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Heat Rate Deviation and Factors Affecting

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ABSTRACT

Heat rate deviation and factor affecting heat rate is a review. This topic is useful for improving thermal power station efficiency. These parameters are obtained from 250 MW TPS paras manual (ref. 250 MW BHEL manual). Being a In-charge of Paras training sub center from 2011 to 2015 different activities of Quality Circles were carried out at this training sub center. Operation section teams and maintenance section teams were working and are working on Quality Circle. Factors affecting heat rate is divided into two factors. 1. Controllable factor and 2. Un-controllable factors like coal quality and ageing. Controllable factor as per name can be control. Operation team continuous watching the controllable parameters like M.S. pressure, M.S. temperature, HRH temperature and try to maintain the design parameters. Other controllable parameters like Condenser Vacuum, Less Economizer Inlet Temperature, Higher Flue Gas Outlet Temperature for Air Heater, Un-burnt in Fly-Ash & Bottom-Ash, Un-burnt in Bottom-Ash, Reheat Spray, Leakages, Air ingress control by caring out quality Maintenance work by concern section Quality circle team by utilizing Quality Circle tools to achieve TPS / MSPGCL/MERC Target.

1. INTRODUCTION

HEAT RATE is defined as "the sum of chemical energy that must be supplied to generate one unit of electricity". For TPS: Heat Rate = Turbine Heat Rate divided byBoiler efficiency.The consumption in terms of Kilo calories we have to spend to get a unit of electricity (1 Kilo Watt Hour) is called as HEAT RATE. It is expressed as Kilo calories per KWH. The values of Turbine Heat Rate as per LOAD are given by Designer in the table below.

Boiler Efficiency =86.41% or 0.8641.It remains more or less same with Load variation.

LOAD	TURBINE HEAT RATE (Kcal/Kwh)	UNIT HEAT RATE(Kcal/Kwh)
125 MW	2148	2485
150 MW	2060	2383
200 MW	1985	2297
250 MW	1936	2240
264 MW	1928	2231

Note: MERC has given a target HEAT RATE of 2500 Kcal./Kwh.

Deviation of Heat Rate from design value can be classified as:

- Deviation in Heat Rate due to Non-controllable factors like Coal quality, ageing etc.
- Deviation in Heat Rate due to Controllable factors.

2. CONTROLLABLE FACTORS AFFECTING HEAT RATE

Controllable factors causing heat rate deviation are identified as below:

- MS Pressure.
- MS Temperature.
- HRH Temperature.
- Condenser Vacuum.
- Less Economizer Inlet Temperature.
- Higher Flue Gas Outlet Temperature for Air Heater.
- Un-burnt in Fly-Ash & Bottom-Ash.
- Un-burnt in Bottom-Ash.
- Reheat Spray.
- Leakages, Air ingress.

2.1 Optimization Of Heat Rate

To optimize the heat rate following parameters are mostly monitored and maintained near to design value.

S.no.	Particulars	Expected Value
1.	**Operating Boiler Efficiency**	86.41
	Un-burnt Loss	2.00%
	Dry Flue-Gas Loss	3.85
	Coal Quality Loss	5.23
	Gross CV of Coal kcal/kg	3400 kcal/kg

2.	**APH Performance**	
	O_2 at APH inlet	3.5%
	O_2 at APH outlet	4.75%
	Flue-Gas at APH inlet	325 ^{0}C
	Flue-Gas at APH outlet	134 ^{0}C
	Air temperature at APH inlet	38 ^{0}C
	Air temperature at APH outlet	304 ^{0}C
	Gas side efficiency	64%
	Air-in efficiency	7.69%
	Excess Air	20%
3.	**Condenser Performance**	
	CW inlet temperature	31 ^{0}C
	Vacuum	680 mmHg
	Cleanliness factor	85 %
4.	**Turbine Performance**	
	MS Pressure	*150 kg./cm^2
	MS temperature	540 ^{0}C
	HRH temperature	540 ^{0}C
5.	**HP Heaters Performance**	
	Economizer inlet temperature	247 ^{0}C
6.	**DM consumption**	
	DM make-up	3%
7.	**RH spray**	0%
	OLCC (On line condenser cleaning)	In-service

Out of the above mentioned factors, Controllable factors again can be classified as

- Operator controllable factors
- Maintenance controllable factors

2.1.1 Operator controllable factors

- MS Pressure
- MS Temperature
- HRH Temperature

All above parameters are generally maintained by operator unless and until he is instructed by some authority for maintaining less pressure or temperature for some reason or the other.

2.2 CONTROLLABLE FACTORS AFFECTING HEAT RATE QUANTIFIED

S.No.	Factor	Deviation in Units	Heat rate Deviation in Kcal/KwH (approx.)
	Operator controllable factors		
1.	MS Pressure	1 kg/cm^2	1.2
2.	MS Temperature	1^{0}C	1.2
3.	HRH Temperature	1^{0}C	1.8
	Maintenance controllable factors		
4.	Condenser Vacuum	1 mmHg	2.2
5.	Economizer Inlet Temperature	1^{0}C	1.77
6.	Flue Gas Outlet Temperature in APH	1^{0}C	2.02
7.	Un-burnt in Fly ash	1 %	26.3
8.	Un-burnt in Bottom Ash	1 %	3.1
9.	RH Spray	1 Ton/Hr.	4.0

3. MAINTENANCE CONTROLLABLE FACTORS

3.1 Deviation due to Condenser Vacuum

Deteriorated condenser performance is the major cause for low vacuum. Following checks helped to improve Condenser Vacuum:

- Ensure proper distribution of water on cooling towers.
- Ensure for the correct cooling water flow to the condenser.
- Periodic Sulphuric acid cleaning of condenser tubes/online condenser cleaning.
- Ensure proper cascading of HP/LP Heaters to reduce heat dumped to condenser.
- Ensure that all unnecessary drain valves, dumping steam to the condenser are closed and not passing. eg. Extraction Line drains, Casing Drains etc.
- Condenser Leak Test carried by filling condenser up to condenser top joint. (This is generally carried out after overhaul)
- Ensure that air ingress into condenser is minimized.

3.2 Deviation due to less Economizer Inlet Temperature of Feed-Water

- If feed water temperature at Economizer Inlet is less than expected more heat addition is needed in boiler and the same affects heat rate. Corrective steps to be taken for getting desired feed water temperature at Economizer inlet was pinpointed after analyzing/calculating temperature rise in individual heater, Feed storage tank,Gland Steam Cooler etc.
- Incorrect cascading, throttled extraction valves, passing of H.P.Heater group bypass valve contribute to less temperature at Economizer inlet than expected and should corrected accordingly to the possible extent.

3.3 Deviation due to Higher flue Gas outlet Temperature for APH

First following needs to be checked.

- APH basket condition.
- APH Soot blowing Pressure.
- APH soot blowing frequency. Second improper combustion may be the reason which should be viewed separately.
- Improper combustion may be the reason for higher flue gas temperature at APH inlet itself. As regards APH, it may be noted that almost all boiler side calculations done with ON LINE instruments are misleading to great extent when APH seal leakages are more**.**

APH seal leakages can be said be more if O_2% at APH outlet minus O_2% at APH inlet is more than 1%. Air Heater seal leakages affects boiler performance in following ways.

- I.D. Fan gets overloaded due to mixing of fresh air in flue gas.
- Combustion air requires is more as only a part of air measured by instrument reach furnace combustion.
- Flue Gas temperature at APH outlet is reduced due to mixing of fresh air.

4. DEVIATION DUE TO UNBURNT IN FLYASH & BOTTOM ASH

Different factors causing un-burnt in Fly-ash & Bottom-ash needs to be attacked to bring down this deviation to minimum. Few of them are as follows:

- Aux. Air Damper condition &operating range.
- Coal Burner conditions.
- Coal Mill internal condition.
- Coal Mill fineness (+50 mesh particularly).
- Excess Air supplied to boiler.
- Air Heater Seal leakage.
- Coal Mill combination.
- Unequal Air Fuel Flow through mill corner pipes.

As regards to these deviations it should be kept in mind while optimizing that deviation of 1% un-burnt in Fly-ash causes heat rate to deviate by 28.3 Kcals/Kwh as against 3.1 Kcal/Kwh for 1 % deviation due to un-burnt in Bottom-ash.

5. DEVIATION DUE TO RH SPRAY

- Lower mill combination, proper coal mill fineness optimized air fuel ratio, proper soot blowing pressure and frequency may help to reduce RH spray.
- Apart from above factors for reduction of Heat Rate, some more checks/conceptshelped to reduce Heat Rate.

6. ZERO INGRESS CONCEPTS

- Creating awareness for reduction of steam/hot water as well as hot flue gas leakages helps to reduce heat rate.
- Air ingress to furnace from peep holes must be reduced to possible extent as the same leads to unaccounted air to furnace and results in overloading of I.D. Fans.
- Air ingress to the system through ESP Hoppers/ESP inspection doors (particularly when hoppers are empty) causes overloading of I.D. Fans.
- This method for Heat Rate improvement was used for old units also where design values are not available.

7. CONCLUSIONS

Controllable factors causing heat rate deviation can be controlled. Un-controllable factors causing heat rate deviation may be due to coal quality or ageing.

8. REFERENCES

[1] 250 MW TPS Manual
[2] 250 MW BHEL Manual