APC REDUCTION IN FEED WATER SYSTEM- NTPC BADARPUR EXPERIENCE

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ABSTRACT

Badarpur thermal power station is one of the oldest power station in India with five no units of total capacity of 705 MW (3X95 MW+2x210 MW). First, second and third units of 100 MW were commissioned in 1973, 1974 and 1975 respectively. Later, on 11th January, 1990 these units were de-rated to 95 MW due to some technical problems. Fourth and fifth units of 210 MW capacity each were commissioned in 1978 and 1981 respectively.

Station Auxiliary Power consumption has a rising trend In the last couple of years, mainly due to high partial loading of units. To address this problem station has implemented some actions in various areas like Draft system, Feed water system, compressed Air system, Ash handling system & Coal Handling Plant.After implementation of all these measures, station is able to reduce the power consumption to a considerable extent especially in Feed water systems, Draft system and circulating water system. In this paper, the actions taken in Feed water systems of 2x210 MW Units will be discussed. Some of the actions were planned to be implemented in R&M of 2x210 MW Units. Due to delay in implementation of R&M, these modifications are done using the scraps or surplus items of other plants. So, this paper also convey a message that even the scarps of some other plant can be used in a running plant successfully if there is a will to improve the system.The saving in feed water system due to modification is approx. 40% of total saving in APC done due to various other initiatives.

INTRODUCTION

As per CERC tariff regulation 2014-2019, normative APC, heat rate and specific oil consumption are very stringent for the station leaving very narrow scope for improvement in marginal contribution. It becomes more difficult to achieve these targets if machine runs on part load. To sustain in power generation market, it is a requirement for power generators to devise innovative ways to reduce APC and heat rate.

Operating power plant efficiently at part load has now become one of the major challenge. So operating units must strive for strategic operation or modifications (innovative approach, best practices),which is the only way to survive. Heat rate and Auxiliary Power Consumption both are significantly affected while operations of units at part load.

At BTPS, during part load operation, the actual APC is exceeding the normative value. Based on options available for APC reduction at part load, in addition to best practices, some new innovative strategies are developed for improving marginal contribution at part load.

1. PROBLEM

In last five years, Generation of NTPC, Badarpur has reduced drastically .The low Generation is due to low grid demand causing reserve shutdown and partial loading. The main reason of Back down/reserve shut down is high cost of power, which further rises due to Partial Loading of units, as Heat Rate and APC (Auxiliary Power Consumption) both increases with partial loading.The trend of APC of Badarpur in last five years is shown in Fig 1.1 below.

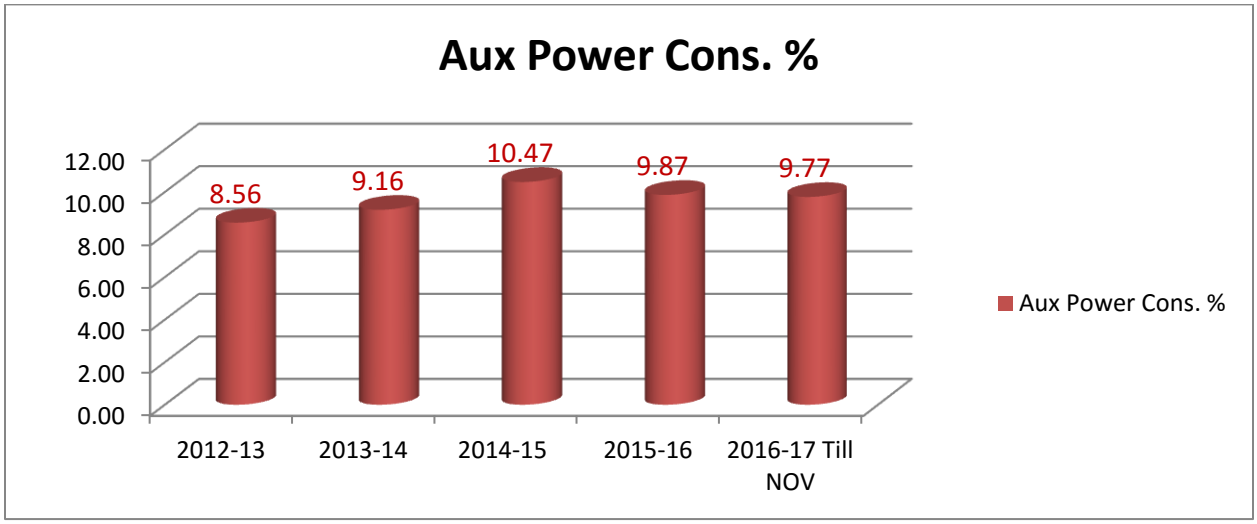


Fig 1.1

2. METHODOLOGY

To break the vicious cycle of high partial loading-high APC –high cost of power, station needed to take some actions with significant impact on Auxiliary Power consumption. It was found that draft systems and feed water systems are two key areas, where maximum potential for improvement is there. Considering this fact, significant attention has been paid in these two systems in last two years with remarkable improvement in Auxiliary Power consumption. As per study it was observed that the power consumption by Feed water system is around 38 % of total consumption. To reduce power consumption in Feed water systems NTPC, Badarpur has implemented following three actions in 2x210 MW Units.

2.1 COMMISSIONING OF AUTO CONTROL OF FEED REGULATING STATION (FRS) DIFFERENTIAL PRESSURE (DP)

The operation of hydraulic scoop control of BFP in DP mode provides a reliable and cost effective method of reducing the auxiliary consumption of the plant. Also it can be used at varying load conditions with negligible drum level fluctuation. It also reduces the dependence on human interference for operation of the system.

Feed Regulating Station (FRS) Differential Pressure (DP) in Unit#4 &5 (2x210 MW) used to maintain high as there was no auto control.The FRS DP auto controller in Unit#4&5 was included in the scope of R&M, but due to delay in implementation of R&M in Unit#4&5, FRS DP used to maintain in manual mode, which resulted in higher DP across FRS. This high FRS DP further contributes in higher power consumption and also results in erratic control behavior in drum level due to higher DP.

To overcome these problems, it was decided to commission BFP scoop tube Auto controller in Unit#4 and Unit#5 in October'14 by reclaiming a surplus PLC based control panel used in DM plant at NTPC, Gandhar. Cost details are as follows

Cost of Development	**Approx. Cost of Materials**	PLC based Control system	µp based PID Controller	Actuator	Misc. Hardware	**Total Cost**
		1000000	120000	300000	30000	**14.5 Lakhs**
	Approx. Cost of Services	Software Development	Engineering & system integration	Erection & commsng	Misc. services	**Total Cost**
		In house	In house	In house	In house	**NIL**
Cost to NTPC is zero						
Market cost of similar system with services 50 Lakhs						

Table 2.1

Fig 2.1

Impact Of Controller on APC

By using auto controller, FRS DP around 3 ksc is being maintained. Specific Energy consumption (KWh/Tones per hr) of BFPs has reduced from 7.85 to . Power saving per Unit is 265.6 KW.

When FRS DP BFP Total Power Saving (KW) per unit	~266
(FRS DP Reduced to 3 Ksc from 20 Ksc at 191MW Load & Drum Pr.135 Ksc,)	
Energy Saving (In Kwh) per unit/Day	6384
Assuming Number of Machine Running days per year	300
Total Energy Saving (In Kwh) per Year	1915200
Saving (Rs.) per year*	7009632

**Energy Variable Charges 3.66 (Rs. per Unit) in November'2016*

2.2 Replacement of old BFP cartridge with energy efficient cartridge

Unit no 4 & 5 at NTPC Badarpur were commissioned on 02/12/1978 and 25/12/1981 respectively. Each of the unit are provided with three nos of Boiler Feed pumps (02 nos in service & 01 no in standby mode) of model-200 KHI supplied by OEM M/s BHEL. These pumps were manufactured by M/s BHEL in technical collaboration with M/s Sigma of Czechoslovakia, supplied about 33 -36 years back. These pumps are semi- cartridge design with design efficiency of **72 %**. In order to meet the demand for efficiency improvement, less power consumption, easy maintainability & reduced down time, the upgraded design of 200 KHI cartridges (M/s BHEL) were procured, which were used in our existing system. The upgraded cartridge has a design efficiency of **80 %**. The features of the new cartridge are:

a) Ease of maintenance due to cartridge design

New design cartridge is full cartridge design type where complete pump assembly can be made outside pump barrel & kept ready for use. No pump centering, bearing fitting required after putting the pump assembly in the barrel only tightening of HP cover bolt is required.

Fig 2.2

b) Balance drum design

The upgraded design cartridge is complete cartridge and fitted with the balance drum arrangement for hydraulic axial thrust balancing, more reliable design, minimizing the risk of seizure, as compared to the balancing disc arrangement and complete cartridge replacement is very fast as compared to old one.

c) **Ease of tightening using Hydraulic tensioner**

The new design cartridge is provided with a hydraulic stud tensioner for loosening and tightening of discharge cover nuts, which will help in more accurate control of the tightening torque value and reduction in operation time compared to old

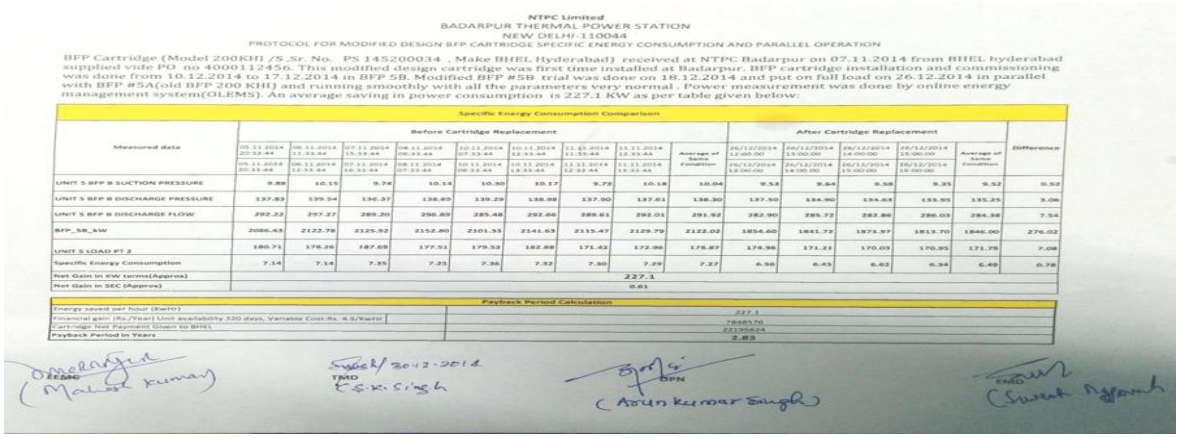
d) No change in pipe lines due to :--

No change in NPSH requirement due to modifications

No change in axial thrust,lube oil requirements, minimum recirculation flow, and balance leak off flow and warm up flow due to modification

e) Energy Saving

The performance of BFP with new cartridge was tested and power consumption was measured. The power consumption of new BFP is compared with old BFP.The power saving per BFP is found to be 227.1KW. Specific energy consumption (KWh/Tones per hr) of BFP reduced from 7.27 to 6.66.



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PROTOCOL FOR MODIFIED DESIGN BFP CARTRIDGE SPECIFIC ENERGY CONSUMPTION AND PARALLEL OPERATION

BFP Cartridge (Model 200KHI /S ,Sr. No. PS 145200034 , Make BHEL Hyderabad) received at NTPC Badarpur on 07.11.2014 from BHEL hyderabad supplied vide PO no 4000112456. This modified design cartridge was first time installed at Badarpur. BFP cartridge installation and commissioning was done from 10.12.2014 to 17.12.2014 in BFP 5B. Modified BFP #5B trial was done on 18.12.2014 and put on full load on 26.12.2014 in parallel with BFP #5A(old BFP 200 KHI) and running smoothly with all the parameters very normal . Power measurement was done by online energy management system(OLEMS). An average saving in power consumption is 227.1 KW as per table given below:

Specific Energy Consumption Comparison

Measured data	Before Cartridge Replacement									After Cartridge Replacement					Difference
	05.11.2014 20:33:44	06.11.2014 11.33.44	07.11.2014 15.33.44	08.11.2014 06.33.44	10.11.2014 07.33.44	10.11.2014 12.33.44	11.11.2014 11.33.44	11.11.2014 12.33.44	Average of Same Condition	26/12/2014 12:00:00	26/12/2014 13:00:00	26/12/2014 14:00:00	26/12/2014 15:00:00	Average of Same Condition	
	05.11.2014 20:33:44	06.11.2014 12.33.44	07.11.2014 16.33.44	08.11.2014 07.33.44	10.11.2014 08.33.44	10.11.2014 13.33.44	11.11.2014 12.33.44	11.11.2014 13.33.44		26/12/2014 13:00:00	26/12/2014 14:00:00	26/12/2014 15:00:00	26/12/2014 16:00:00		
UNIT 5 BFP B SUCTION PRESSURE	9.88	10.15	9.74	10.14	10.30	10.17	9.73	10.18	10.04	9.53	9.64	9.58	9.35	9.52	0.52
UNIT 5 BFP B DISCHARGE PRESSURE	137.83	139.54	136.37	138.65	139.29	138.98	137.90	137.61	138.30	137.50	134.90	134.63	133.95	135.25	3.06
UNIT 5 BFP B DISCHARGE FLOW	292.23	297.27	289.20	296.89	285.48	292.66	289.61	292.01	291.92	282.90	285.72	282.86	286.03	284.38	7.54
BFP_5B_kW	2086.43	2122.78	2125.92	2152.80	2101.33	2141.63	2115.47	2129.79	2122.02	1854.60	1841.72	1873.97	1813.70	1846.00	276.02
UNIT 5 LOAD PT 2	180.71	178.28	187.69	177.51	179.53	182.68	171.43	172.96	178.87	174.96	171.21	170.03	170.95	171.79	7.08
Specific Energy Consumption	7.14	7.14	7.35	7.25	7.36	7.32	7.30	7.29	7.27	6.56	6.45	6.62	6.34	6.49	0.78
Net Gain in KW terms(Approx)	227.1														
Net Gain in SEC (Approx)	0.61														

Payback Period Calculation

Energy saved per hour (Kwh)	227.1
Financial gain (Rs./Year) Unit availability 320 days, Variable Cost Rs. 4.5/Kwh	7648576
Cartridge Net Payment Given to BHEL	22195624
Payback Period in Years	2.83

(Madan Kumar)

(Arun Kumar Singh)

Fig 2.3

f) Payback Period Calculation

Energy saved per hour (KwHr)	=227.1
Financial gain (Rs./Year)*	= 227.1*24*320*3.66= 6383508
Cartridge Net Payment Given to BHEL (Rs)	=19200000
Payback Period (Years)	= 3.0 Yrs

**(Unit availability 320 days, Variable Cost:Rs. 3.66/Unit)*

2.3 Installation of matrix type multi stage, multi path tortuous flow BFP recirculation valve in place of conventional valve

The units of BTPS were commissioned in the period 1973 to 1981. Each of these unit is provided with three nos of Boiler Feed pumps (02 nos in service & 01 no in standby mode) of model-150 KHI (installed in 95 MW Units) & 200 KHI (installed in 210 MW Units) supplied by OEM M/s BHEL. Each BFP is provided with recirculation valve for minimum flow to Dearator to avoid churning in BFP. In 3x95 MW Units, Valves are supplied by BHEL which have single stage with energy absorber device. In 2x210 MW Units, the valve are supplied by Mil control ltd.

Boiler feed pump is an auxiliary which accounts for major share of auxiliary power consumption & any passing in its recirculation valve, contributes energy loss. In order to meet the demand,an matrix type multi stage, multi path tortuous flow BFP recirculation valve was used in place of conventional valve at NTPC,Badarpur

Background for selecting new valve

a. Frequent passing problem
b. Interchangeability with the valve
c. Proven record for such new design valve

Features of matrix type valve:

a) Multi Stage Multi Path Trim Design

New design valve has number of pressure & velocity reduction stages. This design ensures tortuous flow path thus achieving a very high critical flow factor which reduces the chance of cavitation.

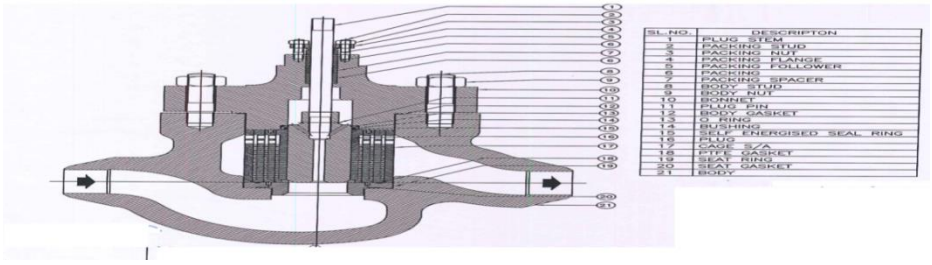

Fig 2.4

b. Discrete Pressure & Velocity Reduction Stages –

It gives very high impedance to flow with low trim velocity and less erosion. Lesser Pressure drop/ Stage increase longevity of internals.

c. Harder Material of Construction - Using hardened martensitic stainless steel material like SS 410/ SS440 C/F91

d. Large stroke valve for better controllability

e. Low noise level

Enthalpy needed to raise pressure from 9 Ksc (Suction 165 deg 697 KJ/Kg) to 150 Ksc (Discharge 168 deg 718 KJ/Kg) of water handled by BFP is 21 (KJ/Kg)*. Any passing of the valve may cause high energy loss. Keeping the view of above thing, Matrix type multi stage, multi path tortuous flow BFP recirculation valves reduced the passing problem in valves hence reduced energy loss & increased availability of BFP.

**All process parameters are running values of Unit 5 (BTPS 210 MW)*

Impact on APC

Energy Saving due to arrest of Recirculation Valve passing in one valve					
S.No.	Press. (kg/sq cm)	Press (bar)	Temp	Enthalpy (KJ/Kg)	Enthalpy Difference (KJ/Kg)
1	9	8.83	165	697	
2	150	147.10	168	718	21
Passing Value(1 Ton/Hr)					1000
Energy requirement (KJ)/Hr					21000
Equivalent Kwh/Hr					5.831
BFP Running Hrs without passing up to March					20823.41
Average flow of passing prevented (Tons/Hr)					8
Energy saved(MU)					0.971

Note: 1KWh =860.42 Kcal = 3601.71812 KJ

Table 2.2

3. GAIN IN APC IN FEED WATER SYSTEM IN A YEAR/ UNIT (ASSUMING PASSING IN ONE BFP RECIRCULATION VALVE)

Project description	Savings vs Investment Rs. (Lakhs)		
	Electricity (Lakhs kWh)	Total savings (Rs. Lakhs)	Investment (Rs. Lakhs)
BFP Cartridge replacement	17.44	63.84	192
BFP Recirculation valve servicing	3.24	11.85	12.95
Commissioning of Auto controller of FRS DP	19.15	72.28	14.5

Table 3.1

CONCLUSION

NTPC, Badarpur is running continuously on part load since last 5 years and average loading factor is around 85%. Many stations in our country is experiencing the same. Although CERC is formulating provisions for compensations for APC due to part load operations, stations should strive for reduction of APC, particularly in areas where potential is high. Two areas, where maximum potential for APC reduction is there are Draft System and Feed Water System. Implementation of action plan in Feed water system resulted a saving of 0.17 % in APC during in FY 2015-16 which is approx. 40% of total saving in APC. After carrying out these actions, Specific Energy Consumption of BFPs of 2x210 MW Units at NTPC,Badarpur is lowest among all 210 MW Units of NTPC.

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