A Journal paper on Fuel Optimization &increase boiler efficiency by heat extraction system

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ABSTRACT The object of the paper is the Fuel optimization. In India the main source of power is coal based thermal power plant. Also the sources of the coal is limited. So this paper resolve the high fuel consumption in thermal industry. Also the paper use the effect of heat extraction during the power plant running. So the use of the heat extraction increase the feed water temperature. Due to this fuel consumption reduced & boiler efficiency increase .So these heat extraction are taken from the different stage of turbine.
KEYWORDS; BOILER EFFICIENCEY, HEAT EXTRACTION, FUEL SAVING

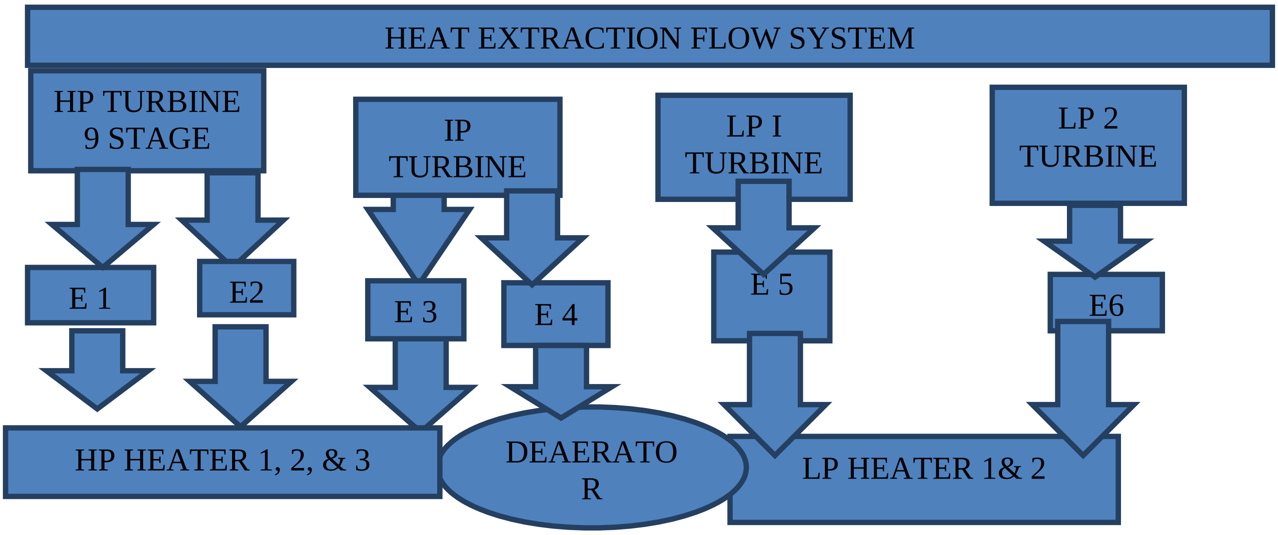
I. INTRODUCTION

The main fuel of the thermal power plant is the coal. Due to limited source of the coal we have required the fuel optimization. For this purpose we have considered the various heat extraction from the different stages of the turbine. IN the boiler feed water temperature is very low around 45 degree. But by the consideration of heat extraction this feed water temperature increase. For this purpose we have used HP heater, LP heater or Deaerator in the boiler feed water system. Due to this boiler efficiency increased and fuel consumption reduced.

2. LITERATURE REVIEW

The Heat extraction system of the steam turbine has 6-stage non-regulatory extraction for three sets of HP heater, one Deaerator and two sets of LP heater, respectively. Water of the HP and LP heaters reflows to the Deaerator and the condenser, respectively by means of cascaded drain. These heat extraction system increase the feed water temperature.

HEAT EXTRACTION FLOW SYSTEM & PARAMETES



HEAT EXTRACTION PARAMETERS

The parameters are taken from the different stages of 42 stage impulse turbine.

EXTRACTION POINT	E1	E2	E3	E4	E 5	E6
STAGE	6	9	11	14	15/21	16/22
EXTRACTION PRESSURE (MPa)	6.546	4.169	2.378	1.148	.432	.241
EXTRACTION TEMP. (c)	383	318.4	439.1	337.1	272.3	209.5
Flow (T/HR.)	64.08	67.34	35.96	21.01	26.12	24.0
PRESSURE LOSS (%)	5	5	5	5	5	5
TEMP. RISE BY EXTRACTION (C)	30	30	30	80	28	27

3. METHODOLOGY

The Methodology used for the fuel optimization & increase boiler efficiency is Observation &calculation based. The Observation collected from the normal feed water flow system through the boiler. According to these parameters boiler efficiency and fuel consumption is calculated.

After that the parameters are taken according to the use of heat extraction parameters. And Based on these parameters fuel consumption and again boiler efficiency is calculated

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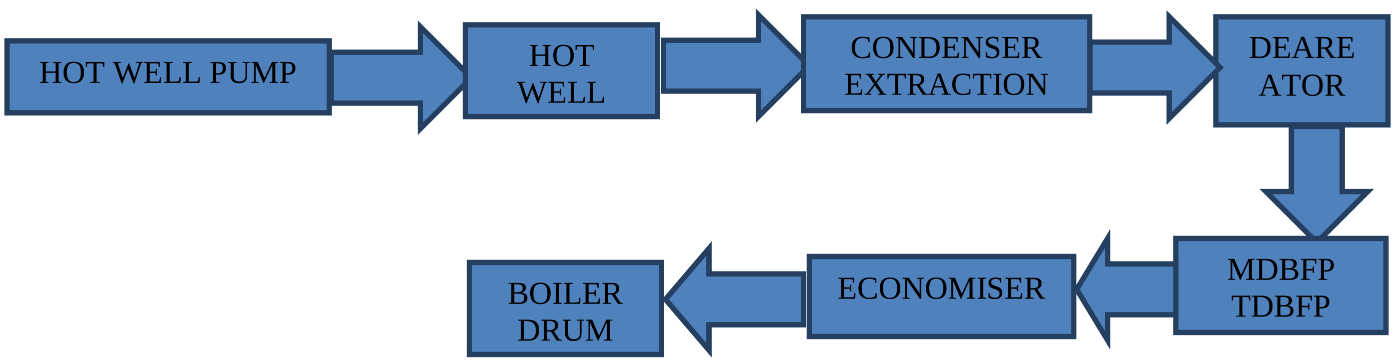
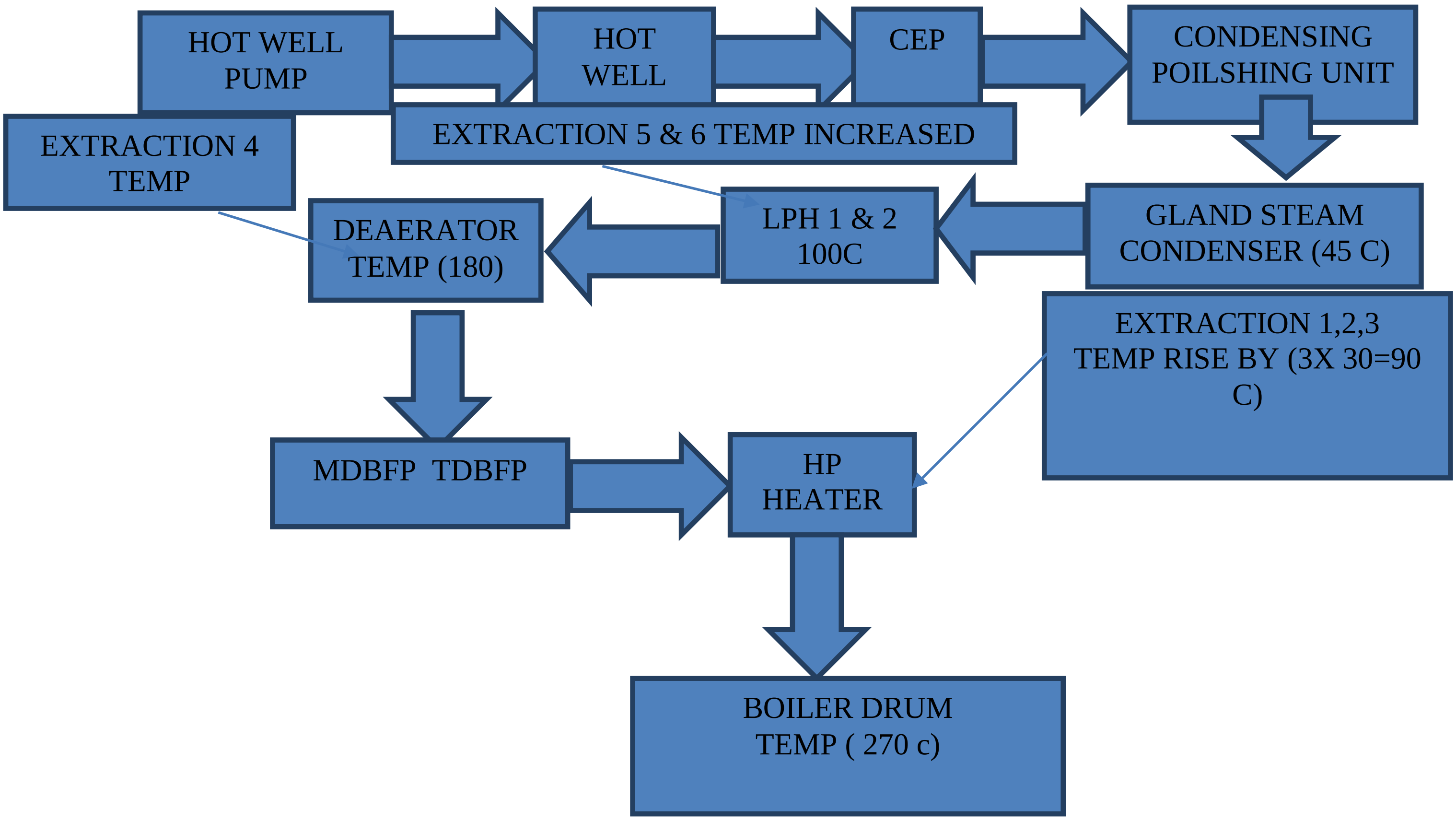
3.1 NORMAL FEED WATER FLOW SYSTEM THROUGH THE BOILER;



3.2 FEED WATER FLOW SYSTEM THROUGH THE BOILER WITH HEAT EXTRACTION SYSTEM



3.2 HEAT EXTRACTION YSTEM

Heat extraction system is considered with different stage of turbine. These system consist of the following components;

1. HP HEATER
2. LP HEATER
3. DEARATER

3.3.1 HP HEATER;The horizontal HP. heaters are U-type tube and tube sheet with full welding structure and consist of the water channel, tube-bundle and shell.

The internal heating exchange zones of the heaters consist of DE superheating zone, condensing zone and drain sub cooling zone. Water Channel is an important box for heater to collect and distribute feed water. The charnel is made up of hemispherical head, manway and feed water inlet and outlet nozzles. A manway with a self-sealed closure is provided on the channel. The removable cover of the seal is fitted with a elliptical gasket. The Manway self-sealed by internal pressure is reliable in sealing and convenient for assembly and disassembly. In the channel, there are several partition plates which separated the channel into two parts. The heat exchange tubes in the feed water inlet parts have been welded casing

Stainless pipe to prevent from the water flush. The channel is well selected

With excellent material 13MnNiMo5-4 and the tube sheet is made of SA-350LF2CL2. Thus the channel and the tube sheet can be welded efficiently and reliably.

Tube bundle is the most important component for heater to exchange heat and consists of tube sheet, U-type tubes, baffle plates, shrouds, spacers and tie rods. The tube sheet is of good welding capability due to the material SA-350LF2CL2 selected. The U type tubes with the sizes dia16x2.12 are made of stainless steel SA-213TP304. And the tubes are welded to tube sheet on the inlet and outlet sides and are additionally secured and sealed in the tube sheet bore holes through hydraulic expansion. There are three areas for heat exchange in every of HP. Heaters, i.e_ DE superheating, condensing and sub cooling zones accordingly. The baffle plates are installed in the zones to support the heat exchange tubes and

Protect them against vibration excitation. The baffle plates are supported and securely fixed by tie rods with spacers' sleeves which are screwed into the tube sheet.

The shell section consists of shell skirt, shell body, standard ellipsoidal head, and nozzles. The main pressured material is SA-387GR11CL2, SA- 516GR70, SA-335P12 and SA-105 carbon steel selected. In the shell of heaters, integral-reinforcing structure with forging connection or thick wall connection style is applied to guarantee integral intensity of shell sufficiently. The HP. Heaters are arranged with 3 saddle vessel supports. One of them is a fixed support and the others are movable ones. The saddle plates of the vessel supports are welded to the heater shell. The movable supports are constructed as rolling supports.

The main feed water flowing out of the Deaerator is heated further in HP feed water heater. The main feed water flows through U-type tubes of the HP feed water heater in two passes. The required heating steam flows into the shell section of the HP feed water heater from extraction point of the turbine. The HP Heater drains produced as a result of the condensation process are subcooled in the sub cooling zone and flow off into the Deaerator due to the existing pressure difference between extraction point and the difference in geodetic height.

3.3.2 LP HEATER

The LP heater consist of horizontal U-type tube which channel up with tube sheet with strength expanding structure and contain water chamber, tube bundle and shell. The internal heating exchange zones of the heaters is condensing zone.

Water Chamber is an important box for heater to collect and distribute the feed water. The channel is made up of the elliptical head, feed water inlet and outlet nozzles. In the channel, there are two partition plates which separated the channel

Into two parts. In LP heater7+8, there are four partition plates which separated it into three parts. The channel is well selected with material SA- 516M Gr.70 and the tube sheet is made of SA-350M LF2. Thus the channel and the tube sheet can be welded efficiently and reliably.

Tube bundle is the key component for heater to exchange heat and consists of tube sheet, U-type tubes, baffle plates, and tie rods spacers. The tube sheet is of good welding capability due to the material SA-350M LF2 selected. The U-type tubes with the sizes dia 16x0.9 are strength-expanded & welded to the tube sheet and are additionally secured and sealed in the tube sheet bore holes with two notches. There are two areas for heat exchange in the LP heaters, i.e. condensing zone and sub cooling zone accordingly. The baffle plates are installed in the zone to support the heat exchange tubes and protect them against vibration excitation. The baffle plates are supported and securely fixed by tie rods spacers that are screwed into the tube sheet.

The shell section consists of shell skirt, shell body, standard ellipsoidal head, and nozzles. The main pressured material is SA-516M Gr 70 selected. Two level angle irons are welded to inside of shell, and that match the rack type wheels which support the tube bundle.

3.3.3 DEARATER

The Deaerator is designed to extract oxygen out of the feed water by using steam. Extracting oxygen is of essential need in systems where water is used because small amounts of oxygen cause great

corrosive activity in the system. The incoming water (condensate I makeup) is put into the Deaerator through a sprayer and at the same time steam is injected under the water level.
The operation of the Deaerator is based on physical deaeration which takes
Place in two steps:
- Pre-deaeration in which water is sprayed in a part of the steam space.
- Final deaeration in the water tank where steam is brought in close contact with the water.

The sprayer and the internal steam rake are specifically designed to deaerated the incoming water. The Deaerator is at the same time used as a mixer *I* preheater and storage tank. The Deaerator is constructed of Carbon-Steel and it consists of a cylindrical shell provided with two ellipse ends. The interior consists mainly of a steam-sprayer device for injection steam under water level, specific baffles. Two manholes are provided to facilitate inspection of the Deaerator. Steam balance line to prevent a possible water back flow into the steam supply-pipes, a steam balance line is installed between the Deaerator vessel and a steam inlet line. In this conduit a check-valve must be mounted in case the pressure of the heating steam would suddenly fall for whatever reason. When this happens, the pressure in the Deaerator will be maintained for a period of time. The balance line will allow steam entering the heating steam supply pipe to prevent the water return to the turbine. Make sure that the check-valve is working in the correct direction. It should be closed during normal operation.

4. OBSERVATION & CALCULATION;

4.1 NORMAL FEED WATER SYSTEM THROUGH THE BOILER;

The Observations are collected as the power plant is running on normal feed water system. According to the observation the boiler efficiency and fuel consumption calculated.

OBSERVATION

S.N.	TIME	MSP (BAR)	MST (C)	FEED WATER TEMP (C)	FEED WATER RATE (T/HR)	TOTAL FUEL USED(T/HR)	PLANT LOAD (MW)
1	09 AM	166.5	536	45	1705	532	601
2	10 AM	169	539	42	1710	530	600
3	11 AM	168	538	45	1708	533	598
4	12 AM	166	540	46	1710	534	601
5	01 PM	168	539	45	1715	532	601
6	02 PM	167	538	45	1705	530	598

7	03 PM	169	536	47	1715	536	602
8	04 PM	172	538	44	1712	532	602
9	05 PM	169	536	45	1710	536	601
10	06 PM	165.5	540	46	1710	535	600
AVG.		**168**	**538**	**45**	**1710**	**533**	**600.4**

BOILER EFFICIENCEY CALCULATION;

BOILER EFFICIENCEY=ENERGY TO STEAM / ENERGY FROM FUEL

BY DETERMINED OBSERVATION

Main steam pressure 168 BAR, Main steam temp. 538 c, feed water temp. 45 c, feed water rate 1710 t/hr., fuel used 533 t/hr. Plant load 600.4 MW

Steam rise per kg of coal = feed water rate/ fuel used
= 1710/ 533
= 3.208
Heat supplied per kg of water = main steam enthalpy – heat by feed water
= enthalpy at p 168 bar and temp. 538 c from steam table (3949 KJ/kg)
= 3949-(4.18* 45)
= 3760.9 KJ/ kg
Boiler efficiency =energy to steam / energy from fuel
Calorific value of coal used = 3500 kcal/ kg
= 3.208* 3760.9/ 3500* 4.2
= 3.208*3760.9/ 14630
= 12064.96/ 14630

BOILER EFFICIENCEY = 82.46 %

4.2 OBSERVATION FROM THE FEED WATER SYSTEM THROUGH THE BOILER WITH HEAT EXTRACTION

Observation are collected as per heat extraction system

OBSERVATIONS

S.N.	**TIME**	**MSP (BAR)**	**MST (C)**	**FEED WATER TEMP. (C)**	**FEED WATER RATE (T/HR)**	**TOTAL FUEL USED (T/HR)**	**PLANT LOAD (MW)**
1	9 AM	170	537	274	1702	376	602
2	10AM	169	536	272	1705	375	601

3	11AM	167	534	270	1710	377	602
4	12 AM	170	535	271	1710	375	600
5	01 PM	167	541	270	1706	380	603
6	02 PM	169	540	267	1705	372	598
7	03 PM	168	535	269	1702	377	602
8	04 PM	167	538	272	1705	379	602
9	05 PM	168	537	270	1712	378	600
10	06 PM	169	540	271	1713	375	598
AVG		**168.4**	**537.3**	**270.6**	**1707**	**376.4**	**600.8**

BOILER EFFICIENCEY CALCULATION;

By determined Observations Main steam pressure 168.4 BAR Main steam temp. 537.3 c, feed water temp. 270.6, feed water rate 1707 t/hr. fuel used 376.4t/hr. Plant load 600.8 MW

Steam rise per kg of fuel = feed water rate / fuel used

= 1707 / 376.4

= 4.53

Heat supplied per kg of water = main steam enthalpy at (p 168.4 BAR Temp. 537.3 c) – feed water rate

= 3946- (4.18* 270.6)

= 2814.89 KJ /KG

Boiler efficiency = energy to steam / energy from fuel coal CV = 3500 KJ/KG

= 4.53*2814.89/ (3500*4.18)

= 12751.45/ 14630

= **87.15%**

5. **FUEL OPTIMIZATION**

According to the normal boiler feed water system the fuel consumption = 533 t/hr.

And the coal flow with heat extraction system = 376.4 T/HR

Coal saving by heat extraction system per hour = 533- 376.4

= 156.4 t

Coal saving / year if power plant is running 275 days at full load

= 156.6 * 24*275

= 1033560 MT/ YEAR

Coal cost = 2200 RS/ MT

COAL SAVING / YAER = 1033560* 2200

= 2273832000

= 227.38 CRORE

6. **CONCLUSION**

BY use of the heat extraction from different stage of turbine the following results are determined.

1. **Boiler feed water Temperature is increased up to 270 c**
2. **Boiler efficiency is increased up to 5%**
3. **Fuel saving up to 156.6 MT/ HR**
4. **Cost saving by the fuel is approximate 227.38 crore/ year**
5. **Thermal Efficiency increased**

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