Need for an integrated approach to conserve energy in paper industry–A fresh look

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ABSTRACT

Indian paper industry still continues to consume both primary and secondary energy in substantial quantities and studies carried by previous agencies have clearly indicated that there is a wide scope to conserve energy in Indian Pulp & paper industry. Looking into the energy intensiveness of the paper industry and increasing cost of energy, Central Pulp and Paper Research Institute formed a team of scientists & engineers to study the possible areas where energy can be conserved. The team resorted the studies to small Pulp and Paper mills as they do not have adequate facilities. Central Pulp and Paper Research Institute acquired necessary monitoring instruments for on spot measurement of some of the process parameters. Unlike other agencies Central Pulp and Paper Research Institute has adopted monitoring and targetting as an approach to conserve energy. The present paper highlights the case studies carried out for two of small pulp & paper mills.

Introduction :

Paper industry is one of the highly energy intensive industry and ranks sixth among the energy intensive industries. The energy input and the cost of energy plays a vital role in determining the cost of production of paper. Further, with the depleting resources of energy sources in India, energy conservation has become an issue of paramount importance on the national perspectives.

After two energy crises in early seventies and early eighties, developed countries have made a tremendous progress in conserving energy and also increased co-generation by applying unconventional fuels. For instance European paper industry has reduced its oil consumption by 22%, and Japanese paper industry by 34%. While Indian paper industry on the other hand has not made any breakthrough in energy conservation programmes primarily due to scale of operation, lack of modernization etc. Monitoring and targetting (M&T) was one of the important approach adopted by developed countries in their energy conservation programme. This approach involves data collection over a period of time, analysis of data and finally targetting the period for reduction in energy consumption. M&T approach is highly realistic and can be easily adopted to Indian conditions. Although in the past a number of agencies have carried out the energy consumption pattern and brought out reports containing various recommendations for energy conservation, however, it seems that due to lack of adequate monitoring facilities some of the small mills were not in a position to adopt these recommendations.

Under the UNDP assisted scheme for assistance to non-wood based paper Industry, a group of scientists

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and engineers are engaged in the field of energy conservation. The methodology adopted by this team is essentially M&T approach and for these studies two mills have been selected. The present paper highlights the work carried out by CPPRI in the area of Energy Conservation employing monitoring, data collection, computer simulation and sensitivity analysis of the data collected. The software developed for energy conservation should be highly useful to a number of Pulp & Paper industries of varying capacities.

Present energy reserves :

Table – 1 gives the comparative per capita recoverable reserves in various countries.

TABLE—1
Recoverable Reserves Per Capita*

Country	Coal (Tonnes)	Oil (Tonnes)	Gas(Cu.m.)
U.S.S.R.	20066	30.3	142860
U.S A	13488	16.0	25000
CHINA	1168	2.3	900
INDIA	176	0.78	1005

* Source - Times of India, New Delhi, March 1992.

Looking into the present energy reserves it becomes important to make consorted efforts to conserve the energy in all industrial sectors. Studies coducted previous teams have clearly indicated back that is scope to conserve as much as 20–30% energy in the paper industry.

Efforts made in developed countries :

Significant development have been achieved in developed countries in conserving energy through

- inplant modification
- modernisation and process control
- increased scale of operation
- capacity utilization

The energy consumption situation in some of the developed countries is given below—

- Japan-reduction in oil consumption 34%
- Europe-reduction in oil consumption 22%
- Sweden-reduction in oil consumption 70%
- U.K.-reduction in primary energy consumption about 8%.

Even a country like Brazil has made significant success in energy conservation. Fig. 1 and 2 show the comparison of energy pattern in modern mill in India and Brazil.

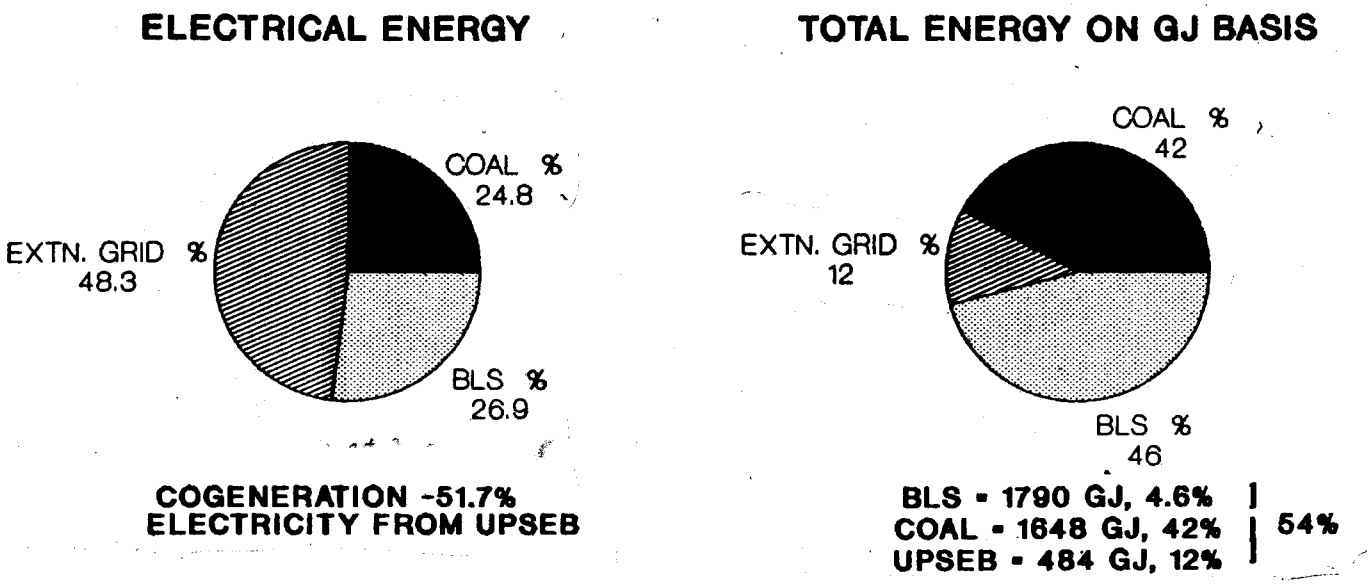


FIG.1 DIFFERENT ENERGY SOURCES IN AN INTEGRATED INDIAN MILL

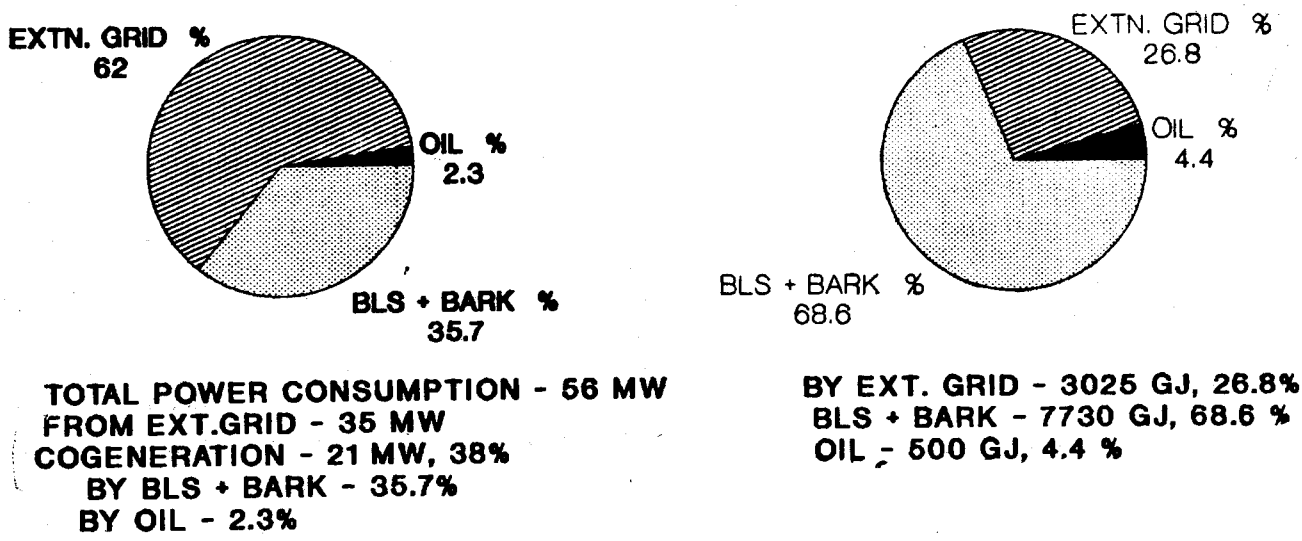


FIG.2 DIFFERENT ENERGY SOURCES IN A MILL IN BRAZIL.

Process control :

Considerable energy saving through process control has been reported. Magnitude of benefits through process control and instrumentation in energy saving in different areas is likely to be—

Digester	—	10-20%
Bleaching	—	5-10%
Evaporator	—	3-5%
Recovery boiler	—	20-30%
Paper machine	—	10-20%

Small and integrated mills which do not have adequate monitoring equipments face problems in energy conservation efforts. Many of them are not even aware of the magnitude of energy losses in various processes within the mill. Energy team at CPPRI is well equipped with various portable instruments and sophisticated laboratory facilities to assess the energy losses (Table-2)

TABLE—2
List of Instruments

Instrument	Applications
Fuel efficiency Monitor	To check the controllable heat losses in boiler house
Non contact Ir. thermometer	To measure the surface temperature
I.R. Gas analyser	To analyse the flue gases
Tongue tester	To measure the running load of electrical instruments.
Temp. probes.	—
Viscometer	Viscosity measurement at various temperature and solids.
Thermal analyser	To understand combustion behaviour
Bomb calorimeter	To determine calorific value
PC.AT computer	For simulation studies related to energy conservation.

Methodology and approach ;

The excessive amount of energy used by most of the Indian paper mills makes the economic evaluation of the conservation measures resonably straight forward. Most of the studies carried out by previous team was essentially based on the data furnished by the mill[1,2]. This kind of exercise have resorted to only big mill.So in the present study CPPRI energy management team has adopted a different approach and methodology. The methodology adopted is essentially a monitoring and targetting system. This system

— relies upon management of energy at all levels.

— at operational level, measures energy consumption over a period of time for a process and product.

— at energy supply level, identifies and relates primary energy (purchased) and secondary (Heat & Power) inputs to consumption.

Besides monitoring and targetting, the other tool used were

— Data collection by actual measuring employing portable instruments

— Analysis of data employing computer simulation technique.

Any effective approach should take into consideration, the various interactions between the different saving measures which are often ignored during the evaluation. The energy consumption in a paper mill depends on various factors like raw material furnish, the process employed at different stages, out put quality, potential ability to recover waste heat in various unit operations etc. Collection of useful information on energy generation and consumption provides a mean for identification of a number of energy saving opportunities in the mill. It is possible to determine the total impact of combination of measures by analysis through energy and material balance calculations. Computer simulation technique and sensitivity analysis are effectively used for this phase of evaluation. Energy Audit of the mill is also made as an attempt to balance the total energy generation, consumption and to identify all the energy streams in the mill.

Data collection and analysis :

Integrated monitoring and targetting approach was carried out by CPPRI energy team during the case studies of the selected mills. Data collected was accomplished in two steps. First the information available from the mill management and personnel was analysed to decide about the necessity of monitoring of process variables in various processes using the equipments carried by the team. Apart from these exercises, the energy team utilized some of the set objectives for various sections of the mill (Table—3) as another step to conserve energy during its study.

Analysis of data involves the computer simulation studies and sensitivity analysis of process variables related to energy conservation.

Computer Simulation :

Process simulation techniques are valuable because they allow the design engineers and production supervisors to optimise the processes with a minimum time instead of time consuming and costly trials. The simulation can be used more accurately to analyse the effects of proposed changes upon a complex, non-linear, highly iterative process then is possible by hand. On the basis of the simulated analysis of the process, the use of computers capability for simulation can result in better decision [3,4].

Although process simulation has been used in other industries for many years, meaningful pulp and paper process simulators have been available during the last decade. Process simulators can be used to play the "what if" game and in terms of energy use, make it possible to determine the optimum process configuration for effective utilization of energy. For minimising energy use without compromising product quality process simulation can be used

TABLLE=3

Energy conservation measurement in various section of a mill & their benefits

Section		Measures	Results
Digester house	—	Adequate process control system like precise pressure, temp. and flow meters	Maintain proper cooking condition
	—	Proper insulation	Radiation losses to be minimised.
	—	Maintaining proper bath ratio by checking moisture in raw material.	Saving of steam
	—	Optimise end cooking temp. by maintaining "H" factor.	Increases no of blows & indirectly reduce steam consumption.
	—	Provision of chemical and material mixing for digester	Reduce steam consumption
	—	Maximum allowable cy. and capacity should be maintained in hydrapulper	Efficient power utilization.
	—	Blow heat recovery arrangement	Saving of steam
Bleaching	—	Proper maintaining of temp. and cy. & proper functioning of heat mixer	Reduce steam consumption
Paper Machine	—	Proper temperature profile of dryer	To increase efficiency of machine,
	—	Dryness measurement	resulting in low
	—	Hood conditions optimization	steam consumption.
Boiler house	—	On line measurement of flue gases, its temperature and composition.	To reduce the heat losses & to increase the thermal efficiency.
General	—	Energy auditing should be done on a specific time interval.	To assess energy efficiency analysis of the process and energy consumption between different products & with other mills.

— off line and

— on line

Off line process simulators are the programmes developed to model pulp & paper processes. Two types of process simulators used in various industries are—

— steady state and

— dynamic

The steady state simulations show averaged material and enery balance where as the dynamic simulators momentary processes. Steady state simulations are most commonly used in pulp and paper industries. However, a programme DYSCO (dynamic simulation & control) has been reported[5]. With the advent of computerized control of processes, on line simulators will provide decisions and implementation of new strategies during process.

A number of commercial simulation softwares are available from the energy point of view. Most of the pulp and paper industries in developed countries use these commercial softwares to avoid the investment of time and manpower necessary to develop and support in house system. Various simulation software have been developed at CPPRI to locate the possibility of energy conservation in pulping and bleaching section of a mill, such as digestor house. blow heat recovery, convection and radiation losses and bleaching-extraction stage. Simulation programmes of boiler house and paper machine are also developed. The sensitivity analysis makes possible to study the response of the system to variation in process variables using computer simulation and is very useful for energy conservation.

Energy audits :

Energy audit is the key step to a systematic approach for decision making in the area of energy management[6]. Energy audits are made to understand the main cost factors in the mill with a specific purpose of determining the whole mill energy balance, energy consumption and cost for different departments or processes, energy efficiency analysis of various processes, energy consumption between different products and energy comparision with other mills in details.

Modern electronic instrumentation and decreasing cost of computer capacity has made "on line" audit calculation economically justified in many developed countries. By connecting the on line measuring circuits directly to the computer, a momentary audit can be performed continuously. To make energy audits easier for Small and integrated Indian paper mills, CPPRI has prepared some formats and a short check list. Filling the information in sequence makes the process of auditing quite simple. It can easily indicate that which area is consuming higher energy than the set point and mill personnel can concentrate on that area to reduce the energy consumption. Softwares for energy audits have also been developed at CPPRI which require entering of the monitored data at a certain interval as input.

Case studies :

Two small pulp and paper mills have been selected by the project authorities for carrying out the case studies in the area of energy conservation. It has often been observed that the mills are seldom equipped with adequate monitoring epuipments. So CPPRI acquired necessary facilities to measure the important process parameters. Table–4 gives the details of mills selected and their energy consumption pattern. During case

Table—4

MILL DATA

MILL—1			MILL—2	
CAPACITY—15000 t/y			CAPACITY—22000 t/y	
RAW MATERIAL—				
Bagasse 80% + Straw Sarkanda—20%			Bagasse—80% Gunny—10% Waste paper—10%	
PRODUCT—Bleached/ unbleached			Unbleached	
ENERGY CONSUMPTION :				
	Steam t/t	Power Kwh/t	Steam t/t	Power Kwh/t
PULPING	4.0	460	2.0	210
PAPER MACHINE	3.5	595	3.0	515
OTHERS	1.5	160	—	85
TOTAL	9.0	1215	5.0	810

studies, CPPRI scientists found that there is a lot of variation in fuel consumption from mill to mill. For steam generation these mills use primary fuel as coal and secondary fuels such as bagasse, bagasse pith and rice husk. Secondary fuels are used on the basis of availability of fuels near mills. Fig 3 indicates the different energy sources for Indian small mills based on non-woody raw materials. Mill-1 uses primary fuel 3 6% and mill- 2 41.0% Fig.4 indicates the different energy cost distribution in the selected mills. Fig 5 shows the distribution of steam and electrical power in different sections of one of the pulp and paper mill. Fig 6 shows specific energy consumption over a period of time for one of the selected mills.

Some of the energy savings by sensitivity in the case studies are given :

MILL—1

— By decreasing bath ratio from 4 to 2.5, steam saving 30 t/day.

— By decreasing radiation losses from 13.7 to 4%. steam saving 10 t/day.

— By installing blow heat recovery 339 tonnes hot water (80°C) can be produced. This amount is quite sufficient for C—filter pulp washing and can save 19.4 tonnes steam per day (steam for E-stage heating).

— By increasing last press pulp consistency by 1%, steam saving 8.3 t/day.

— By decreasing finished paper dryness by 1%, steam saving 3.5 t/day.

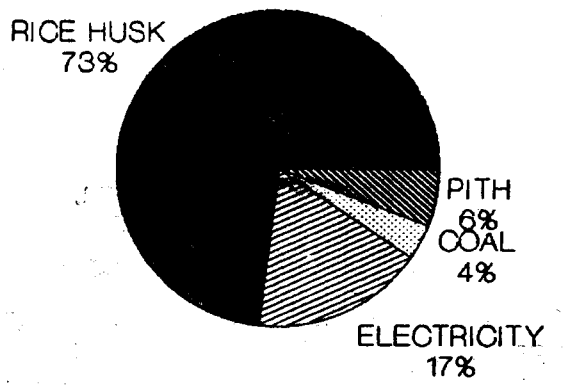
— By decreasing brokes 10% to 5%, steam saving 8.4 t/day.

MILL—2

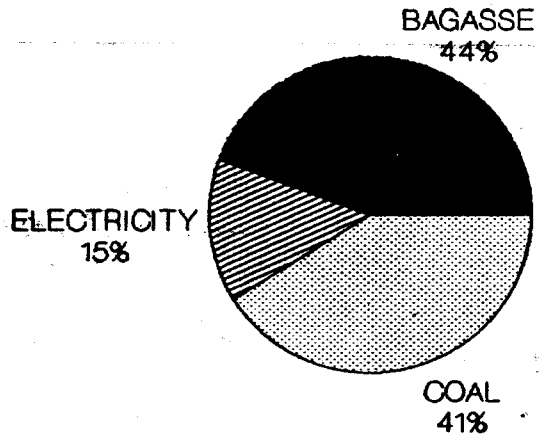
— By decreasing bath ratio from 4 to 2·5 steam saving 50 t/day.

— By decreasing radiation losses from 7 to 4%, steam saving 4 t/day.

— Blow steam can be used to produce 615 t hot water (80°C).

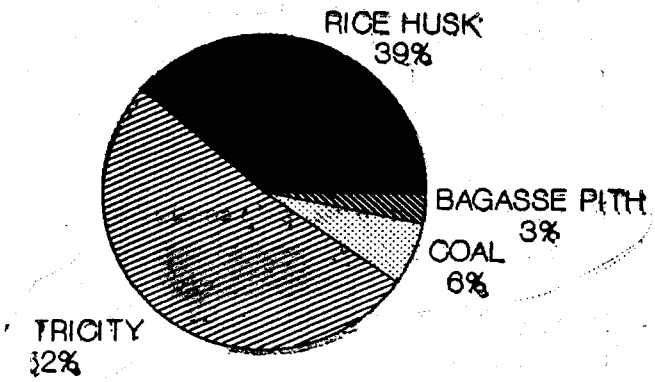


MILL - 1

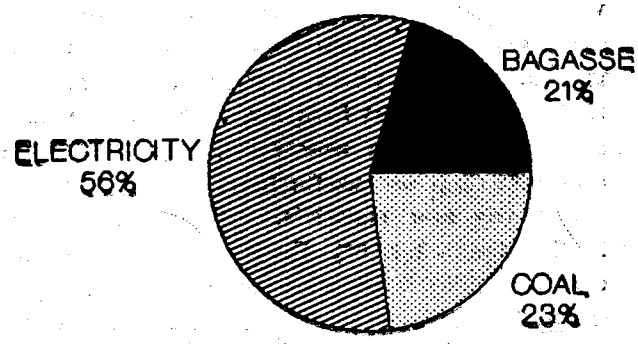


MILL - 2

FIG.3 DIFFERENT ENERGY SOURCES.

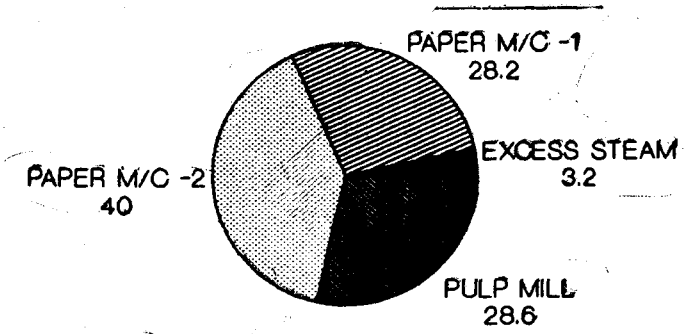


MILL - 1

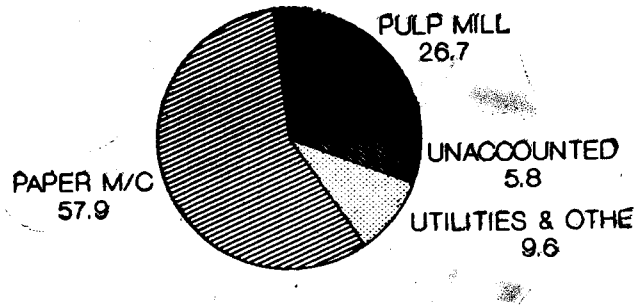


MILL - 2

4 DISTRIBUTION OF ENERGY COST



(% OF TOTAL STEAM)



(% OF TOTAL ELECTRICITY)

FIG.5 DISTRIBUTION OF STEAM AND ELECTRICAL POWER

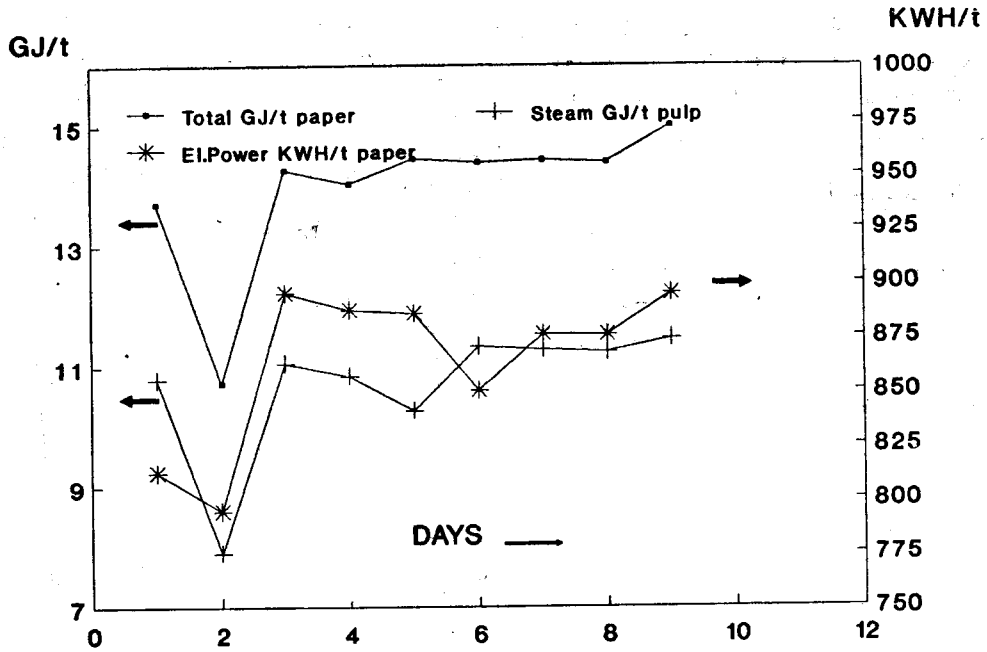


FIG.6 VARIATION IN SPECIFIC ENERGY CONSUMPTION IN A MILL.

— By increasing last press pulp consistency by 1% steam saving 10 t/day.

— By decreasing finished paper dryness by 1%, steam saving 6 t/day.

— By decreasing brokes 10% to 5%, steam saving 12 t/day.

The boiler sensitivity analysis results for the combustion of rice husk and bagasse pith for mill-1 and combustion of bagasse and coal for mill–2 are as follows.

Mill–1

— By decreasing fuel moisture content from 30 to 15%, 70 tonnes excess steam can be produced per day .

— Decreasing excess air from 40 to 20%, 4 tonnes excess steam can be produced per day.

— Decreasing flue gases end temp. from 160 to 140°C, excess steam productin 4 t/day.

— Decreasing radiation and convictions heat losses from 10 to 5%, excess steam production 18.3 t/day

— Increasing feed water temperature form 80 to 100°C, excess steam production 9 t/day.

— decreasing blow down temperature from 180 to 100°C, excess steam produced 2 t/day.

Mill-2

— By decreasing fuel moisture content from 40 to 25%, 68 tonnes excess steam can be produced per day.

— Decreasing excess air from 40 to 20%, 5.4 tonnes excess steam can be produced per day.

— Decreasing flue gasses end temp. from 200 to 140°C excess steam production 23 t/day.

— Decreasing radiation and convictions heat losses from 10 to 5%, excess steam production 6 t/day.

— Increasing feed water temperature from 70 to 100°C, excess steam production 23 t/day.

— decreasing blow down temperature from 180 to 100°C excess steam produced 6 t/day.

The short term programmes including inplant measures supplemented by integrated monitoring and targetting approach were found to provide net energy savings more than 15% in the case studies (Table—5).

TABLE—5

Suggested Measures And Saving

Measures	Mill–1	Saving Rs. lakh/yr.	Mill–2	Saving Rs. lakh/yr.
—reducing idling time in cutter	500kwh/d	1.65	—	
—insulation of digestors	10 t/d	12.00	4t/d	4.80
—use of 1:2.5 bath ratio instead of 1:3.5	25 t/d	28.00	50t/d	56.00
—use of hot water showers on chlorine washers	10 t/d	12.00	—	—
—blow heat available (in terms of hot water)	50 t/d	58.00	80t/d	100
—by improving boiler excess steam generation	24 t/d	28.00	50t/d	58.00
—Rag beater modifications	—	—	2800 kwh/d	13.00
Total :		139.65		231.80

Net energy saving by applying these measures is more than 15%.

Conclusions :

The energy saved in paper industry is going to determine the cost effectiveness of pulp and paper making process. The case studies using the integrated monitoring & targetting approach indicate that there are various avenues available for saving of substantial proportion of energy as short term measures. In short term energy consumption programme we can save 15-20% energy and it requires shorter pay back period with less investment.

Acknowledgement :

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