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Plant Load Factor-Key Parameter for Evaluation of Performance of Thermal Power Plant

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Abstract:
The installed capacity of electricity sector till November 2014 was 255.012 GW and actual generation was found to be around 703 BU for the period April - November 2014. The performance of a power plant can be expressed through some common performance factors; one of them is Plant Load Factor (PLF). It is the key parameter for evaluation of performance of any thermal Power plant. Improving performance of power plants through interventions aimed at strengthening O & M practices, coupled with required rehabilitation and life extension interventions is perhaps the quickest and least cost alternative for augmenting availability of power in the Indian context. In this paper, relation between the availability of the plant and PLF has been discussed.
Keywords*: Availability factor, Plant load factor, Power Generation, Coal fired thermal Power Plants.*

1. Introduction:

Power generation in India first started in the year 1897 in Darjeeling, followed by commissioning of a hydropower station at Sivasamudram in Karnataka during 1902. India's capacity to generate electricity during 1950 to 1985 was very low as compared to other developed nations. Since 1990, India has been one of the fastest growing markets for new electricity generation capacity. India's electricity generation capacity has increased from 179 BU in 1985 to 1053 BU in 2012[1]. The installed capacity of electricity sector till November 2014 was 255.012 GW and actual generation was found to be around 703.1 BU for the period April - November 2014[2]. In the year 2013 India became the world's third largest producer of electricity with 4.8% global share in electricity generation surpassing Japan and Russia [3-4]. A thermal power station (TPS) which generates electricity more than 1,000 MW is referred as Super Thermal Power Station.

Within India, MAHAGENCO has the highest overall generation capacity (10867 MW) and the highest thermal installed capacity amongst all the State Power Generation Utilities in India. In terms of installed capacity, it is the second highest generation company after NTPC. MAHAGENCO formerly MSEB was established by Government of Maharashtra under the central Electricity Act 2003 with the principle objective of engaging in business of generation of electricity, and produces cheapest power for consumers in state. Nasik Thermal Power Station is one of the MAHAGENCO power stations in Maharashtra having generation capacity of 910MW.

2. Performance Parameters:

The performance of a power plant can be expressed through some common performance factors given below

- Heat Rate (energy efficiency)
- Thermal Efficiency
- Capacity Factor
- Plant Load Factor
- Economic Efficiency
- Operational Efficiency

Current practice of performance measurement of the coal fired power plants, in the Indian context done by CEA involves ratio analysis in which set of ratios (input to output and output to input) like Plant Load Factor (PLF), Operational Availability Factor (OAF), Planned Maintenance (PM), Forced Outage (FO), Auxiliary Power Consumption (APC), Specific Coal Consumption (SCC) etc. are computed. These ratios indicate the partial factor productivity of the plants. With different indications being provided by these ratios interpretation becomes subjective leaving the managers to select their set of preferable ratios for decision making. Attempts made by CEA to aggregate the ratios to get a composite index based on predefined weight matrix for the ratios, again suffers from subjective bias.

2.1 Plant Load Factor (PLF):

$$\text{PLF (\%)} = \frac{\textbf{Total Generation}}{\textbf{Installed Quantity}}$$

PLF determines the exact loadability of the thermal power plant. Indirectly, it gives the performance of the power plant. If the PLF is 100%, it means plant is running on full load as per installed capacity. As the PLF approaches 100%, the performance of the thermal power plant also increases. Among various advantages of higher PLF, one of the major one is reduction in the planned or forced outages, that finally optimises auxiliary power consumption. On higher load, all the respective auxiliaries also run on full load, which results in utilisation of various auxiliaries at higher efficiency. Ultimately life of the auxiliary also increases. Hence PLF is found to be the key indicator for the analysis of performance of any power plant.

2.2 Availability factor:

The amount of time that it is able to produce electricity over a certain period, divided by the amount of the time in the period is termed as the availability factor of a power plant. Instances where only partial capacity is available may or may not be deducted. Where they are, the metric is titled Equivalent Availability Factor (EAF). The Availability Factor should not be confused with the capacity factor. The Capacity Factor for a period will always be less than the Equivalent Availability Factor for the same period. The difference depends on the utilization of the power plant. The availability of a power plant varies greatly depending on the type of fuel, the design of the plant and how the plant is operated. Everything else being equal, plants that are run less frequently have higher availability factors because they require less maintenance. Most thermal power stations, such as coal, geothermal and nuclear power plants, have availability factors between 70% and 90%. Newer plants tend to have significantly higher availability factors, but preventive maintenance is as important as improvements in design and technology. The Availability Factor is classified into two, equipment availability and energy availability

- Equipment availability is the ratio of available time (operating and standby time) to the calendar period. Equipment availability characterizes the reliability of a plant.
- Energy availability is the ratio of available energy to theoretically possible energy in the period under report. Characterizes the reliability of a plant in general considering all planned and forced outages.

Availability factor (AF) % = 100 – FO - PM

Where, FO = Forced outage/Unavailability (F.O. %)

$$= \frac{Cfl \times Hf1 + Cf2 \times Hf2 + ...Cfn \times Hfn \times 100}{C \times H}$$

[Where Cfi …….Cfn is the capacities in MW of the units on forced outage and Hfl…… Hfn are the duration of each outage in hours. C is the total capacity in MW and H is the total hours in the period under review].

And PM = Planned Maintenance/Planned Unavailability (P.M %)

The details of Plant Load Factor for different units of Nasik Thermal Power Station from 2001-02 to 2011-12 are as in table 2.

3.3 Year wise Availability factor of NTPS:

The details of availability factor for different units if Nasik Thermal Power Station from 2001-02 to 2011-12 are as in table 3.

$$= \frac{Cpl \times Hpl + Cp2 \times Hp2 + ...Cpn \times Hpn}{C \times H} \times 100$$

The forced outage is the shutdown condition of a power station, transmission line or distribution line when the generating unit is unavailable to produce power due to unexpected breakdown.[5] Forced outage can be caused by equipment failures, disruption in the power plant fuel supply chain, operator error etc.[6] Forced outage rate (FOR or FOAR) of a power station unit is the probability that the unit will not be available for service when required. FOR is defined as the number of hours the unit is on forced outage over the total number of hours in a year (which is the sum of hours the power station is available for service and hours the power station is in forced outage).[7]

Planned maintenance is planned, documented and scheduled to be completed before a breakdown occurs. This is unlike unplanned maintenance. The process of planning the maintenance makes the tasks more efficient and eliminates the effect of maintenance on the operations of the facility.

3. Performance Analysis of Nasik Thermal Power Station (NTPS):

This paper discusses the performance of Nasik Thermal Power Station from year 2001 to 2012. An effort to find out the performance of Nasik Thermal Power Plant during this period has been made here.

3.1 Installed capacity of NTPS:

Nasik Thermal Power Station has an installed capacity of 140*2 + 210*3 = 910 MW. The First unit was commissioned in 1970. The Detail installed Quantity of Nasik Thermal Power Station is given table 1

Table 1: Installed capacity of NTPS

Stage	Unit	Installed Quantity	Commissioning Date
I	1	140 MW	August, 1970
I	2	140 MW	March, 1971
II	3	210 MW	April, 1979
II	4	210 MW	July, 1980
II	5	210 MW	January, 1981
Total		910 MW	

3.2 Year wise PLF of NTPS:

3.4 Comparison between Plant Load Factor and Availability Factor:

From the above data of NTPS for the availability factor and PLF for the year 2001- 2012, it is evident that as the availability factor increases the plant load factor also increases. The comparison between percentage Plant Load Factor and percentage Availability for the above period is shown in figure 1.

4. Conclusion:

With the study of correlation between plant load factor and availability factor for Nasik Thermal Power Station for the year 2001-02 to 2011-12, it is evident that they are directly proportional to each other. Plant load factor is directly dependent on availability of any power plant. Hence plant load factor is the main key parameter for evaluation of performance of power plant.

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Table 2: Year wise PLF of NTPS

	Plant Load Factor(PLF) %										
Unit/ Year	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12
1	70.52	67.75	65.54	72.50	60.09	68.04	79.23	55.52	47.76	53.44	55.37
2	68.18	70.40	35.36	62.00	47.38	71.95	75.19	52.18	54.74	47.40	53.37
3	57.26	32.61	93.40	82.87	84.42	84.73	80.88	80.86	78.48	74.37	75.59
4	85.15	83.13	65.32	86.25	83.07	84.47	84.31	76.12	84.17	63.00	70.80
5	72.81	82.39	79.73	50.74	73.60	92.07	83.53	81.16	74.50	76.00	67.90
Total	71.01	66.98	70.55	71.43	72.17	81.83	81.28	72.13	72.93	65.24	69.93

Table 3: Year wise Availability factor of NTPS

	Availability Factor (AVF) %										
Unit/ Year	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12
1	85.28	93.69	83.52	93.69	74.14	87.30	91.50	73.25	68.45	82.57	19.95
2	87.35	90.50	46.16	80.43	61.55	91.97	86.15	72.19	84.02	76.05	33.06
3	91.51	35.47	94.98	88.35	95.11	91.02	83.79	90.44	86.47	92.33	89.13
4	91.51	92.04	74.42	94.36	89.53	91.70	89.40	86.87	95.35	76.60	86.97
5	82.46	90.85	91.39	60.23	80.27	97.84	89.17	93.91	87.44	95.13	88.14
Total	82.78	78.73	80.13	82.85	82.07	92.32	87.64	85.39	85.91	85.55	82.71

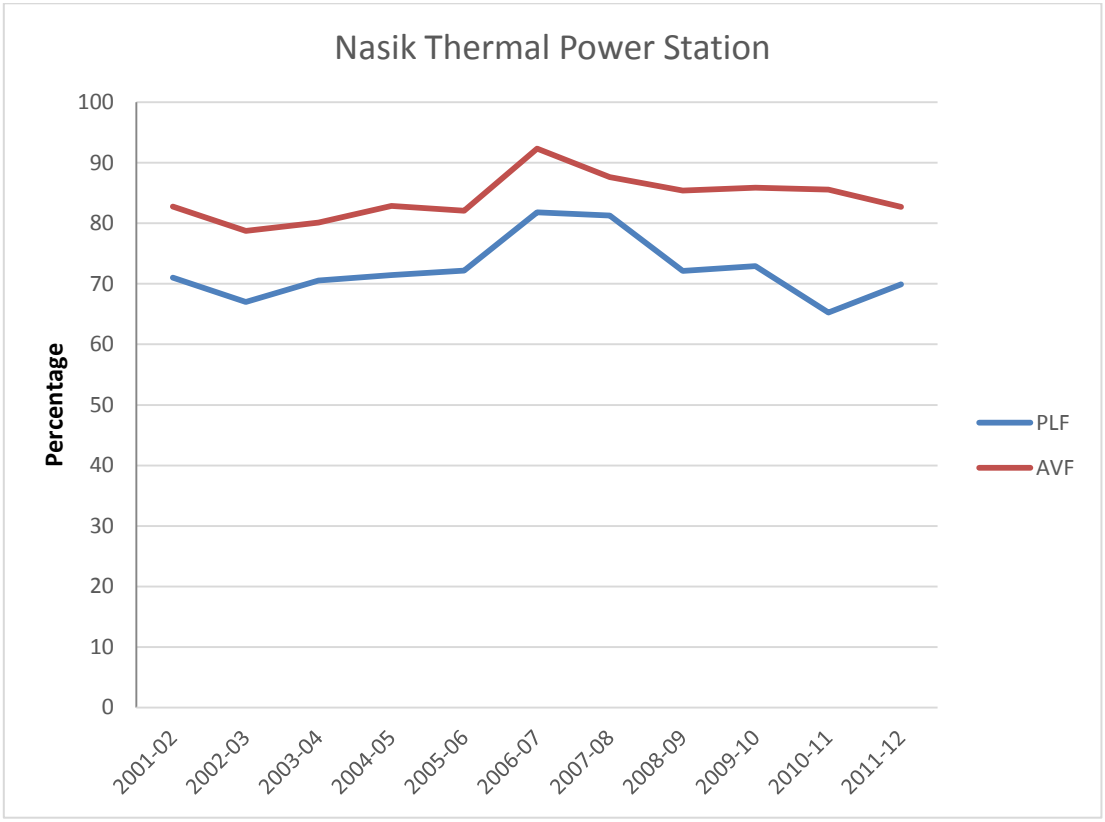

Figure 1: Percentage Plant Load Factor and Availability Factor from 2001-02 to 2011-12