Approach and Findings in Energy Generation at Pulp and Paper Mills- A New Look

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ABSTRACT

The last decade has witnessed a sea of development in the technologies and optimization of energy utilization by the pulp and paper industry sector. However with all this Indian mills lag far behind in terms of specific energy and water consumptive figures when compared to the mills from the developed countries. This itself is an indicator for existence of further scope for optimization of resources. The co-generation by the mills is one of the options, while for existing co-generation facilities it would be advantageous to enhance MW capacity utilization. With such an arrangement, the mills at developed countries utilize only 30-40% of energy requirements from external energy source, whereas Indian mills depend to the extent of 70%.

The economics of co-generation is largely dictated by a careful balancing of heat and power output requirements and cost of purchased power from SEB's. The present case covered by the article outlines a situation where purchased unit cost of power from grid was much less than that of the mill's co-generation plant. However, in depth energy audit of the plant helped in deciding the issues such as options for increased generation from co-generation plant, cost and optimal mix of various sources of power. No doubt a well-established energy audit procedure for pulp and paper industry is already in vogue. Tata Energy Research Institute (TERI) being pioneer in energy conservation studies, it has been a constant endeavor of the company to help the clients in optimizing their resources especially in energy and water. In the present context of competitive market, it is necessary to look for new avenues for energy saving opportunities, including scenario arising out of yearly power tariff revisions from utilities. This paper also highlights the necessity of hiring experienced consultants to conduct instrumented audit, leading to in depth analysis, which will help in deciding the overall benefits to the mills.

INTRODUCTION

Closer look for energy saving potential in pulp and paper mill is a must as now the energy cost next to raw material cost of the producing a tonne of paper. With the technologies available, Indian mills on an average are consuming 150-200% higher energy for their unit paper production in comparison to the paper mills in developed countries. The systematic

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energy audit will help to understand more about the energy and fuel utilization in industry and in identifying the areas and where scope for improvement exists.

Thermal energy requirement in paper mills is normally met by coal and black liquor generated in the process. Since the steam generation optimization leads to reduction of energy input. The following points need verification for individual plants.

- Feasibility for co-generation option in the existing set-up.
- Heat to power ratio for co-generation.
- Present unit supply cost from utilities (SEB's).

Today, co-generation could be considered as two faces of a coin ultimately benefiting both the industry as well as for the electrical supply utilities. For the industry, it represents a major energy conservation opportunity and a means to reduce their production costs. While for the cash starved utilities, it would act as a means for deferring or avoiding of new capacity addition, requiring major capital investment.

The recent audit study done by TERI highlights the opportunity for optimizing the co-generation at the existing pulp and paper mill, Which has helped them to have reliable power supply.

LITEF \TURE

It is an energy audit case of an integrated newsprint mill located in South India, with newsprint production capacity of one lakh MT per year for 49 to 45 GSM. The present output is generally for 49 GSM paper. The mill has a unique of combination both chemical pulp and chemi-mechanical pulp units.

Energy Sources: The major direct energy sources to the plant are electricity, coal, furnace oil and black liquor (produced from wood). The plant has average load of 16 MW, with peak demand of 18 MW. Out of this, generally coal based co-generation plant with its nominal rating of 15 MW meets 10.5 MW load and the balance of 5.5 MW (average) is met by external grid. For emergency requirements 2.5 MVA capacity DG set is also available, which meets very essential loads requirements in case of black out.

Steam Generation and Co-generation Plant: Plant has three fluidized bed combustion (FBC) boilers of rated capacity of 60 TPH each and pressure 60 kg/cm^2. It has one recovery boiler of 19.5 TPH capacity with generating pressure same as that of power boilers. Steam turbines (15 MW) used is of double extraction cum condensing type, which is presently run as single extraction mode. The super heated steam generated from the boilers is supplied to a common header. The steam to turbine is tapped from the header. About 75 TPH steam is passed through 15 MW turbine to have 10.5 MW power generation, which is the present optimal level of power generation due to various constraints exists in the power plant.

Based on the detailed observation for steam generation and utilization areas, some of the energy conservation measures identified were:

- Use of on-line instruments for continuous monitoring of flue gas analysis and control of excess air.
- Optimizing the boiler feed water delivery pressure from the pump.
- Optimizing the steam generating pressure of recovery boiler.
- Integration of plate heat exchanger (in place of shell and tube exchanger), in the blow down heat recovery system of the power boilers to utilize the heat to raise the feed water temperature by 5-10^{0}C more than present temperature.

The detailed steam balance was carried out using ultrasonic flow meter to measure feed water and condensate flow at different sections. Steam consumption at equipment level was also worked out with heat and mass balance.

As the mill works for 24 hours round the clock requires a reliable power supply to meet desired targeted output. However, power receivable during summer months from the grid is not uniform (shortage for hydro-electric generation), requiring examining of possibility of additional generation from co-generation plant itself. This required in depth analysis for full capacity utilization of 15 MW turbine, which is presently delivering only 67% of its nominal rating.

CO-GENERATION AND PRESENT OPERATING PRACTICES

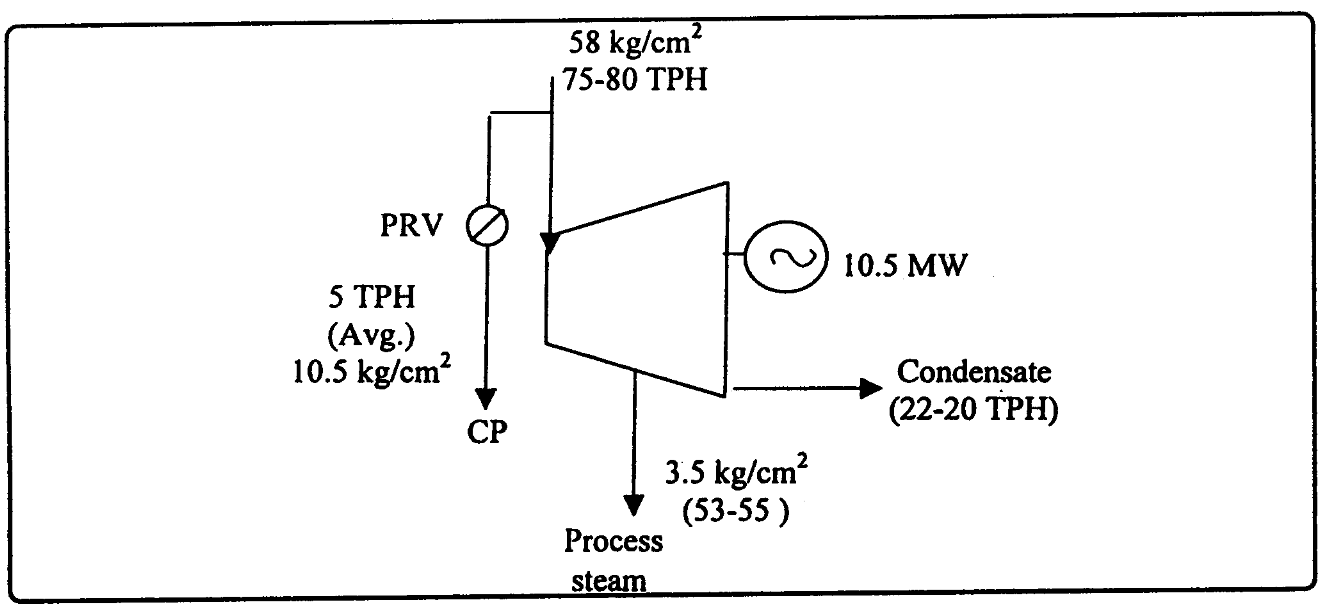
For any co-generation plant, the operation of the turbine and quantum of power generation is dictated by the following consideration.

TABLE-1

STEAM GENERATION AND UTILISATION

Steam Generation		Steam Utilisation	
Boiler	**TPH**	**Area/User**	**TPH**
PB#1	37.0	58.5 kg/cm² steam to TG	75.0
PB#2	33.0	TG condensate flow	22.0
RB	16.0	3.5 kg/cm² Extracted steam	53.0 (55.0)
Total	**86.0**		
		RB internal steam consumption soot Blower 18.5 kg/cm²	0.5
		Air preheating 30 kg/cm²	0.5
		Paper machine thermo-compressor 21 kg/cm²	1.5
		TG internal consumption 16 kg/cm²	1.0
		CP Digester's (Avg.)	5.5
		3.5 kg/cm² extracted steam utilization	
		Paper m/c	24.0
		CMP	2.0
		Recovery old evaporator	11.0
		Recovery new evaporator	4.0
		Dearator	12.0
		Condensate return from process	
		Paper m/c	15.0
		Old Evaporator	10.0
		New Evaporator	3.5
		CP	3.0
		TG condensate	22.0

Figure-1
Operation Mode of Captive Power Generation



- Quantity of process steam requirements.
- Heat to power generation ratio of steam turbine
- Tariff of the grid power for optimal mix.

The cost of power generation during the audit period was calculated at Rs 1.76 per unit as against Rs 2.00 if availed from grid, leading to saving of Rs 0.24 per unit.

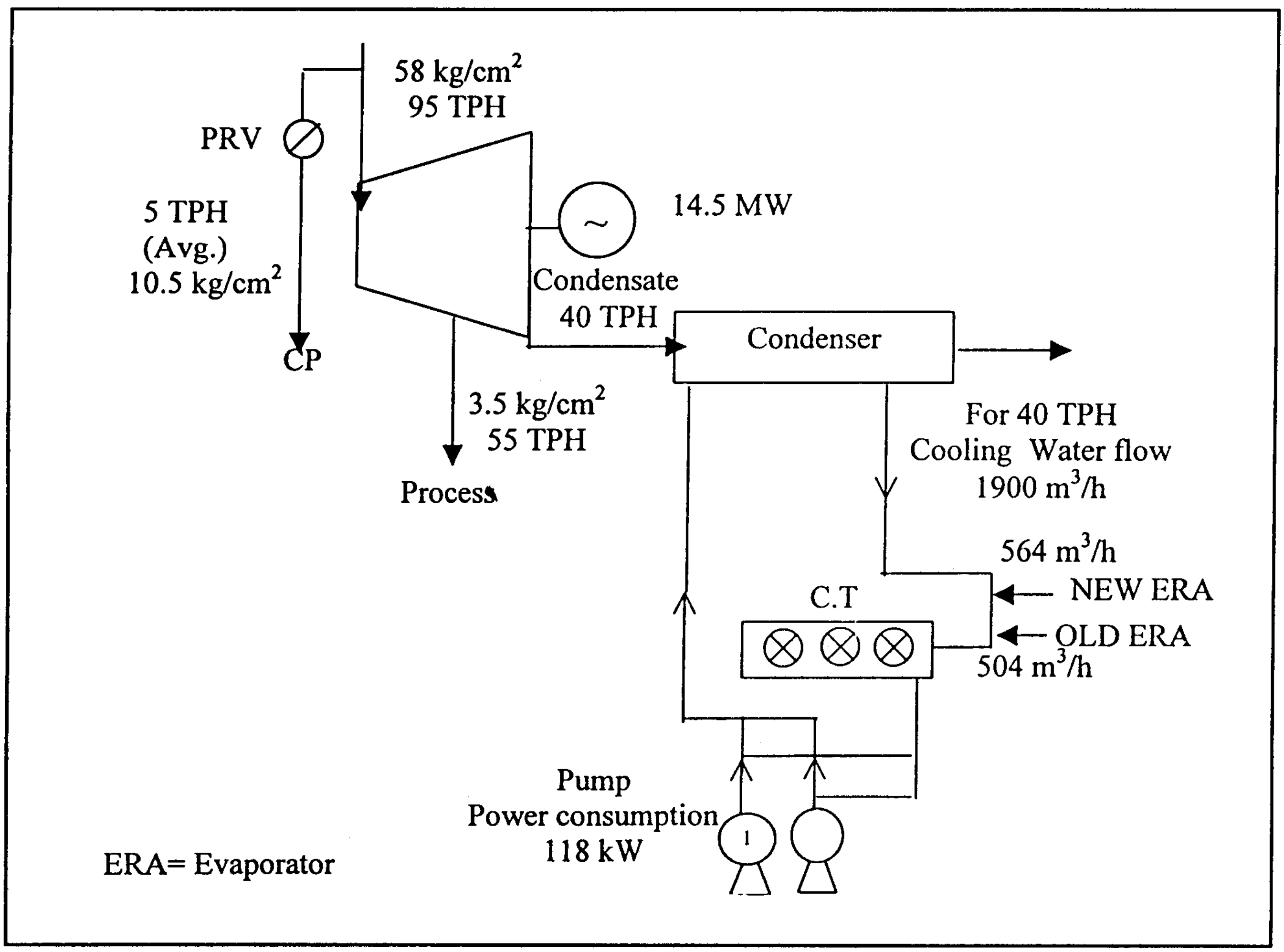
IDENTIFICATION OF SCOPE FOR INCREASING CAPTIVE POWER GENERATION

From the system configuration of steam turbine, with 95 TPH of super heated steam input, generation of 13.5 MW (3 MW more) is possible. Taking process steam requirement of 55 TPH, possible condensate from turbine could be estimated at 40TPH. However detailed observation during audit revealed the following:

- The heat removal rate at condenser was inefficient.
- The cooling water pumps of condenser circuit was loaded to only 60%.
- Power generation was only at 70% of its rating i.e. 10.5 MW (this was true even when stand-by pump was also in operation)

All these observations, along with analysis lead to the conclusion that turbine condenser was unable to take 40TPH condensate required to get additional 3.0 MW Power. This will also lead to a situation of steam venting if extraction steam quantity was more than process requirement. A total review for the possible options for improving the self-generation was

FIGURE-2
IMPROVED SELF GENERATION



the necessity, which are carried out as given:

Option-1: Avoid inter mixing of process cooling water return with co-generation condenser return circuit pipe.

The present configuration of return water pipe circuit, process colling water return mixes with the condensate circuit return water from the co-generation, which was identified as major hindrance for improvement of water flow. It was essential to get the design water flow of 1900 m^3/h through the condenser return circuit, which was at 1200m^3/h. It was suggested to make use of a separate dedicated cooling tower for process side cooling water (without inter mixing with co-generation) and utilize present cooling tower for co-generation alone. With this it would be possible to get extra generation of 3.0 MW, though unit rate will go up to Rs. 2.36/unit (Rs. 0.60 per unit more).

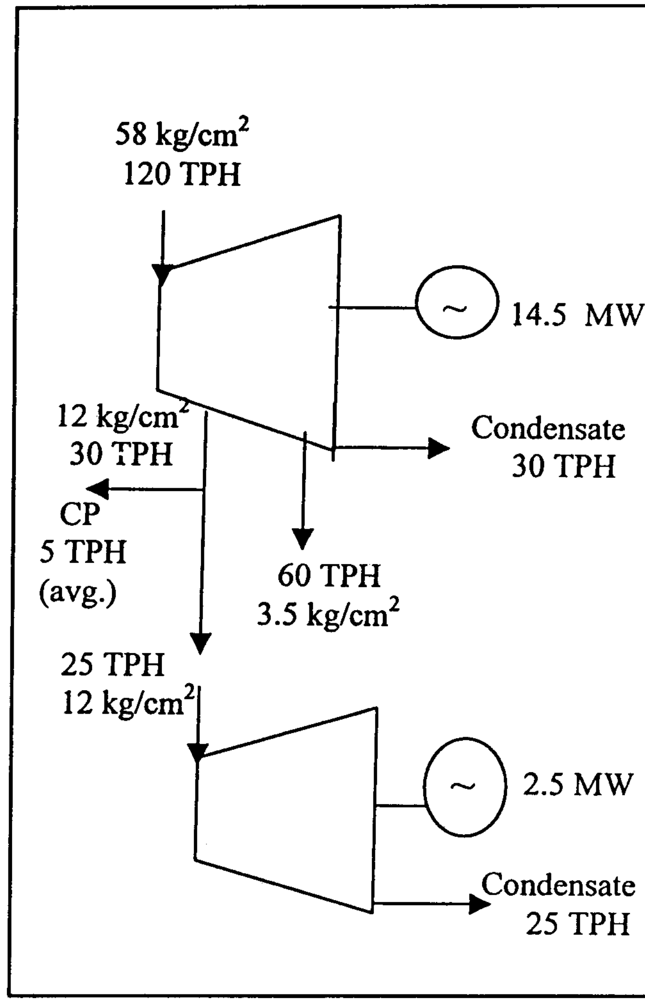
Option-II: Further improving generation to rated capacity of 14.5 MW

The first extraction of 12 kg/cm^2 steam can be passed through a downstream turbine of 2.5 MW. Chemical pulp (CP) unit require 10.5 kg/cm^2 pressure steam and presently this steam is availed by passing 58 kg/cm^2 pressure steam through pressure reducing valve (PRV). By running present steam turbine in double extraction mode, CP steam requirement can be met through first extraction. The total first steam extraction is around 30 TPH. The maximum steam requirement at CP is 12 TPH, 10.5 kg/cm^2 pressure at any given time. As the operation of CP digesters are in batches, steam consumption will vary between 3 to 12TPH. Hence, power generation potential is 1.5 to 2.5 MW for steam flow of 15 to 22 TPH respectively through the proposed downstream turbine. Due to varying load the downstream turbine should be synchronized with grid (infinite source), so as to avoid crippling effect on the electrical system.

To generate 14.5 MW power from present steam turbine in double extraction mode, steam flow rate required is around 120 TPH matching to the existing boiler steam generating capacity. Two power boilers could be loaded to 85-90% to generate 100-105 TPH steam, as the contribution of recovery boiler to main header is 15 TPH after its internal steam consumption. By operating FBC boilers at 85 to 90% load, the efficiency of the boiler improves by at least 2%.

With this extra generation of nearly 4 MW from the present level, the unit power cost may go up to

FIGURE-3
INSTALLING 2.5 MW PARALLEL TURBINE



Rs. 2.57 per kWh. As the present grid power cost is cheaper by Rs. 0.57 per unit, the present proposal does not look very attractive from the financial angle. But with the anticipated revision of electricity tariff (when new Naptha/Nuclear based units are commissioned) the unit rate will be much higher than Rs. 30.00 per kWh, in which case any extra self-generation will be beneficial.

Retrofit: Replacement of PRV for Power Generation

CP requires steam of 10.5 kg/cm^2 for cooking in batch digesters. Presently 58 kg/cm^2 steam pass through PRV to meet this requirement. Installing backpressure steam turbine in parallel with PRV leads to power generation, without extra fuel input. As the availability of present steam quantity varies between 5 to 12 TPH at 10.5 kg/cm^2 pressure, power generation potential works out to be 159 kW to 526 kW depending upon the process steam available. The generated power has to be synchronized at 415 V plant bus level. Installation cost of this retrofit works out to Rs. 25.0 lakh with a simple payback period of 18 months.

DISCUSSIONS

The outcome of energy audit has been reviewed after one year. Plant personnel have implemented low cost investment proposals. By controlling excess air and continuous monitoring of flue gas analysis resulted in 1% efficiency improvement in boilers and reduction in coal consumption was also reported. Feed water pump pressure settings were changed during the study period and reduction in power consumption has been measured. Plant has installed variable speed drives (VSDs) for boiler induced draft fans and realized substantial energy savings. Water pumps and process pumps modifications has done and electrical savings are obtained. Due to tariff revision by supply utility by Rs 0.80 (present rate Rs. 2.80/unit), the payback periods have improved further than anticipated earlier. If the plant completes the measures under option-I will definitely leads to additional generation by 3 MW and higher cost saving benefits than anticipated at the time of audit, due to revision in board tariff.

CONCLUSION

With the ever-growing cost of electricity from Electricity Board and other utilities, improved performance of existing co-generation plants even by 10% will lead to better resource utilization. Unless audit is done in systematic manner, such improvement opportunities at co-generation plants may be lost permanently there by not able to meet the main aim/ objective of the audit itself. Instrumented audit, expertise and experience of the auditors play vital role in audit part, which ultimately lead to un-roll the hidden of the mill performance in achieving a goal of "rational use of energy".

REFERENCES

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