A STUDY ON OPERATION OF 210 MW STEAM TURBINE POWER PLANT AT GHORASHAL POWER STATION

This Thesis submitted in partial fulfillment of the requirements for the Award of Degree of Bachelor of Science in Electrical and Electronic Engineering.

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DAFFODIL INTERNATIONAL UNIVERSITY

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Concern Letter

বাংলাদেশ বিদ্যুৎ উন্নয়ন বোর্ড
BANGLADESH POWER DEVELOPMENT BOARD

ব্যবস্থাপক (তত্ত্বঃ) সংরক্ষণ -এর দপ্তর
৩নং ইউনিট রি-পাওয়ার্ড সিসিপিপি
ঘোড়াশাল বিদ্যুৎ কেন্দ্র
বিউবো, পলাশ, নরসিংদী।

শেখ হাসিনার উদ্যোগ ঘরে ঘরে বিদ্যুৎ

Date:30-11-2019

TO WHOM IT MAY CONCERN

This is to certify that **Md.Safiqul Islam** bearing **ID No. 163-33-3718,** a student of **EEE** department from DIU- Daffodil International University has done his practicum in **Ghorashal Power Station** from 01 October 2019 to 30 November 2019. During his practicum he came to know about the Components & Operation of Steam Turbine Power Plant.

He has been proactive and sincere on his duty.

I wish him every success in his life.

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Certification

This is to certify that this internship entitled **"A Study on operation of 210 MW Steam Turbine Power Plant"** at Ghorashal Power Station a Power Plant of BPDB is done by the following student under my direct supervision and this work has been carried out by him in the Ghorashal Power Station a Power Plant of BPDB in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on January 2020

Signature of the Candidate:

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Md. Safiqul Islam
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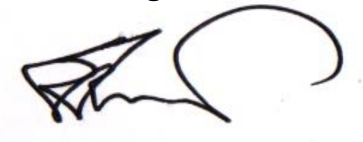
The Thesis entitled **"A Study on operation of 210 MW Steam Turbine Power Plant"** at Ghorashal Power Station a Power Plant of BPDB submitted by Name Md.Safiqul Islam ID:163-33-3718, Session: Fall 2019 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering on January 2020

Countersigned:



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Dedicated to

Our Beloved Parents

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LIST OF ABBREVIATIONS

GPS	Ghorashal Power Station
HPC	High Pressure Compressor
LPC	Low Pressure Compressor
IPC	Intermediate Pressure Compressor
HPH	High Pressure Heater
LPH	Low Pressure Heater
ES	Emergency Stop
RV	Regulating Valve
PSH	Platen Super Heater
RSH	Radiant Super Heater RSH
RAH	Regenerative Air Heater

ACKNOWLEDGEMENT

At first, thank to almighty **Allah** for his mercy on me to continue internship and complete the practicum report perfectly.

In the purpose of doing and preparing my practicum report, I would like to pay my gratitude and respect to some person for their immense help and enormous co-operation.

I would like to thank my honorable internal Supervisor **Md.Mahmudur Rahman,** Assistant Professor for his kind help in completing this heavy task and helping to take right decision at the right time and continuous encouragement on the topic. Then, I would like to thank honorable **Professor Dr. M. Shamsul Alam, Professor and Dean also Mr.Md.Dara Abdus Sattar, Associate Professor & Associate Head** and all faculties of the Electrical and Electronic Engineering department of DIU they always suggested me how to learn perfectly and make a good report. Their teaching always inspires me to go ahead in this learning situation.

Then, My special thanks to **"Ghorashal Power Station"** to give me a chance of training in the 210 MW Steam Turbine Units under the **"Executive Engineer & Member of wing Plant Management Committee"**

I am very much grateful to **Engr. Kshirod Mohan Bose,** Executive Engineer & Member of HRD of Wing Plant Management committee of Ghorashal Power Station and **Engr. Md. Anwar Hossain,** Assistant Engineer of Ghorashal Power Station for their enormous help in my acquiring practical knowledge.

ABSTRACT

Electric power is produced at the power stations by using different type of fuel, which is located at favorable places in a company. The cost of fuel gas is low then the other fuel. For that purpose, gas based steam power plant contributes greatly to supply vast power in the possible time.

Prime mover can be run by different types of fuel like gas, coal, diesel etc. Ghorashal Power Plant is gas based Steam Power Plant. Gas based steam power plant depends on proper fuel treatment system, lubricating oil system, cooling system, electrical generation and safety system, fresh water supply system, heat recovery system etc. Again, lubricating oil is purified by lubricating oil separator that protects engine from friction and damage. Boiler produces steam from the gas and contributes into necessary locations for various purposes. Cooled water is supplied to the various parts of the engine by the help of cooling tower system to prevent damage due to high temperature. The generation of large electric power depends upon the proper operation and immediate maintenance work of the turbine, boiler and other electrical devices.

All system are interrelated deeply and played important roles in power generation. So, if any system is fault whatever it is mechanical or electrical system or others, influence significantly on overall power plant. The proper knowledge of different systems can save the plant from possible hazards and helps genuinely to the proper electric power generation. The power generated from the power plant will be supplied to Bangladesh Power Development Board (BPDB) which is the main customer of the company.

CHAPTER 1

INTRODUCTION

1.1 Introduction:

This report has been prepared as an integral part of the internship program for the Bachelor of Science in Electrical and Electronic Engineering (EEE) Program at the Department of Electrical and Electronic Engineering in D**IU**—**Daffodil International University**. As a partial fulfillment of the **EEE** program this practicum report has been accomplished on **"A Study on operation of 210 MW Steam Turbine Power Plant"** at Ghorashal Power Station under the direction of **Engr. Kshirod Mohan Bose,** Executive Engineer, Ghorashal Power Station was nominated as the organization for the practicum while honorable **Md. Mahmudur Rahman,** Assistant Professor of Electrical and Electronic Engineering Department, rendered his kind consent to academically supervise the practicum period.

1.2 Objective:

The broad objective of the report has been made to know about different components and the Total operation of 210 MW Steam Turbine Power Plant. The specific objective of this report includes:

- To study basic Rankin cycle and its practical application in Steam Turbine Power Plant.
- To understand the flow diagram of 210 MW steam power plant and the location of different equipment and working principle of the equipment of Ghorashal Power Station.
- To study the standard process of Boiler operation.
- To study operational activities of the steam turbine.
- To study operation of Generator.
- To make an operation activities through whole operation Systems
- To study about Substation and The National Grid System

1.3 Scope:

This report will cover the Power generation, operation and a broad knowledge of different kinds of things through electricity power generation sector. Managing the Operation of Power plant to maintain it's require standard and user perception toward it is the main scope of discussion in this report.

All the improved Process that can be used in Power Plant for proper tracking improvement and decreasing extra cost require for operation of technical activities will also discuss here. The scope will be limited to only this type of power Plants and that is also limited in Bangladesh. Because of, this is the biggest Steam power plant in the Bangladesh. But hopefully, in near future the scope is going to be widened.

1.4 Background:

Power plant is one of the few booming industries in Bangladesh generating huge foreign direct investment and also a significant number of employment opportunities. This industry is one of the major driving forces of national economy and with the continuous development of technologies worldwide. In the Power sector, Power industry of Bangladesh promises to bloom further in the coming years.

In today's dynamic business environment, it is even more challenging to run the technology based businesses in the right direction with minimum cost which ultimately maximizes the profit. Such is the pace of technological development & increase of cost in the current world, the technical companies have to maintain a relentless focus on the Maintenance of Plant properly to keep track of all the activities and do benefit by saving extra cost. Seeing an opportunity to cut costs, increase productivity, and streamline its business-support system landscape, the companies began investigating how it could implement a common global system in order to work with its Technical Team in a more productive and uniform way.

1.5 Methodology:

The study was conducted using the participatory method. To know the in-depth information, the topic was discussed with the expert professionals related to Power Station. The purpose was to get an idea about 210 MW steam turbine power plants. The information of this report was collected from the following sources:

- Direct Conversation
- Related Drawings and document of equipment's.
- Plant Operation & Maintenance Manual
- Environment, Health& Safety (EHS) Manual

1.6 Limitations:

During my practicum at Ghorashal Power Station, a huge amount of information has been accumulated from the organization. The employees were very much cooperative. They helped me a lot, thus it was very much easy to understand most of the technical terms. But as it is a government organization, sometimes the employees were busy with their official work. Therefore at all time it was not convenient to communicate with them because of their hard work.

I have faced the following problems, which may be termed as the limitation / short coming of the report:

1. A major portion of the study had been conducted based on the secondary data.
2. Most of the primary data were not available in the form those can help for writing a report.
3. Confidentiality of data is another barrier that was confronted during the conduct of this study.
4. Although high level officials tried to help me to prepare this report, but their nature of job is such kind that can't give enough time to discuss.

CHAPTER 2

COMPANY OVERVIEW

2.1 Introduction:

Ghorashal Power Station is the biggest Steam Power Plant of Bangladesh under Bangladesh Power Development Board. Ghorashal Power Station is situated at Palash Upzilla in Narsingdi District. It has installed Capacity of 1650 MW and Generating Capacity 1715 MW Ghorashal Power Station has total seven units. In Ghorashal power plant Sub-station, this is the biggest sub-station of Bangladesh. Ghorashal Power Station is situated in the bank of Shitalaksha River.

Fig 2.1: Ghorashal Power Station

2.2 Installed Capacity:

Ghorashal Power Plant has Four Steam turbine units and another three are Combined Cycle Power Plant. Installed Capacity of 1650 MW and Generating Capacity 1715 MW which are detailed bellow:

Unit No	Date of Commissioning	Ageing Years	Installed Capacity (MW)
Unit-1	16-06-1974	45	55
Unit-2	13-02-1976	43	55
Unit-3 (Repowered CCPP)	14-09-1986	33	410
Unit-4 (Repowered CCPP)	14-03-1989	30	410
Unit-5	14-09-1994	25	210
Unit-6	30-01-1999	20	210
Unit-7 (CCPP)	05-02-2018	01	365

Table 2.2: Installed Capacity

2.3 Substation of Ghorashal Power Station:

Fig 2.3: Substations of GPS.

Ghorashal Power Station is connected to national grid through 33 kV, 132 kV and 230 kV systems. Usually 33 kV is not used for power evacuation, but used as reserve power supply of unit no. 1 & 2. Unit 1 & 2 is connected with 132 kV grid system and Unit 3, 4, 5 & 6 connected with 230 kV grid systems. In 132 kV section for power import and export purpose Ashuganj, Joydevpore and Vulta is connected. In 230 kV section for power import and export purpose Ashuganj, Rampura, Tongi and Iswardi line is connected.

2.4 Organogram:

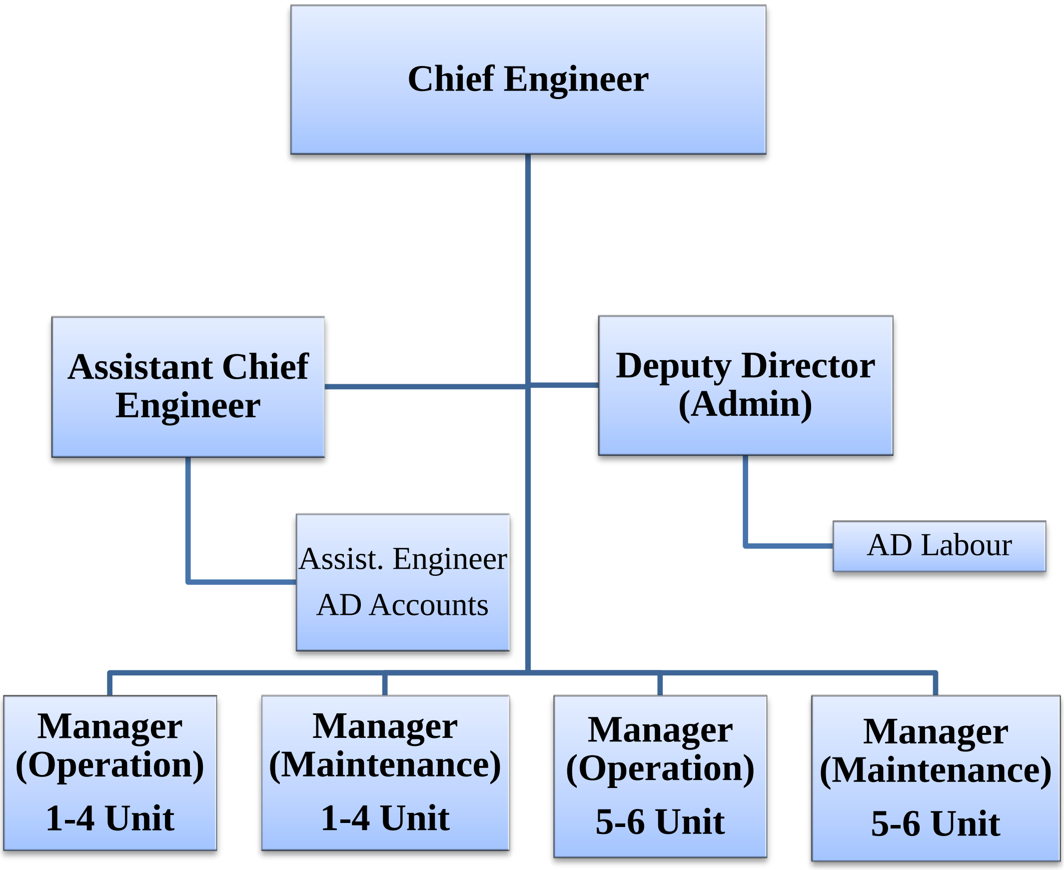


Fig 2.4: Organogram

2.4.1 Organogram under Manager Operation 5-6 Unit:

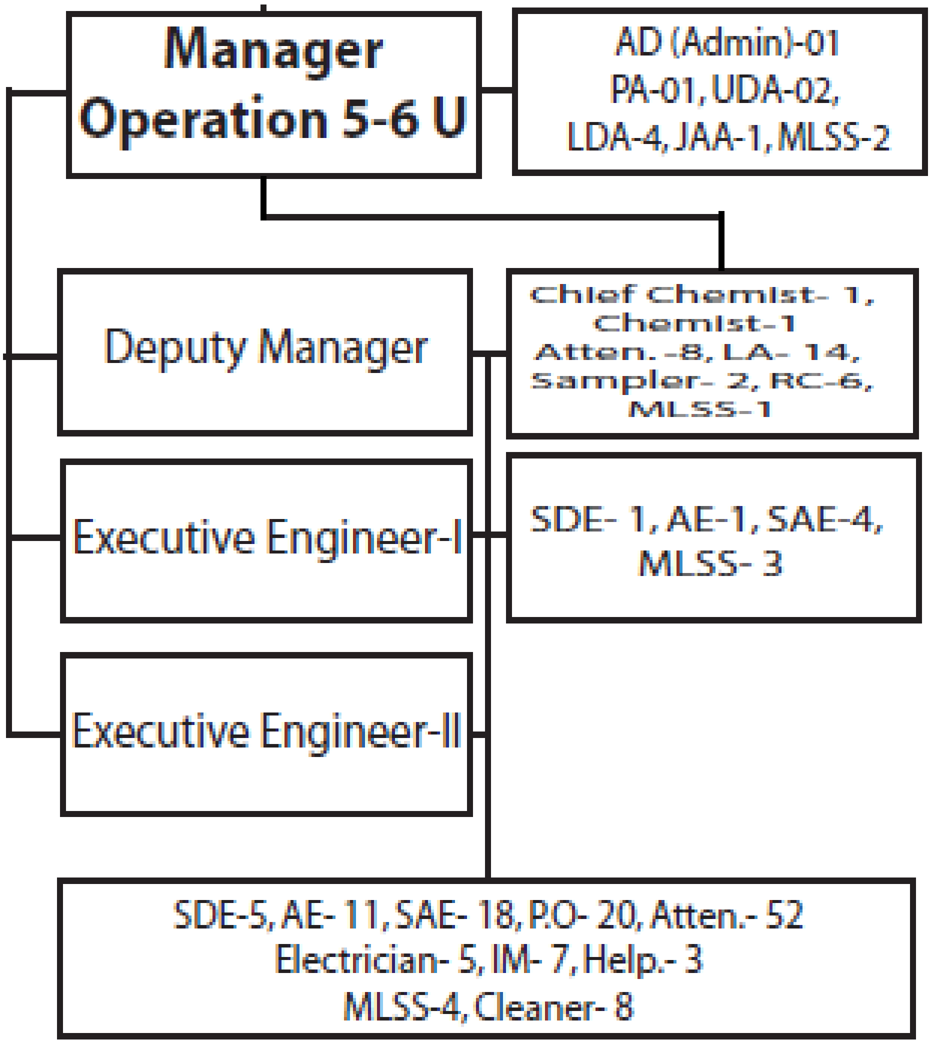


Fig 2.4.1: Organogram under Manager Operation 5-6 Unit

2.4.2 Organogram under Manager Maintenance 5-6 Unit:

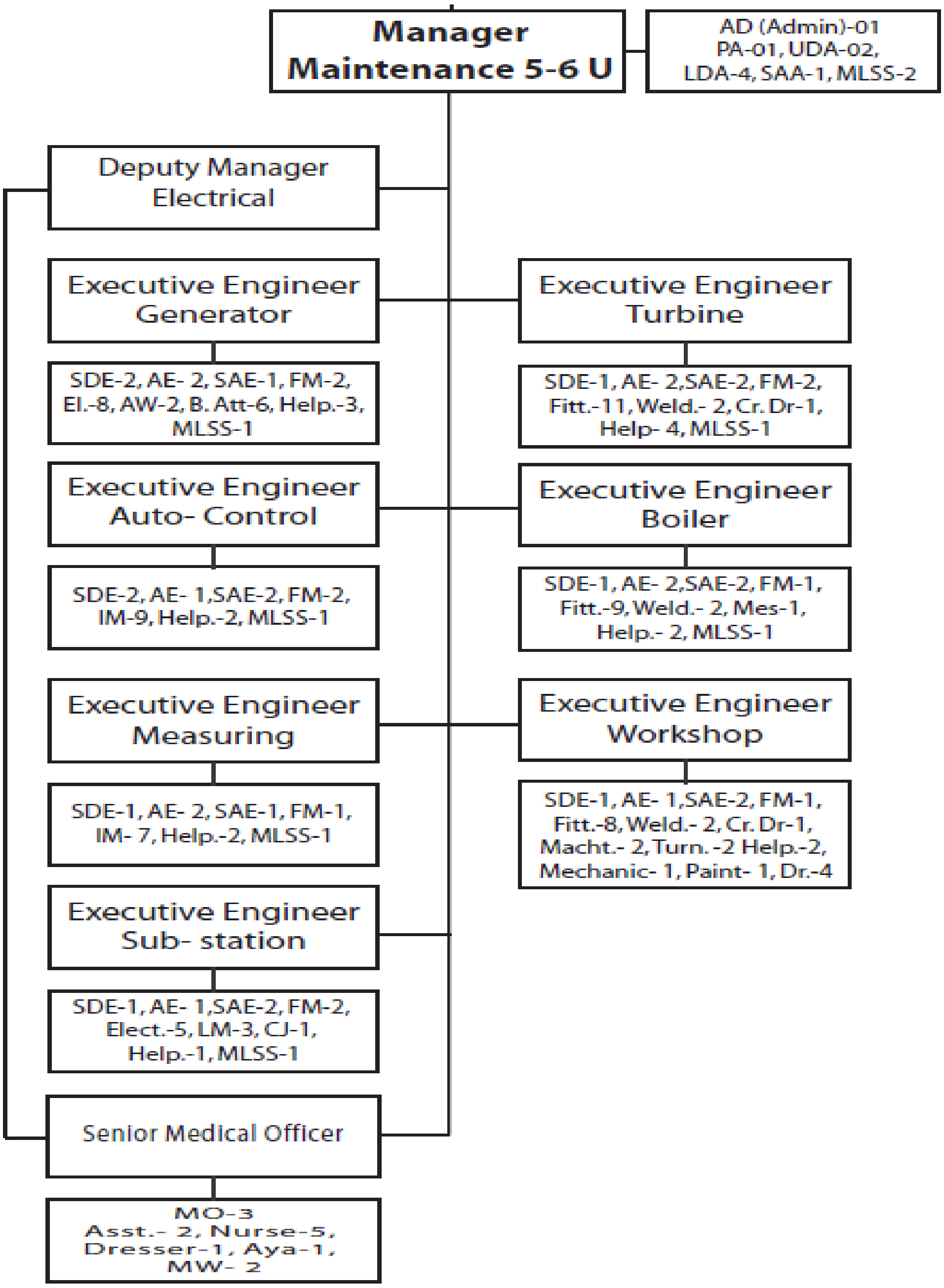


Fig 2.4.2: Organogram under Manager Maintenance 5-6 Unit

CHAPTER 3

RANKINE CYCLE AND THE COMPONENTS OF 210 MW SEAM POWER PLANT

3.1 Rankine cycle:

The Rankine cycle is a model that is used to predict the performance of steam turbine systems. The Rankine cycle is an idealized thermodynamic cycle of a heat engine that converts heat into mechanical work. The heat is supplied externally to a closed loop, which usually uses water as the working fluid. It is named after William John Macquorn Rankine, a Scottish polymath and Glasgow University professor.

3.2 Description:

The Rankine Cycle closely describes the process by which steam operated heat engines commonly found in thermal power generation plants generate power. The heat sources used in these power plants are usually nuclear fission or the combustion of fossil fuels such as coal, natural gas, and oil

The efficiency of the Rankine cycle is limited by the high heat of vaporization of the working fluid. Also, unless the pressure and temperature reach super critical levels in the steam boiler, the temperature range the cycle can operate over is quite small steam turbine entry temperatures are typically around 565°C and steam condenser temperatures are around 30°C. This gives a theoretical maximum Carnot efficiency for the steam turbine alone of about 63% compared with an actual overall thermal efficiency of up to 42% for a modern coal-fired power station. This low steam turbine entry temperature (compared to a gas turbine) is why the Rankine (steam) cycle is often used as a bottoming cycle to recover otherwise rejected heat in combined-cycle gas turbine power stations. The working fluid in a Rankine cycle follows a closed loop and is reused constantly.

The water vapor with condensed droplets often seen billowing from power stations is created by the cooling systems (not directly from the closed-loop Rankine power cycle) and represents the means for (low temperature) waste heat to exit the system, allowing for the addition of (higher temperature) heat that can then be converted to useful work (power). This 'exhaust' heat is represented by the "Q_{out}" flowing out of the lower side of the cycle shown in the T-S diagram below. Cooling towers operate as large heat exchangers by absorbing the latent heat of vaporization of the working fluid and simultaneously evaporating cooling water to the atmosphere. While many substances could be used as the working fluid in the Rankine cycle, water is usually the fluid of choice due to its favorable properties, such as its non-toxic and unreactive chemistry, abundance, and low cost, as well as its thermodynamic properties. By condensing the working steam vapor to a liquid the pressure at the turbine outlet is lowered and the energy required by the feed pump consumes only 1% to 3% of the turbine output power and these factors contribute to a higher efficiency for the cycle. The benefit of this is offset by the low temperatures of steam admitted to the turbine(s). Gas turbines, for instance, have turbine entry temperatures approaching 1500°C. However, the thermal efficiencies of actual large steam power stations and large modern gas turbine stations are similar.

The Temperature and Entropy Diagram of Rankine Cycle are given bellow:

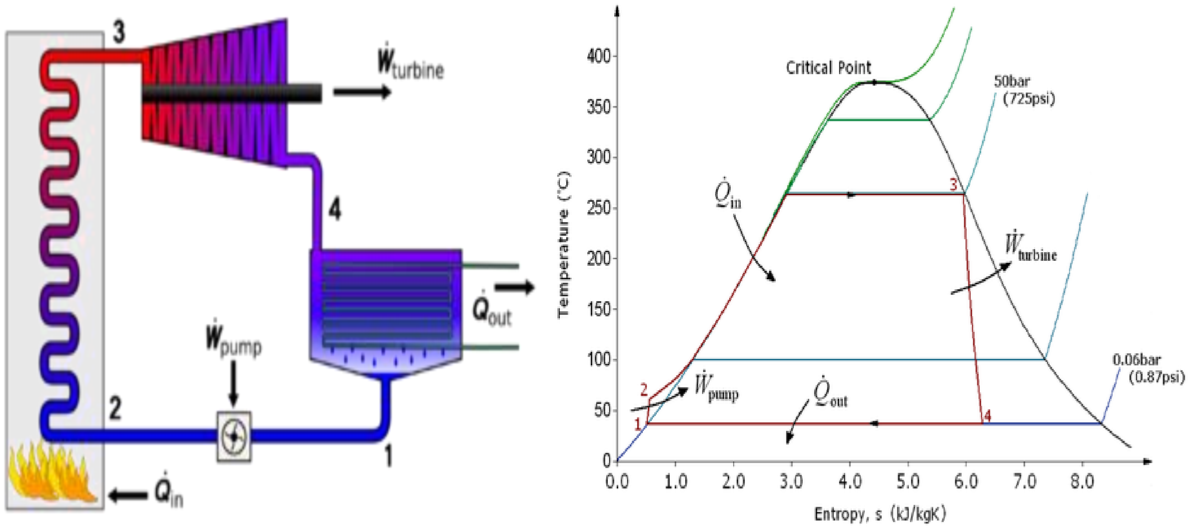


Fig 3.1: Rankine Cycle

3.3 Process of Rankine cycle:

There are four processes in the Rankine cycle. These states are identified by numbers (in brown) in the above T-s diagram.

- **Process 1-2**: The working fluid is pumped from low to high pressure. As the fluid is a liquid at this stage, the pump requires little input energy.
- **Process 2-3**: The high pressure liquid enters a boiler where it is heated at constant pressure by an external heat source to become a dry saturated vapour. The input energy required can be easily calculated graphically, using an enthalpy-entropy chart or numerically, using steam tables.
- **Process 3-4**: The dry saturated vapour expands through a turbine, generating power. This decreases the temperature and pressure of the vapour, and some condensation may occur. The output in this process can be easily calculated using the chart or tables noted above.
- **Process 4-1**: The wet vapour then enters a condenser where it is condensed at a constant pressure to become a saturated liquid.

In an ideal Rankine cycle the pump and turbine would be isentropic, i.e. the pump and turbine would generate no entropy and hence maximize the net work output. Processes 1-2 and 3-4 would be represented by vertical lines on the T-s diagram and more closely resemble that of the Carnot cycle. The Rankine cycle shown here prevents the vapor ending up in the superheat region after the expansion in the turbine, which reduces the energy removed by the condensers.

3.4 Rankine cycle with super heat:

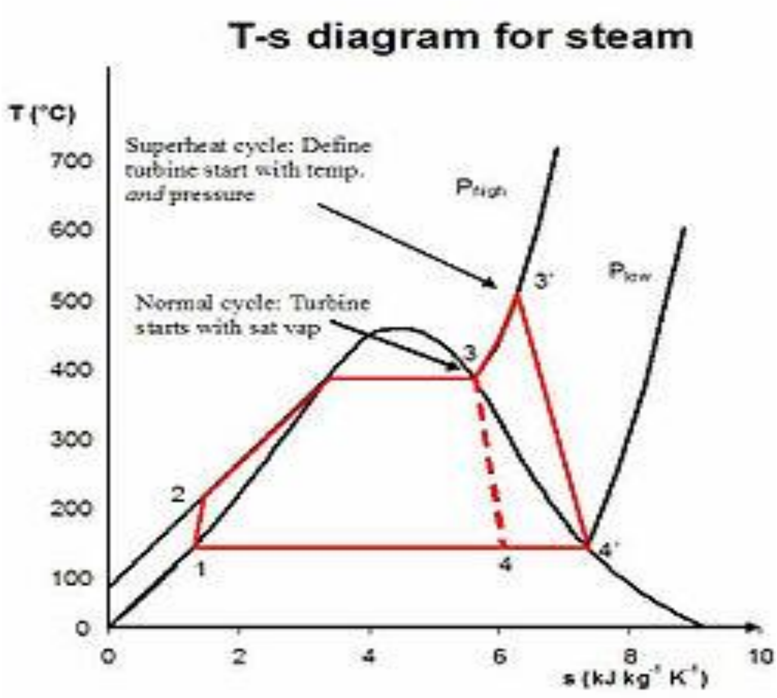


Figure: 3.4 Rankine Cycle with superheat

Basically the Rankine cycle cannot be run by saturated vapor. If the wet particle of steam is allowed to pass through the turbine blade in high pressure the particle will act like bullet, as a result the turbine will be damaged. So it is preferred to use superheated steam which acts like gas. So the figure 3.1 will be modified with figure 3.2 in which the new position of point 3 is shifted to 3'. The super-heated temperature must be above the critical point temperature where no wetness of steam is found.

3.5 Rankine cycle with reheat:

The purpose of a reheating cycle is to remove the moisture carried by the steam at the final stages of the expansion process. In this variation, two turbines work in series. The first accepts vapor from the boiler at high pressure. After the vapor has passed through the first turbine, it re-enters the boiler and is reheated before passing through a second lower-pressure turbine.

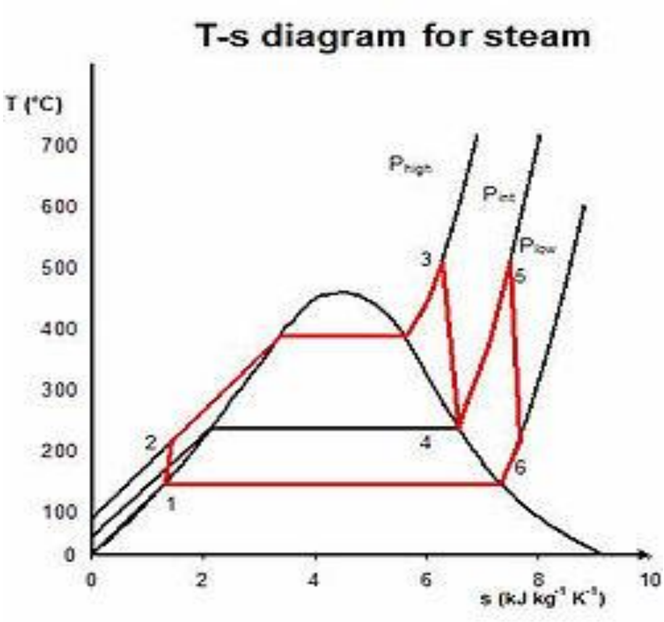


Fig 3.5: Rankine cycle with reheat

The reheat temperatures are very close or equal to the inlet temperatures; whereas the optimum reheats pressure needed is only one fourth of the original boiler pressure. Among other advantages, this prevents the vapor from condensing during its expansion and thereby damaging the turbine blades, and improves the efficiency of the cycle, because more of the heat flow into the cycle occurs at higher temperature.

3.6 Regenerative Rankine cycle:

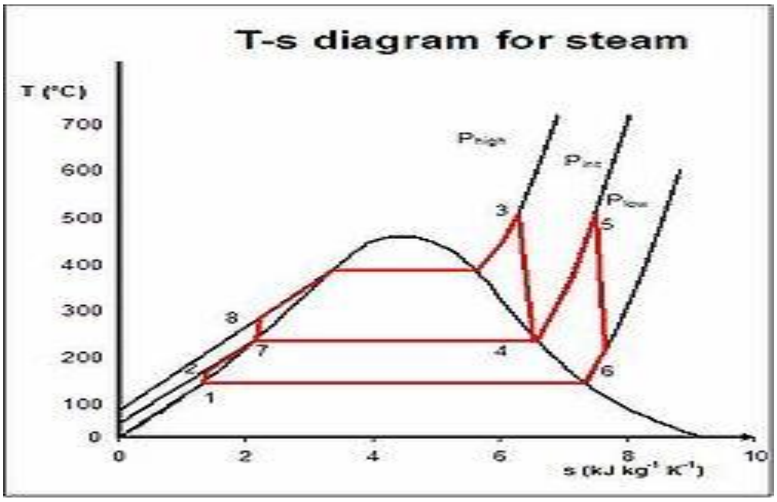


Fig 3.6: Regenerative Rankine cycle

The regenerative Rankine cycle is so named because after emerging from the condenser (possibly as a sub-cooled liquid) the working fluid is heated by steam tapped from the hot portion of the cycle. On the diagram shown, the fluid at 2 is mixed with the fluid at 4 (both at the same pressure) to end up with the saturated liquid at 7. This is called "direct contact heating". The Regenerative Rankine cycle (with minor variants) is commonly used in real power stations.

Another variation sends bleed steam from between turbine stages to feed water heaters to preheat the water on its way from the condenser to the boiler. These heaters do not mix the input steam and condensate, function as an ordinary tubular heat exchanger, and are named "closed feed water heaters".

Regeneration increases the cycle heat input temperature by eliminating the addition of heat from the boiler/fuel source at the relatively low feed water temperatures that would **exist** without regenerative feed water heating. This improves the efficiency of the cycle, as more of the heat flow into the cycle occurs at higher temperature.

3.7 Actual Rankine cycle:

The actual vapor power cycle differs from the ideal Rankine cycle because of irreversibility's in the inherent components caused by fluid friction and heat loss to the surroundings; fluid friction causes pressure drops in the boiler, the condenser, and the piping between the components, and as a result the steam leaves the boiler at a lower pressure; heat loss reduces the network output, Thus heat addition to the steam in the boiler is required to maintain the same level of network output.

3.8 Efficiency of a Rankine cycle:

The efficiency of a Rankine cycle is usually limited by the working fluid. Without the pressure going super critical the temperature range the cycle can operate over is quite small, turbine entry temperatures are typically 565°C (the creep limit of stainless steel) and condenser temperatures are around 30°C. This gives a theoretical Carnot efficiency of around 63% compared with an actual efficiency of 42% for a modern coal-fired power station. This low turbine entry temperature (compared with a gas turbine) is why the Rankine cycle is often used as a bottoming cycle in combined cycle gas turbine power stations.

3.9 Components of 210 MW Steam Turbine Power Plants:

To run a steam turbine power plant so many equipment's are needed. But importance of all equipment is not same. Therefore which equipment's are more important to steam turbine power plant that's are called main equipment's of steam turbine like boiler, generator, turbine, condenser, feed water pump, cooling tower and another important equipment's are- Boiler Drum, Deaerator ,Super Heaters, Main Steam Gate valve, Emergency Steam Stop Valve, Regulating Valve, Low Pressure Heater (HPC), & High Pressure Heater (HPC).

3.10 Boiler:

Boiler is a device which produces steam or vapor by using heat. It is a steam generator which works with a preset pressure and temperature range.

Fig 3.10: Boiler Section.

In the basis of water and fire Boiler mainly two types:

Water-tube boiler:

In this type, tubes filled with water are arranged inside a furnace in a number of possible configurations, often the water tubes connect large drums, the lower ones containing water and the upper ones, steam and water; in other cases, such as a mono-tube boiler, water is circulated by a pump through a succession of coils. This type generally gives high steam production rates, but less storage capacity than the above. Water tube boilers can be designed to exploit any heat source and are generally preferred in high-pressure applications since the high-pressure water/steam is contained within small diameter pipes which can withstand the pressure with a thinner wall. In **Ghorashal power Station** use this type of boiler.

Fire-tube boiler:

Here, water partially fills a boiler barrel with a small volume left above to accommodate the steam (steam space). This is the type of boiler used in nearly all steam locomotives. The heat source is inside a furnace or firebox that has to be kept permanently surrounded by the water in order to maintain the temperature of the heating surface below the boiling point. The furnace can be situated at one end of a fire-tube which lengthens the path of the hot gases, thus augmenting the heating surface which can be further increased by making the gases reverse direction through a second parallel tube or a bundle of multiple tubes (two-pass or return flue boiler); alternatively the gases may be taken along the sides and then beneath the boiler through flues (3-pass boiler). In case of a locomotive-type boiler, a boiler barrel extends from the firebox and the hot gases pass through a bundle of fire tubes inside the barrel which greatly increases the heating surface compared to a single tube and further improves heat transfer. Fire-tube boilers usually have a comparatively low rate of steam production, but high steam storage capacity. Fire-tube boilers mostly burn solid fuels, but are readily adaptable to those of the liquid or gas variety

3.11 Some Accessories and Mountings of boiler:

- Safety valve
- Water level indicators
- Continuous blow down valve
- Flash tank
- Continuous heat recovery system
- Hand holes
- Bottom blow down valves
- Surface blow down line
- Feed water check valve or clack valve
- Super heater
- De-super heater tubes or bundles
- FD & ID fan

3.12 Turbine:

A turbine is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. A turbine is a turbo machine with at least one moving part called a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades so that they move and impart rotational energy to the rotor.

Turbine mainly classified by two types:

1. **Impulse turbine:** This type of steam turbine the rotor spins due to the force, or the direct push of steam on the blades.
2. **Reaction turbine:** This type of steam turbine works on the principle that the rotor spins from, as the name suggests, a reaction force rather than an impact or impulse force. The reactive force comes from the change in steam pressure energy as the steam leaves the blades.

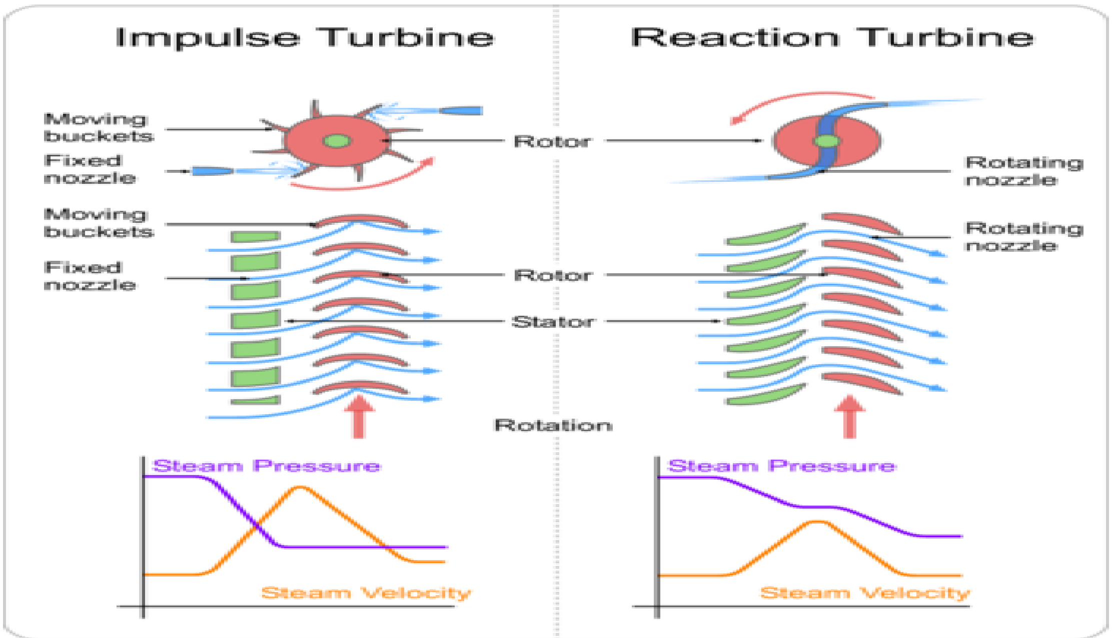


Fig 3.12: Impulse and Reaction turbine

On the other hand, according to condensation of working fluid steam turbine can be classified as:

1. **Non-Condensing** (Back-pressure)steam turbine
2. **Condensing** (Extraction) steam turbine.

3.13 Generator:

A generator is a device that converts mechanical energy to electrical energy for use in an external circuit. The source of mechanical energy may vary widely from a hand crank to an internal combustion engine. Generators provide nearly all of the power for electric power grids.

Fig 3.13: Genarator

Electromagnetic generators fall into one of two broad categories, dynamos and alternators-

- **Dynamos** generate direct current, usually with voltage or current fluctuations, usually through the use of a commutator
- **Alternators** generate alternating current, which may be rectified by another (external or directly incorporated) system.

Mechanical:

- **Rotor:** The rotating part of an electrical machine
- **Stator:** The stationary part of an electrical machine

Electrical:

- **Armature:** The power-producing component of an electrical machine. In a generator, alternator, or dynamo the armature windings generate the electric current. The armature can be on either the rotor or the stator.

- **Field:** The magnetic field component of an electrical machine. The magnetic field of the dynamo or alternator can be provided by either electromagnets or permanent magnets mounted on either the rotor or the stator.

3.14 Condenser:

A surface condenser is a commonly used term for a water-cooled shell and tube heat exchanger installed on the exhaust steam from a steam turbine in thermal power stations.

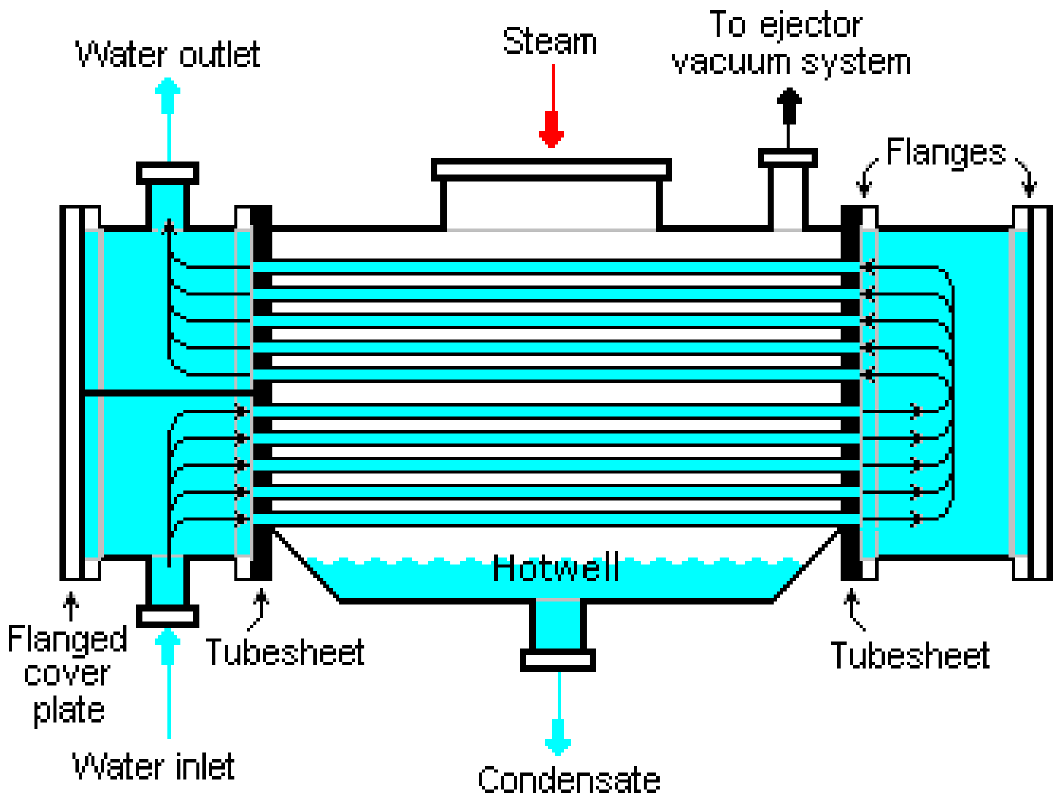


Fig 3.14: Diagram of a typical water-cooled surface condenser

These condensers are heat exchangers which convert steam from its gaseous to its liquid state at a pressure below atmospheric pressure. Where cooling water is in short supply, an air-cooled condenser is often used. An air-cooled condenser is however, significantly more expensive and cannot achieve as low a steam turbine exhaust pressure (and temperature) as a water-cooled surface condenser. The adjacent diagram depicts a typical water-cooled surface condenser as used in power stations to condense the exhaust steam from a steam turbine driving an electrical generator as well in other applications.

The adjacent diagram depicts a typical water-cooled surface condenser as used in power stations to condense the exhaust steam from a steam turbine driving an electrical generator as well in other applications. There are many fabrication design variations depending on the manufacturer, the size of the steam turbine, and other site-specific conditions

3.15 Feed water pump:

A feed water pump is a specific type of pump used to pump feed water into a steam boiler.

Fig 3.15: Feed water pump

The water may be freshly supplied or returning condensate produced by the boiler. These pumps are normally high pressure units that take suction from a condensate return system and can be of the centrifugal pump type or positive displacement type.

3.16 Cooling tower:

A cooling tower is a heat rejection device which rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. Cooling towers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature or, in the case of closed circuit dry cooling towers, rely solely on air to cool the working fluid to near the dry-bulb air temperature.

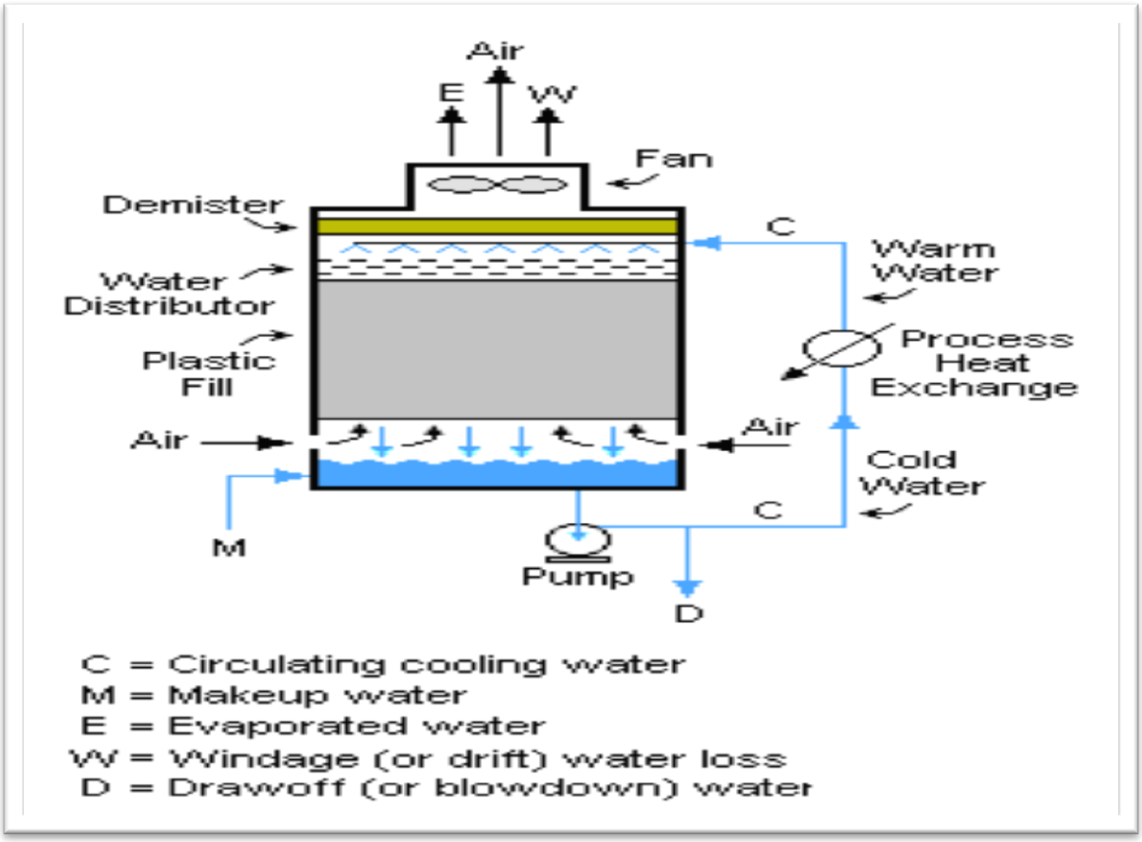


Fig 3.16: Diagram of a cooling tower

3.17 Boiler Drum:

Boiler Drum is a one kind of Reservoir, Steam Separator, & Steam Generator. Collector and Steam Separator. Capacity of boiler drum in 1-2 units: 230 T/H & in 5-6 units: 670T/H

Fig 3.17: Boiler Drum

3.18 Deaerator:

A **deaerator** is a device that is widely used for the removal of oxygen and other dissolved gases from the feedwater to steam-generating boilers.

Two types of Deaeration:-

1. Mechanical (Steam)
2. Chemical (Hydrazine)

Fig 3.18: Deaerator

3.19 BOILER CONDENSER:

One kind of heat exchanger that is used to increase feed water temperature.

3.20 Water Economizer:

It is a Mechanical device that is used to increase feed water temperature. It is placed in down-take gas duct and consists of two inlet headers 219×26 mm and two outlet headers 219 × 36mm and 840 packets of bent pipes made from 28 × 4 mm (st. 20).By height the Economizer can be divided into two parts; each parts consisting of 8 blocks. The side blocks have 54 packets each all the rest-52 packets. All economizer chambers are inside the gas duct in parallel to boiler front,

Each outlet header is suspended on 16 suspension pipes 108×12 mm (st. 20) these pipes being at the same time water tapping pipes. From the suspension pipes water is collected in two headers 273×32 mm, (st. 20). By12 pipes 108×12mm (st. 20) feed water is supplied evenly into the drum by its whole length.

3.21 H.P. Super-heater:

H.P. Super-heater has two flows. Both flows are symmetrical. Coming out from the drum by eight 133×13 mm pipes, steam of each of the flows is then separated into two sub-flows.

By the first sub-flow steam is supplied by 4 133×13mm pipes to 219×20mm pipe-line. At the inlet to this pipe-line one throttline wears for leveling steam rate by sub-flows. From this pipe line steam simultaneously goes by:

- Pipes 76×10 mm to 4 panels of the front wall of the down-coming gas duct.
- Pipes 133×13 mm and 2 pipes 108×12 mm to 3 panels of horizontal gas duct pipes.
- Pipes 76×10mm to 2 panels of side wall of the down coming gas duct.

Steam of the second sub-flow from the drum by 4 pipes 133×13 mm goes to 4 panels of the ceiling superheater. Passing to the rear wall of the down coming gas duct. Then by 4,133×13 mm pipes steam is separated to 219×20 mm header, from this it goes into 325×32 mm header, thus mixing with steam form first sub-flow. After that steam circulates in one flow. All steam transfer-pipes up to the wall radiant superheater are manufactured from carbon steel, after radiant superheater from alloy steel.

3.22 Radiant Super heater:

Radiant super heater is placed in the furnace chamber and consists of 6 units: 2 units on the front and rear wall and one unit on side walls. Length of front and rear panels 9300mm, side walls-7425 mm. Each unit consists of 2 vertical headers 159×16mm (12×IMQ) and 19 horizontal U-type bent pipes made of 42×5 mm pipes (12 ×IM).

The bent sections of pipes in 22 numbers of furnace walls serve to fix radiant super heater. Special panels are welded to support lower pipes of each block of panels. Between plane and pipe there is a strap welded to the lower pipe.

3.23 Platen superheater:

Platen superheater is installed in the upper part of the furnace chamber and consists of one row of platens. There are 24 platens in the row with 713, 736, 732 mm spacing. Each platen consists of two 159×16 mm headers and of 21 U-type vertical bent pipe made of 32×5 mm pipes (12×IM@).

3.24 Convective superheater of high pressure:

It consists of two stages. Steam flow in each of them is parallel. Inlet stage of the H.P. convective superheater consists of 9 blocks. Each block consists of 325 × 25mm headers (st. 12×IM@) and nine packets of bent pipes. Each packet has 6 U-type bent pipes, made of 36×6mm pipes (st. 12×IM).

Outlet stage of H.P. convective superheater consists of 8 blocks also. Each block consists of two headers and 19 packets of bent pipes (two middle blocks have 17 pipes each). Headers are fabricated from steel (12×MI@), inlet header having 325×25mm dia, outlet-325×50mm dia.

The outlet part of the bent pipes is made from 32×4 mm (heated area) st. 12×8H12T, other parts of the bent pipes aremade from 36×6mm pipes (st. 12×IM).

3.25 Low pressure convective superheater:

It consists of two stage-inlet and outlet. The inlet stage goes second as the gas flows and consists of 8 blocks. Each block consists of 2 headers: Inlet header and outlet header .

426×20 mm. (at 12×IM@) and 19 packets of bent pipes (two middle blocks have 17 packets of bent pipes). Each packet consists of 6 two-loop bent pipes made of 42×4mm pipes (st. 12×IM@).

Steam and gas in the inlet stage circulate in back block the Ist gas flow stage (outlet) of L.P. convective superheater also consists of 8 blocks. Each block consists of 2 headers, fabricated from alloy steel; inlet header 426×25mm and outlet header 630×20mm and 19 packets of bent pipes (in two middle blocks there are 17 packets). Each packet consists of 5 two –loop bent pipes 42 ×4mm. The pipes are composed; approx. — outlet pipe is fabricated from 12×18

H12T the rest part made from steel 12×IM@. Steam and gases in the outlet stage have parallel flow circuit.

3.26 FD Fan:

Forced Draft Fan. It is used to supply air from atmosphere to the furnace. When air or flue gases are maintained above atmospheric pressure. Normally it is done with the help of a forced draft fan.

Fig 3.26: Forced Draft Fan

3.27 ID Fan:

Induced Draft fan. It is used to make vacuum in the furnace chamber. Exhaust flue gas passes throughout the air by chimney.

The ID fan is at the exit end of the path of flow, and the system is under negative pressure - that is, the pressure in the flow area is below atmospheric, because the air is being drawn through the fan.

Fig 3.27: Induced Draft fan

CHAPTER 4

FLOW DIAGRAM OF 210 MW STEAM POWER PLANTS & THE WORKING PRINCIPLE

4.1 Single line Diagram of 210 MW in 5th Unit of Ghorashal Power Station:

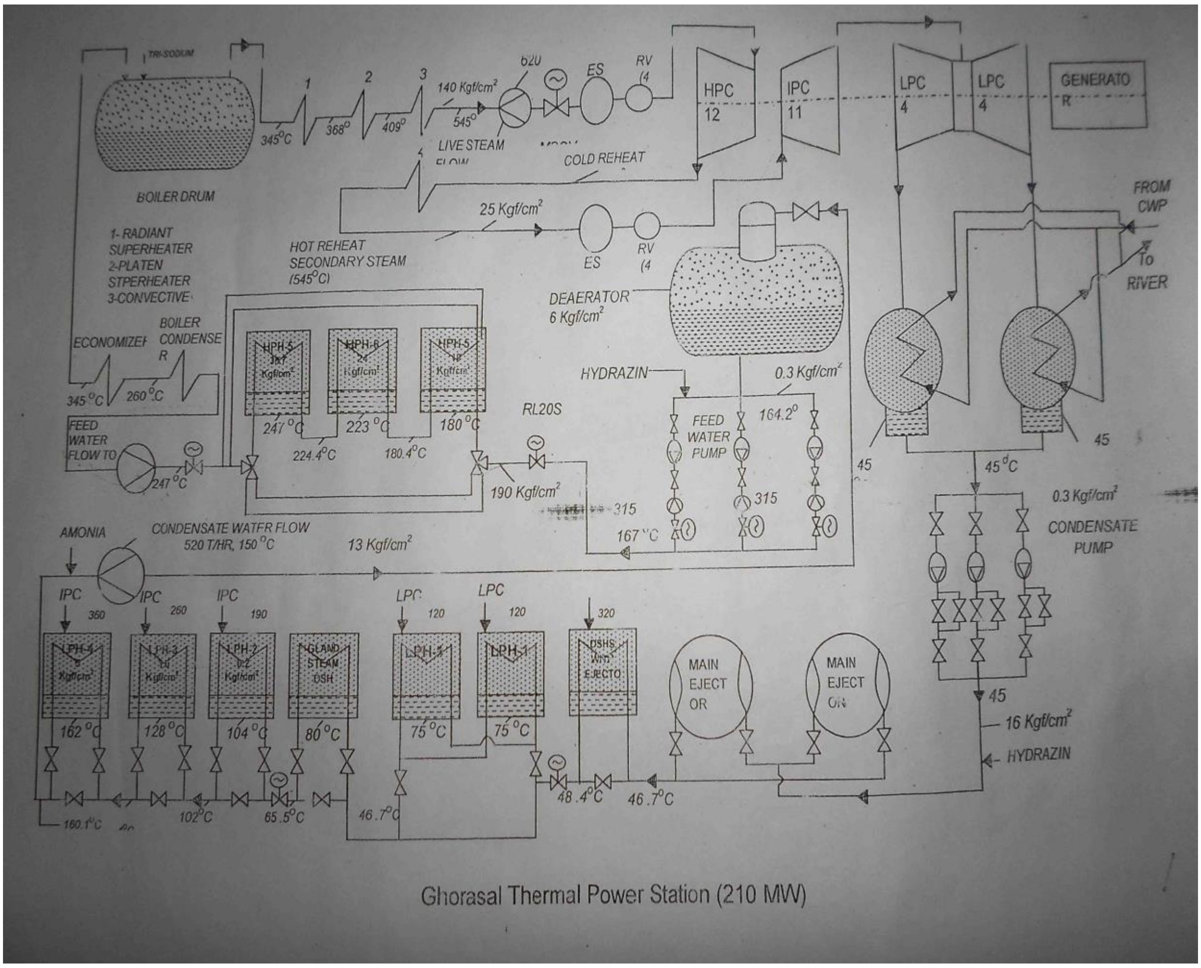


Fig 4.1: Single Line Diagram of 210 MW Power Plants

4.2 Flow Diagram of 210 MW Steam Turbine Power Plants:

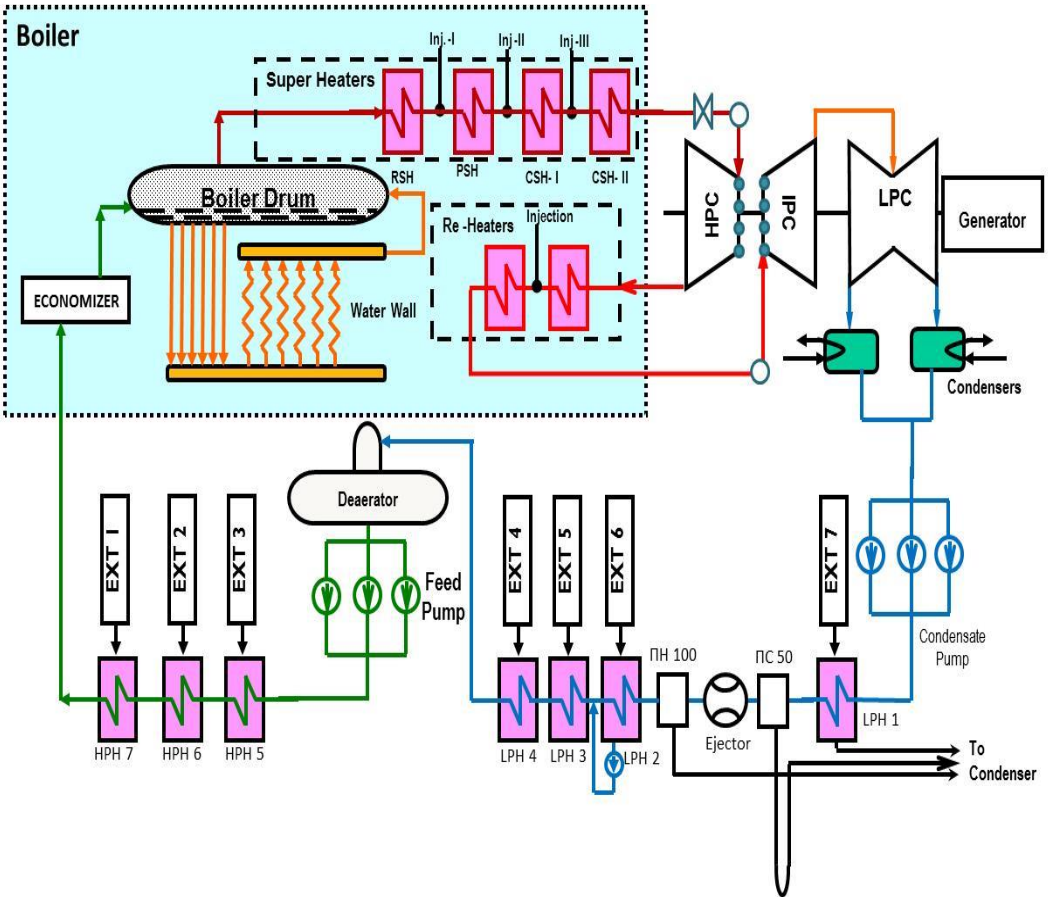


Fig 4.2: Flow Diagram

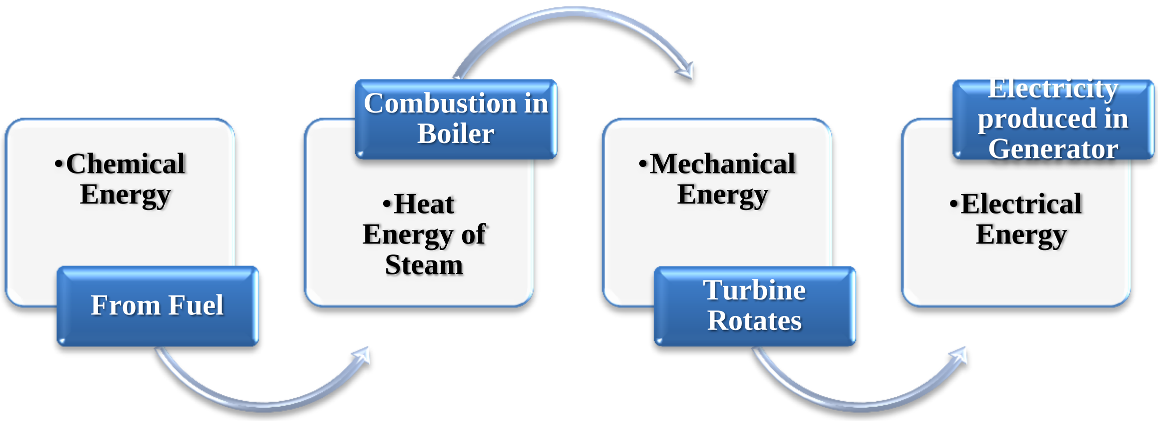
4.2.1 Generation Philosophy:

(a) Chemical Energy of fuel is converted to heat energy in boiler through combustion.

(b) This heat is carried through water/ steam (i.e. steam acts as medium of heat transfer)

(c) The Superheated Steam is allowed to rotate the turbine, heat converted to mechanical energy.

(d) Mechanical energy transformed in to Electrical Energy in Generator.



4.2.2 Steps of Flow Diagram:

(a) Feed water having temperature & pressure of 247.7°C & 182.3 bar respectively allowed to go through economizer. Then after gaining some temperature the water is allowed to go to boiler drum. It is necessary to maintain the water level in drum at its 175 mm below its geometric axis, is the datum line called"0" level.

(b) The water comes through the six down comers and allowed to distribute to the lower header of boiler. This process occurs due to gravity. The water is then distributed to water walls and got change to saturated steam by taking heat of combustion of natural gas fuel.

(c) After taking heat of combustion the steam is allowed to go to drum again. The drum is designed to separate the steam and water through cyclone separator. The water left in the drum and separated steam comes out form the upper side of drum for the purpose of super heating.

(d) There are four stage of superheating procedure. The first super heater is Radiant Super Heater (RSH) and the Second is Platen Super Heater (PSH), there is an injection attemparator (De- super heater) after RSH. Similarly the third super heater is Convective Super Heater Stage- I (CSH-I) and between PSH & CSH-I there is another injection attemparator (De- super heater) and again between CSH-I & CSH-II there is another injection attemparator (De- super heater). This de-super heating process is done for regulation of final temperature of steam. But after final live steam super heater CSH-II there is no de-super heating option because it is mandatory to ensure that there is no trace of water particle before turbine.

(e) The final output of live steam after boiler is kept at $540^{o}C$ temperature and 130 bar pressure. This steam is allowed to enter in High pressure Turbine and after rotating 12 stage the temperature and pressure goes down to $331^{o}C$ & 28.5 bar respectively.

(f) It is not possible to condense the steam of $331^{o}C$ & 28.5 bar so, further expansion is required. But the temperature is below the critical point, i.e. there may be some trace of water particle. This is why the saturated steam is allowed to go to boiler again for re-heat.

(g) After re-heat the temperature of the fluid increase to $540^{o}C$ but the pressure decrease to 24 bar. This pressure drop occurs due to piping losses. There are two re-heater blocks are used for the purpose, between the two there is also an injection attemparators for temperature regulations.

(h) This re-heated steam is allowed to enter in Medium (Intermediate) pressure Turbine and after rotating 11 stage the temperature and pressure goes down to $171^{o}C$ &1.32 bar respectively.

(i) The residual expansion occurs in Low Pressure Turbine by double expanders which contains 4 stages each.

(j) The steam is condensed in condenser in vacuum condition. For creating vacuum two steam jet ejector is used and the heat outlet steam of ejector is used to heating up condensate.

(k) Two condensate pumps are used to pump out the condensate. The condensate is allowed to go to Deaerator through low pressure re-generation system. Low pressure re-generation system consist of (i) Low pressure Heater-1, (ii) Sealing steam ejector (ПС-50), (iii) Ejectors, (iv) Sealing steam Heater/ Cooler ПН-100, (v) Low pressure Heater-2, (vi) Low pressure Heater-3 & (vii) Low pressure Heater-4. The Regenerative Heaters are non-mix type and the heating steam condensate form Low pressure Heater-2,3&4 is collected at Low pressure Heater-2 and pumped to the condensate system using a pump named Drip Pump, maintaining a level in Low pressure Heaters.

(l) De-aeration process is done in Deaerator, it also used as feed tank. Feed water is pumped by two Feed Electric pumps from Deaerator. The feed water is heated through High Pressure Regenerative system before entering economizer. High Pressure Regenerative system consists of (i) High Pressure Heater-5, (ii) High Pressure Heater-6 (iii) High Pressure Heater-7.

4.3 Working Circle:

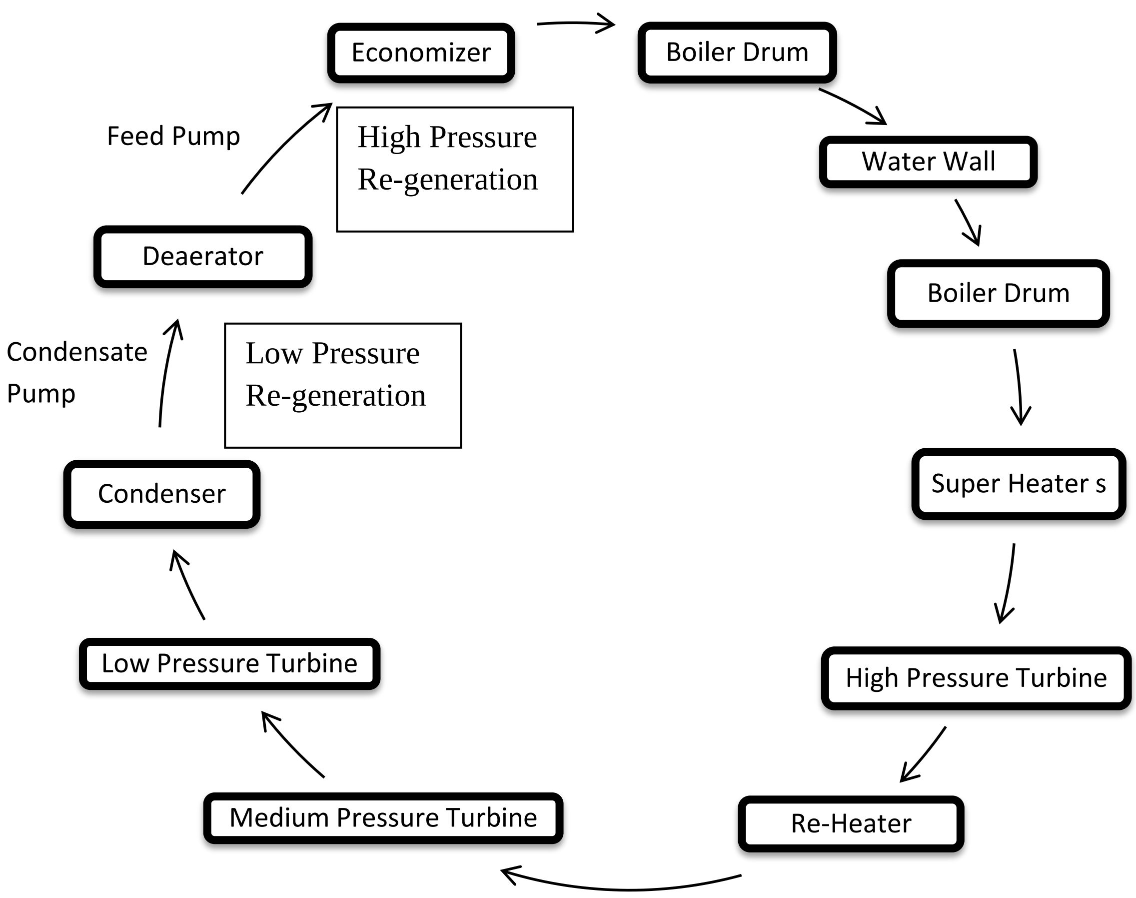


Fig 4.3: Working Cycle

4.4 Startup procedure:

Starting up procedure of the 210 MW units of Ghorashal power station is difficult and is done according to manufacturers' guide line. All the procedure is done in manual process, because the control system is not DCS, old analog system.

In Manufacturers there are three different procedures for starting up the unit depending upon metal temperature of turbine. The conditions are-

a. Cold, Metal temperature of turbine is lower than 200^{o}C
b. Semi Cold, Metal temperature of turbine is higher than 200^{o}C but less than 450^{o}C
c. Hot, Metal temperature of turbine is above 450^{o}C

4.4.1 Cold Startup Steps:

The following procedure is adopted in Ghorashal Power Station during cold startup:

1. Prerequisite for Boiler before startup-

a) Make sure all drain of feed line and periodical blow down valves are closed except the super-heater drain valves.
b) Drum fill up with water, air vents will be opened.

2. Prerequisite for Turbine before startup-

a) Make sure all of steam pipe line drain valves are opened.
b) Circulating Pumps are running and the circulating system in normal condition.
c) The burring gear is 'ON' position.

3. Then start vacuum system through auxiliary steam from other unit or start the vacuum system after firing if auxiliary steam is not available.
4. Start ID Fan then Start FD Fan, Ensure Furnace Pressure (as per design) and air flow.
5. Chemical test of Air of boiler (ensure there is no CH_4), Start Fire of burners no. 2 & 5 (according to Instruction manual).
6. The pressure is allowed to increase up to 5 bar, then close air vent and super-heater drain valves.
7. Circulation is created to increase temperature through purging the steam to atmosphere or to condenser (if vacuum is above -0.6 bar). Also the cooling of re-heater is started if vacuum is above -0.6 bars.
8. When temperature of steam rises to 300^{o}C, open main steam gate valve and open main steam stop valve. The heating procedure is started for cross over piping's.
9. When temperature of cross over piping's rises and the steam temperature 300^{o}C and pressure 30 bar regulating valve is opened and keeps the turbine running at 500 rpm.

10. Inspect the vibration, Expansion and relative expansion increase the speed up to 1000 rpm.
11. Inspect the vibration, Expansion and relative expansion increase the speed up to 3000 rpm. For HP & IP start flange and stud heating system if the rotor expansion is higher than stator expansion.
12. Synchronize the turbo-generator with grid.

4.4.2 Semi Cold:

Procedure for semi cold start up is almost same as cold startup but the temperature for rotating the turbine will be 100^{O}C higher than the turbine metal temperature. The relative expansion of turbine rotor and stator may be beyond the limited value. For that reason the rotor heating line may be applied after keep turbine in rotation. The steps for rotation are 1200 rpm and 3000 rpm.

4.4.3 Hot Startup:

Hot startup procedure is adopted for starting up the plant just after shutdown. For this type of startup no drain line needed to be opened. For achieving 540^{o}C temperature for live steam it is necessary to firing up 4 burners No 2, 3, 4 & 5. After pressure of steam is being 30 bar and temperature being 540 ^{o}C, the steam is allowed to go to turbine at 1200 rpm, if all parameters like vibration of bearing s and relative expansion is normal it is recommended to increase the turbine speed up to 3000 rpm. Then the generator is synchronized.

CHAPTER 5

BOILER OPERATION OF GHORASHAL POWER STATION

5.1 Introduction:

Boiler is a steam generator which works with a preset pressure and temperature range. A boiler is a closed vessel in which water or other fluid is heated. The fluid does not necessarily boil. Fuel (coal, Oil, Gas) is allowed to burn in the boiler and the chemical energy of fuel is converted to heat energy and heat is transferred through water or steam. The process of Heat addition is done in constant pressure process in boiler.

Boiler is a device which produces steam or vapor by using heat. In this chapter we will discuss about Specifications of boiler, Boiler design, Fuel characteristic, Boiler protection, Control and Operation of boiler.

Fig 5.1: Boiler Section

5.2 Basic Factors to select Boiler:

(a) Power required to be generated
(b) Operating Pressure
(c) Fuel-quality and type
(d) Water availibility and its quality
(e) Probable load factor
(f) Location of the power house or process plants
(g) Cost of operations and maintenance
(h) Cost of installations and erection
(i) Availibility of floor space

5.3 Essential Quality Criteria of good Boiler:

(a) It should be capable of quick start-up
(b) Should meet large load fluctuations
(c) Occupy less floor space
(d) Should afford easy maintenance and inspection
(e) Should essentially posses the capacity of producing maximum steam with minimum fuel consumption
(f) Light and simple in construction
(g) Various joints should be accessible for inspection and should be away from direct flame impact
(h) Tubes should be sufficiently strong to resist wear and corrosion
(i) Mud and other deposits should not collect on heated plates
(j) The velocity of water and that of flue gas should be a minimum.

5.4 Specifications of TGME-206/COB Boiler Unit:

Steam Boiler, TGME-206/COB, with natural circulation is designed for reheat steam generation by burning natural gas.

The nominal values of the main parameters are:

Boiler capacity (reheat steam)	670 t/h.
Steam flow-rate through Intermediate super heater	590 t/h.
Pressure in boiler drum	158kg/cm^2
Superheated steam pressure at outlet of boiler	140kg/cm^2
Superheated steam to temperature	545^{0}C
Steam pressure at inlet to reheat	28.5kg/cm^2
Steam temperature at inlet to reheat	334^{0}C
Steam pressure at outlet from intermediate S-H	26.3kg/cm^2
Steam temperature at outlet from intermediate super heater	545^{0}C
Feed water temperature	250^{0}C
Boiler efficiency	93%
Allowable minimal durable load	30%
Heat release rate under nominal load (227.8kw/m^3)	195.1Kal/m^{3}h
Hot air temperature after R.A.H.	251^{0}C
Excess air co-efficient beyond boiler	1.25
Fuel rate under nominal load	53.6 000 N-m/hours.
Temperature of flue gases after I.D. fans	132^{0}C.
Water volume of boiler	122m^3
Steam volume of H.P. Super heater	89m^3
Steam volume of L.P. Super heater (within boiler)	62 m^3

Table 5.4: Specifications of TGME-206/COB Boiler Unit

5.5 Fuel characteristics:

Natural gas from Titas oil-field is burned is the boiler. Gas composition:-

Methane (CH_4)	97.2%
Ethane (C_2H_6)	1.8%
Propane (C_3H_8)	0.5%
Butane (C_4H_{10})	0.2%
Nitrogen, oxygen (N_2, O_2)	0.3%
Sulphar and Hydrogen (S_2, H_2)	None
Carbon dioxide (CO_2)	None
Humidity	0.11 g/m^3
Gas specific weight	0.77 kg/nm^3
Gas specific weight	0.77 kg/nm^3

Table 5.5: Fuel characteristics

5.6 Cross-Sectional Diagram of Boiler:

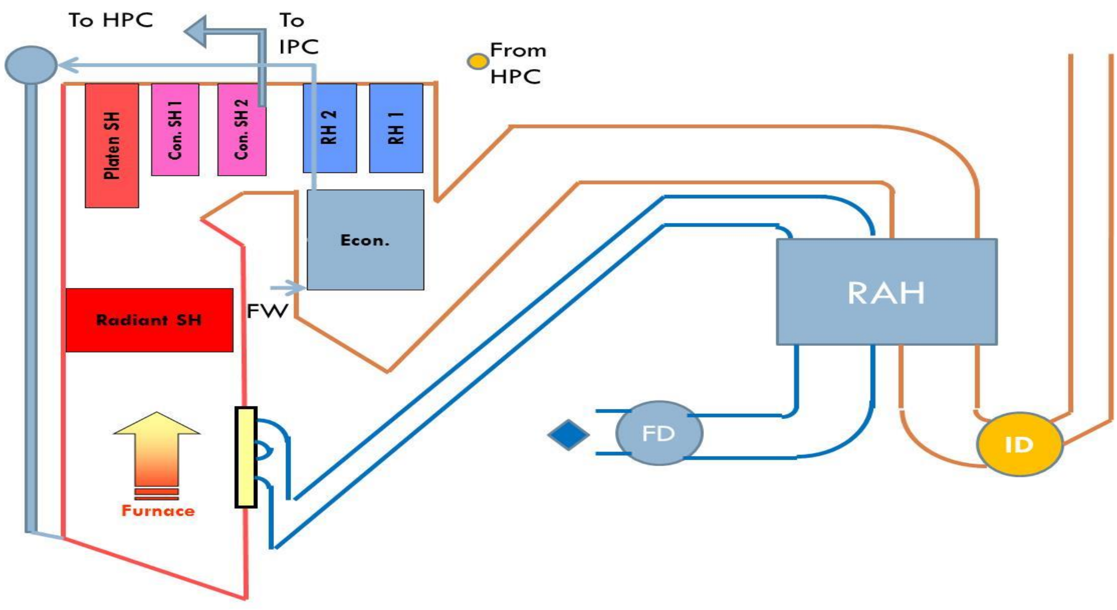


Fig 5.6: Cross-sectional Diagram of Boiler

5.7 Boiler Energy Flow:

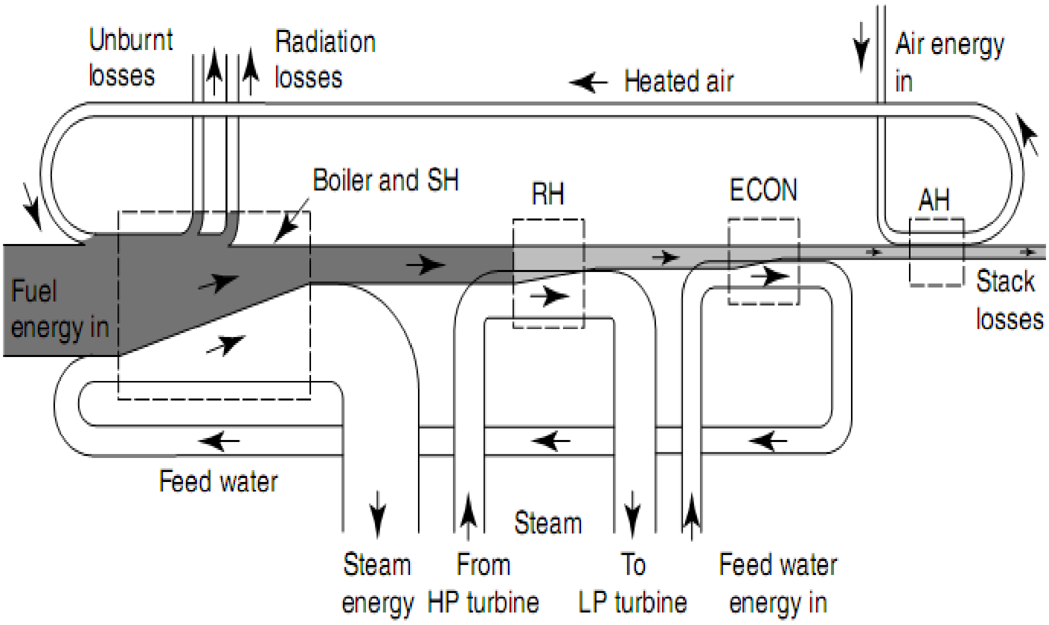
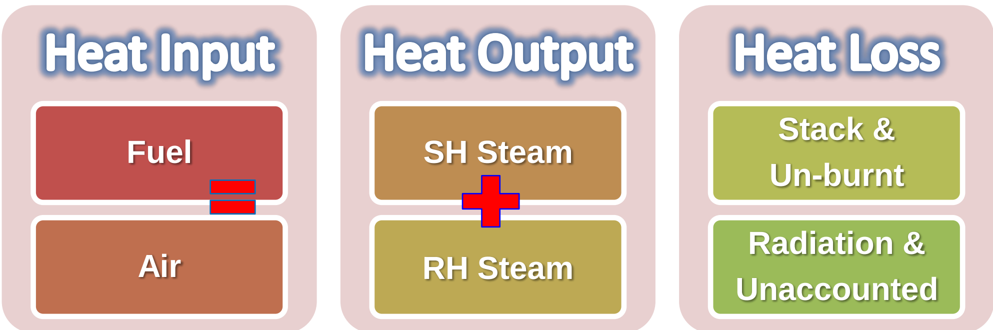


Fig 5.7: Boiler Energy Flow

Heat Inputs, Outputs & Losses:



5.8 Description of the boiler design:

Steam boiler of TGME-206C0B type, made at Taganrog Manufacturing plant is of drum type with two-stage evaporating system. To second belongs external steam separating cyclone. Boiler as a two type design. It is equipped with burners using natural gas. It is gas tight with balanced draft and it has two separate flows passing along steam water ducts.

Fig 5.8: Boiler Design.

Boiler consists of a furnace and down-coming gas pipe-line which are connected in upper party by horizontal gas-ducts.

Evaporation screens and radiant super heater are in the furnace in the upper part of the furnace there is a platen super heater. In horizontal gas-duct there are inlet and outlet stages of convective super heater of high pressure (H.P.C.S.H.) outlet and inlet stages of L.P. convective super heater, all one-by-one along the gas-flow.

The floor of the furnace chamber and of horizontal gas-duct, side walls and bottom of horizontal gas-duct and also, front and rear walls of down coming gas-duct are covered with H.P. Super heater tubes.

5.9 Furnace Chamber:

Fig 5.9: Eye hole at furnace Chamber

The furnace chamber has a prosmatic configuration in lay-out dimensions as follows: 7680×18000 mm. The furnace chamber volume is equal to $2444.4m^3$. The walls are covered with gas-tight pipes, fabricated from 60×6mm finned pipes. All the headers and wall tubes are fabricated of carbon steel. Inter-pipe spacing is 80 mm.

5.10 The interior of the Drum:

The drum is manufacture from increased strength steel 16 THMA, The inner diameter is 1600 mm walls are 112 mm thick, the drum is 24310 mm long. The drum is installed on the two moving roller supports, providing for its free movement due to thermal expansion. The drum has three water indicating gauges glass one of them being used in case of full drum. There is also another water-indicating column at elevation 12mm nearby the emergency drainage gate valve. The middle level of water is 175 mm lower than geometrical axis of the Drum. This level is a zero level on scale of the water columns. The upper and the lower levels of water are respectively 50mm higher and lower than zero level. There is emergency drain pipe to prevent from over feeding the drum. The pipe lets discharge excess water but lower than the middle level.

Separating devices inside the drum consist to the following parts; 84 cyclones 315 mm fixed in two rows by length of the drum 40+44;

-Separating duct of feed water planed by length of the drum in its steam space.

-flusher sheet w/hole;

-ceiling sheets w/holes

5.11 Condensing Plant:

Fig 5.11: Condensing Plant.

There are two condensing plants at the boiler for producing condensate, installed from the both side walls of the furnace chamber at el. 21800. Each plant consists of 2 condenser 426×36mm, two headers 159×15mm for steam supplying, one steam extracting header 159×15 mm and two headers 219×20mm of feed water (delivery and discharge).

From collecting header by 6 pipes feed water goes to three condensers (pipe 159×15mm). Passing along the pipes of condenser water by six 159×15 mm pipes is supplied into delivery header 219×20 mm from where it comes to economizer.

5.12 Burners:

There are 12 cyclone burners placed in two tiers on the rear wall. The burners of the lower tier are installed at elevation 6151 mm, upper at elevation 8750mm and are designed for burning natural gas. The air channel of the burner is divided into inner channel and peripheral one. In these channels air flows before entering the embrasure of the burner come through swirling Vances. Air swirling in the inner channel is done by an axial device which carries 17 permanent blades.

Fig 5.12: Burners

Technical specification of the burner:

Output (regarding gas)	4500nm^3/h
Limits of load regulation	30-100%
Thermal capacity under pressure of gas before burner 0.5 kg/cm	45MW

Table 5.12: Technical specification of the burner

5.13 Boiler insulation

As all the walls of the gas ducts are made of gas-tight all welded screens, there is no refractory protection of the boiler (except several places). All gas-tight panels, except embrasures of burners, man-hole crawl-ways and places where pipes go through a ceiling are insulated by silica-lime plates, 100 mm thickness and pearlite-cement plates, 50mm thickness. The overall thickness of insulation is 160mm. A part of convective shaft is insulated by mineral wool mats. From outside insulation plates an mineral wool mats are covered by relief not on which magnesia coating is applied.

5.14 Draught installation:

There are two F.D. Fans of BDH-325 type. Capacity Q-580/460 thousand m^3/h head pressure H-520/320kg/m^2 under air temperature t = 30^0C el. motors of DA-30-2-18-76-8/10TI, capacity N=1000/550KW with rotations number N=750/600 R.P.M. For regulation of the output in suction of F.D. Fans there are axial guide vanes. In winter period in order to ensure required air heating, coming into R.A.H. it is possible to additionally start into operation a line of hot air recirculation to suction line of F.D. Fans.

5.15 Air Duct:

After R.A.H the main air flow goes to the burners. Out from common airline two air lines go to each of the boiler side, which then are divided into the ducts of central and peripheral air supply to burners. In air lines to the burner channels there are tight valves installed. For ventilation of the Heat wall and for maintaining pressure differential between the “heat wall” and furnace (5-10kg/m^2) there is a Dy. 800 hot air supply line with automatic regulator. For making air pass enabling automation to work. There are two lines Dy. 400 for air extraction to the fan suction. Besides, hot air supply is provided for into recirculation duct for cooling recirculation nozzles when Recirculation I.D. fans in not in operation.

5.16 I.D. Fans:

In order to remove gases from the furnace the boiler is equipped with two I.D. Fans of DH-26×2-0. 62 IM type of designed capacity Q=480/380 thousand m^3/h.

Head pressure H=460/300 kg/m^3 under gas temperature t=100^0C. The I.D. Fan is driven by el. motor DA30-2-17-69-8/10TI, capacity N=800/500 KW and N=744/595 r.p.m

5.17 Recirculation of chimney gases:

Fig 5.17: Recirculation of chimney gases

It is provided for maintaining nominal overheating secondary steam under reduced boiler loads. In order to make recirculation possible there are two gas recirculation I.D. Fans of ID-20-500Y

Type with Q=200000M^3/h and head pressure H-490 kg/m^2 under 400^0 gas temperature. The ID Fan is driven by el. motor DA30 13-67MT2 with N=300 KW, N=1000 r.p.m. Regulation of the output of R.I.D. Fan is done by the guide vanes of axial type, installed at suction line. Chimney gases are tapped after water economizer and are supplied through 16 recirculation nozzles at the front wall and through burners into the furnace.

5.18 Protection, interlocking:

Fig 5.18: Protection, interlocking

5.19 Protection for the shut-down of the Boiler:

- During over feeding up of the boiler by water (2nd limit)-increasing the water level in the drum on 200mm above the medium level.
- While losing water level in the drum-decreasing the water level in the drum on 100mm below the average.
- When the gas pressure behind the regulating valve is reduced till 0.01 kgf/cm^2.
- When the air pressure in front of burners is reduced up to 40 kgf/m^2 with the time delay up to 9 seconds.
- With switching off the two I.D. fans or one of them, if one was not operating.
- With switching off the two F.D. Fans or one of them, if the other one was not working
- With switching off of the two RAHs or one of them, if the other one was not working (protection operates with 9 seconds time delay).

5.20 Protections, Performing local operations:

- When the boiler is over feeded with water (1st limt)-increasing the level in the boiler on 150mm above the medium one is delivered by a signal for simultaneous opening of two subsequently installed gate valves on the pipe line of emergency drainage of water from the drum (gate valves; Nos. NC30S01, NC30S02).
- When the level in the drum is reduced up to valve + 130mm a signal for simultaneous closing of gate valves NC30S01 & NC30S02 is sent.
- When the pressure in the “hot box” of the ceiling is increased upto 50 Kgf/m^2 a signal for opening of all the valves NG41S01, NG41S02, NG42S01, NG42S02 on air discharge from the “hot box” into the atmosphere is sent. If the pressure in the “hot box” is lower than 50 Kgf/m^2 an order for opening the valve is cancelled. When the pressure is reduced up to 30 Kgf/m^2, Valves NG41S01, NG41S02, NG42S01, NG42S02 on the line of the “hot box” blowing though are closed by protection.

5.21 Conditions of interlocking of auxiliary equipment mechanisms:

- With switching off of the el. motor of one out of two working F.D. fan the following is being carried out;
- Reducing of the boiler’s load with switching of the action of the main unit regulator on the working fuel regulator with pre-setting the task for the fuel regulator for keeping up 50-60% load.
- Switching off of the action of the common air regulator into guid vanes of the stopped. F.D. fan with preservation of the action of the regulator onto the guide vanes of the F.D. fan under operation;
- closing of guide vanes NG10S01 (NG20S01) of the stopped F.D. fan
- Closing valves NG11S01, NG11S02, (NG210S1, NG21S02) on the air pipe lines and valves NR11S01, NR11S02, NR11S03 (NR12S01, NR12S02, NR12S03) on gas ducts before and after corresponding RAH.
- Closing of valve NG3S01 (NG23S01) on the line of recirculation of hot air onto the suction of the stopped F.D.fan NG10S01 (NG20S01);

5.22 Ignition protective devices:

- Control of ignition protective devices is performed from the U.C.B and locally, with sending the order the corresponding valve is being opened:
- If the ignition torch appeared (confirmation is given by ionization sensor), a signal to the U.C.B. is sent and the gate valve on the main fuel supply of this burner is opened automatically.
- Closing valve, NP21S02 (NP21S04, NP21S06, NP22S02, NP22S06, NP23S02, NP23S04, NP23S06, NP24S02, NP24S04, NP24S06).
- Switching-off of the corresponding high voltage transformer of the ignition torch.

5.23 Inspection and operation of the boiler for its start-up:

- Before start-up, after the erection or overhaul it is necessary to carry out the internal inspection of the drum to make sure of the absence of strange objects in it, as well as of dirt, fin, sliming, etc. to check up the reliability of fixing to the inner devices of the drum. After the above inspection the man-holes should be closed.
- To make sure that all the repairing works are completed, working places are cleaned and the people are removed. To check up the condition of the furnace, heating surfaces, frame, casing, insulation, service ability, tightness, easiness of gas-air valves motion, serviceability of their remote drives, correspondence of their positions to the indicators and marks.
- To check-up the readiness of I.D. fans, F.D. fans and flue gas recirculation fans for their start-up in accordance with the instruction on their operation.
- To check up the readiness of the RAH for the start-up as per their instruction on operation.
- To check up the serviceability of water and steam valves of the boiler, remote drives to them, correctness of painters on the wheels.
- To check up the serviceability of impulse-safety device of the boiler, paying special attention to the right position of weights, availability of water in the dampers. Erection collars of the weights should be fixed up valves, arms-released in rollers. To check up the reliability of fixing of exhaust pipes of the safety valves.
- To pay attention to the rightness of the position and condition of the primary valves of the control measuring devices and impulse intakes of automatic regulators in the gas ducts and air ducts.
- To check up the condition of the water measuring columns

5.24 Erection of the gas duct schemes:

- During the erection of the above scheme follow the scheme of the boiler gas duct.
- The position of gates and barriers should correspond to the position shown in Table No. 1
- To supply water for cooling the bearings of I.D. Fans, F.D. fans, gas recirculation I.D. fans, RAHs.
- To heck up the rediness for the start-up of the oil station of the RAH;
- To run the pumps of the oil station;
- To put the working pumps into operation;
- To test the operation of Automatic Reserve closing the stand-by pump should be automatically put into operation with reducing the pressure of oil in the pressure line upto 0.5 Kgf/cm^2. To adjust the oil supply to the lower supports of the RAH.
- To test the remote control of gates and guide vanes. The serviceability of the gates with manually operated drive is tested during the erection of the scheme at the site.

5.25 Filling up of the Boiler with water.

- Before filling-in of the boiler with water at the start-up of the boiler after maintenance or erection, it is necessary to make sure that all the man-holes of the drum are completely closed, to mark and write down zero positions of the bench marks, showing movement of its elements.
- Filling-up of the boiler before its lighting-up should be carried out by deaerated water only through the economizer.
- During filling-in of the empty drum the temperature of the water coming into the drum should not differ on more than 40^0C from the temperature of the drum metal as per its perimeter.
- To check up the condition of valves on the feed sub-unit.
- To fill in and keep under pressure the area upto the lowered feed sub-unit. It is necessary to be careful enough during filling-in of the line, avoiding kicks and impacts. If the water jets appear from the air vents of the feed line, it is necessary to close the air vents.
- To open valve Ø 65 (RL32S02) on the by-pass line of the feed sub-unit and start up filling-in of the boiler by the water. Gate valve Ø 100 (NA32S01) on the water

recirculation line from the boiler. After filling-in of the boiler before lighting-up of the burners it is necessary to open gate valve Ø 100 on the recirculation line. Filling-in of the non-cooled drum should be carried out with the opened recirculation line. With the

5.26 Preparation of Gas Equipment for firing:

- Prepare the pipeline inside the boiler (directly before the boiler lighting-up simultaneously with the furnace ventilation).
- Open gas and air slide valves of the boiler (see table 1 of the present instruction);
- Close the guide vanes of I.D.F.D. and flue gases recirculation I.D. fans;
- Close manually and electrically operated gate valves before the furnaces; manually operated valves before ignition torches;
- Open all the gas vents;
- Open the stop valves in succession downstream stroke before the take-off point; slide valves No. NPI0S011, NPI0S012, NPI0S013, NPI0S014, NPI0S07, NPI0S08, NPI0S09, NPI0S10, cut-off valve No. NPI0S02; slide valve No. NP20S01 on the gas-line of the filled fuel; regulating valves No. NPI0S03, NPI0S04, NPI0S05.
- Take out the plug on the main gas line after the valve No. NPI0S1, the latter must be firmly closed;
- Switch the regenerative air preheater, I.D. fan F.D. and flue gases recirculation I.D. fan of both flows on load them by 50 or 60%, make sure that all the mechanisms are in good repair;
- adjust vacuum of 2 to 3 mm of water column in the upper part of the furnace;
- Open the valve No. NPIOS01, fill the gas line in with gas, check the tightness of flange joints and valve glands by means of soaping;
- Prepare gas analyzer or gas sampling cup to determine oxygen content in the gas;
- Switch the flow meter and the gauges on the gas line on (and check the "ON" position).
- Gas line is considered to be filled with gas if oxygen content in it is not above 1%.
- Completion of blow-down is checked either by means of an analysis or by means of on burning the samples which are taken from the connection on the common line of gas vents. Gas burning should proceed smoothly without puffs.
- Pressurized inlet slide valve No. NPI0S01 and quick-acting cut of valve No. NPI0S02, to affect this.

5.27 Firing of the Boiler:

Ventilate the furnace and the air-gas duct thoroughly 15 min.

I.D. and F.D. fans should operate on the Ist speed.

After the gas line is filled in with gas and blow down, close slide valves No. NP10S011 and NP10S013; Close valves No. NP10S03 and NPI0S04 of the pressure regulator.

Lighting-up should be carried up on the lighting-up by pass line (Dia. 150 mm) using valve No. NP10S05.

Close valves (Dia. 20 mm and dia. 50 mm) on the drainage lines of guarding surface and radiation on wall super heater leave Dia. 10 valve open.

After ventilation stop flue gas recirculation I.D. fans, close their guide vanes. In addition close the following.

5.28 Firing the Boiler from uncooled state

- Boiler can be considered as uncooled if there is an excess pressure in the boiler drum.
- The lighting mode and duration of lighting the Boiler are determined by its thermal state before start up. Firing is down in accordance with schedule-task on unit starting up from uncooled state.
- The unit start up from uncooled state is done on unstable parameters with prior increase of temperature and steam pressure before it comes in turbine. As soon as the first to cool down in the Unit is Boiler then during start up from uncooled state it is necessary to light up the boiler, to increases steam temperature beyond the boiler, to heat the pipe-lines up to degree, corresponding to thermal state of pipe-lines and H.P. Cylinder of Turbine.
- Lighting up the boiler is done with the Main stream valves, closed and also their by-passes. In order to about cooling the pipe-lines steam discharge in initial stage of firing is executed through Quick-acting cooling Reducing plant 140/6 kg/cm^2 into Turbine condenser.
- In order to ensure the normal heating the furnace minimizing stratifications of gas temperature in front of super heaters, and also acceleration of parameters grow for the boiler thermal load of the furnace must hot be lower than 20% nominal.

5.29 Servicing the boiler and auxiliary equipment during operation (under load).

- When boiler is working at nominal parameters all automatic controllers must be switched on.
- When performing control the frequent and considerable deviations of the values under regulation are undesirable. In case of such deviations from allowable quantities when any mal operation problems arise in the work of automatic controllers shift to remote controlling. Glands of all stop and regulating valves condition:

-operation of separate boiler units by periodically listening to the gas ducts in the super heater and water economizer areas with the aim of timely detecting the leakage;

-operation of auxiliary equipment basing on corresponding instructions on servicing;

-condition of refractory and insulation of the boiler;

-condition of the main and auxiliary equipment illumination and illumination of the working places.

5.30 Shut-down of the Boiler:

- With the planned shut-down (for reserve) in case if the maintenance of the boiler is not bring foreseen, the shutdown of the boiler is carried out without its cooling at almost invariable live steam temperature and reheat steam temperature.
- Unloading is carried out at first by decreasing of gas pressure up to 0.05 kgf/cm^2 and then by uniform switching-off of the burners of lower and upper tiers.
- To close manual and electrified valves in front of the burner and open safety gas vents;
- During 1-1.5 hours it is necessary to decrease the Unit load up to 70 MW with reducing the load the temperature of the fresh steam should be left invariable, equal to $530+540^0$C.
- To put out all the burners, to stop the turbo/generator with closing the main steam gate valve in accordance with the instruction. The order of switching off of the burners;
- to make sure that there is no a torch of the burners;
- to switch off the protective-ignition device (if it was switched on).
- When the last burner is switched off, make sure that the torch in the furnace is put out, close gate valve NP10S01, NP10S02 and that open the blowing vents NP30S01, NP30S02, gas vents of the line and parts of the gas pipe-lines for the lower and upper tiers of burners (4 Pcs.).

5.31 Emergency shut-down of the boiler:

The boiler set should be immediately stopped and tripped out by the operation of protections or by the personnel in case of

- inadmissible increase (+200mm) or decrease (-100mm) of the level from the average;
- all the water-indicating instruments are out of order;
- breakage of the pipes of the steam-water duct or finding-out creaks and holes in steam pipelines or feed line;
- Decreasing of air pressure in front of the burners up to $40 Kgf/m^2$.
- In admissibly high increase of the steam pressure (1.08 P.non), failure in operation of the safety valves.
- Putting out of the torch in the furnace or inadmissible decrease of gas pressure up to $0.35\ kgf/cm^2$.
- switching-off of two I.D. fans or two F.D. fans;
- switching-off of two RAHs;
- explosion in the furnace, ignition of combustible materials, heating-up of the carrying beams of the frame till they are red and as well as other damage threatening the personnel or equipment;
- discontinuation of the steam consumption through the intermediate steam superheater;
- losses of power on the devices of remote and automatic control and at all the control measuring instruments;
- Fault of more than 50% of safety valve.

CHAPTER 6

OPERATION OF 210 MW STEAM TURBINE IN GHORASHAL POWER STATION

6.1 Introduction:

A steam turbine is a device that extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft. Because the turbine generates rotary motion, it is particularly suited to be used to drive an electrical generator. The steam turbine is a form of heat engine that derives much of its improvement in thermodynamic efficiency through the use of multiple stages in the expansion of the steam, which results in a closer approach to the ideal reversible process.

Fig 6.1: Steam Turbine 5th Unit of Ghorashal Power Station

Fig 6.1: Steam Turbine HP Stage

6.2 Working Principle:

An ideal steam turbine is considered to be an isentropic process, or constant entropy process, in which the entropy of the steam entering the turbine is equal to the entropy of the steam leaving the turbine. No steam turbine is truly isentropic, however, with typical isentropic efficiencies ranging from 20–90% based on the application of the turbine. The interior of a turbine comprises several sets of blades, or *buckets* as they are more commonly referred to. One set of stationary blades is connected to the casing and one set of rotating blades is connected to the shaft. The sets intermesh with certain minimum clearances, with the size and configuration of sets varying to efficiently exploit the expansion of steam at each stage.

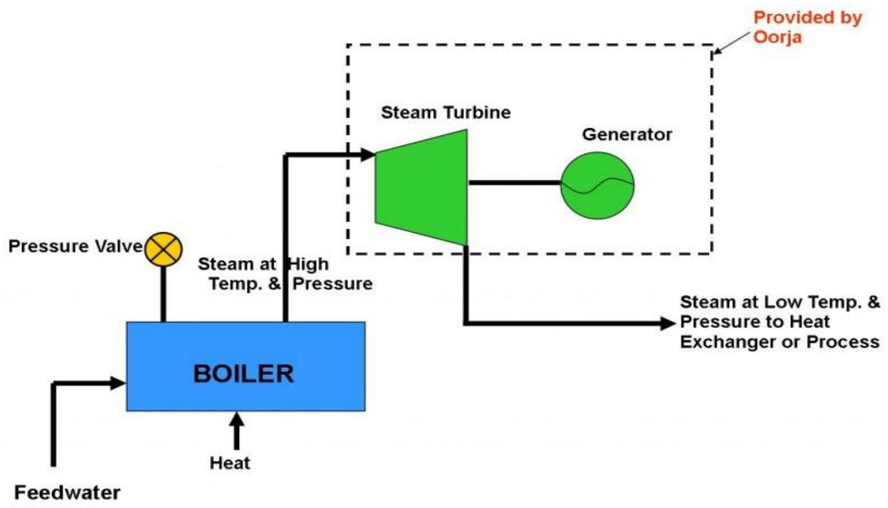


Fig 6.2: Principle of steam turbine

6.3: **Steam Turbine Cycle:**

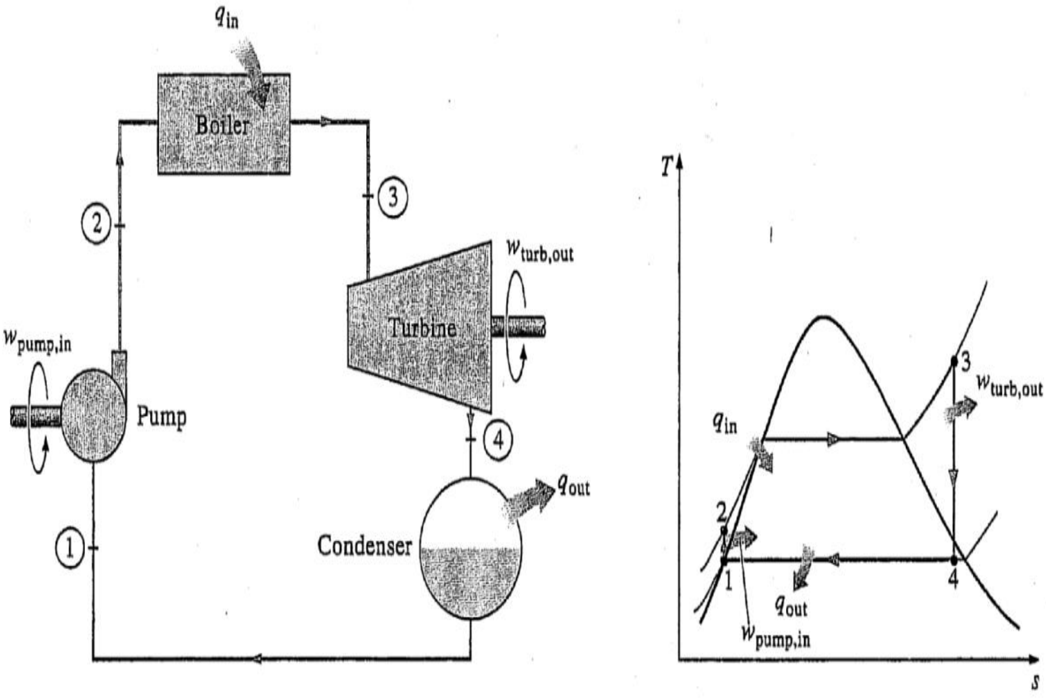


Fig 6.3: Rankine cycle

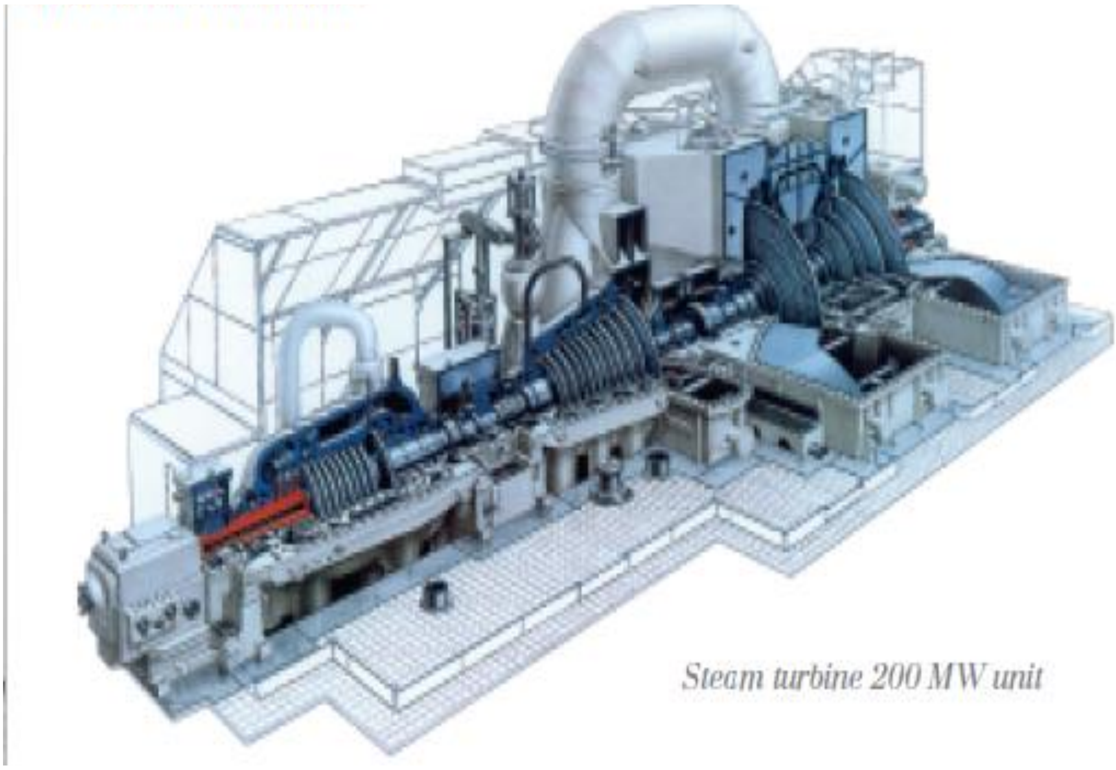
1-2 Isentropic Compression in Pump.

2-3 Constant Pressure heat addition by economizer, evaporator, super heater sequentially.

3-4 Isentropic Expansion in Turbine.

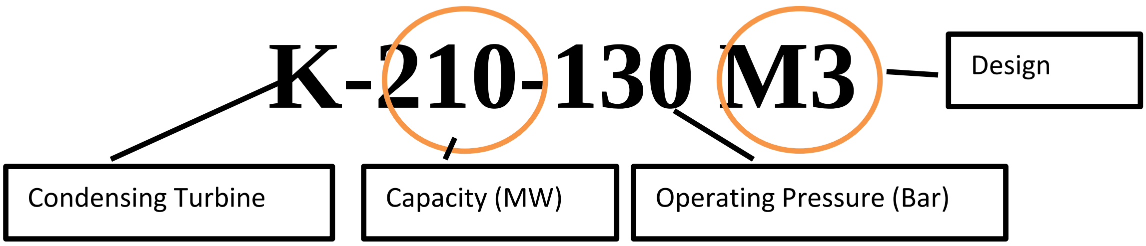
4-1 Constant pressure heat rejection.

6.4: 210 MW Steam Turbines in Ghorashal Power Station:



Steam turbine 200 MW unit

Nomenclature



Steam **condensate** turbine K-210-130 M3 is a **one-shaft three-cylinder** set with **intermediate overheat** (re-heat) of steam and two exhausters (two part Condenser), it is designed for direct rotation of A.C. generator of ТГВ-200 (TGB-200) type and it operates within a Unit jointly with one-body drum boiler ТГМЕ-206 СОБ.

6.5 Main parts of turbine:

1. Turbine rotor
2. Turbine blade
3. Turbine bearing
4. Reduction gear

Main technical characteristics of the turbo set within the nominal duty:

Nominal capacity of the turbine	210 MW
Frequency of the rotor rotation	3000 r.p.m.
Pressure of live steam in front of the stop valves of the H.P. Cylinders	130 ata
Live steam temperature in front of the stop valves of H.P. Cylinders	540^0C
Steam pressure before stop valves of M.P. Cylinders after reheat line	24.8 ata
Steam temperature before stop valves of M.P. Cylinders after reheat line	540^0C
Steam pressure behind H.P. Cylinder	28.4 ata
Steam temperature behind H.P. Cylinder	336^0C
Steam consumption on the turbine at Na = 210 MW	636 t/h
Steam consumption in the condenser at Na = 210 MW	423 t/h
Pressure in the condenser	0.0658 ata
Consumption of cooling water, passing through condensers	27,500 m^3/h
Designed temperature of the cooling water at the inlet into the condenser	24^0C
Feed water temperature after H.P. heater No. 7	244^0C

Table 6.5: Main technical characteristics of the turbo set within the nominal duty

Maximum capacity of the turbine is provided at the nominal parameters of steam, completely switched on regeneration, clean flow part and when the cooling water temperature does not exceed 10^0C -215 MW.

Steam consumption on the turbine at the maximum capacity is 670 t/h.

Maximum steam consumption in the condenser is 461 t/h.

The turbine has 7 non-regulating steam bleed offs, designed for heating of feed water in H.P. Heaters Nos. 5, 6, 7 of the main condensate in L.P. Heater Nos. 1, 2, 3, 4 deaerator 7 ata.

a) The turbine is equipped with the following sub-units-

i. a device for measuring the expansion of the turbine, which allowed to carry out a remote control for the thermal displacements of the bodies and consisting of hinge less variable reluctance pickups, installed at the foundation frame of the first and second bearings and indicating instruments at the CONTROL ROOM;
ii. a device of frequency control of the turbine rotation and issuance of the signaling at the CONTROL ROOM at the excess of the rotation frequency on 10% and 16% above nominal (i.e. at the rotation frequency of 3300 r.p.m and 3480 r.p.m. and also issuance of a signal into the scheme of automatic turn on 540^0 and consisting of four-pole tachometer generator connected with the shaft of the turbine inside the body of the front bearing by the spring coupling; indicating device installed at the cover of the body of the front bearing and indicating instrument at the CONTROL ROOM In the cover of the man-hole of the first bearing there is a hole, usually closed with the plug for the connection of the manually operated tachometer to the end of the shaft of the tachometer generator,

b) Indicators of the relative expansion of L.P., M.P. rotors, which are controlling the difference of expansion of rotors and cylinders with the signaling of admissible values of expansions. Indicator of the relative expansion of the H.P. rotor is installed in the front rack of the turbine, indicator of the relative expansion of M.P. rotor is installed in the support frame of 3.4. Bearing in between M.P. and L.P. cylinders, indicator of the relative expansion of the L.P. rotor is installed in the support frame of 5.6. bearings in between L.P. cylinder and the generator and indicating devices of relative expansions- at the CONTROL ROOM

c) by means of the control device of the rotor axial shift, consisting of two side action relay, installed at the special arm in the body of the second bearing and indicating device at the CONTROL ROOM which provides for: the possibility of remote observation for the axial shift of the rotors to the generator's side as well as to the front bearing side,

- Switching off of the turbine at the excessive shift of rotors to the generator's side as well as to the side of the front bearing.

- Zero of the scale of the axial shift pointer corresponds to the position of the rotor pressed to the working shoes of the supporting bearing (generator's side) Division of the scale to the left from the zero within the limits 0, 0+0,5 mm corresponds to the position of the rotor in between the shoes of the supporting bearing within the limits of the existing adjusted value of the free shift. Division of the scale out of the limits of the adjusted value of the free shift (1.7

mm to the side of bearing No. 1 and 1.2 mm into the generator's side) corresponds to the wear to the shoes.

d) by means of the burring gear which rotates the rotor with 3.4 r.p.m. speed by means of the electrical motor of 380 V, with the capacity of 30 kw at 750 r.p.m. This device prevents the rotor curving in the heated condition at the start-up and shut-down of the turbine. The bearing gear has an automatic device which provides for the turn of the rotor on 540^0C each ten minutes,

e) by the device for heating of flanges and studs of H.P. & M.P. cylinders, the saving the time for heating H.P. & M.P cylinders is provided as well as reducing of temperature difference as on the width of flanges and in between the flanges and studs,

f) the turbine is equipped with the metal temperature control of the cylinders and steam-admitting members as well as with supporting inserts and stop shoes of the bearings with the output of the readings into the CONTROL ROOM,

g) Each bearing has a pickup for measuring vibration in two directions (vertical and horizontal), the stand with devices of vibration condition of the turbine is located at the CONTROL ROOM

6.6 Construction:

H.P. Cylinder casted from chromium-molybdenum-vanadium steel has 12 stages the first one out of those twelve is a regulating one. Steam inlet into the H.P. Cylinder is located form the 2nd bearing side that is why the blade apparatus of the H.P. Cylinder is made for the left rotation H.P. rotor is solid-forged.

M.P. Cylinder consists of the two parts; the first one is casted from chromium-molybdenum-vanadium steel and exhausting part is welded from sheet carbon steel M.P. Cylinder has 11 stage.

M.P. Rotor has seven disks, forged jointly with the shaft and four fitted on disks.

L.P. Cylinder double flow, welded form sheet steel has four stages in each flow.

L.P. Cylinder has eight fitted on disks; four in each flow of L.P. Cylinder. Diaphragms of H.P. Cylinder and M.P Cylinder are of a welded structure. The last, 23rd diaphragm of the M.P. Cylinder and diaphragms of L.P. Cylinder are cast-iron with the directed blades casted into the body of the diaphragm. The diaphragms have redial sealings, which decrease steam leaks through the clearances; above the bands of the impellers and in between the rotor and diaphragm. Guided vanes of the first stage (H.P. Cylinder) are located in the nozzle boxes welded to the cylinder. The guided vanes of the 13th stage (M.P. Cylinder is located directly in the cylinder's body).

The turbo/generator has seven plain bearing, one of them (No.2) is support-thrust; all the others-supporting.

The front bearing is installed at the cast-iron frame on which it is being shifted during the thermal expansion of the turbine. In the body of the front bearing a supporting insert of H.P. rotor is installed and also centrifugal oil pump connected with the H.P rotor through the tooth coupling; oil pipeline to the regulating subunits; regulation and protection sub-units of the turbine.

H.P. & M.P. rotors are connected in between themselves by rigid coupling and have one common bearing.

M.P. & L.P. rotors as well as L.P. rotors and generators are connected in between themselves by semi-flexible couplings.

Rotors are rotating clockwise if to look at the generator from the front bearing side (Turbine side).

All the turbine rotors are flexible.

At the medium frame of the front part of the L.P. Cylinder there is a fixture post of the turbine.

Axial expansion of the turbine from the fixture post happens mainly into the side of the front stand and achieves 12 mm during full heating of the cylinders as on the indicator which is installed in between H.P. & M.P. Cylinders, and 32 mm as on the indicator is front of the first stand of the turbine. The expansion of the L.P. Cylinder achieves 3 mm into the generator side.

Steam distribution is of a nozzle type. Regulating valves of H.P. & L.P. Cylinders, four per each cylinder, are installed directly at H.P. & M.P. Cylinders in the steam boxes. H.P. & M.P. Cylinders are located by steam inlets to each other that provide for the possibility of control for the regulating valves of H.P. & M.P. cylinder by one serve motor and reduces the axial effort into the thrust bearing. The first to be opened are the regulating valves of M.P. Cylinders and when they are almost completely opened, the regulating valves of H.P. Cylinders are being opened.

Regulating valves of H.P. & M.P. cylinders supply steam to the nozzle boxes. First, simultaneously two upper valves are opened, they supplying steam to the upper nozzle boxes and then with some displacement the regulating valves are being opened, supplying steam to the nozzle boxes located in the lower half of the cylinder. Regulating valves of H.P. Cylinder have the following diameters; 1st-125 mm; the other three valves-150 mm. All the four regulating valves of the M.P. Cylinder have one and the same diameter-325 mm.

Non-returned valves, installed at the pipelines of the 1st, 3rd, 5th and 6th Steam extraction from the turbine is designed for prevention speed-up of the turbine by the reverse steam flow at the closed valves of the turbine and switching-off of the generator from the grid.

Impulse for closing of non-return valves is sent from the end switches of the stop valves and switch of the generator or by the switch from the CONTROL ROOM into the solenoid valves of condensate line; which are opening water supply into the hydraulic serve motors of the preventive closing of the valves.

End sealing of the turbine rotors of the labyrinth type are made with the intermediate chambers for supply and extraction of the steam and consist of ring necks on the rotor and immovable sealing ring which are installed at the stator.

6.7 Steam supply to the Turbine:

- Live steam from the boiler is supplied to the turbine by two steam pipelines of 325 ×38 mm in dia. through the main steam gate valves RA11S01 which have by-pass of 133×16 in dia. on which throttle valves RA11S03 & RA12S03 as well as stop gate valves RA11S02 & RA12S02 are installed. After the main steam gate valves, live steam, having passed through two stop valves of 225 mm in dia. comes into four cross-over pipes of 273×32 mm in dia. and further through four regulating valves to the nozzle boxes of the H.P. Cylinders.
- Waste steam from H.P. Cylinder goes as on two steam pipelines of 465 ×16 in dia. to the intermediate steam super heater of the boiler, from there on the four stem pipelines of 426×18 in dia. it comes to the two stop valves of M.P. Cylinders of 420 mm in dia. From the stop valves of M.P. Cylinder the steam goes through the cross-over pipes of 426×18 in dia. through four regulating valves into the M.P. Cylinder. From M.P. Cylinder steam on two pipes of 1520 mm in dia. is directed into double-flow L.P. Cylinder.

- For the discharge of the steam from the boiler during its lighting up, as well as in case of increasing the pressure in the live steam pipelines at the sudden load decrease the quick-acting reducing cooling plant is foreseen, which discharges the steam from the connection of live steam pipelines through the discharge pipeline of 630 ×8 mm in dia. into the turbine condensers. At the nominal parameters of the live steam the designed capacity of the quick-acting reducing cooling plant is 230 tons per hour. The parameters of the reduced steam are: Pressure-6 ata; temperature-200^{0}C, decreasing the temperature of the reduced steam up to 200^{0}C is carried out by means of the injection device of the quick-acting reducing cooling plant. To the condensers the steam is delivered through the special steam-receiving devices in which additional cooling of the steam by condensated delivered from the head of the condensate pumps is carried out.

- From the pipelines of hot reheat the scheme of steam discharge from each line in front of the stop valves of M.P. Cylinder into the condenser through the steam receiving devices is performed. At every discharge pipeline of 273×10 mm in dia. four electrified valves RC21S01, RC22S01 and RC22S02 are installed in series which are opened at closing of the stop valves or at the tripping of the generator from the grid and are closed at the opening of the stop valves and switching on of the generator into the grid also by a remote control from the U.C.B.
- Decrease of the temperature of the operated steam of the reheat up to 200^{0}C is carried out by means of injection devices installed at the discharge pipelines. For the preliminary heating of the reheat steam pipelines before the start-up of the turbine 140/10 reducing cooling plant is foreseen with a capacity of 120 tons per hour (at the nominal parameters of the steam), it supplied the steam from the connection of steam pipelines of the live steam into the cold reheat pipelines.
- To regulate the temperature of the steam in front of the stop valves of M.P. Cylinder within the start-up duties the connection of 273×10 in dia with electrified gate valve RB20S01 and gate valve RB20S02 are performed which can cross over the steam from “cold” reheat pipe lines apart the intermediate steam superheated of the boiler into the “hot” reheat steam pipelines.
- All the steam pipelines working at steam temperature of 545^{0}C are made of 12×MO steel, cross-over pipes of H.P. & M.P. Cylinders of 15×MIO steel. Valve bodies are made of 15×IMIO and 20×MO steel, studs of the flange connections are made of II-723 steel, nuts-II-10 steel.

6.8 Condensate Plant:

Fig 6.8: Condensate Plant.

Condensate plant of the turbine consists of condenser group, condensate pumps, main and start-up ejectors.

Condenser group consists of two surface-two-pass condensers of 200-KUC-5 type.

The body of the condenser is all welded with welded-in from the both sides pipe boards into which the pipes with intermediate pipe partitions are expanded. The water chambers make solid with the body and are closed with the removable covers. Steam spaces of the condensers are united with the leveling branch pipes, with 935 m^2 section.

To avoid the deviation of expanding the pipes in the pipe boards due the thermal shifts of condensers. Lens compensators at their bodies are foreseen, which are providing for mechanical

Compliance of the pipe boards against the body. Condensers by their necks are welded to the exhaust branch pipes of the turbine and to compensate the thermal extension they are installed on the spring supports designed for perception of the condensers weight. During filling-in of the steam space of the condensers with water for the pressure test of the vacuum system the spring supports of the condenser should be unloaded by means of installation of metal blocks under the condensers. Each condenser has a separate delivery and discharge of the cooling water, what allows the tripping of one of the condensers on water when the turbine works under the decreased load. Decrease of the load at this is determined by allowed temperature of the exhausting part of the L.P. Cylinder. Suction of the condensated gases from the steam space is carried out from the sides of the condensers bodies, where the gases are delivered through the especially separate bundles for pipe-coolers.

Pipe system of the unit condensers is made of smooth pipes of MH 5-I alloy. Cooling water is delivered by circulating pumps from the river and having passed through the pipes is discharged into the outfall channel. Steam coming from the turbine, is being contacting with the cooling surface of the pipes and is being condensed on them giving the heat to the water coming through the pipes. Condensate runs off into the hot well from where it is pumped out by the condensate pumps.

6 .9 Technical characteristics of the condenser:

Total cooling surface	13180 m^2
Quantity of pipes	16720 pcs.
Length and diameter of the pipes	9000 mm ϕ 28×1 mm
Cooling water consumption per each condenser	13750 m^3/h
Hydraulic resistance of each condenser at the consumption, 13750 m^3/h	3.7 m of water column
steam consumption into condenser during nominal mode	423 t/h.
most allowable pressure inside the water space	2.5 kg/cm^2

Table 6 .9: Technical characteristics of the condenser:

Maximum temperature in the exhausting part of L.P Cylinder should not exceed:

At the start-up and operation with 30% of load 100^{0}C

During operation with more than 30% load. 60^{0}C

10 ata three condensate pumps of the KCB-320×160 type are provided to evacuate condensate from condensate collectors of condensers.

Performance characteristics of the pumps are specified below:

Capacity	320 m^3 per hour.
Head	160 mm of water column
Rotational speed	1480 rpm
Shaft power	174 KW

Table 6.9: Condensate Pump characteristics

6.10 High and low pressure regeneration system:

Regenerative plant of the turbine is used for warming up feed water and turbine condensate with steam, which is taken form intermediate stages, to 160^0C after the L.P heater No. 4 and 245^0C after the H.P heater No. 7 (at full load). The plant includes the following equipment:

a) four surface low pressure heaters (L.P. heaters) and the 7 ata deaerator for warming up turbine condensate;
b) three surface high pressure heaters (H.P. heaters) for warming up boiler water;
c) Condensate is also warmed up in the coolers of main ejectors and in the steam coolers of rotor and sealing.

Heat exchangers are placed down the flow of turbine condensate and feed water in the following sequence:

a) Coolers of main ejectors (made of U-pipes). After passing the first stage coolers the condensate divides in parallel between the second and third stage coolers
b) A vacuum steam cooler of end sealing of the IIC-50-1 type with cooling surface 50 m^3 made of U-pipes and provided with ejector. The cooler body is divided into two sections, between these there are supply and removal chambers of turbine condensate; each section is two-way for turbine condensate
c) Low pressure water heater No.1 (L.P. heater), its two sections are built in the condenser and are connected in parallel for turbine condensate. Heating steam condensate is directed to the condenser through hydraulic seal;
d) cooler of steam from intermediate chambers of end seals, the II- H-100-16-4-II type, four way, cooling surface 100 m^2

Heater	Type	Heating surface, m^2	Extraction No.	Extraction after Stage No.	Steam pressure m/cm^2	Steam t, ^0C	Steam flow rate tons per hr.	Water flow rate, tons per hr.
1	2	3	4	5	6	7	8	9
H.P. heater No.7	IIB-700-265-45	700	1	9	42.3	388	31	700
H.P. heater No.6	IIB-700-265-31	700	2	12	28.4	336	43	700
H.P. heater No.5	IIB-700-265-13	700	3	15	12.7	453	21	700
H.P. heater No.4	IIB-350-16-7-1 HC	350	4	18	6.7	369	23	575
H.P. heater No.3	IIB-350-16-7-IIHC	350	5	21	2.9	269	18	575
H.P. heater No.2	IIB-350-16-7IIH	350	6	23	1.34	190	27	490
H.P. heater No.1	Built-in	280	7	25	0.282	67	15	440
Ejector sealing steam cooler	IIH-100-16-4-II	100						400
Ejector sealing steam cooler	IIC-50-1							260

Table 6.10: HP Heater, Ejector characteristics

6.11 Regulation system and oil system of turbine:

The K-210-140 steam turbine is provided with an automatic hydraulic control system, which is used for-

a) reliable maintaining of electrical load and idle running of turbine at nominal rotation speed;
b) insuring smooth shift of regulating valves, if load is changed;
c) automatic maintaining of rotation speed of the turbo generator rotor with 4% offset;
d) When load is immediately decreased to 0, for maintaining the rotation speed to rotor, which corresponds to maximal steam flow rate, without operating safety device.

Speed regulation transducer:

It regulates r.p.m. of turbine with 4.0 to 4.5% offset, insensibility not over 0.3%.

Starting operations are performed by synchronizer in the following sequence:

-charging safety regulator slide valves;

-opening servo-motors of H.P.C. and L.P.C stop valves

6.12 Technical data of oil coolers:

(a) Oil flow rate	- 90 m^3 per hr.
(b) Cooling water flow rate	- 108 m^3 per hr.
(c) Cooling surface	- 66m^2 per hr.
(d) Inlet water temperature not above	- 33^0C
(e) Pressure loss, of oil of water	- 0.9 kgf/cm^2

At full turbine load one oil cooler may be put out of operation, if cooling water temperature is not above 30^0C.

The regulator maintains oil-hydrogen pressure drop at the rotating rotor 0.7 to 0.8 atmp. And it maintains the same pressure drop of 2.0 atmp. Shaft-barring gear is in operation (because solenoid valve of additional feed-back opens).

When the slide valve stops rotating, it must be run; if it is possible to run the slide valve, the slide valve must be put out of operation for repair.

6.13 Protections, interlocking and automatic devices:

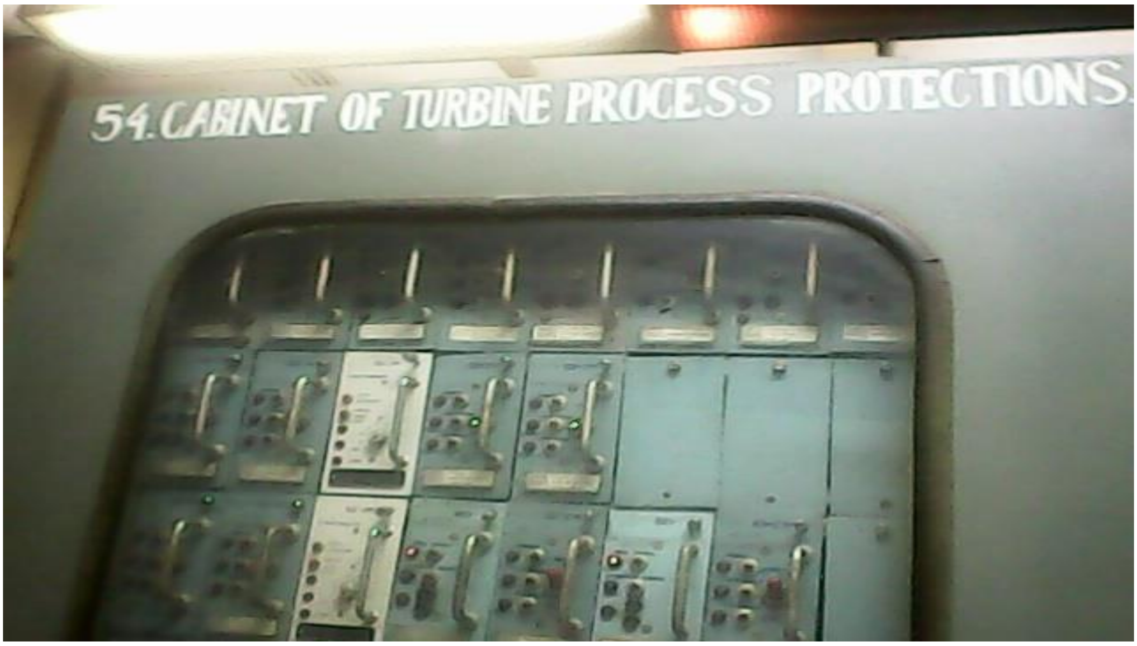


Fig 6.13: protection panel

Protections tripping the Unit off (unit protections):

1. Boiler shut down by auxiliary protection.
2. High axial shift of the rotor (+1.2 mm), (-1.7 mm).
3. Loss of vacuum to the 2nd limit in the turbine condenser (540 mm Hg column).
4. Decrease of pressure of lubricating oil for turbine bearing (decrease till 3rd limit 0.3 atmp.), 3 sec. time delay.
5. Level increase to 3rd limit in any of the H.P. heaters
   (5700 mm for H.P. heater Nos. 5 & 6; 4325 mm for H.P. heater No. 7) with confirmation of the 2nd limit setting.
6. Unit protections "generator-transformer" operates.
7. All the three feed pumps are tripped off. Nine seconds time delay (signal).
8. Generator is tripped from the grid because of outward damages.
9. The Unit may be tripped off by means of keys from the UCB;
   Protections of Para 2, 3, 4 operate in parallel both for shutting down the Unit and tripping the turbine.

6.14 Turbine starting-up from cold state:

Turbine is considered to be in cold state, if the temperature of metal in the bottom part of H.P Cylinder in the regulating state area is not higher than 150^0C.

Turbine is started up from stand-by position under the guidance of the B/T Shop shift supervisor and after maintenance under the guidance of the B/T Shop shift supervisor or his duty.

Before turbine plant start-up the personnel on duty must check;

-completion of all maintenance and adjustment works;

-removal of defects in functioning of turbine plant equipment, recorded in the defect log. Upon receiving the B/T Shop Supervisor’s directions for the start-up personnel on duty must;

-examine turbine, generator and all the auxiliary equipment of the turbine plant;

-make sure that all working places and equipment are clean, and all strange objects are removed;

-check serviceability of communication system, main and emergency lighting of the working places, as well as availability of the necessary fire-fighting equipment;

-check availability of the sufficient quantity of desalted water in the tanks and its quality;

-check serviceability and connection of water and oil gauge glasses, as well as their lighting;

-make sure that the weights on all safety valves of the turbine plant are positioned correctly, and seals are available;

-check lubrication of pump bearings of the turbine plant auxiliary equipment;

-check the oil in the turbine plant oil tank, and availability of stock of replenish the oil system;

-check the seals on the oil system fittings;

-warn the personnel on duty of other shops about the coming start-up of turbine.

6.15 Preparation and start-up of the oil system of turbo-generator:

- To check the level of oil in turbine oil tank. To make sure that the float oil level indicator doesn't stick; to check if signaling device is working. To drain water sump from oil tank. To check if the readings of level indicator are corresponding to the actual quantity of oil in oil tank. To check availability of stock to replenish the oil system (around 2m3).

- To heck serviceability of gate valves, check valves, lubrication oil pipe-lines and regulation system. To make sure that the following gate valves are open and sealed;

  -on suction pumps line of lubrication system and of generator shaft sealing system, of start-up oil pump;

  -on inlet and outlet of oil in oil coolers.

- To make sure that pump of lubrication system and start-up oil pump are filled with oil that bearings of pumps and motors are lubricated enough.
- To switch on a.c. oil pump of lubrication of bearings, to open the gate valve on the head slowly and to make sure that the pump is operating normally; to work it for 10-15 minutes for air removal from lubrication and regulation systems.
- To examine all oil pipe-lines and to make sure of the tightness of fittings, nipple and flange connections. To check oil pressure after oil coolers, which on the level of turbine axis should be 1.0kg/cm^2, to switch off oil pump and to leave the gate valve on the head open.
- To switch on and to check the work of d.c. oil pump, to switch it off after examining it and to leave the gate valve on the head open.
- To switch on start-up oil pump and to open slowly the gate valve on pressure line. To make sure if the pump is operating properly. By that the air vent of the pump should be open for removal of air from the system.

6.16 Checking of the regulation and protection system before starting-up:

- After checking oil system, if the start-up pump operates properly, checking of the regulation system is to be started. By actuating the turbine control mechanism to check opening and closing of stop and actuator valves of H.P. and L.P. cylinders. To make sure that the valves move smoothly and without pushes. Power limit switch should be positioned to the “O” position on the scale.

- Main steam valves and their by-passes should be tightly closed.
- Turbine the flywheel of control mechanism from the “O” position it is necessary to make sure that the stop valves of M.P. cylinder start opening when reading on the scale is about 4.6 mm; the stop valves of H.P. cylinder start opening when reading on the scale is about 5.5 mm; the stop valves of M.P. cylinder are fully open when reading on the scale is 6.3 mm. By turning the flywheel of turbine control mechanism further from 9.6 to 12.8 mm actuator valves of H.P. and M.P. cylinders open fully.
- Actuator valves I & II of M.P cylinder start opening as camshaft is turned by 5^0, valve III-by 30^0, and valve IV-by 65^0.
- Actuator valves of M.P Cylinder are fully open when the turn angle of the camshaft is 293^0 (the valves are counted, if one looks at the turbine from front stand, as follows: the 1st quarter- valve No.-2, the 2nd quarter-valve No.4, the 3rd quarter-valve No.3, and the 4th quarter-valve No.1).
- As the camshaft of M.P. cylinder is turned by 110^0 actuator valves of H.P. cylinders start opening in the following succession; valves I & II when the camshaft of H.P. Cylinder is turned from 0^0; valve III when the angle is 72^0; and valve IV when the turn angle is 90^0; H.P. Cylinder valves open fully with the turn angle of camshaft: by 90^0 for valve I, by 98^0 for valve II, by 110^0 for valves III and IV (the valves are counted, as one looks at the turbine from steam inlet, in the following way; the 1st quarter valve No.1, the 2nd quarter- valve No.4, 3rd quarter-valve No.3, the 4^{th} quarter-valve No.2). Pulsation of the actuator valves servomotor should not exceed 3mm.

6.17 Preparation and start-up of circulating, condensing and regenerating plants:

Parallel to start-up of oil and regulation systems it is necessary to prepare circulating, condensating and regenerating plants. Preparation of the plants for start-up includes checking of their readiness and the serviceability of all I&C devices and fittings, as well as checking of voltage on instruments and electrical motors, checking of interlocking system, assembling of operation diagrams of pipe-lines and examining of each diagram unit and item.

To prepare for start-up and to start up the turbine plant circulating system, that includes condenser and circulating pups with circulation water line, in accordance with the special instructions. For that one must:

-close all valves of water lines dumping and of condensers water chambers;
-make sure that the hatches of condenser water chamber are closed;
-Open drain valves VC12S01, behind condensers on circulating pumps, circulating pumps by 60% according to the position indicator, gate valves on circulation water inlet VC11S01 and VC21S01; close gate valves VC13 (14, 23, 24) S01;
-open manual gate valves for air suction from the condensers upper water chambers;
-switch on the ejector of the circulating system by opening gate valve RQ24S08 and SD31SOI on steam delivery line to the ejector and on the pipe-line of air suction;
-switch on circulating pumps (one of or each half of the condenser);
-as the flow rate of circulation water through the condenser becomes stable, switch off the ejector of circulating system and open gate valves for water drain from the condenser.

6.18 Preparation of vacuum system for start-up:

- To open gate valves on pipe-lines of air suction from condenser to ejectors, the gate valves before ejectors are to be left closed. To check closing of gate valve of vacuum loss SD23S01 and its tightness.
- To warm up the pipe-line of steam supply to ejector and sealing's of the 10 atmp. collectors. To open the valve of steam supply to ejector IIC-50 for steam suction from the last sealing chambers.
- To check rotor running by means of turbine shaft turning gear. Steam supply to the ceilings is strictly prohibited before the shaft turning gear is switched on.
- To open the gate valves before and after regulation valve SG10S02 and to supply steam to the turbine end seals by slowly turning the valves on. The valves, installed on pipe-lines of steam supply to each of the seals, are to be adjusted during the first of the turbine start-ups. To adjust steam pressure in the collector within the limits of 1.15÷1.20 of an atmosphere and after that to put into operation the regulator of steam pressure on turbine sealing. Sealing of seal ends is not permissible.
- Simultaneously with steam supply to the sealing to start vacuum development in turbine condensers. To do that one must;

  - Open gate valve RQ24S04 on steam supply line to the start-up ejector and on air-and-steam mixture supply line to ejector; SD11S01.
  - (Manual valve).

- Open valves of heating steam condensate draining from the steam space of the main ejectors;
- open valves of steam supply to main ejectors RQ24S05; increase pressure before nozzles up to/ 5-6 ata and make sure that the ejector in self-operation creates full vacuum;
- Open gate valves of air-and-steam mixture supply to ejectors.

6.19 Turbine idle running start-up:

- To increase vacuum in the condenser not lower than 350 mm of mercury.
- To light up the boiler according to its operating instructions.
- To get the following diagrams ready: of the main steam lines, of reheat lines, of cross-over pipes and cylinders from turbine to condenser.
- To check heating value of the rotor as shown by instruments at the UCB (not more than 0.07 mm) and by the indicator on the front stool (not more than 0.05 mm) as the rotor is rotating on the shaft turning gear.
- As the temperature of live steam gets to 150^0C to open the main steam gate valves RA11S01, RA12S02 at full (gently); to open the stop valves of H.P. and M.P. cylinders at full. To check on the place if the actuator valves of H.P. and M.P. cylinder are closed tightly. As pressure in the boiler goes up to 5 kg/cm^2 to start dumping steam through quick-acting pressure reducing and de-superheating plant. Valve RC10S02 of quick-acting pressure reducing and de-superheating plant is to be opened slightly. The temperature behind quick-acting pressure reducing and de-superheating plant is to be kept not higher than 200^0C by injection controller.

  -From 100^0C to 200^0C – 4^0C per minute;

  -From 200^0C to 300^0C- 3^0C per minute;

  -From 300^0C to 400^0C-2^0C per minute;

  -From 400^0C to 500^0C- 1^0C per minute;
- To open valves on the supply line of cooling water to stop valves' servomotors.
- Upon finishing the warm-up to switch pressure reducing and de-superheating plant BROY 140/10 to auxiliary unit header, having closed gate valve RQ51S01 and having opened gate valve RQ50S05.The steam lines of steam reheater are to be de-evaporated.
- The pipe-lines of live steam supply for heating flanges and studs are to be heated up.

- Gas coolers pump (HIO) should be switched on, if it has not been switched on earlier; to adjust water flow and pressure in the generator gas coolers so that it would be 0.5 ata higher than hydrogen pressure in the generator body.
- To compare the readings of instruments with the following table of parameters;
  - live steam temperature before H.P. cylinder - 300÷320^{0}C;
  - live steam pressure before cylinder – 25 kg/cm^2;
  - Condenser vacuum not less than-550 mm of mercury; (0.748 kg/cm^2).
  - span of rotor bending indicator at the UCB should not exceed 0.07 mm, (and one of portable indicator-0.05 mm)-0 mm;
  - rotor axial displacement is within the range of (-0.5)÷0mm;

  - comparative expansions of rotors (OPP) should be within the range;
  - For H.P. rotor- from (-1.2) mm to (+4) mm ;
  - For M.P. rotor –from (-2.5) mm to (+3) mm ;
  - For L.P. rotor – from (-2.5) mm to (+4.5) mm.

6.20 Turbine loading:

- After synchronization and switching the Generator in the grid take 5-7 MW load by means of full opening of regulating valves and closing of Quick-Acting Cooling Reducing Plant. Checkup that servomotor of regulating valves does not come opening up to stop position (not more than 280 mm by scale).
- At 5-7 load heat Turbine during 30 minutes. The live steam t^0 must be 350-370^{0}C, pressure about 30 kg/cm^2, hot steam reheat t^0=about 320^{0}C. Thermal expansion of Turbine-about 10 mm. For regulation of steam reheat temperature use connections between “Cold” reheat lines (RB20S01 and RB20S02 gate valves).
- During Turbine heating under 5-7 MW load it is necessary to:

  -write down in operation log-book time of Generator switching in the grid;

  -close drains of Turbine cylinders;

6.21 Turbine startup from hot and un-cooled state:

- The mode of turbine start up is determined by its thermal condition. Turbine is considered to be uncooled if the temperature of H.P Cylinder lower part is within 200 to 400^0C. Turbine is considered to be hot if the temperature of H.P. Cylinder in the steam inlet zone is higher than 400^0C.
- Hot and uncooled start of turbine is forbidden if;

  -Temperature difference of metal top-bottom parts of H.P. Cylinder I.P. Cylinder in sections under control exceeds 50^0C for H.P. Cylinder and 60^0C for I.P. Cylinder;

  -rotor beating in barring gear running mode exceeds 0.07 mm as per indicator of shaft curving or 0.05 mm as per a portable indicator;

  -relative expansions of the rotors achieve the extreme allowable values;

  -in case mentioned in 1.2.16.

6.22 TURBO/SET SERVICING DURING OPERATION:

While servicing the Turbo-set it is necessary to ensure the following:

-reliability of the main and auxiliary equipment;

-cleanness of flow part of Turbine and heat-exchange surfaces, condensers and heaters;

-normal vacuum without increased air suctions in vacuum system (not more than 20 kg/h);

-normal heating of condensate and feed water in all stages of regenerative plant (water temperature after L.P. Heater-4-160^0C, after H.P. Heater-7-245^0C at the nominal load).

- At unit operation under load turbine equipment must operative with full hours record the readings of control-measuring instruments in daily log to systematically record all abnormalities in operating log, mentioning all comments regarding operation of Turbine and auxiliaries and to analyze the defects.

Every shift make control of oil level in oil-tanks (main, feed-pump tank, topping tank, oil collecting tank) and make corresponding record in the log.

LOAD/ NO. of Tap	I	II	III	IV	V	VI	VII
200 MW	39.8	27.0	12.3	6.5	2.8	1.28	0.27
150 MW	23.3	20.2	9.2	4.9	2.1	0.98	0.21
100 MW	19.9	13.6	6.4	3.4	1.5	0.68	0.15

6.23 TURBOGENERATOR SHUT-DOWN:

After getting the instruction on coming shut-down of the turbo generator it is necessary;

-to test the stand-by/emergency oil pumps and their automatic reserve closing;

-to make sure that stop valves and regulating valves of HPC and IPC move smoothly without sticking;

-to test the operation of registering and indicating instruments of the turbo generator;

-to check up wither the main steam valve of by-pass lines are closed;

- To make sure that the quick reducing-cooling system is ready to be set in operation;

-To switch off the protective pressure regulator of fresh steam, if it was in operation (upstream controller makes it manual);

- Decrease the load of the turbine step by step with the help of the control mechanism at the rate of 3 MW per minute up to 70 MW. The rate of decreasing the load should allow the operational personnel to keep the nominal temperature of fresh steam and pressure of fresh steam close to nominal.
- While decreasing the turbine load it is necessary to thoroughly control the relative position of the turbine rotor, difference in temperature between the top and bottom of cylinders in sections under control, vibration of the bearings, temperature of flanges and studs and other indication under control.
- In order to decrease contraction of rotors of HPC and IPC and it is required to apply fresh steam to the secondary chambers of the front seals of HPC and IPC.

The temperature of the applied steam should be higher than the temperature of metal in the area of the regulating stage.

When reducing the load it is necessary;

- -to shut off H.P. heaters at a load of 150 to 160 MW;
- -to supply the deaerator with steam from the 10 ata unit 3 auxiliary collector;
- -to switch off one feed pump out of use and keep another one running continuously at a load of 120 to 130 MW.
- -that the drain drip pump switches off automatically and LPH No. 2 heating steam be condensate drained to the condenser at a load of 70 MW.

6.24 Personnel action in emergency shutdown of Turbine:

At reaching emergency parameters checkup correct functioning of protections and interlocking for Turbine shut down, if they fail to work shut down turbine by actuating the keys of control from UCB or locally (by dubbing protection). At this perform the following operations;

-check up the closed position of stop and regulating valves of H.P. & M.P. Cylinders, extraction valves, Turbine gate-valves, opening of hot reheat valves, make sure that pressure in the regulating stage of Turbine and reheat line is nil;

-trip the Generator off, not allowing steam less operation of Turbine for more than 4 minutes (before tripping the Generator make sure that active power is being consumed by megawatt meter and kilowatt meter),

-start reserve oil pump of lubrications in operation;

-open gate-valve for loss of vacuum and stop supplying steam to ejectors, if shut down is needed with loss of vacuum;

-by tachometer make sure that Turbine reduces rotations;

-Listen Turbine during run-out and if any metal cracklings or strange nose appear inform the shift-in-charge and the Management;

-after rotor stops star the Barring Gear;

-checkup correct position of control keys of tripped equipment and set Turbine Control Mechanism at “O”;

-Perform all other operations on equipment shut-down as during the normal shut-down of Turbine;

-after the reasons for shut down were found out and condition of equipment was defined, on agreement with Station Shift Engineer and Chief of Shop make Turbine ready for start or maintenance;

6.25 Unloading the Turbo-generator:

The signs of partial unloading are:

-decrease of electrical load of the Generator;

-rise of pressure in live steam pipe-lines and decrease of steam flow-rate through Turbine.

-Partial unloading may be caused by;

-unsatisfactory functioning of regulation system;

-breakage of regulating valves;

-abrupt frequency change in the grid;

-abrupt change in steam parameters.

6.26 Turbine load surge:

- During load surge duty personnel shall make sure by mega wattmeter reading, pressure in the chamber of regulating stage of H.P. Cylinder and position of regulating valve that the load surge takes actually place.
- In all cases of load surge personnel shall;

  -restore the load without pressure rising in a chamber of regulating stage more than 98 ata;

  -Check up the temperature of thrust bearing; examine all Turbo set equipment and list the unit;

  -make sure there is no vibration; checkup axial position of rotors.

  -If the load surge was caused by abrupt steam output increase then duty personnel after having taken the above-mentioned steps to eliminate unadmitable operating mode shall quickly make steps to re-set the normal steam parameters before Turbine.
- In cases when the possible load surge is known beforehand (e.g. when there are load swings in the system), power limiting device must be set at such a value that after load surge on the Turbo set took place this value does not exceed the one corresponding to extreme pressure in regulating stage chamber.

CHAPTER 7

OPERATION OF 210 MW GENARATOR IN GHORASHAL POWER STATION

7.1 Introduction:

A generator is a device that converts mechanical energy to electrical energy for use in an external circuit. The source of mechanical energy may vary widely from a hand crank to an internal combustion engine. Generators provide nearly all of the power for electric power grids. In this chapter we discuss about Specifications, Generator Parts, Generator Design, cooling system, control and operation system of 210 MW generator, Excitation system etc.

Fig 7.1: Unit Generator

7.2 Generator:

Regardless of size all electrical generators, whether DC or AC, depend upon the principle of magnetic induction. An EMF is induced in a coil as a result of (1) a coil cutting through a magnetic field, or (2) a magnetic field cutting through a coil. As long as there is relative motion between a conductor and a magnetic field, a voltage will be induced in the conductor. That part of a generator that produces the magnetic field is called the field. That part in which the voltage is induced is called the armature. For relative motion to take place between the conductor and the magnetic field, all generators must have two mechanical parts a rotor and a stator. The Rotor is the part that Rotates and the Stator is the part that remains Stationary. In a DC generator, the armature is always the rotor. In alternators,the armature maybe either the rotor or stator.

ROTATING-ARMATURE ALTERNATORS:

The rotating-armature alternator is similar in construction to the dc generator in that the armature rotates in a stationary magnetic field as shown in figure A. In the dc generator, the emf generated in the armature windings is converted from ac to dc by means of the commutator. In the alternator, the generated ac is brought to the load unchanged by means of slip rings. The rotating armature is found only in alternators of low power rating and generally is not used to supply electric power in large quantities.

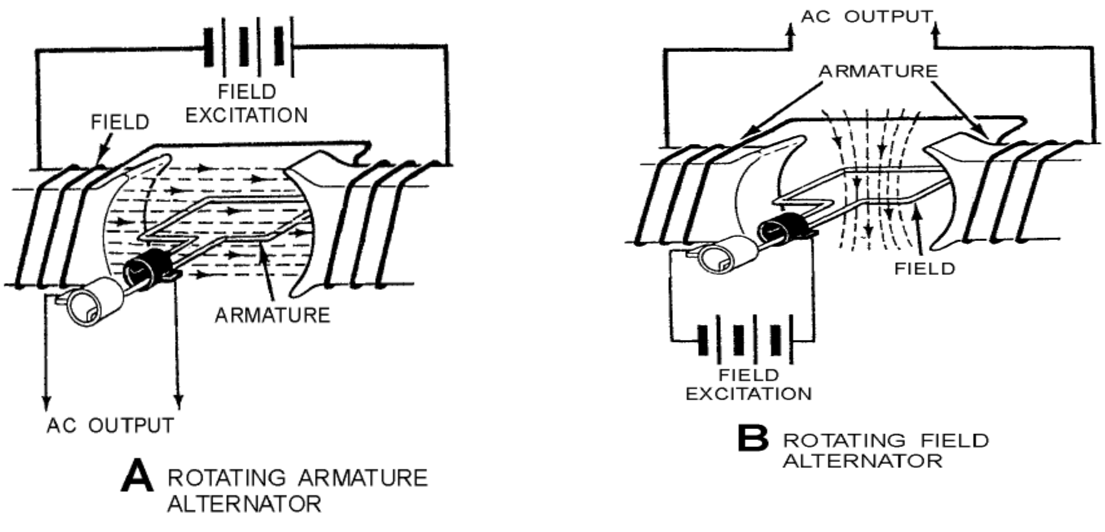


Fig: 7.2 Types of AC generators

ROTATING-FIELD ALTERNATORS:

The rotating-field alternator has a stationary armature winding and a rotating-field winding as shown in figure above, view B The advantage of having a stationary armature winding is that the generated voltage can be connected directly to the load.

A rotating armature requires slip rings and brushes to conduct the current from the armature to the load. The armature, brushes, and slip rings are difficult to insulate, and arc-overs and short circuits can result at high voltages. For this reason, high-voltage alternators are usually of the rotating-field type. Since the voltage applied to the rotating field is low voltage dc, the problem of high voltage arc-over at the slip rings does not exist.

The stationary armature, or stator, of this type of alternator holds the windings that are cut by the rotating magnetic field. The voltage generated in the armature as a result of this cutting action is the ac power that will be applied to the load.

7.3 Generator of Ghorashal Power Station:

Fig 7.3: 210 MW Generator in GPS

The three-phase synchronous hydrogen-and water cooled 210.00 MW, 3000 r.p.m. turbo generator of the type ТГВ-200МТ3 is intended for generating electric power when coupled directly is a 210MW, 3000 r.p.m. steam turbine.

The turbo generator is manufactured according to the USSR state standards and IEC Publications. The turbo generator is designed for operation on under conditions of humid tropical climate during installation directly in a machine room.

The turbo generator of Unit No.-5 utilizes the quick-actuating static self-excitation system with booster transformer in series controlled by silicon valves and strong automatic excitation regulation. This stand-by excitation is an electric machine excitation.

7.4 SPECIFICATIONS:

Characteristics	Value
Power, MVA/MW	247/210
Power factor	0.85
Speed of rotation, r.p.m.	3000
Frequency, Hz	50
Number of phases	3
Phase connection	Star
Efficiency, %	98.45
Stator voltage, V	15750 ± 5%
Stator current, A	9060
x Rotor current (estimated), A	1950
Excitation voltage (estimated), V	430
Static overload	1.71
Short circuit ration	0.52
Hydrogen pressure, Kgf/cm^2	3
Hydrogen purity	98%
Hydrogen temperature	40^0C

Long-life operation of the Turbo generator at rated duties according to Table is provided under the following conditions:

a)Hydrogen characteristics:	
Hydrogen rated gauge pressure, MPa (kgf/cm^2)	0.3 (3)
hydrogen purity in per cents of volume,	not less than - 97.0%
Temperature at gas-cooler outlets ^{0}C about	41
b) characteristics of water entering the gas-coolers:	
flow rate, t/h	380
temperature at inlet, ^{0}C	34
gauge pressure, MPa (kgf/cm^2)	0.35 (3.5)
pressure drop in gas coolers, MPa (kgf/cm^2)	0.08 (0.8)
c) characteristics of water entering the first heat exchanger circuit:	
flow rate, 1/s	about 56
temperature at inlet, ^{0}C	34
gauge pressure at inlet, MPa (kgf/cm^2)	not greater than 0.6 (6)
d) characteristics of distillate, entering stator winding:	
flow rate, 1/s	12.0
temperature at inlet, ^{0}C	41
gauge pressure at inlet, MPa (kgf/cm^2)	not greater than 0.28 (2.8)
gauge pressure at stator winding outlet, MPa/ (kgf/cm^2)	0.05-0.1 (0.5-1)
distillate resistivity at 41^{0}C, kΩ cm not less than	75
e) oil characteristics for bearings and x seals :	
flow rate through the two bearings, 1/s	10
flow rate through the two seals, 1/s continuous duty	3.3
short-time, but not longer than 30 min	5
gauge pressure at entering the bearing, MPa (kgf/cm^2)	0.1-0.17 (1-1.7)
“oil-to-hydrogen” pressure drop, MPa (kgf/cm^2)	0.075±0.005(0.75±0.05)
temperature at entering the bearing and seal, ^{0}C	35-45

Table 7.4: Hydrogen, Cooler, oil, Stator Winding characteristics

7.5 GENERATOR PARTS:

Fig 7.5: Rotor and Stator

1. Rotor:

1. Rotor shaft with Iron core and copper conductor.
2. Slip ring or armature.
3. Cooling mechanism (if necessary)
4. Bearings for support

2. Stator:

1. Stator Core
2. Stator copper conductor/ bars
3. Cooling mechanism
4. Power outlet bus bar
5. Connections for CT & PT

7.6 **Excitation system:**

- Carbon brush assembly
- Automatic voltage regulator for producing variable load.
- Synchronization system for synchronization with grid system.

Fig 7.6: Excitation system

Final data of the stand-by excitation:

Type	Generator (BT 174-7 KT3)	El. Motor (AC3-2-17-61-6T3)
Power, KW	990/3250	1250
Voltage, V	470/840	6600
Current, A	2100/3860	147
Speed of rotation, r.p.m.	990/970	990

Table 7.6: Final data of the stand-by excitation

7.7 Brief Description of Generator Design:

a) Turbo generators TB-200, hydrogen-cooled, 3000 r.p.m. are used for imect coupling with steam turbine, 210 MW capacity. The turbo generator rotates clockwise, if viewed from the turbine side. The turbo generator is here metically closed. This ensures its normal operation with excess hydrogen pressure equal to3 kgf/cm^2.

b) The generator stator consists of two concrtrical parts: body (external part) and frame (internal part), which is secured to the body by means of plate springs located uniformly along the circle.

c) Suspension of the springs of the frame of the core to the generator body is done to avoid vibration of the body with double frequency of 100 Hz during generator operation.

d) The stator body is welded and unsplit. It consists of transverse frames connected with pipes, longitudinal beams and ribs. The casing of the body is welded and gas-tight. Two vertical gas-coolers are mounted in the stator at the turbine side. The gas-coolers are manufactured of brass pipes ribbed with copper wire. The pressure and discharge pipe lines are secured to flanges located on the lower part of the gas coolers. Fill-in with water is controlled by drainage pipe. The terminal ducts are secured to the lower part of the stator body at the slip ring side. There are manholes on the lower part of the stator body, which make it possible to get inside the generator without its dismantling.

e) The sides of the stator body are covered with horizontally splitted shields. The support bearings and shaft oil seals are built in the shields. The support bearing shells are made of cast iron with Babbit lining. The housing of the bearing is electrically isolated form the body at the slip ring side. Lubrication of bearings is of pressure type and is done from the turbine oil system. The control branch pipes are built in external shields to control visually oil discharge from the bearings.

f) The stator core is located inside the frame and assembled of high-alloyed electro-technical steel sheets, 0.5 mm thickness,0-320 quality, insulated with varnish. The core is pressed of segments assembled in stacks, separated by spacers forming ventilation ducts. After pressing, active form is tightened with flanges made of non-magnetic steel.

g) The stator has a double layer chain-type bar winding with inner cooling by distillate circulating through the hollow conductors.

h) The stator winding heads are insulated by means of rubber caps. The stator winding insulation is thermoset plastic, of BC-type, grade while laying stator winding bars, coil ends rest on winding holding brackets via molded "pregreg" plastic and each pair is pressed with radious rods. The use of tightening elements allows secureing of end connections with a predetermined effort and the use of lavsan cord creates additional tightening. After the winding is assembled the end connections are baked.

i) The rotor is a massive solid high grade steel forging with a central hold bored along the entire axial length to control the material of forging; on one side the hole is used for mounting the current-carrying bars from the rotor winding to the slip rings.

    a. 36 slots are milled in the rotor body, where excitation winding is laid. The excitation winding consists of 18 coils. Each coil comprises 10 turns. The rotor winding is made of U-shaped conductors, arranged in paires. Pairs of such conductors form a duct through which the cooling gas is applied. The conductors are made of strengthened copper with an addition of silver.

    b. Gas is fed into the rotor winding at both ends through inlets in coil ends. After the coil ducts along the rotor axis the gas gets out of the radial holes in the middle of the passing rotor body.

    c. The frame insulation is a fibre-glass laminated sleeve and turn-to turn insulation is of fibre glass liners. Insulation of end connection under the retaining bands is of impregnated fibre-glass segments prepared by press moulding and baking. The winding is secured on the rotor with duralumin wedges.

d. The rotor retaining bands are solid non-magnetic steel forgings with one shrink fit into the rotor drum and are locked there with special keys.
e. The slip rings are shrink fitted into the intermediate bush insulated from the rings by micenite. The rings are placed beyond the bearing in a special case with the brush holder gear.

j) The generator has combined cooling. The stator winding, connection bars, and the leads are cooled with water (distillate), and the stator core and the rotor are hydrogen-cooled.

a. Ventilation of the generator is of a closed-cycle type, the gas being cooled by coolers built into the generator frame. There is a division into high and lower pressure zones.
b. Ventilation in the low pressure zone is done by axial-flow fan fitted into the thrust ring of the retaining band of the rotor and connections at turbine side. The fan drives the gas through the gas coolers into the ventilation ducts of the stator core and then into the clearance between the rotor and the stator.
c. The heated gas passes through this clearance back to the axial flow fan. To regulated gas flow through the ventilation ducts and between the stator core stacks the frame of the stator core is enclosed in a housing having holes of different diameters all over its surface.
d. Ventilation in the high-pressure zone is done by a centrifugal compressor fitted onto the rotor shaft at slip ring side which takes a part of the gas which passed through the coolers. To transform dynamic head into static, a diffuser is mounted behind the compressor impeller. After the compressor, at the slip ring side in the high pressure zone, the gas flow is parted into two parts.
e. One part is fed into the hollow conductors of one half of the rotor winding, at slip ring side. The other part, equal to the first, is passed through the two special ducts in the stator frame to the other half of the rotor winding at turbine side. A special seal separates the high-pressure zone and the clearance.
f. The cooling distillate is distributed into the stator winding, connecting bus bars and leads by means of a manifold and fluoroplastic hoses.

g. Only one bar is connected in series for the water flow, and so is in the circuit with connecting bus bar-lead, with the feeding manifold at turbine side and the drain manifold at slip ring side. Distillate is supplied to the manifold through the stator frame and drained by means of through-insulators.
h. The differential manometer is provided in water cooling system of stator winding for continuous control of hydrogen and distillate pressure difference.
i. The manometer provides signals when distillate pressure exceeds hydrogen pressure in the generator at rated operation duty.

k) The centrifugal compressor fitted on the turbo generator rotor, while the generator increases its r.p.m., operates unsteadily. The character static of the centrifugal compressor H= f (O) at n=const. is a parabola. The operation ration of the compressor is determined by an intersection point- of net work for gas circulation and compressor.

a. The ascending branch is characterized by unsteady operation and the descending branch by steady operation of the compressor. While operating on the descending branch, the transient torque of the steady state to the unsteady one is called surging and is accompanied by gas ejection in the direction of suction and by sonic bang. The condition of surging may be clarified as the stall of gas flow from the blades of the compressor. The unsteady operation is accompanied by vibration of the diffuser and the increase in head, produced by the compressor. This leads to the increase in temperature of stator & rotor windings. In order to avoid surging it is necessary during the turn of the generator to increase the gas flow rate through the compressor by means of connecting the suction and head. For this purpose there is an antisurging valve. The handle of the valve is located in the turbo-generator at slip ring side, if viewed from the ring side.

7.8 Thermo control of Generator:

Temperature of rotor winding is determined by formula:

$$t_{rot} = 250 \times \frac{Rt}{R_{15}} - 235$$

Where, R_t-rotor winding resistance at given temperature;

R_{15}-rotor winding resistance at T =15^0C

Temperature of individual sections of the generator under operation should not exceed the following values-

a)	Stator winding	95^0C
b)	Rotor winding	100^0C
c)	Stator steel	105^0C
d)	Hot gas	95^0
e)	Oil at supply point into thrust and support bearing	$40^0 \pm 5^0$;
f)	Oil at discharge from bearings	65^0
g)	Babbit lining of support and packing bearings	80^0
h)	Cold water at inlet of gas cooler	34^0
i)	Cold gas	41^0
j)	Distillate at discharge from winding	80^0

Table 7.8: Temperature of individual sections of the generator under operation

Minimum temperature of cold water in gas coolers should be not less than $+18^0$C.

Settings of temperature signaling operation are executed within the generator:-

a)	Temperature of hot gas at inlet of gas cooler	75^0C
b)	Temperature of cold gas at outlet of gas cooler	50^0C
c)	Temperature of cold gas before compressor	50^0C
d)	Temperature of gas behind compressor	55^0C
e)	Gas temperature at rotor inlet at turbine side	55^0C
f)	Temperature of stator winding	90^0C
g)	Temperature of stator iron	100^0C
h)	Temperature of hot air at air-cooler outlet of stand-by exciter	65^0C
i)	Temperature of cold air at air-cooler outlet of stand-by exciter	40^0C
j)	Temperature of stand-by exciter winding	100^0C
k)	Temperature of stand-by exciter iron	100^0C

Table 7.8: Settings of temperature signaling operation

Temperature of cold and hot gas before and behind gas coolers of the generator is controlled by mercury thermometers.

7.9 Preparation of Generator for start:

It is allowed to proceed with starting operations on generator after completion of all works on the Unit and presence of record in the register of start-up of equipment after erection or overhaul. Shift leader of electrical shop should be the following;

a) to check completion of works on orders;
b) To examine thoroughly and get convinced in absolute cleanness and service-ability of generator-transformer unit. When examining special attention should be paid on fulfillment of safety regulations, antifire measures as well as on lighting of the equipment and premises;
c) to check open position of blow-off valve;
d) to remove all special and protective earthlings;
e) All permanent fencing and placards should be on their places.

The value of absorption factor of insulation 60″/15″ measured at the temperature of windings+ 10+30^{0}C should not be less than 1.3:

$$\frac{R_{60}}{R_{15}} \geq 1.3$$

The value of resistance of the bused generator together with winding 15.75kv of unit transformer and tapped transformer and during circulation of distillate in stator winding is not standardized and putting of generator into a network is allowed if total resistance of insulation is more than 100k Ώ.

The resistance of insulation of generator excitation circuit, measured by megger 1000v should not be less than 0.5mΏ. If the resistance of rotor insulation is less than 0.5mΏ it is necessary to take measures for its restoration.

Operation of generator with resistance of rotor winding insulation less than 0.5mΏ is possible with the permission of Chief engineer.

Resistance of winding 6kv of tapped transformer measured by megger 2500V depends on conditions of measurement and as usual should not be less than 1mΏ for 1kv.

If the resistance of insulation on the equipment is less than the above values shift leader of electrical shop should inform shift leader of the station and Chief of Electrical shop and should act according to their instructions.

The circuit of the unit is assembled by switching on;

a) Short-circulating switch of neutral terminal of unit transformer.
b) bus isolator for a corresponding bus bar system and line isolator of the transformer;
c) Circuit-breakers and knife-blade switches of voltage instrument transformer and emergency reserve transformer;
d) knife-blade switches and circuit-breakers of generator excitation of working or stand-by exciter;
e) Knife-blade power switches to the assembly of forced air cooling of transformers.

7.10 Start of Generator:

- Start of generator on air cooling is allowed only for adjustment without excitation.
- After start of turbine rotation it is considered that the generator and all unit equipment is under
- After reaching 500 RPM it is necessary to check operation of the device of brush holders, to inspect and to listen to the generator.

7.11 Stepping up of voltage synchronization and putting of Generator into Net work:

After receiving an order from station shift leader, shift leader of electrical shop starts synchronization and putting of generator into a network. If the state of thyristor excitation is normal generator should be excited and put into a network on a working exciter and if it is out of order on a stand-by exciter.

The speed of stepping up of voltage is not restricted. It is necessary to control that smooth increase of current in rotor winding corresponds to smooth increase of voltage on generator bush the current in stator phases should equal zero at his. At U_{nom}=15. kv rotor current should be equal to 720A.

Putting of generation in a network is carried out in accordance with “The instruction of synchronization of generator ТГВ200” by shift leader of electrical shop or station shift leader.

7.12 Unloading, Switch –Off and shut down of Generator

- Unloading of generator on active load from 200 to 50MW is done with the rate of 4MW/min.
- Unloading from 50MW to zero is done quickly after required action turbine and boiler.
- Before switch-off of generator from a network it is necessary to shift the supply of auxiliary bays 3BA, 3BB for reserve transformer for what it is necessary to do the following:

a) depending on voltage on 132kv bus bars to place voltage regulator of reserves transformer into a position which corresponds to nominal voltage on 6kv side;

b) To turn on the switch of reserve supply of 3BA section and get convinced in automatic switch-off of oil circuit breaker of working supply of 3BA section. To check the value of voltage on section 3BA;

c) To turn off emergency switch of reserve on section 3BA;

d)To turn on the switch of reserve supply of section 3BB and get convinced in automatic switch-off of oil breaker of working supply on section 3BB. To check the value of voltage on section 3BB;

e) To turn off emergency switch of reserve on section 3BB;

Before switch-off of generator from the system it is necessary to unload it from active and reactive power, to remove forcing, to switch-off of air-blast circuit breaker 220kv and getting convinced if non full phase switch-off on the circuit-breaker to turn off automatic field

7.13 Emergency operation:

- It is prohibited to interfere into operation of relay protection, emergency switch of reserve and forcing for 20 sec.
- Operation of generator ТГВ-200 with load current above 105% of nominal is prohibited.
- In Emergency cases short-time overloading on rotor and stator current is possible.

Possible overload on stator current at hydrogen pressure in generator body of 3.0 kgf/cm^2 is as follows:

current ratio to nominal	$\frac{I}{I_{nom}}$	1.5	1.3	1.25	1.2	1.15	1.1
Value of current of overload, kA	I_{st}	3.5	11.7	11.3	109	10.2	10.0
Duration of current of stator overload min.		1	2	3	4	6	10

Table 7.13: Possible overload on stator current at hydrogen pressure in generator body

The following short-time overload is allowed on rotor current:

current ratio to nominal	$\frac{I}{I_{n.r.}}$	2.0	1.7	1.5	1.2	1.06
Value of current of overload, a	I_r	3900	3300	2900	2150	2000
Duration of overload	min.	0.3	0.5	1.0	4.0	10

Table 7.13: short-time overload is allowed on rotor current

CHAPTER 8

SUBSTATIONS OF GHORASHAL POWER STATION

8.1 INTRODUCTION:

Ghorashal Power Station is connected to national grid through 33 kV, 132 kV and 230 kV systems. Usually 33 kV is not used for power evacuation, but used as reserve power supply of unit no. 1 & 2. Unit 1 & 2 is connected with 132 kV grid system and Unit 3, 4, 5 & 6 connected with 230 kV grid systems. In 132 kV section for power import and export purpose Ashuganj, Joydevpore and Vulta is connected. In 230 kV section for power import and export purpose Ashuganj, Rampura, Tongi and Iswardi line is connected.

Fig 8.1: Air Insulated Substation

Fig 8.1: Unit Transformer

8.2 Power Evacuation System:

Electrical power is generated in Generator, at voltage level of 15.75 kV. This voltage is stepped up to 230 kv through two parallel operated step up transformers. The capacity of each transformer is 125 MVA. The single line diagram of the scheme is shown in figure-

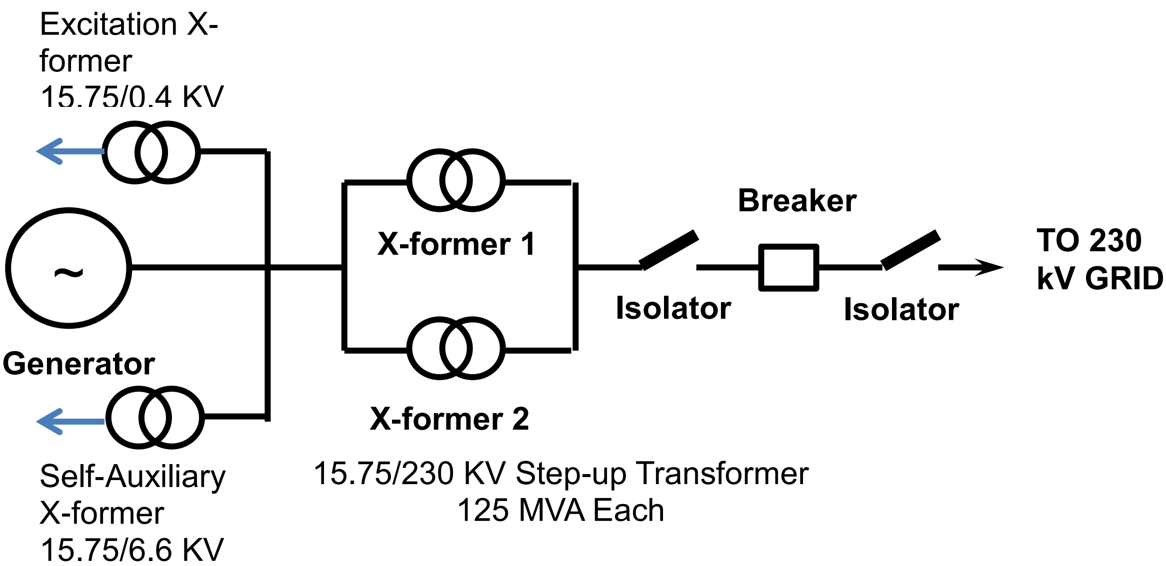


Fig 8.2: Power Evacuation Systems

8.3 Transmission Line of Ghorashal Power Station:

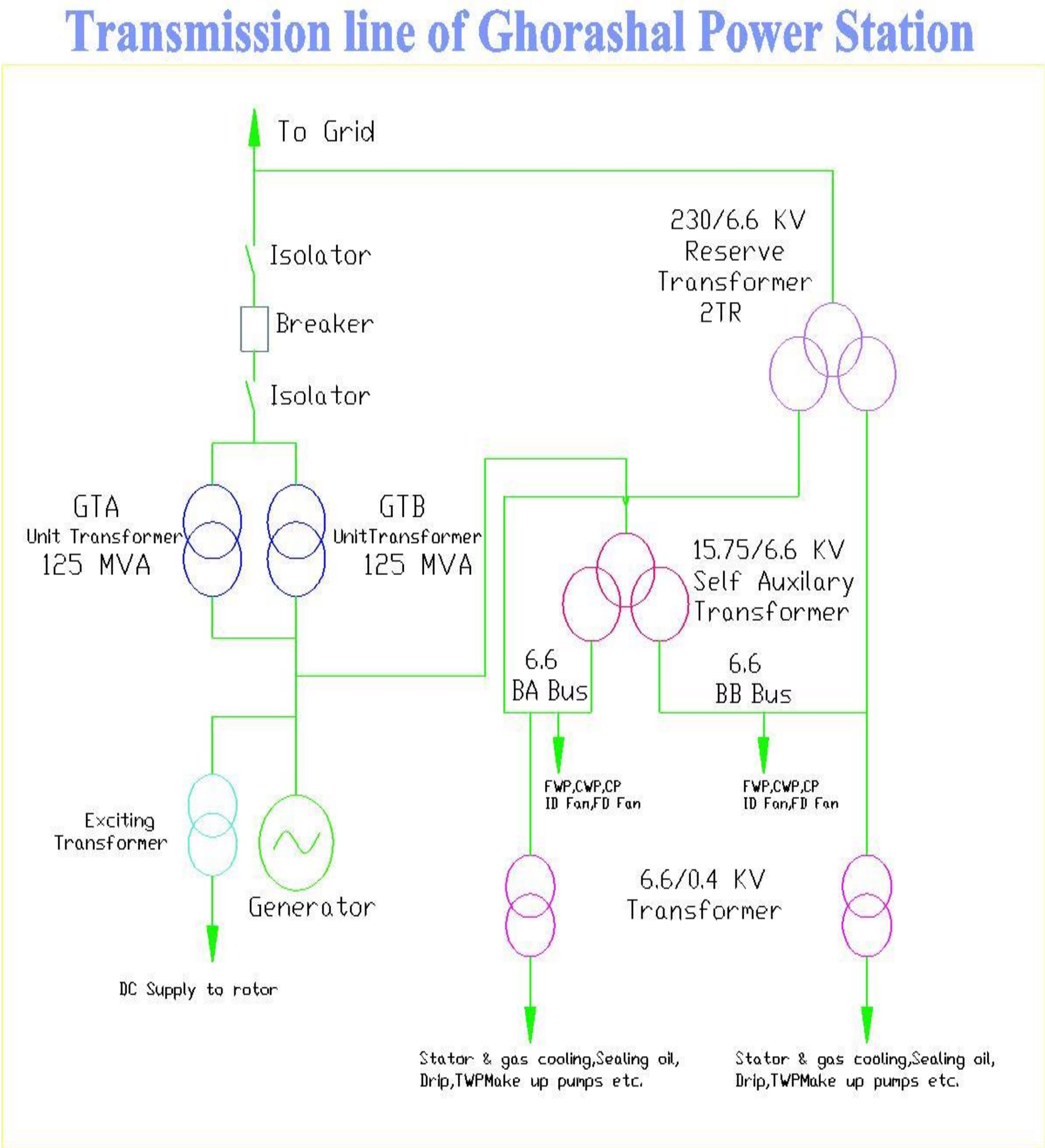
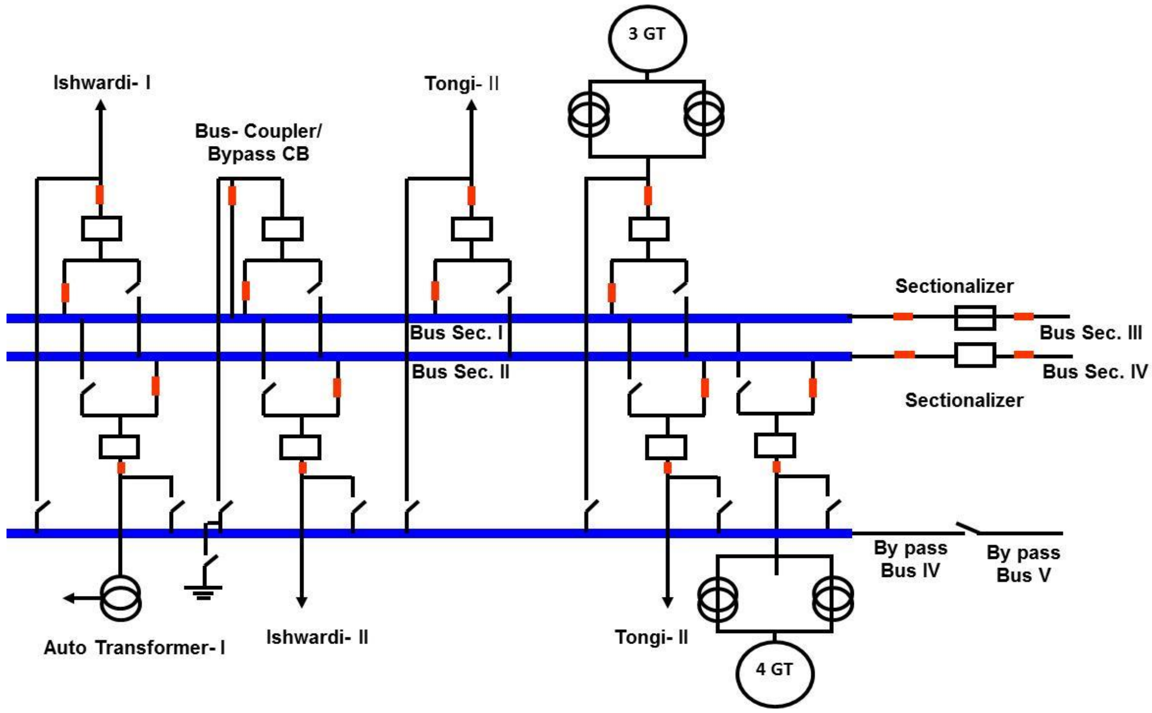


Fig 8.3: 230 kv Transmission Line of Ghorashal Power Station

8.4 Electrical Circuit of the 230 KV Switchyard (Bus sections I & II) (Normal Scheme):



8.5 Electrical Circuit of the 230 KV Switchyard (Bus section III & IV) (Normal Scheme):

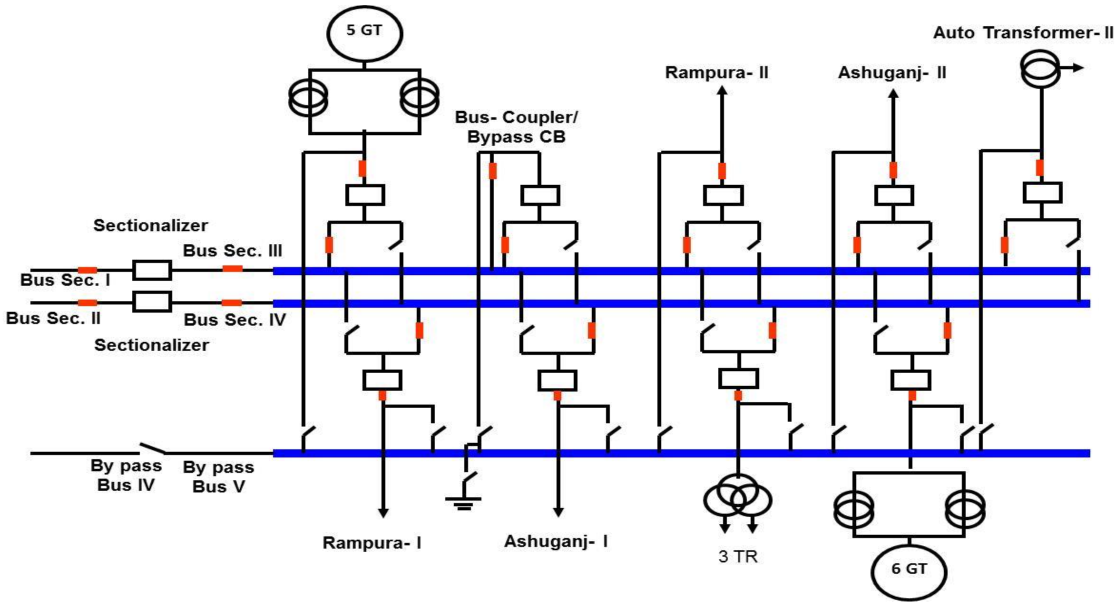
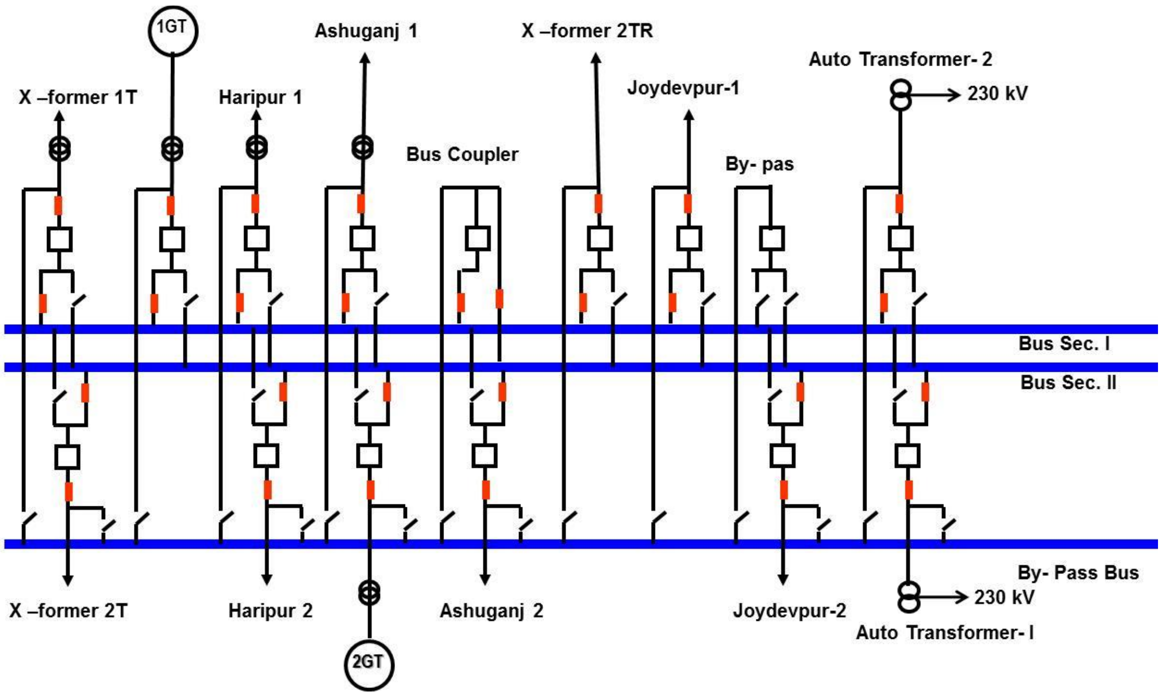


Fig (8.4-8.5): Electrical Circuit of the 230kv Switchyard Bus section (I- II & III – IV)

8.6 Electric Circuit of 132KV Switchyard:



8.7 Electric Circuit of the 33 and 11KV System of GPS Complex:

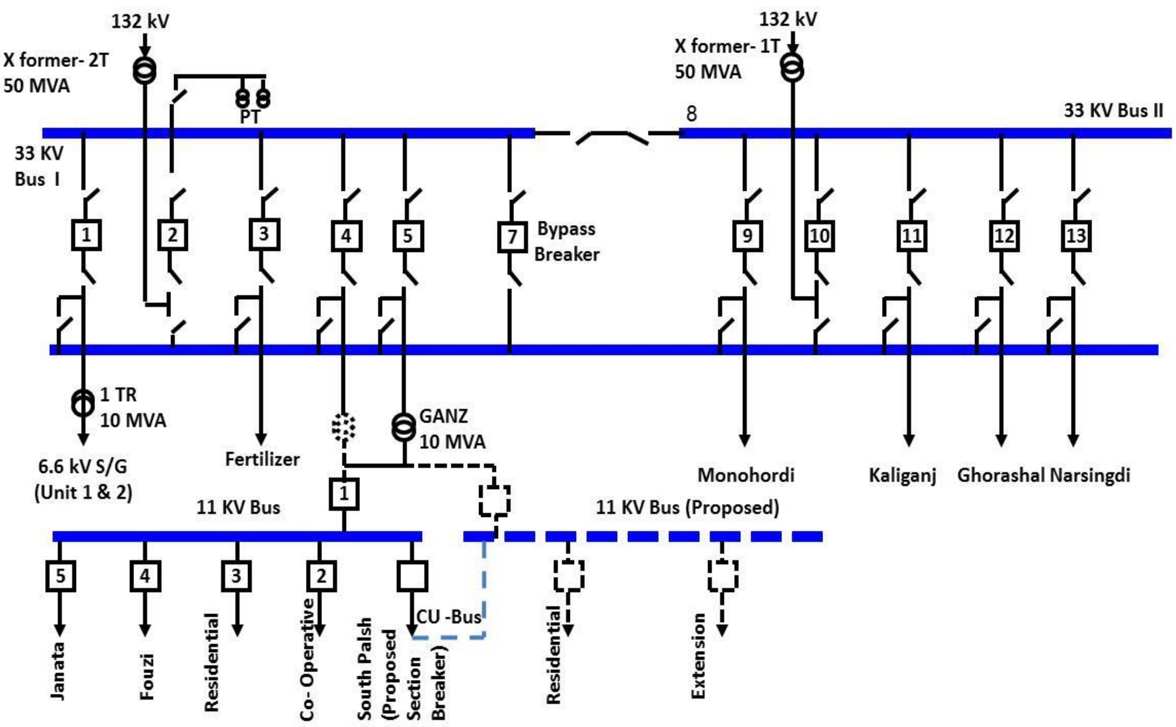


Fig (8.6-8.7): Electrical Circuit of the 132kv, 33/11kv system of GPS Switchyard

CHAPTER 9

RECOMMENDATION AND CONCLUSION

9.1 Recommendation:

The Power organization of Bangladesh has a lot of Weakness but at the same time it has a lot of opportunities also. The prospect of the organization is positive. It is a promising Industry. During the internship session it was observed that 210 MW power generating units are not efficiently functioning. The following problems were observed-

- From my study on this Organization, It was observed that some of the Mechanical equipment’s are not in good conditions. It's need to be changed or need to be performed overruling which is not done due to electricity demand of the country.
- High pressure regeneration system is not working.
- Some of the pumps are working with lower efficiency.
- Heat insulation is not sufficient in many places.
- In some points insulation Mechanism is to be enhanced for better efficiency.
- Most of the electrical Protection system is of Analogue system which is changed with digital system.
- Control and Instrumentation (C & I) system is also Analogue system, which must be converted with digital system. Distributary Control System (DCS) needs to be installed.
- Needs to update information regularly.
- For an efficient generation system, consultant department should continue their analysis.
- Proper maintenance is very essential to increase the production.
- The Government should take proper steps to reduce the electricity crisis and also increase the unit generation system of this organization.

9.2 Conclusion:

Industrial training is important and essential parts of education as through this training I have learned all the Components and the processes which we have studied theoretically. It gives me an opportunity to compare the theoretical knowledge with practical facts and thus develop my knowledge and skills. This industrial training also gives me an opportunity to enlarge my knowledge of power system, operation system, procurement system, production process, and machineries and teach me to adjust with the industrial life. I have found myself fortunate to have my industrial training at **Ghorashal Power Station.** At the end of the day I realized that industrial Training make my knowledge's application practically and make me confident to face any problem of my job sector.

Considering all this things I can say that,The power generation system by combined Rankine cycle is most efficient in our country and this type of power plant is effective to reduce the lack of power and also for efficiently operation of the power station, it is mandatory to follow the guide line of manufacturer.

References:

- www.bpdb.gov.bd
- Operation & Maintenance Manual of Boiler type TGME-206/COB.
- Operation & Maintenance Manual of Turbine type K-210-130 M3.
- Operation & Maintenance Manual of Generator type ТГВ-200МТ3.
- Most of the help from Executive Engineer, Assistant Engineer and Sub-Assistant Engineers of Ghorashal Power Station.