OPTIMISATION OF STATION NET HEAT RATE IN PARTIAL LOAD OPERATION

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ABSTRACT

The need for running units in partial load operation has become inevitable due to ABT & surplus power in the grid. Now the real challenge for generating stations is to maintain Heat rate & Auxiliary power consumption (APC) during partial load operation. For maintaining the heat rate & Auxiliary power consumption (APC) in partial load operation, strategies like sliding pressure mode operation, Reduction of ΔP across FCV, using of VFDs & stopping of auxiliaries based on load condition are being followed.

In most of the stations, more than one unit are connected to the grid and maintain the ABT schedule as combined commitment. This paper analyses the Boiler efficiency (η_b), Turbine heat rate (THR) & Auxiliary power consumption(APC) at various loads. Using the data the best combination of sharing of loads by the units in partial load are identified with optimal Average unit net heat rate (AUHR) & maintaining ABT schedule.

By optimisation of Average unit net heat rate(AUHR), Station Net Heat rate (SNHR) will get optimised & Cost of production of per unit power will also significantly trim down.

KEYWORDS

Boiler Efficiency(η_b), Turbine heat rate(THR), Auxiliary power consumption(APC), Average unit net heat rate (AUHR), Unit auxiliary consumption(UAC), Station auxiliary consumption(SAC), Station net heat rate(SNHR)

1. INTRODUCTION

All thermal power plants are designed to give maximum efficiency in their full load operation. Nowadays because surplus power in the grid & uneven TOD (Time of Day) pattern in Power demand, it is necessitated to run the unit at partial load based on ABT schedule. In this paper, the study was conducted by taking into account the Stage-1 units of Thermal power station-2, NLC INDIA LIMITED, Neyveli. Stage-1 consists of 3x210MW units. Initially during surplus power in the grid, load reduction was up to 75% of its capacity now it has been reduced to 70%.

By varying the load from 150 MW to 210 MW at the interval of 10 MW Boiler Efficiency(η_b), Turbine heat rate (THR) & unit auxiliary power Consumption (UAC) and Unit net heat rate were calculated & analysed.

By assuming the same trend of unit net heat rate in all three units, the optimum combination of load sharing by all the three units in partial load were computed. Based on the results the optimum value of Average unit net heat rate (AUHR) in partial load operation was arrived. By optimising Average unit net Het rate(AUHR), Station Net Heat rate(SNHR) get optimised.

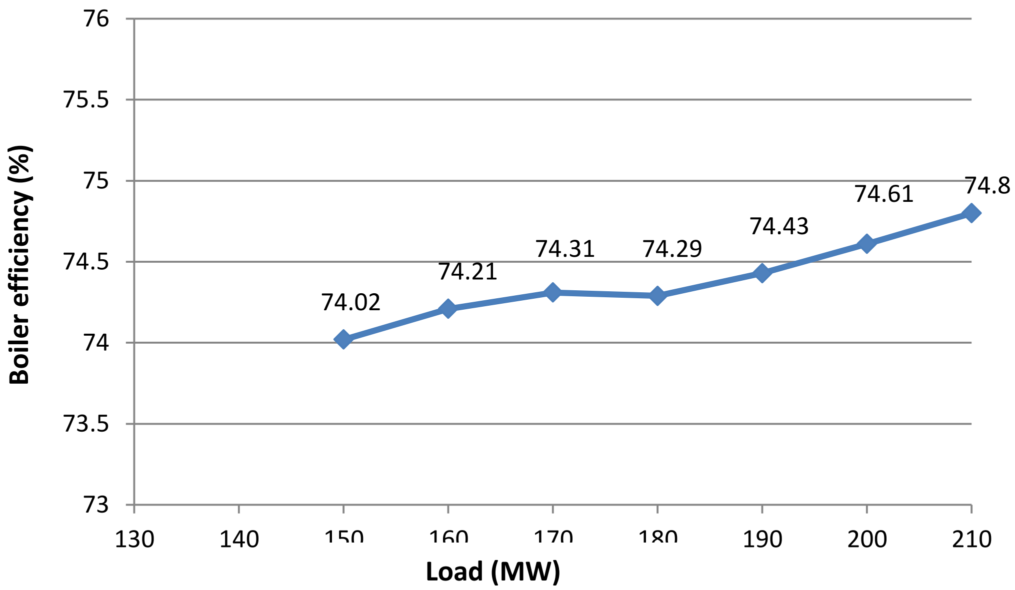
2. BOILER EFFICIENCY(η_b):

NLC's Thermal power station-2, stage-1 boilers are of capacity 210 MW lignite fired boilers. Lignite is having 50% moisture and 7% Ash. Boilers are designed for the efficiency of 77%.

Boiler Efficiency (η_b) decreases marginally from 74.8% to 74.02 % for the load variation from 210 MW to 150 MW. As load decreases, O2 % increases and flue gas temperature decreases at ID exhaust. Hence a marginal decrease in boiler Efficiency is observed.

2.1 LOAD VS BOILER EFFICIENCY (η_b)

Figure-1

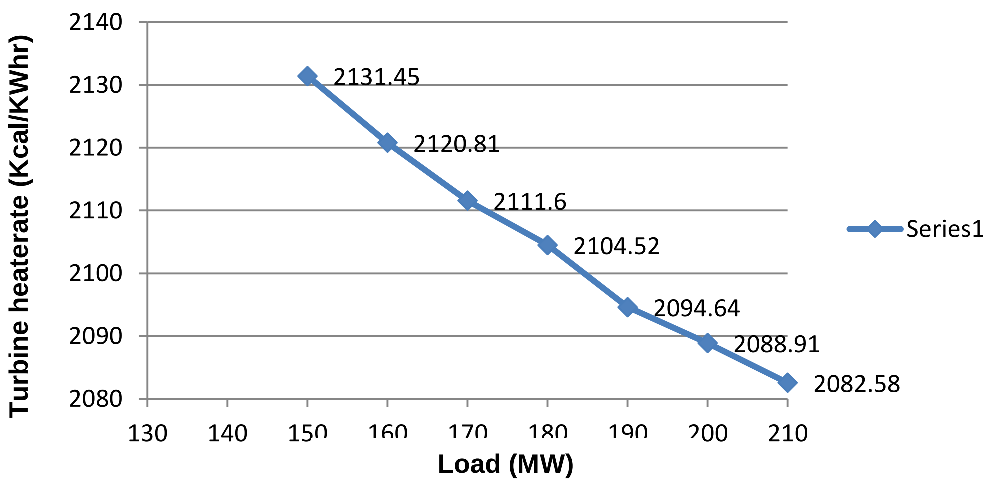


3. TURBINE HEATRATE(THR)

Turbine heat rate(THR) increases marginally from 2082 Kcal/KWhr to 2131 Kcal/kWhr for the load variation from 210MW to 150 MW. As the load decreases, HP turbine efficiency decreases but due to increase in condenser vacuum, LP & IP turbine efficiencies increase.

3.1 LOAD VS TURBINE HEAT RATE(THR)

Figure-2



4. AUXILIARY POWER CONSUMPTION (APC)

Auxiliary power consumption(APC) is the amount of power consumed by auxiliary equipments in the unit & Station. Most of the unit auxiliary equipments are in continuous service while the unit is in service. Station auxiliaries are having uneven TOD (time of Day) running pattern. To identify & analyse the performance of the unit, it is better to take Unit Auxiliary consumption(UAC).

4.1 UNIT AUXILIARY CONSUMPTION (UAC) OF STAGE –I LIGNITE FIRED POWER PLANT

Table-1

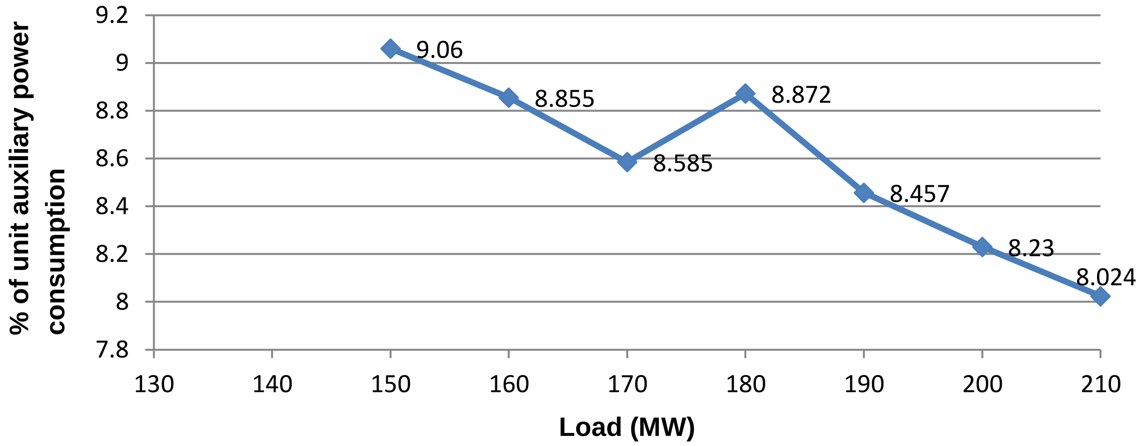
Equipments	210MW	
	% Gen	% UAC
BFPs	2.55	31.80
CEPs	0.20	2.50
CWPs	1.20	15.00
ID fans	1.62	20.25
FD fans	0.58	7.25
Mills	1.25	15.63
Excitation	0.33	4.13
others	0.29	3.63
Total	8.02	100

**APC of stage-1, Thermal Power station-2 is 9.6% (including both unit & station loads)*

For lignite pulverisation Beater wheel type mill is used. The Beater wheel mill draws hot flue gas from the furnace through a resuction duct. Five out of six mills will be in service for normal operation. Before the lignite enters the mill, some moisture is removed from lignite by hot flue gas. Mill acts as pulveriser & fuel pumping equipment. Air required for combustion is supplied by FD Fans .This is the reason for higher auxiliary consumption in Mills & FD Fans.

4.2 LOAD VS % OF UNIT AUXILIARY POWER CONSUMPTION (UAC)

Figure-3



For the load variation from 210 MW to 150 MW, Unit Auxiliary Consumption (UAC) varies from 8.02% to 9.06%. At the load of 170 MW there is a sudden drop of 0.5% in auxiliary power consumption. 0.25 % of auxiliary power consumption drop is due to stopping of 5th mill and another 0.25% is due to reduction in loading of FD & ID fans.

5. UNIT NET HEAT RATE:

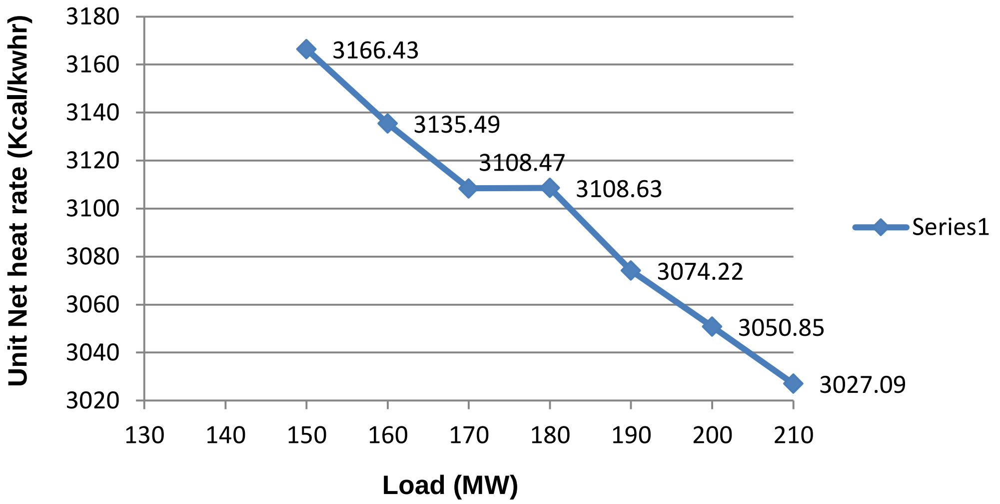
Unit Net heat rate is the amount of heat required in Kcal to generate & supply one KWh of power at the exit of Generator transformer. Unit net heat rate is used to measure the performance of the unit. It includes the performance of Boiler, Turbine & Unit auxiliaries.

Table-2

Load(MW)	**210**	**200**	**190**	**180**	**170**	**160**	**150**	**170 (5mills)**
Boiler Efficiency (%)	74.8	74.61	74.43	74.29	74.31	74.21	74.02	**74.27**
Turbine Heat rate (kcal/kWhr	2082.58	2088.91	2094.64	2104.52	2111.6	2120.81	2131.45	**2111.24**
UAC (%)	8.024	8.23	8.457	8.872	8.585	8.855	9.06	**9.09**
Unit net heat rate (Kcal/kWhr	**3027.09**	**3050.85**	**3074.23**	**3108.64**	**3108.47**	**3135.5**	**3166.44**	**3126.89**

5.1 LOAD VS UNIT NET HEAT RATE

Figure-4



Unit net heat rate increases with decrease in load. At the load of 170MW slight increase in trend was observed due to stopping of 5th mill.

6. ANALYSIS OF UNIT NET HEAT RATE VS LOAD VARIATION

Table-3

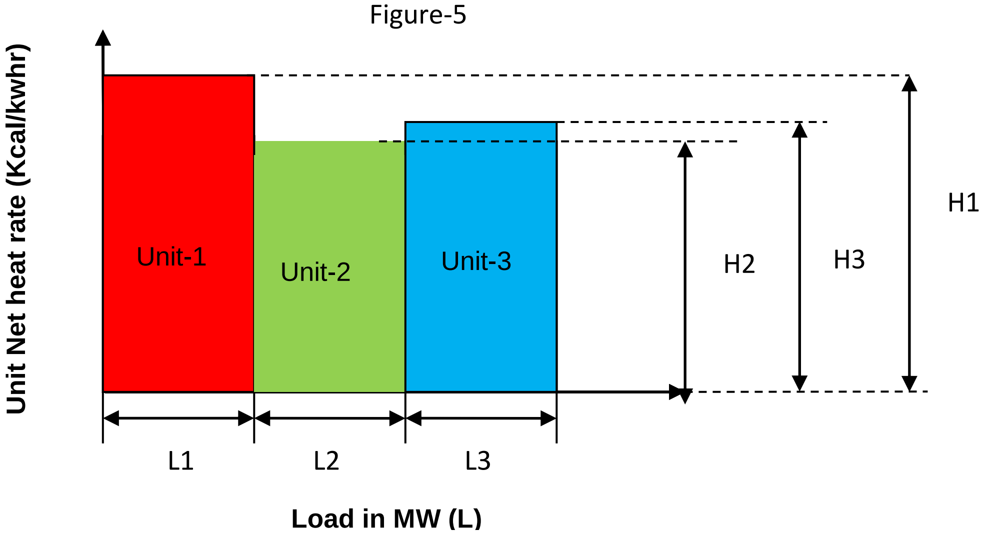
Load variation	210-200	200-190	190-180	180-170	170-160	160-150
Heat rate variation	23.76	23.38	34.41	-0.17	27.03	30.94

- As the load decreases, unit net heat rate increases. Unit net heat rate variation with load is uneven.
- For the load range from **180 MW to 170 MW** a small decrease in heat rate is due to stopping of 5th mill.
- No appreciable change in Heat rate variation from 210 MW to 190 MW, but from 190 MW to 180 MW the rise in heat rate variation is due to increase in variation of %UAC.
- Heat rate variation raises from 170 MW to 160 MW & from 160 MW to 150 MW. This is due to rise in turbine heat rate & %UAC variation. In 160-150MW Boiler efficiency also decreases.

7. COMBINATION OF SHARING OF LOADS

In stage-I all three units combined as a single entity & ABT schedule is being maintained among these units. Total area under this plot is the total heat required to generate total energy.

Figure-5



L1= Load in Unit-1 H1=Unit net heat rate in Unit-1

L2=Load in Unit-2 H2=Unit net heat rate in Unit-2

L3=Load in Unit -3 H3 =Unit net heat rate in Unit-3

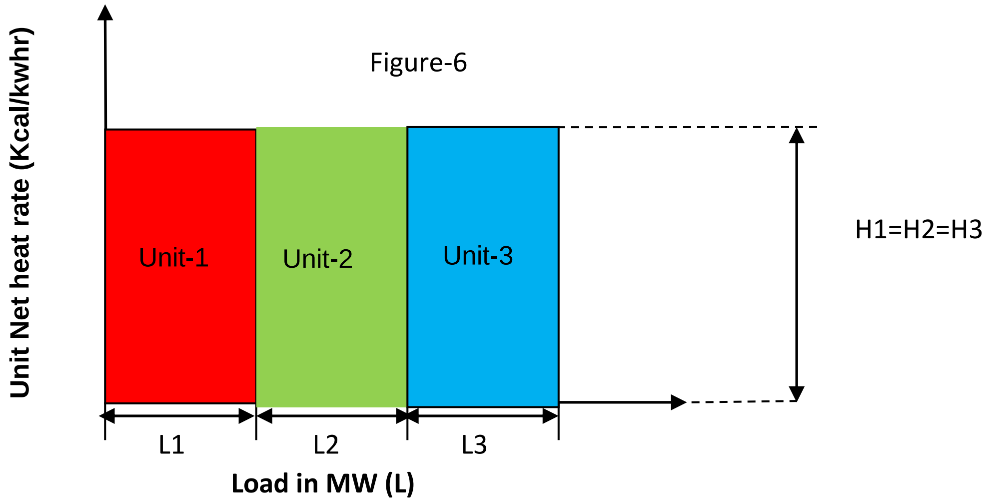
Total load = L1+L2+L3 (Equation-1)

Total heat = L1 x H1+L2 x H2+L3 x H3 (Equation-2)

Average unit net heat rate(AUHR) = Total heat / Total load

7.1 CASE-1

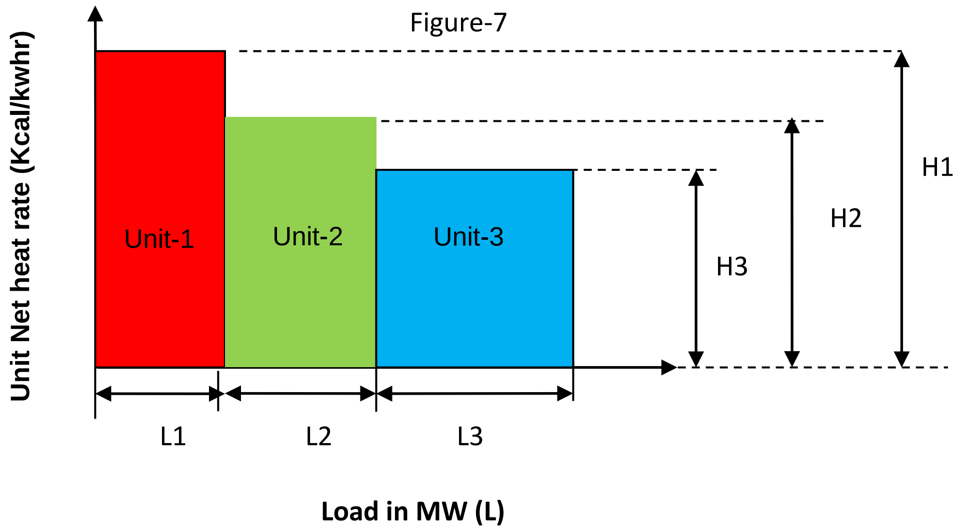
Considering three units as a single entity, it needs to generate 570 MW as per ABT schedule and distributing the load evenly to all three units.



L1= L2=L3	= 190 MW
H1=H2=H3	= 3074.23 MW
Total heat	= 3xL1xH1
	= 3x3074.23x190
	= 1752311.1x10^3 Kcal
Average Net heat rate(AUHR)	= Total heat/Total load
Average net heat rate (AUHR)	=1752311.1x10^3/570x10^3
	=3074.23Kcal/kWhr

7.2 CASE-2

Considering to spilt the load as: Unit-1=170 MW, Unit-2 =190 MW & Unit-3 =210 MW



L1= 170 MW	H1= 3108.47
L2=190 MW	H2= 3074.23
L3=210 MW	H3= 3027.09
Total heat	= L1xH1 + L2xH2 + L3xH3
	= 170x3108.47+ 190x3074.23 + 210x3027.9
	= 1748232.5x10^3 Kcal
Average Net heat rate(AUHR)	= Total heat/Total load
Average net heat rate (AUHR)	= 1748232.5x10^3/570x10^3
	= 3067.07 kcal/kWhr

By this way of distributing the load a saving of 7 kcal per kWhr power generation can be achieved. In case of load distribution like 200/190/180MW, the optimum heat rate could not be achieved due to uneven heat rate variation in 180MW. If the generation is 400 MW in two units, it is better to chose 210 MW &190 MW, rather than 2x200MW each. This is due to uniform variation from 190MW to 210MW. If the units are operating from 185 MW to175 MW with 5 mills, the heat rate variation will be higher. During that condition we can rise load the in one unit & reduce load in other unit and stop 5th mill in one unit thereby saving in Unit net heat rate & Unit Auxiliary power consumption. Similarly running of units in the range of 160MW-150MW will result in higher heat rate variation even in 4 mill condition. This may be further improved by studying variation in all the three units. Hence optimisation at better combination of load can be achieved.

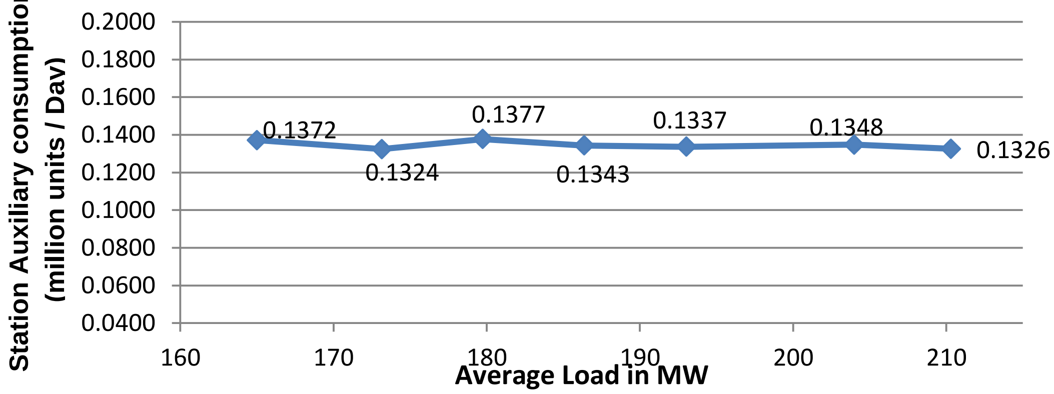
8. STATION NET HEAT RATE(SNHR)

Station heat rate(SNHR) is the best way to quantify the performance of Station which comprises one or more number of units. Station net heat rate is defined as the amount of heat required for the station in Kcals to supply one KWhr of power to the grid.

Station Net Heat Rate (SNHR) can be computed from the Average unit net heat rate (AUHR) and Station auxiliary power consumption(SAC). Station Auxiliary power Consumption (SAC) is having an uneven TOD Pattern. For analysis purpose the Station Auxiliary Consumption (SAC) is taken for the day at various average loads.

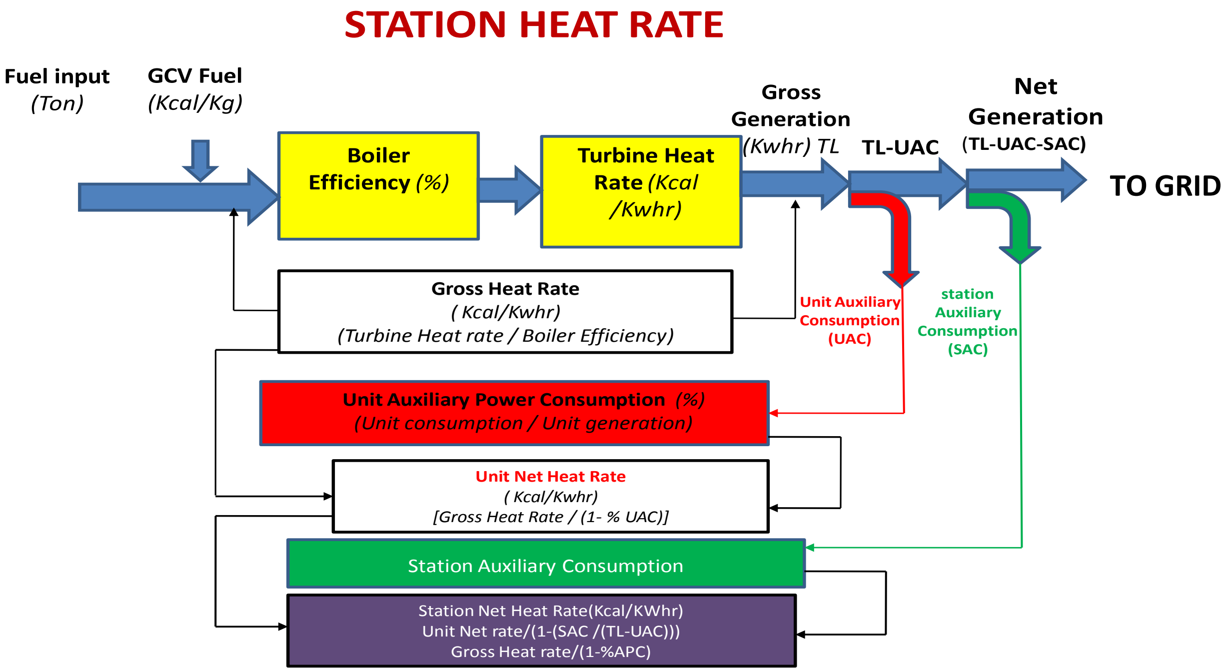
8.1 LOAD VS STATION AUXILIARY CONSUMPTION (SAC)

Figure-8



From the trend, we can identify Station Auxiliary consumption (SAC) varies from 0.132 to 0.138 Million units/Day for stage-1 units of TS-2. It doesn't depend on Station Load & individual unit loads.

Figure-9



Station Heat Rate(Kcal/Kwhr)=unit Net Heat rate/(1-(SAC/(TL-UAC)))

**For station having many units Unit net heat rate should be taken as Average Unit Net heat rate, TL should be taken as Total Load & UAC should be taken as Total unit auxiliary consumption of all the units*

Total load (TL) & Station Auxiliary Consumption (SAC) doesn't vary by varying the combination of load among the units. Slight variation may be observed in Unit Auxiliary Consumption (UAC) which is comparatively negligible. Hence by Optimising Average unit net heat rate (AUHR), Station net heat rate (SNHR) got optimised.

9. CONCLUSION

Based on this analysis it is better to have pattern for sharing of loads between units during partial load operation. This pattern for load sharing of station may be computerised, so it is easy to follow. When there is uniform variation of heat rate with load, it is better to share loads unevenly for decreasing Average unit net heat rate(AUHR) & Station net heat rate(SNHR). Where there is higher variation in Unit Net Heat Rate it is better to avoid that range of load operation. In TS-II units because of stopping of 5th mill at 170 MW create an advantage in partial load. Similarly when operating units at 180 MW with 5 mills create increase in Average unit net heat rate (AUHR) & Station heat rate (SHR)

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