Energy Conservation Approaches in Digester House

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The power scenario in the country in the last ten years had been facing shortage of power in many regions through out the year. The shortage of power has a cascading effect on the industrial production and consequently the economic development of the country. Hence energy conservation is the foremost talk of the day and efforts are to bring down the power consumption in the view of present supply / demand position. Even though there is awareness to use energy optimally, in industries. Barriers like, lack of priority, lack of finance, prevent work being done towards optimization of energy. The aim of this paper is to study the potential for energy conservation measures in digester house of pulp mill without affecting production, yield or quality. Energy conservation measures in the pulp mill are discussed.The digester house is a major consumer of energy in terms of steam. The energy consumption in the pulp mills is around 1.6 tonne per tonne of unbleached pulp as steam and 7.0 kWh per tonne of unbleached pulp as electrical energy (Figures drawn from integrated Indian paperboard manufacturing industry).

There are various possible measures in pulp mill to conserve energy, there are:

Indirect steaming of digesters. Optimize digesters scheduling by proper control on various parameters. Recover heat from continuous relief vapor from digesters. Steam packing of digesters. Two stage steaming of digesters. Recover blow heat from the digesters by suitable displacement of cold blow technique. Use of continuous digesters. Modified / new cooking process (use of Rapid Displacement Heating)

INTRODUCTION

The Pulp and Paper Industry is highly energy intensive. The main fuel used in the paper industry is coal. The other fuel used are Furnace oil, Diesel, Black liquor etc. Large mills generate most of power through Co-generation, while smaller mills depends exclusively on purchased power. Energy cost accounts for 25 % of the total cost of manufacturing and it is rising by leaps and bounds every year. The breakup of cost of production under various heads is shown in Fig. (1),

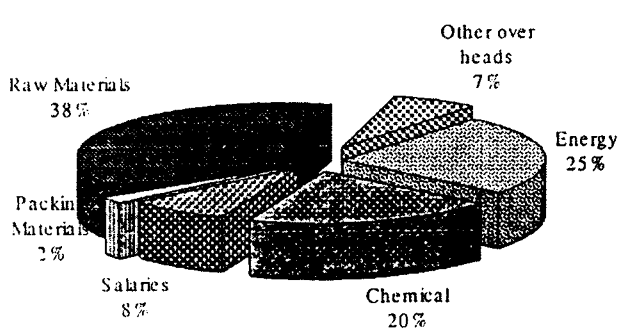

Fig. 1 : Breakup Cost of Production per tonne of paper (1)

Most of the digesters in Indian are conventional batch type. Only 2/3 paper mills in India have adopted continuous digesters. Where modified cooking process (RDH) still has to come in Indian pulp mills, only single mill (JK Corp.) have started running with modified cooking process.

Continuous Digester

Continuous digesters were successful in replacing batch systems as the predominant technology for Kraft pulping primarily due to the inherent advantages of a continuous process over a batch process. As with any chemical reactor system, a continuous digester requires less reactor volume per unit retention time compared with batch. This is because batch reactor volumes cannot be used for process retention time during the batch filling and batch discharge parts of a cycle. Besides making better use of available reactor volume, the continuous process also uses a single, vertical vessel. The batch system requires many individual reactors. The continuous process is therefore considerably more space efficient. In addition, the flow capacity required for inlet streams and outlet streams is much lower for the continuous, steady state process. This means that the continuous, steady state flow rate of reactants and final product is much lower than the discrete, "peak" flow rate necessary for rapid batch fill and batch discharge cycles. The results are lower installed horsepower requirements, smaller feed and discharge equipment capacities, and more suitable operations with the continuous process. Continuous digesters offer the following advantage

- More space efficiency.
- Less installed horsepower.
- Lower volumes of inlet streams and outlet streams.
- Steady state operation Vs. batch fill and discharge cycles
- More energy efficiency.
- Lower environmental impact.
- Efficient first stage of brown stock washing.
- More flexibility in process configuration.

Displacement batch cooking

Displacement batch cooking is essentially a batchcook where heat and residual chemicals remaining in the black liquor at the end of cooking are captured for reuse in subsequent batch cooks. This occurs by placing the black liquor in separate pressure accumulators for later use to heat chips and white liquor for later cooks. Displacement batch cooking offers the following advantages.

- It saves thermal energy.
- It saves chemicals in cooking, washing and bleaching operations.
- It produces pulp, which has 15-20% higher tear-tensile strength. Hence better machine runnability is assured due to excellent quality of pulp.
- Environmental friendly,
  a. Less TRS emissions
  b. No-emissions to mercaptan, malodorous gases.
  c. Drastic reduction in AOX, BOD & Color.
- One stage of in digester helps in minimizing alkali losses.
- Pulp results in lower viscosity of black liquor going to chemical recovery .

The possible improvement in energy economy by continuous digester and by displacement batch cooking process have compared with present system of conventional batch cooking during the study. The results of the study have given in Fig. 3. The results have found to be, continuous digester pulping is 24 % energy efficient and displacement batch cooking is 23 % energy efficient than the present conventional cooking practice.

Case studies

The possible improvement in digester house have highlighted from the study made in integrated pulp mill.

The mill has totally 8 digesters, out of which 6 are of 80 m^3 capacity and 2 are of 100 m^3. All digester are batch type. To recover the heat from the blow pulp, the mill has installed heat recovery system. In a day of maximum 39 blows are blown, each of 15 to 20 minutes duration. The total quantity of pulp blown is about 2332 tonne / day for 80m^3 digester and 884 tonne / day for 100 m^3 digester.

Case 1: Two stage batch digester steaming Present practice:

After charge of white liquor and black liquor into digester according to liquor to wood ratio, the liquor get circulated through indirect heat exchanger to attain cooking pressure of 7 bar, 165°C. The heating to this cooking temperature is carried out by MP steam supply to heat exchanger at pressure 11 bar. Since the heating is carried out by single stage MP steam.

Recommended practice

In two stage steaming, the digester is initially heated and pressurized by low-pressure steam. After the digester has been partially brought to cooking pressure and temperature, it is switched over to 11 bar pressure steam, which takes the digester to full pressure (7 bar)

Table 1 : Blow heat recovery system, recommended pump capacity

Particular	Existing pump capacity		Proposed pump capacity	
	PC	SC	PC	SC
Flow rate, m^3/hr	380	190	632	159
Head, m	15	15	Supplier recommendation	-do-

* Taking the secondary pump handling capacity of 20% of total flow.

Table 2 : Improvement in performance of blow heat recovery system by applying proper system accessories

Parameter	Performance value for existing process	New performance value by retrofitting	Remarks
Temperature of foul condensate at inlet of PC and SC, °C	66	55	Decreased temperature will enhance the performance of the condensers.
Hot water temperature at outlet of heat exchanger, °C	65.5	75	Achieving the desired hot water temperature.
Heat transfer area of the plate heat exchanger, m^2	83	174	Increased heat transfer area to attain hot water temperature of 75°C.
Additional LP steam usage in the hot water tank. TPH	5.74	2	Reduction in steam consumption at the hot water tank.

and completes the cooking cycle.

By increasing demand for low-pressure steam, this method allows a change in the extraction ratios of mill turbine generators. The amount of 4 bar extraction may be increased while 11 bar extraction is decreased. This measure would boost the turbine's electrical output while using the same amount of input steam. Savings would be realized through the replacement of purchased electricity with less expensive co generated power. The plant, MP steam (11 bar) extraction from TG plant is 10 tph and remaining demand is taken care by CFB (Coal fired boiler). Now MP steam extraction from TG plant is nil, results in increasing cogeneration of the plant.

Possible savings

Flash vapor recover at 4 bar pressure (LP steam) from MP steam condensate = 18 tonne / day Electrical energy savings = 0.12 MW.

Annual savings = Rs. 48 lakh.

* Unit cost of electricity from grid =Rs. 3.25 per kWh

Steam generation cost = Rs. 300 per tonne

Number of working days = 330 days per year.

Case 2: Improvement of blow heat recovery system of digester house Present practice

It was observed the temperature of the foul condensate at the outlet of the heat exchanger is 66°C. The foul condensate temperature inlet to the Primary Condenser and Secondary Condenser is going as high 66°C with flow of 570 m^3/hr: this is resulting in inadequate condensation of flash steam. The system efficiency is found about 55 %.

It was observed that the temperature of hot water generated is about 65.5°C for a flow rate of 230 m^3/hr, while the required hot water temperature in new fibre line (system of screening and washing) is 80°C. The low temperature of hot water is due to in-sufficient heat transfer in the plate heat exchanger. This has resulted in direct steam usage in the hot water tank to maintain the temperature of 80°C. On an average the LP steam usage for hot water generation is about 5.74 tonne /hr. The existing plate heat exchanger has a total heat transfer area of 83 m^2 and this has got adequate provision for providing additional plates to increase the heat transfer area.

Recommended practice

The following measure needs to be taken to increase the BHRS efficiency,

- Replace the existing foul condensate pump with the higher capacity pump. The capacities of the existing and proposed pumps are given in the following Table (1).

Increase the heat transfer area in the plate heat exchanger to 174 m^2 from the present area of 83 m^2.

The performance value for existing process and performance value after retrofitting are listed in the Table (2)

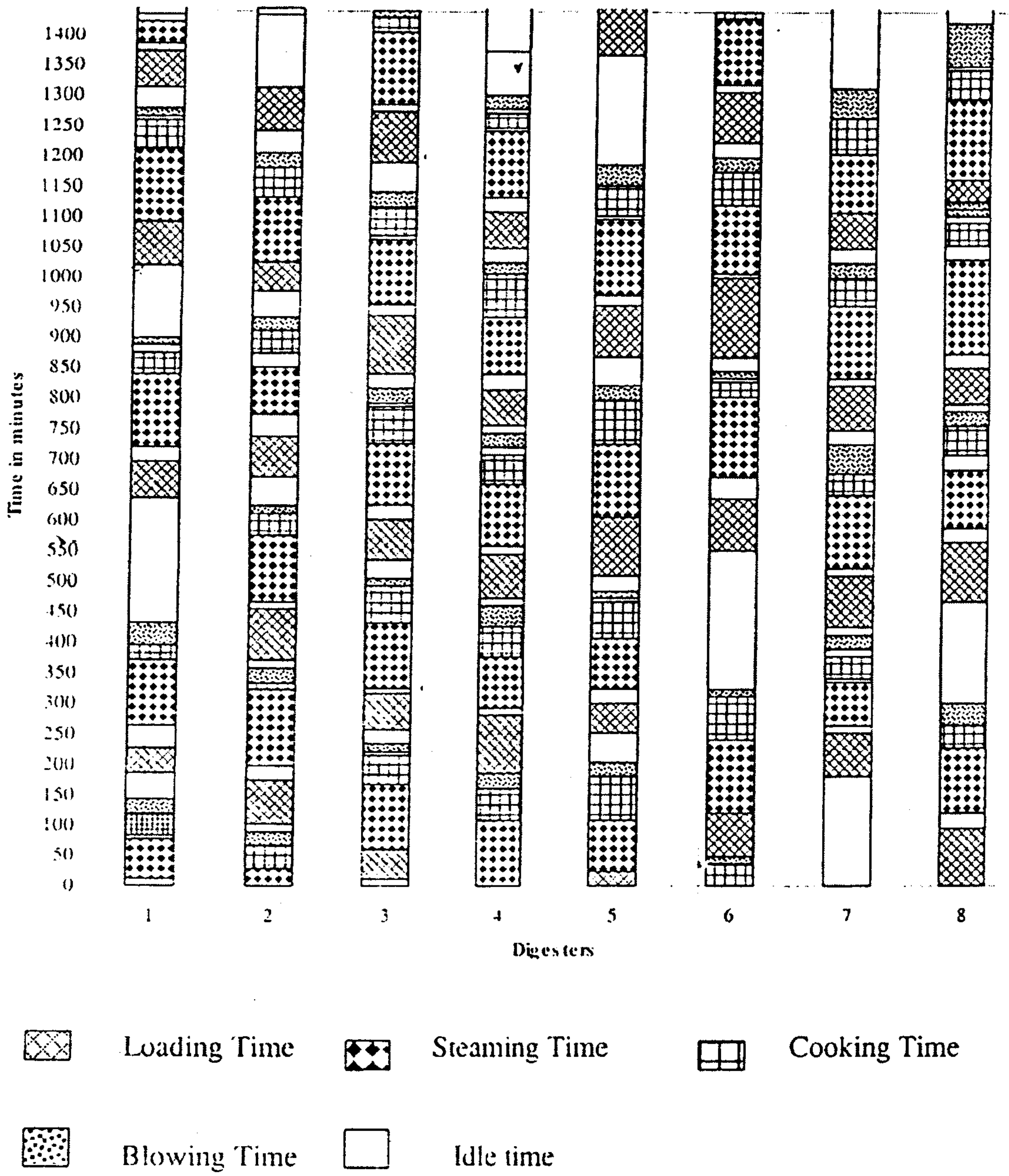

fig. 2 : Scheduling of Digester

Possible savings

Stearn savings for hot water generation =3.74 tph Annual savings =Rs.91 lakh.

Case 3: Proper scheduling of digesters

Digester cycle consists of a series of operations in sequence. The time of duration of each is dependent upon the pulping process followed. The various operations are carried out as follows:

I. Chip cooking and liquor filling.

II. Steaming for attaining the cooking temperature.

III. Holding at the cooking temperature.

IV. Blowing of pulp at the end of cooking.

Of these operations digester loading and digester blowing are insignificant contributors to cycle time and total energy consumption. Steaming for attaining the cooking temperature and holding at cooking temperature are interdependent for manufacturing a pulp of desired properties like Kappa number and viscosity.

Generally in mills following Kraft cooking cycle,

Table 3: Analysis figures of cooking schedule of eight digesters

For 80 m^3 digester (6 nos.)

			Time in Minutes	
Particular	Min	Max	Standard Deviation	Average
Loading Time	42	132	20.97	7437
Steaming Time	66	126	16.37	106.85
Cooking Time	24	72	16.30	46.61
Blowing Time	12	36	7.75	21.6
Idle Time	6	228	51.39	42.51
Cycle Time			-	291.94
No. of cycle per day			-	29.60

For 100 m^3 digester (2 nos.)

		Time in Minutes		
Particular	Min	Max	Standard Deviation	Average
Loading Time	36	96	20.28	72
Steaming Time	72	132	25.61	112.5
Cooking Time	36	60	8.93	43.5
Blowing Time	24	72	17.49	37.5
Idle Time	12	180	60.63	45.88
Cycle Time			-	309 .88
No. of cycle per day			-	929

holding time at cooking temperature is not changed from cook to cook to correct pulp properties rather it is the chemical charge which is varied. It is a common occurrence in digester operation that while steaming is going on for attaining cooking temperature the steam pressure falls. Consequently the time to attain the cooking temperature exceeds the allowed time. The cooking reaction is highly sensitive at high temperature and delignification has already progressed to a significant extent by the time the target cooking temperature has been reached in such cases. Cooking is required to be carried for lesser time for these cooks. However, in the absence of H-factor integrator instruments this cannot be done. Pulps obtained from these cooks therefore show lower kappa number and yield. Additionally production goes down. Since steam pressure fluctuations is a perennial problem a H-factor integrator set at a target H-factor will be extremely beneficial in terms of uniformity of pulp properties and reduced production loss. Further, installation of a steam accumulator to smoothen the steam input pressure to liquor preheaters make good sense.

The purpose of study is to find out the operational bottleneck and possible way of reducing it. This is likely to increase the productivity of digester house with reduced specific energy consumption. For finding out the possibility of operational bottleneck, the study is carried out for 24 hours.

A systematic study of the cooking cycle of the eight digesters is given the Table (3) using the analysis shown in fig. (2).

From the above analysis figure it has observed that mill average cooking cycle is about 4.8 hours for 80 m^3 digesters and 5.16 hours for 100 m^3 digester. The average number of batches is about 38 batches per day.

An approximate impact of these improvements on scheduling is likely to give another 20 % additional production or the present production being achieved from 8 digesters can be achieved in 4 digesters of 80 m^3 and 2 digesters of 100 m^3. The increase in capacity utilization will have its favorable impact to bring down the specific energy consumption.

Table 4: Findings of bottleneck and possible savings by proper scheduling of digester

Particular	Observation	Reason	Possible saving
Loading Time	• In both digesters (80 and 100 m^3 the maximum time observed to be 3 times the minimum time, this is too high. • Average loading time of 100 m^3 digester is less than 80 m^3 digester. • Before and after chips loading, there is idle time in most batches. Of 39 batches, this is time for 24 batches.	Monitor the loading arrangement of digester with proper supervision management	By doing so, Time saving per day For 80m^3 = 603 min For 100m^3 = 195 min Increase in production capacity, For 80m^3 = 17.65 TPD For 100 m^3 = 6.79 TPD
Steaming Time	In both digesters the maximum. time observed to be 2 times the minimum time. • Bottleneck appears to be non-availability of full pressure steam. where more than one digester is waiting for steaming, the steam pressure falls down where the concerned digester are steamed, result increase in steaming time.	Improve steam-feeding arrangement of digester Installations of steam accumulator for digester to act as surge tank, and thereby permit steaming of two digester without increase in steaming time.	By doing so, Time saving per day For 80m^3 = 227 day For 100 m^3 = 121 day Increase in production capacity For 80 m^3 = 6.6 TPD For 100 m^3 = 4.2 TPD
Cooking Time	• The average time taken for cooking is about 46 minutes for 80 m^3 and 43.5 minutes for 100 m^3 digesters. • The cooking time for 80 m^3 digester is higher than higher capacity digesters. And time variation for cooking is about 16.30 minutes for 80 m^3 digester and 17.49 minutes for 100 m^3 digesters.	This appears to have proper H-factor control with proper supervision management.	By doing so, Time saving per day For 80 m^3 = 307.9 min For 100 m^3 = 67.5 min Increase in production capacity For 80 m^3 = 9.0 TPD For 100 m^3 = 2.0 TPD

Blowing Time	• In both digesters the maximum time observed to be 3 times the minimum time. • Bonleneck appears to be an improper supervision management, waiting for blow due to overlapping of proceeding batch, and longer blow duration.	This appears to have changes in blow lines (i.e. making available of blow tank to all digester) and increase in size of blow line. Along with good supervision management.	By doing so, Time saving per day For 80 m^3 = 104.4 min For 100 m^3 =13.5 min Increase in production capacity For 80 m^3 = 3.05TPD For 100 m^3 = 0.5 TPD
	• From the schedule it is observed that there are long hours of gap between two successive operations due to no apparent reason. • The average idle time per batch is observed to be 42.51 minutes tor 80 m^3 digester and 45.88 minutes tor 100m^3 digester.	With bener supervision, this can be bringing about a signiticant saving.	By doing so, Time saving per day For 80 m^3 =986 min For 100 m^3 =252 min Increase in production capacity For 80 m^3 =28.87 TPD For 100 m^3 =8.78 TPD

* Above Possible savings are calculated at 50% more than minimum time of present schedule.

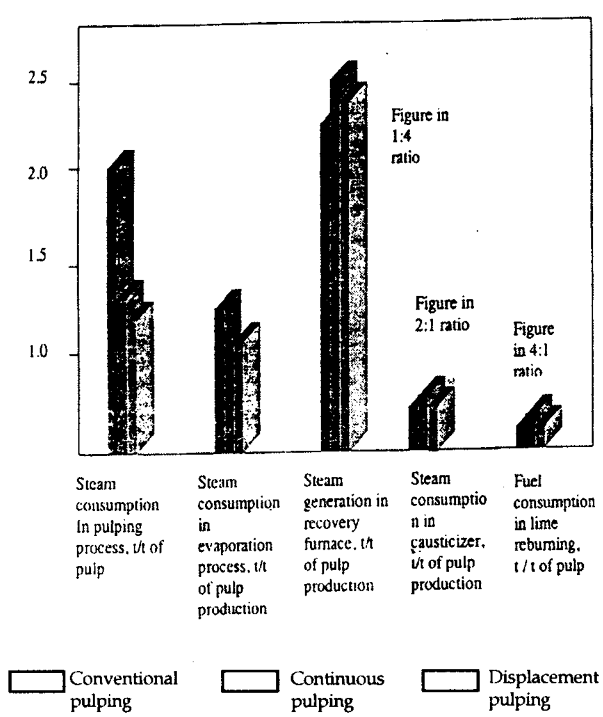

Fig. 3 : Comparative study of energy consumption and generation of different pulping process

Case 4: Improvement in energy economy by new technological options (By continuous digester and Displacement batch cooking).

Increased pressure to minimize environmental impact and effluent volumes, contributed to the development of continuous digester and batch cooking using modified cooking chemistry principles and extended cooking.

CONCLUSION

In this paper a various possible measures of energy conservation in digester house have found out during the study and came out with new performance value by retrofitting the process. The study is found to save 4% of mill total annual energy cost.

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