transmission line and Turbine are the major parts that need to be protected all the time. All of these protections are automatically programmed to trigger as per situation and they are controlled and monitored from control room.

Figure 4.8: Lighting arrester

4.13 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.

Chapter 5

Conclusions and Recommendations

5.1 Problems

In our internship program we faced some problems. Those are as follows:

- During our internship one generator unit was turned off for breaking machine bearing. This is why we could not observe full load of the power station.
- The time of the internship was too short for which we could not learn all the sections thoroughly.
- Before the internship we did not have any academic knowledge about the mechanical section of the power plant, for which we faced some problems in our internship.
- In the time of internship, 3 engine did not work properly. In this reason we did not collect proper data.

5.2 Recommendations

- **Internship duration:** The length of the internship duration should be increased. We think the duration should be spare for at least three months.
- **Offer Mechanical engineering course:** University authority should offer at least one course related to mechanical engineering to understand the mechanical parts of the power station.
- **Be careful:** Substation is a high voltage area. So everyone should be aware of the precautions of power station.
- **Safety first:** This plant's fire protection system is not good. It has just fire Extinguisher for fire protection. We think they need to take central fire protection system for more safety. Other safety system is sufficient.
- **This is 24 hour running plant so need to be more alert:** Every shift personnel need to be more alert. For small mistake it will be very harmful for the plant. So carefully operate the equipment.
- **Don't operate any unknown switch:** Please don't operate any unknown switch. Because if you don't know the function of the switch and you operate this switch it can be very harmful.
- **Exhaust gas temperature**: Abnormal exhaust temperature that cause the engine great damage

can be minimized by decreasing the loads monthly or opening the waste gate more.

- **Bearing temperature high:** Problem since bearing temperature high, high oil pressure and temperature are normally occurs because of inappropriate quality lubricating oil. So, analysis is recommended to find more appropriate lubricating oil.

5.3 Conclusion

Power sector is a very important and thoughtful issue for any country for its industrial thus economic growth. But, from the beginning Bangladesh is facing many problems in power sector. Among them the main problem is its inadequate generation of electricity. Day by day the demand is increasing but the generation of power is not enlarged in the same manner. As a result, load-shedding is occurring frequently. We are lucky for getting internship chance in Santahar HFO Based Power Plant and pleased about its training system. Every employee was very helpful to us. Plant Manager was very sincere and careful about us. We are debt to especially Santahar HFO Based Power Plant for providing practical experience which will make our future engineering life better.

Power plant is a very promising sector in Bangladesh. In near future our government has plan on generating a huge amount of electricity. Saying that, it is great opportunity for the new comers to work and develop their career in power plant. Hence, 'BPDB' is the one of the biggest electricity generating company in Bangladesh. In Santahar HFO Based Power Plant used MAN18V32/40 engine. How this engine operates, it's working principle, starting procedure, everyday checklist, their auxiliary components as in air starting compressor, air reservoir, lubrication oil tank, engine pre-heater etc. has been learned. In under graduation courses like IC engine power plant engineering discussed about various systems of power plant, but in the internship period difference both the theoretical and practical knowledge. All problem solution has been done by using some instruction. All thus procedure has been learned in this internship.

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