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Performance Assessment of 2X250 MW Coal Based Thermal Power Plant

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Abstract – *Coal, being the least costly and most accessible fuel in India, is used abundantly in power generation. Coal based thermal power plants play a dominant role in energy production in our country. Assessment of efficiency of power plant is the first step towards plant performance improvement. In the present study the performance of a 500 MW coal based thermal power plant comprising of 2X250 MW units is assessed in terms of the plant availability factor, plant load factor, planned and forced outage rate, reliability, overall unit efficiency, thermal efficiency, operational efficiency and economic efficiency.*

Keywords: **coal, efficiency, power plant, 250 MW**

1. INTRODUCTION

Coal is the least costly and most accessible fuel for some of the most dynamic developing countries. In the past coal fired power plants have made a significant contribution in meeting energy demands of India and would continue to play a dominant role in the coming two to three decades. To maximise the utility of coal use in power generation, plant efficiency is an important performance parameter; furthermore, it is the first step towards plant efficiency improvement practices. The purpose of the performance test is to arrive at the efficiency parameters for the power plant as a whole and also the various components of the power plant. Performance of a power plant is normally judged by the plant availability factor, plant load factor, planned and forced outage rate, and reliability, while the efficiency of the plant is expressed in terms of overall unit efficiency, thermal efficiency, operational efficiency and economic efficiency.

2. MATERIAL AND METHODS

The present analysis was conducted on a coal based thermal power plant of 500 MW capacity comprising of 2X250 MW units and the following parameters were recorded:-

(a) Plant Availability Factor (PAF)

To calculate PAF of a power plant the amount of time that it is able to produce electricity over a certain period is divided by the amount of the time in that period.

PAF (%) = (operation Hours / total hours for period under review) x100

(b) Plant Load Factor (PLF)

Plant load factor is a measure of the output of a power plant compared to the maximum output it could produce, thus measuring average capacity utilization. Plant Load Factor is calculated as the ratio between the actual energy generated by the power plant to the maximum possible energy that can be generated by the plant working at its rated power and for duration of an entire year.

PLF (%) = (no. of hours electricity generated in a year/no. of hours in a year) X100

(c) Planned Outage Rate

Planned outages of power plants are taken for annual/capital maintenance or monthly, weekly routine checks; and are calculated using the following formula:

Planned outage rate (%) = (outage hours /hours in period under review) x100

(d) Forced Outage Rate

Forced outage is the removal of a generating unit from service availability for emergency reasons or a condition in which the equipment is unavailable due to unanticipated failure; and is calculated using the following formula:

Forced outage rate (%) = (forced outage hours/hours in period under review) x100

(e) Reliability

Reliability is an indication of how well maintenance management programmes are being executed at the power plant and is calculated as follows:

Reliability (%) = 100% - forced outage rate

(f) Overall unit efficiency

The overall unit efficiency (ή) is calculated using the following formula:

ή= ήBoiler x ήTurb x ήGen

Where:

ήBoiler – boiler efficiency

ήTurb - turbine efficiency

ήGen – generator efficiency

The efficiency of boilers is measured by measuring all the losses occurring in the boilers and subtracting it from 100.

Various losses from boiler are

L_1= Dry flue gas loss (%)

L_2=Loss due to moisture in fuel (%)

L_3=Loss due to hydrogen in fuel (%)

L_4=Loss due to unburnt carbon bottom ash (%)

L_5=Loss due to unburnt carbon fly ash (%)

L_6=Loss due to moisture in air (%)

L_7=Sensible heat loss from fly ash (%)

L_8=Sensible heat loss from bottom ash (%)

L_9=Radiation loss (%)

Turbine cycle efficiency is defined as the amount of electricity produced to the heat input to the turbine.

Turbine cycle efficiency (%)= (860/Turbine heat rate)*100

Turbine heat rate is defined as the amount of heat input to the turbine in kcal for generating one unit of electricity.

Turbine heat rate (kCal/kWh)= [Q1X(H1-h2)+Q2X(H3-H2)]/Gross Generator Output

Where

Q1= Main steam flow, kg/hr

H1= Main steam enthalpy, kcal/kg

h2= Feed water enthalpy, kcal/kg

Q2= Reheat steam flow, kg/hr

H3= Hot reheat enthalpy, kcal/kg

H2= Cold reheat enthalpy, kcal/kg

In most of the thermal power stations generator efficiency is not independently calculated as rotor shaft work (WT) is not estimated (Niwas, 2014); however at the plant the turbogenerators (BHEL make) has reported efficiency of 98 per cent.

(g) Thermal efficiency

Thermal efficiency is an indication of how well the power plant is being operated as compared to the design characteristics of the plant; and is calculated as follows:

Thermal efficiency ή = ((Energy generated x time) /(MC x CV)) x100

Where:

MC – quantity of coal consumed

CV- calorific value of coal

(h) Operational efficiency

Operational efficiency is calculated using the following formula:

Operational efficiency = (E/E100%) x 100

where:

E = energy output from the power plant in the period

E100% = potential energy output from the power plant operated at 100% in the period

(i) Economic efficiency

Economic efficiency is the ratio between productions costs of electricity and energy output from the power plant for a period of time and can be calculated as follows:

Economic efficiency= Production cost for a period/Energy output from the power plant in the period (kWh)

3. RESULTS

Plant Availability Factor (PAF, %)

Mean value of the PAF for unit I was reported to be 77.91 per cent, while for the unit II it was 66.80 per cent. The mean value of the PAF for the plant from January 2017 to December 2017 was 72.36 per cent.

Table 1. Plant Availability Factor (PAF) during January 2017 -December 2017

Sr. No.	Month	PAF (%)	
		Unit I	Unit II
1.	January 2017	16.13	48.39

2.	February 2017	78.57	55.01
3.	March 2017	13.82	93.26
4.	April 2017	86.78	100
5.	May 2017	100	100
6.	June 2017	100	99.67
7.	July 2017	93.55	31.78
8.	August 2017	46.1	83.87
9.	September 2017	100	17.81
10.	October 2017	100	17.74
11.	November 2017	100	54.11
12.	December 2017	100	100
	Mean	77.91	66.80
		72.36	

Plant Load Factor (PLF, %)

Mean value of the PLF for unit I was reported to be 52.51 per cent, while for the unit II it was 44.74 per cent. The mean value of the PLF for the plant from January 2017 to December 2017 was 48.62 per cent.

Table 2. Plant Load Factor (PLF) during January 2017 -December 2017

Sr. No.	Month	PLF (%)	
		Unit I	Unit II
1.	January 2017	10.07	30.78
2.	February 2017	48.83	34.73
3.	March 2017	8.76	60.09
4.	April 2017	56.13	67.68
5.	May 2017	68.29	70.72
6.	June 2017	65.25	65
7.	July 2017	62.83	20.58
8.	August 2017	31.76	59.9
9.	September 2017	76.44	12.72
10.	October 2017	68.76	11.86
11.	November 2017	66.85	36.04
12.	December 2017	66.13	66.75
	Mean	52.51	44.74
		48.62	

Planned Outage Rate (PO, %)

There was no planned outage during the study period.

Forced Outage Rate (FO, %)

Mean FO for the unit I was found to be 22.78 per cent, while the same for the unit II was 31.40 per cent. The mean FO for the plant during the study period was reported to be 27.09 per cent.

Table 3. Forced Outage Rate (FO) during January 2017 -December 2017

Sr. No.	Month	FO (%)	
		Unit I	Unit II
1.	January 2017	86.62	53.29
2.	February 2017	21.88	42.78
3.	March 2017	89.05	7.09
4.	April 2017	13.20	70.50
5.	May 2017	0.00	0.00
6.	June 2017	0.00	0.00
7.	July 2017	6.67	98.77
8.	August 2017	55.96	0.00
9.	September 2017	0.00	0.00
10.	October 2017	0.00	58.40
11.	November 2017	0.00	45.91
12.	December 2017	0.00	0.00
	Mean	22.78	31.40
		27.09	

Reliability

The average reliability of unit I was 77.22 per cent, while for unit II it was 68.61 per cent. The overall plant reliability during the study period was 72.91 per cent.

Table 4. Reliability during January 2017 -December 2017

Sr. No.	Month	Reliability (%)	
		Unit I	Unit II
1.	January 2017	13.38	46.71
2.	February 2017	78.12	57.22
3.	March 2017	10.95	92.91
4.	April 2017	86.80	29.50
5.	May 2017	100.00	100.00
6.	June 2017	100.00	100.00
7.	July 2017	93.33	1.23
8.	August 2017	44.04	100.00

9.	September 2017	100.00	100.00
10.	October 2017	100.00	41.60
11.	November 2017	100.00	54.09
12.	December 2017	100.00	100.00
	Mean	77.22	68.61
		72.91	

Overall unit efficiency

Overall unit efficiency of unit 1

(a) Boiler efficiency (ήBoiler)

The efficiency of boiler for the Unit 1 was calculated to be 86.56 per cent.

Table 5: Parameters for Calculation of Boiler Efficiency of Unit 1

PARAMETER	UNIT	VALUE
Total moisture	%	8.72
Ash	%	36.75
V.M.	%	21.6
Fixed Carbon	%	32.93
Ambient temp		28.50
Average Co2at APH inlet	%	13
GCV of coal	Kcal/Kg	4020
Average 02.at APH inlet	%	4.00
Average N2 at APH inlet	%	83
Average load		250
Unburnt carbon in bottom ash	%	1.43
Dry bulb		21
Unburnt carbon in FLy ash	%	0.39
Moisture		0.011
Wet Bulb Temp		16
No. of mill in service	No.	4
No. of mill in service	KW	1800
Bottom Ash temp	Deg C	1110
Coal Flow Rate	t/h	151
Average APH outlet temp	Deg C	148.5
Nitrogen % in coal	%	1.84
Total combustibles	%	54.53
V M % of Combustibles	%	39.61
Hydrogen as % of total combustbles	%	5.855
Hydrogen as fired	%	3.19
Sulphur	%	0.4
Total Carbon (including Sulphur 0.3 %)	%	39.77
Carbon	%	39.370
Oxgen In Coal	%	9.726
Weight of dry flue gases / Kg of carbon	Kg/Kg of carbon	19.385
Carbon in bottom ash	KGg/Kg of fuel	0.001
Carbon if fly ash	KGg/Kg of fuel	0.001
Weight of carbon consumed	Kg of carbon / kg of fuel	0.366
Weight of Dry air supplied / Kg		6.458
Weight of Dry air supplied / Kg	Weight of fuel burnt / Kg of fuel	0.631
Weight (W)		0.070
Weight of dry flue gases / Kg of fuel	Kg/Fuel	7.089
Dry Flue gas loss	Kcal / Kg	204.558
Dry Flue gas loss (l_1)	%	5.088515208
Loss due to moisture in fuel	Kcal / Kg	55.10832381
Loss due to moisture in fuel (l_2)	%	1.370853826
Loss Due to hydrogen in fuel	Kcal / Kg	181.6106257
Loss Due to hydrogen in fuel (l_3)	%	4.517677256
Loss Due to unburnt carbon (Botton ash)	Kcal / Kg	4.2317275
Loss Due to unburnt carbon (Botton ash) (l_4)	%	0.105266853
Loss Due to unburnt carbon (Fly ash)	Kcal / Kg	10.3869675

Loss Due to unburnt carbon (Fly ash) (l_5)	%	0.258382276
Loss Due to moisture in air	Kcal / Kg	3.985489936
Loss Due to moisture in air (l_6)	%	0.099141541
Sensible Heat loss from fly ash	Kcal / Kg	7.056
Sensible Heat loss from fly ash (l_7)	%	0.175522388
Sensible Heat loss from Bottom ash	Kcal / Kg	22.25727
Sensible Heat loss from Bottom ash (l_8)	%	0.553663433
Radiation Loss (l_9)	%	1.5
Heat Credit	Kj / Kg	40.768
Heat Credit	Kcal / Kg	9.707
Heat Credit (HC)	%	0.2415

Boiler efficiency= $(100+HC) - (l_1+ l_2+ l_3+ l_4+ l_5+ l_6+ l_7+ l_8+ l_9)$

=(100+0.24)-(5.09+1.37+4.52+0.11+0.26+0.10+0.18+0.55+1.5)

=86.56%

(b) Turbine efficiency

The turbine efficiency is calculated to be 43.46 per cent.

Table 6. Calculation of turbine efficiency of unit 1

PARAMETER	Unit		Value	Ent (KJ/KG)	Ent (KCAl/KG)
FEED WATER FLOW	T/Hr	HBD	723		
FEED WATER PRESSURE(HPH -6 outlet pressure)	Kg/cm ^{2}		163		
HPH-6 Outlet temp(feed water temp. at ECO i/l)	°C		245	1062.70	254.23
HPH-5 Outlet temp	°C		196	841.07	201.21
HPH-6 Extraction steam pressure	Kg/cm ^{2}		35	3087.80	738.71
HPH-6 Extraxtion Steam Temperature	°C		343		
HPH-6 DRIP temperature	°C		208	889.21	212.73
HPH-6 steam flow	T/Hr	HBD	72.88		
Main Steam Flow(Feed Water Flow + SH Spray) Q_1	T/Hr	HBD	725		
Cold reheat (CRH)/ Hot reheat (HRH) FLOW Q_2	T/Hr	HBD	652.12		
Main Steam Temperature	°C	PG	547.5	3454.3	Main steam enthalpy H_1 826.3876
Main Steam Pressure	Kg/cm ^{2}	PG	140		
CRH Pressure	Kg/cm ^{2}	PG	34	3097.5	CRH enthalpy H_2 741.0287
CRH temperature	°C	PG	346		
HRH Pressure	Kg/cm ^{2}	PG	33	3520.7	HRH enthalpy H_3 842.2727273
HRH temperature	°C	PG	529.63		
Feed water temperature at eco inlet	°C	PG	245	1062.6	Feed water enthalpy h_2 254.2105263
Feed water Pressure at eco inlet	Kg/cm ^{2}	PG	158		

Turbine heat rate (kCal/kWh)= $\frac{Q_1 X(H_1-h_2)+Q_2 X(H_3-H_2)}{\text{Gross Generator Output}}$

$=\frac{725(826.39-254.21)+652.12(842.27-741.03)}{243}$

=1978.81

The turbine efficiency of Unit 1 is calculated as

Turbine cycle efficiency (%) = (860/1978.81)*100

=43.46%

(c) Generator efficiency

Generator efficiency= 98%

(d) Overall unit efficiency,

ή= ήBoiler x ήTurb x ήGen

Where:

ήBoiler – boiler efficiency

ήTurb - turbine efficiency

ήGen- generator efficiency

= 86.56 X 43.46 X 98= 36.86 %

(e) Thermal efficiency = Thermal efficiency ή =

((Energy generated x time) /(MC x CV)) x100

Where:

MC – quantity of coal consumed

CV- calorific value of coal

= [100/(MC X CV/ Energy generated X time)]

= [100/ HR (kCal/kWh)] x conversion factor

Where

HR= Heat rate in kCal/kWh

Conversion factor= 1 kilo watt hour is equal to 860 kilo calorie

= (100/1978.81) X 860

=43.46 %

Overall unit efficiency of unit 2

(a) Boiler efficiency (ήBoiler)

The boiler efficiency of the Unit 2 was reported to be 86.16 per cent.

Table 7: Parameters for Calculation of Boiler Efficiency of Unit 2

PARAMETER	UNIT	VALUE
Total moisture	%	8.92
Ash	%	38.61
V.M.	%	22.61
Fixed Carbon	%	29.86
Ambient temp		28.50
Average co_2at APH inlet	%	13
GCV of coal	Kcal/Kg	4020
Average 0_2.at APH inlet	%	4.2
Average N_2 at APH inlet	%	82.8
Average load (MW)		243
Unburnt carbon in bottom ash	%	1.46
Dry bulb		21
Unburnt carbon in FLy ash	%	0.42
Moisture		0.011
Wet Bulb Temp		16
No of mill in service	No.	4
No of mill in service	KW	1800
Bottom Ash temp		1110
Coal Flow Rate	t/h	150
Average APH outlet temp	Deg C	149.5
Nitrogen % in coal	%	1.83
Total combustibles	%	52.47
Vm as % of combustibles	%	43.09
Hydrogen as % of total combustbles	%	5.953
Hydrogen as fired	%	3.12
Sulphur	%	0.4
Total Carbon (including Sulphur 0.3 %)	%	37.61
Carbon	%	37.209
Oxgen In Coal	%	9.909
Weight of dry flue gases / Kg of carbon	Kg/Kg of carbon	19.390
Carbon in bottom ash	KGg/Kg of fuel	0.001
Carbon if fly ash	KGg/Kg of fuel	0.001
Weight of carbon consumed	Kg of carbon / kg of fuel	0.384
Weight of Dry air supplied / Kg		6.835
Weight of fuel burnt / Kg		0.612
Weight (W)		0.075
Weight of dry flue gases / Kg of fuel	Kg/Fuel	7.447
Dry Flue gas loss	Kcal / Kg	216.69
Dry Flue gas loss (l_1)	%	5.390407
Loss due to moisture in fuel	Kcal / Kg	56.41475238
Loss due to moisture in fuel (l_2)	%	1.403352049
Loss Due to hydrogen in fuel	Kcal / Kg	177.7818951
Loss Due to hydrogen in fuel	%	4.422435203

(l_3)		
Loss Due to unburnt carbon (Botton ash)	Kcal / Kg	9.078350914
Loss Due to unburnt carbon (Botton ash) (l_4)	%	0.225829625
Loss Due to unburnt carbon (Fly ash)	Kcal / Kg	10.4463216
Loss Due to unburnt carbon (Fly ash) (l_5)	%	0.259858746
Loss Due to moisture in air	Kcal / Kg	4.332262097
Loss Due to moisture in air (l_6)	%	0.107767714
Sensible Heat loss from fly ash	Kcal / Kg	7.475
Sensible Heat loss from fly ash (l_7)	%	0.185942687
Sensible Heat loss from Bottom ash	Kcal / Kg	23.3837604
Sensible Heat loss from Bottom ash (l_8)	%	0.581685582
Radiation Loss (l_9)	%	1.5
Heat Credit	Kj / Kg	41.040
Heat Credit	Kcal / Kg	9.771
Heat Credit (HC)	%	0.2431

Boiler efficiency= (100+HC) – (l_1+ l_2+ l_3+ l_4+ l_5+ l_6+ l_7+ l_8+ l_9)

=(100+0.24)-(5.39+1.40+4.42+0.23+0.26+0.11+0.19+0.58+1.5)

=86.16%

(b) Turbine efficiency

The heat rate of the Unit 2 was calculated to be 1989.79. Thus the turbine efficiency is calculated to be 43.22 per cent.

Table 8. Calculation of turbine efficiency of unit 2

PARAMETER	Unit	Value	Ent (KJ/KG)	Ent (KCAl/KG)
FEED WATER FLOW	T/Hr	692		
FEED WATER PRESSURE(HPH -6 outlet pressure)	Kg/cm²	163		
HPH-6 Outlet temp(feed water temp. at ECO i/l)	°C	245	1062.70	254.23
HPH-5 Outlet temp	°C	204	876.40	209.67
HPH-6 Extraction steam pressure	Kg/cm²	35	3095.10	740.45
HPH-6 Extraxtion Steam Temperature	°C	346		
HPH-6 DRIP temperature	°C	209	893.74	213.81
HPH-6 steam flow	T/Hr	58.564		
Main Steam Flow(Feed Water Flow + SH Spray) **Q_1**	T/Hr	723.94		
CRH/HRH FLOW **Q_2**	T/Hr	665.38		
Main Steam Temeprature	°C	542	3439.6	Main steam enthalpy H_1 822.8708
Main Steam Pressure	Kg/cm²	140		
CRH Pressure	Kg/cm²	35	3090.2	CRH enthalpy H_2 739.2823
CRH temperature	°C	344		
HRH Pressure	Kg/cm²	34	3534.1	HRH enthalpy H_3 845.4784689
HRH temperature	°C	536		
Feed water temerature at eco inlet	°C	246	1067.3	Feed water enthalpy h_2 255.3349282
Feed water Pressure at eco inlet	Kg/cm²	159		

Turbine heat rate (kCal/kWh)= $\frac{Q_1 X(H_1-h_2)+Q_2 X(H_3-H_2)}{\text{Gross Generator Output}}$

$=\frac{723.94(822.87-255.33)+665.38(845.48-739.28)}{242}$

=1989.79 kCal/kWh

The turbine efficiency of Unit 2 is calculated as

Turbine cycle efficiency (%)= (860/1989.79)*100

=43.22%

(c) Generator efficiency

Generator efficiency= 98%

(d) Overall unit efficiency,

ή= ήBoiler x ήTurb x ήGen

Where:

ήBoiler – boiler efficiency

ήTurb - turbine efficiency

ήGen- generator efficiency

= 86.16 X 43.22 X 98= **36.49 %**

(e) Thermal efficiency = Thermal efficiency ή = ((Energy generated x time) /(MC x CV)) x100

Where:

MC – quantity of coal consumed

CV- calorific value of coal

= [100/(MC X CV/ Energy generated X time)]

= [100/ HR (kCal/kWh)] x conversion factor

Where

HR= Heat rate in kCal/kWh

Conversion factor= 1 kilo watt hour is equal to 860 kilo calorie

= (100/1989.79) X 860

=43.22 %

Operational efficiency

Operational efficiency = $(E/E_{100\%})$ x 100

where:

E = energy output from the power plant in the period

$E_{100\%}$ = potential energy output from the power plant operated at 100% in the period

Table 9. Energy output from the power plant during January 2017- December 2017

Sr. No.	Month	Energy output (MU)
1.	January 2017	75.98
2.	February 2017	140.38
3.	March 2017	128.06
4.	April 2017	222.85
5.	May 2017	258.56
6.	June 2017	234.44
7.	July 2017	155.15
8.	August 2017	170.47
9.	September 2017	160.50
10.	October 2017	149.95
11.	November 2017	185.18
12.	December 2017	247.15
	Total	2128.67

E= 2128 MU

Potential energy output from the power plant operated at 100% in the period-

Plant capacity 500 MW/h

In one day = 500 MW X 24 h

= 12000 MWh

In one year = 12000 MWh X 365

= 4380000 MWh

= 4380000000 kWh

= 4380 X 10^6 Unit

= 4380 MU

Thus $E_{100\%}$ = 4380 MU

Thus, operational efficiency = (2128/4380) X100

= 48.58%

Economic efficiency

For calculation of economic efficiency the total energy output and total cost required to generate the electricity for the financial year 2017-18 were recorded and economic efficiency was calculated to be Rs. 4.91/kWh.

Table 10. Parameters for calculation of economic efficiency of the plant for FY 2017-18

Sr. No.	Particulars	Cost (Crores)

1.	Total fixed cost	732.97
2.	Total variable cost	729.42
	Total	1462.39

Energy output = 2978.40 MU

Economic efficiency= Production cost for a period/Energy output from the power plant in the period (kWh)

=1462.39 Cr/2978.40 MU

= Rs. 4.91/kWh

4. DISCUSSION

During the study period from January 2017 to December 2017 the mean value of PAF was reported to be 72.36 per cent. 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 [1]. The mean value of PLF was reported to be 48.62 per cent. According to the Executive Summary, CEA (2017) the average PLF of all India coal and lignite based power plants were 63.48 and 60.37 per cent for January 2016 and January 2017; respectively [2]. The average PLF of all India private sector coal and lignite based power plants were 62.60 and 56.45 per cent for January 2016 and January 2017; respectively. PLF determines the exact load ability 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 [1].

Planned outages of generating units are taken for annual/capital maintenance or monthly, weekly routine checks. Inadequacies in the annual planned/ capital maintenance carried out by power stations resulted into known defects in various systems of power stations remained unsolved during regular annual planned maintenance of units causing subsequent forced outages and loss of power generation; moreover delayed receipt of new or repaired parts during scheduled annual maintenance period resulted in a subsequent additional outage for replacement of parts. Power stations suffered loss of 35.97 million units of power generation during 2006 to 2014 due to subsequent avoidable forced outages on account of above reasons [3]. In the present study the planned outage during the study period is not reported as it had already been carried out in December 2016. In the present study the FO was 27.09 per cent, the reasons for this being coal shortage (36.36 per cent) and equipment problem (63.64 percent), with about 90.91 per cent shut down of more than 24 hours. The reliability was calculated to be 72.91 per cent. As per the Performance Review of Thermal Power Stations 2011-12 the loss of generation due to non-availability of thermal units because of forced outages during 2011-12 increased to 11.46 per cent as compared to 10.32 per cent during 2009-10. The increased forced outage was due to increased forced shutdown of units due to coal supply problem and transmission constraints and equipment problems of some new units. The study revealed that 59.87 per cent of the total forced shut down were of duration up to 24 hours. 38.67 per cent outages were of duration varying from 1 to 25 days and only 1.45 per cent of shut downs were for more than 25 days [4]. The boiler efficiencies of Unit 1 and Unit 2 were 86.56 and 86.16 per cent; respectively. The heat rate and turbine efficiency of Unit 1 were reported to be 1978.81 and 43.46 per cent; while these values for Unit 2 were 1989.79 and 43.22 per cent; respectively. The overall unit efficiency of Unit 1 and Unit 2 were 36.86 and 36.49 per cent; respectively. The operational efficiency of the plant during the study period was 48.58 per cent. The economic efficiency of the plant for FY 2017-18 was calculated to be Rs. 4.91/kWh.

5. CONCLUSION

Assessment of performance parameters plays a major role in economics of generation from a power plant. Better efficiency of the plant and its components result in less consumption of resources required for energy production. The differences in the calculated efficiency from the designed efficiencies indicate the urgent need to control the parameters within the designed ratings and to evolve measures to improve the efficiency of the plant.

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