Operational Experience with High Pressure Captive Cogeneration Plant in Paper Mill

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The State-of-art High Pressure Captive Cogeneration Plant in operation since March 2005 in Seshasayee Paper & Boards Limited is meeting bulk of the steam and power requirements with high degree of efficacy. High pressure steam (105 bar, 51°C) generated in the Atmospheric fluidized bed combustion boiler supplied by M/s Enmass Andritz is integrated to the highly efficient double extraction condensing steam turbine of BHEL for the combined heat and power requirements of the paper mill.

The boiler is firing Enviro-friendly imported coal with thermal efficiency of 85 % on GCV of the fuel. With high combustion efficiency and advanced ESP in place at the back-end of the boiler, the particulate emission through the stack is well under 50 mg/Nm^3 – which is on par with International Standards. Extraction steam from the turbine at 10bar & 4bar are being used in the process apart from meeting Deaerator steam requirements. Specific steam consumption is around 5TPH/MWh in the cogeneration mode of operation.

Innovative features viz., Process Condensate polishing scheme related to high purity feed water requirements of the boiler, low stack gas temperature, VFD for Fans and advanced chemical dosing scheme have contributed towards energy conservation. Direct Energy Balance algorithm developed in-house integrating Power and steam energies had been the hall-mark in Control Automation and had resulted in reduction in auxiliary power consumption.

The operational experiences from the Coal fired high pressure boiler and the Double extraction Condensing steam turbine and the integrated auxiliaries are being discussed in the paper. As a matter of fact, the operational success of the CCP had paved the way for a host of other paper mills to put up high pressure cogeneration plants to meet their internal steam and power requirements.

INTRODUCTION

Energy Conservation is multifaceted, with power, steam, water and environment management all go hand in hand, with Climate change development adding as a fifth dimension.

Cogeneration implies steam and power generation from the same source. Paper and pulp industry is energy intensive (in terms of combined heat and power). As compared to International standards, unit steam consumption level for Indian paper and pulp industry is by and large much higher (Table-1).

Appreciating the above fact that specific energy consumption of thermal and electric consumption of paper being quite high, disturbing not only the paper production costs, but also impairing environment and climate, SPB thought it fit to go in for in-house power generation complementing steam requirement of the process thereby reducing the dependence on the costly grid power import.

As the first logical step, SPB had made the right decision to go in for state-of-art high pressure steam cogeneration plant, mainly with a view to reduce specific steam consumption and achieve quantum jump in overall cycle

Table - 1: Comparative study of CHP

Parameter	Unit	Internl.	Indian	SPB
Steam	Te/Te	5.5	9.0	8.5
Power	MW/TPH	0.8	1.3	1.2
Water	m^3/Te	50	200	100
CCP- Station Power Consumption	Fraction of Power Generated	-	0.12	0.13*

Note : * :The primary reason for high specific steam consumption is due to increased Boiler main steam pressure and high head being AFBC Boiler.

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efficiency of the cogeneration plant. In the selection of the power boiler, emphasis was given to achieving high thermal efficiency which would relate to high steam evaporation ratio.

Over the years, steam pressure and temperature levels adopted in Pulp & Paper industries have gradually gone up from medium pressure level (42 bar,420°C) to higher pressure level (64 bar,490°C). As for the progress achieved over the last 30 years or so, refer Fig.1.

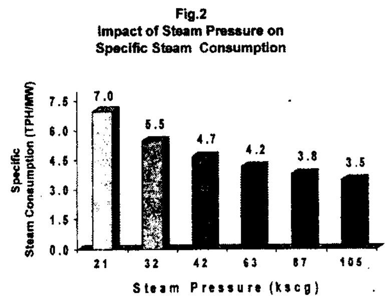


Fig 2: Impact of Steam Pressure on Specific Steam Consumption

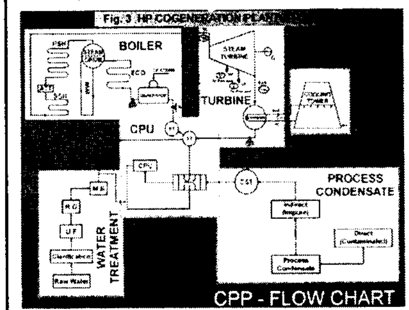


Fig 3: HP Cogeneration Plant at SPB

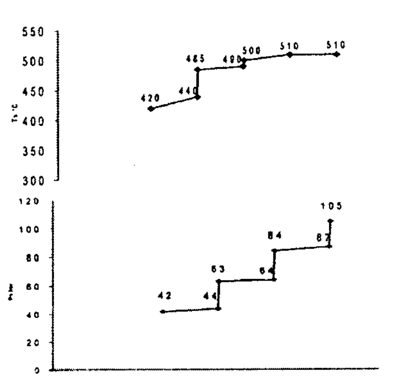


Fig. 1 : Progress in Operating Steam Pressure and Temperature of Cogeneration Plant in Indian Paper Mills over the years

Table -2 : Salient Facets of Captive Cogeneration plant at SPB

- Highest Steam Pressure (105 bar) Coal Fired Boiler with very high thermal efficiency (85 % on GCV)
- Double – Extraction condensing Steam turbo-generator with low specific steam consumption (~ 5 TPH/MW)
- conservation and very high Condenser vacuum (0.92 ata)
- Operating in islanding mode or parallel with grid.
- Uninterrupted high quality power
- Quality Steam at the desired pressure levels for process
- Flexibility in maneuvering to system / process requirements
- Flexibility to change over for additional Power / Steam generation to suit
- Higher Deaerator operating pressure and temperature (135 Deg C) enhancing cycle efficiency (over 70%).

Captive Cogeneration Plant

Existing Low pressure boilers (30 bar) with associated steam turbines and PRDS had given way to High pressure (105 bar) boiler integrated with double extraction condensing steam turbine. Though the premier mills in this sub-continent have settled for boilers with steam pressure of 64 bar, SPB had gone a step further in going in for a high pressure boiler with steaming conditions of 105 bar, 510°C. Steam pressure selection was primarily aimed at achieving low specific steam consumption in steam turbine as can be seen from Fig.2. The Cycle efficiency of the unit in Cogeneration mode (as operating) is over 70 %.

Salient features of installed high pressure captive cogeneration plant are elicited in Table-2.

The flow-chart of the H.P. Cogeneration plant at SPB is illustrated in Fig.3.

Cogeneration Plant -Brief

The Recently installed Captive Cogeneration Plant (CCP) consists of a High Pressure Atmospheric Bubbling Fludised Bed Combustion (AFBC) Steam Generator (hereafter termed as Boiler#10) supplied by Enmass Andritz and a matching 21MW Double Extraction Condensing Steam Turbine of BHEL. The steaming conditions of the Boiler are illustrated in Table-3 for ready reference.

Table - 3 : Boiler Details

Steaming Conditions	Unit	Value
Steam Evaporation Rate (MCR)	TPH	117
Economic Continuous Rating	TPH	106
Steam Outlet Pressure	Kscg	105
Steam Outlet Temperature	°C	510
Steam Temperature Control	%	70 to 100
Feed Water Inlet Temperature	°C	135
Fuel	Coal	

The Boiler (Mitsui-Babcock Design) is connected to the Steam Turbine through the heavily insulated High Pressure Main Steam line.

There is provision for part by-passing of the High Pressure Steam. Small amount of steam at High pressure and temperature is led to Pressure Reducing De-Superheater, from where the Medium pressure steam is taken for process use or Power Generation in L.P. turbine.

High pressure steam entering the Steam turbine generates power in the Generator section. Steam from Extraction-1 (Medium Pressure) and Extraction-2 (Low Pressure) are used for process (Paper as well as Pulping sectors).

Exhaust Steam leaving the Turbine is at vacuum and is condensed in surface condenser (with closed cycle Cooling Water as the cooling medium for Steam Condensation).Turbine Condensate is returned to the Deaerator via the condensate feed storage tank (FST).

Steaming details of the Steam Turbine are elicited in Table-4.

Flow-chart of steam turbine with condenser is shown in Fig.4.

Table-4 : Steam Turbine Details

Inlet	**Unit**	**Value**
Flow	TPH	90 - 106
Pressure	Kscg	104
Temperature	°C	505
Extraction-1 (M.P)		
Flow (max.)	TPH	40
Pressure	Kscg	10
Temperature	°C	220
Extraction-2 (L.P)		
Flow (max.)	TPH	60
Pressure	Kscg	4
Temperature	°C	170
Exhaust (Condensing)		
Flow (max.)	TPH	50
Pressure	Ksca	0.1
Temperature	°C	45
Dryness Fraction	Minimum	0.88-0.90

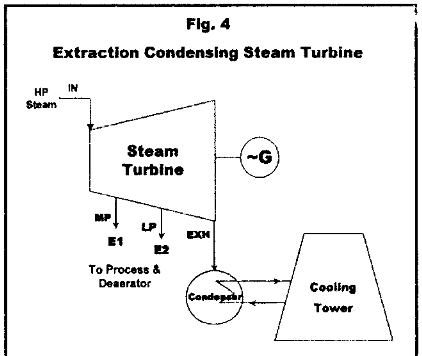


Fig. 4: Extraction Condensing Steam Turbine

Power is produced in the 21 MW (26 MVA with P.F. of 0.80) Generator. The Generator winding which gets heated up with increasing load needs to be kept at a constant temperature(say< 85°C).To avoid overheating , air cooling scheme is adopted.

The air which is in closed circuit, in turn needs to be cooled using Cooling Water, which is derived from the closed cycle Cooling Water system.

Choice of Condenser Cooling

Water has been selected as cooling medium because of its merits over air cooling. Also water is available for condenser cooling. In Captive Cogeneration Plant (CCP), cooling water coming out from Turbine Condenser rises well above inlet water temperature (ΔT : 8°C) entering the Condenser. Water leaving the condenser must be cooled, before the same is returned to the condenser.

Because of its inherent advantages, Closed cycle Cooling water system is employed with Cooling tower serving as the heat sink. Cooling tower is having three cells with common water holding basin. Cooling water treatment is meticulously practiced, as it would ensure avoidance of scaling, foulant deposits, microbiological growth prevention & corrosion control.

BOILER

Air & Flue gas Diagram of the boiler is depicted in Fig.5. Specific features are listed in Table-5

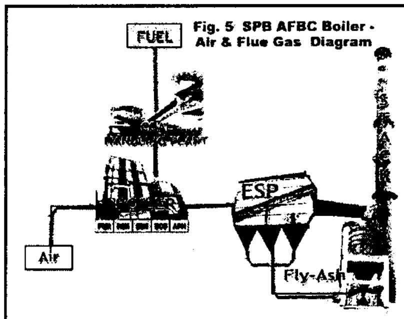


Fig. 5 : SPB AFBC Boiler-Air & Flue Gas Diagram

TABLE-5

Salient Features of AFBC Boiler (Boiler # 10)

- Atmospheric Bubbling Fluidised Bed Combustion (ABFBC) Boiler with bed temperature of 930-950 °C
- No in-bed Superheater
- Single Drum design
- Studded (SS-310) Bed Coil Design
- Membrane wall (water –walls) Construction
- Balanced Draught system with 2x60 % F.D. Fans & 2 x 60 % I.D. Fans in

the Circuit

- Air Heating of both Primary & Secondary Air
- Fine Inter-stage Spray Attemperation of Superheated steam temperature control (65 to 100 % MCR)
- Liberal Circulators (with High Circulation ratio).
- Very High Combustion efficiency
- High Thermal Efficiency with low stack flue gas temperature

Enviro-friendly coal (low ash & Sulphur content) is being used as fuel for the boiler. Detailed analysis of the coal is elicited in Table - 6.

Table- 6 : Coal Analysis

Source : Imported Coal (Indonesia)

A. Proximate Analysis

		As Fired	Dry Basis	Dry Ash Free
Moisture	%	23 to 29	-	-
Ash	%	1 to 2	2	-
Volatile Matter	%	36 to 39	50	51
Fixed Carbon	%	34 to 37	48	49
GCV	kcal/kg	4950 – 5150	6900	7100

B. Elemental Analysis

Carbon	:	74 %
Hydrogen	:	5 %
Nitrogen	:	0.9 %
Sulphur	:	0.1 %
Oxygen	:	20 %
Halogens	:	Traces
Heavy Metals	:	BDL

C. Hardgrove Index : ~ 50

D. Ash Fusion Temperature °C (Reducing Atmosphere)

IDT	: 1050 – 1150
HT	: 1100 – 1200
FT	: 1150 – 1250

E. Chemical Analysis of Ash (%)

Silica	SiO_2	25 – 35
Aluminum	Al_2O_3	12 – 15
Iron	Fe_2O_3	20 – 25
Calcium	CaO	12 – 15
Magnesium	MgO	3 – 4
Sodium	Na_2O	2 – 3
Potassium	K_2O	7 – 10
Titanium	TiO_2	0.5 – 0.8
Phosphorus	P_2O_5	0.2
Manganese	Mn_3O_4	0.3 – 0.4
Sulphur Oxide	SO_3	9 – 12

Water Treatment for the High Pressure Boiler

- Raw Water from the river contains all sort of impurities, which are totally unacceptable to the Cogeneration Plant. Hence water treatment is a must.
- Raw water is first pretreated to minimize suspended impurities, silica etc.,
- This is sent to ultra-filtration wherein the silt, colloidal silica, fine particulates, and iron compounds are removed. Silt density index (SDI) of <4 is easily achieved.
- The water is then led to Reverse Osmosis Plant, wherein the dissolved solids, silica and other impurities are reduced to a great extent.
- Finally water is sent to mixed-bed unit for removing balance impurities (Silica & TDS)
- The treated water (Table-7) serving as boiler feed make-up is sent to the Deaerator.

Table -7 : Treated Water Quality

Impurity	Unit	Value
TDS (as $CaCO_3$)	PPM	< 0.3
Silica (as SiO_2)	PPM	< 0.02

Pictorial view of UF and RO units installed is elicited in Annex-1.

Advanced Feed Water Conditioning

Boiler Feed water encompasses turbine return condensate, treated make-up water from MB as well as the treated process condensate from Condensate Polishing unit (CPU). However, as the water is highly pure and just neutral, chemical conditioning of the boiler feed water is a must. Feed water conditioning is carried out in two stages.

Firstly, the pH of the feed water shall be raised by using ammonia or morpholine of highest purity (Laboratory grade) to 8.5 -9.0. Subsequently, though the dissolved gases are removed through thermal deaeration in deaerator, chemical deaeration is carried out using oxygen scavenger.

In CCP, both Conventional chemical dosing as well as polyamine dosing had been successfully practiced. In the Conventional treatment, the treatment is one of adding hydrazine hydrate in small doses in L.P. dosing end followed by tri-sodium phosphate (laboratory grade) as H.P. dosing reagent added to the steam drum.

Steam purity in terms of TDS and Silica levels have been maintained as per the turbine supplier's recommendations. In Advanced water conditioning scheme, HELAMIN – a polyamine based reagent had also been used successfully. It does not add any solid impurities to water and is also non-carcinogenic. SPB is the first paper plant in the world to use HELAMIN for boiler water conditioning.

OPERATIONAL EXPERIENCE

With the CCP in operation for over 15 months, the operational feedback as expected is quite encouraging. The operational feed-back results are summarized as under :

Boiler - Operational Results

- High thermal efficiency of the Boiler

Evaporation ratio (Steam Generation (per tonne of Coal) is as high as 6.3 on a continued basis pointing to high thermal efficiency of the boiler (84% to 86% on GCV).

With Boiler Operating at low flue gas exit temperature (135-140°C) and low excess air (35%) on a continued basis, the stack heat losses are under 11-12 %. This had been possible even with high moisture fuel, where high moisture losses in flue gas leaving the stack are unavoidable.

A. Thermal Efficiency

Output : Steam and Water

Outlet Steam Enthalpy	:	810 kcal/kg
Inlet Feed Water Enthalpy	:	137 kcal/kg
Differential enthalpy	:	673 kcal/kg
Input	**:**	**Heat Available in Coal**
GCV of Coal	:	4900 – 5100 kcal/kg
		(say 5000 kcal/kg)
Evaporation Ratio	:	6.3
Thermal Efficiency on GCV	:	[6.3 / {5000/673}] = 85%

Very High Combustion Efficiency

Unburnt combustible loss with low ash enviro-coal as fuel, is 0.3 to 0.5% only. Combustion efficiency of 99.5% is indeed quite high.

B. Combustion Efficiency

UBC in Ash	:	5 to 10%
Ash in Coal	:	2%
UBC Loss	:	[8/(100-8)] (2) {8080/5000} = 0.3%
Combustion Efficiency	=	100-0.3 = 99.7%

With the above 2 aspects the operating thermal Boiler efficiency is around 85% resulting in steam evaporation ratio of around 6.3.

- High Cycle Efficiency with Steam Turbine.

Low specific Steam Consumption (< 5 tph/MW) is achieved with the high efficiency double extraction condensing Steam Turbine. Rated steam pressure and temperature being maintained at STG inlet (104 bar & 505° C) with very good vacuum level (0.92 to 0.93 ata) have ensured increased power output from STG.

Control Automation with VFDs - Special Facets

SPB had developed in-house control automation algorithm along with control logic which directly integrates the turbine output (in terms of steam for both extraction and power generation) to boiler fuel input and combustion air.

Through implementation of this Direct Energy Balance (DEB) scheme, main steam pressure swings (overshoot and under swing) are minimized resulting in finite saving in auxiliary station power consumption. VFDs had been installed in F.D. & P.A. fans resulting in substantial saving. Through the adoption of the Control automation system package (Integrated Steam & Power Balance -ISPB) in CCP along with VFDs in place,, power saving to the tune of 0.3 to 0.35 MW (~10 % on station power consumption) is being achieved on a continued basis.

Importance of Steam Pressure Levels

In SPB, utmost importance is being given to steam pressure extraction levels. Medium pressure steam at 10 bar is being considered at a level higher because of higher power potential associated with it, as compared to Low Pressure Steam at 3.5 bar. As a matter of fact, M.P. steam has a 50 to 60 kw/Te tag over L.P. steam in that for every tonne of steam switch from M.P. to L.P. level of Extraction, realization to the tune of 50-60 units is manifested

The above gains are being realized because of going in for very high steam pressure cogeneration plant. Hence , but for such of those select units and systems, requiring 10 bar steam for their process (such as Digesters, coating plant, vapour absorption chillers of paper machine), most others have been fed by L.P. steam from the new turbine extraction.

ENERGY EFFICIENCY SCHEMES

Not withstanding the gains achieved with Cogeneration Captive Plant (CCP), following Energy efficiency schemes have ensured steam and power conservation.

Heat Recovery Related to CPU

Process condensate derived from the pulp and paper sections can be classified under 2 categories viz., Direct and Indirect. Direct condensate mixes with the process and is totally lost. In the case of Indirect Condensate, as there is no direct contact of steam condensate with the process, the same could be (and is being used) used in the boilers as feed.

However, the same logic is not possible for high pressure boilers. The condensate , as it passes through the pipe-lines etc., is bound to pick up crud

Table - 8

No.	Scheme	Area / Center	Result
A	Condensate heat recovery PHE	Preheating Feed Water	Reduction in LP Steam Consumption
B	Heavy insulation of Main steam Line	Maintaining rated main steam temperature & temperature	Increase in Power Generation
C	Energy Efficient Motors & Premium Motors	High Motor Efficiency	Reduction in Auxiliary Power Consumption (APC)
D	Judicious operation of Cooling Tower Fans	Cooling Tower	Reduction in APC.

(iron oxides), silt, TDS etc which cannot be tolerated for very high pressure boilers as make-up water. Hence is the need to purify the impure condensate so as to make it fit for reuse in boilers. The hot condensate cannot be sent to Condensate polishing unit (CPU), as the resins would be affected by the high temperature of the condensate. In order to recover the otherwise wasted thermal energy as also avoid loss of water (for which both treated water and heat are required afresh), SPB had adopted a novel approach by way of installing plate heat exchangers (Fig.6) for extracting all the low temperature heat from the process condensate , by way of transfer of heat to the cold treated feed water.

Through this approach , not only the condensate temperature is brought down to ambient condition fit for passing through CPU, but also effect reduction in deaerator steam (L.P.) consumption. (See Table-9A & 9B for the gains achieved).

Fig. 6 Plate Heat Exchanger Process Condensate Heat Recovery

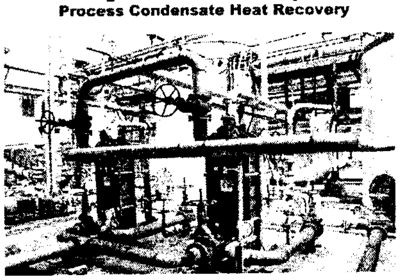


Fig. 6 : Plate Heat Exchanger Process Condensate Heat Recovery

Table -9B : Energy Gains After Installation of WHR unit in Process Condensate Return

Parameter	Units	Before WHR	After WHR	Saving
Feed Temp. to Deaerator	°C	50	60	-
Feed To Deaerator	TPD	2200	2200	-
E2 Steam to Deaerator	TPD	290	260	30
Feed to Boiler	TPD	2490	2460	30
Blow-Down	TPD	10	10	-
Main Steam at Boiler exit	TPD	2500	2470	30

Table –10 : Energy management through reduced steam temperature and pressure drop across main steam line

Main Steam Line	Conventional System	Present (Improved) Design
Pressure drop-ΔP_s (kg/cm^2)	ΔP_s:2 (Ps :105 → 103)	ΔP_s :< 1 (Ps :105 → 104)
Temperature drop-ΔT_s (°C)	ΔT_s :10 (Ts: 510 → 500	ΔT_s : 5 (Ts : 510 → 505)
Enthalpy difference (kcal/kg)	5	2.5
Steam flow rate (TPH)	90-110	90-110
Total energy loss (Mkcal/hr)	0.6	0.3

Table – 9A : Process Condensate Heat Recovery Scheme

Condensate Quality	:	Impure
Impurities	:	Crud ,Silica, Dirt, TDS
Heat Recovery Unit	:	Plate Heat Exchanger ; No. of Units :2

Item	Hot	Cold
Fluid	Process Condensate	D.M. Water
Heating Surface	Corrugated Plates	Corrugated Plates
Temp. In ,°C	90-95	30
Temp. Out ,°C	35-38	55-60
Fluid to	CPU	FST /Deaerator

Energy Conservation Scheme Related to High Pressure Main Steam Line

Main steam pipe line carrying very high temperature steam from the boiler to the steam turbine had been sized with energy conservation approach as under :

- Higher Steam Pipe Size → Resulting in Low Steam Velocity → Consequently Low Pressure drop.
- External pipe insulation of high thickness with very low conductivity

insulation material → Resulting in low radiation and convection losses → Achieving low steam temperature drop.

This is illustrated in Table – 10.

Apart from energy saving of 0.35 MW(t) additional merit is that any increase in steam pressure at turbine inlet is bound to have small increase in power generation which cannot be quantified.

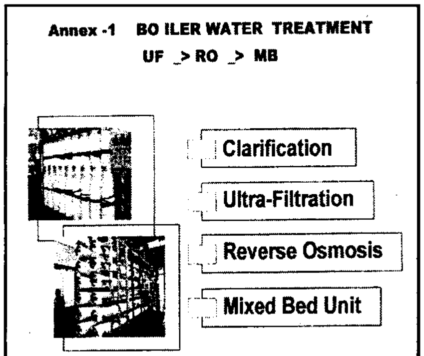
Station Power Consumption Reduction

Net Power Available for the process is computed by deducting station power consumption figure from gross power generation figure i.e.,

Net Power available = Gross Power generation - Station Power Consumption

For a high pressure cogeneration plant relating to CHP, Station Power Consumption is high at 14 to 15% of total power generation. However, with usage of energy conservation scheme viz., VFD's, DEB automation controls, minimization of E2 and E1 steam in favour of E1 steam and condensing respectively, and going in for high efficiency rotating equipment, the station power consumption is being brought down to < 12%.

One of the areas, we in SPB are focusing is relating to electrical drives (Motors). Power Conservation is achieved by going in for appropriate classes of motors (refer Table-11) thus effecting reduction in auxiliary power consumption.



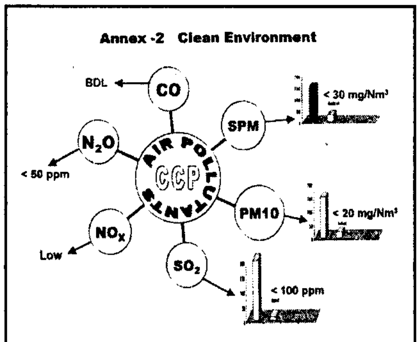
Annex-1 : Boiler Water Treatment UF_> RO _> MB

Table-11: Motor Classification & Recommendations

No.	Grouping	Present Efficiency Level	Proposal
A	Old Vintage & inefficient motors (ready for rewinding)	70% to 80%	Replace with premium efficiency motors (Eff – 2 Level)
B	Other Motors	80% to 85%	Change to PEM/Energy Efficient Motors (Eff -2/ Eff-1 Level)
C	Standard Motors	85% to 90%	Change to / Go in for Energy Efficient Motor.

ENVIRONMENT MANAGEMENT

As a part of QEEHS policy , SPB attaches importance to Cleaner Environment. Low Particulate Emission is achieved through State of art Electrostatic Precipitator in place as shown in the chart (Annex-2).



Annex-2 : Clean Environment

Select Features of ESP

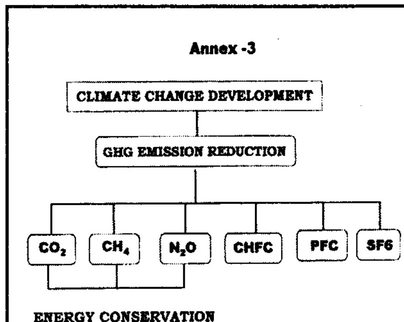
- ESP with 1 pass & 3 Fields- to achieve SPM of < 50 mg/ Nm³.(though the TNPCB norm is 150mg/Nm3 max.)
- Spiral electrodes facilitating easy removal of particulates with rapping
- State-of art AVR Controls for optimizing auxiliary power consumption,
- Low Migration Velocity & Liberal Collecting surface

Gaseous Pollutants Control

- Low Sulphur Coal and adoption of FBC technology ensures low SOx emission
- Low Excess Air and controlled stage air Admittance, and lower Combustion temperature, ensure lowered NOx emission.
- High Bed Temperature reduces N_2O (GHG) emission (<50ppm).

CLIMATE CHANGE DEVELOPMENT

It would not be out of place to state that energy management has direct impact on Climate Change Development. (Refer Annex-3).Through Energy Conservation, healthy climate through Greenhouse gas (GHG) reduction in CCP is achieved. Refer Table-12.



Annex-3 : Energy Conservation

Table-12 : GHG Reduction Measures in CCP

- High Boiler thermal efficiency with reduced Stack heat loss
- High Cycle efficiency of Cogeneration plant
- Station Power Consumption reduction through Energy Efficiency schemes adoption
- Low Temperature Waste Heat Recovery from impure process condensate
- M. P. steam consumption

minimization / L.P. steam consumption reduction in process

CONCLUSIONS

- With the successful operation of the high pressure cogeneration plant at SPB, steam and power (CHP) are made available through in-house generation thus greatly reducing the import power thereby lowering the final product cost.
- High thermal efficiency of the AFBC boiler –low stack gas temperature and very high combustion efficiency- relates to high evaporation ratio.
- Envirocoal (of low ash & Sulphur content) is being used as fuel in Boiler. The low bottom ash generation, low SO2 & NOX levels through stack and very low SPM levels have ensured cleaner environment. With ESP of state-of-art technology and judicial usage of AVR controls and fields in service, SPM emission is maintained well below 50 mg/Nm3 but also reduced power consumption.
- With Chemical conditioning of feed and drum water done with advanced boiler water conditioning, the blow-down is reduced and energy conserved.
- Integrated Direct energy balance automation using in-house developed technology had effected power saving.
- With increase in operating pressure of the boiler, the lowered specific steam consumption had resulted in increased power generation in-house.
- Cycle efficiency of CCP is over 70%.
- VFDs installed for the fans in Boiler had greatly contributed to lowering of station power consumption of CCP.
- With Closed cycle cooling water and with judicious operation of the cooling tower fans, not only high condenser vacuum is maintained but also increased net power available for process use is ensured.
- Impure Condensate heat recovery and subsequent treatment through CPU leads to dual gains viz., waste heat recovery and reduced intake of treated DM water.
- Climate gains are ensured through lowered GHG emission resulting from a mix of high thermal efficiency of boiler, increased cycle efficiency, reduced station power consumption and optimum utilization of M.P./ L.P. steam in process.

ACKNOWLEDGMENT

The author gratefully acknowledges the management for all the encouragement provided related to Energy Management in Captive Cogeneration Plant.