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## Topic 2

### Did you know that, ...

Under normal circumstances the system efficiency of a power plant may be improved only by 0.5% to 1% through additional energy efficiency measure.

### Can you tell us, ...

There are success stories and reports about power plants in India that reduced Gross Heat Rate i.e. specific energy consumption per kWh generated, by 20% within 1 year.

**Yes** it is true that under normal circumstances, the system efficiency of a power plant may be improved only by 0.5 % to 1%, as the overall power plant efficiency calculations includes the losses in the condenser, which is maximum for a steam cycle (or combined cycle) power plant, and mostly this system operates up to the expectation and nothing much can be done, if already the power plant has a good maintenance management system. The Turbine and Generator efficiency cannot be increased much. So the efficiency gain comes from the different measures like reducing the boiler losses by taking various actions in this regard.

$$\text{Gross Unit Heat Rate} = \frac{\text{Gross Turbine Heat Rate}}{\text{Boiler Efficiency}}$$

**Heat Rate** depends on a lot of factors, including the boiler efficiency. It not only depends on the boiler efficiency but the other factors like Steam temperature, Flue gas losses, Make up losses, Unburnt carbon losses, Fuel properties and overall the **Ageing factor of the TURBINE**.

If the conditions are already up to the maximum achievable limits, it may not be possible to reduce the heat rate by as much as 20%. But if the plant is not being maintained up to the mark and the operational parameters are not being maintained, it is certainly possible to do by taking various measures.

### **First: Ageing of Turbine**

The manufacturers guaranteed heat rate for equipment like Turbine also has a gradually aging tendency. **The ageing increases the heat rate**. This heat rate deterioration is on account of increase of clearances, disturbing of seals; deposits on turbine blade etc. **To arrest the deterioration and to bring back the heat rate to its design value the only solution available is to take the turbine under Capital Overhaul**. If flow path correction, re-adjustment of clearances between the stationary & moving parts, refining if required will help in bringing back the heat rate to its original value. **The quality of work carried out during the overhaul, will play vital role in heat rate improvement**. The turbine heat rate is further affected by boiler efficiency to arrive at the station heat rate. Similar exercise carried out at the boiler to improve efficiency will resulting heat rate improvement in station. The equipment like turbine has a gradually ageing tendency. The ageing increases the heat rate over a period of time.

**As per BHEL**, after the major overhauling, the turbine performance is considered to be as good as new turbine and the ageing calculation again starts from the commissioning of the turbine after the major overhaul.

### **Second: Parameters other than ageing of turbine, which affects the Gross Heat Rate.**

For a designed **250 MW** unit, the approximation of the parameters can be as follows:

1. **Main Steam and Reheat temperature:**  
**For every 1 °drop in Main Steam/ R H temperature than the designed value of 537 °C, causes a heat loss of approx 0.67 KCal/KWh,**
2. **Main Steam Pressure**  
**For every 1 KG/CM2 drop in Main Steam Pressure at Turbine Inlet than the design value i.e 150 KG/CM2 causes a heat loss of approx. 1.31 KCal/KWh**
3. **Flue gas temperature**  
**For every 1 °C rise in Flue gas temperature at Air Preheater outlet than the design value i.e 134 °C causes a heat loss of approx. 1.13 KCal/KWh**

The Inputs required for Calculation of Heat Rate are:

Load (MW)
MS flow (Feed water flow to Eco.) ton/h
MS temperature Deg C
MS pressure kg/sq.cm
Reheater Flow ton/h
CRH temperature Deg C
CRH pressure kg/sq cm
Reheater temperature Deg C
Reheater Pressure kg/sq cm
FW Temp. at Eco.inlet Deg C
FW pre. Eco.inlet kg/sq.cm
Condenser vacuum
Auxiliary Power Consumption %
MS/CRH/HRH/FW Enthalpy kJ/kg K

By using these inputs **actual heat rate** is calculated. If a power plant is maintaining these parameters up to the maximum possible conditions and there is no scope for further improvement, it may not be possible to improve the heat rate any further by a larger extent, although the conditions are not always ideal and there is always a scope for improvement somewhere or the other.

If the power plant is old or not being maintained properly or even the operational parameters are not being monitored properly, surely the heat rate will go up for that plant. Then by proper monitoring and control and by following a stringent maintenance management system, the parameters can be improved to have a moving trend towards achieving the design value and this will lead to improvement (reduction) in the heat rate for that plant.

So it is not such that heat rate cannot be reduced by 20%. The only thing is that it totally depends on the operating condition of the plant and a will to achieve that.

**There are instances where not only heat rate but also several other parameters have been improved by a large extent by NTPC in the cases where it has taken over the plants from SEBs.**

### Third: Loading of the plant

This factor also plays a very important role in the gross unit heat rate of the power station.

Generally a power plant operates consistently at full or rated capacity, as it feeds to the grid or sell the power to a larger base of consumer like State Electricity Boards and the load variation is much less, unless otherwise necessary. **So maintaining the various parameters required for obtaining a good heat rate is not a much problem, assuming the other conditions in the plant being good.**

But in the plant like ours, the generation has to be varied as per the demand of the consumers, which have a general tendency to fall down during night hours and again move up in the morning hours, especially in the winter season. So to match the demand, the power station has to back down the generation below the rated capacity of the plant (say our load goes down to 420-450 MW, whereas the rated capacity is 500 MW) during night hours and again move up in the day time.. During this process of variation of load, while going down or going up, the parameters affecting the HEAT RATE cannot be kept at the constant level, as the demand have to be matched with the generation at every point of time. So a variation occurs in the various parameters affecting the Heat Rate. In this condition it is very difficult to control the heat rate and keep it down to the expected level. As we have seen above the affect of variation of some parameters on the heat rate, it can be easily understood that the variation in these parameters is going to deteriorate the heat rate rather than to lower it. So this factor cannot be neglected.

### Fourth: Average load of the plant.

Also if the plant is run at a lower load than its rated capacity, not only the other parameters will be affected but also the auxiliary power consumption of the plant will be higher than the somewhat designed aux power consumption, which will affect (increase) the sent out heat rate, the calculation and projection of which is

still not prevalent in case of Indian power plant. In foreign countries, this factor is very well taken into account for the calculation and benchmarking purposes.

So overall it can be seen that Whether the HEAT RATE CAN BE IMPROVED & TO WHAT EXTENT, depends totally on several factors related to the calculation of Heat Rate and not a single factor. But yes, it is true that that still a lot of plants are there in India, whose heat rate can be improved, if so desired by taking various actions, as is clear from the above explanation.

### **Fifth: Tripping of the Unit**

Last but not the least is the condition of unit tripping. If by proper monitoring, maintenance and other preventive measures, the trippings are brought to the minimum, the heat rate improvement can be achieved. After the tripping, when the unit is lighted up again, a loss called Start up loss come into picture, which increases the heat rate as the quantum of loss increases.

So if avoidable Unit trippings are arrested, this loss will become less and the improvement in Heat Rate can be achieved.

Thus we can see that the various conditions, under which there is deterioration in the Heat Rate, can be possibly controlled to improve this important aspect of a power plant.

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