Captive/Cogen Power Generation in Pulp & Paper Industry

Ravi R., Agasibagil N.C.

ABSTRACT

"Globalisation and liberalisation policy of the Government has thrown challenges to Indian pulp and paper industry to compete with open market. Industry has to look forward for cost reduction, quality improvement, through alternate processes, raw materials and energy generation. Cost of energy is one of the major contributing factor in the production cost. Brief facts about the energy generation and efficient utilisation with regard to process industries are discussed."

INTRODUCTION

Pulp and Paper Industry is a Capital and Power intensive industry. In the total manufacturing cost of the industry, around 25% is used for power and fuel.

Till 90's the economic scenario of the Pulp and Paper Industry was different under the protected market conditions and cheaper grid power supply for industrial consumers. Under the globalisation and liberalisation policy of the Government, Paper market is thrown open globally, which has resulted in tough competition with global players, both in respect of quality and cost of product leaving little margin. The problem has further aggravated as cost of power, fuel and raw materials have increased considerably.

To play with international players in the market, our industry has to look forward for cost reduction measures without compromising on quality. As industry is quite aware of high transmission and distribution losses, very low tariff structure for different non-industrial, farming and rural sectors, have resulted in steep increase in the cost of electricity to the industry ranging from 300 to 400%, from State Electricity Boards in recent years. Figure-1 shows a comparision of M/s Karnataka Power Transmission Corporation Limited's cost per unit from 1990-91 to 1998-99 for Industrial consumers and the cost of captive power generation.

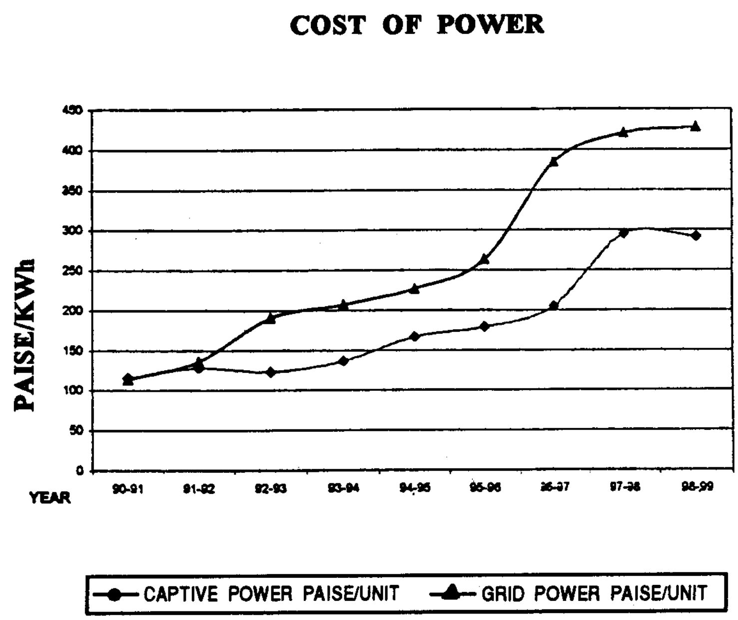
Till 1990-91 captive generation of Mysore Paper Mills was in the range of 25 to 30% of the total power requirement. This has been improved to 64% during 1998-99 by adopting following steps.

1. Retrofitting of Stoker Fired Boilers to Atmospheric Fluidized Bed Combustion (AFBC) system having thermal efficiency of 81%.
2. Increasing the condensing capacity from 30 TPH to 45 TPH of 12.5 MW Double extraction condensing turbines by retrofitting the LP governing valves.
3. Reducing the Coal sizing for AFBC Boilers from - 12 to - 8 mm in turn improved steam to coal ratio as shown in the figure-1A.
4. Use of imported low ash high heat value coal blending with indegenious high ash low heat value coal and Low cost Lignite.
5. Burning of combustible wastes like Pith, Bamboo dust, Wet pith generated inside the Mill.

The Mysore Paper Mills Limited,
P.O. Paper Town, Bhadravathi
Dist. Shimoga - 577 302 (Karnataka)

FIGURE-1

YEAR	CAPTIVE POWER PAISE/UNIT	GRID POWER PAISE/UNIT
90-91	116	114
91-92	128	137
92-93	123	191
93-94	137	207
94-95	167	227
95-96	179	264
96-97	205	385
97-98	295	421
98-99	292	428



COST OF CAPTIVE POWER VERSUS GRID POWER FOR MPM

FIGURE-1A

YEAR	Steam/ Coal ratio
91-92	3.28
92-93	3.49
93-94	3.84
94-95	4.23
95-96	4.27
96-97	4.33
97-98	4.37
98-99	4.34
99-2K	4.67

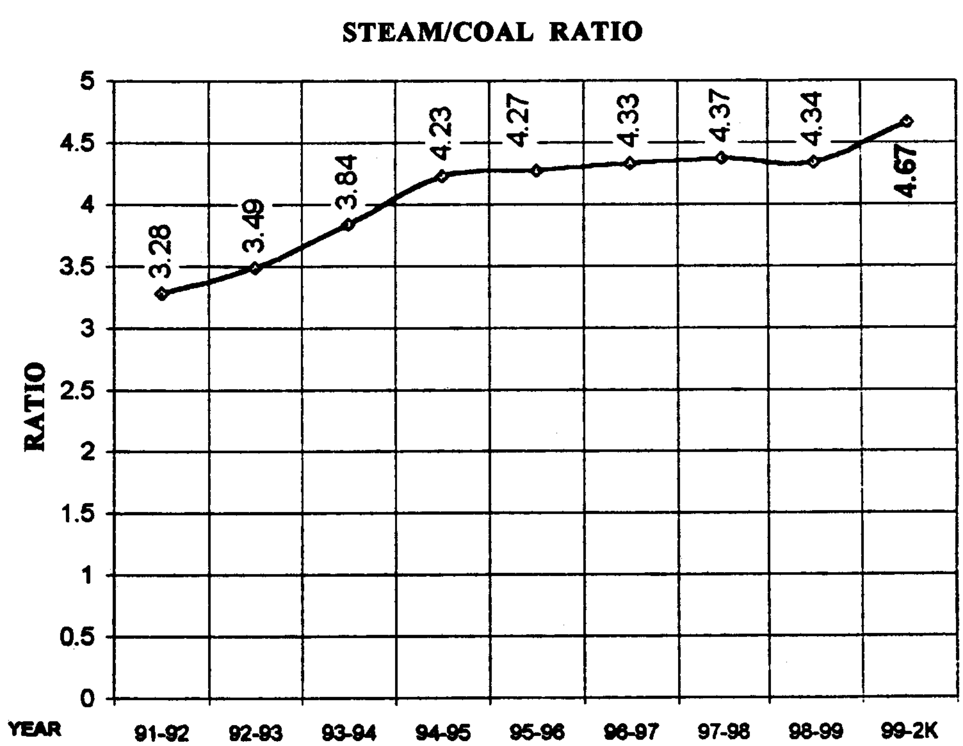
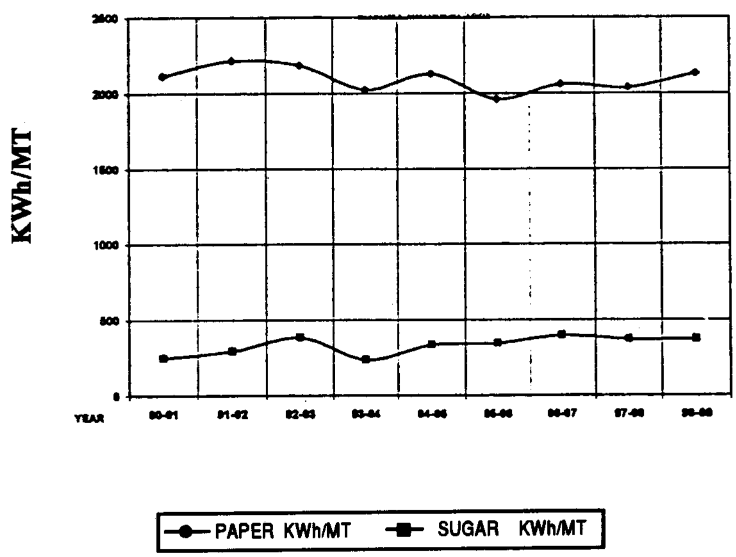


FIGURE-2

YEAR	PAPER KWh/MT	SUGAR KWh/MT
90-91	2115	250
91-92	2217	295
92-93	2186	385
93-94	2026	238
94-95	2127	337
95-96	1962	346
96-97	2059	398
97-98	2039	372
98-99	2131	371

ENERGY CONSUMPTION



ENERGY CONSUMPTION PER TONNE OF PAPER AND SUGAR PRODUCED

This has helped in offsetting the cost of production to the extent as shown in Table-1A

In continuation of the above improvements MPM has further augmented the captive power generation capacity by installing one 90 TPH Circulating Fluidized Bed Combustion (CFBC) system multifuel Boiler having latest compact seperator design, DCS Control System and very high thermal efficiency of 84% using crushed coal of size-12 mm and one 16 MW Turbogenerator having latest EHTC Governing System. This has helped MPM to achieve the captive power generation to the extent of 69% of the total power requirement during the year 1999-2000. Further MPM is aiming to achieve 75% of its power requirement through captive generation by improved condensing facility by the recently added parrallel dump condensers utilising the optimum heat energy from the steam fed to the turbines. Improvement of condensing in the turbines over the years can be seen as below.

a. 1995-96 - 2,39,759 MT

b. 1996-97 - 1,82,846 MT

c. 1997-98 - 3,21,548 MT

d. 1998-99 - 3,15,696 MT

e. 1999-2K - 3,45,390 MT

As part of better energy management programme MPM has sourced cheaper energy from Private Power Producers in the state, reduced contract demand from the State Electricity Board.

As part of Energy Conservation measure MPM has taken/propose taking following steps.

1. Energy Audit has been carried out by M/s Confederation of Indian Industries (CII). As many as 71 areas have been identified as potential for energy savings amounting to Rs. 943.51 lakhs/annum. Many of the them have been implemented. Some are under implementation and detailed analysis stage.

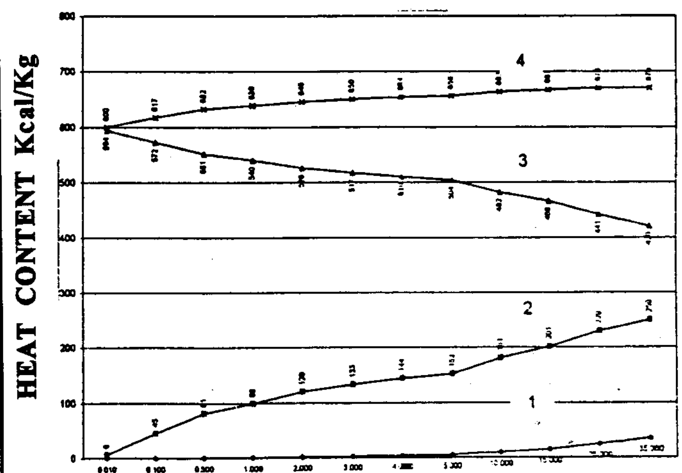
2. Burning of excess bagasse in the mill during off Sugar Season substituting for non renewable fossil fuel like coal, furnace oil and reducing cost of steam.

3. Burning of ETP Sludge in CFBC Boiler by dewatering it in belt filters.

FIGURE-3

Absolute Pressure in Kg/cm²	Sensible Heat in Kcal/Kg	Latent Heat in Kcal/Kg	Total Heat Kcal/Kg
0.010	6	594	600
0.100	45	572	617
0.500	81	551	632
1.000	99	540	639
2.000	120	526	646
3.000	133	517	650
4.000	144	510	654
5.000	152	504	656
10.000	181	482	663
15.000	201	466	667
25.000	229	441	670
35.000	250	420	670

HEAT VALUE OF STEAM



ABSOLUTE PRESSURE

—●— Absolute Pressure in Kg/cm² —■— Sensible Heat in Kcal/Kg —▲— Latent Heat in Kcal/Kg —▲— Total Heat Kcal/Kg

HEAT VALUE OF STEAM/PRESSURE FOR PROCESS REQUIREMENTS

4. Installation of HT capacitors for improving power factor of the system.
5. Blowdown heat recovery system.
6. Installation of primary air heaters using LP steam for Coal Fired Boilers.

Pulp and Paper Industry needs large amount of thermal energy for the process requirements like Pulping, Paper drying, Black liquor evaporation etc, in addition to the large amount of electrical energy for drives. The electrical energy consumption per tonne of paper produced and per tonne of Sugar cane crushed with regard to The Mysore Paper Mills Limited, Bhadravathi is shown in the Figure-2, which shows the impact of power consumption per tonne of paper & sugar produced.

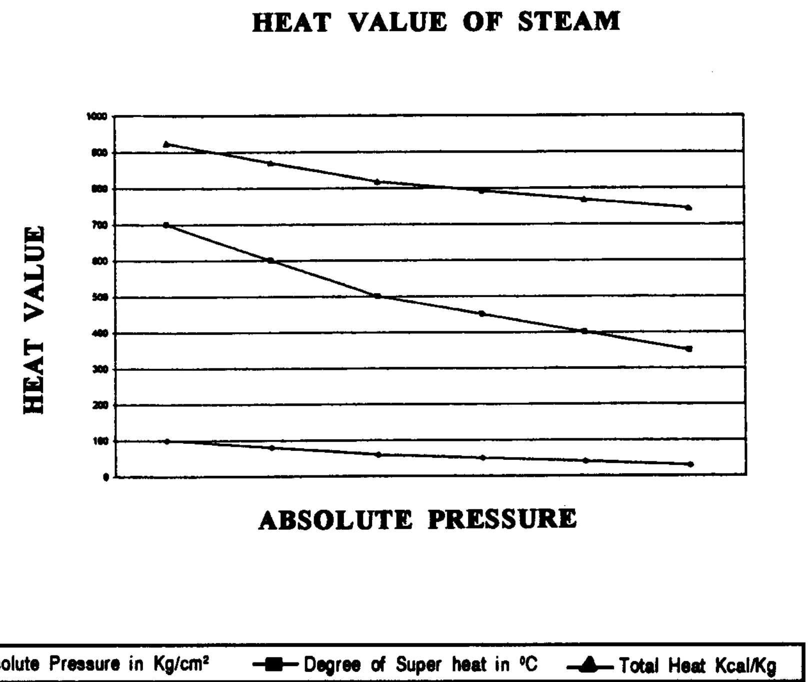
Today major sources for raising steam and power are conventional fuels like coal, furnace oil, natural gas, bagasse and forest/agro bio-mass materials. Thermal energy available in these natural fuels is being converted to useful heat energy by burning the fuels in different types of furnaces, combustures and gassifiers. Boilers are one of the major energy converters from natural fuel to useful heat energy for process and power generation needs.

Normally combustion of fuels takes place at a temperature around 800 to 1000°C in any boiler. Combustion products (flue gas) get cooled at different temperature levels transferring the heat to water, steam, combustion air and lastly to atmosphere. Once this has taken place, it is irreversible. Hence, it is implied that high level of thermal energy produced by combustion is to be utilised effectively before it gets lost to the atmosphere.

It is well known that any process like pulping, paper drying, black liquor evaporation, sugar mill operations need more quantum of heat energy rather than high temperature and pressure. Only latent heat of steam is being utilised for this purpose and sensible heat is carried back with the condensate. Latent heat of steam gets reduced when steam pressure gets increased which can be seen from figure-3. Super heat affects the heat transfer efficiency adversely and dry saturated steam is the one which is ideal for the process requirements. Hence, it is more economical to carry out all the cooking and drying operations at low pressures as much as possible even adopting

FIGURE-4

Absolute Pressure in Kg/cm^2	Degree of Super heat in °C	Total Heat in Kcal/Kg
100	700	925
80	600	870
60	500	818
50	450	792
40	400	768
30	350	744



HEAT VALUE OF STEAM FOR POWER GENERATION

cascade operations. In case of power generation the phenomenon is different. In steam turbines, the pressure energy of super heated steam gets converted to velocity (kinetic energy) utilising only super heat and then to mechanical and electrical energy. In this process except super heat entire latent heat of steam goes to atmosphere through cooling towers via condensors. Additional energy has to be spent to evacuate this energy to atmosphere in the cooling towers.

In order to achieve the maximum utilisation of the thermal energy in steam it is necessary that super heat, latent heat and sensible heat are utilised to the maximum extent. Hence...

- Generate steam at high pressure and temperature as much as possible considering metallugrical constraints of boilers and turbines bringing down the combustion temperatures and superheated steam temperature gap to the minimum possible i.e. around 100 to 200°C.
- Utilise the high pressure and high temperature steam in turbines, extract the process steam requirements at a low pressure as much as possible depending on the actual process needs to make use of super heat as well as latent heat.
- Condense the balance steam in condensers at very low pressure as much as possible at 0.10 to 0.12 Kg/cm^2 (absolute) (0.9 to 0.88 vacuum) to recover the sensible heat.

Co-gen power generation achieves the maximum utilisation of the thermal energy of the steam which is in the form of super heat, latent heat and sensible heat there by brings down the cost of production. It also reduces the dependency on the grid power supply from the State Electricity Boards which are unstable, poor in quality with regard to supply voltage and frequency which in turn affects the performance of the critical equipments of the plants.

Therefore it is very vital to look into all the Captive/Cogen Power installations to upgrade them for optimum utilisation considering basic principles of combustion and thermal energy traasfer. It can be seen from the figure-4 that the effect of raise in pressure and degree of super heat which reflect the total heat carried along with each kg of steam. It is seen that for power generation we have to use the high pressure and high temperature steam to get maximum output from steam turbines.

TABLE-1

Effect of steam pressure and temperature on specific steam consumption for captive power generation

Sl. No.	Steam pressure at Turbine inlet Kg/cm² (abs)	Steam temperature at Turbine inlet°C	Enthalpy of HP steam in Kcal/Kg	Enthalpy of LP steam extracted process@3 Kg/cm² (abs) and 160°C	Enthalpy of condensing steam@0.12 Kg/cm² (abs) and 49°C	Enthalpy drop in Turbine for power generation		Steam consumption in Kg/KWh@95% of Turbine efficiency	
						Extraction Kcal/Kg	Condensing Kcal/Kg	Extraction	Condensing
1	40	400	768	665	619	103	149	8.79	6.11
2	60	440	783	665	619	118	164	7.67	5.52
3	80	500	812	665	619	147	193	6.16	4.69
4	100	550	837	665	619	172	218	5.26	4.15
5	120	600	863	665	619	198	244	4.57	3.71

TABLE-1A

Cost benefit of improved captive power generation achieved in MPM as compared to the year 1990-91

Year	Total energy Consumed in lakh units	Captive energy generated in lakh units	Additional captive energy generated over & above base Year 1990-91	Grid energy cost Rs/unit	Captive energy cost Rs/unit	Reduction in energy cost achieved by improved captive generation Rs in lakhs
1990-91	2060.17	601.38	0	1.14	1.16	0
1991-92	2321.73	524.45	-76.93	1.37	1.28	-7
1992-93	2160.54	632.28	30.90	1.91	1.23	21
1993-94	2446.83	947.68	346.30	2.07	1.37	242
1994-95	2536.63	978.49	377.11	2.27	1.67	226
1995-96	2553.71	1255.9	654.52	2.64	1.79	556
1996-97	1844.21	1047.35	445.97	3.85	2.05	803
1997-98	2125.51	1323.19	721.81	4.21	2.95	909
1998-99	2142.82	1361.38	760.00	4.28	2.92	1034

TABLE-2

Condensate Recovery in MPM

YEAR	DMwater	Condensate recovered	LP steam to feed water	Total	% condensate recovery
1994-95	616603	526336	66220	1209159	43.54
1995-96	694908	628159	87901	1410968	44.52
1996-97	591592	540387	75457	1207436	44.75
1997-98	567990	653471	80541	1302002	50.19
1998-99	596282	702556	79028	1377866	50.99

From the figure-3, it can be seen that the latent heat (heat of evaporation) of steam gets reduced drastically with the increase in pressure. However the sensible heat increases significantly and there is marginal increase in the total heat. Since the process needs only dry saturated steam for optimum heat transfer as it utilises the latent heat, extraction of steam at low pressures, boost the captive power generation. Table-1 shows the specific steam consumption per kwh corresponding to steam pressure and temperature at the turbine inlet. Where the process steam demand is limited, to increase the captive power generation for the same quantity of process steam requirement, it is possible by increasing the inlet steam pressure and temperature. Incorporating the condensing facility in the turbine not only boosts the captive power generation but also lends flexibility in absorbing process steam demand variations keeping the constant load on boilers which improves boiler performance and efficiency.

Hence the process Industries have to optimise the thermal energy utilisation by combining captive-co-generation technique and upgrading the boiler and turbines working parameters.

CONDENSATE RECOVERY AND EFFICIENT USE OF STEAM

Captive/Co-gen power generation calls for high pressure boilers. High pressure boilers demand for stringent water quality. Demineralisation of water becomes absolutely necessary for boiler water requirements. This eralisation calls for capital cost and operating cost on chemicals.

To reduce the size of Demineralisation plant as well as treatment cost, condensate recovery plays a vital role in the system. As already explained above, steam transfers latent heat to the process and gets condensed as water. Depending on the pressure at which it gets condesed as water still it carries the sensible heat along with it corresponding to that pressure. In case it requires to transfer this sensible heat to process it calls for a very large area of heat transfer and differential temperature between the two media for quick heat transfer. This is not an economical proposition.

Condensate recovery is the best solution, which brings back the demineralised water and heat to the system. This brings down the cost of steam generation and improved power plant performance.

Mysore Paper Mills also progressively implementing steps in this direction. Condensate recovery particulars are shown in Table-2, which indicates an increase of 5 to 6% over the years.

Further, MPM has taken up detailed study of steam and condensate handling system of Newsprint Machine as well as Cultural Paper Machines which are expected to show positive results in steam economy and condensate recovery.

It is under consideration to provide vent condensers to recover condensate from steam vents and flash tanks.

Evacuation of the condensate from the process equipments also plays important role in the heat transfer process. Following are some of the key factors to be considered for efficient heat transfer and system efficiency.

- Working at the lowest practicable steam pressure.

- Using the right quality of steam.
- Reducing the unnecessary heat demand.
- Correct distribution.
- Productive heat transmission.
- Correct steam trapping.
- Air venting of steam spaces.
- Recovery of condensate.
- Recovery of flash steam.

CONCLUSION

The basic concepts in heat and power production for captive use, indicate the generate steam at a maximum possible working pressure and temperature. Extract and condense at lowest practicable pressure which boosts the optimum utilisation of thermal energy in the steam and this brings down the coast of production. MPM has taken steps right from 1980's progressively and drived the benefits of captive power generation.

ACKNOWLEDGEMENT

The authors thank the Management of The Mysore Paper Mills Limited, Bhadravathi for the encouragement given to write this paper and publish in the IPPTA magazine.