Bangladesh Ghorashal 4th Unit Re-powering Project

China Energy Engineering Group Guangdong Power Engineering In

Co., Ltd.

Study On combined cycle power plant Bangladesh Ghorashal 4th unit Repowering Project

An internship submitted in partial fulfillment of the requirements for the Award of Degree of
Bachelor of Science in Electrical and Electronic Engineering

Submitted By

Md. Easir Arafat
172-33-4231

Supervised by

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DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
FACULTY OF ENGINEERING
DAFFODIL INTERNATIONAL UNIVERSITY

LETTER OF TRANSMITTAL

15 November, 2020

Mojibur Rahman

Assistant Engineer

Bangladesh Ghorashal 4th unit Repowering Project.

Sub: Submission of the Internship Report.

Dear Sir,

It is a great pleasure to submit my report prepared by me during my internship in combined cycle power plant of Bangladesh Ghorashal 4th unit Repowering Project. The internship provided me great opportunity to experience the real life development environment, modern technology and techniques.

I hope that it will ensure positive role in the development of my future career. In this report, I tried to summarize what I have done and experienced during my internship period in combined cycle power plant of Bangladesh Ghorashal 4th unit Repowering Project.

I am really lucky to have the chance to take part in this internship program. I express my sincere gratitude and thankfulness to my co-supervisor **K.B.M Rakib Hasan** for guiding me continuously for the successful completion of the internship report.

Thank You.

Yours sincerely,

Easir arafat

ID:172-33-4231

Department of Electrical and Electronic Engineering, Faculty of Engineering.

Approval letter

中国能源建设集团广东火电工程有限公司
CHINA ENERGY ENGINEERING GROUP GUANGDONG POWER ENGINEERING CO.,LTD

Date: 15-09-2020

To

Associate Head

Department of EEE

Daffodil International University.

Subject: Approval for Internship.

Dear Sir,

As your field study proposal (12th September 2020), we are pleased to offer you an internship program for a period of two months.

Mr. Easir Arafat student of Electrical & Electronic Engineering Department of Daffodil International University is approved for field study at China Energy Engineering Group Guangdong Power Engineering Company. Details of Student under below,

SL	Name	ID	Email	Contact Number
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Sincerely,

Mojibor Rahman
Asst. Engineer, Operation

Prince 15-09-2020

Syed Shourav Wahid Prince
Assistant Manager
Administration Department
For & on behalf of
Re-power project of Ghorashal Power Plant 4th Unit, Palash, Narsingdi.
China Energy Engineering Group Guangdong Power Engineering Co., Ltd. (GPEC).

Re-Powering Project of Ghorashal 4th Unit of China Energy Engineering Group Guangdong Power Engineering Co., Ltd. (GPEC)
Address: Floor 3,kehui 3rd Street,No.6,kexue Avenue(M),No.99,Science City,Guangzhou510663, P.R. China Tel: +86-20-32096491, Fax: +86-20-32096753, Email: ghorashal40803@ceec.net.cn

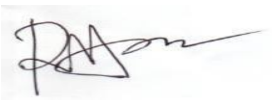
Certification

This is to certify that this internship entitled **"Study on combined cycle power plant of Bangladesh Ghorashal 4th unit Repowering Project"** is done by the following students under my direct supervision and this work has been carried out by 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.

Signature of the candidates

Md. Easir Arafat
172-33-4231

Countersigned



K.B.M Rakib Hasan

Lecturer

Department of Electrical and Electronic Engineering Faculty of Engineering

Daffodil International University

DECLARATION

The internship entitled **"Study on combined cycle power plant of Bangladesh Ghorashal 4th unit Repowering Project"** submitted by Name: **Md. Easir Arafat** Id No: **172-33-4231**, Session: Summer-2020 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering on 2020.

BOARD OF EXAMINERS

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Acknowledgement

First I express my heartiest thanks and gratefulness to almighty Allah for his Divine blessing makes me possible to complete this field study successfully. I feel grateful to and wish my profound my indebtedness to Professor **Dr. Shamsul Alam**, Professor& Dean, Faculty of Engineering, Daffodil International University, Deep knowledge & keen interest of my supervisor in the field of Electric power influenced me to carry out this thesis paper. His endless patience, scholarly guidance, continual encouragement, energetic supervision, constructive criticism, valuable advice at all stage made it possible to complete this paper. Next, I am grateful to **Mojibur Rahman (Assistant Engineer)**, Md. **Shoriful Islam (Sub-assistant Engineer)**, of Ghorashal power plant 4th unit for them vast support for this internship. I would like to thank my entire course mate in Daffodil International University, who took part in this discuss while completing the course work. I also want to convey my thankfulness to my Field study co-supervisor **K.B.M Rakib Hasan (Lecturer) Department of EEE**, for his help, support and constant encouragement Finally, I must acknowledge with due respect the constant support and patients of my parents.

ABSTRACT

Grorashal power station (GPS) is the largest power station in Bangladesh which plays a major role in the power sector of Bangladesh. GPS produces 950 MW electricity. This station is located on the Eastern bank of river Shitalakkha at North East of Dhaka under Palash, Narsingdi district.I did my internship at GPS 4th unit from 16th September to 15th November 2020. During this period I visited all the sections of the plant and saw different auxiliaries of the plant. I learned about the generation, controlling, and maintenance system of GPS. Sub-station is one of the most major parts of the power plant. I have visited the sub-stations and gathered knowledge about transformers, bus-bars, circuit breakers, lightning arresters, current transformer, potential transformer, and other equipment of the substation. During My internship period, I observed and gathered practical knowledge and experiences over the topics which I have learned inside the classroom or from the textbooks. In this report, I have focused on the process which is used in GPS for power generation, distribution and transmission of various equipment, and protection of power system.

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Chapter 01: Introduction

The power plant is the most important part of the power sector in any country. There are 126 power plants in different places in Bangladesh. Bangladesh Power Development Board (BPDB) established Ghorashal Power Station in 1974. The initial and present capacities are 55 MW, and 950 MW, respectively. At present there are two plants in GPS, one is a steam turbine and the other is a combined cycle power plant. I started my internship on 15th September 2020 and completed on 15th November 2020. During this period I have gathered practical knowledge about the power generation, transmission, and distribution process of GPS. During my internship, I relate my theoretical knowledge with the practical activities in GPS and got the chance to observe the industrial environment of power generation, distribution, and transmission systems. [1]

1.1 Objective of the Internship

The primary objective of the internship is to complete my requirements for graduation. The secondary objectives are to gather practical knowledge on the followings:

I. Generator, stator, rotor etc.
II. Water treatment plant of the power plant
III. Control room and protection system
IV. Substation and distribution
V. Protection system and fault management[1]

1.2 Company Profile

GPS is the largest power station in Bangladesh. It has started its operation in the year of 1974. It is situated at the Eastern bank of the river Shitalakkha, at Palash, in Narsingdi district. GPS is a thermal power plant. It has an installed capacity of 950 MW which consists of six units of steam turbines. The 7th unit and the 4th unit is a new unit which is a combined cycle power plant and the 7th unit generates 365 MW and the 4th unit will generate 409 MW respectively. [1]

1.3 Vision of BPDB

To deliver uninterrupted quality power [1]

1.4 Vision of mission

To secure continuous growth of electricity for sustainable development and ensure customer satisfaction [1]

1.5 Objectives

Objectives of BPDB is

I. To be engaged in implementing the development program of the government in the power sector

II. To adopt modern technology and ensure optimum utilization of the primary and alternative source of fuel for sustainable development of power generation projects

III. To purchase power as a Single Buyer from power producers

IV. To provide reliable power supply to customers enabling socio economic development

V. To promote a work culture, team spirit and inventiveness to overcome challenges

VI. To promote ideas, talent and value systems for employees [1]

1.6 Unit-4 (re- powering) projects of GPS

The objective of these projects is to increase the generation capacity and efficiency of the power plant. The key activity of this project is to convert Unit 4, one of the four 210 MW gas-fired steam units at GPS, into a combined cycle unit for an upgraded total capacity of about 400 MW. The steam unit is currently generating 170 MW and the overall efficiency of the unit is around 31%. This project would increase the overall efficiency of the unit to 54% and the generated output will also be doubled with only an 18% increase in gas requirement. Fuel consumption (per GWH) would be reduced by 44%, resulting in a reduction of greenhouse gas emissions. [1]

Fig. 1.1. Construction of 4th unit re-powering project

1.7 Production capacity

GPS has seven units. Units 1 and 2 produce 55 MW each and generate a voltage of 10.5 kV. For units 3, 4, 5, and 6 the generated voltage is 15.75 KV and capacity equals 210 MW. Six out of seven units are steam turbine power plant. Unit 7 is a 365 MW Combined Cycle Power Plant (CCPP). In CCPP, gas turbine generated voltage and capacity equal 20 KV, and 254 MW, respectively, and stream turbine generated voltage and capacity equal 20 KV, and 109 MW, respectively. All the units have been installed by a company named Technoprom Export, Russia. The power Generation capacity of GPS is summarized in Table 1.1. [1]

Table 1.1. Description of power generation unit of GPS

Unit No.	Date of Commissioning	Installed Capacity (MW)	De-rated Capacity (MW)	Present Status
Unit-1	16/06/1974	55	40	Running
Unit-2	13/02/1976	55	50	Running
Unit-3	14/09/1986	210	170	Running
Unit-4	14/03/1989	210	180	Running
Unit-5	14/01/1994	210	190	Running
Unit-6	30/01/1999	210	-	Under process for repair since 2010
Unit-7	23/01/2018	365	365	Running
Unit-4 (re-powering)		409		Under-construction

1.8 Scope and methodology

This internship report is based on the knowledge I gathered during the training period at GPS. In this report, I emphasized the generation, transmission, protection scheme, maintenance, and control system about unit-4 of GPS. [1]

1.9 Report organization

Chapter 1 contains the objective of the internship, company profile, mission and vision, production capacity, running projects of GPS, scope, and methodology. Chapter 2 discusses combined cycle power plant of GPS unit-4, Chapter 3 is about gas turbine section, components of a gas turbine, working principle Chapter 4 contains details about the steam turbine, a configuration of steam turbine, turbine cylinder, turbine parts, function and speed of turning gear, condenser, governing system and lubricating system, water treatment plant, the boiler of GPS and their working principle. Chapter 5 discusses detail about the generator, components of the generator, excitation system, generator synchronization system, and generator cooling system. Chapter 6 discusses the substation of GPS, major equipment of a substation, different equipment of a transformer, transmission line. Chapter 7 discusses the control room, different desks of the control room. In chapter 8 the policy on environment awareness, the problems I faced during the internship, and my recommendation for students interested in an internship at power station have been discussed.

Chapter 02:
Combined Cycle Power Plant

2.1 Introduction

The combined cycle power plant is the combined gas and steam turbine plant, which produces 50 to 60 percent more electricity from the same amount of fuel along with exhaust heat from the gas turbine. Reuse of the exhaust heat from the gas turbine increases the efficiency of the combined cycle power plant (CCPP). My internship was on (unit-4) repowering project. (unit-4) is former Russian 210 MW unit, The Bangladesh Power Development Board planned to reconstruct (unit-4) of Ghorashal Power Plant from gas power unit into gas turbine combined cycle power unit, with net output 409 MW of combined-cycle unit. Natural gas is the main source of fuel for this power plant. This plant uses new technological equipment for the full repowering of Unit 4. The major plant equipment contains a new Gas Turbine and Generator, a Heat Recovery Steam Generator (HRSG), a Distributed Control System, a gas booster compressor, the main stack, a bypass stack, and all other associated ancillary equipment. Unit-4 is more efficient than other units. Project Implementation Start Date 01-Mar-2016. [3]

Table 2.1. Specification of about combined cycle power plant

Implementing Agency	Bangladesh Power Development Board (BPDB)
Project ID	P128012
Location	Palash, Narsingdi, Ghorasal
Project Implementation Start Date	01-Mar-2016
Project Implementation End Date	31-Mar-2021
Name of the Contractor	China Energy Engineering Group Guangdong Power Engineering In Co., Ltd.
Total project cost	US$ 263.00 million
Net Capacity	Combined Cycle : 409MW
Main Equipment	Gas and Steam, Turbine, Generator, Transformer, HRSG, Cooling Tower etc.
Efficiency	54%
Fuel	Natural Gas

Fig. 2.1 Real view of 409 MW combined cycle power plant

2.2 Working principle of combined cycle power plant

In this project, CCPP uses natural gas as fuel in gas turbines. Firstly, the pressure of the natural gas is enlarged from 7 to 31.5 bar using a gas booster compressor. Then the combustion chamber is mixed with air heated up to a very high temperature. Then the mixture delivers through the gas turbine, where the thermal energy creates the turbine revolve and drives the generator attached to the turbine shaft. Now, from the gas turbine exhaust gas deliver through HRSG. It has many vertical water tubes that are heated by this exhaust. To produce steam in the HRSG this exhaust is used. Generated steam of the HRSG passes through the steam turbine and spins the steam turbine. Lastly, the steam produced in the Heat Recovery Steam Generator (HRSG) enters the steam turbine cycle, making the steam turbine spin and thus moving the electric generator shaft fixed to the turbine. Used steam is cooled down to the water by the condenser. Cooling tower this water to the Heat Recovery Steam Generator using condensate and feed pump. In this way, the combined cycle power plant, gas turbine, and steam turbine are functioned together using the same fuel. [2]

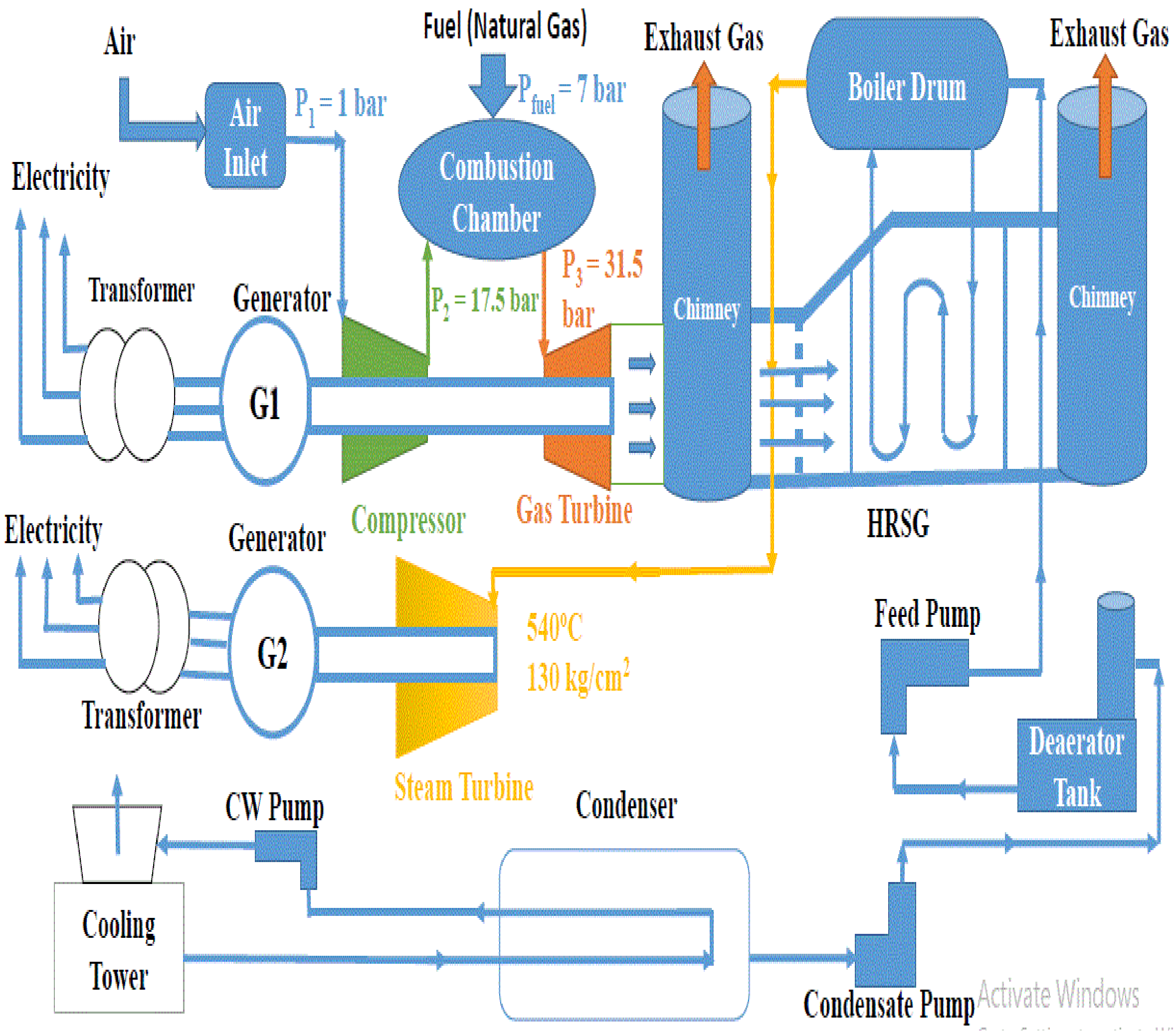

Fig. 2.2. Flow diagram of combined cycle power plant (CCPP)

2.3 Major equipment of CCPP

A combined-cycle power plant (CCPP) uses a different kind of equipment. These are air inlet, gas booster, compressor, gas turbine, steam turbine, HRSG, feed pump, and condensate pump, condenser cooling tower, two exhaust chimney, three boiler drum are used H.P.C, M.P.C, and L.P.C of the steam turbine, two generators one for steam turbine and one for gas turbine, etc.

2.3.1 Air inlet

The generated power and efficiency of gas-steam combined cycle power plants depend on the temperature of the air inlet. The air inlet is a device that is used to take out a foreign element from the air. Air has many foreign particles. Air particle is mixed with fuel and produce flue gas which can destruction turbine blades. For that reason, the air is cleaned in 3stages by this device.

Fig. 2.3. Air inlet at GPS unit 4

2.3.2 Contaminants of incoming air

In general, the incoming air contains many kinds of foreign elements. These can be divided up into solid, gaseous, and liquid states. The gaseous elements take in Ammonia, Chlorine, Hydrocarbon, Sulfur, in the custom of water (H2O), Surfer dioxide. The solid elements consist of Sand, Alumina and Silica, Rust, Road dust, Alumina and Silica, Calcium sulfate, Vegetation, Airborne seeds. The liquid state contaminants chloride salts melted in water, for example, Nitrates, Sulfates.

2.3.3 Heat recovery steam generator(HRSG)

Heat recovery steam generator (HRSG) is very popular. They are frequently joint with a gas turbine and produce extra electricity with the steam. Heat recovery steam generator is a one kind boiler that is worked to recover exhaust heat from the gas turbine and create steam for the steam turbine. Hot gas from the turbine passes through the heat recovery steam generator to heat water. Heat recovery steam generator contains four components, these are evaporator, economizer, super-heater and water preheater. At GPS (unit-4), a Heat recovery steam generator is a vertical type where water tubes are vertically placed. Heat recovery steam generator has three boiler drum that is high pressure, medium pressure, and low-pressure boiler drum. [3]

Fig. 2.4. HRSG at GPS unit-4

2.3.4 Cooling tower

The cooling tower is used to cool the hot water and produce cool water. This is a heat exchanger where water and air get mixed with each other to lessen the water hotness. During this procedure, a minor amount of water is dissolved, decreasing the high temperature of the water being spread through the tower. This cooling water once more passes to the Heat recovery steam generator (HRSG) through the feed and condensate pump.

Fig. 2.5. Cooling tower at GPS Unit-4

2.3.4 Chimney

There are used two chimneys at GPS (unit-4), one for gas turbine and the other for the steam turbine. Chimney of gas turbine releases high-temperature exhaust at 605°C when it works as a simple cycle. Chimney of steam turbine releases normal temperature exhaust 60°C when it works as a combined cycle.

Fig. 2.6. Chimney at GPS unit-4

❖ combined cycle power plant can be divided into two parts:

1. Gas turbine section.
2. Steam turbine section**.**

Chapter 3: Gas Turbine

3.1 Introduction

The plant's gas turbine is the PG9351FA heavy-duty tandem compound gas turbine of GE's MS9001FA series, including gas turbine, combustion chambers and two supporting bearings. The fuel is natural gas; the power output mode is cold end output Gas Turbine Section is the most vital part of Combined Cycle Power Plant (CCPP). In order to produce electricity, CCPP uses gas as fuel that is supplied by Titas. In this procedure, air is used as a raw material, obtains chemical energy from fuel and converts into mechanical energy. [4]

Figure 3.1: Gas Turbine Section

3.2 Working Principle of Gas Turbine

A Gas Turbine plant consists of compressor, combustion chamber and a turbine. In a Gas Turbine plant LP, HP, Intercooler is also used. The compressor draws air from the atmosphere through the Air Intake Filter. Gas is used as fuel which is next sent to combustion chamber and burnt there. Hot gas produced from the combustion chamber, passes through the turbine and rotates it and produces mechanical power. Through this power, compressor and other rotating part of generator are also able to rotate. The turbine, combustion chamber and compressor are connected to a shaft which also rotates and an output power is produced. Table 2.1 shows The gas turbine technical specification.[4]

Table 3.1 The gas turbine technical specification

Item		**Unit**	**Value**
Gas turbine	Manufacturer		GE Company
	Model		9F.03 AGP
	Simple cycle power (ISO)	MW	248.120
	Stage No.		3
	Type		Impulse type
	Inlet absolute total temperature of the primary nozzle	°C	1420
	Inlet absolute total temperature of the primary bucket	°C	1327（ISO） 1327 (ISO)
	Smoke exhaust temperature of gas turbine	°C	648.9
	Exhaust pressure of gas turbine	Kpa	103.8
	Exhaust flow of gas turbine	T/h	2195.6
	Ignition rotating speed	rpm	420
	Self-sustaining speed	rpm	2400
	Split casing type		Horizontal type
	The rim rotating speed of exhaust stage vane	m/s	532

3.3 Equipment of Gas Turbine

In Gas Turbine Power Plant, we saw that several types of equipments are used, but we came to know details of some equipment that are described below:

- Air intake filter,
- Compressor,
- Combustion chamber,
- Diesel Engine,
- Gas Generator,
- Diffuser,
- Bearing **s**.
- flame detectors

Equipment Overview and Technical Specification

3.3.1 Overview of the air intake system

(1) The air inlet system includes following equipment: filter, and inlet air pipe system The filter chamber is located at the top of the supported structure of inlet air pipe. The inlet air pipe system is installed on the inlet air pipe supported structure together with the inlet air extraction heating assembly. Air enters filter chamber and passes through transition piece, silencer, inlet heating assembly and IGV, and enters compressor after passing through inlet pressure measuring device.

(2) When the pressure drop on both sides of the filter is greater than the desired value, the differential pressure switch operates to activate the revertive impulse type automatic cleaning system The automatic control program device cleans the filter cartridge in a special sequence. The automatic control program device operates a series of solenoid valves; each solenoid valve controls the cleaning small portion of filter with a small portion. During the cleaning period, each solenoid valve releases the high-pressure air of instantaneous pulse. The pulse impacting on the filter with the formed instantaneous revertive airflow, which dissipates the accumulated dust and falls into the hopper, and discharges after completing cycle cleaning. When the pressure drop at both sides of filter is less than the desired value, the differential pressure switch activates to complete the cycle cleaning. [4]

Table 3.2 Air inlet system technical specification

	item	unit	Value
Air inlet system	Quantity of filter elements	个 Piece	912
	Average air flow of the filter elements	kg/s(m3/s)	0.921
	Design air flow velocity	m/s	0.016
	Dust arrest capacity	kg/m2	0.244
	Forecast life of filter material	h	17520-35040 17520-35040 based on the environment
	Dust filter efficiency		98% of particles >5 micron
	Type		Parallel baffle
	Noise attenuation	dB	98
	Design air flow	m3/s	526.7
	Flow velocity between dampers	m/s	26
	Type of damper plate		Parallel baffle
	Quantity of silencer		set
	Flow velocity in the air duct	m/s	13.4
	Air duct design shall prevent vibration		Check the structure vibration when it reaches 120% of the rated flow

3.3.2 Compressor overview

The compressor is of axial flow configuration consisting of compressor rotor and casing. 18-stage compressor buckets and stationary blades, adjustable inlet guide vane and outlet guide vane are installed in the casing. The adjustable inlet guide vane is used to limit the airflow during the start-up period and to increase the efficiency of combined cycle under partial load.[4]

Table 3.3 Compressor technical specification

Item		Unit	Value
Compressor	Pressure ratio		
	Rim rotating speed of primary vane	m/s	391
	Rotor structure type		Laminated type
	Adjustable vane series		1
	Angle limit of inlet guide vane (from opening to closing)	Degree	70 opening—33 closing
	Height of primary bucket	m	0.504
	Wheel hub diameter of primary bucket	m	1.474
	Height of exhaust stage bucket	m	0.147
	Wheel hub diameter of exhaust stage bucket	m	1.701
	Tension stress of primary bucket root	kg/mm	Maximum tension stress=71.01
	Bending stress of primary bucket root	kg/mm	11.4
	Quantity of primary stationary guide vane	No.	46
	Quantity of primary bucket	No.	32
	Quantity of exhaust stage stationary guide vane	No.	108
	Quantity of exhaust stage bucket	No.	60

3.3.3 Combustion chamber overview

The combustion chamber is of dry and low nitrogen (DLN2.6) structure with 2 stages connected in series. Each unit is equipped with 18 DLN burners in the way of circumferential arrangement, which is viewed in a counterclockwise direction, the 18th burner is located at the 12 o’clock position, there are 5 fuel nozzles in each burner, the middle ring is fed with the natural gas from D5 control valve, and the external ring is fed with the premixed natural gas from PM1 or PM4 control valve.[4]

Table no: 3.4 Combustion chamber technical specification

Item		Unit	Value
Combustion system	Type		Circle backflow
	Quantity of igniter	个 Piece	2
	Igniter type		Spark plug
	Quantity of flame detector	个 Piece	4
	Type of flame detector		Silicon carbide
	Type of air cooling system at burner/combustion liner		Collision
	Type of air cooling system at transition piece		Collision
	Design life of burner/combustion liner	h	8000
	Design life of transition piece	h	8000
	Seal type between combustion liner and transition piece		Hula seal
	Quantity of combustion chamber	个 Piece	18
	Fuel nozzle quantity of each combustion chamber	个 Piece	5

3.3.4 Diesel Engine

Diesel Engine in Gas Turbine Power Plant, which is very vital part because Gas Turbine is not a self-started machine. Gas Turbine requirs to be attached with Diesel Engine to rotate the turbine when fuel and air are burnt in Combustion Chamber. Figure 2.3 represents Diesel Engine to revolve the turbine. Table 2.2 shows the state of the Gas Turbine with respect to the turbine speed.

Figure.3.2represents Diesel Engine to revolve the turbine

Table 3.5: The state of the gas turbine with respect to the turbine speed.

RPM of Turbine	Situation
0 rpm	Diesel start
750 rpm	Fire or ignition inside combustion chamber
1800 rpm	Diesel off
2300 rpm	Excitation on
3000 rpm	At no load condition

3.3.5 Diffuser overview

Diffuser is a part of gas turbine plant, which made of aluminum. I observed it to be used for passing the waste heat as an output from the turbine.

Table 3.6 Exhaust diffuser technical specification

Exhaust diffuser	item	unit	value
	Design of internal pressure	Inch H_2O	28
	Design flow velocity of gas	m/s	Average: 57m/s
	Protection area	3 个	sections

3.3.6 Bearings overview

Turbine rotor is supported by two sliding bearings. #1 bearing and #2 bearing are both tilting-pad journal bearings, which are placed at both ends of the rotor. The axial thrust of rotor is self-balanced by two-sided axial thrust bearing. These bearings are placed in two bearing shells: #2 bearing housing is placed in the exhaust frame of turbine, due to the high temperature here, the bearing cooling fan (88BN-1/2) is provided to cool down and seal #2 bearing housing; #1 bearing is placed at the inlet of compressor. These bearings are lubricated by the lubricating oil supplied by lubricating oil system. [4]

Table 3.7 Bearings technical specification

	item	unit	value
Bearings	Type of radial bearing		Pivoted shoe type
	Quantity of radial bearing	个 Piece	2
	The quantity of plummer bearing		1
	Type of plummer bearing		Pivoted shoe type

3.3.7 Overview of compressor and turbine rotors

The compressor rotor adopts the disk-drum structure that is peripherally connected with stay bolts and has good rigidity, and the centrifugal force is borne by the disks. The tie rods press the end faces and transmit the torque by friction. It is fixed by stop pin between discs near the center. Both ends of tie rods are locked with special-shaped nuts to avoid looseness. The turbine rotor adopts drum frame with segmented type and external drawbar type, transmitting the torque relying on the friction force on the compression surface, the pressed twisted surface is not totally on casing surface at the same radius.[4]

3.3.8 Gide vane

The deflation of 9th and 13th stage is used as the cooling air source of the gas turbine 3rd stage and 2nd stage stationary guide vane meanwhile, the cooling air of the first stage stationary guide vane is extracted into the tail end directly of turbine stationary guide vane at the outlet plenum of compressor and passed into the interior of the vane to cool down from the tail end of the turbine stationary guide vane. The cooling air of bucket is extracted from the inner bore of compressor (after the 16th-stage) and transmitted to the interior of rotor, cooling disc, blade root and the 1st and 2nd buckets via cooling air duct inside rotor; one part of air comes out from compressor exhaust chamber and enters combustion chamber after cooling transition piece, and the other part of air cools combustion liner; the 3rd-stage bucket of gas turbine is not cooled.

Table 3.8Vane technical specification

	item	unit	value
Design life of vane	a） 1st Stage Buckets	h	24000hours/1200 times to start (maintenance) 48000 hours/2400 times to start (replacement)
	2nd Stage Buckets	h	24000hours/1200 times to start (maintenance) 24000 hours/1800 times to start (replacement)
	3rd Stage Buckets	h	24000hours/1200 times to start (maintenance)48000 hours/3600 times to start (replacement))

3.3.9 Overview of flame detectors

There are totally 4 ultraviolet flame detectors, one of which is for #15, #16, #17 and #18 burners respectively. The highest working temperature of each flame detector is 150°C, to cool down the flame detector with 10-57°C inlet cooling water by using spiral tube, the cooling water flow of each sensor is 3.8--5.7 liters/min

3.3.10 Spark plug overview

There are two high voltage electrode spark plugs in total in the gas turbine, one is arranged respectively in #2, #3 burner, pushing the spring when it is ignited, when the rotor rotating speed and the exhaust pressure of compressor is rising up, it will automatically exist.

3.3.11 Chimney

Chimney mentions to a configuration that deliver away hot waste gases or smoke from a boiler, stove, furnace to the outside atmosphere. A chimney at gas turbine power plant that chimneys the waste gases of the plant. The waste gases from the boiler first enter into precipitors to be divided from solid dust elements. the waste gases are aired through the chimney to the atmosphere Figure 2.7 represents Chimney of Waste heat recovery unit.


Figure3.3: Chimney of Waste heat recovery unit in combined cycle plant.

3.4 Systems of Gas Turbine

In Gas Turbine, for maintenance and the generation of power, I observed five major systems which are given below:

- Fuel system,
- Front natural gas module (natural gas pre-treatment) system
- Fuel gas control system
- Fuel gas purging system
- Inlet air system of the gas turbine
- Lube oil system,
- Cooling and sealing air system

3.4.1 Fuel System

The unit has two sets of absolute separators of 100% gas (one is for running, and one is for standby), natural gas chromatograph, one set of gas performance heater, one set of gas scrubber. The absolute separator is used to remove the liquid and solid particles in the fuel flow. The gas performance heater is used to heat the gas fuel, when the feed water system is stopped, the inlet and outlet valves of gas performance heater are automatically closed, and the inlet and outlet valve to the opening water tank valve is automatically opened. Natural gas chromatograph is used to detect the composition of natural gas; the gas scrubber is designed to remove the entrained liquid and solid particles in the gas flow.[4]

Figure 3.4: Fuel system of combined cycle power plant

3.4.2 Front natural gas module (natural gas pre-treatment) system

Once the operator selects to start the unit on the gas turbine control panel, the gas turbine is started automatically. The gas turbine control system monitors start-up and operation of the front natural gas module. After the fuel flow is built, the natural gas absolute separator (front filter) and gas scrubber (terminal filter) will separate the fluid from settled particles when the fuel flows through them. The natural gas absolute separator (front filter) and gas scrubber (terminal filter) will continue operating as long as the fuel flows. The DCS will put the temperature controller of the natural gas heater into operation when meeting following conditions: The heater will continue to provide heating function for maintaining the required fuel temperature.

3.4.3 Fuel gas purging system

After the operator selects to start the gas turbine through the gas turbine control panel, the gas turbine is started automatically. In the start-up and operating process of the unit, the gas turbine control system is able to monitor and control the purging air system. [4]

Table no: 3.9 Fuel gas purging system

Code	Name	Function	Setpoin	Unit
63PG-1A	Gas fuel system purge pressure switch		3.515±0.1406 3.515 + 0.1406	kg/cm2
63PG-1B	Gas fuel system purge pressure switch		3.515±0.1406 3.515 + 0.1406	kg/cm2
63PG-1C	Gas fuel system purge pressure switch		3.515±0.1406 3.515 + 0.1406	kg/cm2
63PG-3A	Gas fuel system purge pressure switch		3.515±0.1406 3.515 + 0.1406	kg/cm2

3.4.4 Fuel gas control system

Once the operator selects to start the gas turbine through the gas turbine control panel, the gas turbine starting sequence will be performed automatically. The MK VI control system will monitor the fuel gas control system in the whole start-up and operating process of the unit.

Switching the inlet strainer of the fuel gas control system. Open the strainer balancing valve to pressurize the standby screen; Turn the switching hand-wheel to put the screen into operation; Close the screen balancing valve; As required, open the blowoff valve of the screen that is not put into operation Usually replace the screen in an off-line manner.

2.4.5 Cooling and sealing air system

Once the operator selects to start the gas turbine through the gas turbine control panel, the gas turbine should be started automatically. In the whole start-up and operation process of the unit, the gas turbine control system will monitor the cooling and sealing air system. The operator does not need to take any measure, but only monitors the system parameters of the cooling and sealing air system.

Normal operation

When the cooling and sealing air system is operating normally, all compressor blowoff valves (VA2-1, 2, 3 and 4) are closed, and the stage 9 air enters the stage 3 nozzle for cooling, and the stage 13 air enters the stage 2 nozzle for cooling. One #2 bearing cooling fan (88BN-1 or 2) and one exhaust frame cooling fan (88TK-1 or 2) should supply cooling air on-line. In addition, it is also required to adjust the air flow path to ensure that the filtered air has the blowoff valves (VA2-1, 2, 3 and 4) closed through the 20CB-1 and 2, and at the same time, that the discharged air of the compressor normally provides air for inlet gas heating, fuel gas purging and control air system.[4]

Table no: 3.10 Cooling and sealing air system

code	Name	Function	Set point	Unit
63BN-1	Exhaust pressure switch of the cooing fan in the cooling fan#2 bearing area	Monitor its outlet pressure	1.120±0.0249 1.120 + 0.0249	kpa
63BN-2	Exhaust pressure switch of the cooing fan in the cooling fan#2 bearing area	Monitor its outlet pressure	1.120±0.0249 1.120 + 0.0249	kpa
63TK-1	Exhaust pressure switch of the turbine housing and exhaust frame fan	Monitor its outlet pressure	6.221±0.1991 6.221 + 0.1991	kpa
63TK-2	Exhaust pressure switch of the turbine housing and exhaust frame fan	Monitor its outlet pressure	6.221±0.1991 6.221 + 0.1991	kpa

3.4.6 Gas turbine heating and ventilating system

Through the MK VI control system, the PG9351FA heating and ventilating system will be started automatically whenever required. During normal operating period, no intervention by the operator is required, except for monitoring the system parameters used to detect any abnormal operating condition.[4]

Table no: 3.11 Gas turbine heating and ventilating system

Code	Name	Function	Setpoint	Unit
26BT-1	Turbine compartment temperature switch	Start the 88BT at high temperature	46.11±2.778 46.11 + 2.778	°C
26BT-2	Turbine compartment temperature switch	High alarm	176.7±1.111 176.7 + 1.111	°C
26HT-1	Turbine compartment thermostatic regulator	Start the heater	10.00±1.111 10.00 + 1.111	°C
26HT-3	Turbine compartment thermostatic regulator	Start the heater	37.78±1.111 37.78 + 1.111	°C
26VS-1	Thermostatic regulator of the gas fuel module	Start the heater	10.00±1.111 10.00 + 1.111	°C

3.4.7 lubricating oil system

Start one smoke exhaust fan of the main oil tank, and set the other one to interlocking mode, as well as open the outlet damper of the smoke exhaust fan of the main oil tank. After conducting interlocking test for the smoke exhaust fan of the main oil tank and confirming that it is normal, one fan is for service, and the other fan for standby. Start one AC lubricating and sealing oil pump, and inspect and confirm whether the current is normal and the motor rotates in correct direction, and the outlet pressure remains normal. Through on-site inspection, confirm that the oil system and bearings are free from oil leakage, and the return oil flow of bearings remains normal, and the lubricating oil pressure is normal. Put the interlocking system of the standby AC lubricating and sealing oil pump, DC emergency lubricating oil pump and DC emergency sealing oil pump into service, and enable it to be in standby state. Conduct electric and I&C interlocking test for the AC lubricating and sealing oil pump, DC emergency lubricating oil pump, DC emergency sealing oil pump, and confirm that they remain normal, one AC lubricating and sealing oil pump is for service, and the other AC lubricating and sealing oil pump and DC emergency lubricating oil pump, and DC emergency sealing oil pump are set to standby mode

Switch the oil cooler/screen selector valve to the #1 or #2 oil cooler/screen. Inspect and confirm that the oil filling valve is closed Open the bleed valve on the oil cooler/strainer, and then close it after the air is fully removed, as well as inspect the oil flow indicated on the flow indicator in the upstream of the #1 or #2 oil cooler remains normal; Open the manual water inlet and outlet valves of the oil cooler. Deliver cooling water based on the oil temperature, and adjust the set point of the temperature control valve VA32-1 to make the lubricating oil temperature kept within normal range. After the oil cooler/strainer gets normal, open the oil filling valve of the standby oil cooler/strainer to fill oil to the standby oil cooler and strainer to remove the air, and then close the oil filling valve after the air is fully removed. Inspect and confirm that the pressure control valve of the main lubricating oil pipe works normally,[4]

and controls the pressure of the main lubricating oil pipe to a value not less than 1.72bar Open the inlet valve of the jacking oil system. Open the inlet valves of the #1 and 2 jacking oil pumps, and confirm that the oil pressure remains normal. Start the #1 or #2 hydraulic jacking oil pumps 88HQ-1/88HQ-2, and inspect and confirm whether their outlet pressure remain normal; otherwise, adjust the outlet pressure adjusting valve of the jacking oil pump, and have the pressure of the main jacking oil pipe kept within a range of 16892-18099KPA

Figure 3.5: Lube Oil cooling plant

3.5 Different Test and protection

Types of tests are used for the protection of machines. The tests and protection systems used at the CCPP are:

•Bearing test,

•Winding temperature excessiveness test,

•Protection against vibration,

•Cooling air protection,

•Pressure level test of gas, liquid and steam,

•Meggar test.

3.6 Gas turbine water wash system

- **On-line water washing**
- **Off-line water wash**

3.6.1 On-line water washing Process

Inspect whether the load is close to the basic load and remains stable. 10°C Inspect whether the compressor inlet temperature and washing water temperature are more than 10℃ Open the outlet valve of the water wash tank.Open the outlet valve of the water wash pump. Close the water draining valve at bottom of the water wash pump Close the water discharge valve of the online main water wash pipe, and open the discharge valve at bottom of the air inlet chamber of the compressor. Mark VI"WW-Online" "On Line Water Wash" "On" Select the Mark VI "WW-Online" page, and click the "On" button below the "On Line Water Wash", as well as start the on-line automatic water wash procedure**.** Inspect whether the on-line water wash solenoid valve is open, and have the water wash pump started. The L2WWP begins time recording, and the washing procedure is automatically finished after 30 minutes. Enter the Mark VI to select "On Line Water Wash" page, and click "Off" below the "On Line Water Wash" to enable the "Off" light to come on to finish the on-line water wash procedure. Inspect whether the on-line water wash solenoid valve has been closed, and have the water wash pump started. Close the water outlet valve of the water tank, and water outlet valve of the water wash pump. Close the blow-down valve of the compressor Enter the Mark VI to select the "Start up" page, and check whether the "Auto" lamp below the "Mode Select" gets on. Select the "IGV Control" page, and click the "On" button below the "ST Temp Matching" to enable the "On" light to get on, so that the IGV is put into operation automatically.[4]

3.6.2 Off-line water washing Process

Turn the switches of the exhaust frame cooling 88TK-1 and 88TK-2 to the manual open position, so as to start the fan. Main resetting and diagnostic resetting are conducted on the Mark VI control panel. Select the “WW-OFF LINE” page, and click the “On” below the “Off Line Water Wash” to make the “On” light come on. Enter the Mark VI to select the “START-UP” page, and click the “Crank” below the “Mode Select” to make the “Crank” light come onEnter the Mark VI to select the “START-UP” page, and click the “START” below the “Master Control” to make the “Start” light come on. Theunit is brought to cranking speed to inspect (when the Mark VI monitors the “Crank” and no-flame signal) whether the IGV is turned to the full opening position. Switch the manual three-way valve of the water wash supply pipe to the blow-down position Manually start the water wash pump 88TW-1, and observe and confirm that some water flows from the discharge outlet of the manual three-way valve of the pipe. Switch the manual three-way valve of the water wash supply pipe to the supply position Set the water wash pump 88TW-1 switch to “Auto” position Enter the Mark VI to select the “WW-OFF LINE” page, and click the “Initiate Wash” below the “Off Line Water Wash” to make the “Initiate Wash” light come on The off-line water wash ejecting solenoid valve 20TW-4 is powered on, and the off-line water wash ejecting pneumatic valve VA16-1 is open. The water is injected for 1 minute Switch the manual three-way valve of the water wash supply pipe to the blow-down position. Open the manual globe valve at the outlet of the detergent dosing tank. Manually start the water wash pump 88TW-1, and observe and confirm that some water flows from the discharge outlet of the manual three-way valve of the pipe. Switch the manual three-way valve of the water wash supply pipe to the supply position. Set the water wash pump 88TW-1 switch to “Auto” position Adjust the opening of the manual globe valve at the outlet of the detergent dosing tank, and adjust the flow at the ratio of the detergent to the water. Enter the Mark VI to select the “WW-OFF LINE” page, and click the “Initiate Wash” below the “Off Line Water Wash” to make the “Initiate Wash” light come on. Start to inject the detergent (8 times in total).[4]

3.6.4 The washing water must meet requirements specified in the table.

Table no: 3.12 Washing water quality criteria

Total amount of solid substance	≤5ppm
All alkali metals and other metals that may be thermally corroded.	≤0.5ppm
PH value	6.5-7.5

3.6.5 The washing water temperature should be within 10~82.2℃

Table no: 3.13 Adjust the state of the valve as per the following table.

S/N	**Valve Description**	**STATUS**
1	Detergent reservoir level indicator draining valve	Closed
2	Detergent tank draining valve	Closed
3	Floating valve at internal inlet of the detergent reservoir	Automatic
4	Detergent reservoir inlet separating valve	Closed
5	Detergent reservoir inlet supply valve	Closed
6	water wash tank level gauge draining valve	Closed
7	water wash tank draining valve	Closed
8	Internal floating valve of the water wash tank	Automatic
9	water wash inlet valve	Open
10	“Y” strainer draining valve at inlet of the water wash pump	Closed
11	Manual valve at outlet of the water wash pump	Open
12	Re-circulating manual valve of the water wash pump	Open
13	Outlet valve of the water wash pump system	Open
14	Manual draining valve for the gas inlet chamber of the gas turbine (WW33)	Closed

Adjust the state of the valve as per the following table.

S/N	Valve Description	STATUS
15	Manual draining valve of the false start-up main draining pipe (WW33)	Closed
16	Manual draining valve at the manhole of the turbine housing (WW30)	Closed
17	Manual draining valve of the turbine housing (WW10)	Closed
18	Front manual draining valve of the exhaust frame (WW15)	Closed
19	Rear manual draining valve of the exhaust frame (WW16)	Closed
20	Manual draining valve of the exhaust pipe (WW24)	Closed
21	Manual three-way valve of the water wash supply pipe	Supply position
22	Manual re-circulating isolating valve at outlet of the water wash pump	Open
23	Recirculating solenoid valve at outlet of the water wash pump	Automatic
24	Off-line water wash ejecting solenoid valve 20TW-4	Automatic
25	Off-line water wash ejecting pneumatic valve VA16-1	Automatic
26	On-line water wash ejecting solenoid valve 20TW-6	Automatic
27	On-line water wash ejecting pneumatic valve VA16-3	Automatic
28	Isolating valve of the water wash pump inlet pressure switch	Open
29	Test valve of the water wash pump inlet pressure switch	Closed
30	Isolating valve of the water wash pump outlet pressure gauge	Open
31	Isolating valve of the water wash pump outlet pressure switch	Open
32	Test valve of the water wash pump outlet pressure switch	Closed
33	One-way valve for the water wash pump outlet pipe	Automatic

3.6.6 The washing water and detergent must meet requirements specified in the table below.

Table no: 3.14 Washing water

All solid substances (Soluble and insoluble)	≤100 ppm
Amount of all alkali metals	≤25 ppm
Metals that may be thermally corroded (such aluminium and vanadium)	≤1.0 ppm
PH value	6.5-7.5

Table no: 3.15 Chemical composition of the detergent

All alkali metals Na+K	≤25 ppm
Magnesium + calcium Mg+Ca	≤5 ppm
Vanadium V	≤0.1 ppm
Lead Pb	≤0.1 ppm
Tin Sn	≤10 ppm
Sulphur S	≤50 ppm
Chloride ion CL-	≤40 ppm

Chapter 4
Steam Turbine section

4.1 Introduction

Exhaust gas from the gas turbine section is used here to produce steam. So the efficiency of the plant increases very much. Exhaust gas coming from the GT section contains high temperature. Which is used to evaporate water and create steam. And this is the main difference between the steam turbine sections of the combined cycle power plant and the steam turbine section of the steam power plant. Because in the case of a normal steam power plant there is a furnace that produces the heat or flue gas but in the combined cycle there is no furnace. The role of flue gas, in this case, is done by exhaust gas from the gas turbine section. [6]

Fig. 4.1. Steam turbine section at GPS unit-4

4.2 Steam turbine

The steam turbine converts thermal energy into mechanical energy. In a power plant, a steam turbine is involved with a generator to act as the prime mover. The turbine arranges for the rotatory motion for the generator, while the generator employs the laws of electromagnetism to produce electrical power.

Table 4.1. Configuration of steam turbine of GPS unit-4

Manufacturer	DONGFANG TURBINE CO. LTD
Nominal speed	1493 RPM
Live steam pressure	**90 kg/cm^2**
Steam flow at rated or Full load	2016 Ton/hr
Live steam temperature	535^{o}C
Type	Impulse type
Power factor	0.915
frequency	50HZ

4.3 Components Used and Their Functions

The Steam engine comprises of the following parts which are employed in combination to produce electricity with the help of steam supply. They are described in the following sections.

4.3.1 Turbine cylinder

Turbine cylinder has to withstand the pressure of the steam and therefore, they are of robust design of thick walls. There are three types of cylinders in unit-4 at GPS for 210 MW steam turbine, these are, Low-pressure cylinder, Intermediate pressure cylinder, high-pressure cylinder where LPC, IPC, and HPC describe the pressure of the steam. After passing through the HP stage, the steam is given back to the boiler to be re-heated to its unique temperature with abridged

4.3.2 Turbine rotor

The steam engine comprises of the following parts which are employed in combination to produce electricity with the help of steam supply. They are described in the following sections.

The rotor has a strong axle, running through the center of the turbine. The blades are the most vital part of the turbine, their design is important in capturing as much energy from the steam as possible and converting it into rotational energy by spinning the rotor.

4.3.3 High pressure cylinder

From the superheater, steam with 130 kg/cm2 pressure and 540oC temperature enters into the high-pressure turbine. A high-pressure turbine has twelve stages with moving and fixed blades. After completion of steam flow throughout the twelve stages of the High-pressure cylinder, the steam temperature falls to 336oC and pressure falls to 28.4 kg/cm2. This steam enters into the re-heater to gain heat once again and leave the re-heater with 540oC. But the pressure remains almost the same (25 kg/cm2). High-pressure cylinder rotor of unit-4 at GPS.

Fig. 4.2. Rotor of high pressure cylinder at GPS

4.3.4 Intermediate pressure cylinder

From the re-heater, the steam goes to the intermediate pressure cylinder which has eleven stages. Here, steam pressure is 25 kg/cm2 and the temperature is 545ºC. If the temperature falls below 440oC or rises above 565oC then the intermediate pressure cylinder valve trips. After completion of steam flow throughout the eleven stages of the intermediate pressure cylinder, the stream temperature falls to 171oC, and pressure becomes1.34 kg/cm2. Intermediate pressure cylinder rotor of unit-4 at GPS.

Fig. 4.3. Rotor of Intermediate pressure cylinder at GPS

4.3.5 Low pressure cylinder

From the intermediate pressure cylinder, the steam goes to LPC. Here, the pressure is about 1.34 kg/cm2 and the temperature is about 172oC. LPC blades are larger than the previous two sections but the energy of steam is less here compared to the other two sections. the low-pressure cylinder is divided into two sections and each section contains four stages. Following the low-pressure cylinder, steam moves to the condenser.

Fig. 4.4. Rotor of low pressure cylinder at GPS

4.3.6 Auxiliary equipment of turbine

Governor, turbine bearings, condenser, nozzle are the main auxiliary equipment of a turbine. Governor helps to control the rotating speed of turbine, bearing is used to support the weight of turbine rotor, and nozzle is used to rotate the turbine at a low speed during starting and tripping condition.

4.3.7 Governor

Governor, turbine bearings, condenser, nozzle are the main auxiliary equipment of a turbine. Governor helps to control the rotating speed of the turbine, the bearing is used to support the weight of the turbine rotor, and the nozzle is used to rotate the turbine at a low speed during starting and tripping conditions.

4.3.8 Super Heater in ST:

A superheater is a device used to convert saturated steam or wet steam into superheated steam to produce enough rotation in the turbine, that's why a supper heater is employed to extend the temperature of the steam. It's within the bottom of the plant. Exhaust gas is flooded over the bundle of tubes that carry the steam. The temperature of the exhaust gas from the turbine is about 500°C; this gas is employed in the supper heater as a component. From the superheater, the super-heated steam goes to the high turbine. When the steam gets heated using a supper heater its temperature rises to 400°C which matches the high turbine

4.3.9 Condenser

A condenser is a device that condenses the exhaust steam from a steam turbine to get hold of maximum efficiency, and also to convert the turbine exhaust steam into clean water so that it may be used again in the boiler as boiler feed water. The main determination of a steam condenser is to maintain a low back pressure on the exhaust side of the steam turbine. For unit-4 of GPS, two condensers are used. One is the left condenser and another is the right condenser. The working procedure of both condensers is the same.

Fig. 4.5. Steam turbine condenser of unit-4 in GPS

4.3.10 Nozzle

The nozzle may be a device which is employed to rotate the turbine at a little speed during the starting and tripping condition. Nozzle receives steam through a governing valve and converts the pressure and heat energy of steam into kinetic energy and guides the steam into the first stage of moving blades. Nozzle reduces the possibility of damage to the turbine at the sudden change of speed.

4.4 Turbine protection

During emergency conditions, the steam turbine protection system is designed to protect the turbine automatically. To care for the turbine a number of protection systems are used.

4.4.1 Turbine pressure control

Turbines are activated at assured pressure and listed pressure is throw down at each stage of the steam turbine sector. The pressure within the turbine has to be maintained to operate the steam turbines efficiently. At the steam turbine section, steam pressures are usually measured at the main steam line and the boundary line. At GPS, two types of pressures are checked in the turbine. These are above atmospheric pressure and below atmospheric pressure, Steam turbines are operated more efficiently at greater vacuum and operated less efficiently at lower vacuum.

4.4.2 Bearing temperature control

Bearings have low melting points they are usually made of metals. Therefore, the bearing can damage if worked at a very high temperature. At GPS, there are used two types of the temperature measurement system, one is bearing oil temperature and another is bearing temperature. During common action, heat is normally removed by oil that is used to lubricate the bearings. In the oil leaving path of each bearing thermocouples are placed, which provide the exact temperature of the bearing oil.

4.4.3 Lube oil temperature control

Lube oil is used for cooling and lubrication of turbine and generator bearings. Its actions as a cleaning agent. The sensor passes a signal and the alarm alerts the operator about the condition and agrees to a time to take proper action if the lube oil temperature is over 60ºC or under 40ºC. If the lube oil temperature is below 17ºC the regulation system does not work. So, lube oil temperature varies essentially to confirm the sound performance of the turbine.

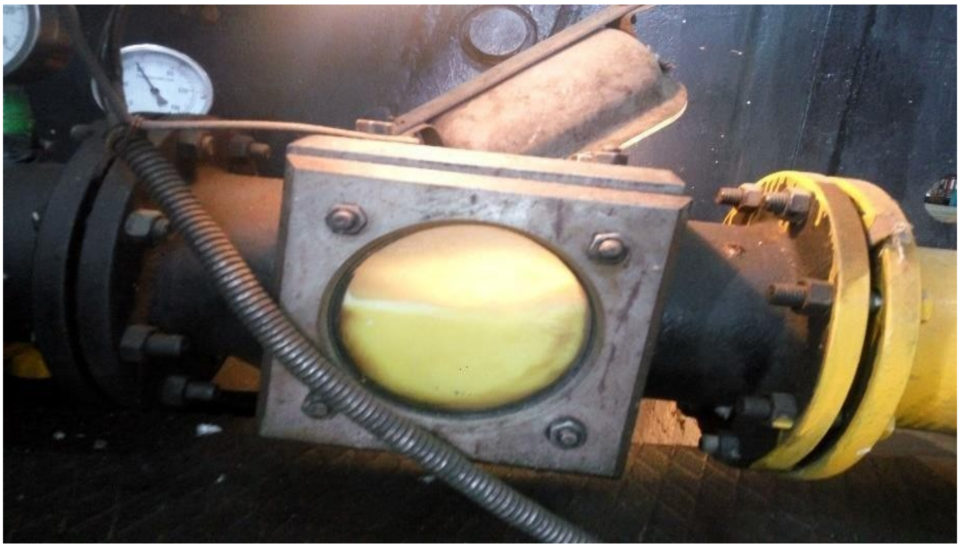

Fig. 4.6. Lube oil pipe at GPS

Water Treatment

4.5 Introduction

The water treatment plant is also called a chemical plant. It is used to chemically treat water to produce de-mineralized or demi water. The water can be gathered from the river. in GPS unit -4, the raw water is gathered from the underground. In the Under- groundwater remains more mineral than river water. that is dangerous for the power station tools. Therefore, As the raw water has minerals, organic matter, bacteria, etc, this water cannot be used to makes steam. This mineral can destruction the water tubes and turbine blades. It can drop the efficiency of the plant. This is the main fact to treat the raw water in the chemical plant to eliminate the mineral from it.

Fig. 4.7. Water treatment plant at GPS unit-4

4.6 Use of demi water

Demi water is used for two purposes:

(i) To produce steam to revolve the steam turbine and

(ii) (ii) To refrigeration purpose.

The demi water keeps low conductivitywhich is good for stator make cold system. Therefore, demi water is used for generator stator make cold. In the condenser, to cool the steam demi water is also used. [4]

4.7 Objectives of water treatment plant

The water treatment plant's Objective is to lessen corrosive agents from the raw water. These are scaling, corrosion, erosion, etc.

4.7.1 Scaling

Scaling happens when the chemistry and temperature situations are such that the melted mineral salts in the water are produced to hurried and form solid deposits. These can be mobile, like fine silt, or can build up layers on the metal surfaces of the systems. Scaling is a problem because; (i) its heat exchange becomes less proficient as the scale thickens, which trashes energy. (ii) It narrows pipe sizes and therefore rises the energy desires in pumping the water through the pipes

4.7.2 Corrosion

Corrosion happens when the parent metal oxidizes (as iron rusts, for example) and gradually the integrity of the plant tools has cooperated. The corrosion products can occur similar problems like scaling, corrosion can command to leaks, which is an under-pressure system can lead to terrible failures.

4.7.3 Erosion

Erosion is a mechanical method that contains friction, flow, etc. Erosion happens due to water flow, resistance, or other mechanical procedures.

4.8 Production of de-mineralized water

Demineralized Water also well-known as Deionized Water, The principal impurities present in the waters are dissolved solids (cations, anions), suspended solids or particulate matter, colloidal species, and dissolved organic matter. These impurities and their individual levels in the water supply determine the appropriateness of the water for use in the several procedures of a power plant or the essential treatment necessities to make it adequate for use. So, the water necessities to be de-mineralized. The water free from any mineral is called de-mineralized water. At GPS unit-4, the water treatment plant maintains a flow to treat the water. To eliminate all the element from mineralized water, GPS follow a method that is demonstrated in Fig 4.1. First of all, raw water is gathered from the under ground using a circulating water pump This water is stored in a big water tank. Clarification, mechanical filtering, cation, and anion staging, and mixed bed exchanger, etc are serially completed to present demi water.

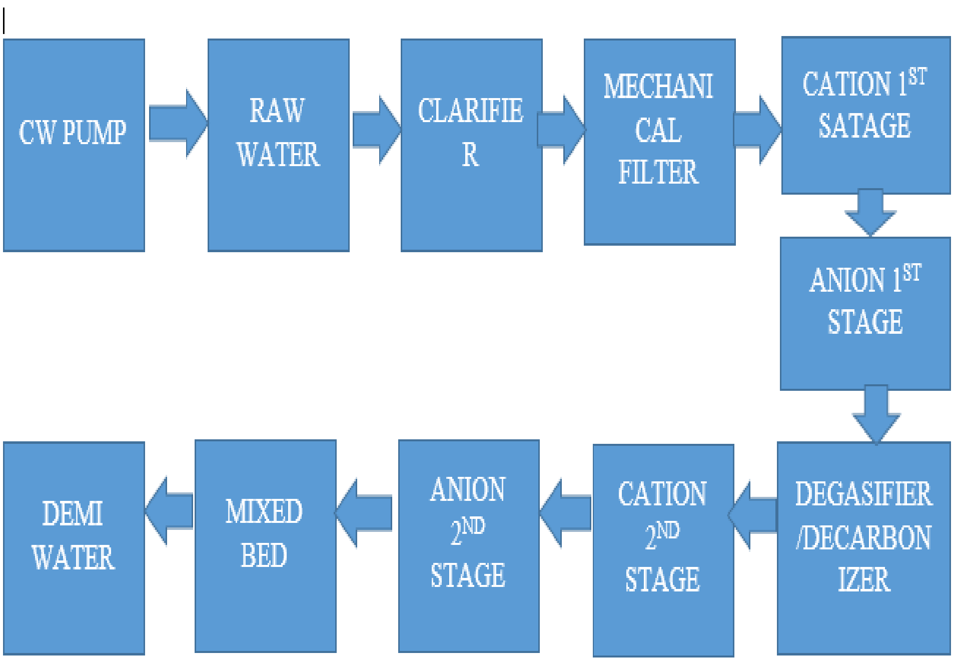

Fig. 4.8 Flow diagram of water treatment process at GPS unit-4

4.9 Quality of de-mineralized water

Finally after the chemical treatment the demineralized water posses the following properties.

Table 4.2. Quality of demi water

Conductivity	0.2 – 0.3 µS/cm
Hardness	< 1.0 µg-eq/l.
Sulfur dioxide	< 20 µgm/l
Chlorine ion	Trace
Iron	< 20 µgm/l

Fig no: 4.9 de-mineralized water tank

4.10 Boiler

A boiler or steam generator is a device used to produce steam by applying heat energy to water. A boiler refers to a closed chamber where water is heated at a high temperature and steam is produced to rotate the turbine. At GPS, gas is the main fuel to produce fire in the furnace. The boiler was divided into four sections: L.P. evaporator, Forced flow section, H.P. evaporator, and superheater. The feedwater is pumped via the forced flow section of the boiler to the system steam drum. In the H.P. evaporator section water from steam, the drum is circulated at high pressure to produce steam for the superheater. In the superheater, the wet steam is superheated and transformed into dry steam. Water in the tubes is heated and reaches 540°C temperature. The steam of that temperature is used to rotate the turbine. [6]

Table 5.1. Boilers specification

Description	**Unit-4**
Model No.	NG-9F-03-R
Manufacturer	Hangzhou boiler group
Steam generating capacity (Ton/hr)	2137 t/h
Steam pressure at boiler out let (Kg/cm^2)	540
Rated live steam temperature (^{o} C)	540
Secondary steam temperature (^{o} C)	540
Efficiency (%)	93
Flue gas temperature (^{o} C)	648.9

4.11 Forced circulation

Water takes place because of the difference in thickness caused by the heat of the water in the natural circulation boiler. The boiler is known as a forced circulation boiler when the circulation is done with the help of a pump. At unit -4 boiler is a forced circulation boiler. The feed water pump continues the water circulation.

4.12 Boiler accessories

There are some kinds of boiler accessories that have been used in GPS unit-4. These are economizer, boiler drum, super-heater, induced draft pump fan, forced draft fan, water wall, air pre-heaters, furnace, etc.

4.12.1 Furnace

The furnace is that the chamber inside a boiler where gas or coal is burned with the presence of air to supply heated gas or flue gas. The ratio of gas to air is 1:10. In the furnace. The temperature inside the furnace chamber is 1500 - 1800oC. The preserved water from the feed water tank first passes through the economizer and then enters into the furnace through the tube. then flue gas releases heat to the water and water becomes saturated steam. The temperature of this saturated steam is about 355oC. A small amount of natural gas and air is needed, at the first of the firing of the burner. This small gas is understood as ignition gas which is supplied into the burner by an ignition pipe. When the ignition line of the burner is turned off, the mainline for fuel and air supply is turned on. The draft fan powerfully deliveries air to the furnace and then the saturated steam from the furnace goes to the boiler drum. [6]

4.12.2 Boiler drum

The Water which comes from the economizer is reserved in the boiler drum. Inside the boiler drum, the level of water is measured by a level transmitter. The plant will trip when the water level will crosses the limit, that's why it is very vital to control the water level . This is done by an automatic system. From the boiler drum, the saturated steam is shifted into super heater.

4.12.3 Economizer

A device that makes progress some of the heat carried by exhaust flue gas. The improved heat is used to increase the temperature of feed water. Then the feed water at raised up temperature is delivered to the boiler. If the feed water at raised up temperature is delivered to the boiler, it needs less heat to convert the water into the system. As a result consumption of fuel shrinkages. [6]

4.12.4 Water wall

Furnace chamber is bounded by many tubes with water inside. These surrounded water tubes are called water wall. Steam is created in the tubes and then go to the boiler drum[6]

4.12.5 Air pre-heaters

Between the economizer and the chimney Air pre-heaters are installed and it removes heat from the flue gases and transfers a portion of the heat that otherwise might pass up the chimney to waste.

4.12.6 Chimney

To release the exhaust gas in the air Chimney is used. Remaining from the intake combustion air Flue gas is generally composed of carbon dioxide, as well as, nitrogen, water vapor and excess oxygen. It also has a small section of pollutants for example particulate matter, sulfur oxides, nitrogen oxides, and carbon monoxide.

4.12.7 Steam separator

A device which can isolate the particle of water and oil from steam. If the steam contains water and oil particles then the steam can destruction the turbine. At GPS centrifugal stem separator is used to isolate the particle of water and oil.

4.13 Boiler protection

Boiler protection is an important part of any power plant. To protect the boiler the parameter settings need to be maintained according to table 4.4.

Table 4.4. Boiler protection parameter at GPS unit-4

Description	Parameter settings	Time settings
gas pressure Decrease before burners	0.01 kgf/cm^2	_
Drum Level Decrease	-160 mm	_
Drum Level Increase	+200 mm	_
Decreased of stem flow through reheat lines	0.1 kg/cm^2	20 sec
Tripping of both FDF/IDF/RAH	By interlock contracts of circuit breakers	9 sec
Air pressure drop of air supplied to burners	40 kg/cm^2	9 sec

Chapter 5: Generator

5.1 Introduction

A generator is an electrical machine, which changes mechanical energy into electrical energy. In-house and different industry AC current is used. The power plants mostly use AC generator to produce AC current. GPS has only an AC generator to produce AC current. In GPS unit-4 has been used tow generator one for steam section and another for gas turbine only AC Generators are used which produces interchanging current. The generator has two-part, rotor and stator. There are two types of the generator are used at GPS. 55 MW generator and 210 MW generator. Unit-4has a 210 MW generator.

5.2 Generator of steam turbine

It generally works according to Faraday's Law. The main two parts of the generator are the rotor and stator. The rotor is connected with the turbine by a shaft. So the turbine rotates allowing the rotor to spin and the mechanical energy is converted to electrical energy. It running at a speed of 3000 rpm and the frequency was 50 Hz. The power factor is 0.85 and the field current is 1500 A. the generator is capable of producing 210 MW of power. [4]

Fig. 5.1. Generator of unit-4 of GPS

Table 5.1. Information of generators and its ratings at GPS unit-4 in steam turbine

Description	Unit 4
No of generator	1
type	TRB20021y3
Rated output (MW)	210
Rated terminal Voltage (kV)	15.75
Stator Current (A)	9490
Rotor Voltage (V)	450
Rotor Current (A)	2015
Rated speed (rpm)	3000
Power factor	0.85
Mass of generator	240000 kg
Rated frequency (Hz)	50

5.3 Generator of gas turbine

The gas turbine generator is a synchronous one, which is manufactured by GE with a full hydrogen-cooled type; it utilizes a 6.6KV factory bus to supply a static excitation system for excitation. Under the normal operation, the outlet voltage of the generator is 15.75KV, which is connected to the main transformer via the generator outlet GCB breaker and connected to the 230kv system in the form of a unit system. During the unit star-up period, the generator is started by LCI as the synchronous motor control unit. One circuit breaker and one isolated switch are installed between the generator and the main transformer, and the circuit breaker and isolated switch are not installed in the branch of the plant. The branch of the plant is connected to the low voltage side of the main transformer; the normal start-stop of the unit is achieved through the main transformer charged from the service power source. The generator is synchronized by GCB, it is not required to do the auxiliary power switchover operation to meet the requirement of various peaking operation. [4]

Fig. 5.2. Gas turbine Generator of unit-4 at GPS

Table no: 5.2 Information of generators at GPS unit-4 in gas turbine

	item	unit	value
generator	Model		H53
	Serial number		GG10606
	Cooling method		4.1Bar（g） (60 PSIG) 40°C Hydrogen-cooled 4.1Bar(g) (60 PSIG) 40°C
	Rated capacity	MVA	352
	Rated power	kW	248120
	Rated voltage	kV	15.75
	Rated current	A	12903
	Power factor		0.80
	Speed rpm		3000
	Frequency	Hz	50
	Excitation voltage	V	693
	Excitation current	A	1909

5.4 GCB equipment overview

The full name of GCB is Generator Circuit Breaker (it is translated into generator outlet circuit breaker in Chinese). The generator lead-out line and off-phase seal at the low voltage side of the main transformer are connected to the two sides of GCB separately. The plant power is supplied in reverse via the main transformer to start and stop the unit normally, generator is synchronized by GCB, it is not required to do the auxiliary power switchover operation to meet the requirement of various peaking operation. [4]

5.5 LCI device overview

LCI (Load Commutated Inverter) static starter is an AC driven system that is especially designed to start the gas turbine and generator unit, the rotating speed of which is adjustable. The static starter adopts Load Commutated Inverter (LCI) technology, which is applied to control the static and frequency regulation for synchronous motor. The input power of each LCI device is taken from 6.6KV isolation transformer of each unit, any LCI starting device can start the unit, its output is connected to the generator via the auxiliary bus through 89SS switch. The generator is operated in synchronous motor mode; the static starter accelerates the turbine unit based on the special speed curve for the purpose of providing an optimal starting environment for the gas turbine. All LCI devices in this unit adopt LS2100e static starter with 11MVA capacity class supplied by GE. [4]

5.6 Rated operation mode of generator

The way of operating according to the generator manufacturer's rated parameters on the data plate is called rated operation mode, which allows the generator to run continuously for a long period. The normal output of the generator is 248.120mw. [4]

5.7 Regulations of generator voltage, current, frequency and power factors

5.7.1 Provisions on generator voltage

The voltage for normal operation of the generator is the rated voltage, and the variation range shall be within ±5% of the rated value without affecting the stability. The generator shall be capable of continuously outputting the rated capacity without impacting the stability or bringing damage to the equipment when the rated power factor is 0.85 (lag) and the voltage is within ±5% of rated voltage.

5.7.2 Provisions on negative sequence current of generator

The negative sequence current that is allowed to operate for long time to the generator shall not exceed 7.61% of the rated value; the maximum phase current shall not exceed the rated current.

5.7.3 Provisions on generator frequency

The active power load of the generator shall be adjusted according to the system frequency. Under the normal circumstances, the system frequency shall be maintained in the range of 50±0.2HZ.the generator can be operated according to the rated capacity this moment, not including the accidents, but it shall be dealt with recovered immediately.

5.7.4 Provisions on power factor

A. The rated value of generator is 0.85 lag. Under the rated capacity; the specified power factor under leading phase operation is 0.95; the power factor is kept at 0.85 lag to 0.95 lead during the normal operation of generator. When the generator is running at reduced power factor, the rotor current of the generator shall not exceed the rating. When the generator is running with the power factor exceeding the rated value, the parameters of all parts of the generator shall not exceed the rated value[4]

B. When the power factor of the generator varies within the range of 0.85~1, the apparent power of the generator shall remain unchanged. When the power factor of the generator is lower than 0.85, the apparent power of the generator shall be reduced. See the table below for specific parameters:

Table no: 5.3 Power factor

Power factor	1	0.9	0.85	0.8	0.6
Percentage of rated apparent power	100	100	100	96	89

Note: the above calculated value of hydrogen is figured out when the rated hydrogen value is 40°C.

C. Power factor control is put into operation when load is rising above 60MW.

D. When the excitation voltage and current of the generator does not exceed 1.1 times of its rated excitation voltage and current, the excitation system shall ensure continuous operation.

E. The power factor is kept at 0.85 lag to 0.95 lead during the normal operation of generator. [4]

The generator operates continuously under rated working mode and the allowable temperature value of each component

Table no: 5.4 Generator operates

Name of generator parts	**Measurement method**	**Insulation class**	**Temperature rise**
Stator winding	Embedded temperature measuring components	F	B
Rotor winding	Hot-wire method	F	B

5.7.5 Provisions on generator operating load

(1) The generator is allowed to run continuously for a long time according to the parameters on the data plate. Generator stator current is not allowed to exceed the rated value during normal operation. When the stator voltage is reduced to 95% of the rated value, the generator stator current is allowed to reach 105% of the rated value, but not to exceed 105% of the rated value. (

(2) After the generator is integrated into the power grid, it will automatically charge an initial load not less than 1.7MW. It shall be noted that the reactive power shall not be too low this moment and the change of power factor shall be noted.

(3) The speed of generator with the active load is determined by the gas turbine. When the load is charged too fast, it shall be noted that the temperature change of the generator cooling gas shall be in the specified range.

(4) When the inlet hydrogen temperature of generator is 50°C, Overloading is not allowed for any length of time

(5) In the case of accident, in order to prevent the destruction of the static system stability, short-term accidents are allowed to run under load. The values of overload and the allowable time refer to the following table.

(6) Table no: 5.5 The values of overload and the allowable time

Time (s)	10	30	60	120
Percentage of stator rated current	226	154	130	116

(The operation of the generator mentioned above shall not result in the rapid temperature rise to winding to lead the winding insulation9 damage and harmful deformation)

5.7.6 Provisions on rotor overloading

Table no: 5.6 rotor overloading

Time (s)	10	30	60	120
Percentage of stator rated current	208	146	125	112

(The manufacturer confirms that the rotor winding will withstand 200% of the rated excitation voltage for 10 seconds. It is recommended to be 5 seconds at 200%, and then it is limited for 20 seconds under 1.25*AFFL (the rated magnetic current) and returning to AFFL level thereafter)

(7) Under the rated speed of generator, the generator and excitation unit are allowed to operate for a long period when the vibration value at each bearing does not exceed 0.127mm/s.

(8) The generator is allowed to run by peak load regulation, but it must be noted that the load increasing and decreasing rate during peak load regulation shall not exceed 3~%PN.

(9) The rated of hydrogen temperature is 40°C, the generator output power is executed as the table below when it is exceeding 40°C. The highest hydrogen temperature shall not exceed 51°C, the cooling hydrogen temperature rise shall not exceed 20°C.

(10) Generator has four sets of hydrogen cooler in total and all the four sets of hydrogen cooler are put into operation during the normal operation to ensure the cold hydrogen temperature constant inside the cooler. When one of the hydrogen coolers is out of operation, it can carry at least 2/3 of the rated load, but it shall be noted that the temperature of each part of the generator shall not exceed the specified value. [4]

5.8 Components of generator

The major components of generator that I observed at GPS are stator, carbon brush, exciter, slip ring, rotor, cooling system and other apparatus.

5.8.1 Stator

It is the most important part of a generator. The stator of the generator is a stationary part. In many cases, depending on the configuration of the generator stator may act as the field magnet. The stator consists of a cylindrical ring which is made of iron. The stator has only one coil which consists of a number of turns and the stator core is made of thin sheets of magnetic steel. The cylindrical ring delivers an easy path for the magnetic flux. When the rotor rotates, a voltage is induced in the stator coil.

Fig. 5.3. Stator of generator at GPS

5.8.2 Rotor

The rotor is the rotating part of the electric generator, these rotors are coupled with the prime mover. Subsequently, the magnetic field is rotating, the rotor necessities dc supply for creating the magnetic field. It rotates due to the electromagnetic induction torque developed about the rotor's axis. The rotor conductor bar is created like a squirrel cage.

Fig. 5.4. Rotor of generator at GPS

5.8.3 Insulation

Insulation is very important for a generator. Because it's getting too much hot, if insulation is not properly used machines around the generator can be damaged. In GPS they use high-temperature resistant textile and insulation board for insulation.

5.8.4 Carbon brush

The shaft voltage monitoring carbon brush device is an important part of the GE shaft voltage monitoring system. The carbon brush device is provided with a grounding carbon brush that makes the shaft grounded, an isolating carbon brush used to measure dangerous shaft voltage and a low impedance shunt used to measure current flow. The shaft voltage monitoring circuit monitors continuously the shaft voltage and current passing through the grounding carbon brush, by making use of the voltage and current signal from the carbon brush device, and triggers an alarm when either of the values is too high. This will send an alarm for deterioration of the grounding carbon brush or bearing insulation, so as to take actions to avoid damage to the bearing.

5.8.5 Slip ring

Slip rings are circular rings that are linked to the armature and revolve with the armature. It is generally made of nonferrous materials like bronze. Two slip rings are used in the generator. Those slip rings are divided from each other. It holds a spring which maintains the pressure of carbon brush for joining with the rotor. It supplies a continuous electrical connection through brushes on stationary contacts.

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Fig. 5.5. Slip ring of generator at GPS

5.8.6 Power factor

It is the ratio of real and apparent power. The power factor of unit-4 is maintained at 0.85. Since the generator comprises a coil in the stator it makes apparent power and shrinkage the power factor.

5.8.7 Pole

All generators in GPS unit-4 are two poles mechanism. The number of poles is all the time an even number for a generator. Magnetic lines are generated between the poles. Electricity is produced when the conductor cuts the magnetic lines. The generator rotation speed depends on the number of poles, according to the following justification

Here,

N=Rotating speed of the rotor per minute

$$N = \frac{120 \times f}{P}$$

f= frequency

P= Pole

5.8.8 Armature winding

It is the leading current-carrying winding in which the electromotive force of rotation is induced. The armature winding current is known as the armature current.

5.9 Excitation system overview

All excitation systems of unit 4adopt EX2100e excitation control device supplied by GE. EX2100e excitation control device adopts thyristor excitation system, which generates excitation current to control the voltage and reactive power of the generator end. The excitation power is taken from the excitation transformer of the 6.6kv high voltage plant bus. The principle of excitation control is to control the silicon rectification output, the current of generator line and the voltage of stator is the main feedback of de-excitation device to control the DC current and voltage of the rotor

5.9.1 DC excitation

At GPS Unit-4 use a DC excitation system. The exciter is a small DC generator joined to the same shaft as the rotor. When the rotor revolves this exciter produces the power for the electromagnet. The field current of the exciter Controls the exciter output. The magnetic field of the rotor is controlled by the output of the exciter.

5.10 Generator oil system

Fig: 5.6 Generator oil system

5.10.1 Generator sealing oil system

(1) Slightly open the generator sealing oil pressure control valve, and inlet isolating valve, and fill oil to the sealing soil system. Also, the manual bypass valve of the sealing oil pressure control valve can be open to have the system put into operation;

(2) Monitor the oil level of the oil tank for the sealing oil float collector. During start-up of the sealing oil system, low internal pressure of the generator will result in increase in the oil level. To prevent return of the sealing oil to the generator, the bypass valve of the oil float collector is adjusted manually to maintain oil level of the oil tank for the oil float collector at half the visible level indicated on the oil indicator of the float collector

(3) With increase in the gas pressure in the generator, close its bypass valve when the oil level of the float collector is maintained automatically;

(4) When the pressure in the generator further increases, fully open the sealing oil pressure control valve of the generator and inlet isolating valve. Note that the sealing oil pressure control valve is in automatic mode, and a certain sealing oil differential pressure is maintained; [4]

5.10.2 Hydraulic oil system

Start the hydraulic oil pump 88HQ in the Mark VI interface, inspect and confirm that the pump and motor make normal sound, and the current returns normally and the outlet pressure remains normal; Inspect and confirm that the system is free from external leakage

In the shut-down process of the unit, execute the sequential control procedure so that the hydraulic oil system is shut down automatically.

5.11 Synchronization system

A synchronization system is a method of joining a three-phase AC generator to another generator of the grid. Some conditions require to be sustained to synchronize the alternator. The terminal voltage, frequency, and phase should be unchanged. A generator synchronizing with the grid is one of the most important jobs in power transmission.

5.11.1 Voltage synchronization

The output voltage of a generator has to be equal to the grid voltage which is generally 15.75 kV for unit 4. Controlling the rotor current the stator line voltage is maintained.

5.11.2 Frequency synchronization

The generator has to be motivated by the first cause at such a speed that the generated power frequency is adequate to the grid frequency. The generator frequency has got to be adequate to the grid frequency. Our national grid frequency is 50 Hz. For that reason, to synchronize with the national grid frequency, the generator revolves at a speed of 3000 rpm.

5.11.3 Phase synchronization

The generator phase must be synchronized with the phase of the grid. This necessitates that the generator’s phase and phase sequence got to be synchronized thereupon of the type the gird. If the grid sequence is R-Y-B then the generator arrangement must even be R-Y-B. The phase of a generator and therefore the phase of a grid has to be equal. By adjusting the sector current the stator angle is often controlled.

5.12 Generator cooling system

The temperature of the generator increases during the running condition for the reason that the Generator deals with very high power. There are cooling systems installed for the generator which absorb the heat of the generator while it is running In GPS. A generator features a lot of conductors and a high amount of current flows through the conductors. When current flows during a conductor, heat is generated. If that heat isn't removed, then the windings are going to be damaged and eventually, insulation will breakdown. In the synchronous generator, the heat generated thanks to high current flow within the rotor winding also must be removed.

At GPS, two sorts of generator cooling systems are employed. One is a water cooling system and the other is a hydrogen cooling system

5.12.1 Water cooling system

This cooling system is used for stator cooling. Water drift is used in the generator for cooling purposes. The water tube encloses the Stator. The water controls heat and then transfers the heat away. Water flows always to dissolve the heat. The stator winding of the generator is refrigerated by circulating demi water through the coolers, windings, and filters. Water is discharged into a separated compartment of the sealed enlargement tank.

5.12.2 Hydrogen cooling system

In hydrogen cooling system hydrogen gas circulates through the generator and around the rotor to dissolve heat. Hydrogen gas is lighter than air so it does not apply any pressure to the speed of the rotor**.**

5.13 Generator Protection System

Various sorts of electrical and mechanical faults can affect the performance of the generator. To guard the generators against those faults, different electrical and mechanical protections are required, which can be described nest.

5.13.1 Over current and under voltage protection

Over the current situation happen due to overload short circuit or ground fault current flows through the equipment or conductors exceeds the rated current. Overloading of the generator may cause the breakdown of winding insulation and unnecessary supply of power on the system. As a result, the generator may trip or gets cut off from the system. These circumstances may happen when one generator trips suddenly and the other generator tries to supply the load. The current will rise and the terminal voltage will decrease. In GPS automatic voltage regulator is linked to the system which tries to restore the voltage. Under voltage, the relay is additionally used for under-voltage protection. In GPS, over current relay is employed for overcurrent protection. To construct this relay only a current coil is required, there is no need for a voltage coil.

5.13.2 Over speed protection

Over speed, protection is generally delivered for prime mover driven generators. All generators in unit-4 at GPS are prime mover driven generator. Prime mover is the part that takes tums the rotor of the generator. In GPS, a steam turbine works as a prime mover. If the prime mover speed rises then the generator frequency rises. The speed of the rotor is controlled by the speed governor. If any deviation is seen, the speed control relay will detect the fault and the generator of the circuit breaker will trip.

5.13.3 Over voltage protection

Overvoltage may occur if abruptly the load is reduced on the generator. Prime mover speed does not alter with the load alterations, two over voltage relays offer the over voltage safety, these are immediate relay and Inverse Definite Minimum Time relay. These two relays will detect the deviations and the circuit breaker will trip.

5.13.4 Stator earth fault protection

When the stator of the generator gets shorted with the ground this fault happens. Normally the stator of a generator is too close to the ground, accordingly, this fault may happen. the degradation of insulation in the windings can also fault the Stator earth. If this fault occurs, the normal low neutral voltage will increase as high as the line-to-neutral voltage, which causes serious injury. This fault can be sensed by measuring the secondary voltage of the neutral grounding transformer.

5.13.5 Under frequency protection

Under frequency happens due to overload. The demand for overload results in an upsurge in generation voltage and a decrease in frequency. If this happens, vibration happens in the generator, which can destruction the rotor. During this situation, if the frequency falls below 48 Hz, the relay operates. An automatic load shedding facility needs to be applied to care for the system.

Chapter 6: Substation

6.1 Introduction

A substation could also be a neighborhood of an electrical generation, transmission, and distribution system. Substations transform voltage from high to low or low to high and perform the other important functions. The facility is produced at the facility stations which are located at favorable places, normally quite far away from the consumers. It's provided to the consumers through an outsized network of transmission and distribution. Electric power flows through numerous substations inside the generating plant of GPS. The electricity generated in any power station first gets transformed into the substation. Consistent with the road to line voltage, the substation has some parts like 11KV, 33 KV, 132 KV and 230 KV. Substations at GPS are outdoor type substation [1]

Fig. 6.1. Substation at GPS

Table 6.1. Rating of substations for unit 4 at GPS

Unit	Generating voltage	Transmission voltage
Unit 4	15.75 KV	230 KV

6.2 List of equipment of a substation

in substation major equipment's are used of GPS are outgoing feeder different types of a relay, bus bar, lightning arrester, different types of the circuit breaker, isolator, different types of transformers like power transformer(PT), single-phase transformer, auxiliary transformer, instrument transformer, current transformer (CT) and potential transformer

6.2.1 Outgoing feeder

From substation to consumers these feeders are carrying power. I observed outgoing feeders for different bus bar systems In GPS which is used for power transmission and reception purposes. There are

11 KV outgoing feeder,33 KV outgoing feeder,132 KV outgoing feeder, 230 KV outgoing feeder, 230KV Outgoing Feeders are, Ashuganj-1, Ashuganj-2, Ishwardi-1, Ishwardi-2, Rampura-1, and Rampura-2.Tongi and 132KV Outgoing feeders are, Narsingdi-1, Ashuga1, Bhulta-1,-1, and Joydebpur-2.

6.2.2 Bus bar

A bus bar is used to conduct electricity within an electrical substation it,s a strip of metal, distribution board, electric switchboard. Bus bars are made of copper or aluminum bars. In a substation, incoming and outgoing lines are connected to the bus bars. In GPS I have seen 132KV and 230 KV bus bar. Numerous bus bar arrangements can be used in a substation. Normally in GPS two types of bus bar arrangements are used. One is a single bus bar and another is a double bus bar arrangement. A single bus bar arrangement is the simplest form of bus-bar in which each generator and feeder is controlled by a circuit breaker. The 11 KV is a single bus bar arrangement, it is low cost and low maintenance arrangement. Two bus bars are present in such a way that any outgoing or incoming feeders can be energized from any of the buses in a double bus bar system. Two circuit breakers require in a double bus bar arrangement. Through a separate isolator, every feeder is connected to both of the buses. I have seen a double bus bar system In GPS between 132KV and 230KV system.

Fig.6.2. Bus bar at GPS

6.2.3 Bus coupler

Bus coupler may be a device with none interruption in power supply and without creating hazardous arcs it is used to couple one bus to the opposite. A bus coupler is a breaker used to couple two bus bars to perform maintenance of circuit breakers associated with that bus bar. It is achieved with the assistance of a breaker and isolator .

Fig. 6.3. Bus coupler at GPS

6.3 Circuit breaker

A circuit breaker is an electrical switch that operates automatically. It is designed to protect an electrical circuit from damage when an overload or short circuit occurs. The basic task of a circuit breaker is to sense a fault condition. When it senses any fault condition in the system, it discontinues the electrical flow by interrupting continuity. There are three types of circuit breakers in GPS.

6.3.1.1 Oil circuit breaker

In the oil circuit breaker, oil is used as an arc extinguishing medium. The fixed and the moving contacts are dipped in the oil. When the circuit breaker cuts off, the arc creates and this arc is quenched by oil vaporization. There is a few oil circuit breaker in GPS.

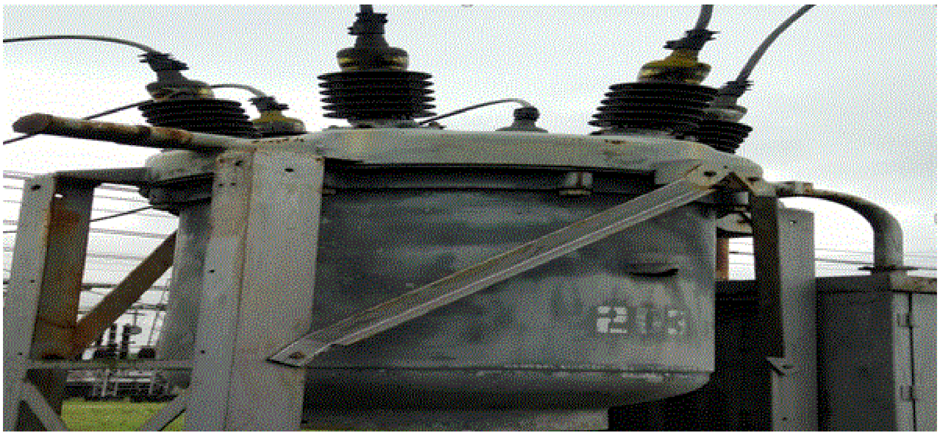

Figure6.4: Oil Circuit Breaker at GPS

6.3.1 Air blast circuit breaker

High-pressure air is used as an arc reducing medium in the air blast circuit breaker. Arc makes due to sudden break of the circuit, high pressure air flows to the arc between moving and the fixed contacts to turn cold the arc. This process is very safe.

Fig. 6.5. Air blast circuit breaker at GPS

6.3.2 SF_6 circuit breaker

Sulfur Hexafluoride (SF6) gas is used as an insulating and arc quenching medium In Sulfur Hexafluoride circuit breaker. The operation of the SF6 circuit breaker is often similar to the air blast circuit breaker. Here SF6 gas is compressed and stored in a high-pressure tank. Highly compressed gas is released through the arc in the breaker and collected in a relatively low-pressure reservoir during the operation of the SF6 circuit breaker,. SF6 circuit breakers have very good arc reducing properties. The temperature range of the SF6 circuit breaker is (– 25°C to +55°) . [7]

Fig. 6.6. SF6 circuit breaker at GPS

6.4 Lightning arrester

A lightning arrester is a protective device which conducts the high voltage surges on the power system to the ground. A lightning arrester is also called a surge arrester. It consists of a spark gap in series with a non-linear resistor. Lightning occurs when clouds are highly charged for the ground. Lightning arrester has a high voltage terminal and a ground terminal. One end of the arrester is connected to the terminal of equipment to be protected and the other end is grounded. When lightning strikes a power transmission line, the induced high voltage travels along the line towards both ends; lightning arresters will bypass this high voltage to the ground so that the nearby transformer will not be damaged. Arresters like this usually have a counter to count the number of impulse voltages that it has arrested. In GPS, I observed lightning arresters and the counter of the arrester. There are various types of lightning arresters. In GPS, polymer-metal oxide, zinc oxide arresters, and rod gap are used.

Fig. 67. Lightning arrester at GPS

6.5 Wave trap

Wave Trapper was utilized in the power grid for carrier communication. It traps the upper frequency above 50 Hz. We saw power plants and substations being connected by high voltage power transmission lines which transmit power typically at 50 or 60 Hz. These lines also carry communication and control signals for the operation of the grid. Wave trappers were wont to separate the facility and communication signals at every receiving end

Fig. 6.8. Wave trap at GPS

6.6 Isolator

An isolator may be a part of a circuit and at off load condition, it electrically isolates the circuit that's connected thereto. For safety and maintenance operations, high-voltage isolators are utilized in electrical substations like circuit breakers, transformers, and transmission lines. it's called an “offload isolator” because it's open only after the current has been interrupted by another control device. Normally Isolators are installed alongside the circuit breakers. If a breaker trips then an isolator is employed to separate the breaker from the system. If the isolator opens under on load condition then an arc is made and it might be harmful to the system and therefore the things near the isolator. [7]

Fig. 6.9. Isolator at GPS

6.7 Relay

A relay is an electrically operated switch. It sprees the circuit breaker for disconnecting the faulty portion of the electrical circuit from the rest of the circuit. At GPS some relays are used, these are a protective relay, over current relay, and distance relay.

6.7.1 Protective relay

The protective relay is a device that responds to signals from the transducers by quickly initiating or allowing a control action to be implemented in order to prevent damage to the faulty equipment and to restore service as soon as possible. Protective relays continuously monitor voltage, current, and power.

6.7.2 Over current relay

Over-current relay senses the current flow and sprees the circuit breaker if overcurrent flow is sensed. Overcurrent Relay is used for primary ground-fault protection on most transmission lines. It is connected to a current transformer and adjusts to operating at a specific current level. The relays do not need an AC voltage source for operation.

6.7.3 Distance relay

Distance relays are used for phase faults. It works by a double-action, which means one coil is energized by voltage and the other coil is energized by the current. When a fault occurs on a transmission line, the fault current increases and the voltage reduces. These relays respond to the distance between the relay location and the fault location, assuming constant impedance. [7]

6.8 Transformer

A transformer is an electrostatic device that can Transfers electricity between two circuits through electromagnetic induction without changing the frequency. It consists of two or more coils which are connected with a standard magnetic flux present within the core. One among the transformer winding is the primary coil connected to a source of AC electric power and another is the secondary coil which supplies electric power to loads. There are used in GPS unit 4 a 360 MVA transformer and it is the main transformer in this plant which model no is SFZ-360000/230. There are used many kinds of transformer current transformer, auxiliary transformer, power transformer, etc. [4]

Fig. 6.10. Transformer at GPS unit 4

Table no: 6.2 technical specification of transformer

Name	No.4 main transformer
Model	SFZ-360000/230
Rated capacity MVA	360
Rated voltage	(230+8 12*1.25%) /6.9-6.9kv
Rated frquency	50HZ
Wiring group	YNdl-dl
Cooling methode	ONAN
PHASE	3
Manufacturer	Shandong electric equipment manufacturing Co.Ltd

6.8.1 Instrument transformer

The task of the instrument transformer is to transform the voltage or current in power lines for the operation of measuring instruments and relays. The measuring and defensive devices are designed for low voltage and current. Therefore, to create the current and voltages calculable by these devices, we used an instrument transformer to transform voltage and current in a measurable range. There are two types of instrument transformer. one is a current transformer (CT) and another is a potential transformer (PT).

6.8.2 Current transformer

Current transformer is an instrument transformer used in connection with ammeters, over current relays etc. Current transformer is a step up transformer, It steps down current from high value to low value steps down current in a required ratio. The phase angle error of current transformer is in limit and for given range of primary current the current ratio is constant. There are many current transformers used in GPS with current rating is 2000/2400A.

Fig. 6.11. 230 KV CT at GPS

Table 6.2. Ratings of 230 KV current transformers

Type	IMB 245
Highest System Voltage	245 KV
Rated Primary Normal Current	2000 A
Rated Frequency	50 Hz
Class of Insulation	A
Weight of Oil	270 Kg
Total Weight	K

6.8.3 Potential Transformer

The potential transformer is a step-down transformer, Potential transformer is just like a current transformer which is also an instrument transformer that is commonly used for measurement and protection which steps down the voltage in a calculable range. The potential transformer is connected in parallel. There are many potential transformers used in GPS. These are single-phase outdoor type potential transformers. The ratio of potential transformer is 230/100 KV for 230KV bus bar. .

Fig. 6.12. 230 KV PT at GPS

Table 6.3 . Ratings of 230 KV potential transformers

Type	WP 245N2
Highest System Voltage	245 KV
Rated Insulation Level	245/460/1050 KV
Rated Frequency	50 Hz
Rated Voltage	230/3 KV
Total Nominal	6125 mm
Rated Secondary Voltage	110/3 V

6.8.4 Auto transformer

The autotransformer is an electrical transformer. In an autotransformer, portions of the same winding work as both the primary and secondary sides of the transformer. Autotransformer is generally used in the position where the primary and secondary voltage ratio is larger than 0.5 or smaller than 2. In GPS, between 132KV and 230KV transmission lines, an autotransformer is used.

6.9 Transformer protection

Transformers are one of the most important and costly components of the power system. Repair or replacement of a transformer is very pricy. The protective devices of a transformer two types, one is mechanical protection and another is electrical protection. Electrical protection is used to protect the transformer and Mechanical protection is used to protect the transformer physically from any electrical fault.

6.9.1 Oil cooling system protection

In large transformers, there are some cooling systems for the transformers oil. There are Oil Natural Air Natural Cooling, Oil Natural Air Forced Cooling, Oil Forced Air Forced Cooling, etc. In GPS, a cooling system is used for oil cooling. Heat loss can be increased with forced air circulation dissipating surface is bigger. To operation, fans blowing air on the cooling surface are employed. Forced air takes away the heat from the surface of the radiator and delivers better cooling.

6.9.2 Buchholz relay protection

Buchholz relay is a safety device that is generally used in large oil-immersed transformers It is a type of oil and gas actuated protection relay. This type of relay is linked between the top of the transformer main tank and the conservator. The task of the relay is to sense an abnormal condition of the tank. It works within two stages. In the first stage it sends an alarm and second stage it trips the circuit breaker.

6.10 Transformer test

Transformers are too costly to replace regularly and must be properly kept up to maximize their life expectancy. Some tests are performed to ensure the proper operation of the transformer. These are explained next.

6.10.1 Oil test

Transformer oil is an insulating oil and also it's known as a cooking oil. Transformer oil is utilized in transformers and other electrical tools. must be tested periodically to make sure that it's still appropriate for determination. This is because it tends to get worse over time. The fluid of the transformer not only serves as a heat transfer medium but also deeds as part of the transformer's insulation system. It is therefore prudent to periodically perform tests on the oil to determine whether it is accomplished of fulfilling its role as insulation.

6.10.2 Ratio and polarity test

A ratio test is carried out on every transformer to confirm that the turns ratio of the windings is correct and the tapping on any of the windings have been created at the right location. The British standard tolerance for each ratio is + 0.5% of the stated no-load ratio. The ratio of the transformer can be checked by the ratio meter method or voltmeter method. In the voltmeter method, the transformer is keyed up from a low-voltage supply, and voltage is measured on both high tension and low tension side. This method is not considered to be adequately correct. The ratio can be measured correctly using a ratio-meter.

6.10.3 Load loss and impedance test

Load loss and impedance test, these two tests are carried out altogether. A low-voltage is applied to the winding and winding being short-circuited. The power is measured at high tension side by a two-wattmeter process. An ammeter is joined in one phase. The applied voltage is increased slowly until the ammeter point to the full load current. The voltage at which the rated current flows is to be verified. The impedance voltage can be shown as follows:

% Impedance =Voltage at which rated current flow×100/ Rated Voltage. The copper loss would be the same if measured on the low tension side

Chapter 7 : Control Room

7.1Control room of steam power plant

Control rooms are vital for organizations to efficiently and effectively monitor multiple information streams and make accurate mission-critical decisions. Power plants can benefit from control room solutions in a variety of ways, helping operators work more efficiently and make better decisions. At GPS unit 4, there are many control rooms. Each of the rooms is individually known as a unit control room. There are some sections in the control room. These are named as electric control room, gas booster control room, Turbine desk, and Generator desk. [4]

Fig. 7.1. Electric control room unit 4

Chapter 8: Conclusion

One of the largest power plants in our country is Ghorashal Power Station (GPS). My internship was in unit 4 of GPS Where the main fuel of GPS is natural gas. Generally, unit 4 is a combined cycle power plant. During my internship period, I gathered practical knowledge of how a combined cycle power plant work, generates, transmits, and distributes power. I observed how water is collected, purified, and then boiled to produce steam. There are many control rooms to control the overall power generation process. Various types of relays are used for protective purposes that are also controlled by the control room. The internship opportunity at GPS has added a unique experience in my engineering study and increased my confidence to pursue a carrier in the power sector. In my university course plan of EEE, there are no mechanical courses. I faced some problems understanding the mechanical terms during this internship, I have faced some challenges, these are discussed below:

8.1 Problems

I. In my university course plan of EEE, there are no mechanical courses. I faced some problems understanding the mechanical terms.

II. During this Covid 19 situation, I faced many restrictions that's why I could not visit all the area of this company.

III. The company did not provide me enough data for security purposes

8.1 Recommendations

8.1.1 A student must fulfill the requirements to be eligible for doing internship. To fulfill the requirement a student must take at least one course from power section of academic courses.

8.1.2 The suggestion from academic adviser regards power station internship would be very much effective.

8.1.3 Operation of power station requires knowledge equally about the mechanical engineering as well as electrical engineering. Therefore, we faced difficult to understand the mechanical section as we have not studied any mechanical engineering course.

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