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COMPARATIVE PERFORMANCE ANALYSIS OF STEAMPOWER PLANT AT DIFFERENT LOADS

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ABSTRACT

India is a power deficit country and major source of its power generation is from coal based steam power plants of different capacities ranging from 110MW to 660 MW. Coal as fuel is the major contributor to cost of power generation from these power plants. Due to large variations in demand of power generation during the day and night and in various seasons of the year, these power plants run on full load capacity if the demand of power is high or on partial loads called back down if the demand is lower than the full load. If the power plant is required to run on full load capacity then the cost of power generation is less but if the plant is to run on low loads due to less demand of power then there is a large significant rise in cost of generation of power. This is largely attributed to increase in heat rate of the plant. This work intends to strengthen the idea of running the plant on full load capacity. Moreover, effort has been made to calculate the variation of different plant performance parameters in under load running of the power plant, because changes in plant performance parameters affects the key plant efficiencies and results in increase in heat rate of power plant.

I. INTRODUCTION

Although the Indian power sector has witnessed a phenomenal growth in the installed capacity and also in the energy generation, most regions of our country still face severe shortages in power availability. At the moment, while the average shortage of energy availability is not that high, the peaking shortages are more acute. The gap between supply and demand is increasing day by day. The situation obviously calls for innovative strategies and actions to overcome the situation. There has to be a greater emphasis on the management of the existing capacity by increasing the plant load factor (PLF). To increase the plant load factor and thus capacity utilization, the availability of the plant and equipment, and also the power transmission and distribution networks are to be increased. The plant maintenance is of great importance as it provides means to maintain the plant in a high state of operating efficiency and hence enhances its productivity. Steam Turbine being one of the most critical equipment of thermal power plant, its maintenance cost is a sizeable expenditure. Hence there is a need for optimal policy of maintenance. Industrial sector is the single largest consumer of the commercial energy, accounting for about 52 percent of the total energy consumed. In paper, steel, foundries, chemicals, cement, synthetic fibers and textiles, energy costs account between 15 to 20 percent of the total production costs.

Reasons of Poor Performance of Thermal Plants

- Quality of Coal being fired in the Thermal Plants
- Insufficient Operation and Maintenance practices
- Design deficiencies, manufacturing defects
- Cumulative/delayed maintenance
- Inadequate and non timely availability of spare parts
- Lack of resources, not able to take up renovation and modernization programs.
- Inadequate trained manpower for O&M of plant.

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Modern Steam Cycle

A Thermal Plant operates on a closed steam power cycle, where water undergoes various thermodynamic processes in a cycle. Figureshows a simplified diagram of a modern steam plant, showing most of essential elements. One half of the cycle consists of the Boiler and its auxiliaries and other half the Turbine cycle, condenser, feed pump and feed water heaters.With optimum operation and maintenance practices energy wastage can be detected hence efficiency of the power system can be increased. Also while watching the system parameters and hence taking the remedial actions loss due generation can be avoided. It may be considered similar to the monthly disclosing statement in an accounting system. It blends technically feasible solutions with economic and other organizational considerations within a specified time frame. It is more beneficial than a piecemeal introduction of short term measures as it is a comprehensive strategy that also envisages gearing up of organizational structure and other infrastructural requirements.

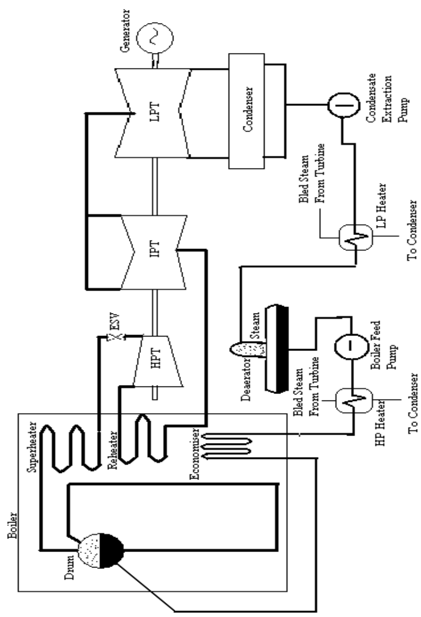

Figure-1Modern Steam Cycle

HP Turbine

The construction of HP Turbine permits rapid start-up from any thermal state and allows it to withstand the instantaneous changes in load, even at high initial steam conditions. The steam and metal temperature matching requirements are also less stringent. HP turbine used in 210 MW KWU systems is single flow type, with initial steam temperature of 535^{0}C and pressure 147 kg/cm2.

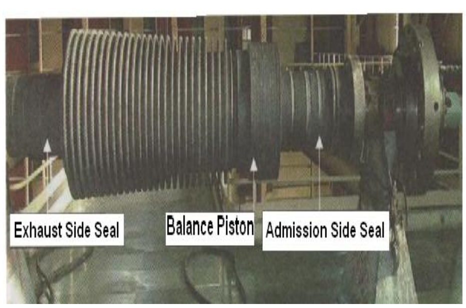

Figure-2 HP Turbine

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IP Turbine

The IP turbine is double flow type construction that permits the axial thrust, produced due to reaction stages, balanced by itself and does not impose any loading on thrust bearing. The reheated steam is admitted to the inner casing through the top and bottom centre of the casing. At the inlet of IP turbine the temperature of reheated steam is 535^0C and pressure is 34 kg/cm^2.

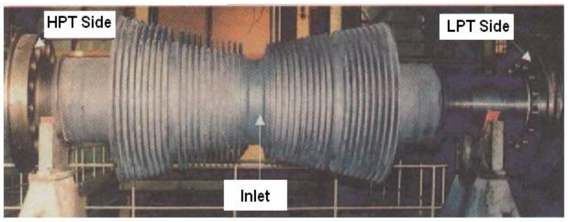

Figure-3 IP Turbine

LP Turbine

LP Turbine is also double flow type with exhaust area optimally selected for the expected vacuum conditions. The casing of LP Turbine is connected with IP cylinder by two cross around pipes. Low pressure extraction has been optimized not only from thermodynamic considerations but to effectively drain out moisture also.

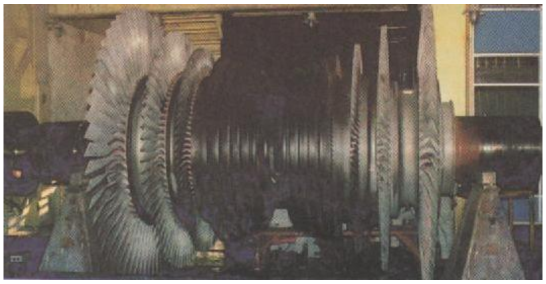

Figure-4 LP Turbine

Table-1Design parameters of turbo-generator set 210 MW

Parameters	Description	
Type	Three cylinder, single shaft reaction turbine, Tandem coupled, double flow exhaust, Reheat type	
Condition of Steam	**Temperature (^{0}C)**	**Pressure (kg/cm^2)**
Main Steam	535	147
HP Exhaust	343	39
IP Inlet	535	34
Extraction-6	343	39
Extraction-5	433	16.7

Extraction-4	316	7.06
Extraction-3	200	2.37
Extraction-2	107	0.85
Extraction-1	62	0.21
LP Exhaust	49	0.11
Economizer I/L	243	170.7
TG Heat Rate (kCal /kWh)	1966	--
Rated Apparent Power (MVA)	247	--
Rated Voltage (kV)	15.75	--
Power Factor	0.85(lagging)	--
Turbine Speed (rpm)	3000	--

II. RESULTS

After analyzing the collected data and calculations made on it on different load conditions, the following outcomes are obtained:

1) It is found that there is excessive deviation in Heat Rate of Steam Turbine and the efficiency from the designed values; Turbine Heat Rate is 314 kcal/ kWh more than the design value of 1966 kcal/kWh and short fall in overall unit efficiency from the design value is about 7.34%. Gross Unit Rate is worked out to be 2791 kcal/kWh with a Boiler efficiency of 81.68% at 210 MW load.
2) At 160 MW load, Turbine Heat Rate increased excessively to 2631 kcal/kWh and the machine performance is found poor at low load. Loss of efficiency at low load operation is evident.
3) Overall turbine efficiency is 11.05% less than the design value at 160 MW load condition.

Table-2Efficiency & specific coal consumption (@ 210 MW& 160 MW

S. No	Parameters	UOM	Design	Actual @ 210 MW	Actual @ 160 MW
1	TG heat rate (HSC)	kcal/kWh	1966	2280	2631
2	TG η	%	43.74	37.72	32.69
3	Boiler η	%	87.16	81.68	82.34
4	Unit Heat Rate	kcal/kWh	2255.62	2791.38	3195.28
5	Overall Unit η	%	38.14	30.80	26.91
6	Specific Steam Consumption (MS)	kg/kWh	-	3.23	3.66
7	Coal Consumption	TPH	-	147.66	126.153
8	Generation	MW	-	209.5	161.30
9	Specific Coal Consumption (MC)	kg/kWh	-	0.705	0.782

It is found that there is excessive deviation in Heat Rate of Steam Turbine and the efficiency from the designed values; Turbine Heat Rate is 314 kcal/ kWh more than the design value of 1966 kcal/kWh and short fall in overall unit efficiency from the design value is about 7.34%. Gross Unit Rate is worked out to be 2791 kcal/kWh with a Boiler efficiency of 81.68% at 210 MW load.

Overall turbine efficiency is 6.02% less than the design value at 210 MW load condition.

III. CONCLUSION

Various techniques are being developed to counter the cost of power generation throughout the world for power stations. Moreover, it can be stated that there is a limit below which we should not run the power plant in back down conditions, as it will lead to flame failure condition in the boiler or the losses of energy in turbine side are such that no more cheaper power can be generated. As it is apparent in the present work, the losses of pressure and temperature are higher as load reduces to 160MW.As the load approaches 160MW, turbine heat rate increases by665 kcal/kWh from the design value at 210 MW.

- It is evident that pressure and temperature drops on turbine side increases significantly by under load running of the power plant.
- Due to low load running of the power station the machine performance lowers in proportion to the load of the power plant.
  The Unit should be operated at good constant load continuously.

Avoid backing down and reserve shut downs to the extent possible.

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