International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Energy Conservation of Boiler Feed Pump by Differential Pressure Auto Scoop Control Method (Audit & Result Analysis)

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Accepted 05 May 2015, Available online 10 May 2015, **Vol.5, No.3 (June 2015)**

Abstract

The proposed project is to perform Energy audit of Feed water system at Abhijeet MADC Nagpur Energy Private Limited (AMNEPL), 4X61.5 MW Mihan Power Plant, Khairy Khurd, Hingna, Nagpur. The objective of the audit is to identify and obtain energy efficiency through operation of boiler feed pump by means of scoop control in auto mode (DP method) during daily operation of the plant at varying load conditions. The scope of the audit covers the boiler feed pumps and the feed water system in each unit of the AMNEPL power plant. Boiler feed pump is one of the equipments in a power plant with the highest auxiliary consumption.

Keywords: *Thermal Power Plant, Energy Conservation, Energy Audit, Boiler Feed Pump, 3 Element Method, Differential Pressure Method, Hydraulic Scoop Coupling, Boiler Drum.*

1. Profile of Mihan Thermal Power Plant

The Mihan power plant has 4 units having a generation capacity of 61.5 MW each. The electricity produced is supplied to Multimodal International Hub and Airport at Nagpur (MIHAN) as well as to private and government parties.

The audit is specifically targeted at the feed water system and its potential for obtaining considerable energy and cost savings. The feed water system comprises of the Deaerator, Boiler feed pump (BFP), high pressure heaters (HPH), Feed regulation station (FRS) and Economiser. The major energy saving can be obtained by reducing the power consumption of the Boiler Feed Pump. The BFP supplies feed water to the boiler against boiler drum pressure. The BFP has a high tension motor of 6.6 KV and power required is 1.6 MW. The speed regulation of the pump is achieved by means of a hydraulic scoop control. The BFP is operated 24 hours per day for 15 days. Thereafter, the standby BFP is operated for the next 15 days, 24 hours per day. In all four units for maintaining drum level three element control is used where the feed control station was kept in 3 element mode.

2. Introduction to Boiler Feed Water System

In the boiler, heat produced by combustion of fuel is transferred to the feed water and steam is generated. So, feed water is the medium to receive heat. Heat transfer takes place from hot flue gas to feed water. In a water tube boiler, flue gas moves outside the boiler tube in which feed water flows. As steam is taken out from the boiler continuously, so it is required to pump feed water continuously into the boiler.

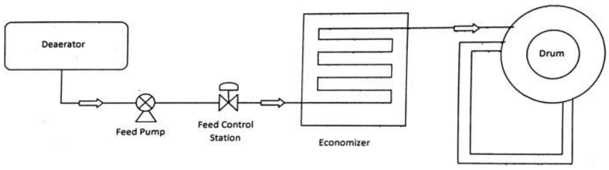

Fig.1 General Schematic of Feed Water System

3. Aims and Objectives

- To identify and obtain energy conservation through operation of the Boiler feed pump scoop control in auto mode by using the differential pressure method.
- To reduce Power consumption of the Boiler feed water system as Boiler feed pump is one of the equipments in a power plant with the highest auxiliary consumption.
- Safer operation of the equipment at optimum level.
- To reduce Human interference due to automation.
- To obtain smooth operation in the fluctuating load conditions.
- To increase Equipments life.
- To increase the overall efficiency of the system.
- To increase the cost saving.

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4. Technical Specifications

Table 4.1 Boiler Specifications

Technical Specification	Parameters
Year of installation	2009
Type of boiler	CFBC
Type of furnace	Membrane wall
Capacity	250 TPH
Peak capacity	270 TPH
Temperature	540 Deg C
Design steam pressure	11.781 Mpa
Boiler drum pressure	11.22 Mpa
Type of cyclone	Steam cooled
Type of fuel feeding	Belt conveyor and pocket feeder

Table 4.2 Turbine Specifications

Technical Specification	Parameters
Year of installation	2009
Model no.	N61.5-8.83/537
Type	High temp.& high press.non control extraction condensing
Maximum continuous output at generator terminal at mcr condition	61.5 MW
Main steam pressure	8.83 Mpa
Main steam temperature	537 ^{0}C
Main steam flow	238 TPH
Rated speed	3000 RPM
Flow path series	21 (1 governing stage + 20 pressures
Turbine heat rate	9287 kj / kwhr(T-MCR),2218 Kcal /
Regeneration series	6 (2 HPH + 3 LPH + 1 deaerator)
Points for non - controlling extraction	Behind stages no. 5, 8, 11, 15, 17, 19

Table 4.3 Boiler Feed Pump Motor Specifications

Technical Specification	Parameters
Type	Squirrel cage motor
Rated voltage	6600v
Frequency	50 hz.
Connection	Star
Phase	3
Speed	2985 rpm
Power factor	0.88
Current	166 amps
Efficiency	96.1%
Rated power output	1600 kw

Table 4.4 Boiler Feed Pump Specifications

Technical Specification	Parameters
No of stages	14
Liquid handled	Boiler feed water
Diff. Head/ ham	1505 m
NPSH r	7.2 m
Speed	2905 rpm (+ 5% slippage)
Efficiency	81%
Power	1142 kw
Suction temp.	158.1 0c
Suction pressure	6.0 kg/cm2
Discharge pressure	142 kg/cm2
Discharge temp.	160.1 0c
Discharge flow	300 m3/hr

Table 4.5: Energy Consumption and Energy Generation of Single Unit per Day

Sr.No.	Parameters	UOM	Design Value	Operating Value
1	Generation	MWH	1476.00	1444.00
2	Net Power Export	MWH	1321.02	1251.62
3	Net Power Import	MWH	-	0.00
4	Load on Station Transformer	MWH	-	101.69
5	Auxiliary Consumption	MWH	-	82.59
6	UAT	MWH	-	81.40
7	Total Unit Auxiliary Consumption	MWH	154.98	163.99
8	Total Unit Aux. Consumption	%	10.50	11.36
9	Running Hours of Generator	Hrs	24.00	24.00
10	Average Load (Running Hrs Basis)	MW	61.50	60.17
11	Plant Load Factor	%	100	97.83
12	Plant Availability Factor	%	100	100
13	Total Steam at Boiler Outlet	TPD	5760.12	5627.31
14	Steam Inlet to Turbine	TPD	5712.12	5442.38
15	Steam Consumption per KWH	Kg / KWH	3.87	3.77
16	Turbine Heat Rate	Kcal /KWh	2218	2231.84
17	Station Heat Rate	Kcal /KWh	2650	2688.96
18	Running Hours Boiler	Hrs	24.00	24.00
19	Raw Water Consumption	Cu. M	20599.00	5924.00
20	DM Water Consumption	Cu. M	< 180	60.00
21	Coal Consumption	MT	1220.00	1153.69
22	G.C.V of feed coal	Kcal / Kg	3432.00	3711.00
23	Specific Coal Consumption	Kg / KWH	0.83	0.80

Table 5.1: Instruments used for measurements

Parameter	Instrument	Accuracy
Flow	Magnetic Flow Meter	± 1 %
Head	Bourdon Tube Pressure Gauge & Pressure Transducer	± 0.5 %
Power	3-phase watt transducer in conjunction with current & potential transformers	± 0.5 %
Speed	Electronic Revolution Centre	± 0.1 %
Temperature	Resistance temperature detector with electronic indicator	± 1 ^{0}C
Vibration	Spectrum analyzer with accelerometer probe	± 5 %

5. Procedure

The experimentation is carried out in the normal working conditions to get as accurate results as possible. Initially the feedwater system is maintained at normal operation conditions i.e. the Deaerator is charged from steam side to maintain a pressure of 5.8 Bar and the feed storage tank of the deaerator is filled to 50% of its storage capacity, the Boiler feed pump is in operation and the drum level is maintained at 50 % by the three element drum level control method. The boiler feed pump scoop control mechanism is operated manually to adjust the feedwater pressure so that the pressure is incremented by a value of 80 m^3/hr against the boiler drum pressure. The flow is controlled automatically by the flow control valves which receive commands from the three element mechanism. The readings necessary for the analysis and calculation are recorded.

After the readings are taken, the system is prepared for the implementation of the proposed system. It is to be noted that for the accurate results the feedwater flow in both cases is to be kept the same. Also, since the objective is to reduce the power consumption of the boiler feed pump and yet maintaining the required pressure across the feed control station, the flow control valves are opened manually to a 70 % open condition in order to maximize the results and balance the controlling conditions governed by the flow and pressure requirements. The scoop is adjusted manually till the flow and pressure match with respect to the control valve openings. Thereafter the scoop command is actuated in AUTO mode when the flow reaches the test flow of 281m^3/hr, and the scoop operates to maintain the differential pressure across the feedwater station provided as the set point by the operator. The minimum set point provided is 10 Kg/cm^2, as this is minimum set point that can be provided for the safe and stable operation of the system. The flow control valve operates to maintain the flow and the pressure.

The flow transmitter and the flow element are provided at the discharge end of the Boiler feed pump. While the flow element maintains the required flow through the feed line the flow transmitter measures the flow across the feed line. Two pressure transmitters are provided in the feed water system. One transmitter is provided just near the discharge end of the boiler feed pump i.e. before the Feed regulation station and the other transmitter is provided at after the feed regulation station near the economiser inlet.

These transmitters transmit the pressure readings to the distributed control systems in the control room and help in continuous monitoring away from the field. Similarly, a pressure gauge is provided at the discharge end of the Boiler feed pump for on-field monitoring of the discharge pressure. A temperature element and a temperature gauge are also provided at the discharge end of the boiler feed pump for measuring the temperature of the discharge feed. Other than the above mentioned instruments, a parallel arrangement of three flow control valves is also provided on the feed line which together constitutes the feed regulation station. The main purpose of the feed regulation station is to maintain the necessary pressure so that the feed water is discharges against drum pressure. The detailed process and instrumentation diagram of the feed water system is provided in the appendices.

6. Performance Test Record

Table 6.1: 3 – Element Method

Equipment	Boiler Feed Pump	Date	26thMarch,2015
Model No	MD 100-300 / 14	Serial No	386620
Suction/Discharge NB (mm)	400 / 125	Impeller Diameter	297
Driver KW	1600	RPM	2905
STANDARD OPERATING PARAMETERS			
Liquid Duty		**Liquid Data**	
Flow (m^3 / hr)	300	Specific Gravity	0.909
TDH (mwc)	1505	Temperature (^0C)	158.1
Pump Input (KW)	1442	Viscosity	0.15 P
Efficiency (%)	81	Ke : 1 Kh : 1	Kq : 1
$NPSH_r$ (mwc) : 7.20	H atm (mwc) : 10.2	Shut Off Head (mwc) : 1884	

Speed		RPM	2734	2708	2726	2726	2772.51
Flow		m^3/hr	0.00	80.10	161.00	242.70	281
Suction	Gauge	Bar	5.8	5.8	5.8	5.8	5.8
	Correction	M	0.70	0.70	0.70	0.70	0.70
	Hs	mwc	59.86	59.86	59.86	59.86	59.86
Disch.	Gauge	Bar	164.30	161.00	153.70	141.00	137.61
	Correction	M	0.70	0.70	0.70	0.70	0.70
	Hd	mwc	1676.56	1642.90	1568.44	1438.9	1404.32
TDH		mwc	1616.68	1583.02	1508.56	1379.02	1344.44
Voltage		volts	6600	6600	6600	6600	6600
Current		Amps	69.60	99.20	115.63	131.20	137.18
Wattmeter		KW	8.75	12.47	14.54	16.49	17.24
Multi factor			80	80	80	80	80
Motor Input		KW	700.15	997.92	1163.20	1319.83	1379.95
Motor Efficiency		%	95.23	95.36	95.57	96.01	96.34
Pump Output		KW	0.00	345.50	661.79	911.95	1029.39
Pump Efficiency		%	0.00	25.53	63.43	79.88	80.85
Performance Corrected to Rated Speed : 2905 RPM							
Flow		m^3/hr	0.00	85.92	171.57	258.63	294.42
TDH		mwc	1825.23	1821.71	1713.18	1566.06	1476.00
Pump Input		KW	0.00	980.13	1098.51	1222.67	1269.89
Efficiency		%	0.00	25.53	63.43	79.88	80.85

Table 6.2: DP Method with Scoop in Manual Mode

Equipment	Boiler Feed Pump	Date	26thMarch,2015
Model No	MD 100-300 / 14	Serial No	386620
Suction/Discharge NB (mm)	400 / 125	Impeller Diameter	297
Driver KW	1600	RPM	2905
STANDARD OPERATING PARAMETERS			
Liquid Duty		**Liquid Data**	
Flow (m^3 / hr)	300	Specific Gravity	0.909
TDH (mwc)	1505	Temperature (^{0}C)	158.1
Pump Input (KW)	1442	Viscosity	0.15 P
Efficiency (%)	81	Ke : 1 Kh : 1	Kq : 1
NPSH $_r$ (mwc) : 7.20	H atm (mwc) : 10.2	Shut Off Head (mwc) : 1884	

Speed		RPM	2679	2653	2671	2671	2655
Flow		m^3/hr	0.00	80.10	161.00	242.70	281
Suction	Gauge		5.8	5.8	5.8	5.8	5.8
	Correction		0.70	0.70	0.70	0.70	0.70
	Hs		59.86	59.86	59.86	59.86	59.86
Disch.	Gauge		164.90	137.43	120.50	120.06	117.67
	Correction		0.70	0.70	0.70	0.70	0.70
	Hd	mwc	1682.68	1402.48	1229.8	1225.31	1201.02
TDH		mwc	1622.80	1342.60	1169.92	1165.43	1141.14
Voltage		volts	6600	6600	6600	6600	6600
Current		Amps	69.60	89.60	110.38	118.40	108.52
Wattmeter		KW	8.75	11.26	13.87	14.88	13.64
Multi factor			80	80	80	80	80
Motor Input		KW	700.15	901.35	1110.39	1191.07	1091.68
Motor Efficiency		%	95.49	95.89	96.27	96.50	96.50
Pump Output		KW	0.00	293.03	513.23	770.70	873.73
Pump Efficiency		%	0.00	29.93	64.53	83.55	86.75
Performance Corrected to Rated Speed : 2905 RPM							
Flow		m^3/hr	0.00	87.62	176.13	265.51	307.45
TDH		mwc	1942.49	1607.11	1400.39	1395.01	1366.16
Pump Input		KW	0.00	795.33	979.05	922.44	1007.18
Efficiency		%	0.00	29.93	64.53	83.55	86.75

Table 6.3: DP Method with Scoop in Auto Mode)

Equipment	Boiler Feed Pump	Date	26thMarch,2015
Model No	MD 100-300 / 14	Serial No	386620
Suction/Discharge NB (mm)	400 / 125	Impeller Diameter	297
Driver KW	1600	RPM	2905
STANDARD OPERATING PARAMETERS			
Liquid Duty		**Liquid Data**	
Flow (m^3 / hr)	300	Specific Gravity	0.909
TDH (mwc)	1505	Temperature (^{0}C)	158.1
Pump Input (KW)	1442	Viscosity	0.15 P
Efficiency (%)	81	Ke : 1 Kh : 1	Kq : 1
NPSH $_r$ (mwc) : 7.20	H atm (mwc) : 10.2	Shut Off Head (mwc) : 1884	

Speed		RPM	2653	2657	2660	2650	2655
Flow		m^3/hr	277	280	285	270	281
Suction	Gauge		5.8	5.8	5.8	5.8	5.8
	Correction		0.70	0.70	0.70	0.70	0.70
	Hs		59.86	59.86	59.86	59.86	59.86
Disch.	Gauge		125.35	118.16	118.16	117.67	117.67
	Correction		0.70	0.70	0.70	0.70	0.70
	Hd		1279.27	1205.93	1205.93	1201.02	1201.02
TDH		mwc	1219.39	1191.64	1146.05	1167.98	1141.14
Voltage		volts	6600	6600	6600	6600	6600
Current		Amps	105.38	110.10	115.71	103.98	108.52

Wattmeter	KW	13.25	13.84	14.55	13.07	13.64
Multi factor		80	80	80	80	80
Motor Input	KW	1060.09	1107.57	1164.01	1046.01	1091.68
Motor Efficiency	%	96.40	96.50	96.60	96.40	96.50
Pump Output	KW	920.35	909.15	889.98	859.27	873.73
Pump Efficiency	%	86.25	86.40	86.55	86.80	86.75
Performance Corrected to Rated Speed : 2905 RPM						
Flow	m^3/hr	303.31	306.13	311.25	295.98	307.45
TDH	mwc	1462.04	1424.47	1366.88	1403.57	1366.16
Pump Input	KW	1067.07	1052.25	921.30	989.94	1007.18
Efficiency	%	86.25	86.40	86.55	86.80	86.75
Ambient Temperature : 30.23 ^{0}C Bearing Temperature : D.E – 43.00 ^{0}C N.D.E – 55.00 ^{0}C						

7. Analyses and Calculations

Calculation for Proposed System

Rated Speed, N= 2905 RPM
Test Speed, N1 = 2772.51 RPM
Rated Flow = 300 m^3 / hr
Test Flow, Q = 281 m^3 / hr
Operating Temperature T_o= 158.1 ^{0}C
Suction NB, Ds= 400 mm
Discharge NB, Dd = 250 mm
Elevation difference between suction gauge and pump centre, HS= 0.7 m
Elevation difference between Discharge gauge and pump centre, HD = 0.7 m
Atmospheric Pressure, Ha = 10.2 mwc
Vapour Pressure, Hv = 59.62 mwc
Density of water at operating temperature = 0.9093 kg / m^2

A) **Suction Head,**
Hs = Ps x 10.2 ± HS
= 5.8 x 10.2 + 0.7
Hs = 59.86 mwc

B) **Discharge Head,**
Hd = Pd x 10.2 ± HD
= 137.61 x 10.2 + 0.7
Hd = 1404.32 mwc

C) **Suction Velocity Head,**
K1 = $6.382 \times 10^{-9} \times \{1 / (D_s)^4\} \times Q^2$
= $6.382 \times 10^{-9} \times \{1 / (0.4)^4\} \times 281 \times 281$
K1 = 0.01968 mwc

D) **Net Velocity Head,**
K = $6.382 \times 10^{-9} \times [\{1 / (D_d)^4\} - \{1 / (D_s)^4\}] \times Q^2$
= $6.382 \times 10^{-9} \times [\{1 / (0.25)^4\} - \{1 / (0.4)^4\}] \times (281)^2$
K = 0.109 mwc

E) **Total Differential Head,**
TDH = Hd – Hs + K
= 1404.32 – 59.86 + 0.109
TDH = 1344.56 mwc

F) **NPSH $_a$** = Ha + Hs + K1 – Hv
= 10.2 + 59.86 + 0.01968 – 59.62
NPSH $_a$ = 10.45 mwc

G) **Power Output of Pump,**
Pout = Q x TDH / 367
= 281 x 1344.56 / 367
Pout = 1029.49 KW

H) **Power Input to motor,**
Pm = Wattmeter X Multi factor
= 17.24 x 80
Pm = 1379.95 KW

I) **Brake Kilowatt, bKw** = Pm x $\eta_m \times \eta_c$
= 1379.95 x 0.9610 x 0.96
bKw = 1273.09 KW

J) **bKw $_{Hot}$** = bKw x ρ / η_{Hot}
= 1273.09 x 0.9093 / 0.80
bKw $_{Hot}$ = 1447.02 KW

K) **Efficiency of Pump, η_p** = (Pout / bKw) x 100
= (1029.49 / 1273.09) x 100
η_p = 80.86 %

The above calculations are made at operating conditions and hence need to be extrapolated to rated conditions to determine the exact effect of the modification on the system operation. The corrections to rated conditions are calculated below.

Correction to Rated Speed

1) **FFlow, Q $_{rated}$** = (N / N1) x Q
= (2905 / 2772.51) x 281
Q $_{rated}$ = 294.42 m^3 / hr

2) **TTotal Differential Head,**
TDH $_{rated}$ = $(N / N1)^2$ x TDH
= $(2905/2772.51)^2$ x 1344.44
TDH $_{rated}$ = 1476.00 mwc

3) **NNPSH $_{a\ rated}$** = $(N / N1)^2$ x NPSH
= $(2905 / 2772.51)^2$ x 10.45
NPSH $_{a\ rated}$ = 11.47 mwc

4) **bbKw $_{rated}$** = $(N / N1)^3$ x bKw
= $(2905 / 2772.51)^3$ x 1447.02
bKw $_{rated}$ = 1664.53 KW

Calculation for Proposed System

Rated Speed, N= 2905 RPM
Test Speed, N1 = 2772.51 RPM

Rated Flow = 300 m^3 / hr
Test Flow, Q = 281 m^3 / hr
Operating Temperature T_o= 158.1 ^{0}C
Suction NB, Ds= 400 mm
Discharge NB, Dd = 250 mm
Elevation difference between suction gauge and pump centre, HS= 0.7 m
Elevation difference between Discharge gauge and pump centre, HD = 0.7 m
Atmospheric Pressure, Ha = 10.2 mwc
Vapour Pressure, Hv = 59.62 mwc
Density of water at operating temperature = 0.9093 kg/ m^2

A) Suction Head,
Hs = Ps x 10.2 ± HS
= 5.8 x 10.2 + 0.7
Hs = 59.86 mwc

B) Discharge Head,
Hd = Pd x 10.2 ± HD
= 117.67 x 10.2 + 0.7
Hd = 1201.02 mwc

C) Suction Velocity Head,
K1 = $6.382 \times 10^{-9} \times \{1 / (D_s)^4\} \times Q^2$
= $6.382 \times 10^{-9} \times \{1 / (0.4)^4\} \times 281 \times 281$
K1 = 0.01968 mwc

D) Net Velocity Head,
K = $6.382 \times 10^{-9} \times [\{1 / (D_d)^4\} - \{1 / (D_s)^4\}] \times Q^2$
= $6.382 \times 10^{-9} \times [\{1/(0.25)^4\} - \{1 / (0.4)^4\}] \times (281)^2$
K = 0.109 mwc

E) Total Differential Head,
TDH = Hd – Hs + K
= 1201.02 – 59.86 + (- 0.019)
TDH = 1141.141 mwc

F) NPSH $_a$ = Ha + Hs + K1 – Hv
= 10.2 + 59.86 + 0.01968 – 59.62
NPSH $_a$ = 10.45 mwc

G) Power Output of Pump,
Pout = Q x TDH / 367
= 281 x 1141.141 / 367
Pout = 873.73 KW

H) Pump Input to motor,
Pm = Wattmeter X Multi factor
= 14.55 x 80
Pm = 1091.68 KW
I) Brake Kilowatt,
bKw = Pm x η_m x η_c
= 1091.68 x 0.9610 x 0.96
bKw = 1007.14 KW

J) bKw $_{Hot}$ = bKw x ρ / η_{Hot}
= 1007.14 x 0.9093 / 0.80
bKw $_{Hot}$ = 1144.74 KW

K) Efficiency of Pump,
η_p = (Pout / bKw) x 100
= (873.73 / 1007.14) x 100
η_p = 86.75 %

The above calculations are made at operating conditions and hence need to be extrapolated to rated conditions to determine the exact effect of the modification on the system operation. The corrections to rated conditions are calculated below.

Correction to Rated Speed

1) **FFlow, Q $_{rated}$** = (N / N1) x Q
= (2905 / 2655) x 281
Q $_{rated}$ = 307.45 m^3 / hr

2) **TTotal Differential Head,**
TDH $_{rated}$ = $(N / N1)^2$ x TDH
= $(2905 / 2655)^2$ x 1141.141
TDH $_{rated}$ = 1366.16 mwc

3) **NNPSH $_{a\ rated}$** = $(N / N1)^2$ x NPSH
= $(2905 / 2655)^2$ x 10.45
NPSH $_{a\ rated}$ = 12.51 mwc

4) **bbKw $_{rated}$** = $(N / N1)^3$ x bKw
= $(2905 / 2655)^3$ x 1007.14
bKw $_{rated}$ = 1319.27 KW

8. Comparative of Power consumption

Table 8.1: Comparison of Old & New system

Power Consumption of Existing System		
Feed Water eco inlet pressure	Kg/cm2	108.50
Feed Water pressure before FCS	Kg/cm2	137.61
Scoop % (Command)	%	67
Scoop % (Actual)	%	73.25
Control Valve opening position	%	53
Differential Pressure across FCS	Kg/cm2	29.12
Boiler Feed Pump Speed	Rpm	2772.51
BFP Current	AMP	137.18
BFP Power Consumption (Per day)	KWH	33871.65
Power Consumption of Proposed System (Based on Theoretical Calculations, Motor & Pump Efficiency Curves)		
Feed Water eco inlet pressure	Kg/cm2	108.50
Feed Water pressure before FCS	Kg/cm2	117.67
Scoop % (Command)	%	70
Scoop % (Actual)	%	70
Control valve opening position	%	73
DP Set point for BFP scoop control	Kg/cm2	10
Differential Pressure across FCS	Kg/cm2	10
Boiler Feed Pump Speed	Rpm	2655
BFP Current	AMP	108.52
BFP Power Consumption (Per day)	KWH	26795.09

Table 9.1: Actual Net Energy saving for new system

Actual Net Energy Savings:		
Cost Benefits		
BFP Current	=	108.52 amps
BFP Power Consumption (Per day)		26795.09
Annual Energy Saving Potential	=	33871.65 – 26795.09
	=	**7076.56 KWH/day**
Annual Cost Saving	=	7076.56 x 365 x 4.35 x 4
	=	**Rs. 44943232.56 per year (For 4 Unit)**
Investment	=	Nil
Simple Payback Period	=	Immediate

For the calculations it is imperative that one condition is always fulfilled under every operating load conditions. The feed water discharge pressure at the economiser inlet is always greater than the boiler drum pressure. If this condition is reversed then it might lead to tube ruptures of the economiser due to overheating. At full load conditions the drum pressure is always 10 kg/cm^2 above the main steam pressure i.e. at full load condition the maximum allowable main steam pressure is 90 kg/cm^2, therefore the corresponding drum pressure will be 100 kg/cm^2. Hence, while considering the calculations it is always made sure that the feed water discharge pressure at the economiser inlet or the feed regulation station outlet is above the maximum pressure range of the boiler drum for safe operation. The rest of the calculations are completely dependent on only the power requirement and consumption of the boiler feed pump corresponding to the discharge pressure. The power consumption and the discharge pressure are in direct proportion i.e. an increase in discharge pressure increases the power consumed and a decrease in discharge pressure decreases the power consumed.

9. Calculations of Energy Savings

BFP rating: 6600 Volts, 1600KW
Power Factor: 0.88
Reduction in BFP current: 28.66 Amps
Cost of 1KWH unit: Rs4.35 (inclusive of coal cost, water cost and auxiliary consumption cost)

Savings = √3 VI Cos Ø
= 1.732 x 6600 x 28.66 x 0.90 x 24/1000 KWH /day
= 7076.56 KWH/day (in terms of units per day)
= 7076.56 x 365 x 4.35 x 4 (in Rupees per annum)

= Rs. 4, 49, 43, 232.56 per year (For 4 Units)

= Rs. 1, 12, 35, 796.94 per year (Per running unit)

Since, all the instruments and equipments for controlling and monitoring the experimentation are already installed in the system, no extra cost of purchasing and installation is required. Therefore, the payback is immediate. Also, the success of the experiment provides both tangible and intangible benefits. It is very robust control and can be used during varying loads without any major drum level fluctuation. With decreased DP across FRS life of control valve also increases. Life of a bearing is inversely proportional of the seventh power of its speed hence as the speed of BFP decreases its bearing life also increases.

Therefore, from the above calculations for the proposed modification in system it is clear that the

1. NSHP $_a$ for the proposed system is greater than NSHP $_a$ for the existing system and will always be greater than NPSH $_r$ under operating conditions
2. The changes in Flow and Head are small compared to the previous system.
3. The efficiency of the pump increases by 5.9 % compared to the previous system.
4. The power input to the motor decreases by 288.27 KW compared to the previous system
5. The efficiency of the motor more or less remains the same with respect to Power factor as a component of load and speed.

10. Energy Conservation Recommendations

Operating hydraulic scoop control of BFP in Differential pressure mode

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 is robust and can be used at varying load conditions with negligible drum level fluctuation. Moreover, it reduces the dependence on human interference for operation of the system.

Lock the feed regulation station flow control valves to operate between 0% (min) - 75% (max) open condition

Operating the control valves within the maximum and minimum values ensures that the sensitivity of operation of the valves is preserved for a long time also it enables the operator to control the system effectively during sudden load throw off conditions. Also, this measure ensures that at no point in the operation does the discharge pressure reduce below the drum pressure.

Provide tripping interlocks for the BFP at a pressure below 100 kg/cm^2

This measure ensures that in conditions where there is a sudden tube leakage or blackout of the plant the plant can be tripped safely and the equipment is safe from damage.

Summary

- The audit deals with the Energy conservation achieved through operation of boiler feed pump by means of scoop control in auto mode (DP method) during daily operation of the plant at varying load conditions.
- The scope of the audit covers the boiler feed pumps and the feed water system in each unit of the AMNEPL power plant.
- Boiler feed pump is one of the equipments in a power plant with the highest auxiliary consumption.
- There is a scope of energy saving if the Boiler feed pump power consumption is reduced.
- A major saving can be obtained in the Total auxiliary consumption.
- Safer operation of equipment can be obtained at the optimal level.
- Human interference is negated due to automation.

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