5 MW Co-generation Power Plant-Salient Features

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ABSTRACT

The mill had two medium presure boilers and pressure reducing stations (PRS) for generation and supply of process steam, but did not have any facilities for the Generation of Power. The mil had been experiencing the brunt of the vagaries of power supply and the resultant production loss. With the expanded production, the effect had further aggravated. For sustained operation of the mill and achievement of optimal production, Installation of a Co-generation Power Plant was considered.

INTRODUCTION

Emami paper mills limited (EPML), located at Balasore in Orissa was established in 1982, primarily as an agro based unit for manufacturing of writing and printing paper, with an installed capacity of about 22 tonnes per day (tpd). To improve the long-term viability of the company, a techno-economic study was Conducted. A Technical Audit of the mill to evolve a comprehensive plan for growth and development was performed. Accordingly, EPML had expanded the mill capacity to around 100 tpd, by installing PM#2 of 76 tpd. The total installed capacity of the mill at present is as under.

PM#1	25 tpd	or	8000 tpa
PM#2	75 tpd	or	25000 tpa
Total	100 tpd	or	33000 tpa

EPML was experiencing frequent interruption in the Power supply. Average number of interruption during 1997 & 98 work out to around 315 hours, as detailed below:

- Line fault and Power trippings
- Fluctuation in voltage/dip in voltage.
- Frequent load shedding during monsoon/inclement weather.

A review of the records of the past operations of the mills reveals that a minimum of 4.5% of the planned operating hours was lost on account of power cuts and voltage dips in Grid power. A statement of the loss of production due to power interruption during the period from April 1997 to March 1999 is furnished in Table 1.

Table 1 Power failure and loss of production

Year and Month	No. of	Down time
1997	interruptions	Hrs
April	10	23.45
May	16	37.25
June	8	37.4
July	7	17.2
Aug	2	52.15
Sep	7	21.25
Oct	3	23
Nov	16	19.58
Dec	10	14.66
1998		
Jan	9	17
Feb	4	14.17
Mar	13	60.34
April	13	34
May	20	36.9
June	8	56.16
July	4	46.47
Aug	11	23.84
Sep	11	19.33
Oct	16	12.20
Nov	19	15.55
Dec	11	6.2
1999		
Jan	8	5.4
Feb	16	21.5
March	24	10.55
Annualized Total	266	625.55
Average production loss hours: 315 per annum		

It is seen from Table 1 that the company, with the Grid supply, would be incurring a regular loss of production to the tune of over 1325 tpa due to power interruption at the rate of 4.2 tonnes per hour. Further it should also be mentioned that the frequent interruptions do affect the life of critical Electrical components and cause an adverse impact on overall productivity and result in higher cost of repairs and maintenance (Table 2).

An overall review and analysis of the national power scenario, as well as the specific position with respect to the State of Orissa, leads to the following conclusions:

- The demand and supply gap will continue to be felt in most parts of the country including Orissa, at least for the next decade.

Table 2 Cost Benefit Analysis

Description	Actual per day in Rs	Actual per kWh in Rs
Variable Cost		
Coal	124960.00	1.60
Consumption (Rs)		
Chemical consumption		
RO Plant	1359.00	0.02
Boiler	1417.00	0.02
Cooling Tower	1250.00	0.02
Stores consumption	13038.00	0.17
Total Variable cost	**142023.00**	**1.82**
Fixed overheads		
Demand charges	18065.00	0.23
Salary & Wages/ overheads	17702.00	0.23
Interest on working capital	5479.00	0.07
Interest on term loan	55334.00	0.71
Total cost of production	**238603.00**	**3.06**
Net Realization		
Power (Rs)	257400.00	3.30
Process Steam	82189.00	1.05
	339589.00	4.35
Cost of capital employed	35753.00	0.46
Depreciation	38334.00	0.49
Net Profit	**26899.00**	**0.34**

- Variation in quality of power (voltage, frequency) is to be anticipated, in addition to power cuts during peak power requirement periods.
- Steep hikes in power tariff rates are to be anticipated.

The above conclusions lead Emami to install 5 MW Co-generation power plant.

Installation of Co-generation Power Plant had insulated the mill operation from the vagaries of State Electricity Grid supply and the resultant drop in production & also reduced the energy cost.

The Co-generation Power Plant

The Co-generation Power Plant broadly consists of the following:

- High Pressure Boiler
- Turbo-Alternator
- Reverse-Osmosis Plant
- Cooling Tower
- Coal Handling Plant
- Ash Handling Plant
- Steam Distribution system
- Control system consists of DCS & field Instruments
- Power Distribution system

High Pressure Boiler

The Co-Generation Power Plant comprises of one Coal fired Boiler, generating steam at 63 kg/ sq cm. The Boiler is of atmospheric fluidized bed combustion (AFBC) type, which incorporates a highly efficient combustion system, involving turbulent and rapid mixing fluid bed. The bed material, which is primarily fuel and bed ash, is fluidized by air introduced through the air nozzles on the distributor plate.

The following factors in a Fluidized bed combustion system result in more efficient combustion of fuel when compared with the other stoker fired boilers.

- Larger surface area per unit mass of fuel.
- Longer residence time.
- Thorough mixing of air and fuel due to high turbulence.

These factors justify the selection of AFBC Boiler for the Co-Generation Plant. Also AFBC Boiler meets the stringent requirement of Pollution Control Boards in respect of Sox and Nox emissions.

The Boiler is of natural circuation, Bi-drum, indoor, bottom supported, balanced draught furnace,

adopting atmospheric fluidized bed combustion, designed for firing high ash content coal. The furnace section is formed with water wall tubes of fusion welded, memberance construction, arranged as a gas and pressure tight chamber. The bed evaporator tubes are immersed in the fluidized bed and studded with carbon steel studs.

The Super-heated coils are of semi radiant convective type comprising of primary and secondary section placed at furnace outlet. An interstage spray type de-superheater is provided in between the two stages of superheater to control the final steam temperature.

The Boiler is provided with a bare tube economizer fabricated from plain seamless steel tubes. The economizer is arranged after first stage low temperature main bank zone and before the air pre-heater. The Boiler is also provided with a tubular air heater as the last heat recovery equipment. The bed is divided in to four sections, with over bed feeding for each section. The fluidization is effected be means of nozzles fixed to a distribution plate. The Boiler is provided with crushed coal-bunker, with SS lining for the bottom conical portion of the bunker. The fuel feeding system consists of drag chain conveyors with independent drive and control system for varying the fuel feed. Fuel is fed to the fluidized bed, by adopting under-bed pneumatic feed system and by gravity for overhead feeding system.

The Boiler is provided with one (1) Induced Draft (ID) fan and one (1) Forced Draft (FD) fan and one (1) Primary Air (PA) fan for pneumatic transportation of fuel. Boiler is provided with tubular air heater as the last heat recovery unit for heating both combustion and secondary air. The draft system consists of cold and hot air ducting, dampers, expansion joints etc.

The Boiler is provided with three fields of Electrostatic recipitator to control the particulate matter emission from the outlet flue gas. The Boiler is provided with a Deaerator to remove dissolved gases from the Boiler feed water in which the temperature of the BFW is raised to 135°C.

Turbo Alternator

The Turbo-Alternator is of Single Extraction cum Condensing type coupled to an Alternator set of 5 MW Power generating capacity. The Turbine is of impulse/reaction type with casing of welded construction. The guide blade carriers are of cast construction. Blading system, attached to rotor, consists of a set of impulse blading and multiple stages of reaction blading. The operating speed of the turbine is reduced to 1500 rpm at the gearbox before alternator. The gearbox is of single stage, double helical, parallel shaft with flexible couplings at input and output ends. The turbine is provided with safety and operating control devices. Steam admission to the turbine is accomplished by a set of control valves. Controlled extraction system is provided for low-presure steam, achieved by electronic governor and a set of control valves. The Turbine lubricating oil system consists of an oil tank, main oil pump and AC motor driven auxiliary oil pump, DC motor driven emergency oil pump, oil purifier, oil cooler etc. The main oil pump is shaft driven from gearbox.

Condenser is of two-pass two compartment type.

The Alternator is of salient pole design and insulated with winding of 'F' category, with temperature rise limited to class B. The cooking method for alternator is of closed air circuit, water-cooled design. Brush less excitation with solid-state voltage regulator is provided.

Reverse Osmosis Plant

The Process condensate and Turbine condenser together return the condensate of the steam used, which is estimated around 84% of the total steam supplied to the process and turbine. Considering the past experience with the other power plants, EPML had decided to install an advanced water treatment plant to meet the stringent Water and Steam parameters required for Boiler & TG. Also Emami being dependent on sab-soil water, silica was considered a problem. In view of the above Emami decided to opt for Reverse Osmosis water treatment plant followed by a mixed bed unit for makeup water treatment (Table 3.)

Advantages of RO Plant Compared to DM Plant

- Less chemical consumption
- Lesser requirement of space
- Consistent water quality
- Trouble free operation
- Regeneration not required
- Waste water handling easy
- Utilization of waste water in other areas without any treatment
- Less Pollution
- Easy Chemical handling
- Easy maintenance

RO Plant consists of the followings:

- Iron removal filter

- Dual Media filter
- Micron cartridge filters
- High Pressure pumps
- RO pressure tubes with Dow Role membranes.
- Chemical dosing systems
- Degassed tower with storage tank
- Mixed Bed unit

Table 3 Quality of final treated water from plant

Particulars	UNIT	
Total reactive silica	ppm	0.02
Total dissolved solids as $CaCO_3$	ppm	1 mg/1
Total Hardness	ppm	Nil
Free CO_2 as CO_2	ppm	Nil
Iron as Fe	ppm	Nil
Chloride as Ca CO_3	ppm	
Copper	ppm	-
pH value		6.5-7.2
Conductivity	Micro-mho/cm	

Coal Handling Plant

Coal is brought by front-end loaders from the storage yard and dumped on the ground level hoppers and the same is fed through vibrating feeder to belt conveyor # I. The belt conveyor discharges the fuel into the crusher. The crushed fuel is screened and the accepts fed to the Boiler bunker through a system of conveyors. The rejects of the screen is again fed back to the input conveyor for re-crushing.

Since the AFBC Boiler requires coal having size below 6 mm, the coal handling plant is desinged to meet the requirement. The capacity of the coal handling plant is 25 tph and the plant able to meet the complete day's requirement of coal in 12 hours operation spread out over two shifts.

Ash Handling Plant

the Boiler generates bed ash and fly ash to the extent of 40 tpd and 5 tpd respectively. The Boiler is provided with a sophisticated pneumatic ash handling system for removal of both the bed ash and fly ash from the boiler. The fly ash and bed ash are stored separately in an individual ash silo having a capacity to store one day's generation of ash. The fly ash from the silo is conditioned and is transported for disposal to brick manufacturing and low land filling. The bed ash is screened on a vibrating screen and the recovered particles more than 0.8 mm and less than 3.6 mm is recycled as bed material in Boiler. The entire system is operated and controlled by a PLC.

Cooling Tower

The Co-generation Power Plant consists of Cooling Tower of capacity 1500 cum/h. The cooling tower consists of 2 cells with open gravity type water distribution system and axial flow propeller fans for each cell. The water pump circulates the cooling water through the condenser. The cooling tower is designed to perform a differential temperature of 8°C, at the rated circulation.

Steam Distributions System

The system consists of the followings:

- HP header
- PRDS - I (63 kg/sq cm to 8 kg/sqcm, 490°C to 180°C)
- PRDS - II (63 kg/sq cm to 4.5 /sqcm, 490°C to 153°C)
- Extraction De-superheater
- Hp Steam piping
- MP steam piping
- LP steam piping and PRSs (from 4.5 kg/sq cm to 2.8 kg/sq cm)

DCS and Field Control Instruments

A DCS of 192 DI, 96 DO, 72 AI, 32 AO, 16 T/C input, 16 RTD inputs and one communication module is the heart of the control system of the entire Co-generation Power Plant. The system mainly consists of 2 control stations of which one is an Engineering console and the other a pure operator station. However both the stations can function as operator stations when no engineering function is being performed.

Since the Co-generation Plant depends completely on DCS a complete redundancy was built in to the system, where in a hot stand by processor and communication bus have been provided to take care of any failure instantly.

The DCS is connected to various field instruments such as Transmitters, Vibration sensors, Control valves I/Ps, ON-OFF valves, VFDs, motor remote controls

Governor, Scanners, Energy meter, analyzers etc.

Power Distribution System

Power Distribution system consists of the following:

- Generator - Stator, Rotor, Armature winding, Field windings etc.
- Field Exciter Static Rectifying Unit and AVR
- Synchronizing and Protective Relays
- Circuit Breakers and Relays
- Bus Ducts and Transformers
- LT Distribution systems

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CONCLUSION

The generation power plant at Emami has fully automomised control systems through DCS for Boiler and TG operation. The boiler combustion system is optimized for fluctuating load condition. Overall thermal efficiency of Power Plant is 55% (against standard figures available 45% max). No stand by Boiler/TG is available. Losses are minimized through optimized CBD. VFDs are provided for all high rated AC motor drives. It has most modern and sophisticated utility systems. There is well established water chemisty and management to protect Boiler and TG. It has advanced Ash Handling System operated through PLC. Selection of equipments has been made considering trouble free operation and maintenance has been achieved 84% condensate recovery from TG and Process is achieved and thus needing only 16% make-up water. The cooling water efficiency and utilization is also noteworthy.