A Case Study on Heat Rate of Boiler and Turbine in NSPCL Durgapur

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***Abstract:*-A power plant is used to generate and transmit electricity. There are various kinds of power plants depending on their input. NSPCL is a thermal power plant of Durgapur Steel plant situated in West Bengal. It is a joint venture of NTPC and SAIL, with a capacity of 120MW (2 units of 60MW capacity each.) The plant supplies its entire power to the Durgapur Steel Plant. Being a thermal power plant it uses coal as a major fuel. The heat rate of a power plant is the amount required to produce 1KWHr of power. This value indicates the efficiency of the power plant. It is done by controlling the fuel, in this case coal and the GCV of coal. The higher the heat rate of the power plant the less efficient it is.**

***Keywords*: Thermal Power Plant, Heat Rate, Flue Gas, Load Factor, Fly Ash, NSPCL**

I. INTRODUCTION

Power Plant is a utility Unit which Generates Power and transmits the Power to another utility called Transmission Utility. Power Plant generates the Electric Power which is finally consumed either by Industrial Units or by Domestic/Government or other Units. The Power is generated in a Generator or Alternator which is driven by Turbines. The turbine may be driven by various inputs and the Power Plant is generally named as per the inputs used like thermal power plant use input as coal or oil, Gas power plant use input as Natural gas, Nuclear Power Plant use input as Uranium or thorium and so on. Some of these Power Plants like Solar Power Plant, Geo Thermal Power Plant, Wind Energy Power Plant and Hydro electric Power Plant are Power Plant with renewable resources. However except Hydro Electric Power Plants other Power Plants are very rarely available. As per the reports available Hydro Electric Power Plants constitute nearly 6.7 % of the Global Power Generation and 2.2 % of Power Generation globally is through renewable resources. However nearly 86 % of the world Power Generation is from fossil fuels or non renewable resources consisting of the following- Oil – 32.9 %, Coal – 30.1 % and Natural Gas 23.7 %

Power plant runs on rankine cycle. The efficiency of the power plant depends on the combined efficiency of boiler turbine and generator. The efficiency of generator is around 98%, boiler is 90% and in turbine the efficiency is around 45 to 50%. Thus, the combined efficiency of a power plant is around 40%. A lot of heat is rejected in the condenser which results to a lower efficiency of the turbine. As power plant runs on rankine cycle, the main aim is to improve upon the cycle efficiency. To improve the cycle efficiency, the pressure and temperature is increased to a value which present metals can withstand. Condenser back pressure is lowered as far as possible and condensed water from the condenser is heated up by extracting steam from the turbine before feeding it to the boiler. The heating of condensate water by extracting steam from turbine is done through in heaters which are called as regenerative feed heating process. This increases the efficiency of the cycle. In power plants, the heat released during combustion is to be used to the maximum extent possible. The heat transferred from combustion to steam and ultimately power generation is calculated by measuring the heat rate of the plant. Thus, heat rate of the plant is the amount of heat required in kCal to generate 1KWHr of power. This value indicates the efficiency of the plant and its equipment.

The flue gas loss in a Boiler is always higher than any other loss [1]. The flue gas loss is minimized by maximum heat extraction in the corrective surfaces of the broiler. The efficiency calculation by indirect method is the best way to account all the Boiler losses. The important step to improve the performance of Boilers was the detailed study of the broiler in the plant and then calculating the efficiency calculation. A marked improvement was observed in energy conservation and increase in overall efficiency of the plant when fly ash utilization - mentioned methods promise upto 60 percent of utilization, fuel switching – reduction in coal consumption by 1545 tonnes per annum, condenser tube cleaning – reduction in coal consumption by 360 tonnes per annum,replacement of bfp cartridges – upto 13,252 kwh of power saved per day, three element mode of operation – power savings per hour range from 40 – 130 kw per hour and converters for lesser loads – power demand goes down by 4.13 kva, improved power factor [2]. The factors affecting thermal cycle efficiency are the initial steam pressure, steam temperature, condenser pressure and regenerative feed water heating [3].

The designed heat rate of any power plant is calculated by the designer based on the different parameters taken during designing. The heat rate depends on the power plants steam parameters and the different equipments involved in power generation. As such, the heat rate for individual power plant may not be same. If the heat rate during operation is more than the designed heat rate, it indicates more energy is required to generate 1KWHr and the plant is running inefficiently. If the heat rate is nearly equal or lower than the designed heat rate it indicates that the plant is running efficiently. Hence, in all power plants, heat rates are continuously monitored to establish the condition and efficient running of the plant. If in a plant, the heat rate is 3000 Kcal/KWHr, it means to generate 1 KWHr of power, 3000 kcal of heat is required. Thus, the heat value of coal and the heat rate of the plant are regularly monitored and actions are taken to keep heat rate as close to design values.

The purpose of a heat rate monitoring and subsequent improvement is to maintain the heat rate as close to design value and to take steps whenever it is higher than the designed value of a unit. So, the present study was carried out to understand how improving the heat rate can have the benefits such as less expenditure on fuel, reduction of emissions to the environment, less ash produced and amount of wear on the equipment.Heat rate improvement will result in an increase in the net generation of the unit allowing the unit to run at a higher plant load factor [(actual generation/ generation capacity)*100]

II. METHODS

A. *Calculation of heat rate in a power plant*

The heat value of coal is measured as gross calorific value of coal or GCV and is denoted by Kcal/kg. Thus, GCV indicates the amount of heat which shall be released on burning of 1 kg of coal. This is the chemical energy released in the boiler. For complete combustion:-

$$C+O_2 \longrightarrow CO_2 + \text{heat (GCV)}$$

In Indian power generation, the GCV of coal ranges from 3000Kcal/kg to 5000Kcal/kg. This is the heat input to the boiler. Now the conversion of the heat input to the boiler determines the efficiency of the power plant. Thus, the heat rate measures the heat required to generate 1 KWHr of power.

Heat rate= Heat required to make 1KWHr power

The heat rate of a conventional coal fired power plant is a measure of how efficiently it converts the chemical energy in the fuel to electrical energy. This conversion is achieved in four major steps.

1. First, the chemical energy in the fuel is converted to thermal energy
2. Then the thermal energy gets converted to kinetic energy
3. The kinetic energy gets converted to mechanical energy and
4. The mechanical energy gets converted to electrical energy.

In each sub process, some energy is lost to the environment; some fuel may not be burnt completely, kinetic and mechanical processes form heat instead of electricity, etc. The heat rate of a power plant is the amount of chemical energy that must be supplied to produce one unit of electrical energy. If a power plant converts 100%of the chemical energy in the fuel to electricity, the plant would have a heat rate of 860 kcal/kwhr. But due to losses, a modern power plant would have a heat rate of 2200kcal/kwhr {ie, 40%efficient}.

Many factors affect the heat rate of the plant.

1. The initial design
2. Ambient conditions
3. Load factor
4. The fuel that is supplied
5. How the plant is operated and maintained.

B. *Heat Rate Generation in Durgapur Steel plant*

Unit heat rate:

A unit heat rate includes all heat inputs to the boiler. The heat input to the boiler should include all forms of chemical energy supplied and gross electrical generation. Heat rate monitoring is focused on identifying heat rate problems and then identifying and implementing corrective actions to eliminate the efficiency loss. The power plants today are becoming better and bigger only to reduce heat rate. Typically a power plant of the size of 1000MW has a heat rate of around 1900Kcal/KWHr. whereas, the design heat rate of NSPCL Durgapur, which is 60MW per unit is 2580Kcal/KWHr. This clearly indicates that the bigger sized power plants are more efficient and heat is efficiently transformed to power.

Generally the electrical efficiency is in the order of 99%. Thus it is not considered while calculating the heat rate. So the heat rate in a power plant is generally limited to the heat rate of boiler and the heat rate of the turbine. In all power plants, heat rates are carefully measured and the reasons for deviations if any are recorded. Actions are taken to reduce these deviations as far as possible, so that the plant runs at the desired efficiency. In boiler, heat rate depends on the following main problems:-

1. Dry Flue Gas loss
2. Loss due to combustible (un-burnt carbon) in ash.
3. Radiation loss
4. Loss due to moisture in coal.

Generally for higher size boilers operating at a pressure 275Kg/cm^2 or more and temperature 565^{o}C or more, the efficiency of boiler is 90-92% and thus total loss is 8-10%. Typically, dry flue gas loss is 4%, loss due to combustible in ash is 1%, loss due to moisture is 4% and unaccountable loss is 1%. In NSPCL the design loss for:

- Dry flue gas= 5.53%
- Combustible in ash= 1.07%
- Radiation loss=2.2%
- Total loss= 13.58%
- Efficiency of boiler= 86.42%

Monitoring of heat rate

Heat rate monitoring is done by measurement of certain parameters of turbine and boiler. In turbine steam pressure, temperature and flow along with feed water temperature and pressure is measured in boiler calorific value of coal. Flue gas exit temperature, chemical analysis of coal, unburnt in fly ash and bottom ash is measured. The steam and water parameters of boiler and turbine are taken from the control room instruments. The coal analysis along with unburnt in fly ash and bottom ash is done in a chemical laboratory.

Pressure measurements are done by pressure transmitters mounted on the line whose pressure is to be measured. Temperature measurements are done by RTD's/Thermocouples located in the line whose temperature is to be monitored. Flow measurement is done by differential pressure across a pipe line where flow exists. These transmitters are connected to digital indicators in the control room where all readings as required for heat rate calculations are available. The Chemistry Department collects the sample of coal and ash (both fly and bottom ash) and does the chemical analysis of coal and ash. This is reported daily by department of chemistry to control room so that heat rate monitoring is possible.

C. Turbine heat rate:

In turbine the heat rate for 1000MW plants is generally in the range of around 1700 Kcal/KWHr. The design value in NSPCL is 2246Kcal/KWHr. The main inputs for heat rate in a turbine are:

- Steam pressure and temperature.
- Steam flow
- Feed water temperature and pressure
- Make up water
- Condenser pressure and
- Sealing losses inside the turbine.

Heat rate variation due to steam pressure

If a turbine is operated at a pressure less than the designed pressure but at designed temperature, the enthalpy of steam is lower than the designed enthalpy. Hence heat energy available to steam turbine is less which is depicted in the diagram below. The loss of work done is also shown in the diagram. For running a turbine at a pressure less than the designed pressure, heat rate increases. Typically for each Kg/cm^2 the heat rate deviation is 1Kcal/KWHr..

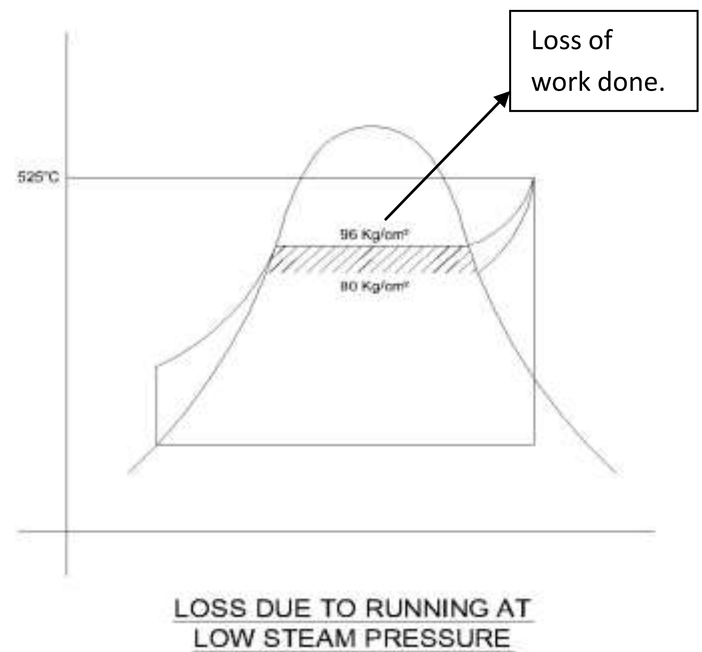

Fig. 1 Loss due to running at low steam pressure

Heat Rate variation due to steam temperature

If a turbine is operated at a temperature less than the designed temperature but at designed pressure, the enthalpy of steam is lower than the designed enthalpy. Hence heat energy available to steam turbine is less which is depicted in the diagram below. The loss of work done is also shown in the diagram. For running a turbine at a temperature less than the designed temperature, heat rate increases. Typically for each ^{o}C the heat rate deviation is 0.5 Kcal/KWHr..

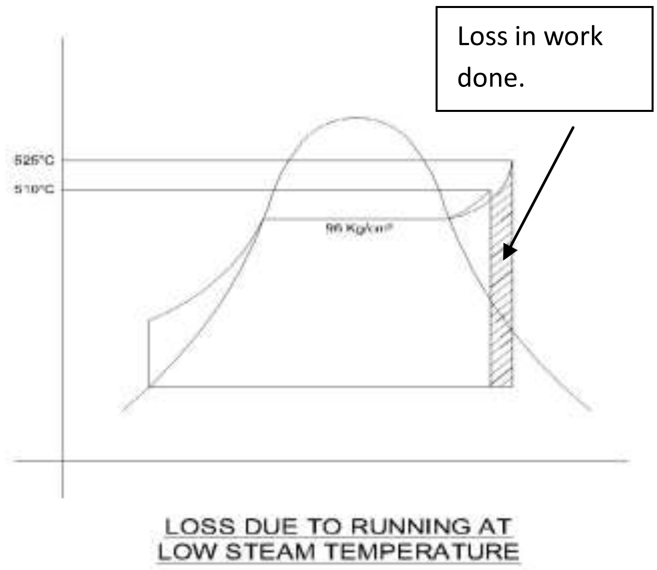

Fig. 2 Loss due to running at low steam temperature

Heat rate variation due to feed water temperature

If the feed water temperature at the entry of the boiler is less than the designed temperature there is a loss of work done and the heat rate increases which is depicted in the figure below. Typically for each °C the heat rate deviation is 1 Kcal/KWHr..

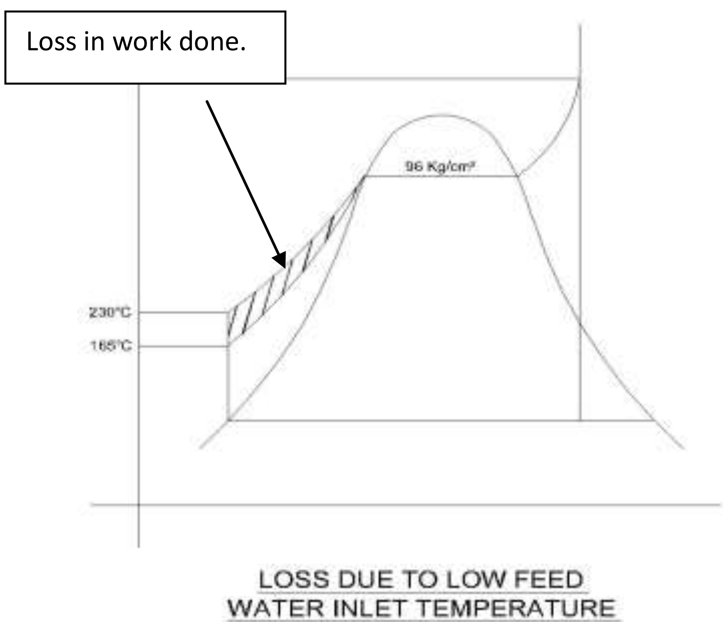

Fig. 3 Loss due to low feed water inlet temperature

Heat rate variation due to condensor back pressure

If a turbine is operated at a higher condenser back pressure than the designed value, then the work done is less and heat rate increases. This is depicted in the figure below. For 0.1Kg deviation the heat rate deviation is 14 Kcal/KWHr.

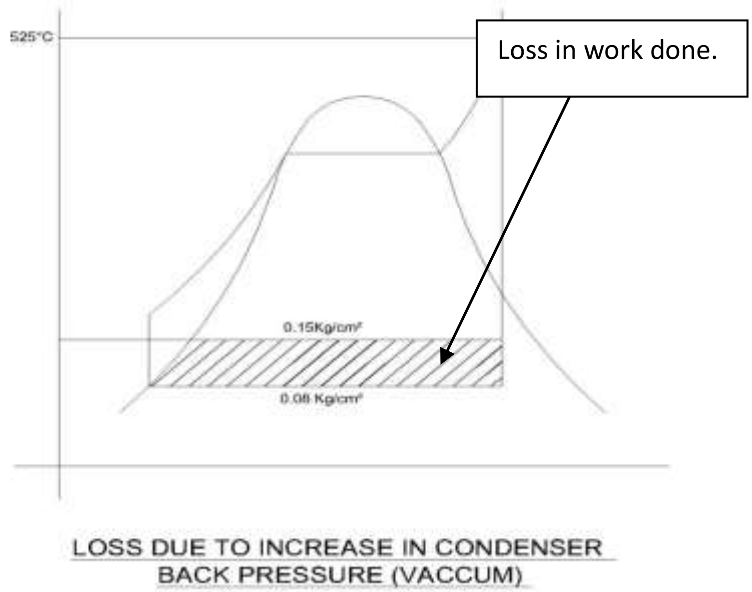

Fig.4 Loss due to increase in condenser back pressure

Heat rate variation due to steam flow and sealing losses.

If the sealing losses inside the turbine are more than some steam passes inside the turbine without doing any work. As such to get the same output, more steam is required. This increases the heat rate of the cycle as boiler has to generate more steam. If steam requirement increases by 1 tonne per hour then heat rate increases by approximately 5 Kcal/KWHr.

$Q=MCp(dt)$

As Q is directly proportional to M (mass) so heat rate increases as mass of steam increases.

Heat rate variation due to make up water

Make up water is given to take care of the steam losses in the system. The designer designs with no steam loss from the system. However practically it is very difficult to achieve 0 leakages. It is assumed that some leakages shall always be present in the system. To take care of the loss of steam make up water is added to the system. Heat is applied to convert water into steam. Any leakages involve the heat applied as loss of the system. Make up water is measured as percentage of the total steam required. For every increase of 1%make up the heat rate increases by 10Kcal/KWHr. The heat rate of turbine in NSPCL, Durgapur for 30th may and 9th june as taken from control room is given below.

Table: 1

mtpo&e106								
NTPC-SAIL POWER COMPANY (PVT.) LIMITED.								
HEAT RATE DEVIATION REPORT FOR			**30-May-15**					
Parameter	Unit	**Design Value**	**Unit-1**			**Unit-2**		
			Actual	Diff	HRD	Actual	Diff	HRD
TG Heatrate Deviation								
Load	MW	60	53.00	7.0		64.80	-4.8	
Main steam temp	ºC	525	525.00	0	0.0	517.50	8	3.4
Steam Press at Turbine I/L	bar-abs	91.2	91.20	0	0	93.50	-2	-2
Enthalpy of Steam I/L	Kcal/kg	823.54	823.62			818.52		
Total Steam Flow	T/Hr	232	233.00	-1		258.30	-18	
Feed water Temp at Eco I/L	ºC	230.8	215.20	16	13	231.50	-1	-1
Feed water Pr. at Eco I/L	bar-abs	118	103.00	15		110.00	8	
Enthalpy of Feed water	Kcal/kg	243	220.58			238.42		
Make up water consmp	T/Hr	0	1.00	1	11	3.70	3.70	34
Condenser Back Press.	Mbar	91.2	108.00	17	25	114.00	23	34
Aging Factor,sealing steam leakages,Partial Loading losses etc	Kcal/kg	0			356			2
TG Heat Rate (Gross)	Kcal/KWh	**2246**	**2651**	405	**405**	**2312**	66.23	**66**

Table:2

mtpo&e106								
NTPC-SAIL POWER COMPANY (PVT.) LIMITED.								
HEAT RATE DEVIATION REPORT FOR			**09-Jun-15**					
Parameter	Unit	**Design Value**	**Unit-1**			**Unit-2**		
			Actual	Diff	HRD	Actual	Diff	HRD
TG Heatrate Deviation								
Load	MW	60	53.00	7.0		63.40	-3.4	
Main steam temp	ºC	525	525.00	0	0.0	521.70	3	1.5
Steam Press at Turbine I/L	bar-abs	91.2	101.00	-10	-11	92.60	-1	-2
Enthalpy of Steam I/L	Kcal/kg	823.54	821.04			821.28		
Total Steam Flow	T/Hr	232	233.00	-1		256.00	-24	
Feed water Temp at Eco I/L	ºC	230.8	214.40	16	13	230.60	0	0
Feed water Pr. at Eco I/L	bar-abs	118	100.70	17		109.20	9	
Enthalpy of Feed water	Kcal/kg	243	219.69			237.42		

Make up water consmp	T/Hr	0	1.00	1	11	4.71	4.71	44
Condenser Back Press.	mbar	91.2	116.00	25	36	118.00	27	39
Aging Factor,sealing steam leakages,Partial Loading losses etc	Kcal/kg	0			347			28
TG Heat Rate (Gross)	Kcal/KWh	**2246**	**2644**	397.53	**398**	**2358**	111.42	**111**

In NSPCL,Durgapur on 30th may the turbine heat rate was 2651 Kcal/KWHr for unit 1 and for unit 2 is 2312Kcal/KWHR. And on 9th june the heat rate for unit 1 and unit 2 respectively were, 2644kcal/KWHR and 2358Kcal/KWHr. For unit 1 the difference in heat rate from designed value is 405 and 389Kcal/KWHr and for unit 2 the differences are 66 and 111Kcal/KWHr. Thus in unit 1 there is a lot of scope for improvement. On detailed analysis, it is observed that the maximum loss for unit 1 is due to sealing losses which is 356 and 347Kcal/KWHr. This loss is nearly 87.9% and 87.1%. whereas, for unit 2 the sealing losses are 2 and 28Kcal/KWHr. This loss is nearly 3.03% and 25.2%. So in unit 1 the sealing leakages are to be immediately attended. As per NSPCL these leakages can only be attended when the turbine is opened, which is already planned in the month of august 2015.

Heat rate deviation due to make up water is 11 in both the days. Whereas for unit 2 it is 34 and 44 for 30th may and 9th june respectively. The steam leakages have already been identified in both the units and shall be attended during available opportunities. In unit 2 the major contributor for heat rate deviation is make up water which is 39.6% of total heat rate deviation. As such it is expected that the deviations can be controlled by NSPCL. For condenser back pressure, the heat rate deviation is 25 and 36 for unit 1 in both these days respectively and for unit 2 is 34 and 39 respectively. It was checked that in the month of april, the heat rate deviation in both units where nearly 0. This implies the present heat rate deviation was due to very high ambient temperature along with very high humidity. It is expected that as soon as the weather improves the heat rate deviation for these parameters shall be under control. The heat rate deviations for other parameters are nearly negligible though actions have already been taken to minimize these deviations also. It is inferred that for unit 1 to improve heat rate deviation, as soon as possible, losses due to steam inside the turbine has to be attended along with attending the steam leakages outside. Fir unit 2 the main thrust shall be to attend to steam leakages outside.

It is worth mentioning that the plant is already run continuously for 25 years. As such steam leakage losses inside the turbine of around 50Kcal/KWHr is acceptable and unit 2 the heat rate deviation for these parameters is nearly equal to 50Kcal/KWHr. Hence it is difficult to get any improvement in this parameter for unit 2.

D. BOILER HEAT RATE:

The Boiler heat rate depends on:-

1. *Dry flue gas*

   Dry Flue Gas loss is the loss in boiler where flu gas is allowed to escape at a temperature of around 140^{o}C. the combustion temperature in the boiler is around 1300 to 1400^{o}C. heat from flue gas is extracted in superheaters, economizer and air pre heater. Flue gas contains sulphur dioxide which is the limiting factor for the temperature at which it can be thrown into the atmosphere. At below 80^{o}C sulphur dioxide combines with water vapour to form sulphuric acid. As such dry flue gas is released to atmosphere at temperatures quite above 80^{o}C. normally the exit temperature is 140^{o}C.

   As the flue gas per design is to be released to the atmosphere at 140^{o}C hence there is a heat rate loss which is incorporated in the design. For NSPCL Durgapur, the design loss for dry flue gas is 5.53%. for every increase in 1% of dry flue gas loss the heat rate deviation is around 30Kcal/KWHr.

2. ***C**ombustible in ash.*

   Coal contains ash which after combustion forms either fly ash or bottom ash. The fly ash is taken away along with the flue gas whereas the bottom ash falls at the bottom of the boiler and is removed separately. If complete combustion takes place then entire carbon in the coal shall get burnt and combustibles in ash shall be nil. However practically it is impossible to have complete combustion. As such combustibles in both fly ash and bottom ash are provided by the designer. Generally 80% of the ash is fly ash and 20% is bottom ash. In NSPCL the design value for combustibles in fly ash and bottom ash is 1.07%. For every percentage increase in combustibles, the heat rate deviation is around 30 Kcal/KWHr.

3. *Radiation loss*

The furnace temperature during combustion is 1300-1400^{o}C. Hence the entire inside of the boiler remains at a very high temperature. The boiler is completely insulated so that heat loss from the boiler to the atmosphere can be minimized. The design heat loss for radiation is 2.14%

4. *Loss due to moisture*

In coal, moisture is present in two forms- moisture due to water seepage over the coal which can be removed by slightly heating the coal. Also moisture is inherently present in the coal which cannot be removed easily. This moisture is released only during the process of combustion. As moisture does not add to any heat value during combustion as such, presence of moisture and converting it into water vapour is taken as a loss during combustion. The design loss due to moisture in NSPCL,Durgapur is 4.78%. Increase in moisture by 1% in coal results to a heat rate deviation of 30Kcal/KWHr.

Table:3

NTPC-SAIL POWER COMPANY (PVT.) LIMITED.								
HEAT RATE DEVIATION REPORT FOR			**05-Jun-15**					
Boiler Losses		**DESIGN LOSS**	**BOILER #1**			**BOILER #2**		
			Actual Loss %	Diff	HRD [kacl/kwh)	Actual Loss %	Diff	HRD
Dry Flue gas loss	%	5.53	6.68	1.16	38.2	6.32	0.79	21.2
Loss due to moisture+ H2	%	4.78	4.98	0.20	6.6	5.02	0.23	6.2
Loss due to unburnt gas	%	0.06	0.08	0.03	0.9	0.05	-0.01	-0.2
Loss due to combustible in Ash	%	1.07	4.27	3.19	105.0	4.20	3.13	83.9
Loss due to air moisture	%	0.24	0.24	0	0.0	0.24	0.00	0.0
Radition loss+unaccountable loss	%	1.9	2.1	0.17	5.6	2.12	0.22	5.9
Total losses	%	13.58	18.33	4.75	**156.24**	17.95	4.37	**117.08**
Boiler Efficiency	%	**86.42**	**81.67**			**82.05**		
Loss due to HRD of TG					**541.1**			**-55.39**
UNIT HEAT RATE = [TG HEAT RATE / BOILER EFF]	Kcal/ Kwh	**2599**	**3291**	692.19	**697.4**	**2682**	82.89	**61.7**

Table:4

NTPC-SAIL POWER COMPANY (PVT.) LIMITED.								
HEAT RATE DEVIATION REPORT FOR			**08-Jun-15**					
Boiler Losses		**DESIGN LOSS**	**BOILER #1**			**BOILER #2**		
			Actual Loss %	Diff	HRD [kacl/kwh)	Actual Loss %	Diff	HRD

Dry Flue gas loss	%	5.53	6.67	1.14	37.1	6.29	0.76	21.2
Loss due to moisture+ H2	%	4.78	4.90	0.11	3.7	4.93	0.14	4.0
Loss due to unburnt gas	%	0.06	0.08	0.03	0.9	0.05	-0.01	-0.2
Loss due to combustible in Ash	%	1.07	4.71	3.64	118.3	4.14	3.07	85.2
Loss due to air moisture	%	0.24	0.24	0	0.0	0.24	0.00	0.0
Radition loss+unaccountable loss	%	1.9	2.1	0.17	5.5	2.12	0.22	6.1
Total losses	%	13.58	18.67	5.09	**165.52**	17.77	4.19	**116.32**
Boiler Efficiency	%	**86.42**	**81.33**			**82.23**		
Loss due to HRD of TG					**490.0**			**43.30**
UNIT HEAT RATE = [TG HEAT RATE / BOILER EFF]	Kcal/ Kwh	**2599**	**3252**	652.64	**655.5**	**2775**	175.80	**159.6**

The heat rate deviation for boiler for unit 1 and 2 was taken for 5th june and 8th june. It is observed that for unit 1 heat rate deviation are 156 and 165Kcal/Kwhr. Whereas for unit 2 the losses are 117 and 116 kcal/KWHr. The pre dominant losses from above are dry flue gas loss and combustibles in fly ash. Losses due to combustibles are nearly 70% and losses due to dry flue gas are nearly 22%. As such nearly 90% of the loses are due to above parameters only.

Measures to be taken to control losses for dry flue gas.

The loss in dry flue gas is mainly exchange of heat from flue gas to air in air pre heater not taking place properly. There are lot of leakages inside the air pre heater which is contributing to these losses. Losses due to heat transfer in economizer and sperheaters is minimum. So NSPCL has taken up a plan to reduce the loss in air pre heater. In short term all seals shall be replaced during the next available opportunity and in long term the entire air pre heater shall be replaced to reduce the dry flue gas loss. In running condition except for maintaining all parameters, no other measure can be taken to reduce these losses.

Measures to be taken for to reduce losses due to combustible in ash

Losses for combustibles in ash are mainly due to improper combustion and carbon of coal not getting burnt completely. Unburnt carbon is found both in fly ash and bottom ash. The design unburnt in fly ash is 1% and the designed un burnt in bottom ash is 5%. In NSPCL the unburnt in fly ash varies from 2%-4% and for bottom ash varies from 6%-9%

The main reason for unburnt being high is improper combustion. Combustion depends upon

a) Volatile matter in coal
b) Fineness of the coal
c) Air distribution in the boiler
d) Amount of carbon present in the coal
e) Source of the coal

The major factors are the ratio of carbon to volatile matter and fineness. The carbon to volatile matter ratio should be in the range of 1.6-2 for best combustion and fineness should be around 200 mesh per 1 inch for 70% of coal. Presently in NSPCL, the fineness of the coal is within norms. The main reason for poor combustion is the source of coal where the ratio of carbon to volatile matter is more than 2. This is resulting to higher unburn in both fly ash and bottom ash. NSPCL is trying to change the sources of coal to reduce this ratio such that the combustibles in ash can be reduced. The air distribution to the boiler is also being studied and improved upon for better combustion. It is expected once better coal with carbon to VM ratio is available the loss due to combustibles in ash shall reduce considerably.

E. Total losses in NSPCL

A total loss in unit 1 is around 650Kcal/KWHr. Out of which losses in turbine is 400 and rest is in boiler. for unit 2 the total losses is around 175 kcal/kwhr out of which turbine losses are 36kcal/kwhr. Rest is in the boiler. so a major thrust is required in unit 1 turbine and in combustible loss in both units so that the deviations can be minimized.

Approximate loss in NSPCL DURGAPUR due to heat rate deviation

A chart showing approximate losses due to heat rate deviation in NSPCL Durgapur is given below.

Table:5

Impact of Parameters deviation on Unit Heat Rate for single unit

Parameters	Design	Deviation	↑ ↓	HR loss Kcal/Kwhr	Loss In Lacs/Year
Load	**60**				
Main Steam Pr before QSV	**91.2**	**1 ksc**	↓	**1.00**	**5**
Main Steam Temp before QSV	**525**	**1 deg c**	↓	**0.50**	**3**
FW temp at HPH-2 outlet	**230**	**10 deg c**	↓	**9**	**47**
Condenser Back Pressure	**0.089**	**10 mmbar**	↑	**13**	**67**
Make up water	**0**	**1.00%**	↑	**34**	**175**
Combustible in BA ash	**6**	**1%**	↑	**5**	**26**
Combustible in Fly ash	**1**	**1%**	↑	**23**	**119**

*** considering 1 kcal cost 0.1 paisa, and Unit sale price 4/-

1 kcal/Kwhr / annum savings for the station is equivalent to Rs10 lacs

In unit1 total losses is arund 650Kcal/KWHr. As such saving potential for unit 1 is 6500 lakhs per annum and for unit 2 the heat rate 175 kcal/KWHr and saving potential is Rs. 17500 lakhs.

III. CONCLUSION

Heat rate monitoring and adherence is directly related to the profitability of a power plant. The study shows that there is a potential of Rs. 82 crores per annum. For NPCL Durgapur, if the heat rate can be brought down to design value. Actions have been initiated to reduce the heat rate. However lot remains to be done to bring down the heat rate.

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