Winter Training Report

ON

Harduaganj Thermal Power Plant

A report submitted in partial fulfilment of the requirements for the Award of Degree of

BACHELOR OF TECHNOLOGY

in

ELECTRONICS AND COMMUNICATION ENGINEERING

By

ABHINAV

(00211502820)

under guidance of

Er. Alok Tripathi

EXECUTIVE ENGINEER

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Harduaganj Thermal Power Project

CANDIDATE'S DECLARATION

It is hereby certified that the work which is being presented in the B. Tech Industrial/In-house training Report entitled **"Harduaganj Thermal Power Plant"** in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology** and submitted in the **Department of ELECTRONICS AND COMMUNICATION ENGINEERING** of **BHARATI VIDYAPEETH'S COLLEGE OF ENGINEERING, New Delhi (Affiliated to Guru Gobind Singh Indraprastha University, Delhi)** is an authentic record of my own work carried out during a period from **25/2/23 – 10/03/23** under the guidance of **Er. Alok Tripathi, Executive Engineer, C&I department.**

The matter presented in the B. Tech Industrial/In-house training Report has not been submitted by me for the award of any other degree of this or any other Institute.

Student Name: ABHINAV
Enrollment No: 00211502820

This is to certify that the above statement made by the candidate is correct to the best of my knowledge. He/She/They are permitted to appear in the External Industrial/In-house training Examination.

Trainer Name: ALOK RRIPATHI
Executive engineer
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The B. Tech Industrial/In-house training Viva-Voice Examination of **Abhinav (00211502820)** has been held on **…….**

Industrial/In-house training Coordinator **(Signature of External Examiner)**

ACKNOWLEDGEMENT

I express my deep gratitude to **Er.L.P. SHUKLA** , A.E, C&I department for his valuable guidance and suggestion throughout my training. We are thankful to **Er. Alok Tripathi** for their valuable guidance.

Sign (Abhinav)

00211502820

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Abstract

The Harduaganj Thermal Power Plant training program provides a comprehensive understanding of the role of engineers in producing power which run the country. The program covers essential concepts such as coal management system security, detailed analysis of each component and their usefulness, which are crucial for production of electricity.

The training program enables participants to develop skills and knowledge required to run and manage a thermal power plant. The hands-on approach of the training program provides a practical understanding of the subject matter, which is essential for effective learning and problem-solving.

The scope of the training program is bright, considering the evergreen demand of power and electricity. With the growing demand for electricity and the increasing complexity of systems, the demand for skilled engineers with knowledge of the electrical and electronics field is likely to surge.

In conclusion, this training program provides an excellent opportunity for engineering students to acquire essential skills and knowledge in this field. The training program's future scope is bright, considering the increasing demand for skilled engineers in the rapidly expanding industry. The knowledge and skills acquired through the training program are likely to be highly valued by the industry, enabling participants to advance their careers in this exciting field.

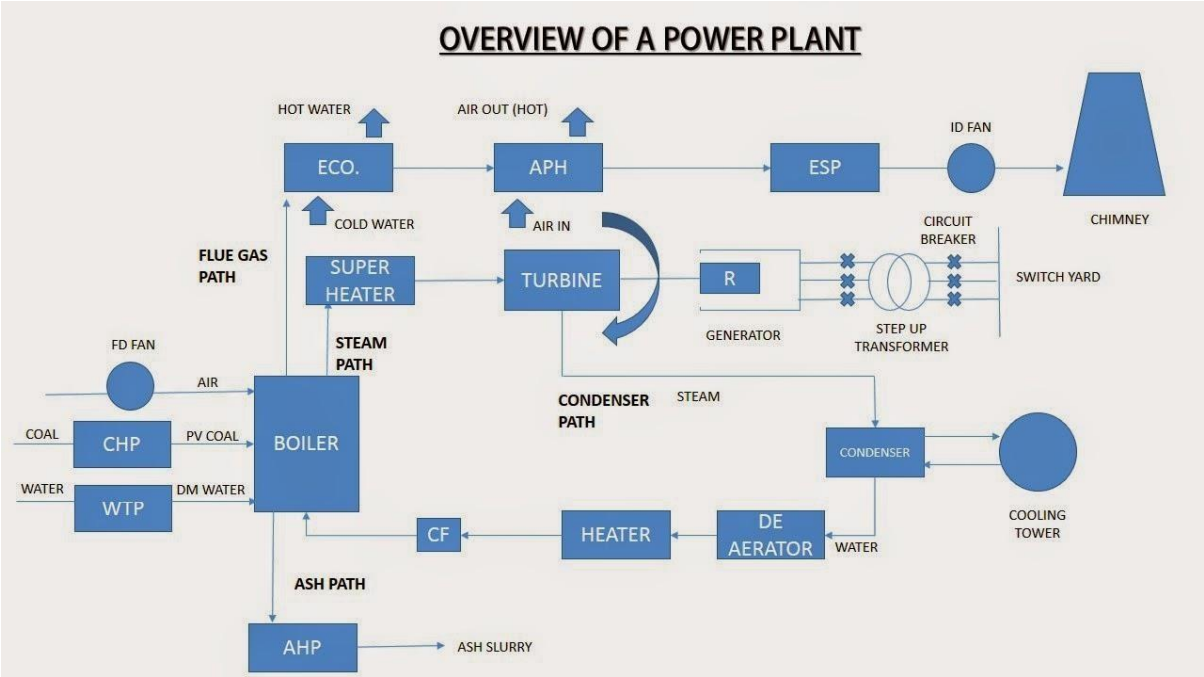
INTRODUCTION

Harduaganj Thermal Power Project is one of subsidiaries of UPRVUNL(Uttar Pradesh Rajya Vidyut Utpadan Nigam Limited), also known as UP electricity board, comes under the Govt. of Uttar Pradesh. Harduaganj Thermal Power Station is located at Qasimpur Power House Colony which is 1 km distance from Harduaganj railway station at Harduaganj in Aligarh district in the Indian state of Uttar Pradesh, about 18 km from Aligarh and 105 km from Agra. It is the new electric power station established in Aligarh district. The power plant has the capacity of 1270 MW. It was setup in year 1977. The plant has one 110MW capacity two 250MW capacities and one capacity of 660MW installed recently in 2020.Two necessary raw materials that a power plant needs for its operation are coal and water. The coal is provided by Bharti Cooking Coal Limited(BCCL) and Eastern Coal fields Limited(ECL) or sometimes from the coal belt region comprising of Jharkhand, Chhattisgarh, and Orissa etc. while Upper Ganga Canal serves as the source of water.

Outline of Power plant

The basic principle behind any thermal power plant is the generation of steam from water to rotate the turbine. The energy required to convert water to steam comes from heating of coal. To be a bit more precise any thermal power plant can be described through four flow paths. These are:

- Steam
- Condenser
- Flue gas
- Ash



The coal reaching the plant is converted to pulverised coal in CHP. The water from the reservoir is converted to DM form in DM Water

Treatment Plant. The coal and water is fed to boiler. Steam is produced due to heating of water. In addition flue gases and ash is produced as a result of burning of coal. The steam goes from boiler to turbine through super heater. The turbine is coupled with a generator which generates voltage. From the generator it goes to switch yard where the voltage is stepped up to desired level and feed to the transmission line.

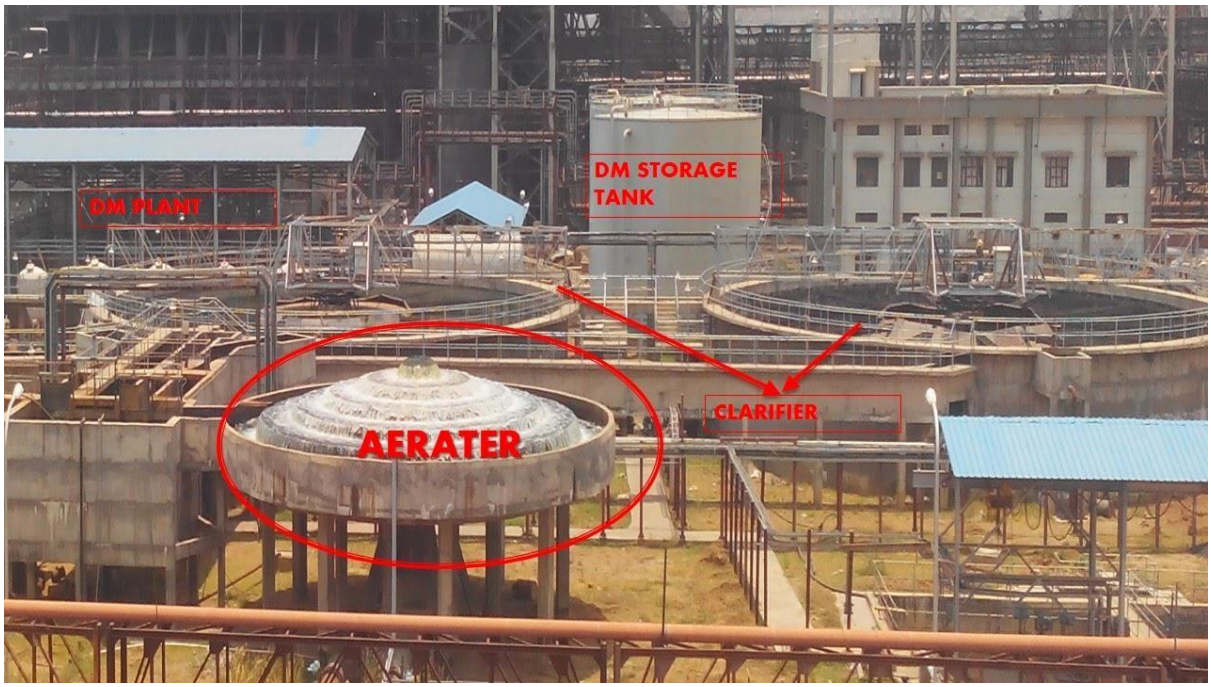
The steam then needs to be cooled down to be used again. So the steam is passed on to the condenser. For Cooling of steam in Condenser, Cooling water is used, From there Cooling water (CW water) goes to the cooling tower where the temperature falls and water is circulated back in close cycle to the Condenser whereas steam condensed into water is stored in Hotwell again to be used as feed water in boiler. Before reaching the boiler it passes through de-aerator and Heaters and then pumped to the boiler by circular feed water pump.

The flue gas that is produced in the boiler goes through the economiser. Heat in flue gas is used to heat the water. Thus temperature falls. Next

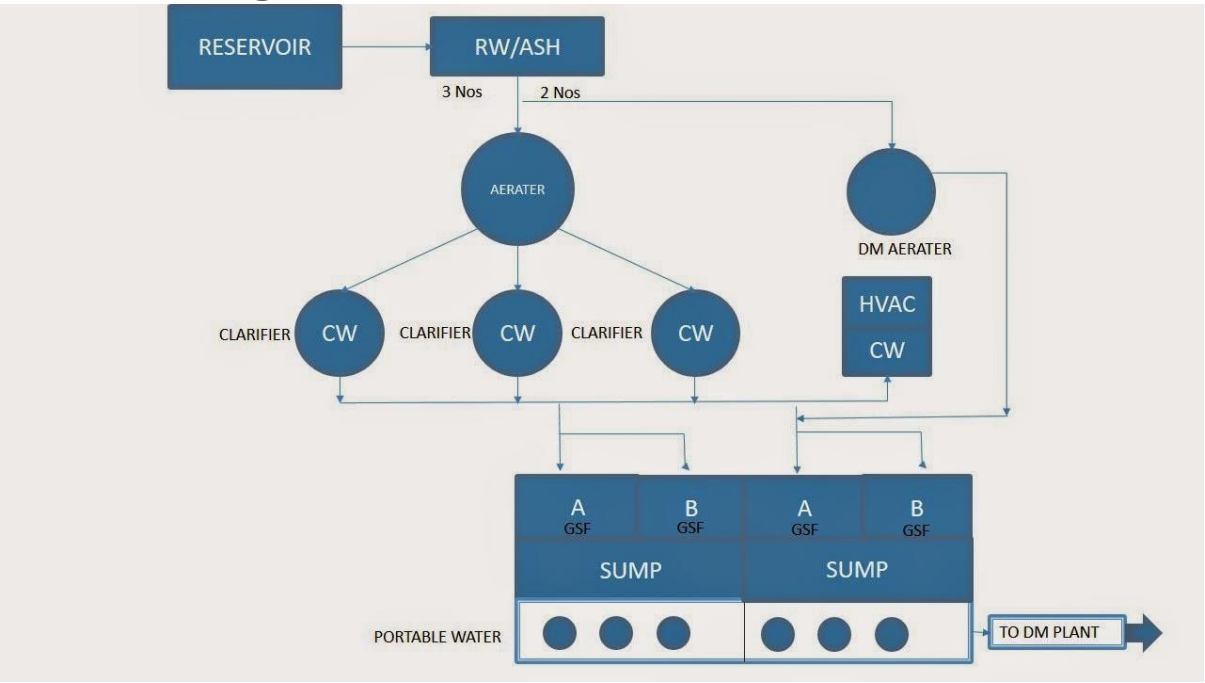
stage is an air preheater stage where temperature still falls. The energy is used to heat the air which is required for combustion. Next the cooled flue gas goes to Electrostatic precipitator (ESP) and then the gas escapes from the Chimney.
The ash produced from the burning of coal which settles down are carried to the ash handling plant and removed in the form of slurry.

Detailed Discussion of Different Parts of Plant

Power plants need enormous amount of water on hourly basis for normal functioning of plant. They can’t afford to waste water. Also there are restriction imposed by the government on the amount of water these power plant draw form natural source and the waste water the discharge. So every power plant needs to have an efficient water treatment section which would enable them to utilise the waste water most judiciously.



Flow Diagram of WTP



The water from the reservoir is sucked into 3 raw water handling plant and 2 Ash water handling plant. The water is sent to the aerator. The

aerator function is to remove the foul odour from the raw water by increasing the surface area. There are 3 clarifier to which the water is moved henceforth. In clarifier alum and lime are added to the water. Alum helps to settle down the solid particles and lime helps to maintain the pH of the water. Clarifier is actually a big tank in which the incoming water is mixed with alum and lime and agitated with the help of shaft with long blade connected to 3 phase induction motor. The solid particles get attracted towards the centre and get collected in concentric cylindrical structure from where it is moved out through duct in the form of slurry. The clear surface water moved down to a water pool. A part of water from the pool is collected and used for Air conditioning (HVAC) and for makeup water for circulating water (CW). The rest is divided into two parts. One is exposed to gravity sand filtering and is collected in sump and after further processing is used as portable water. The other part goes through gravity sand filter and carbon filter. DM water is obtained from it after ion exchange process.

Specifications

Raw water Pumps

No of pumps	3
Make	FLOWMORE
Type	Vertical , Single stage
Capacity of each pump	2200 M^3/ Hr
Pump head	25 Meters
Shut off head	36.5 meters
Pump Efficiency at guaranteed flow	87.5 %
Thrust Bearing	1
Thorden type	6
Motor Make	CGL
Rating	200 KW
Speed	990 RPM

Cascade aerator

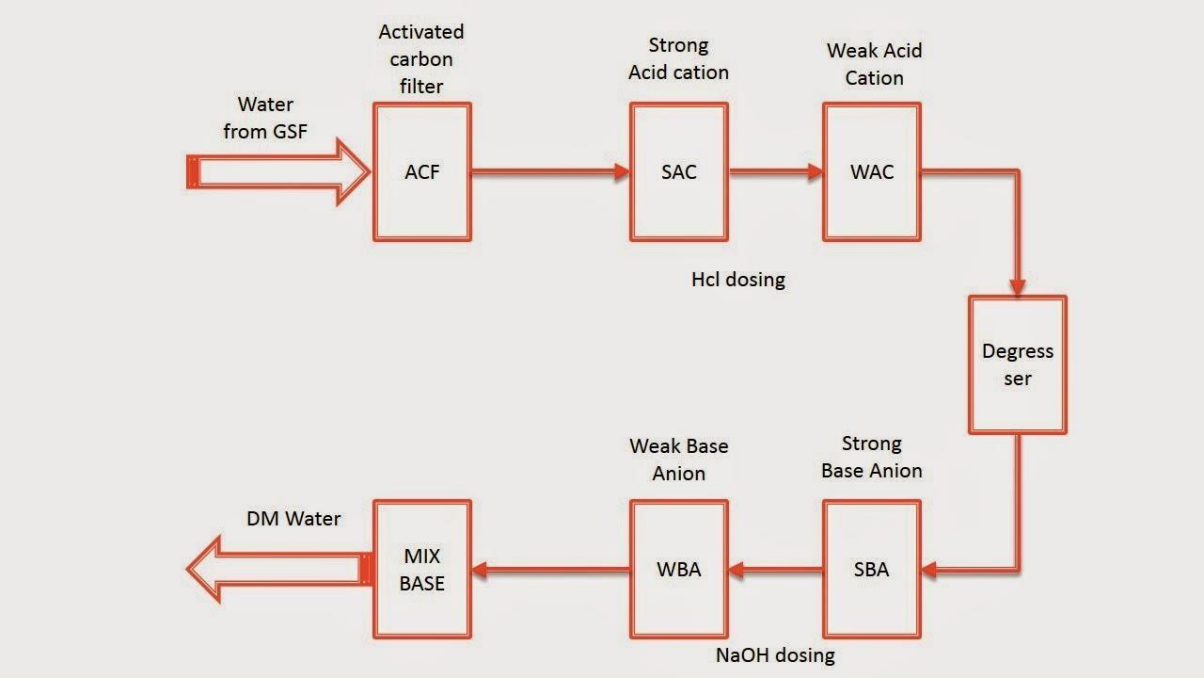
Description	PT-CW System	PT-DM System
No.	1	1
Type	Circular Cascade Type	Circular Cascade Type
Material of Construction	RCC	RCC
No. of Steps	4	4
No. of falls	5	5
Total height of fall	1.5 m	1.5
Design flow	4950 M^3/Hr.	150 M^3/Hr.

Clarifiers

Description	PT-CW System	PT-DM System
Nos.	3	1
Type	Circular Reactor	Circular Reactor
Design flow	1650 m^3/hr.	150 m^3/hr.
HP of Motor for Impeller Drive	5.0 HP	1.5 HP
RPM of Impeller	22/60 (min/max)	5/15 (min/max)
No. of Blades	6	6
Impeller Dia.	1372 mm	935mm
HP of Geared Motor for Rake Drive	0.75 HP	0.75 HP
Rake Type	Centrally Rotating	Centrally Rotating
Arm Speed of rake	0.04 rpm	0.13 rpm
MOC of rake mechanism	MS	MS

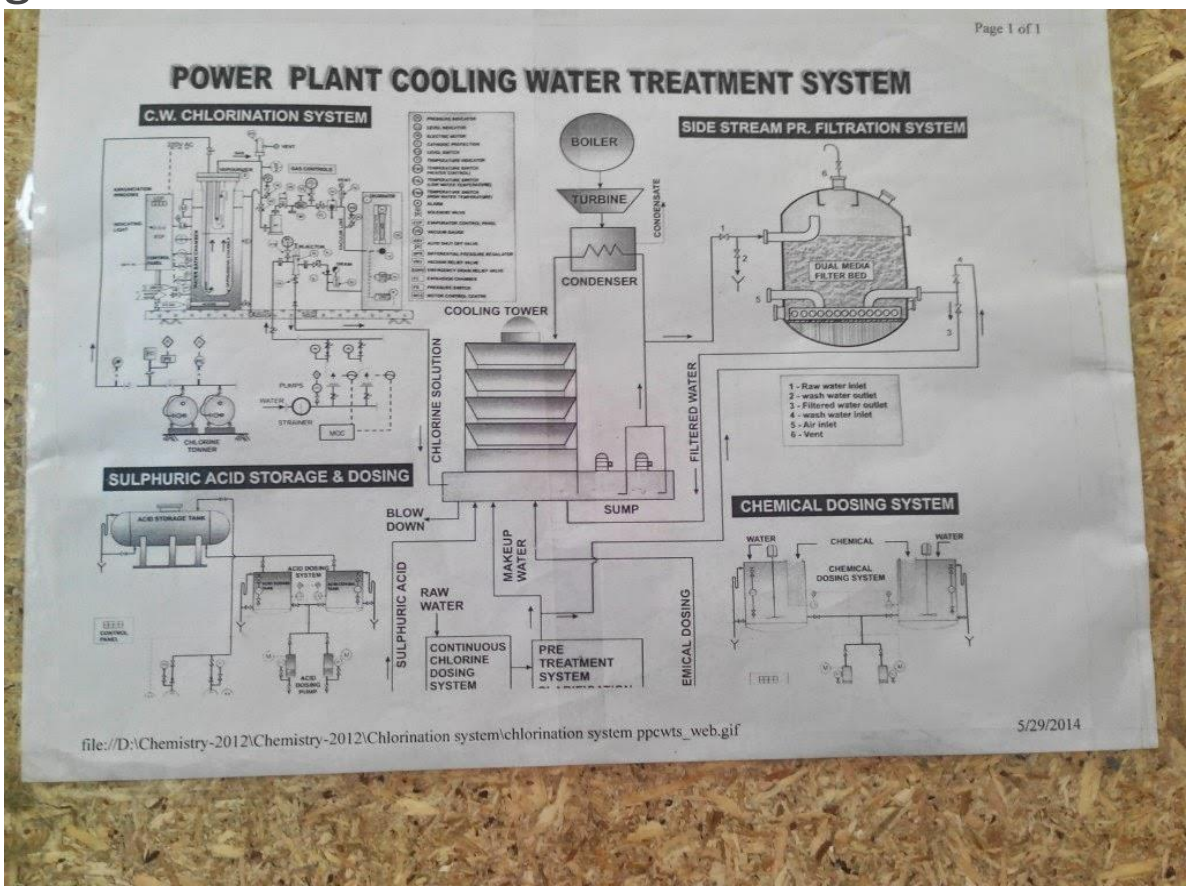
DM Plant

After gravity sand filtering the water is passed through activated coal filter. Then we have strong acid cation and weak acid cation tanks where HCl dosing is done to remove cation. Then water goes to digresser where CO2 removal takes place. Then we have strong base anion and weak base anion tank where NaOH dosing is done to remove anion. Then mixed acid base dosing is done to if any alkalinity or acidity is still left. Then the water is collected in DM water tank.



There are 2 functional streams for portable water and 3 for DM water. A channel from the raw water treatment plant goes to DM aerator. From there it directly goes to the GSF filter and follows

the same route as the last process.
The waste water coming from various section of the plant which can't be further used are treated in lamina separation where the water is slowly stirred with the help blades mounted on shaft of induction motor. A part of the treated water is used for cooling coal and the other is used for cleaning aerator.
Chlorination and sulphonation in done on main stream water going to the condenser. Process is given in chart.



Specification

DM water tank

Type	Vertical Cylindrical Atmospheric
Number	Two
Diameter	14000 mm
Height	11000 mm
Storage Capacity Tank	1600 m^3
Shell Material	Mild steel
Internal protection	Solvent free epoxy coating
External painting	Chlorinated Rubber Plant

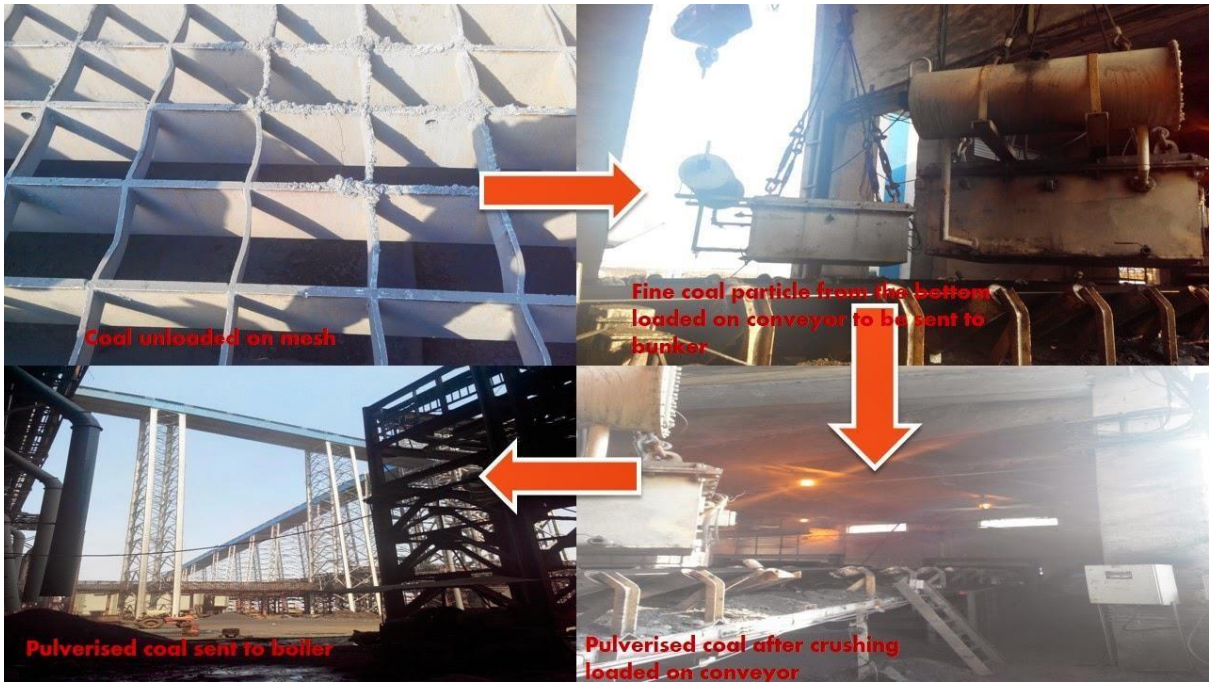
Coal handling Plant

Coal handling Plant, as the name suggest is responsible for whatever happens to the coal from the point the wagon filled with coal comes to the plant and until the time it reaches the boiler.
The coal which comes to the plant are in the form of large lumps. Coal needs to be converted to fine powdered form to be used in boiler for burning.

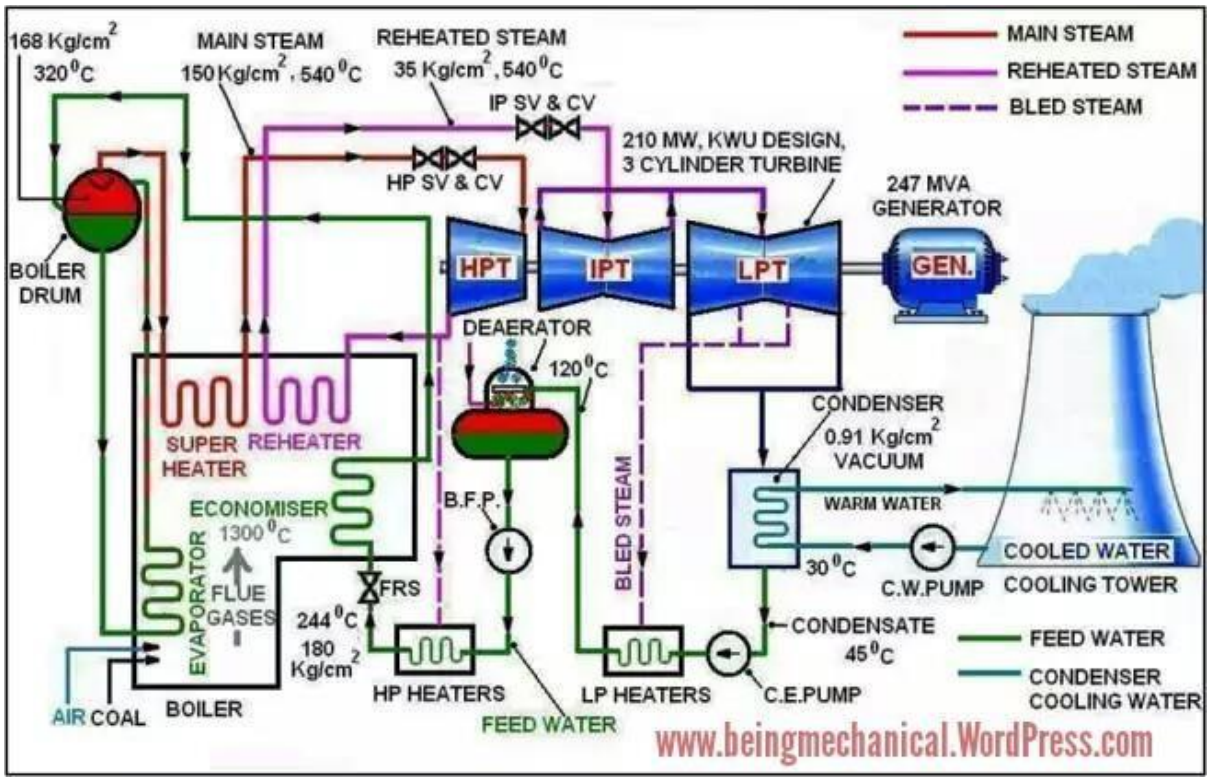
Powdered form increases the surface area of coal which helps in burning it mostly efficiently. In between the coal needs to be stocked, tested for the calorific value and then sent in a controlled right amount to the boiler. All these steps are managed by coal handling plant.

Wagons filled with coal coming to the power plant are unloaded using wagon triplers. There are 3 sets of wagon triplers in the plant of which 2 are commissioned. The wagon triplers unload the wagon on a mess network of 250*250mm each. This mesh network are 4 quarter sectors each. Lumps smaller then specified size move down while the larger ones stay there until they are not broken into small pieces manually. Below the mesh are levels extending up to 100m deep. The coal lumps cannot be allowed to fall on the conveyor belt all at once. This would choke the conveyer belt, so a controlled

amount is allowed to fall on the conveyor at a time. From the last level (100m) the conveyor belt starts. Magnetic separators are present at initial stage to separate the magnetic components. Safety lines are present along the side of conveyor belt. There are 13 Transfer plants. They are used for transferring coal from one conveyor belt to the other. They are made to fall down from 1 conveyer to other in a controlled amount through vertical ducts. 2, 3 and 12 are used for sending to bunker for stacking purpose. From the bunker it goes to the crusher on conveyor belt. Crusher has grinding balls which breaks down big lumps of coal to smaller and still smaller chunks and finally to pulverized form up to 70% ash. Then to boiler through different TPS (Transfer Point Station).



Main Plant


168 Kg/cm2
320 0C
MAIN STEAM
150 Kg/cm2 , 540 0C
REHEATED STEAM
35 Kg/cm2 , 540 0C
IP SV & CV
HP SV & CV
210 MW, KWU DESIGN,
3 CYLINDER TURBINE
247 MVA
GENERATOR
MAIN STEAM
REHEATED STEAM
BLED STEAM
BOILER
DRUM
HPT
IPT
LPT
GEN.
DEAERATOR
120 0C
CONDENSER
0.91 Kg/cm2
VACUUM
SUPER
HEATER
REHEATER
ECONOMISER
1300 0C
B.F.P.
BLED STEAM
WARM WATER
COOLED WATER
30 0C
C.W.PUMP
COOLING TOWER
EVAPORATOR
FLUE
GASES
FRS
244 0C
180
Kg/cm2
CONDENSATE
45 0C
FEED WATER
CONDENSER
COOLING WATER
AIR
COAL
BOILER
HP HEATERS
LP HEATERS
C.E.PUMP
FEED WATER
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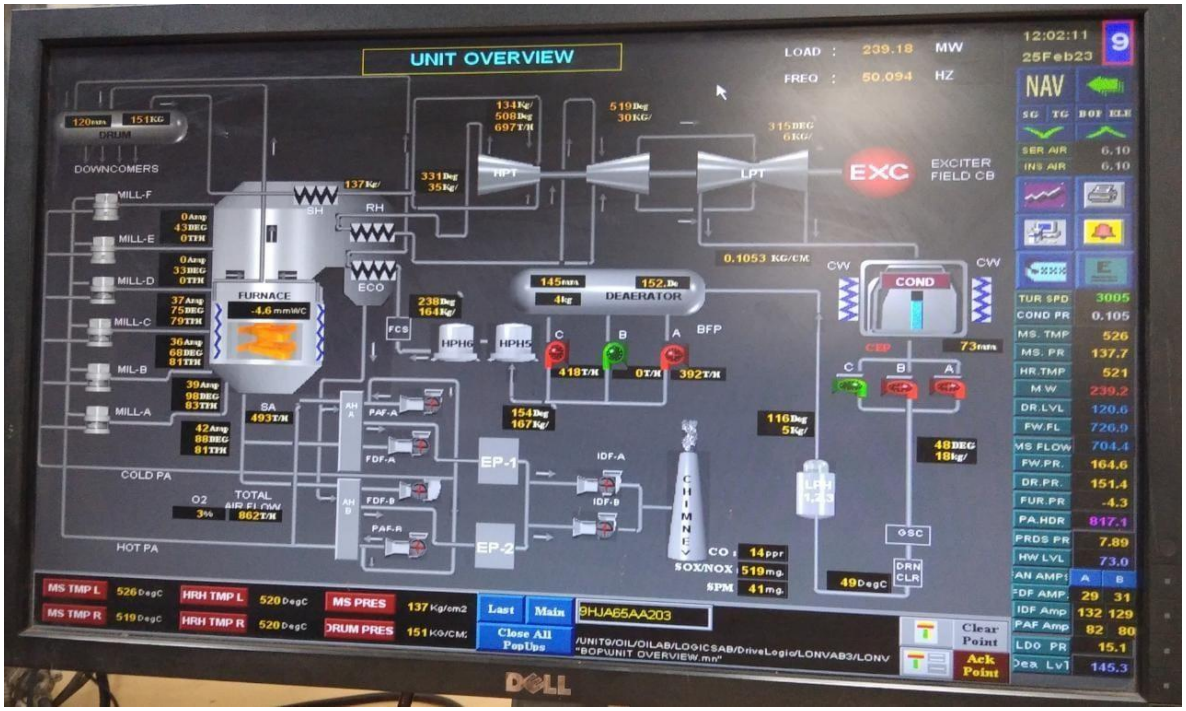
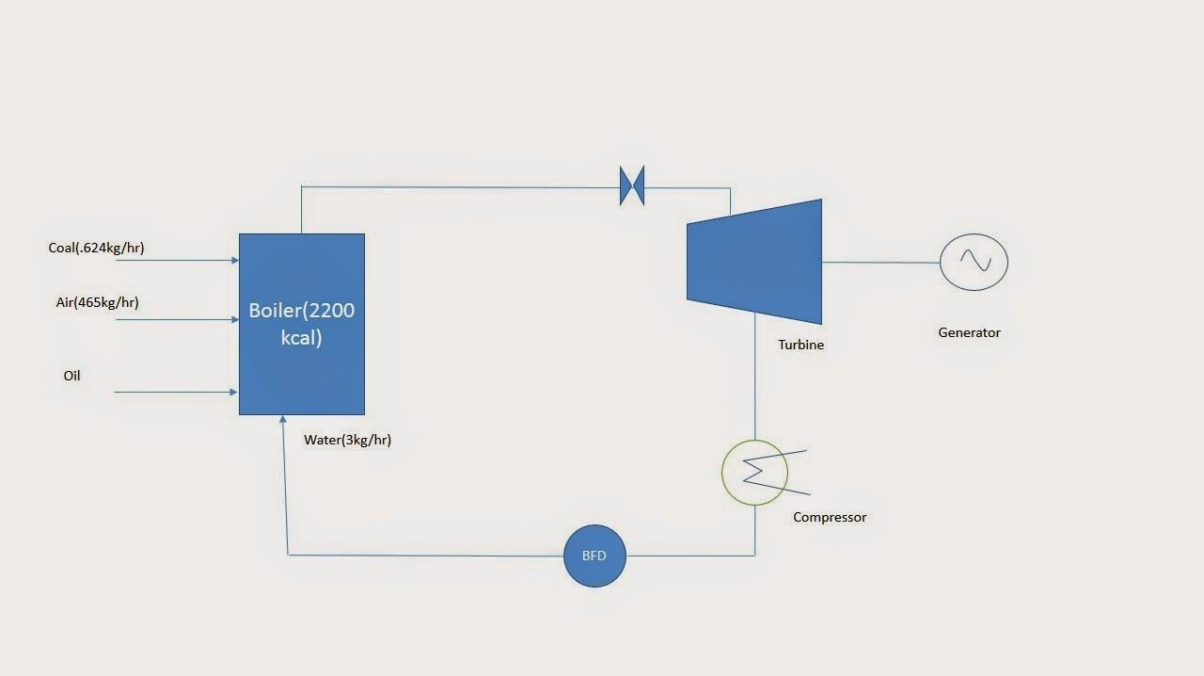

UNIT OVERVIEW
LOAD : 239.18 MW
FREQ : 50.094 HZ
12:02:11
25Feb23
NAV
EXC
EXCITER
FIELD CB
DOWNCOMERS
DRUM
MILL-F
MILL-E
MILL-D
MILL-C
MIL-B
MILL-A
FURNACE
-4.6 mmWC
SH
RH
ECO
DEAERATOR
BFP
COND
CW
HPHC
HPHS
FCS
EP-1
EP-2
IDF-A
IDF-B
PAF-A
PAF-B
FDF-A
FDF-B
COLD PA
HOT PA
TOTAL
AIR FLOW
862T/H
SA
493T/H
CHIMNEY
SOX/NOX
519mg.
SPM
41mg.
MS TMP L
MS TMP R
HRH TMP L
HRH TMP R
MS PRES
DRUM PRES
Last
Main
Close All
PopUps
Clear
Point
Ack
Point
DELL

The pulverized coal from the CHP is lifted to the boiler by PA Fan. The coal stays in the furnace for less than 2 seconds. The energy from the burning coal heats up the water running in the tubes lined on the furnace walls. Coexisting heated water and steam moves up to the boiler drum. Here the water separates from the steam. Steam further moves up to the super-heater where it is heated to 540c at which only steam exist. This steam goes to the High Pressure Turbine. The temperature of the steam falls. So it is again heated in re-heater to 340c and moved forward to the IPT and finally to the low pressure turbine. All these turbines are mounted on a common shaft coupled to generator. Now the steam is extracted from LP heaters to the condenser and allowed to cool to 45c. Condensate extraction pump transfers the condensate to the DE aerator through LP heater where dissolved gases like co2 and o2 are removed. LP dosing is done to savage oxygen. It is transfer to feed storage tank. Finally it goes to the boiler drum after being heated again in HP heater (which has steam bleeding from HP turbine) and the economizer.

BOILER



The figure given above is of a boiler. Considering 100% heat generation in the boiler, 12% of it is lost as flame loss. 2% loss occurs at the turbine as mechanical loss and 45% loss occurs at the condenser. 4% additional loss occurs in the generator. So only 39% of the heat generated is utilized for electricity generation. The numerical values given are for production of 1kW in a 500MW plant. Considering this fact, a **500**MW plant requires 310Tonnes/hr of coal.

There are 2 types of boiler:

- **Fire Tube Boiler**
- **Water Tube Boiler**

Fire tube boiler where used in old steam run trains in which the fire ran through the tube and heated the water outside it. Water tube boiler have water running in the tube. The heat

due to fire outside causes them to get converted to steam. This type of boilers are used in power plants.

BOILER GENERATION SPECIFICATIONS

Manufacturer	M/s. BHEL (C.E.Design.)
Type	Controlled Circulation With Rifled Tubing, Dry-Bottom, Radiant Reheat, Single Drum, Top Supported, Balanced Draft Furnace.
Type of Firing	Tilting Tangential.
Minimum Load At Which Steam Generator Can Be Operated Continuously With Complete Flame Stability Without Oil Support (%BMCR) when firing coal alone	30% to 40% BMCR with adjacent coal elevations in service & 50% min mill loading
Designation	19177 301-51 CC + 16115 235-51

Components of boiler:

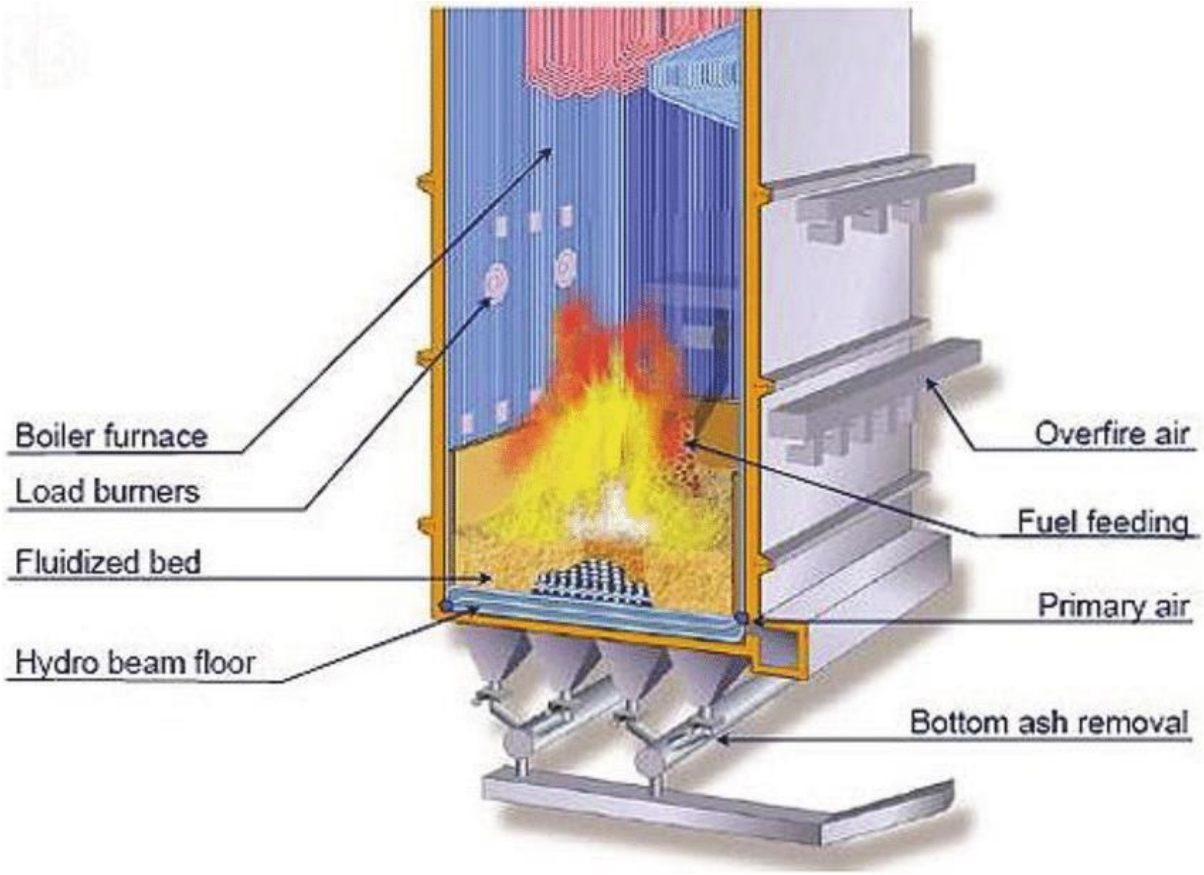
- Furnace
- Boiler Drum
- Super Heater
- Re Heater
- Economizer

Auxiliaries of Boiler:

- PA Fan
- ID Fan
- FD Fan
- Air Heater

FURNACE

Furnace is a place where the pulverised coal burns in sufficient amount of air. The heat generated converts the water in the tubes lined on the wall of the furnace to steam.

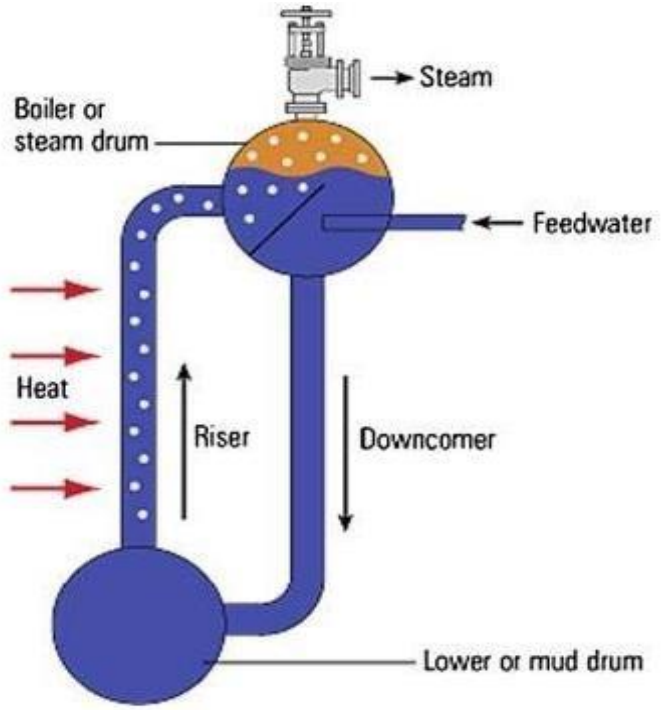


SPECIFICATIONS

Type	Balanced draft furnace with fusion welded water walls, Single Radiant, Dry Bottom, Controlled Circulation.
Wall	Water steam cooled
Tube arrangement	Membrane
Explosion/implosion with stand capacity at 67% yield point	+/- 660 wc
Residence time for fuel particles in the furnace	1.78 Secs.
Effective volume used to calculate the residence time	5598 M^3
Height from furnace bottom ring header to furnace roof	65.576 m
Depth	16115 mm
Width	19177 mm
Furnace Volume	17599 M^3
Drum elevation	76.552 M
Fuel Heat input	1234.2 X 10^6 KCal/hr @ BMCR DC
Furnace bottom opening	1.151 m
Total water wall area	4099 m^2
Total water wall tube	1072

BOILER DRUM

Water and steam both co-exist after being heated. In the boiler drum water and steam separates out. Water flows back through another path while steam moves to the super heater.



Schematic diagram of boiler drum

Specification

Material Specification	SA-299
Design Pressure	210 kg/cm²(g)
Design metal temp.	368 °C
Operating Pressure	196 kg/cm² (g)
Actual thickness for straight portion	185/155 mm.
Overall length of drum (with dish ends)	22078 mm
Internal dia	1778 mm
Corrosion allowance	0.75 mm
No. of distribution headers	6 nos.
No. of Cyclone Separators	92
No. of secondary driers No. of antivortex spiders	92 6
Shroud material	Carbon Steel
Max. permissible temp. difference between any two parts of the drum	50 deg c
Water capacity at MCR conditions (in sec) between normal & lowest water level permitted	10
Boiler Drum Wt. (without internal)	221000 (Kg)
Boiler Drum Wt. (with internals)	231000 (Kg)

SUPER HEATER

Super Heater has the task of heating the steam to 540 C at which no trace of water is left. This ensures that the blades of turbine are not corroded by water in long run.

Specifications

	LTSH (Stage # I)	**Divisional Panel (Stage # II)**	**Platen (Stage # III)**
Material	SA 213 T11	SA 213 T11,T22,T91	SA 213 T22,T91,TP347H
Type	Convective	Radiant	Radiant
Drainable / Non-drainable	Drainable	Non-drainable	Non-drainable
Effective Heating Surface area	8650 M²	1700 M²	1733 M²
Gas flow path area (m²)	183.5	Radiation section	327.4
Max steam gas side metal temp	450 deg c	525 deg c	600 deg c
Max gas side metal temp (ºC)	460	540	620
Type of flow	Counter	Parallel	Parallel
OD	47.63 mm	44.5 mm	51.0 mm
Gross length (/one tube) (m)	84	42.4	42.4
Tube pitch a) Parallel to gas flow b) Across gas flow	101 mm 152.4 mm	54 3048	60.3 762
Total no. of assembly	124	6	25
Total no. of tubes	744	432	400
Temperature ºC	493	513	592

Reheater

After the steam is used up in HPT, it loses its energy and begin to condense. Reheater does the task of heating it again but upto 340 C to be used in IPT.

Specifications

	Reheater-1	**Reheater-2**
Type	Radiant front platen	Convective rear pendant
Total heating surface area	4390 m²	4680 m²
Design pressure (abs)	53.4 ksc	-
Max operating pressure	46.5 ksc	-
Max steam side metal temp	534 deg c	587 deg c
Max gas side metal temp	575 deg c	628 deg c
No. of assembly	74	74
No of element	1036	888
Tube OD	54 mm	63.5 mm
Gross length (per one tube)	36.1	34

ECONOMISER

Economiser does the job of utilizing the energy of the flue gases to heat up the water which is used in boiler.

Specification

Type	Plain Tube Non-steaming,Drainable,Inline tube arrangement(Horizontal)
Effective Heating Surface Area	19000 M^2(gas side),12800 m2 (water side)
Design Pr. of tubes	216 kg/cm^2(g)
OD of tubes	38.1 mm
Minimum thickness tubes	6.2 mm
Length of tubes	158700 M (approx) vol3 pg 205
Pitch	76.2 mm (SL) 103 mm (ST)
No. of blocks	3 Nos.
Assembly	184
Element	552
Max. metal temp	336°C (steam side), 342 deg c (gas side)
Min temp of feed water that economizer can handle safely	172 deg c
ASME Specification	SA210 Gr A1
Gas flow Path area	168 M^2 (free gas area)

ID FAN

Induced draft fan are used in systems such as steam boilers and thermal oil heaters to draw out and remove flue gases from combustion chambers, by creating a vacuum of negative air pressure (typically -10 mm Hg). This is achieved by using a blower to to suck air through the combustion chamber and the rest of the system, before discharging the air and flue gas through a stack or chimney.

Specifications

Type	NDZV 47 SIDOR (Radial double suction simply supported bearing)
Make	BHEL
Orientation	Inclined (60 deg top left) Suction, Bottom Horizontal Delivery (right)
Medium Handled	Flue gas
No. per Boiler	2
Location	Out door
Speed	Variable RPM, 560 max
Capacity (design)	609 m^3/sec.

FD Fan

Furnace requires a large quantity of air for efficient burning of the fuel (coal or oil). Forced Draft Fan are used to suck in the air required for efficient burning of fuel in furnace. It supply the air necessary for fuel combustion by pushing air through the combustion air supply system and into furnace. These fans are located at the inlet of boiler to push high pressure fresh air into combustion chamber, where it mixes with the fuel to produce positive pressure.

Specifications

Make	BHEL Bhopal
Duty	Continuous
Frame Size	1LA7802-6
Mounting	Horizontal(B3)
Direction of rotation viewed from DE	CW
Permissible variation of V, F, combined V & F	+/- 10%, +3/-5 %, 10% (abs)
Minimum permissible starting voltage	85 %
Starting current at 100% voltage	600
Starting time with min permissible voltage a) Without driven eqpt coupled b) With driven eqpt coupled	 2 sec 13 sec
KW	1425 (at 50 deg c), 1523 (at 40 deg)
Stator voltage	3300 V
Full load current	307 A
RPM	994
Phase	3
Hz	50
Insulation	F
Amb. Temp.	50°C
Connection	Star
Deg. Of protection	IP 55
Rotor type	Sq. Cage
DOR	CCW from Motor NDE

Fan data

Type	AP1 26/16 (Axial Profile-Stage 1)
No. per Boiler	Two
Capacity (design)	277 m^3/sec.
Total head developed (design)	410 mmWC
Medium handled	Atmospheric Air
Location	Out door
Orientation	Vertical Suction Horizontal Delivery.
Temp. of medium	50°C
Specific wt. of medium (design)	1.021 kg/m^3
Fan Speed	980 RPM
Fan Regulation	Blade pitch control

PA Fan

Primary Air Fan are used to lift the pulverised coal to the boiler for burning.

Specifications

Fan

Type	AP2 20/12 (Axial profile fan-2 stage)
No. per boiler	2
Orientation	Vertical Suction Horizontal Delivery
Medium Handled	Atmospheric Air
Location	Out door
Type of Regulation	Blade Pitch Control
Speed	1480 RPM

Motor

Make	BHEL Bhopal
Motor type	SCIM
Frame	ILA7 905-4
Duty	Continuous
kW	2950 (at 50 deg c)
Stator Volts	11000
Stator Amp	180
RPM	1494
Ph	3
Hz	50
Insulation Class	F
Connection	Star (Stator) - (Rotor)
Starting time with min permissible voltage a) Without driven equipment coupled b) With driven equipment coupled	 5.5 sec 10.5 sec
Power Factor	0.89 (100% load)
Efficiency	96.7 % (100% load)
Ambient Temp.	50° C
Temp Rise	70° C
Permissible variation of V, F, combined V & F	+/- 6%, +3/-5 %, 10% (abs)
Minimum permissible starting voltage	80 %
Starting current at 100% voltage	600
Degree of Protection	IP55
Total Weight	14500
Max permissible temp of rotor	400 deg c
DOR	CCW from Motor NDE

AIR Heater

Fuel (coal) burns more efficiently if the temperature of air is high. For this purpose air is heated before it is used in boiler.

Air Preheater does this task. They are divided into two stages:

- **Primary Air preheater**
- **Secondary Air preheater**

Specification

PRIMARY AIR PREHEATER (PAPH)

Make	BHEL
Type	Ljungstrom Bisector (Regenerative)
Air heater size	27.5 VIM 2000
No. of Air Pre-heater Material specification,thickness: Cold end elements Intermediate elements Hot end elements	2 per Boiler 1.214 mm- NF6 profile 0.8 mm-DU profile 0.8 mm-DU profile

SECONDARY AIR PREHEATER(SAPH)

Make	BHEL
Type	Ljungstrom Bisector (Regenerative)
No. of Air Pre-heater Material specification,thickness: Cold end elements Intermediate elements Hot end elements	2 per Boiler 1.214 mm-NF6 profile 0.8 mm-DU profile 0.8 mm-DU profile
Size	30 VIM 2000

TURBINE

Function of the turbine is to convert the heat energy of the steam to rotational energy of the turbine. High pressure steam is allowed to enter the turbine through small orifice. The turbine has 3 set of blades:

- **Impulse blade**
- **Guide blade**
- **Reaction blade**

There are 2 set of impulse blade where the steam first impacts. The structure of the blades are such that steam keeps on oscillating between the fixed guide blades and the movable reaction blades until is it finally moved out of the turbine. This change in momentum produces torque on the rotor blades and the rotor rotates. By the time the steam reaches the last stage in the turbine its pressure and temperature drops to greater extent and it is extracted by the condensate extraction pump.
In a 660MW plant 3 cylinder reheat condensing turbine is used.

HPT:

High pressure turbine(HPT) is a pump specifically designed for boiler feed applications in thermal power stations. The pumps are optimized to provide high-efficiency operation over an extended period of time, thus reducing operating and maintenance. It has barrel type construction of outer casing. Inner casing has guide valves in it. The inner casing is fixed in both the planes to the outer casing which makes it free to expand radially from the shaft. Barrel construction

makes it easier for maintenance. It has 17 reaction stages. It is smallest in size. Turning gears are mounted in front of HPT to rotate the turbine at low speed to have uniform heating or cooling to protect the rotor from distortion or hogging. This turning gear is rotated by the pressure of oil.

IPT:

In general IPT(Intermediate Pressure Turbine) working pressure is 20–25% of HPT working pressure. After expansion in HPT steam send to reheater and heating done at constant pressure which is 20–25 % of initial steam pressure known as reheat pressure. In reheater steam reheat up to 537 degrees centigrade and send to IPT. In 250 MW KWU IPT steam enter from both Top and Bottom . Both side have a set of 1 IP stop valve and 1 IP control valve. At inlet of IPT in 250 MW unit steam parameters are pressure about 40 kg/cm2 and 537 degree centigrade temperature. Inlet pressure depends upon current running load but temperature will be always near by 537 degree centigrade. 250 MW IPT have 18 stages of reaction types blades. At 10th stage steam bleed from top and bottom for Extraction-5 of HPH-5. After expansion steam exhausted and send to LPT via cross around pipe from both Left and Right side. At outlet steam pressure and temperature are 6.6 kg/ cm2 and 310 degree centigrade respectively. Exhaust pressure may vary according to loading conditions.

LPT:

Low pressure turbine. In thermal power plant LPT used after IPT. As name suggests in LPT steam expansion takes place at very low pressure as compare to HPT(In 250 MW steam

turbine LPT inlet pressure is around 6.5 kg/cm2). In 250 MW KWU steam turbine LPT is double flow and having 8 stage of blades in each side.

In all three turbines HPT,IPT and LPT, work done by LPT is maximum because volume of steam in LPT is huge. No of LPT depends upon unit capacity and manufacturer . There is one no of LPT in 250 MW unit but in 660 MW two no of LPT used. Last stage of LPT may be free standing of shrouded depends upon manufacturers. The last stage blades of LPT are under highest forces because they handle vapour water mixture and having blade height maximum. Outlet of LPT directly connected to vacuum as condenser situated just below the LPT.

Specification

Make	BHEL
Design	KWU, West Germany
Type	Three Cylinder Reheat Condensing Turbine.
Stages	Single flow HPT 17 Reaction stages.
	Double flow IPT 12 X 2 Reaction stages
	Double flow LPT 6 X 2 Reaction stages.
Valves	HPT -2 Main Stop and Control Valves.
	IPT -2 Reheat Stop and Control Valve.
	CRH line - 1 Swing Check Valve.
	HPBP – 2 Bypass Control Valves
	LPBP – 2 Bypass Stop and Control Valves
Direction of Rotation	Anticlockwise (Viewed from Front Pedestal towards Generator

Load

LOAD	
Rated load	660MW
Max^{M} load	525 MW (valve wide open condition)

Speed

Rated Speed	50 C/Sec
Max^{m} Speed	51.5 C/Sec (No Time Limitation)
Min^{m} Speed	47.5 C/Sec (No Time Limitation)
Speed Exclusion Range(without load)	7 to 47.5 C/Sec
Standard Over Speed Trip Setting	55.5 C/Sec
Permissible for max. 2hrs during the life of LP Blading	Speeds below 47.5 C/Sec
	Speeds above 51.5 to 60 C/Sec

Generator

A generator converts the rotational energy to electrical energy. This conversion is based upon the Faraday's Law which states that relative motion between conductor and magnetic flux induces emf in the conductor.

Generator or alternator consist of stator and rotor. But unlike DC machines the AC generator/ alternator have poles which rotate while the armature remain fixed to the stator. Depending upon the construction there are 2 types of rotor:

- **Salient Poles**
- **Cylindrical Poles**

Salient Pole rotor have number of projected pairs of laminated poles bolted on the magnetic wheel while the Cylindrical Poles have numerous cylindrical slots in which field winding are wound. The excitation current to the field winding or the magnetic poles is given by exciter.

The alternator used in plant is a cylindrical types which rated speed of 3000rpm. Stator winding is star connected. It

produces active power of 660MW at .85 lag at rated rpm. The stator winding are water cooled while the core and the rotor are hydrogen cooled. The output voltage produced is 21KV.

Specification

General

Make	BHEL
Type	THDF 115/59
Duty	S1
Insulation class	F
Cooling of stator winding	Directly water cooled
Cooling of stator core & rotor	Directly hydrogen cooled

Rated data

Apparent Power	655MW
Active power	660MW
Current	16166 Amps.
Voltage	21 KV ± 1.05 KV
Speed	3000 rpm
Frequency	50 Hz
Power Factor	0.85 (lag)
H_2 pressure	3.5 bar (g)
Cont. perm. unbalance load	8%
Rated Field current for rated output	4040 A
Rated Field Voltage	340 V
Inner connection of stator wdg	YY
No. of terminals brought out	6
Stator winding resistance at 25°C	U-X = 0.0014747 ohms
	V-Y = 0.0014747 ohms
	W-Z = 0.0014747 ohms
Rotor winding resistance at 25°C	F1–F2 = 0.067873 ohms

Exciter

Excitation current is required to set up the working magnetic flux in the alternator. This necessary excitation current is provided by the exciter. It is transferred to the magnetic poles or field winding through slip ring. The output of the ac

exciter is given to rectifier wheel. It rectifies the current and feeds it to the field winding through the slip ring.

There are 3 types of exciter:

- **Static exciter**
- **Brushless exciter**
- **Pilot exciter**

Specification

Excitation System

A) Main exciter

Type	ELR 70/90-30/6-20
Active Power	3780 KW
Current	6300 Amp.
Voltage	600 V
Speed	3000 rpm
Stator winding resistance at 25°C	F1-F2 = 0.6036 ohms
Rotor winding resistance at 20°C	U-V = 0.000469 ohms
	U-W =0.000469 ohms
	V-W = 0.000469 ohms

B) Rectifier Wheel

No. of wheels	2 (one positive and one negative)
No. of Fuses per rectifier wheel	30
Fuse resistance/Voltage/current	Approx. 150 Micro ohms/800V/800A
No. of diodes per rectifier wheel	60
No. Of RC networks per rectifier wheel	6 Nos.
No. Of fuses blown per bridge arm & rectifier wheel	1) 2 fuses- Switch off field forcing 2) 3 fuses- Shutdown turbine-generator, replace fuses and diodes

C) Pilot Exciter

Apparent Power	65 KVA
Current	195 A
Voltage	220 V ± 22 V
Speed	3000 rpm
Frequency	400 Hz
Stator winding resistance at 25°C	U-O = 0.002579 ohms
	V-O = 0.002579 ohms
	W-O = 0.002579 ohms

OIL HANDLING PLANT

For balance of plant an oil handling plant is very essential. Oil is required as lubricant. Also for starting the combustion after a shutdown, oil is required as fuel.

Components of OHP

AOP (Auxiliary oil pump): There are 2 AOPs. They are required for lubrication of bearing or turning gears and motor gears.

MOP (Main oil pump): It is single in number. AC motor pump and mechanical pump mounted on the turbine shaft in front of the HP turbine constitute MOP. It comes in service when the turbine achieve its full speed. AOP is closed when MOP starts.

DC oil Pump: It is an emergency oil pump. It supplies oil when AOP and MOP are not in service.
Jacking Oil Pump: They are two in number. They are used to jack or lift the rotor in initial condition when the rotor is required to be rotated.

ASH HANDLING PLANT

Burning of coal produces ash. The ash on getting collected on the walls would reduce the efficiency of the power plant. So they need to be removed.

Bottom Ash Removal

For the removal of the bottom ash that get collected in the furnace, the boiler has a many funnel shaped structure called Hoppers. The settled ash at the bottom keep on getting drifted to the due to funnel shape and get collected. The collected ash is mixed with water to form slurry and is moved out of the plant.

Fly ash removal system

For the removal of ash content from flue gas we have Electrostatic Precipitator. It has two large parallel plates to which high DC voltage is applied. The ash particles in flue gases when pass between them get polarised and get attracted to the plates. The stuck particles on the plates is removed by rapping mechanism. It is mechanical process of hitting the plates with hammer. Also there are hoppers at the lower end of APH, ESP etc. for collection of ash content that may get collected there. The ash is collected and made into slurry and moved out of the plant.

SWITCH YARD

The voltage obtained from the generator as such fed to the grid. They need to be stepped up. To fulfil this need Switch Yard is required.

Harduaganj thermal power project has 2 switch yard of 400kV and 220kV. These two switch yards are interlinked together through two auto transformers. There are three generating transformer for each

phase (RYB). The MVa rating of these transformers depend upon the rating of the generator. The generator installed in the plant is 588MVa. So all the three phase transformer are 200MVa each.

Details of auxiliaries at Switch Yard

1. **Transformer**
2. **Bus bars**
3. **Circuit Breakers**
4. **Current Transformers(for auxiliary)**
5. **Potential Transformers(for auxiliary)**
6. **Isolators**
7. **Lightening Arresters**
8. **Insulators**
9. **Control Room Containing various auxiliaries**
10. **DC Battery**

TRANSFORMER

Transformers are required to step up or step down the voltage level depending upon the requirement. They are constant flux device. A basic transformer has two sets of winding namely primary and secondary winding. Ratio of number of turns in both winding determine whether it is step up or step down transformer.

Working Principle:

At the most ground level transformer is just an application of Faraday's Law which states that emf is induced in a coil if the magnetic flux linked to it changes.
Alternating current given to primary winding of transformer produces alternating flux. This alternating flux is linked to the secondary through a common core. The alternating flux through the turns of the secondary winding induces emf in the winding. If the number of turns are greater then the voltage is stepped up, else it is stepped down.

Cooling:

Heat loss through the transformer occur in the form of hysteresis loss, eddy current loss, copper losses etc. This heat loss tend to increase the temperature of transformer which could be fatal after certain limits. So cooling mechanism is required.
Small transformers generally have natural air cooling, while transformer with high power rating have air forced and oil natural cooling in addition. Still larger transformer have oil forced cooling as well.

Different rating of transformer are required at various parts of power plant. They are:

- **Generator Transformer**
- **Station Transformer**
- **Unit Transformer**
- **Offsite Transformer**

Important Accessories of transformers:

1. **Buchholz relay**
2. **Conservator**
3. **Silica jell breather**

Conservator

Now it happens that the oil which is circulated through the transformer for cooling may expand or contract depending upon the varying temperature and pressure condition to which it is exposed. In summer there is an expansion of the oil. If suitable arrangement is not made for the storage of excess oil, then the oil tube may bust. On the other hand, in winter season, due to contraction, the availability of oil necessary for cooling the transformer will be less leading to shortening of the life of transformer. Here comes the action of conservator. The conservator stores the oil in case of expansion and provides the deficit amount in winter.

Action of Buchholz Relay:

Buchholz relay is a mechanical actuator, which trips the transformer in case of internal faults like insulation breakdown, short circuit of winding etc. Due to these faults the temperature rises and there is decomposition of insulating oil and gases are produced which get accumulated in the upper part of the Buchholz relay. This leads to tilting of the mercury switch. Based upon the level, the alarm is produced and relay comes in action.

The operator in control room receives an alarm, the transformer is turned off. The mouth of the gas valve on Buchholz relay is opened and a match is lighted. If the gas escaping the transformer catches fire, then this is an indication that the winding have burned and it requires immediate maintenance. On the other hand if it does not catch fire, then it is an indication that air was collected. The air is allowed to escape and the normal function of the transformer is resumed.

Silica jell breather

One of the biggest enemy of transformer is the moisture. To deal with these, the transformer are provided with silica jell box. It is blue in colour. As it absorbs moisture it becomes pinkish. Then it is required to be replaced. They can be reused after placing them in light for some time. They lose their moisture content and become blue again and ready to be reused.

Details of various transformer are as under:

GENERATOR TRANSFORMER

Manufacturer	ABB Limited, Vadodara
Nos. of Units	3 nos. per Unit
Rating HV & LV (MVA)	200 MVA each phase
No Load Voltage, HV	420 / √3 KV
No Load Voltage, LV	21 KV
Winding Connection	Star-Delta
Rated Current, HV	824.79 Amps.
Rated Current, LV	9523.81 Amps. (each phase)
No. of Phases	3 X1 phase
Frequency	50 Hz
Type of cooling	OFAF
Vector group	YNd11
Impedance at principal TAP	13.5% ± 5%.
OFF Load TAP changer	Tapping in steps of 2.5% each
Variation of High Voltage	provided on HV winding to give + 5% to - 5%
Temp. Rise in top oil over an ambient of 50 deg c.	35 °C
Temp. Rise in winding over an ambient of 50 deg c.	40 °C
Grounding	HV – Solid
No of Coolers	5 (Main)+ 1(Standby)
No of Cooling Fans	2 Fans per Cooler
No of Oil Pump	1 Pump per Cooler

STATION TRANSFORMER

Manufacturer	ABB Limited, Vadodara
Nos per Unit	01
Capacity	80/40/40 MVA
Voltage Ratio	132/11.5/11.5 KV
Winding Connection	Star-Star
Vector group	YNyn0yn0
Line current HV	349.92Amps.
Line current LV1,2	2008.23 Amps.
Temp. rise :-	
Oil	50°C
Winding	55°C
Cooling arrangement	ONAN/ONAF
Type of Neutral Grounding	HV-solid, LV – NGR:22.13Ω

UNIT TRANSFORMER

Manufacturer	ABB Limited, Vadodara
Total nos.	1 no. per unit.
Rating	45 MVA
Winding-Connection	Delta-Star
Vector Group	Dyn1
Number Phases	3
Voltage Ratio	21/11.5 KV
HV Current	1374.64 Amps.
LV Current	2510.22 Amps.
Vector group	Dyn1
Cooling Type	ONAN/ONAF
Type of Neutral Grounding	LV - NGR – 22.13Ω
Impedance at Principal Tap(75 C)	11.5 %
Temp. Rise in top oil over an ambient of 50 deg c.	50
Temp. Rise in winding over an ambient of 50 deg c.	55
No of Coolers and its rating as % of transformer cooling equipment	2 X 50% cooling, 6 radiators per bank
No of Fans per cooler	2 Fans per bank

BUS BARS

The bus bars are aluminium or copper conductors which carry electric current in open air to which various connection (feeders, equipment) can be made. There arrangements are such that work on any equipment can be done without causing any trouble to incoming and outgoing feeders.

Specification:

BUS BAR

System	2 Bus , 1½ Breaker Tubular bus conductor,4 inch IPS tube
Manufacture	Hindalco Industries Ltd
Bus Conductor Rating	3000 Amps
Withstand capacity for 1sec.	50KA

Circuit breakers

Circuit Breakers used for making and breaking of electrical contacts. This task can't be done in open air as this high voltage will ionize the

air and produce spark. Circuit breaker contains inert medium like vacuum or SF6 in which the making and breaking of contact is done. Their outer cover is made of porcelain. Also they ensure that the operation is done very fast so that arc is quenched faster. Before the circuit breaker is operated, it is necessary to ensure that correct pressure is maintained in the circuit breaker and the gas cylinder.

ISOLATORS

Isolators are disconnection switch. They can be controlled from switch yard or from the control room. These isolators are in open air, so they are used only in no load condition ie. they are operated only after the circuit breaker is brought to action. By looking at the position of the isolators we can tell whether it is connected or disconnected. For repairing purpose circuit breaker is tripped first and then the isolators contact are removed which isolates the equipment for repair purpose.

Current and potential transformers

For the safety of the instruments and economic reasons, we need to keep a record of the current and voltage at various points in the circuit. Such high voltage and current is highly unsafe to directly give to the measuring equipment. Their values have to be lowered down. For this we require CT and PT. These can be seen at various points in the switch yard. These are step down transformers.

400 KV CAPACITIVE VOLTAGE TRANSFORMER (PTs)

Make	ABB LTD,INDIA
Rated Voltage (KV)	$400/\sqrt{3}$
Rated Frequency (Hz)	50
No.Of Secondary	3

400 KV CURRENT TRANSFORMER (CTs)

Make	M/S Crompton Greaves Ltd ,India
Rated Voltage (KV)	420 rms line to line
Rated Continuous Normal Current (A)	2000 A
Rated Frequency (Hz)	50
Short Time Thermal Current With Stand For 1 Sec	50 KA
Dynamic current withstand	125 KA peak
No.Of Cores Per CT	5

Insulators

The heavy current carrying conductors if directly mounted on the poles or support will directly ground them to earth. So we requires some insulator through which we can hang them on poles and propagate them. The insulators should have high resistivity to prevent the leakage of current to earth. Along with this it should be able to withstand the weight of the conductor (wire). Depending upon the rated kV the line is carrying the size of conductor changes so does the insulator required to support them. For 33kV and below we use pin type insulator and for higher rating we use suspension type insulators. These insulators have porcelain covering. These have discs whose number depend upon the kV rating of the line. Eg. If the discs are of 11kV rating, then we would require 20 of them to hang the conductor through the support.

Lightening arrester

Lightening arresters protect from surge due to switching the machines on and off and due to lightening. They have nonlinear resistance whose conductivity increases with increase in voltage above the safe value. A 400kV transformer can sustain voltage up to 500kV. Above this limit the resistance path of arrester become conductive and conduct the surge current to the ground without harming any equipment.

Control room

It has arrangement for the remote monitoring of each of the auxiliaries, feeders etc. and controlling them. The office has single line diagram of the switch yard. Also the power being sent to various parts and the generated power, power factor etc. displayed on the screen.

DC battery

For the proper functioning of the relay and other protective gears we requires uninterrupted dc supply. They are crucial even when the whole grid terminates. We have 2 banks of 169 cells each of 1.4V summing up to 220V battery in the plant. Along with this we have 48v battery for PLCC with 2 banks with 38 cells each.

Specification:
220 V BATTERY

Make	AMCO SAFT INDIA LTD
Type	Ni-Cd
Capacity (AH)	265
No.Of Cells	169
No of banks	2 (169 cells in each)
Nominal Cell Voltage	1.40 - 1.42
Specific Gravity At 27 ^{0}C	1.20

COOLING TOWER

In the processes of condensing the steam, the circulating water in the condenser gets heated. This heated water needs to be cooled down in order to be used again in the condenser. Here comes the role of cooling tower. The cooling tower takes the circulating water from the condenser cools it and returns it through the main stream.

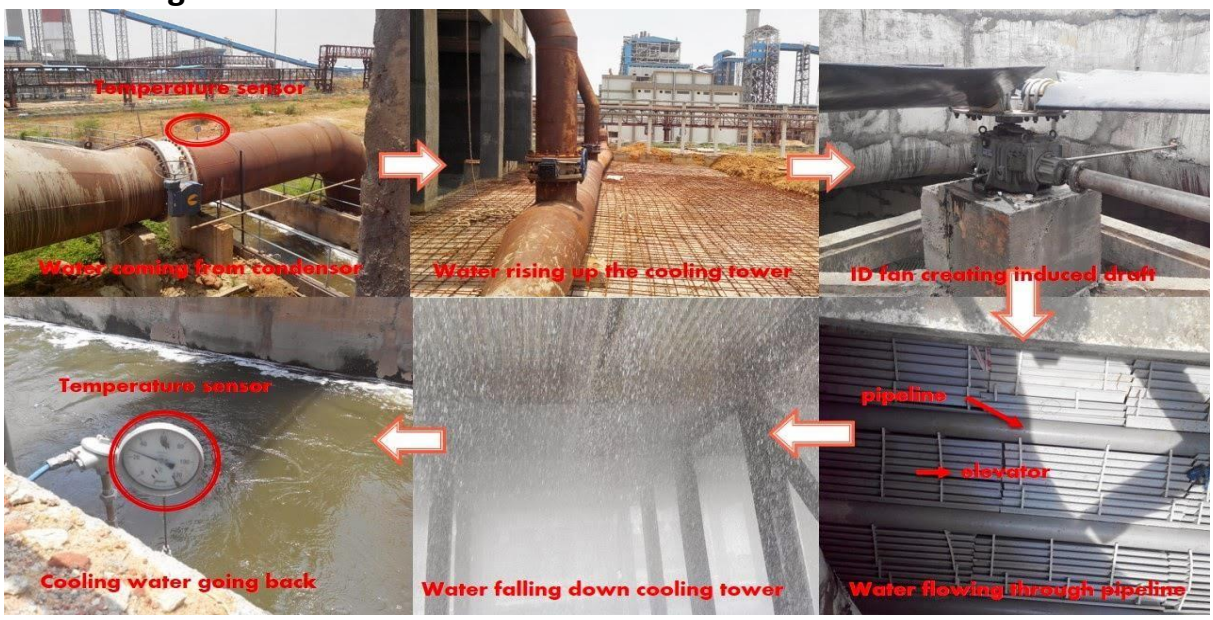
There are two types of cooling tower:

- **Natural Cooling tower**
- **Induced draft cooling tower**

Natural Cooling tower required comparatively large tower height for cooling by the same temperature. Also they are bit risky and unsafe compared to Induced draft cooling towers.

The cooling towers used in the plant are Induced draft type. These towers are of 100 - 110 m height. There are 9 individual tower in each set. A 30kW 3phase induction motor drives the ID fan through a long shaft coupled to a set of gears with gear ratio 12:1. Below the 4 blade ID fan, there are elevator and networks of small pipes through with the incoming hot water flows. These pipes have nozzles below them and layers of pvc v bar arranged in slant fashion. For collecting cool water the base is made 3m deep. It has an outlet connecting it to the open main channel.

Functioning:



The circulating water from the condenser comes from the through large tubes under pressure enough to give them a head of 90m. Water from here get distributed among a number of small pipes network just below the Induced Draft fan. The nozzles at the bottom end of the pipes breaks the water and sprinkles them on the pvc v bar layer. This water falls on the bed in the form of splendid shower in

front of which everyone would like to get a snap. The ID fan creates suction to remove the vapour from the water which helps to cool the water. Along with the vapour there is large chance of tiny water droplets to get sucked by the ID fan which will corrode the fan in long run. For this elevators are installed parallel to the pipelines which prevent the water droplets from reaching the induced fan. The water is cooled by 10 -15 C. This cooled water from the bed joins the main open channel which goes back to condenser along with required make up water after chlorination and sulfonation.

There are two temperature sensors available in cooling tower system. One for the inlet water (hot) and other for the outlet water (cool). The temperature noted at that instance was 39c for inlet and 29 c of the outlet.

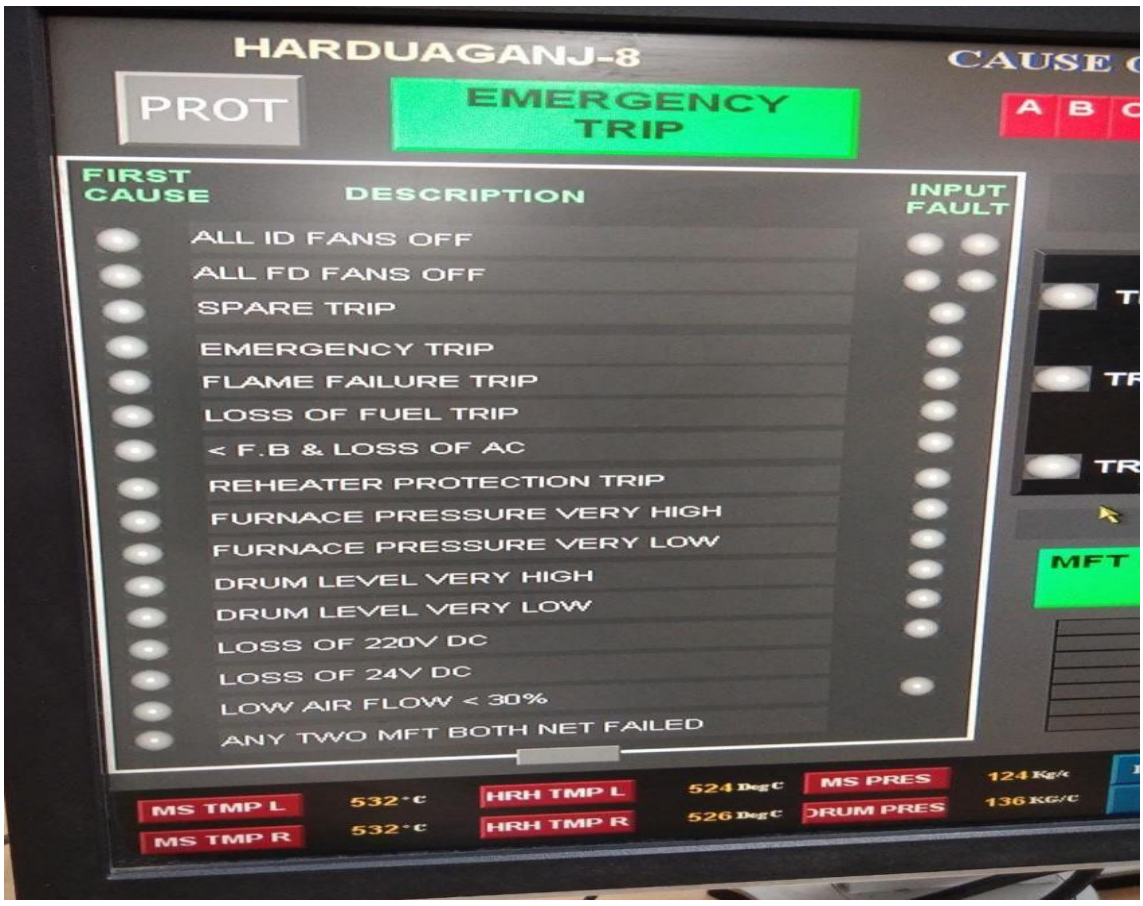
The rubber system is used for coupling the shaft and motor. Proper alignment is essential. As the length of shaft increases, the accuracy required also get increased. The accuracy in this case was .001m in up, down, left, right direction.

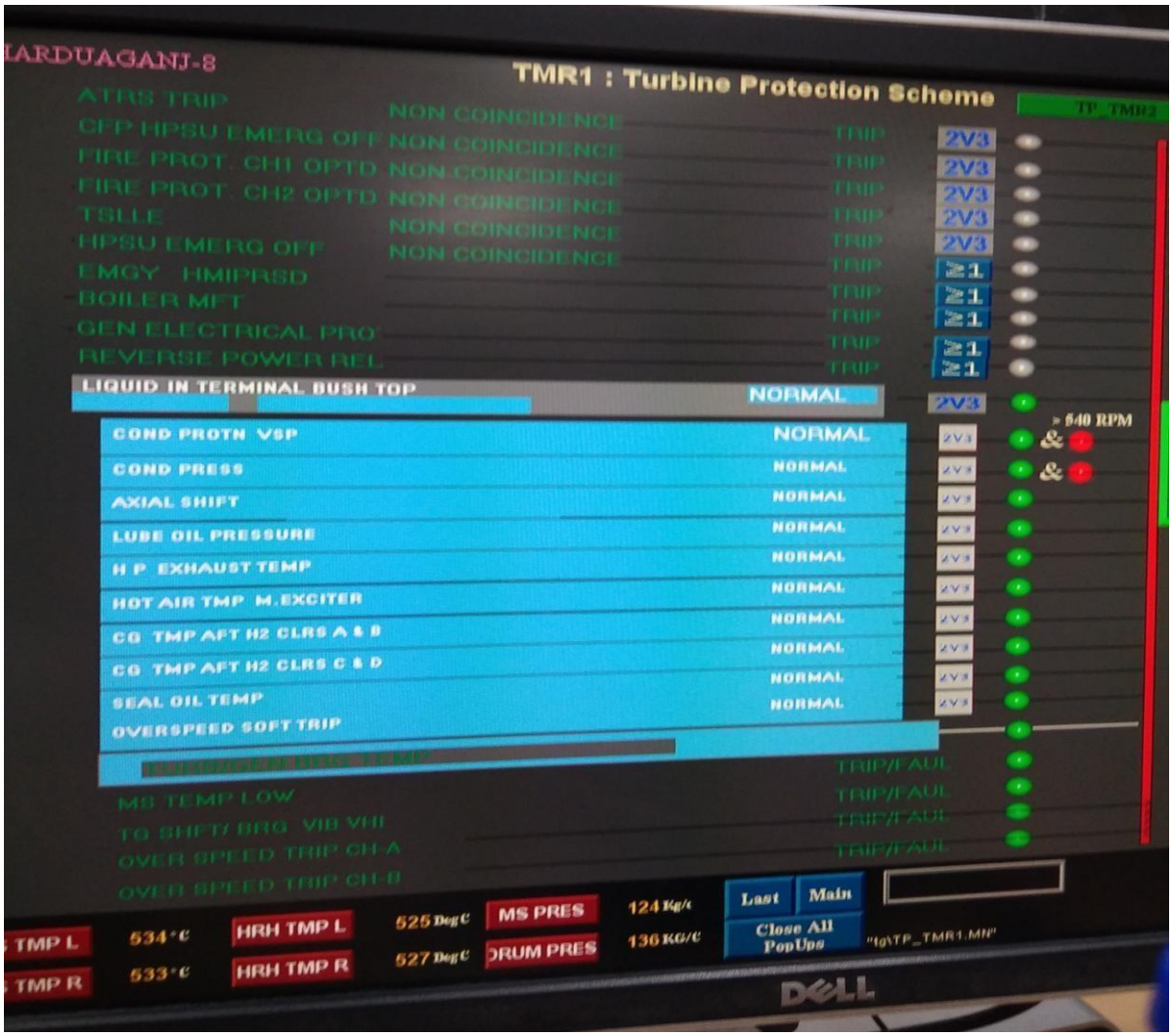
The opening and closing of the valve for water, and supply to motor are remotely controlled from DCS. Also they are controls available on site but rarely used. Protection against vibration, over speed, overcurrent etc. are provided.

SECURITY SYSTEMS

In any thermal power plant we require certain emergency systems which can locate any problem in the overall plant and can timely inform the control room about the same through which the problematic part can be stopped so as to prevent the problem or fault to spread and thus avoids any damage to other parts of the plant reducing the cost of repair and also the possibility of any injury or casualty.

The following images are the security systems which can be operated from control room, which are present in Harduaganj thermal power project-




ARDUAGANJ-8
TMR1 : Turbine Protection Scheme
ATRS TRIP
CFP HPSU EMERG OFF
FIRE PROT. CH1 OPTD
FIRE PROT. CH2 OPTD
TSLLE
HPSU EMERG OFF
EMGY. HMIPRSD
BOILER MFT
GEN ELECTRICAL PRO
REVERSE POWER REL
NON COINCIDENCE
TRIP
2V3
N1
LIQUID IN TERMINAL BUSH TOP
NORMAL
COND PROTN VSP
COND PRESS
AXIAL SHIFT
LUBE OIL PRESSURE
H P EXHAUST TEMP
HOT AIR TMP M.EXCITER
CG TMP AFT H2 CLRS A & B
CG TMP AFT H2 CLRS C & D
SEAL OIL TEMP
OVERSPEED SOFT TRIP
> 540 RPM
MS TEMP LOW
TG SHFT/ BRG VIB VHI
OVER SPEED TRIP CH-A
OVER SPEED TRIP CH-B
TRIP/FAUL
TMP L
534 °C
HRH TMP L
525 Deg C
MS PRES
124 Kg/c
TMP R
533 °C
HRH TMP R
527 Deg C
DRUM PRES
136 KG/C
Last
Main
Close All PopUps
DELL

CONCLUSION

India is a country which is largely dependent on coal for producing power, this power not only light homes but is also required in the industries which fuels the economy of our country. Through this training program I got the chance to learn in depth about this crucial power source of our country also got the industry experience in the engineering field.

From the collection, transportation and management of coal to it's use in the production of electricity and the reuse of flew gases so as to economize the whole process and also reduce environmental pollution, I learned it in detail and have presented everything regarding the same with the best of my knowledge in this report.

I have also learned about the management of each and every component from the oil handling system required in the movable parts to reduce friction, to the circuit breakers, isolators and the crucial security systems which manages the components in the times of an emergency, all of which has been discussed in detail in the report.

All in all this has been a very knowledgeable and inspiring experience for me and through the report I hope to convey everything that I have learned in detail.