REPORT

ON

ENERGY PERFORMANCE EVALUATION AND OPTIMISATION IN PULP & PAPER INDUSTRY

SUBMITTED TO

CESS GRANTS AUTHORITY

(DEVELOPMENT COUNCIL FOR PAPER, PULP & ALLIED INDUSRIES)

BY

CENTRAL PULP AND PAPER RESEARCH INSTITUTE

SAHARANPUR, U. P., INDIA

WWW. cppri .org.in

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Project Profile

Project	:	Energy Performance Evaluation and Optimization in pulp and paper Industry
Objective	:	-To improve energy efficiency in paper manufacturing. -To reduce energy costs, while maintaining consistent product quality
Duration	:	*August 2001 to June 2004*
Research Team		
Technical Advisor	:	Dr. A. G. Kulkarni Director Central Pulp and Paper Research Institute Saharanpur, U. P., India
Principal Investigator	:	Dr. R. M. Mathur Scientist E-II Chemical Recovery & Energy Management Division
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ENERGY PERFORMANCE EVALUATION AND OPTIMIZATION IN PULP & PAPER INDUSTRY

EXECUTIVE SUMMARY

GENERAL INTRODUCTION:

Pulp & Paper Mills are large and complex facilities consuming enormous quantities of steam & electricity. The industry is under pressure to reduce energy consumption to become cost competitive in the open economy and globalization. At the same time there is public demand for improving product quality and reducing green house gas emissions. In view of these and world energy crisis, the industry has made important strides for reducing total energy use and increasing the Cogeneration through self generated biomass sources. The pulp & paper industry has been more effective in reducing steam demand than electricity demands in new and retrofitted mills. Thus new and modernized plants use less energy than old plants. For instance, state of art bleached Kraft pulp mills in the U.S. use about 40% less steam and 5% less electricity than typical mills installed in the 1980's. The Indian Pulp & Paper Industry on the other hand, is traditionally large consumer of energy and is yet to achieve sizable reductions in energy consumption. This is a challenging task particularly due to the complex structure of Indian paper industry. Therefore industry needs to adopt structured programme for achieving the energy efficiency targets for its sustainability. Energy performance evaluation of the paper industry is a specialized job and needs services of experts. Based on the evaluation of energy performance, industry can suitably optimize its unit operations and processes. Realizing the need for energy efficiency in pulp and paper sector, CPPRI and NCBM initiated a project study under cess-funded schemes. The report highlights achievements of this study.

The energy team during its studies collected data on operating parameters to study the process efficiency and suggested various optimization measures for increasing the efficiency level.

The report prepared is divided into three main chapters. In chapter –1 following areas have been covered:

a.) **Background:**

The high energy consumption in Indian mills is due to various factors such as mill integration, its design, processes & equipments in addition to the raw materials and product mix, capacity utilization & size of the plant. The absence of modernization has also resulted in poor energy efficiency of the Indian mills. Besides this, the lack of energy efficient process technologies, lack of energy monitoring & reporting is also one of the reasons for high-energy consumption. In many mills un-optimized process operations without energy accounting result in large amount of energy wastage, which can be trapped by following simple measures thereby saving considerable energy.

b.) **Status Of Indian Paper Industry:**

Paper industry is one of the energy intensive sector, ranking 6^{th} among the high energy consuming industries in India. Indian Paper Industry consumes 4 million tonnes of coal and 2 million MWh of purchased energy. Out of the total energy requirement of the pulp & Paper production, 75-85% energy is used as process heat and 15-25% as electrical power. More than 40 % of the electricity and more than 30% of the fuels consumed is cogenerated or recovered.

c.) **Energy Consumption Pattern:**

The consumption of energy in Indian mills varies, depending on the mill integration, its design of processes and equipments, raw materials, products, size of the plants etc. Looking into wide variation in energy consumption in different categories of mills, energy norms have been setup for these mills as given below *;

Particulars	Steam, t/t	Power, KWh/t
Large paper mills	9.00	1400
Newsprint mills	4.70	2000
Medium & small agro mills	5.75	1200
Small waste paper based mills	2.80	700

* *CII Report on Specific Energy Consumption Norms in Indian Pulp and Paper Industry (1996-97)*

However, the energy consumption figures are much higher in the mills than the set norms. The high cost of excessive energy used by most of the Indian mills makes the economic evaluation of conservation measures reasonably straightforward for cost effective production.

In chapter – 2 following areas have been covered:

a.) **Methodology:**

A planned methodology was adopted for executing the activities under the project as

- Collection of data through questionnaire
- Mill visits
- Data collection & evaluation

b.) **Details of industrial partners:**

Energy Performance Evaluation and Optimization Studies in the selected Pulp & Paper Mills (Listed below) were carried out to critically evaluate the energy generation, distribution and consumption patterns in various sections. Based on these studies, recommendations have been submitted to the mills to enhance their energy efficiency.

LARGE WOOD BASED PULP AND PAPER MILLS;

1. ,M/s Seshasayee Paper & Boards Ltd. Erode (T.N.)
2. M/s Tamil Nadu Newsprint & Paper Ltd., Distt. Karur, (T.N.)
3. M/s Ballarpur Industries Ltd. (BILT), Unit: Ballarpur, Distt. Chandrapur (Maharashtra)
4. M/s Ballarpur Industries Ltd. (BILT), Unit: Shree Gopal, Yamuna Nagar (Haryana)
5. M/s The Sirpur Paper Mills Ltd., Sirpur – Kaghaznagar (A.P.)

AGRO BASED PULP AND PAPER MILLS;

6. M/s Shreyans Industries Ltd., Ahemadgarh (Punjab)
7. M/s Kailash papers, Unit: Kailash Papers Ltd., Aghwanpur, Distt. Moradabad (U.P.)
8. M/s Yash Papers Ltd., Darshannagar, Faizabad (U.P.)

WASTE PAPER BASED PAPER MILLS;

9. M/s Kalptaru Papers Limited, Tal. Kalol, Gandhinagar, Gujarat
10. M/s Well Pack Papers & containers Ltd., Vamaj, Tal. Kalol, Gujarat
11. M/s Rainbow Papers Limited, Ahmedabad, Gujarat
12. M/s Karan Paper Mills, Chhatral, District - Mehsana, Gujarat
13. M/s Shelavi Pulp & Paper Mills Pvt. Ltd., Chhatral, District - Mehsana, Gujarat
14. M/s Plaza Papers Pvt. Ltd., Village Ghunna, Behat Road, Distt. Saharanpur (U.P.)

c.) **Expertise gained & infrastructure created:**

During course of the project, CPPRI developed expertise in the area of electrical, thermal and process auditing in different categories of pulp and paper mills like large wood based pulp & paper mills, agro based pulp & paper mills and waste paper based pulp & paper mills by constituting a dedicated energy audit team of scientists and engineers.

Under the project activities following equipments have been procured to strengthen the Energy Management Division of the institute.

i. Motor Top along with transducers -Portable equipment for motor and pump efficiency analysis
ii. Energy Auditor-portable equipment for evaluation of electrical parameters
iii. Flue gas analyzer- Portable equipment for the measurement of O_2, CO_2, CO, NO_X, SO_X and Hydrocarbons
iv. Non Contact Thermometer- for the temperature measurement at various uninsulated surfaces
v. WinGEMS 5.0 Computer simulation software for energy and material balance studies
vi. Computer Systems – for data analysis and documentation
vii. LCD-for presentation and information dissemination during energy audits

Based on the audit studies carried in different categories of pulp and paper mills, recommendations submitted to the mills have been covered in chapter –3. The mills have implemented most of the recommendations.

The studies have been useful to identify areas where improvement can be made and implementation of recommendations have resulted in overall savings of energy to the tune of 7-10%. The mill managements have appreciated the studies conducted under the project activities. A large number of energy saving options have also been identified during the project studies. The energy saving proposals cover all sections of the mill for pulp and paper production.

REPORT

ON

ENERGY PERFORMANCE EVALUATION AND OPTIMIZATION IN PULP & PAPER INDUSTRY

CHAPTER – 1

REPORT

CHAPTER - 1

BACKGROUND:

Paper Industry is one of the highly energy intensive industry and consumption of energy is considerably higher in Indian paper industry as compared to developed countries. On an average, energy inputs contribute more than 25% towards cost of production. The energy cost component is today dictating the cost of production and the Indian paper industry is facing tough challenge of competition in the "Global Market".

The high energy consumption in Indian mills is due to various factors such as mill integration, its design, processes & equipments in addition to the raw materials and product mix, capacity utilization & size of the plant. The absence of modernization has also resulted in poor energy efficiency of the Indian mills. Besides this, the lack of energy efficient process technologies, lack of energy monitoring & reporting is also one of the reasons for energy inefficiency. In many mills un-optimized process operations without energy accounting result in large amount of energy wastage, which can be trapped by following simple measures thereby saving considerable energy.

Studies conducted by CPPRI during last decade have revealed that there is potential to save upto 15% energy in Indian pulp & paper mills by following simple energy management practices. Adopting energy management practices in a paper mill is a well-planned programme with actions aimed at reducing the organization's energy bills & minimizing the detrimental environment effects.

Indian pulp and paper industry has taken up large number of initiatives and energy management programmes to reduce the energy consumption. However the efforts made by the mills are not adequate to embark upon the complete energy management drive within the sector. As a result the mills in India still consume higher amount of energy compared to mills in developed countries. Therefore looking into energy consumption pattern and significant effect of energy inputs in the cost of production, Central Pulp and Paper Research Institute (CPPRI) along with National Council for Cement and Building Materials (NCBM) initiated the project on "Energy Performance Evaluation and Optimization in Pulp and Paper Mills" funded by CESS Grants Authority to check out an energy efficiency programme for the pulp and paper industry.

This proposal was made with the intention of studying the energy performance of paper industry. By improved energy management practices, the energy efficiency of paper manufacture would be improved resulting in reduced cost of production. The study was planned to carry out the diagnostic energy audits of the representative paper units covering wood, agro, waste paper and newsprint grade mills and to identify main areas of energy wastages in various sections & measures for minimizing the energy losses and improving energy efficiency.

OBJECTIVE:

The main objectives of the study are to:

1. Improve energy efficiency in paper manufacturing.
2. Reduce operating energy costs, while maintaining consistent product quality.

The energy audit studies ware carried out in 14 mills of different categories and the results have shown remarkable saving potential upto 5 to 15% of the energy consumption.

INTRODUCTION:

STATUS OF INDIAN PAPER INDUSTRY:

The paper industry has an important role to play on Indian economy and the rising demand of pulp & paper products has made India a large market, therefore various International suppliers are willing to step in. The pulp and paper sector is one of the complex industrial sectors with diversity of raw material, variation in scale of operation and utilizing old technology. Today Indian pulp and paper industry consists of about 618 paper mills, mainly of small and medium size which are based on obsolete technologies & are uneconomical when compared with the mills of developed countries. There is a growing need to invest, thus capital is needed for mill modernization, productivity improvements and building of new capacity.

Among the three segments based on raw material usage in the paper industry, the mills based on forest raw material, are slowly moving towards competitiveness through adequate modernization over the years despite the fact that these mills are old and still a significant proportion of paper industry is yet to undertake modernization programs.

The agro-residue based segment has only a few mills complying with quality & environmental requirements, whereas large number of units under this category do not have proper technology to produce quality products at a competitive price. This segment is also having serious environmental pollution problems due to lack of chemical recovery systems. Major portion of this segment requires modernization and up-gradation in order to become competitive.

The third segment, i.e. based on recycled fiber also has a number of small pulp & paper mills, which are based on obsolete technology. One of the major concern of these mills is lack of adequate equipment for processing of recycled fibers and as a consequence, the quality of paper products produced from these mills are not conforming the national standards. The competitiveness of this segment without modernization and up-gradation would be difficult.

Paper industry is one of the energy intensive sector, ranking 6th among the high energy consuming industries in India. Indian Paper Industry consumes 4 million tonnes of coal and 2 million MWh of purchased energy. Out of the total energy requirement of the pulp & Paper production, 75-85% energy is used as process heat and 15-25% as electrical power. More than 40 % of the electricity and more than 30% of the fuels consumed is cogenerated or recovered.

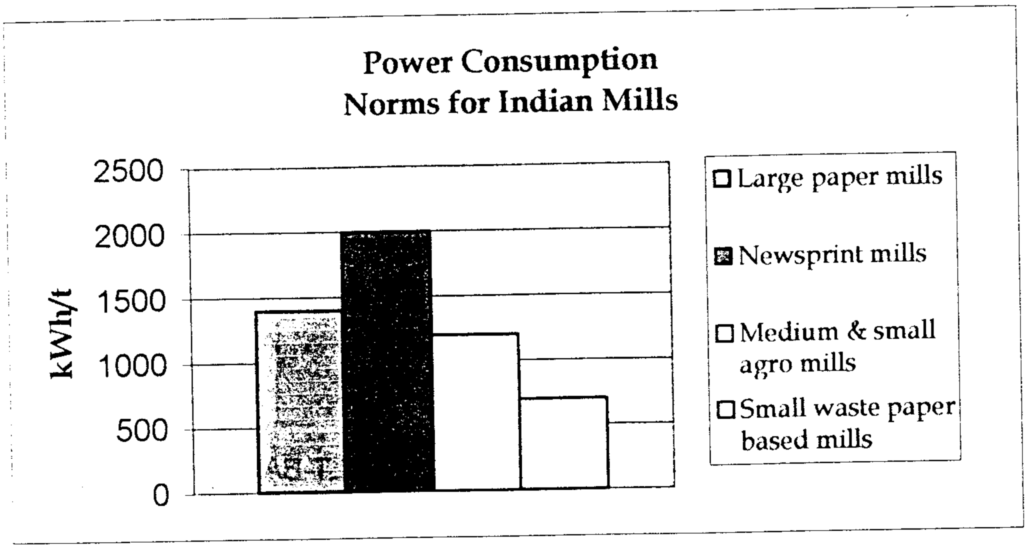
In India, most of the small & medium paper mills rely on purchased power & looking into the cost constraints, mills are switching to the internal energy generation facilities. The internal energy generation is mainly from cogeneration by generating steam from boiler at high pressure & utilizing this in steam turbine for generation of power. The steam extracted in the form of low & medium pressure is utilized for the process requirements.

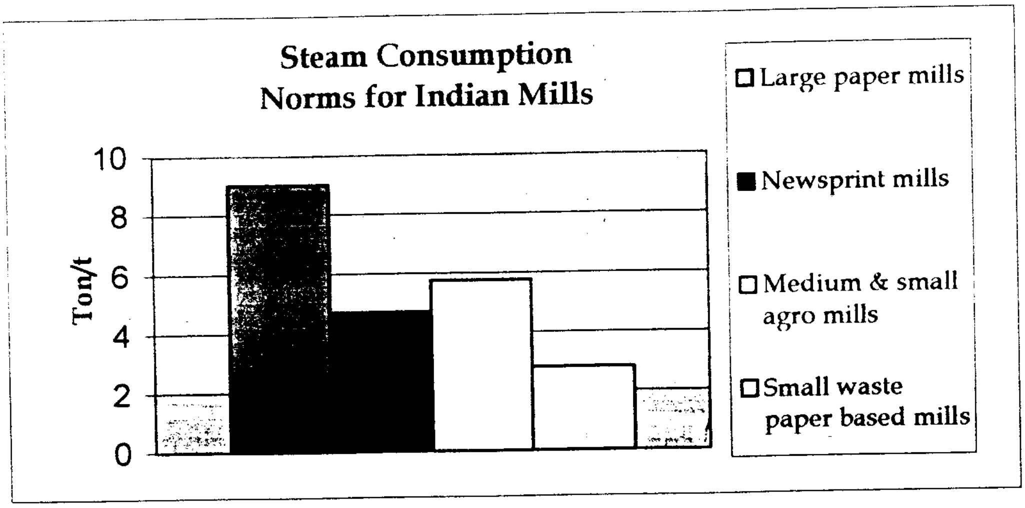
The fuels used in boiler are mainly coal, lignite, rice husk, sawdust & other agro residues, while the coal is main fuel for large pulp and paper mills. The solid fuel consumption per tonne of paper varies from 1.5 to 2.5 t/t.

ENERGY CONSUMPTION PATTERN:

The consumption of energy in Indian mills varies, depending on the mill integration, its design of processes and equipments, raw materials, products, size of the plants etc. Looking into wide variation in energy consumption in different categories of mills, energy norms have been setup for these mills as shown below *;

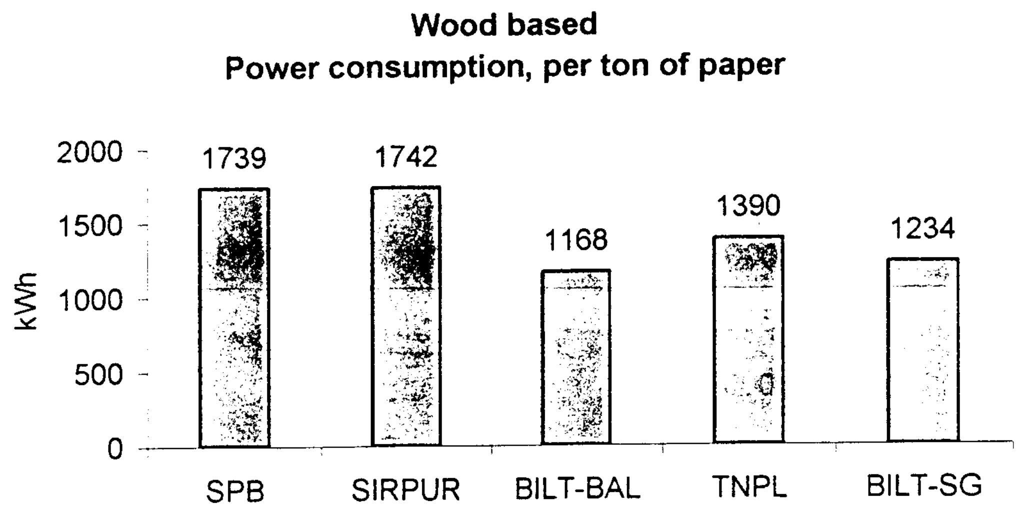
- *CII Report on Specific Energy Consumption Norms in Indian Pulp and Paper Industry (1996-97)*

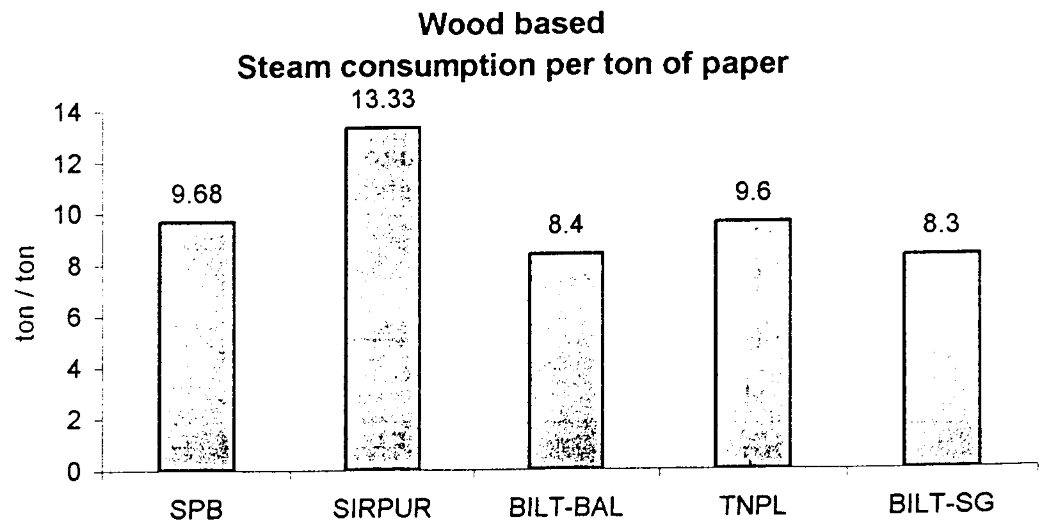




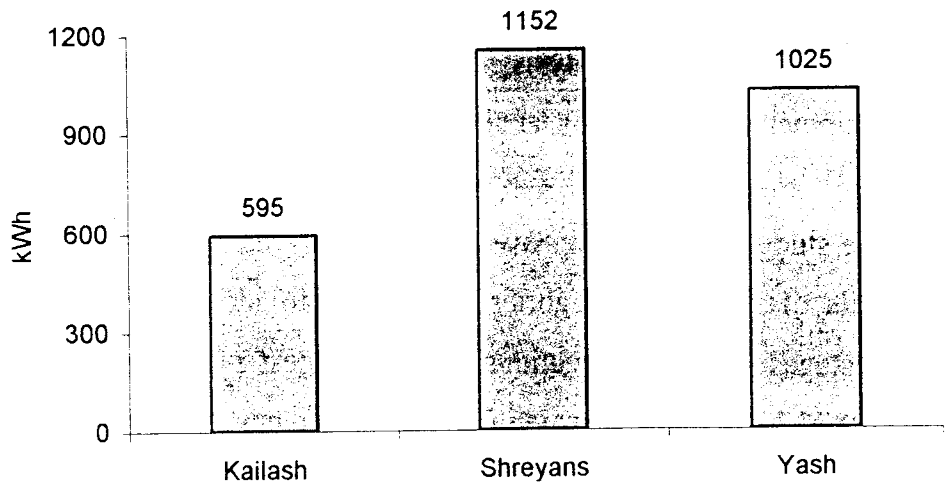
However, the energy consumption figures are much higher in the mills than the set norms. The high cost of excessive energy used by most of the Indian mills makes the economic evaluation of conservation measures reasonably straightforward for cost effective production.

The energy consumption pattern of Wood and Agro based mills in a few selected mills is shown below. The figures show that there is wide variation in energy consumption among the mills.

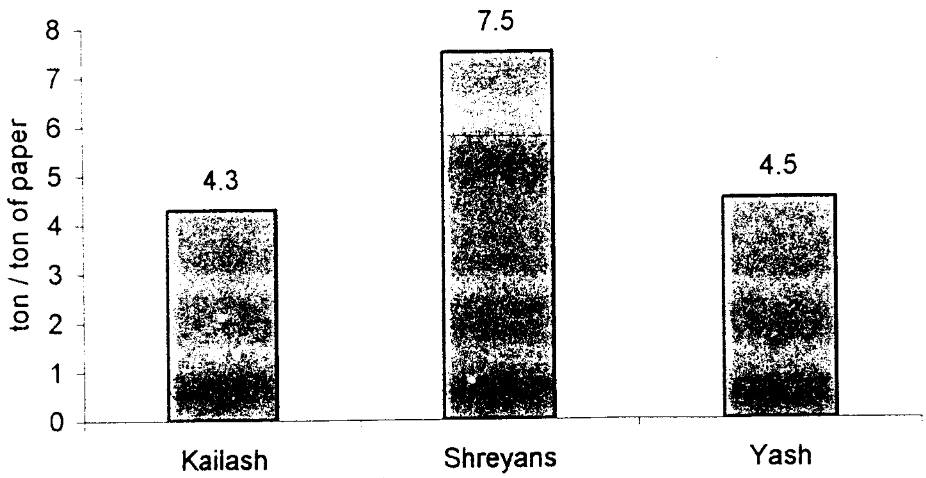




Agro based
Power consumption, per ton of paper



Agor based
Steam consumption, per ton of paper



Implementation of energy management programmes in mills of different categories with different sizes, different raw materials, products, mill layout, design of processes & equipments etc. is quite difficult. A uniform methodology cannot be applied in all the mills for energy management activities. Studies were conducted during the project implementation in representative mills to find out the areas with maximum saving potential. The studies in mills covered wide domain of activities such as good management practices, good house keeping, analysis of process parameters, process wise energy efficiency analysis, evaluation of energy consumption in major equipments and sections, at site energy efficiency monitoring etc.

The study helped to improve energy management practices in some selected mills of different categories as well as to identify main areas of energy wastages in various sections and to suggest measures for minimizing the energy losses for improving energy efficiency. Some of the participating mills contributed upto 50% cost for conducting the studies under the project. The major activities undertaken during the project period are highlighted in next chapter.

CHAPTER – 2

CHAPTER - 2

ACTIVITIES UNDERTAKEN:

METHODOLOGY:

A planned methodology was adopted for executing the activities under the project. Major activities were:

1. **Collection of Data Through Questionnaires:**

   A questionnaire was prepared to obtain details of mill processes, raw materials, chemicals and products. These questionnaires were sent to the mills after they agreed to participate in the project study. The data was evaluated at CPPRI and from the information; energy consumption pattern in mill and various processes was determined. The data collected by questionnaires was useful for the energy team as first hand information and from the information available detailed plan for the mill visits was made. The copy of the questionnaire is enclosed as Annexure -III.

2. **Mill Visits:**

   The visits to the mills were undertaken after confirmation of dates from the mills. The audit team comprised of scientists & engineers from CPPRI and NCBM. The team carried portable equipment/instruments for data collection and monitoring of process variables in the plant. The duration of mill visit was upto 5 days during which team interacted with the mill management & shop floor personnel and conducted plant studies.

3. **Data Collection & Evaluation:**

   Relevant data was collected during the mill visits and studies conducted at plant to evaluate and find out the system efficiency in the plant. Following areas were covered during the mill visit.

- Raw material storage, handling and preparation
- Digester House - Cooking of raw material
- Washing, screening & cleaning of unbleached pulp
- Bleaching section
- Stock preparation
- Chemical additives
- Paper machine
  - Wet end
  - Pressing & drying
- Finishing & converting
- Chemical recovery
  - Black liquor evaporation
  - Recovery boiler
  - Causticization
- Power House
  - Power boilers
  - Co generation
  - DG - Sets
- Steam distribution and consumption in different sections / processes
- Electrical energy management
  - Electrical load management
  - Electrical distribution
  - Status of major motors in the mill
  - Status of major pumps in the mill

Details of the activities undertaken by the energy management team in above listed areas, is presented below for large, medium & small mills.

a) **Raw Material Storage:**

- Details of storage yard losses including the mode of storage of logs piling and time of storage.
- Finding out the extent of degradation of the raw material cellulosic content during the storage. The raw material samples collected from mills were analyzed at CPPRI laboratories to find out the extent of degradation in the raw material storage yard.

b) **Handling of Raw Materials:**

- Mode of transportation of logs from the storage yard to the chipper house and determination of its efficiency.
- Suggestions for suitable transportation alternatives, if possible.

c) **Raw Material Preparation:**

- Analysis and evaluation of the preparation of wood (debarking), raw material preparation including chipping and chip classification.
- Evaluation of opportunities for energy savings in the wood preparation area by optimization of chippers. The energy team during the studies looked into the chipper operations critically w.r.t.;
  - Proper feeding of the raw materials
  - Type of chippers, capacity and running hours.
  - Knife arrangement in the chipper i.e., their numbers, alignment, changing frequency etc.
  - Chip collection mode
  - Dust collection and utilization

The team also looked into the quality & uniformity of the chips produced during the visit. The opportunities for energy saving in the wood preparation area, indirectly linked with the quality & uniformity of the chips were evaluated. The study team tried to find out the ways to improve the chip quality for;

- Better utilization of the digesters through better packing
- Reduced cooking time
- Reduction in rejects
- Simplification of the pulp cleaning systems thereby reducing the energy requirements.

d) **Pulping:**

- Evaluation of chip storage, conveying and feeding mode to the digesters.
- Evaluation of the cooking chemicals to the digesters such as;
  - Strength
  - Chemical characterization
  - Temperatures etc.
- Evaluation of other inputs to the digester such as steam and black liquor for dilution etc.
- Optimization of cooking conditions in terms of active alkali, time & temperature, steam consumption etc. so as to reduce the energy consumption while maintaining the pulp quality for bleaching.
- Energy team looked into various opportunities for energy saving in the pulping of raw materials. Some of the points evaluated for energy savings in chemical pulping were;
  - Possibilities to reduce the liquor to wood ratio in the digester, provided that yield and quality are maintained. The lower the liquor to wood ratio, the lower the steam consumption for a certain set of operational conditions.
  - Increase the temperature of white liquor, using waste heat available in the mill and by insulation of storage tanks.

- Feeding of chips, cooking chemicals etc.

Blow heat recovery- the audit team has also found out the possibilities of blow heat recovery, if not practiced in the mill. Alternate utilization was also suggested for use of energy from blowing of the batch digesters in the mill.

e) **Washing of Pulps:**

The washing efficiency determines the steam load in evaporators in chemical recovery and chemical losses during washing. Scope for improvement of the washing efficiency was studied by optimization of dilution during the pulp washing.

The dissolved organics carryover with the pulp and the soda losses were evaluated and its impact on the bleach section was quantified.

f) **Bleaching:**

Most of the Indian mills use chlorine based bleach chemicals. Common bleaching sequences are CEH and CEHH. Some large mills also use chlorine dioxide and peroxide partially i.e., CE_pHD. Audit study has concentrated its efforts in this field for optimization of bleaching parameters so as to reduce the chemical and energy consumption during bleaching operation.

Impact of optimization studies leading to environmental benefits was also carried out.

g) **Stock Preparation:**

Stock preparation is one of the major power consuming areas in paper making processes. The energy efficiency during refining is influenced by the type of refining equipment and its configuration. During audit studies following possibilities were explored to reduce the energy consumption.

- Control pulp consistency to the optimum levels.
- Control of pulp inlet & outlet pressures.
- Evaluation of alternate disc patterns.
- Utilization of more energy efficient refiners.

h) **Paper Machine:**

The paper machines consume high quantities of steam & power and constitute 30-35% of the mills energy requirement. The high specific energy consumption of the paper machine is due to practice of old conventional methods of papermaking. These includes head box, slice, foil, table rolls and machine clothing, which produce low consistency web. Low consistency forming increases evaporation loads on the dryers. Press section is also very conventional in most of the mills. Paper machine mostly have partial closed dryers section. Condensate recovery ranges between 60-90%.

During studies these processes were critically evaluated for their efficiency. Some of the points for energy audit studies are narrated below:

i. **Reduce paper breaking** – Paper-breaking leads to wastage of energy and reduced yield. Improved understanding of the process, efficient equipment design and better instrumentation controls can minimize it. Study team looked into optimization of processes to reduce paper breaking.

ii. **Improved removal of sand and foreign substances in the approach flow systems** – A systematic study of the pulp screening before head box was undertaken to find out its efficiency and best practiced ways were suggested to improve it.

iii. **Study of the formation section** (Fourdriener or double wire) - Suggestions have been given for improving the formation after conducting a detailed study of the wire part. An increase in the consistency of the paper web before its transfer to the press improves resistance of the paper sheet to breaks and reduces the paper moisture in the web after press section.

iv. **Study of the press section** - A detailed study of the press section has been made and suggestions were given to improve the out let paper web consistency and improve dewatering efficiency in the press section. The main factors affecting the removal of water in the press section, as given below, have been looked after;

- Nip pressure
- Uniform distribution of the pressure in cross direction
- Type of press, its configuration and no. of nips.

v. **Options for increase in temperature of the paper sheet** by using steam shower on the press have also been evaluated for improved dewatering by reducing the viscosity of water.

vi. **Improvement in the drying of the sheet** by increasing the heat transfer in the steam cylinders. It can be achieved by reducing the resistance posed during drying by reducing condensate layer thickness by properly removing condensate from the cylinder. The study of condensate removal assembly has been made for determining its condensate removal efficiency.

vii. **Utilization of the flash steam leaving the dryer with condensate** (Blow-through Steam). The condensate recovery system in paper machines were studied and possible improvements were suggested for effective utilization of flash steam in some of the dryer groups.

viii. **Pocket ventilation system** to remove the build up of humidity in the pockets between the dryer cylinders.

ix. **Hood ventilation system for improving paper drying**. Study of the economizer heat recovery system in the paper machine.

x. **Study of the recycling of white water** has been evaluated case by case.

i) **Recovery Section:**

Large mills in India are equipped with chemical recovery systems. During energy audit studies black liquor evaporation, incineration in recovery boiler, causticization and lime reburning operations have been evaluated.

Evaporation of black liquor: The steam consumption in evaporators depends on some operational variables such as solid content and temperature of weak black liquor, solid content of the strong black liquor and pressure/vacuum in the evaporators.

Following points have been evaluated for energy savings in evaporators.

- **Increase of the solid content of weak black liquor from washing-** Optimization of the washing operation in the pulp mill leads to increase in percent solid content of the weak black liquor. Studies on steam saving by optimization of washing operation have been conducted.
- **Temperature of the weak black liquor** – During the study, black liquor storage has been evaluated for maintaining the high temperature of the black liquor feed to the evaporators. An increase in the temperature of weak black liquor can result. in considerable steam economy in the evaporators.
- **Solids content of the Strong black liquor** - Possibility for increase in the solids content of the strong black liquor for higher thermal efficiency of the boiler has been evaluated.
- **Possibility of increasing the number of effects in multiple effect evaporators** – In many mills in India direct contact evaporators are being used in the finisher stage. During the studies, effect of direct contact evaporators was evaluated and alternative MEE's were suggested with financial analysis.

a. **Recovery Boiler** – During the studies, the team evaluated the boiler design and operating parameters and subsequently suggestions were given for:

   i. Selection of proper primary, secondary and Tertiary air.

   ii. Black liquor characteristics, which can affect the combustion behavior etc.

b. **Causticizing:**

The recausticizing process was evaluated considering production of clean and hot white liquor and suggestions were given to improve the caustisization efficiency.

j) **Power House:**

Efficiency Evaluation of boiler by conducting a detailed survey of boiler operation, which includes;

- Boiler details – Type of Boiler, designed capacity (t/hr), feed water flow rate, steam pressures, fuel consumption etc.
- Fuel analysis
- Bottom Ash Analysis
- Flue gas analysis

Optimization studies in the boiler by conducting a simulation exercise for;

- Maintaining optimum excess air level
- Optimization of blow down
- Waste heat recovery by use of heat recovery systems, if not existing
- Performance evaluation of existing heat recovery systems
- Reduction of radiation and other structural losses.

k) **DG Sets:**

The DG sets consist of two main sub systems:-

- An Internal combustion engine (Most frequently, a compression ignition one) and
- An alternator

While conducting an energy audit, it is the engine or the prime mover part, which is concentrated upon. Some conservation options for fuel and lubricating oil usage in the DG set have been considered, such as;

- Assessing the operating efficiency of the DG set in terms of SEGR (Specific Electricity Generation Ratio) with the unit of kWh/litre. The figures, which are computed, have been compared with the normative figures supplied by the DG set manufacturer. Efforts have been made to identify the cause of lower SEGR of the sets.
- Proper engine loading was determined. The drop in efficiency becomes fairly pronounced at loads below 60% and this results in energy losses.

These activities were sufficient to assess the overall energy efficiency of pulp and paper mills. Based on the results of the study a large no. of measures were suggested for improvements and are discussed in the next section.

DETAILS OF INDUSTRIAL PARTNERS:

Energy Performance Evaluation and Optimization Studies in selected Pulp & Paper Mills were carried out to critically evaluate the energy generation, distribution and consumption patterns in various sections. Based on these studies, recommendations have been submitted to the mills to enhance their energy efficiency.

Most of the recommendations have been implemented by the mills.

The energy team during its studies collected data on operating parameters to study the process efficiency and suggest optimization measures for achieving higher energy efficiency targets. Many new opportunities for increasing the efficiency level were observed during the studies and are listed in this report as an Energy Conservation Proposals.

The study indicated that there is a large potential of energy savings in many mills by implementation of CPPRI recommendations on short, medium and long term basis under a planned energy management programme. The studies have been carried out in the mills categorized in 3 different categories as wood, Agro and Waste paper based mills.

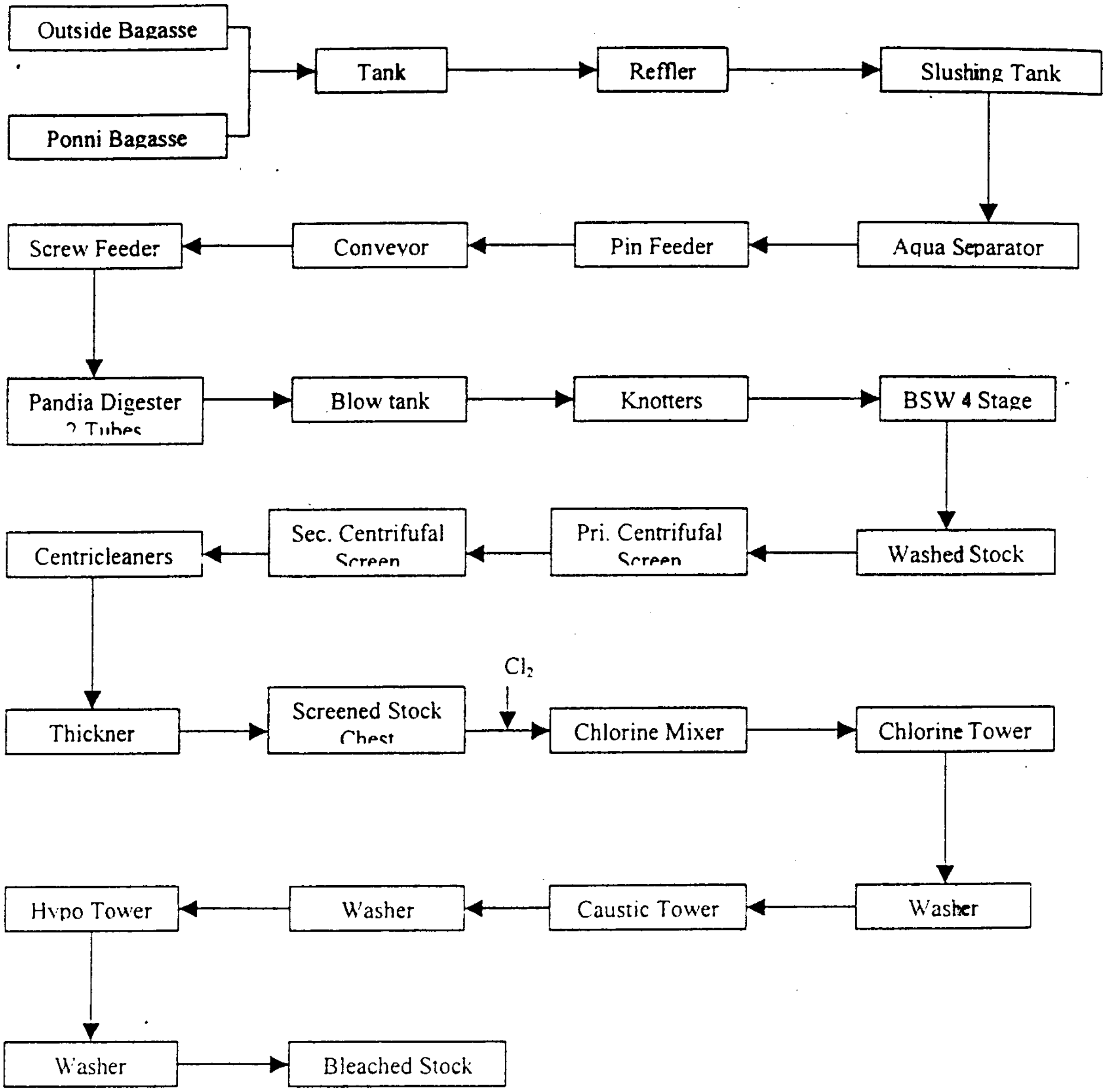
LARGE, WOOD BASED PULP AND PAPER MILLS

Energy performance evaluation and optimization studies were conducted in following wood based mills:

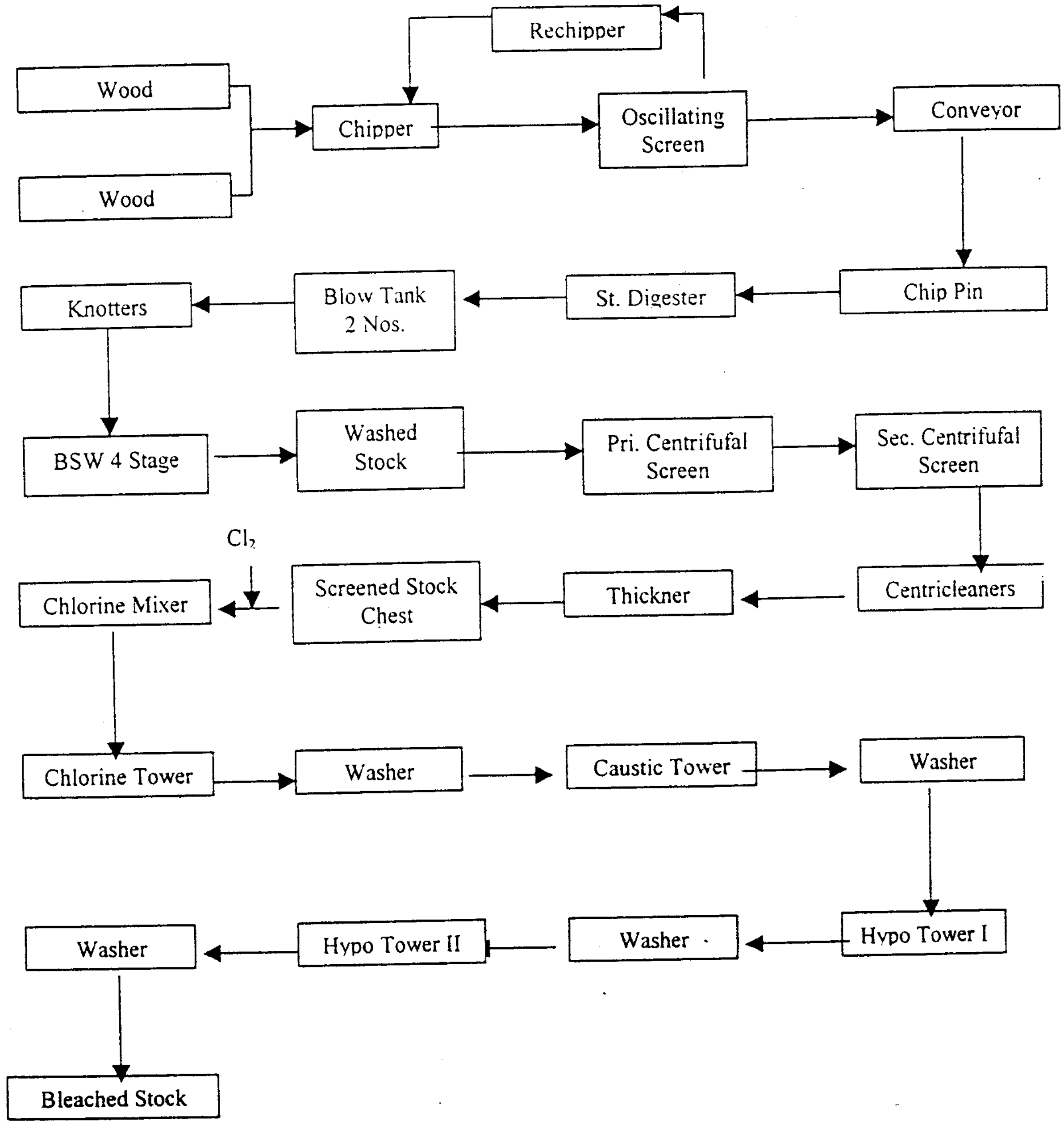
1. **M/s Seshasayee Paper and Boards Ltd., Erode, T.N.,**

The study on energy performance evaluation and optimization was conducted at M/s Seshasayee Paper & Boards Ltd., Erode (TN). from 14.5.2001 to 19.05.2001 and 04.11.2003 to 06.11.2003.

M/s Seshasayee Paper & Boards Ltd., Erode is a leading firm under Esvin Group of Companies, located at Erode (TN). The mill was established in 1960. Commercial production was started in the year 1962 with collaboration of Parson & Whittmore, South Asia, USA for a production capacity of 20,000 tpa. As on today, mill produces 1,15,000 tpa paper and board utilizing bagasse, casurina, eucalyptus hybrid, waste paper and imported pulp as main raw materials. Mill produces a wide range of products with 5 machines viz. writing and printing papers, multi layer duplex, boards and packaging papers. Mill has three pulping streets for producing bagasse chemical pulp (110 tpd), hard wood chemical pulp (110 tpd) and recycled paper street (80 tpd). The mill has 3 chippers, 4 stationary digesters, 2 continuous digesters, 3 washing sections, 4 power boilers, 3 turbo generators and 2 recovery boilers.

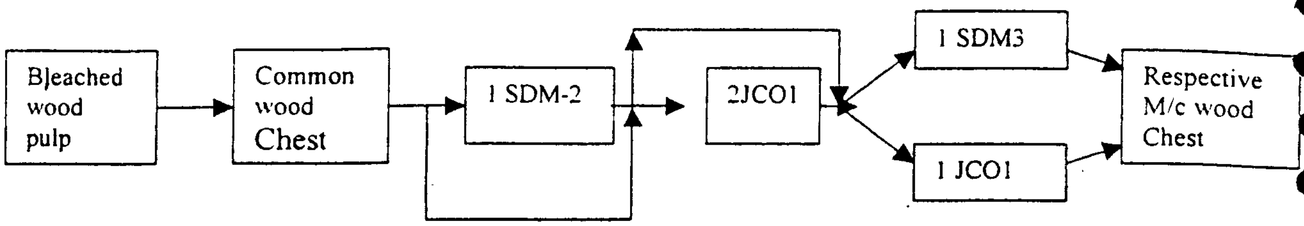


Schematic Layout of Pulp Mill (Bagasse Street)
Seshasayee Paper and Boards Ltd.

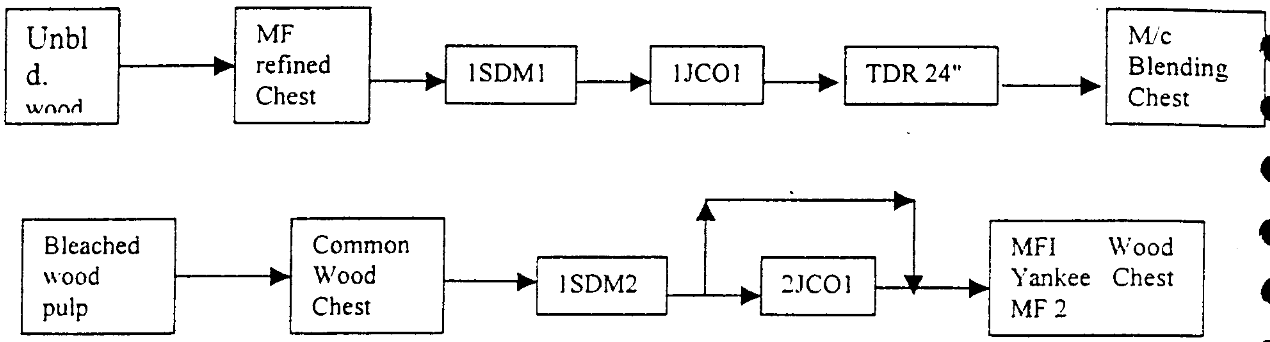


Schematic Layout of Pulp Mill (Hard Wood Street)
Seshasayee Paper and Boards Ltd.

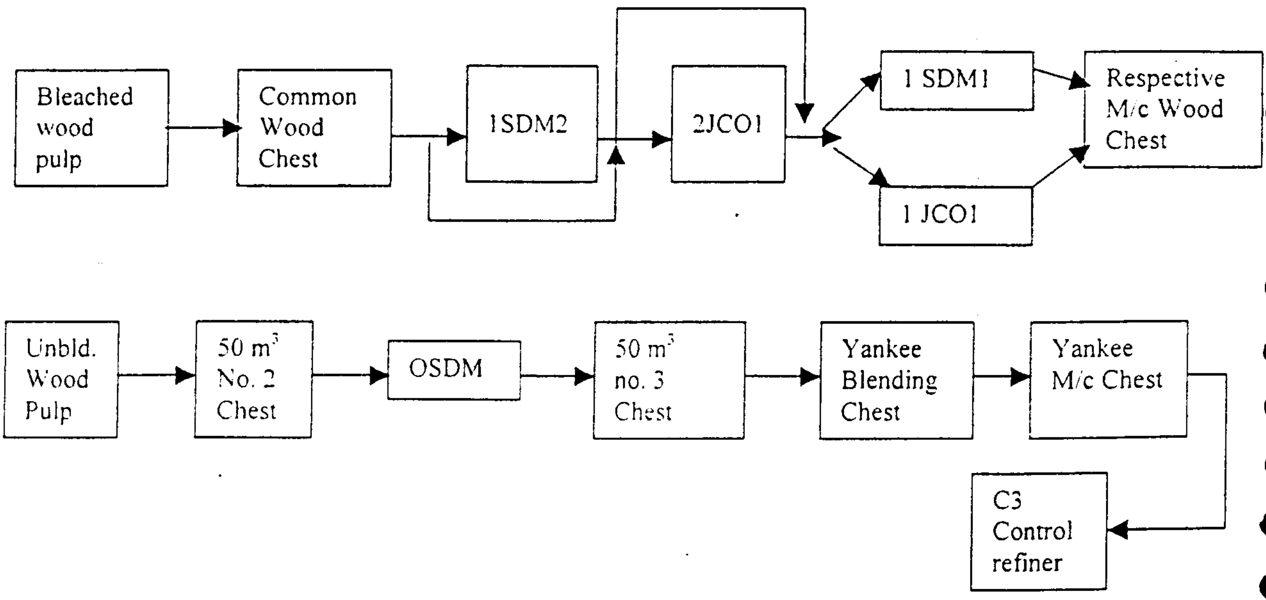
(A) When all M/c's run on bleached varieties



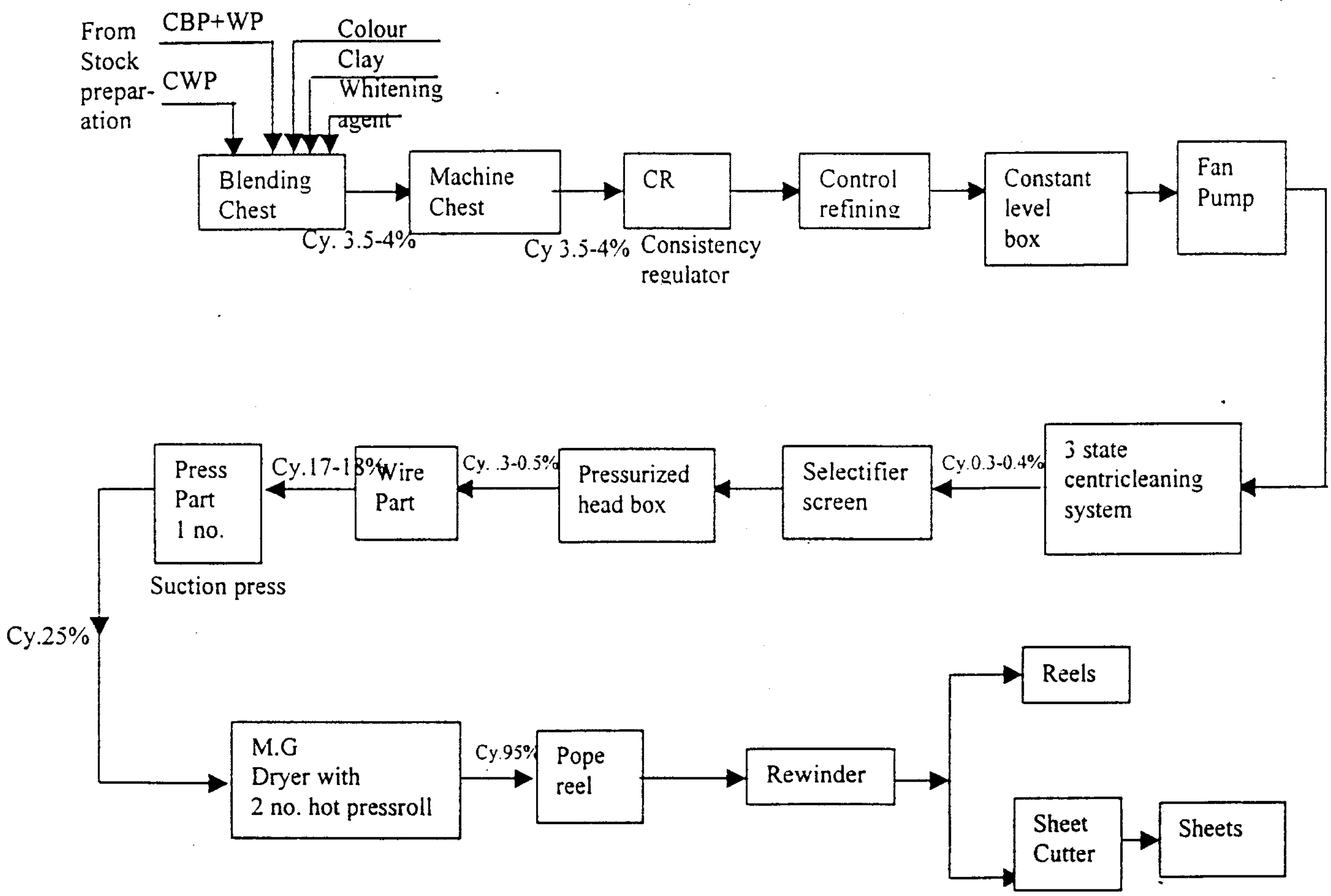
(B) When PM-2 (MG) runs on unbleached variety and PM-1 (MF-1)PM-3 (Yankee) & PM-4(MF-2) runs on bleached varieties



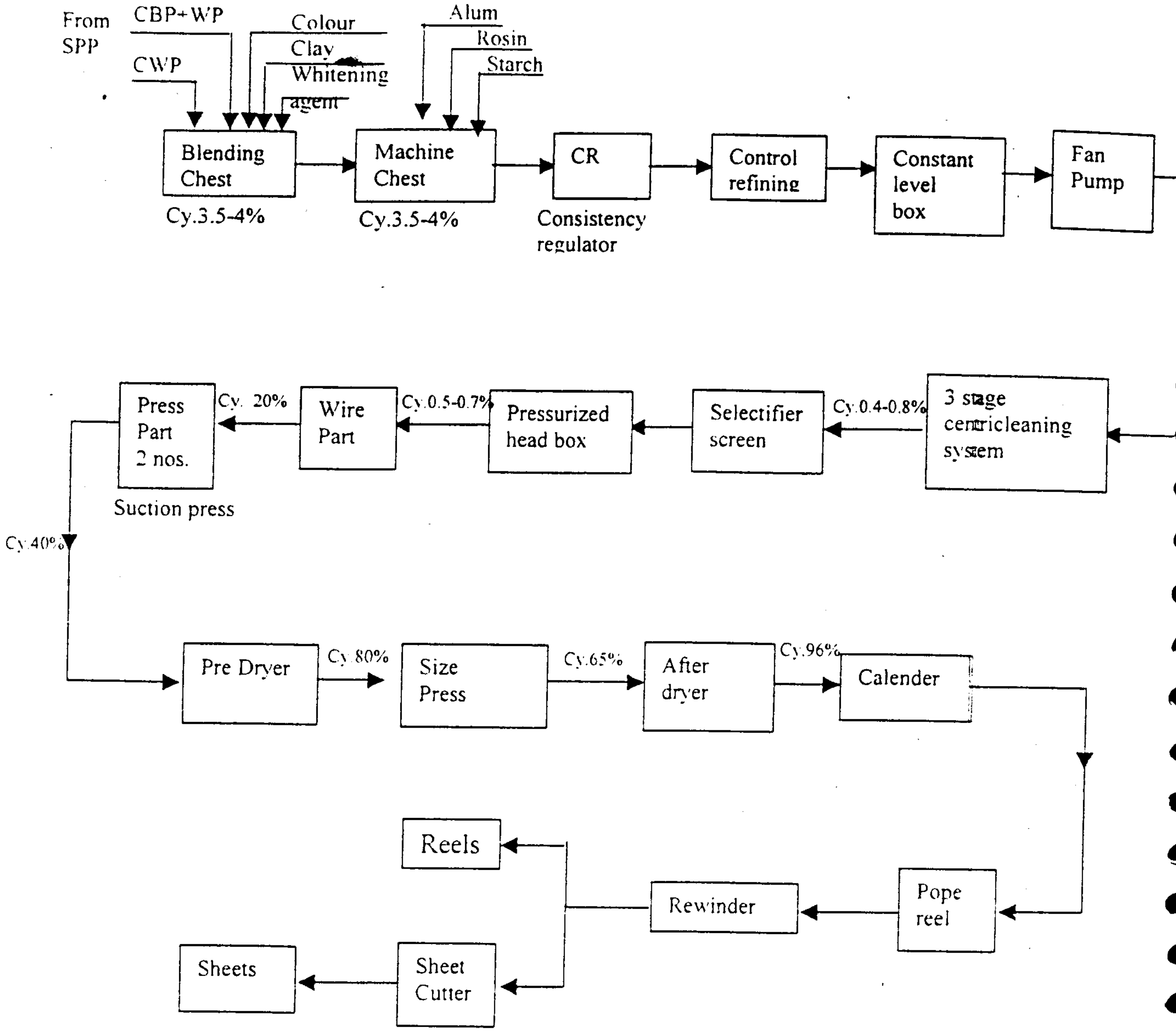
(C) When PM-3(Yankee) runs on unbleached variety and PM-1(MF-1)PM-2(MG) andPM-3 (MF-2) runs on bleached varieties.



Schematic Diagram for Wood Pulp Refining Sequence in M/c's 1 to 4
Seshasayee Paper and Boards Ltd.



Process flow block diagram of Paper Machine-3 (Yankee M/c)
Seshasayee Paper and Boards Ltd.



Process flow block diagram of PM-4 (Yankee M/c)
Seshasayee Paper and Boards Ltd.

2. M/s Tamil Nadu Newsprint & Paper Ltd., Distt. Karur (T.N.) (20.05.2001 to 26.05.2001)

Tamil Nadu Newsprint & Papers Ltd. (TNPL) is one of the worlds largest bagasse based paper mills, located at Kagithapuram in Karur District of Tamil Nadu. TNPL was established in 1979 by the Govt. of Tamil Nadu under a world Bank supported project for increasing the National Production of both Newsprint and writing and printing paper and for utilization of bagasse, a renewable non-conventional raw material.

Initially Mill was designed to produce 50,000 tpa of Newsprint and 40,000 tpa of writing and printing paper. Bagasse pulp accounted for over 70% in the Newsprint furnish and 75% in writing and printing furnish, while hard wood (Eucalyptus) and other tropical imported wood pulp accounted for the balance.

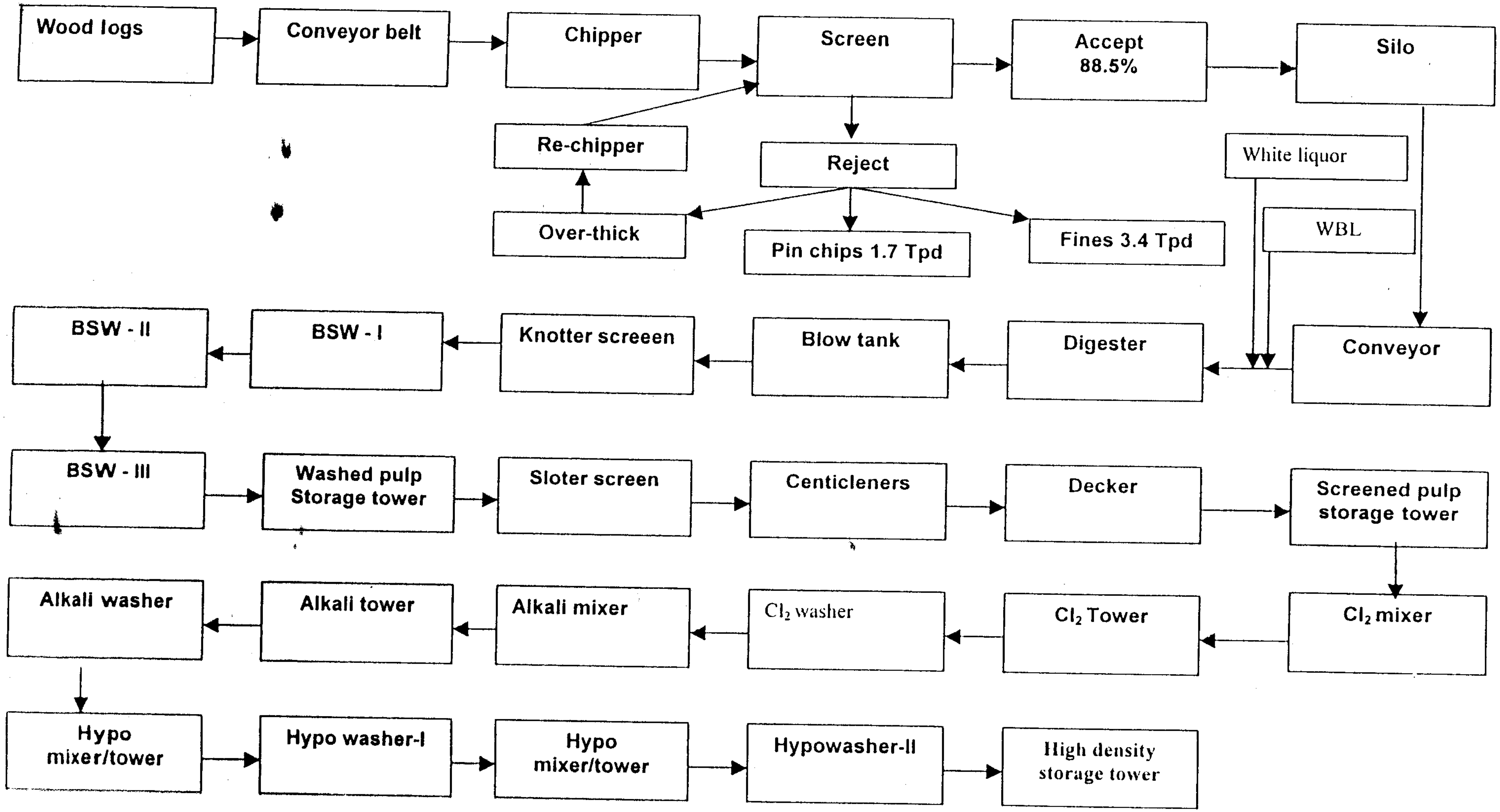
The capacity was increased in 1995 to 1,80,000 tonnes of Newsprint Paper annually from the earlier level of 90,000 tonnes. At present 100% bagasse pulp is used for production of Newsprint. The furnish of Newsprint consists of 60% Chemical bagasse pulp and 40% Mechanical bagasse pulp. Writing & printing paper is manufactured using 75% chemical bagasse pulp and 25% chemical wood pulp procured from locally available hard woods.

The plant of TNPL is designed with the State of Art Technology. It has one of the most modern pulp mills with a unique bagasse handling, mechanical & chemical pulping systems, hard wood pulping, two latest paper machines. No. 1 from Beloit Walmsley, U. K. with Bel Baie II twin wire former and No. 2 from J.M. Voith, Germany, with CFD Duo former.

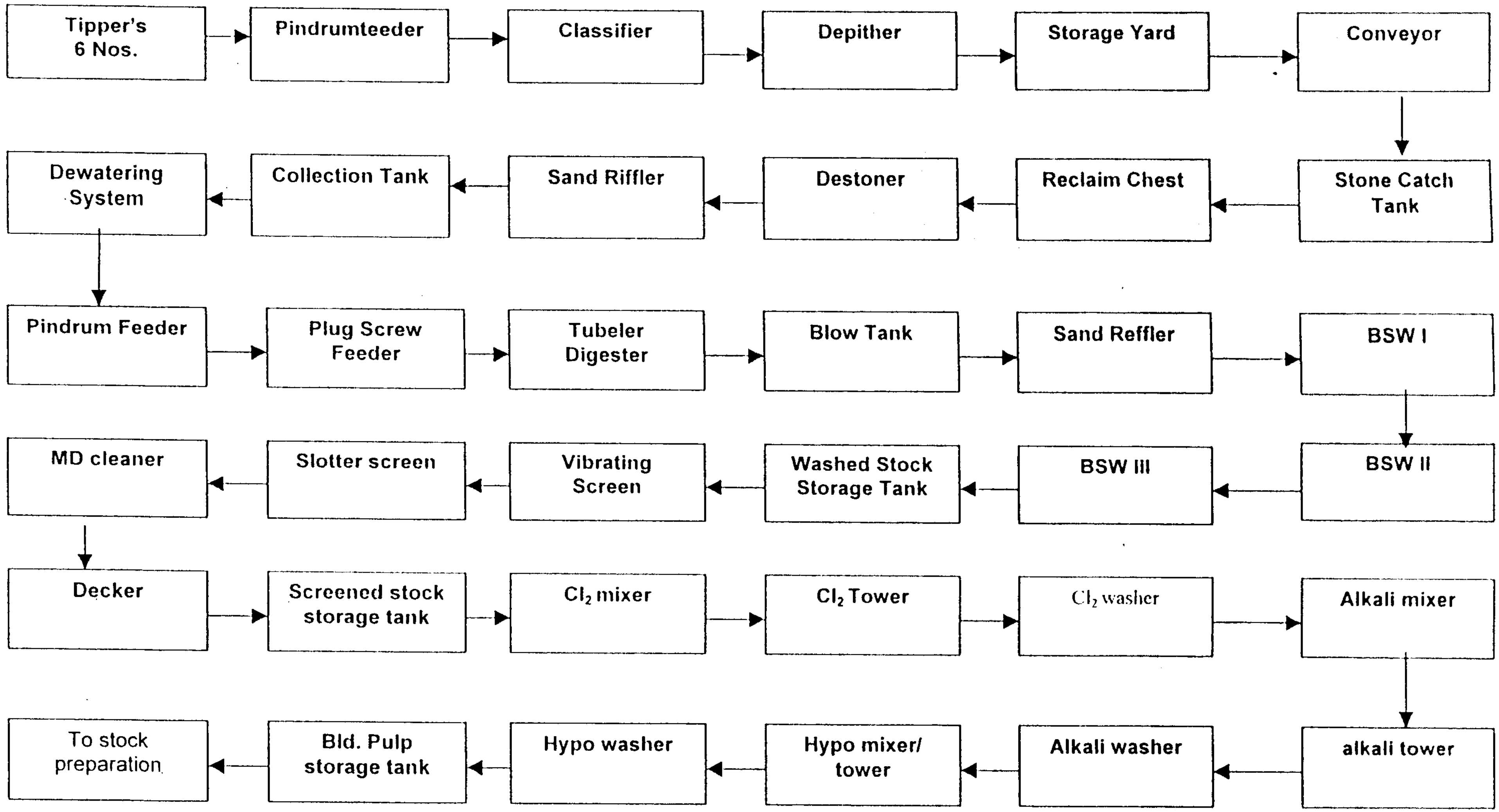
The mechanical bagasse pulping has two stage pressurized primary refining and atmospheric secondary refining system. Mill has 2 streets of 6 effect LTV evaporators with FC concentrators, and one street 7 effect falling film black liquor evaporation plant. Concentrated black liquor is fired on two recovery boilers of 285 and 375 tpd BLDS with steam generation of 35 t/hr. and 45 t/hr. @ 44 kg/cm^2 pressure and 440°C temperature. Mill is equipped with 4 power boilers having 60 t/hr. steam generation capacity at 44 kg/cm^2 pressure and 440°C temperature and one power boiler having 90 t/hr. steam generation capacity at 44 kg/cm^2 pressure and 440°C temperature, three turbo generators having 8 MW, 18 Mw and 10.5 MW capacity. Water intake is from River Cauvery through a 4 Km. pipe line.

TNPL produces quality Newsprints like standard Newsprint (49 gsm) high brightness Newsprint, Pink Newsprint etc. Its writing & printing papers include telephone directory paper, computer stationary paper, SS maplitho, offset printing paper, Cream wove paper, super printing etc.

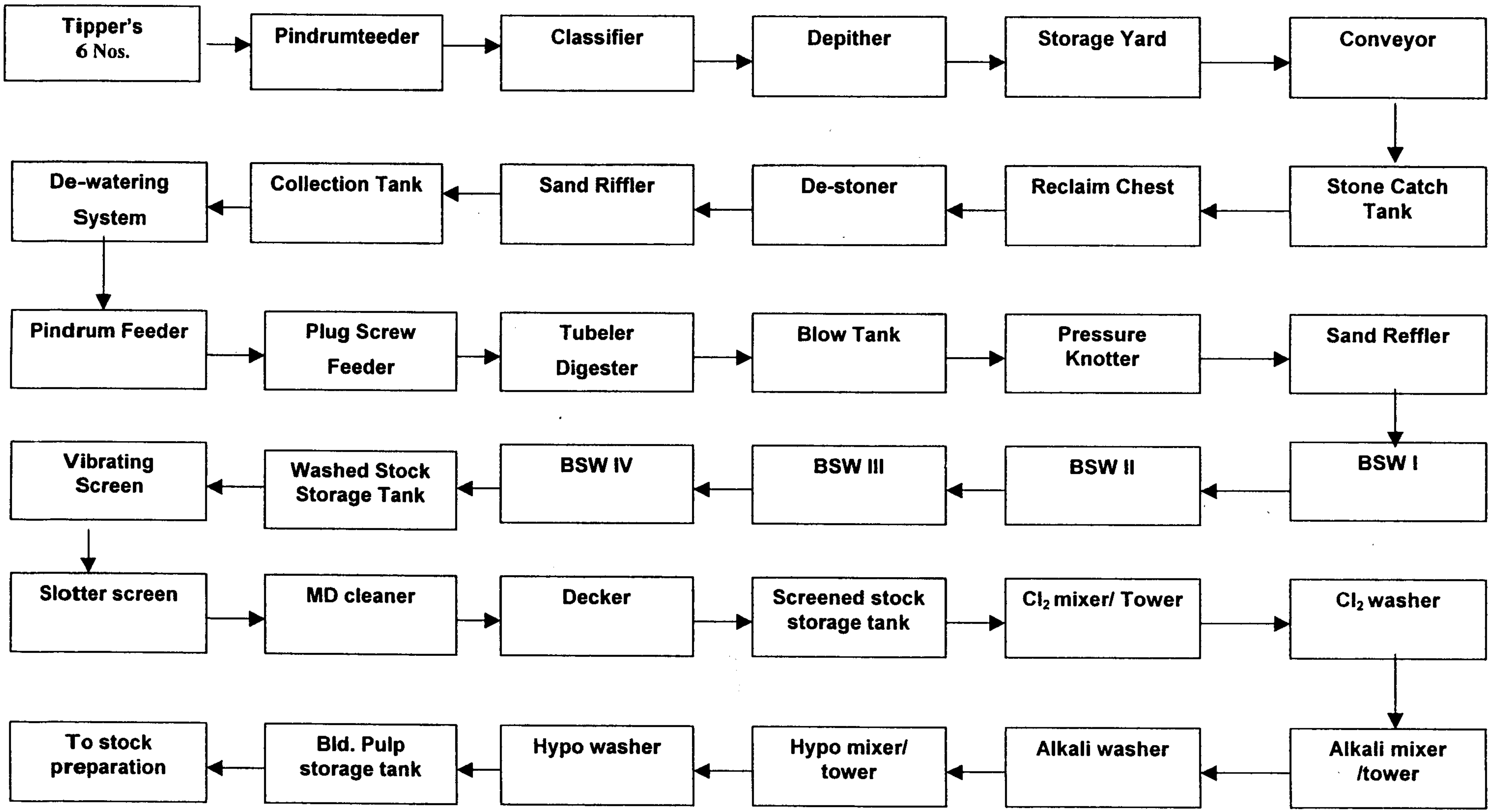
The Company has recently introduced photocopier paper with brand name TNPL copier.



Schematic diagram of Hardwood pulping street - TNPL



Schematic layout of CBP–I street - TNPL



Schematic layout of CBP-II Street - TNPL

3. **M/s Ballarpur Industries Ltd. (BILT), Unit: Ballarpur, Distt. Chandrapur (Maharashtra)**
   (27.04.2003 to 03.05.2003)

M/s Ballarpur Industries Ltd. (BILT), Unit: Ballarpur, is located at Ballarpur, District Chandrapur, Maharashtra, 200 km from Nagpur. The average production of the mill is 116269 mt against the installed capacity of 89500 tonnes per annum. The main raw material is hard wood and bamboo in the ratio of 55:45. mill produces writing & printing paper of different grades and quality on six nos. of paper machines. The mill has 10 nos. stationary batch digesters, Brown stock washing section, Bleaching section (CDEopHHD), four power boilers (two running) and three turbines.

The present energy consumption of the mill is given below

1. Electrical energy consumption, kWh/t of paper = 1168
2. Steam, t/t of paper = 8.4
3. Fresh water consumption, m^3/t of paper = 142

4. **M/s Ballarpur Industries Ltd. (BILT), Unit: Shree Gopal, Yamuna Nagar (Haryana)**
   (28.07.2003 to 06.08.2003)

M/s Ballarpur Industries Ltd. (BILT), Unit: Shree Gopal is located at Yamuna Nagar (Haryana). The average production of the mill is 75,000 MT against the installed capacity of 53,000 tonnes per annum. The main raw material is hard wood and bamboo in the ratio of 84:16. Mill produces writing & printing paper of different grades and quality on six nos. of paper machines. The mill has 3 nos. stationary batch digesters, Brown stock washing section, Bleaching section (CDEoD1D2), five power boilers (three running) and two turbines.

The present energy consumption of the mill is given below

4. Electrical energy consumption, kWh/t of paper = 1235
5. Steam, t/t of paper = 8.3
6. Fresh water consumption, m^3/t of paper = 190

5. M/s The Sirpur Paper Mills Ltd., Sirpur – Kaghaznagar (A.P.) (25.08.2003 to 30.08.2003)

M/s The Sirpur Paper Mills Ltd. Is located at Sirpur – Kaghaznagar (A.P.). The average production of the mill is 77,974 MT against the installed capacity of 83,550 tonnes per annum. The main raw material is hard wood and mill produces writing & printing, Packaging, board and specialty paper of different grades and quality on seven nos. of paper machines. The mill has 14 nos. stationary batch digesters, Brown stock washing section, Bleaching section ($CEpH_1H_2$), Eight power boilers (three running), two recovery boilers and four turbines.

The present energy consumption of the mill is given below

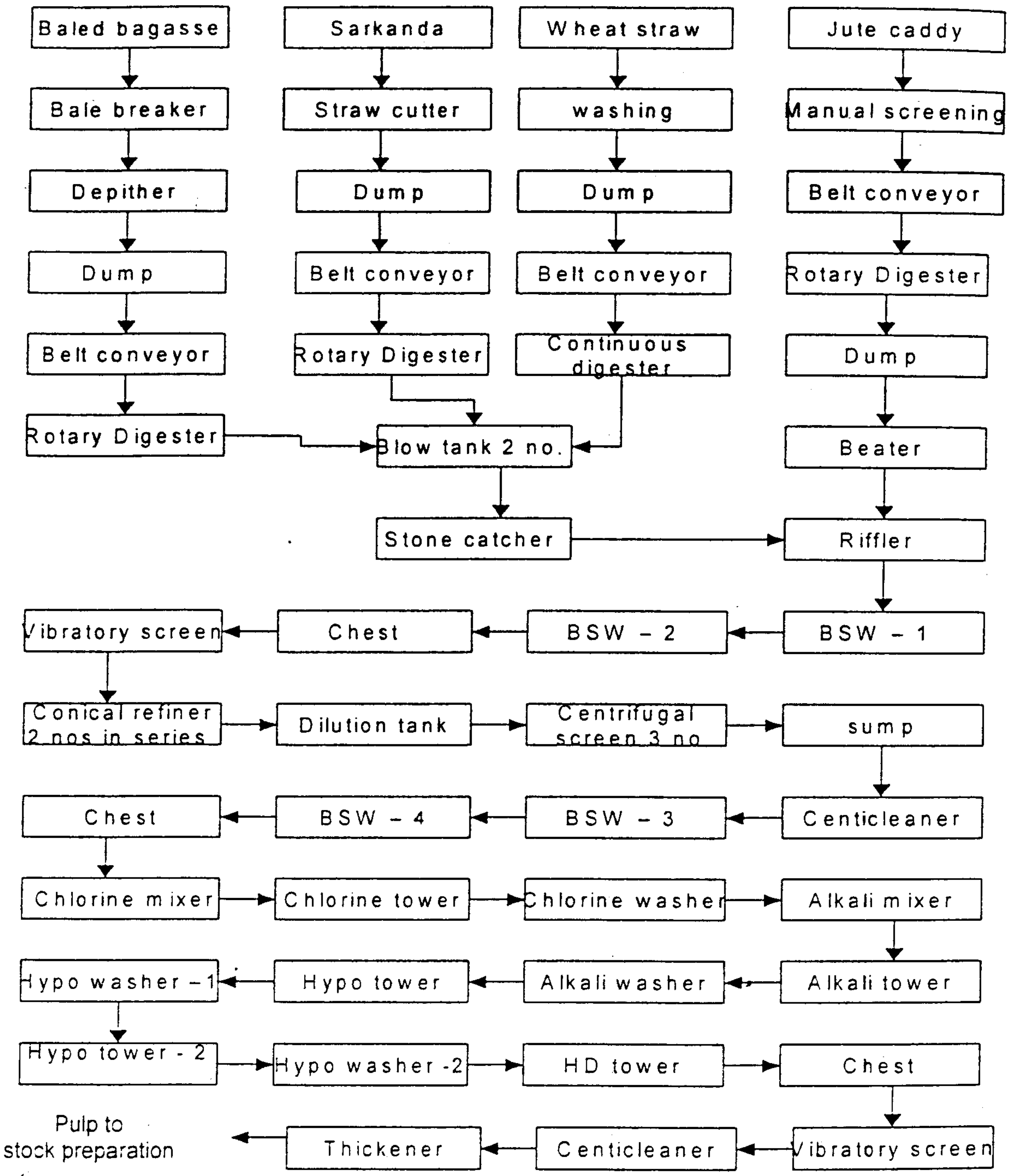
7. Electrical energy consumption, kWh/t of paper = 1742
8. Steam, t/t of paper = 13.33
9. Fresh water consumption, m^3/t of paper = 193

AGRO BASED PULP AND PAPER MILLS

Energy performance evaluation and optimization studies were conducted in following agro-based mills;

1. **M/s Shreyans Industries Ltd., Ahemadgarh (Punjab) (27.08.2001 to 31.08.2001)**

M/s Shreyans Industries Limited, Unit: Shreyans Paper, Ahmadgarh is a leading firm under Oswal Group of Companies, located at Ahmadgarh (Punjab). The mill was established in 1982. Commercial production started in 1984 with production of 30 tonnes per day. As on today, mill produces 80 tonnes paper per day utilizing wheat straw, bagasse, sarkanda grass, jute caddies and imported waste paper as main raw materials. Mill produces writing and printing paper with one machine. The mill has ten rotary spherical digesters, one continuous digester, washing and bleaching section, four power boilers, a turbo generator and the Enders fluidized bed reactor for recovery of inorganic pulping chemicals.

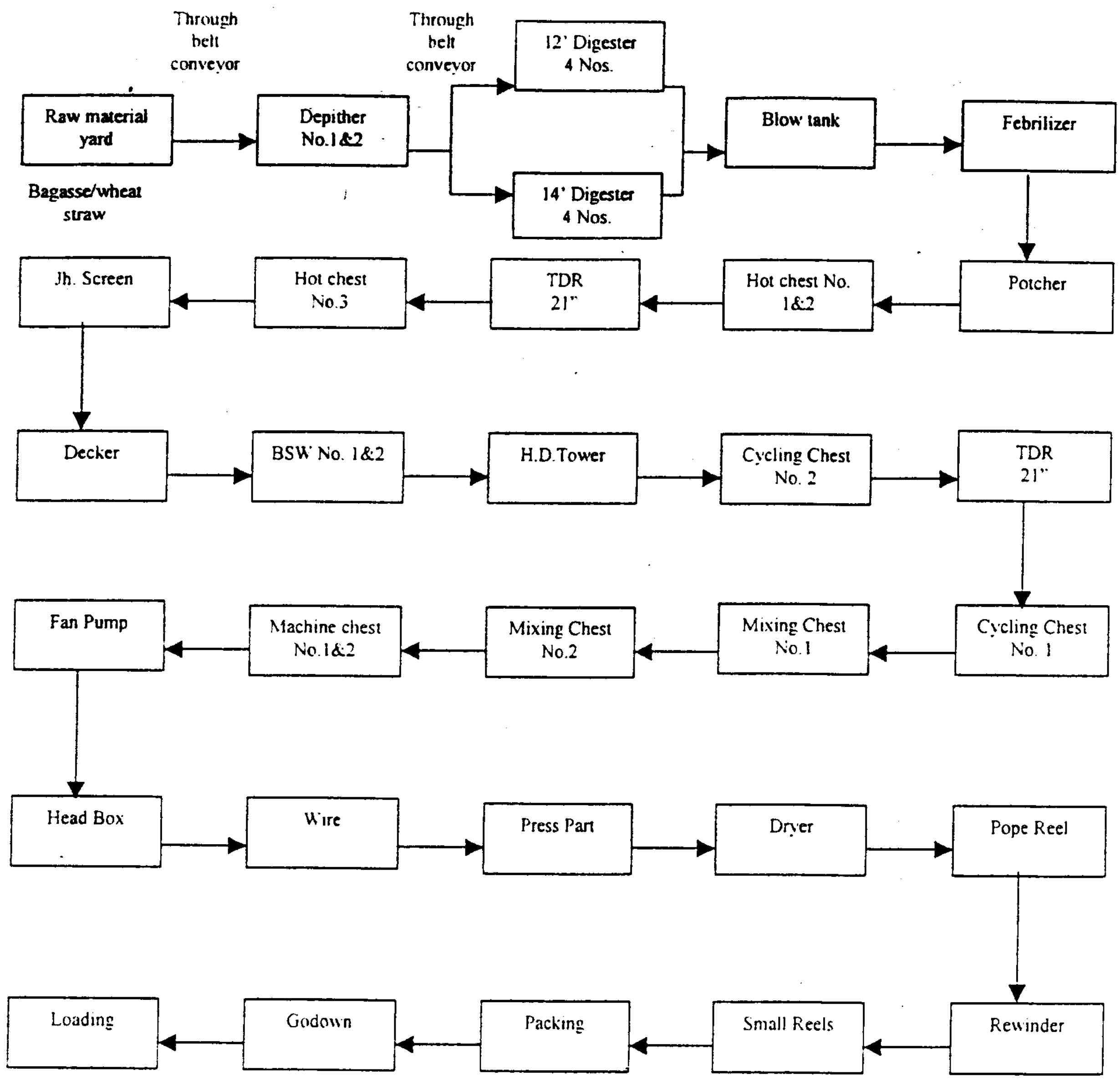


Schematic diagram of Pulping/bleaching Street
Shreyans Industries Ltd.

2. M/s Kailash papers, Unit: Kailash Papers Ltd., Aghwanpur, Distt. Moradabad (U.P.)

(13.06.2002 to 15.06.2002)

M/s Kailash papers, Unit: Kailash Papers Ltd. is located at village Aghwanpur,13th km east from Moradabad - Dhampur road. Initially the mill was promoted by Dhampur Sugar Mills Ltd., for the manufacture of semi kraft paper in year 1977 with an installed capacity of 30 tonnes paper per day. The capacity was upgraded to 50 tonnes per day in year 1988 and the management was taken over by M/s Kailash Papers Ltd. in December 2001. As on today, mill produces 50 - 55 tonnes of Kraft paper per day by utilizing Bagasse and Wheat Straw as main raw materials and 15-16% imported & indigenous waste paper. Mill produces kraft paper of 22 BF in the range of 80 GSM to 210 GSM, on one fourdriner paper machine. The mill has 8 rotary spherical digesters, brown stock washing section, one power boiler and 5 DG sets. There is no bleaching section and chemical recovery section. The schematic diagram of the plant is given in below.



Schematic Diagram of Plant – Kailash papers

3. M/s Yash Papers Ltd., Darshannagar, Faizabad (U.P.)

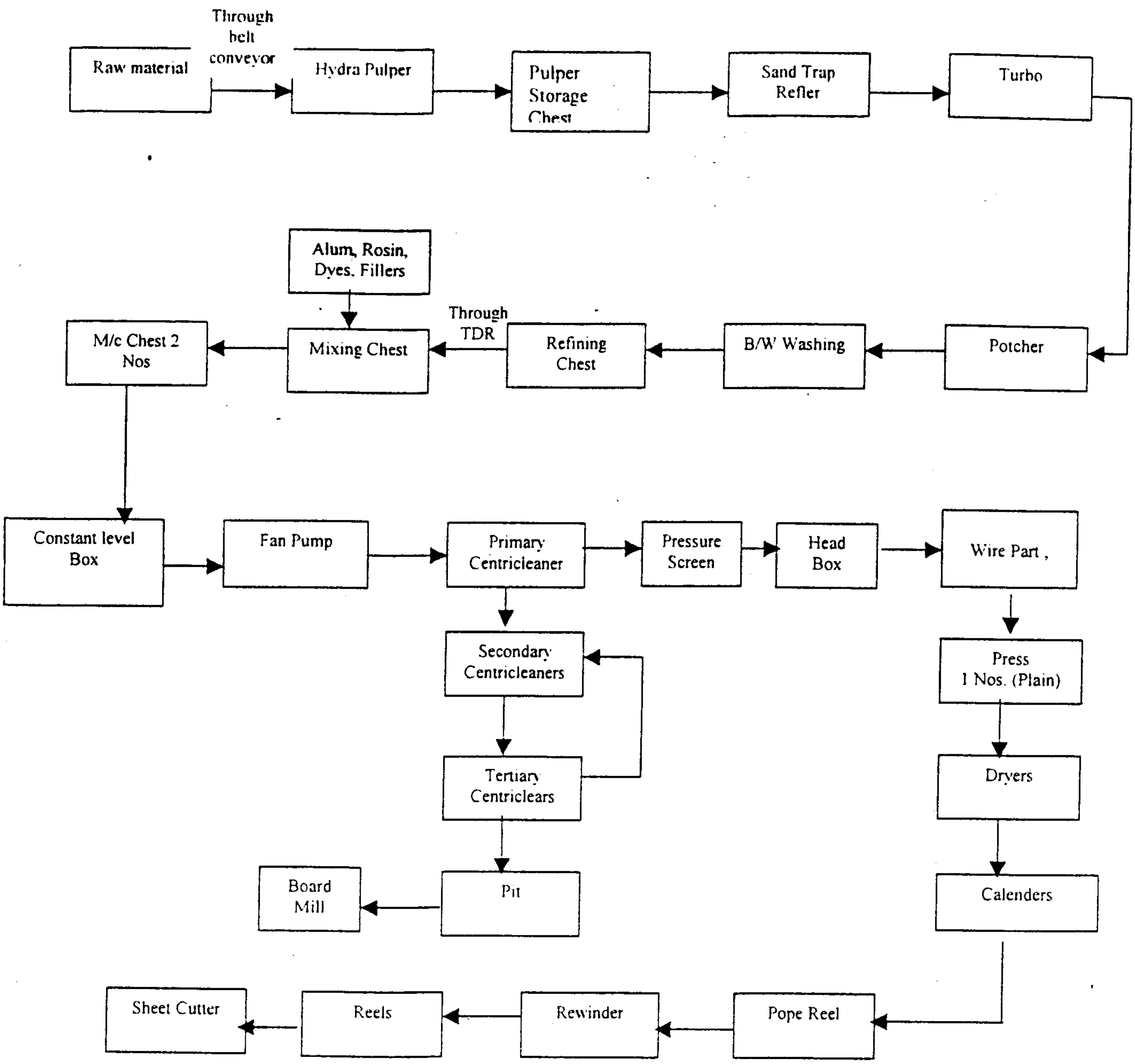
(23.06.2003 to 26.06.2003)

M/s Yash Papers Ltd. is located at Darshananagar, about 10 km from Faizabad (U.P.). The mill was established in 1983 with an initial capacity of 1940 MT of Kraft Paper per annum based on waste paper. Capacity enhanced from 1940 TPA to 3010 TPA with addition of gunny & bagasse pulping unit in the year 1984. Further capacity enhanced from 3010 TPA to 4000 TPA in the year 1989. Mill has set up unit-2 with an installed capacity of 6000 TPA to manufacture kraft paper in the year 1991. Under Modernization and expansion programme the capacity increased from 4000 TPA to 6000 TPA of unit 1 and from 6000 TPA to 10,000 TPA of unit 2 in the year 1995. As on today the capacity of the mill is 16000 MT per annum and mill produces 40 – 45 tonnes of kraft paper per day by utilizing 75% bagasse as main raw material and 20% gunny and 5% waste paper/KCB. Mill produces kraft paper and super deluxe in plain & ribbed of 20-100 GSM. The mill has 6 rotary spherical digesters, 3 power boilers, one 2.5 MW. Turbine & and two MG paper machines. The mill is self sufficient in power. There is no bleaching section and chemical recovery section.

Present Energy Consumption is given below:

(i)	Water Consumption, m^3/t_p	: 120—140
(ii)	Steam Consumption, t/t_p	: 4.5
(iii)	Electricity Consumption, KWh/t_p	: 900—1150

The schematic diagrams of both the units are given below



Schematic Diagram of Plant – Yash Papers Ltd.

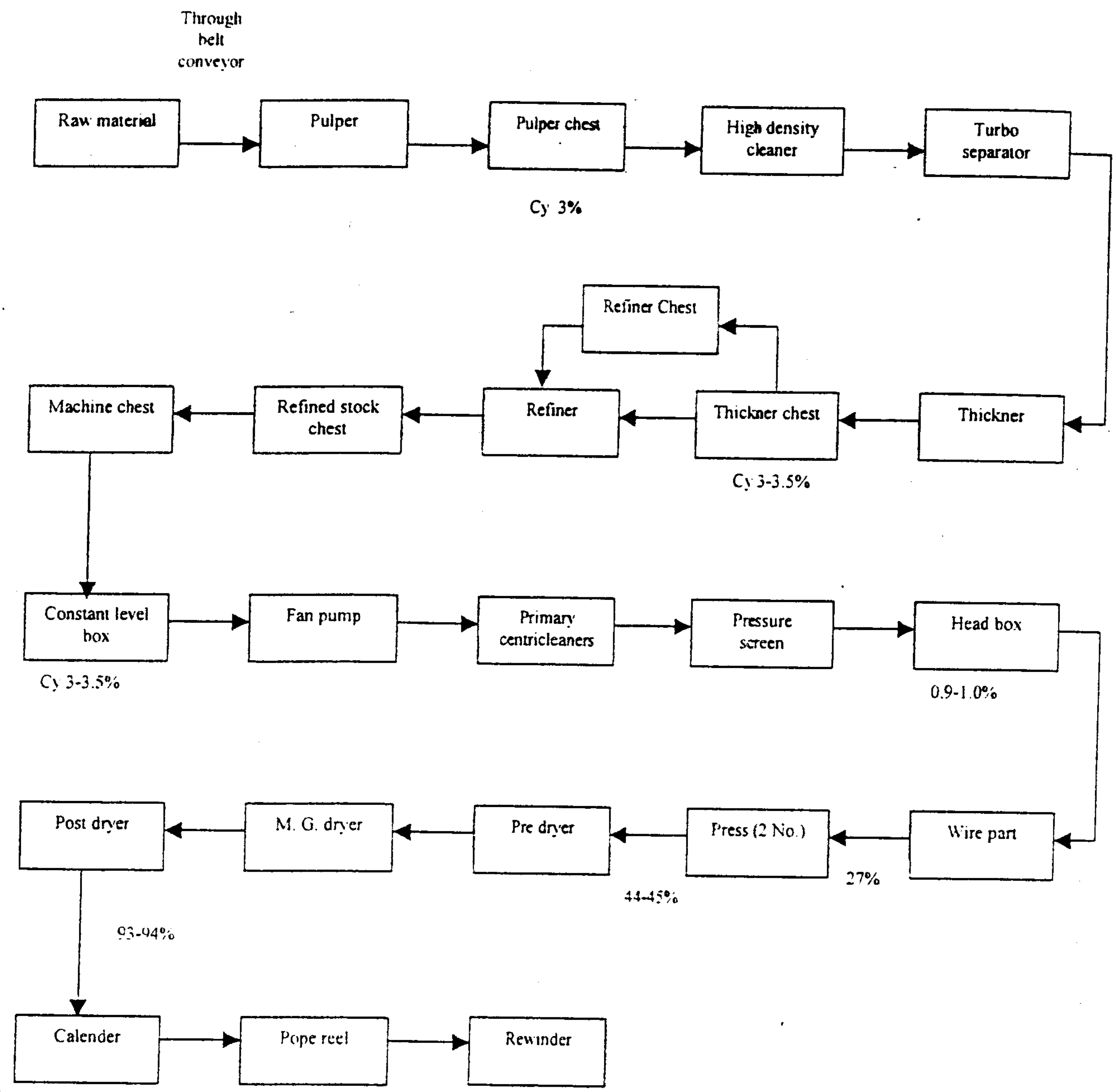
WASTE PAPER BASED PAPER MILLS

Energy performance evaluation and optimization studies were conducted in following Waste based mills;

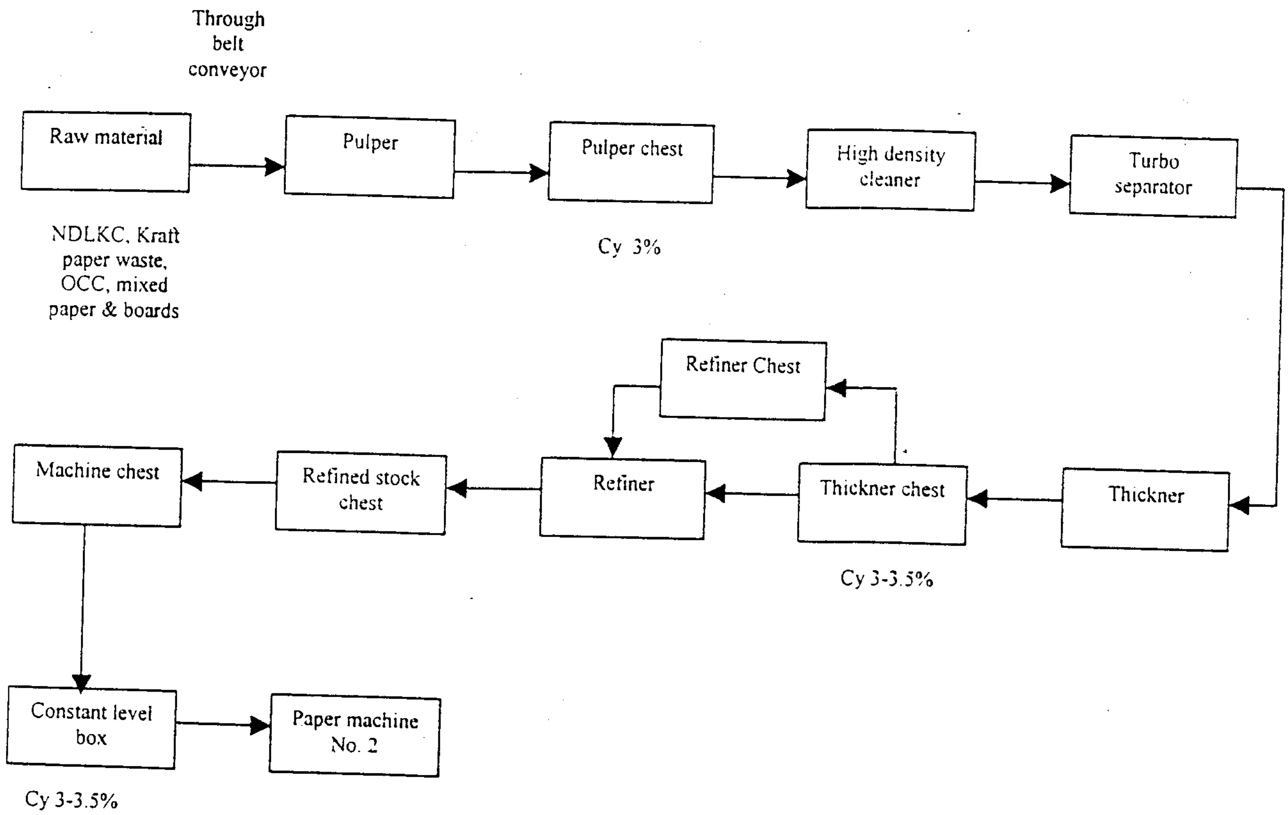
1. **M/s Kalptaru Papers Limited, Tal. Kalol, Gandhi Nagar, Gujarat**

   (29.01.2002 to 31.01.2002)

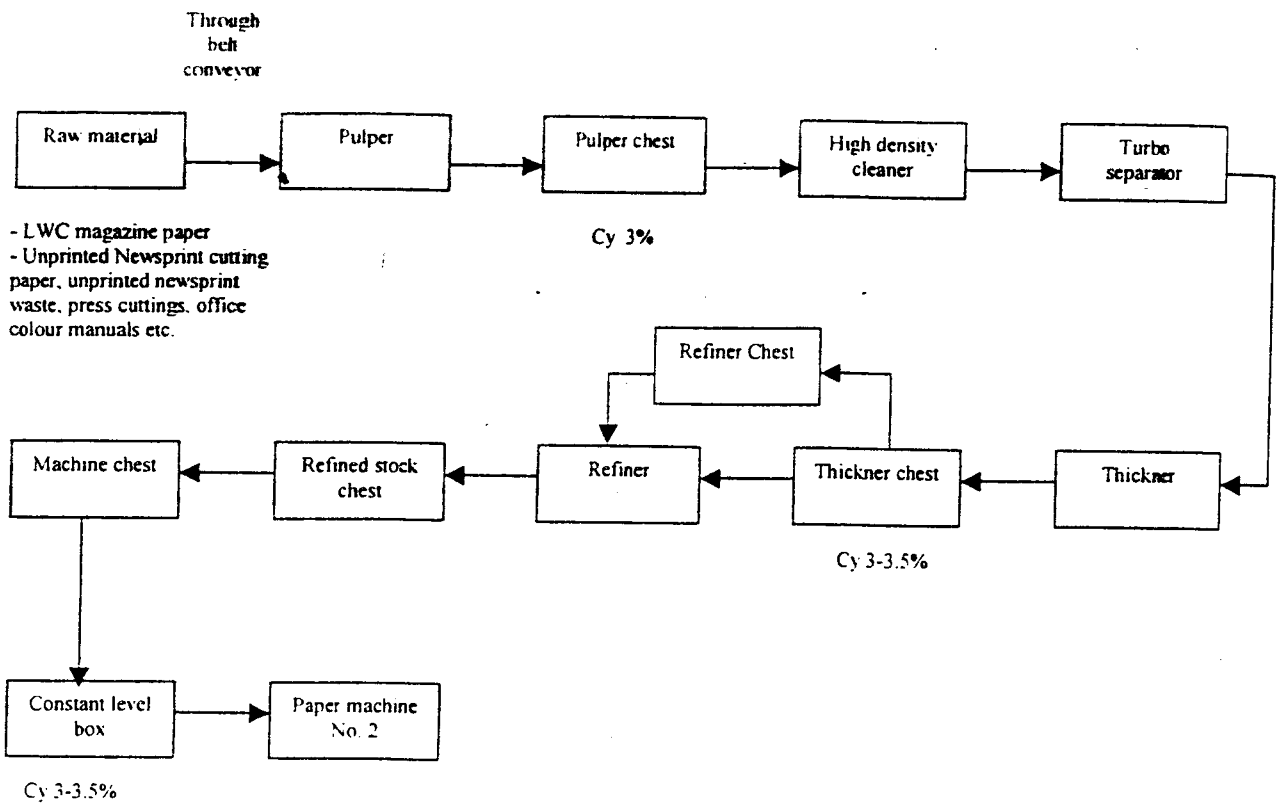
M/s Kalptaru Papers Limited is a leading firm located at Tal. Kalol, Distt. Gandhinagar. The mill was established in 1990 and commercial production started in 1990 with the production capacity of 10 tonnes per day. As on today, mill produces about 30 tonnes of Newsprint and 60 tonnes Absorbent Kraft paper per day by utilizing imported and indigenous waste paper as main fibrous raw materials. Mill produces Newsprint and Absorbent Kraft paper with two machines.



Flow Diagram of Paper Machine No. 1 - Kalptaru Papers Ltd.



Pulp Street for the manufacturing of absorbent grade paper on PM – 2
Kalptaru Papers Ltd.

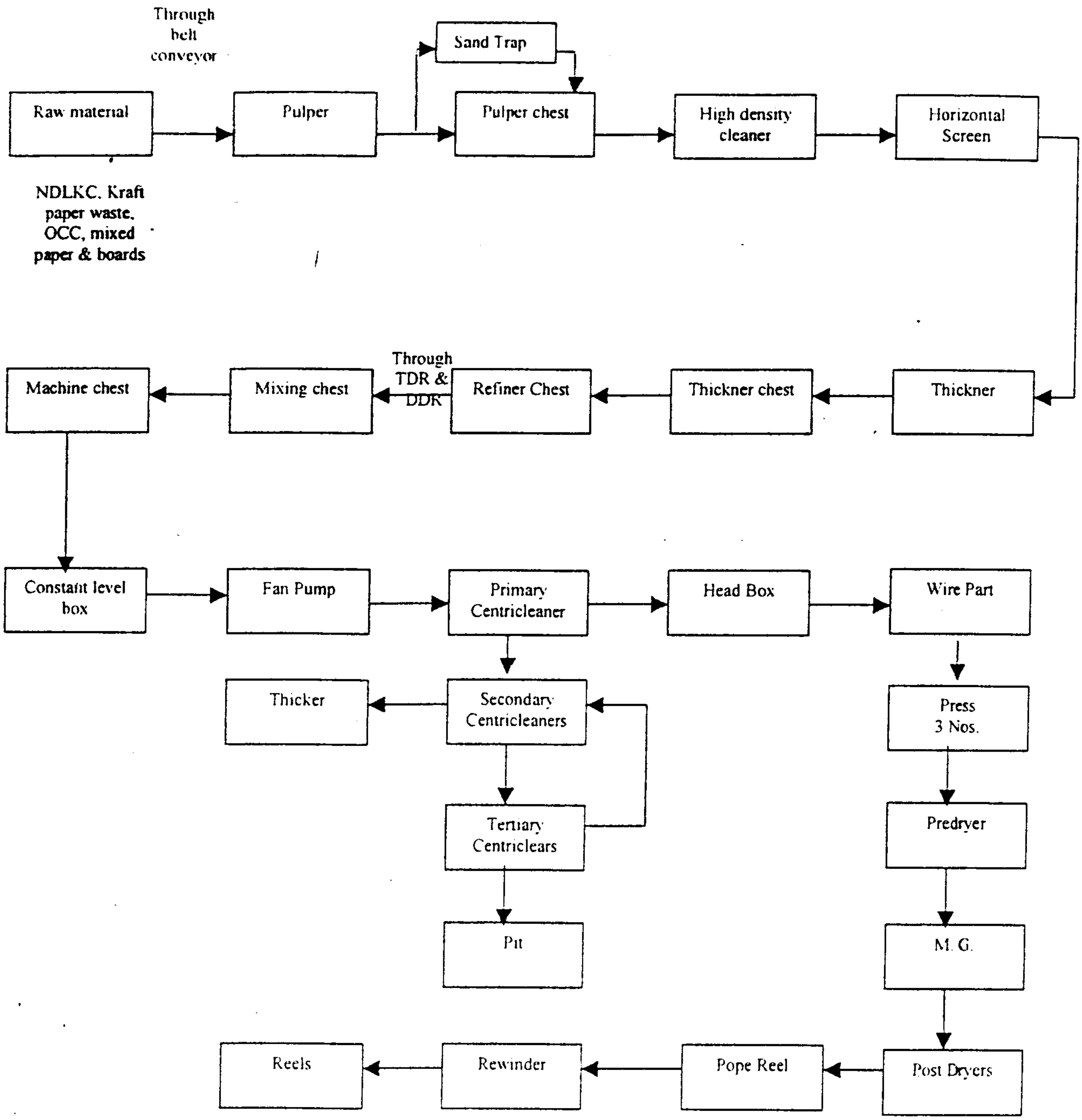


Pulp Street for the manufacturing of Newsprint paper on PM - 2
Kalptaru Papers Ltd.

2. M/s Well Pack Papers & Containers Ltd., Vamaj, Tal. Kalol, Gujarat

(02.02.2002 to 04.02.2002)

M/s Well Pack Papers and Containers Limited is located at village Vamaj, 6th km west from Mehsana high way road with an installed capacity of 13,200 tons/annum. The project came into production on 16 November 1995. As on today, mill produces about 43 tonnes of Kraft paper per day by utilizing imported & indigenous waste paper as main raw materials. Mill produces Kraft paper of 16 BF to 28 BF in the range of 100 GSM to 220 GSM, on one fourdriner paper machine.



Schematic Diagram of Plant – Well Pack Papers & Containers Ltd.,

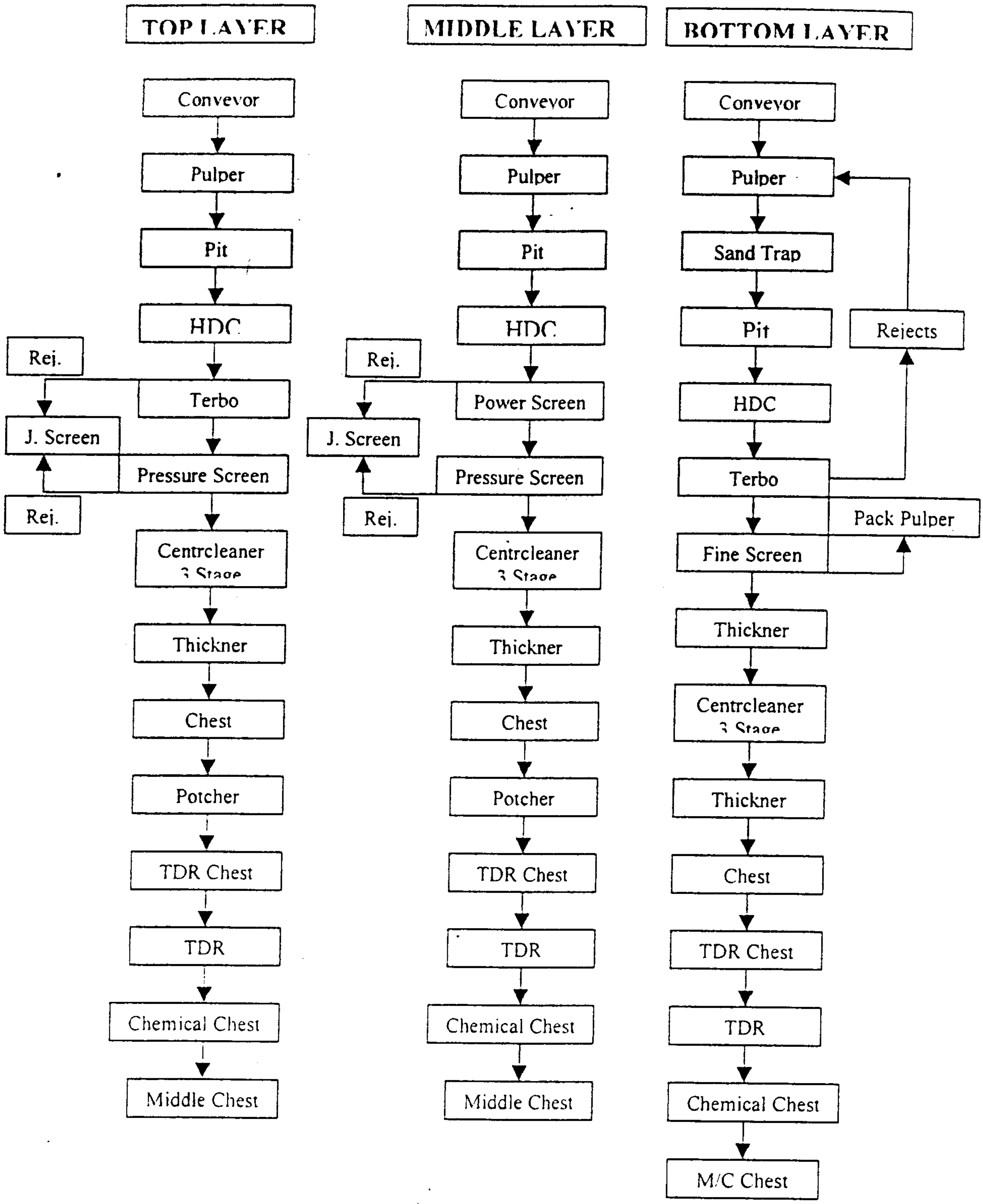
3. **M/s Rainbow Papers Limited, Ahmedabad, Gujarat**

(05.02.2002 to 07.02.2002)

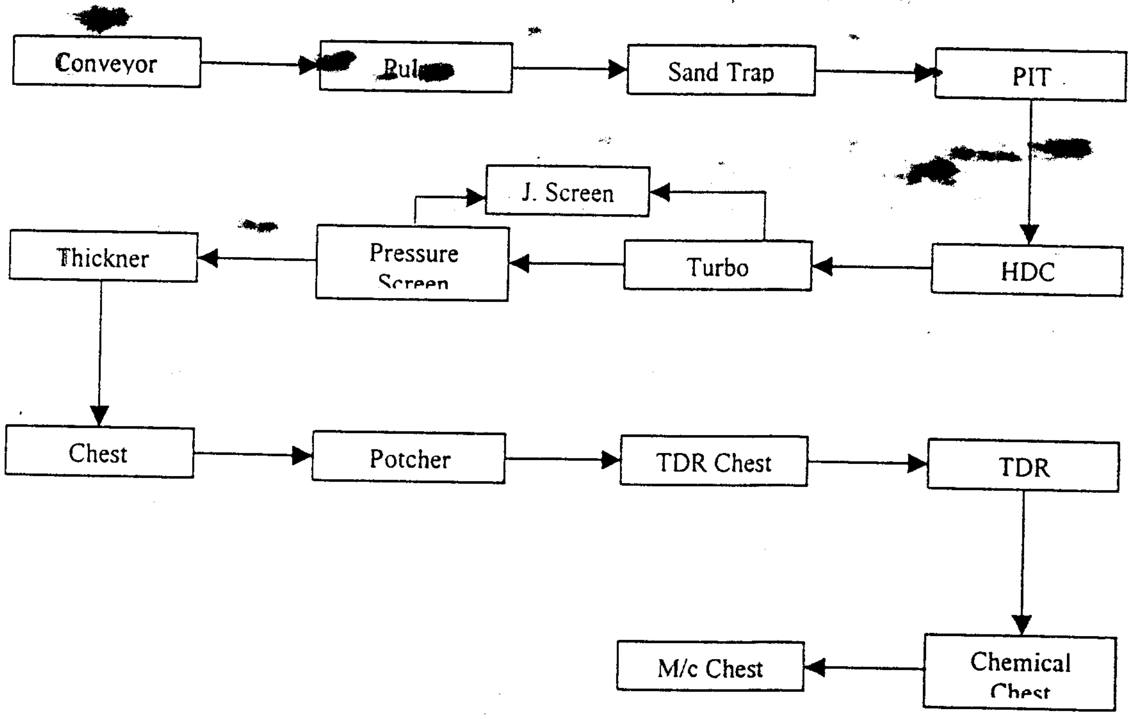
M/s Rainbow Papers Limited is a leading firm located at Ahmedabad. The mill produces about 80 tonnes paper per day of different varieties. Mill is utilizing wide variety of waste paper both indigenous and imported grade for the production of duplex and other varieties of papers. The Imported grades are hard white cuttings, soft white cuttings, envelop with window cuttings, super mix mixed waste paper, mechanical cuttings (newsprint), NDLKC, OCC etc. Indigenous grades are; white cutting, note books, CPU, office records, LCC, bottom layer duplex cutting, text books, mixed cuttings, Kraft cuttings, paper tubes etc.

Paper machine No. 1 & 2 are multi cylinder mould machines producing 34 to 38 t/day and 25 to 30 t/day respectively. PM-3, a fourdrinier machine with yankee dryer produces M.G. poster.

The mill has two boilers, one supplied by M/s Thermax, Pune and other one supplied by Par Techno (Ahmedabad).



Pulp Mill No. I & II For Duplex Board - Rainbow Papers Ltd.

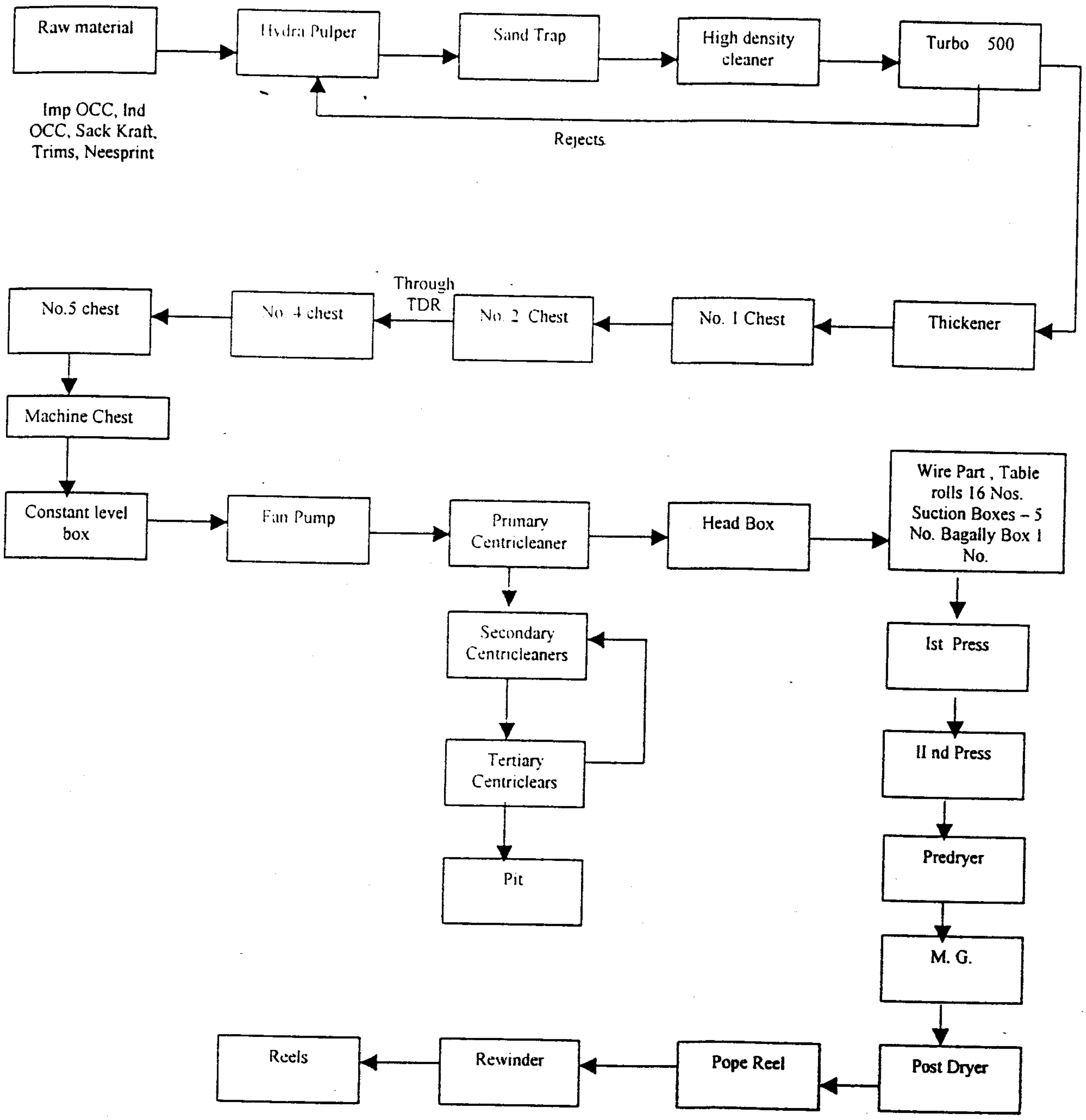


Pulp Mill No. 3 For M G Poster - Rainbow Papers Ltd.

4. M/s Karan Paper Mills, Chhatral, District - Mehsana, Gujarat

(15.4.2003 to 16.4.2003)

M/s Karan Paper Mills is located at Kadi - Kalol Road, Chhatral, District - Mehsana, Gujarat. As on today, mill produces 45-48 tonnes of Kraft Paper, Media (B grade), Ribbed Super Deluxe, Ribbed Kraft, Poster White and Newsprint by utilizing waste papers like imported OCC, indigenous OCC, sack kraft, white cutting and newsprint as main raw materials. Mill produces Kraft paper of 14-28 BF in the range of 100 GSM to 160 GSM, on two M.G paper machines.

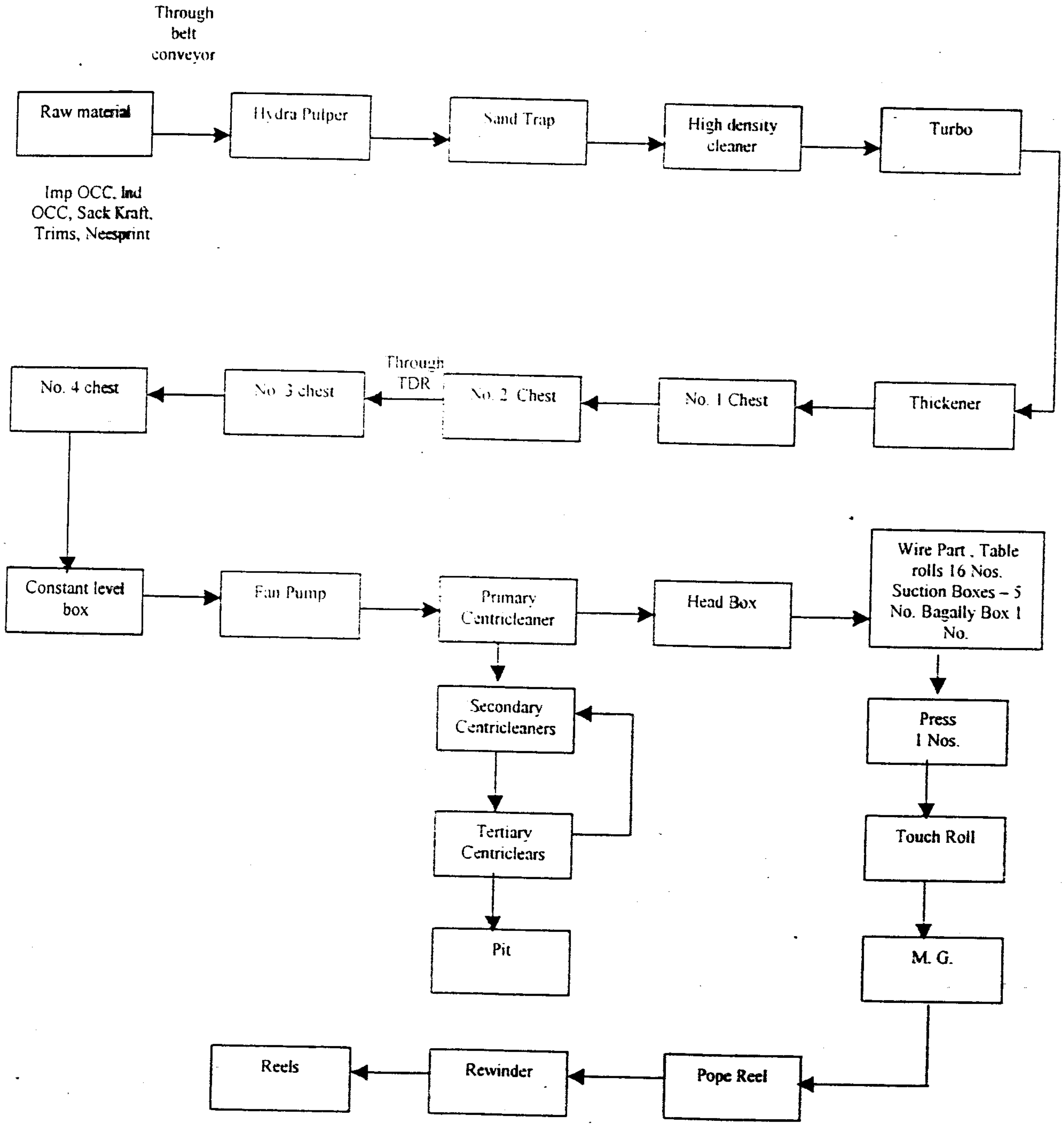


Schematic Diagram of Plant – Karan Paper Mill

5. M/s Shelavi Pulp & Paper Mills Pvt. Ltd., Chhatral, District - Mehsana, Gujarat

(17.4.2003 to 18.4.2003)

M/s Shelavi Pulp & Paper Mills Pvt. Ltd. is located at Kadi - Kalol Road, Chhatral. District - Mehsana. Gujarat. As on today, mill produces 15 tonnes of Kraft paper. media (B grade). ribbed super deluxe, ribbed kraft, poster white and newsprint by utilizing waste papers like imported OCC, indigenous OCC, sack kraft. white cutting and newsprint as main raw materials. Mill produces Kraft paper of 14-18 BF in the range of 60 GSM to 150 GSM. media (B Grade of 12 BF in the range of 60 GSM to 120 GSM, ribbed super deluxe in the range of 40 GSM to 80 GSM, poster white in the range of 32 GSM to 46 GSM. ribbed kraft in the range of 44 GSM & 58 GSM and newsprint in 39 GSM on one M.G. paper machine.



Schematic Diagram of Plant
Shelavi Pulp & Paper Mills Pvt. Ltd.

6. M/s Plaza Papers Pvt. Ltd., Village Ghunna, Behat Road, Distt. Saharanpur (U.P.)

(12.05.2003 to 13.05.2003)

M/s Plaza Papers Pvt. Ltd.. is located at village Ghunna, 12.5 km north from Saharanpur. Initially the mill was promoted by Shri Ashok Agarwal and Shri Rakesh Chhabda for the manufacture of Insulation Paper (Electrical grade) in year 1989 with an installed capacity of 1 tonne paper per day. The unit got sick and the management is taken over by Mr. Ashok Kuchhal in the year 1992. The unit was converted to writing printing papers with significant changes in pulp mill section & machine section. As on today, mill produces 4000 tonnes of writing printing paper per annum by utilizing imported & indigenous waste paper. In the year 1997. Computer Stationary section was added, finally in the year 2002 a board mill was also installed to utilize the ETP sludge for board making. Mill produces writing & printing paper like white cream wove in the range of 44-70 GSM. Colored printing –44 GSM and computer stationary paper in the range of 60-90 GSM on one paper machine (MF). The mill has one rotary spherical digester to cook wet strength paper, one power boiler and 2 DG sets.

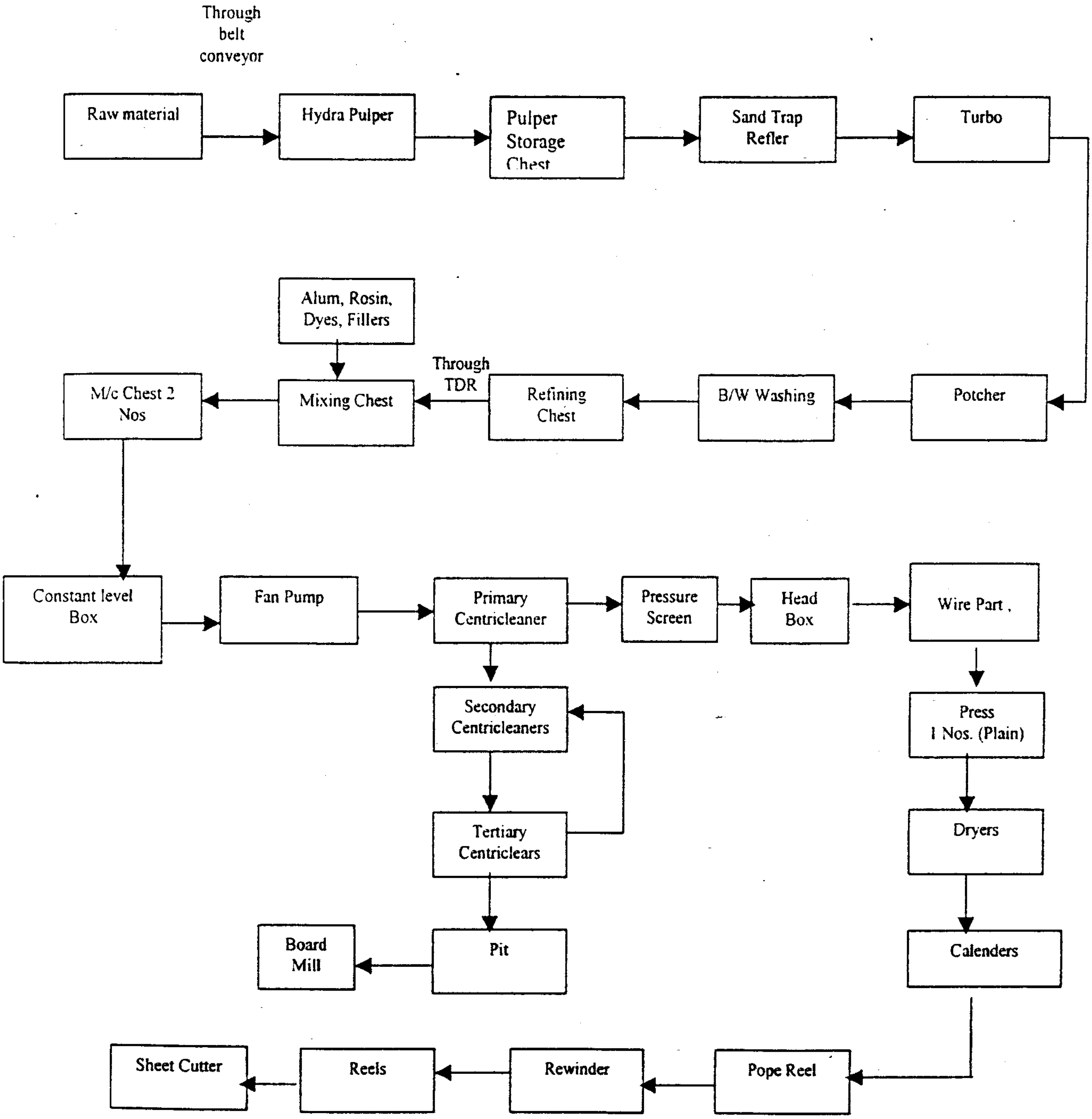
Present Energy consumption of the mill is given below:

(i) Water consumption. m^3/t_p : 60

(ii) Steam Consumption. t/t_p : 2.37

(iii) Electricity Consumption. kWh/t_p : 600

The schematic diagram of the plant is given below



Schematic Diagram of Plant – Plaza Papers Pvt. Ltd.

EXPERTISE GAINED & INFRASTRUCTURE CREATED:

Energy audits constitute the first step towards the adoption of an energy conservation program through energy performance evaluation and optimization in any mill. Energy audits are generally classified as preliminary and detailed audits. During the course of project, CPPRI developed expertise in the area of electrical, thermal and process auditing in different categories of pulp and paper mills like large wood based pulp & paper mills, agro based pulp & paper mills and waste paper based pulp & paper mills by constituting a dedicated energy audit team of scientists and engineers.

While most of the other auditing agencies conducting energy audits in pulp and paper sector are capable of conducting only electrical and thermal audits, the scope of CPPRI studies covers pulping and papermaking process optimization also. The energy conservation opportunities identified by CPPRI during the audit studies range from operating and maintenance in the area of process, electrical and utility sections that reduce energy usage by optimization of the process operations. The measures aim at improving the energy efficiency of the whole mill.

Infrastructure Created:

Under the project activities following equipments have been procured to strengthen the Energy Management Division of the institute.

Name of the Equipments:

1. **Motor Top along with transducers -Portable equipment for motor and pump efficiency analysis**

The instrument is manufactured by M/s Vogelsang & Benning Prozessdatentechnik, GmbH and supplied by M/s V B India, Bangalore. Well-matched motors and load are essential for minimizing energy costs and ensuring motor longevity. Generally the motors and pumps installations in the pulp and paper industry are more than 5-10 years old. Over a period of time, efficiency losses take place; therefore determination of pump efficiency is a direct measure of energy losses. CPPRI has acquired facilities for performing electrical energy audits in plants with this unique instrument called Motor Top, which is a sophisticated computerized equipment for 3 phase asynchronous motors to provide precise overview about optimally matched motors to their load cycle. Motor troubleshooting is greatly simplified by Motor Top.

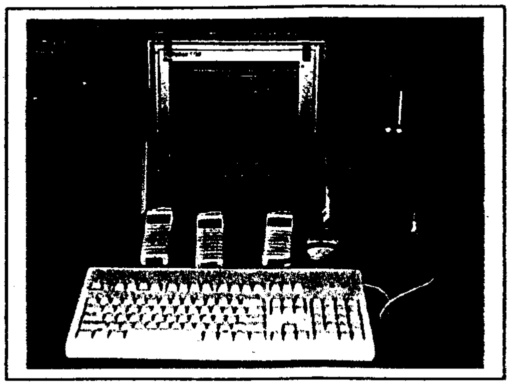
CPPRI conducts following tests by using Motor Top

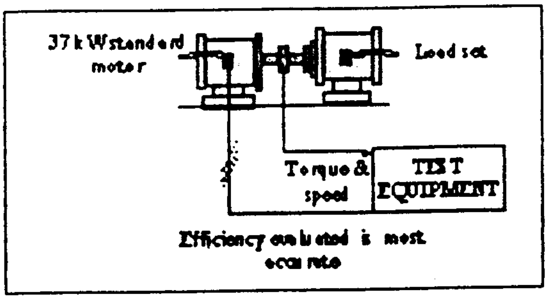
i) Efficiency Test: to evaluate the efficiency of motor at particular load for providing basic information on the status of the motor.

ii) Endurance Test: For loading pattern over a period of time to provide information on the minimum, mean and maximum/peak load.

iii) No-load-curve test: To evaluate losses – copper, friction and iron losses, which provides information for remedial actions or repairs.

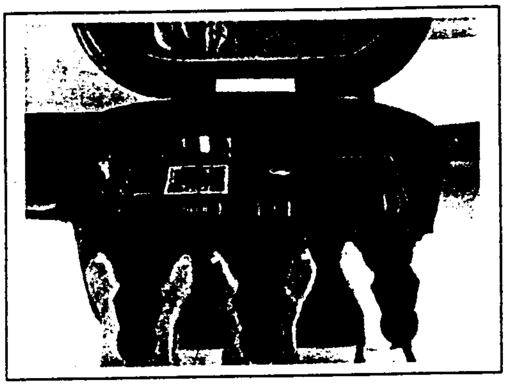
iv) Pump Efficiency Analysis: Q-H characteristics of pump can be performed on-line at field with instrument by monitoring and analyzing analog signals from discharge & suction pressure transducers and flow transmitters installed on site. NPSH characteristics of pumps can be evaluated at the workshop.





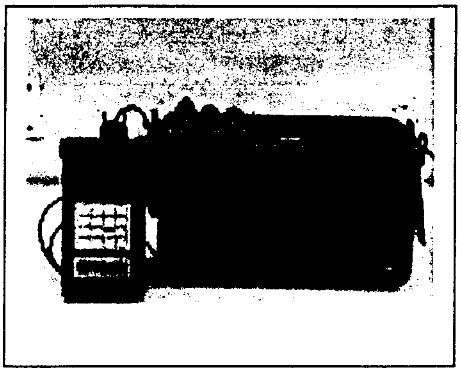
2. **Energy Auditor-portable equipment for evaluation of electrical parameters**

The instrument is manufactured and supplied by M/s MECO Instruments Pvt. Ltd., Mumbai. CPPRI audit team uses this portable energy auditor (on-line power analyzer) to measure voltage, current, active power, reactive power, apparent power, active energy, frequency, power factor, phase angle, presence of Harmonics and peak value.



3. **Flue gas analyzer- Portable equipment for the measurement of O_2, CO_2, CO, NO_X, SO_X and Hydrocarbons**

The instrument was procured for combustion efficiency analysis in the power boilers during energy audits. The instrument is manufactured by Kane International Limited, UK and supplied by M/s Nevco Engineers Pvt. Ltd., New Delhi. The instrument determines the oxygen, carbon di oxide, carbon mono oxide, oxides of nitrogen, oxides of sulfur, hydrocarbons and temperature in the flue gases with the help of module fitted in the equipment. The novel feature of the equipment is that the CO_2 value is always the measured value not the calculated value.



4. **Non Contact Thermometer- for the temperature measurement at various uninsulated surfaces**

The instrument was purchased for the measurement of surface temperature of hot, hazardous, moving or hard to reach objects without contact.

Principal:

Infrared thermometer measures the surface temperature of an opaque object. The unit's optics senses emitted, reflected, and transmitted energy, which are collected and focused onto a detector. The unit's electronics translate the information into a temperature reading, which is displayed on the unit.

5. **WinGEMS 5.0 Computer simulation software for energy and material balance studies**
6. **Computer Systems – for data analysis and documentation**
7. **LCD-for presentation and information dissemination during energy audits**

CHAPTER – 3

CHAPTER - 3

OBSERVATIONS & RECOMMENDATIONS

During the studies CPPRI team conducted energy conservation studies in various sections of the mill like raw material preparation, pulping, stock preparation, papermaking and chemical recovery. The study included the utilities section also. Most of the recommendations arising out of the process optimization and modernization have shown potential for huge savings. The utilities section covered the water treatment, boiler house, power generation, pumps, motors and effluent treatment plant. Though there are a no. of energy saving opportunities available in the utilities section, most of the recommendations are of general nature and are based on good house keeping practices.

The strength of CPPRI audit team has been in the area of process understanding related to the pulping, papermaking and chemical recovery operations. These audits have, therefore, resulted in overall savings of energy to the tune of 7-10%. The mill management have appreciated the recommendations and most of these recommendations have been implemented. This section highlights the major recommendations grouped into various areas for wood based, agro based and waste paper based mills.

LARGE WOOD BASED PULP AND PAPER MILLS:

I. Raw Material Preparation and Handling:

1. **Debarking of hardwood for Chemical & Energy Savings and Pulp Yield Improvement During Cooking in the Batch Digesters:**

In general, mills in India do not practice debarking and the chips with bark are used for pulping. In one of the mills covered under the study, producing bleached varieties, casurina was being chipped and cooked without debarking. The casurina logs procured by the mill ranged between 4 inches to 6 inches in diameter and up to 6-meter length. These logs, clad with a very thin bark, difficult to peel off when fresh, and green logs, could be easily removed in dry logs. The logs are transported from the storage yard to the chipper house by trucks and in many cases truck loads of fresh green log are taken directly to chipper house and used for cooking. A study was done at laboratory in CPPRI, which revealed that bark resulted in higher cooking chemicals and steam consumption. It was indicated to the mill that it can reduce its chemical charge by optimizing cooking after properly debarking the logs. It was proposed that mill should install a chain de-barker in its chipper house or get the debarked logs from the forest. At present the mill is using debarked logs procured from the suppliers for chipping and has substantially reduced its chemical and steam consumption.

2. **Increasing the Chip Silo Size and Chip Feeding Rate in Stationary Digesters for Reducing Chip-Filling Time:**

Chip production, storage and transportation needs to be managed in a well-planned way. A large number of mills do not follow the best practice for chip management. The reason is mainly the lack of proper facilities and lack of planning. During studies conducted by CPPRI, it was observed that the chips were being taken to the chip silo through a belt conveyor and from chip silo these were fed to digester. The time required for chip filling into the digester was approximately 2 hrs., as the chip holding capacity of chip silo was not sufficient for a single charge.

It was proposed that by increasing the size of the chip silo and chip-feeding rate, mill could save up to 60 minutes time per cook, in chip filling and thereby reduce the cooking cycle by one hour. The cooking cycle which is 7 hours may be reduced upto 6 hours and as a result, the number of cooks per day can be increased upto 16 from 14.

3. **Replacement of Depither Motors:**

   In a large mill producing chemical pulp from hard wood and bagasse, it was observed that bagasse received from the sugar mills was being depithed in 10 depithers, which were driven by 110 KVA motor each. The energy audit team conducted studies in depither and it was observed that these motors are running under load during depithing. It was suggested that the motors of depithers could be replaced with 55 KVA motors, which could result in huge amount of energy saving.

4. **Installation of Suitable devices for reducing the blockage in Chip Bin:**

   Process related problems some times affect the efficiency of the system. Some simple measures some times help to remove the bottleneck and operate them optimally. During the audit in one of the mill it was observed that the time of chip filling in the digester was more i.e. 90 minutes, due to jamming problem of chips in the chip bin. The time for chip filling in the digester should not be more than 60 minutes. It was therefore suggested that a portable magnetic vibrator may be used with chip bin at the time of filling or a hole of 20 mm diameter may be made on two sides of chip bin to regulate the chips manually with the help of a solid steel rod.

5. **Proper Arrangment of Shower Piping on Log Conveyor in Chipper House:**

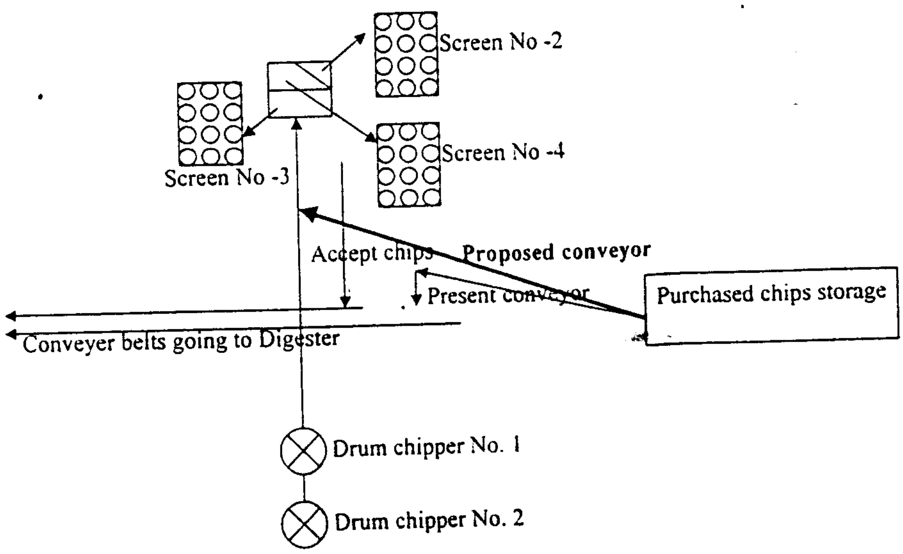
   Minor design faults can lead to system inefficiency and must be looked very keenly by the mill personnel as well as the out side agencies. During the audit in one of the mill it was observed that the showers provided at log feed conveyors were parallel to conveyor belt and water sprayed to wet the logs was falling only on one side, therefore proper wetting of logs was not taking place. In absence of proper wetting the dust and pin chip formation was excessive. It was also resulting in frequent changes in knifes as a result of increased wear out. It was suggested that the showers may be provided perpendicularly with two pipes. over the belt conveyor to get the proper wetting of wood logs.

6. **Proper Screening of Chips by Selecting Appropriate Chip Screen Hole Diameter in Oscillating Screen:**

Selection of proper equipment design affects the operation of other subsequent unit operations. During the audit in one of the mills, it was observed that the upper screen hole diameter of oscillating screen installed at chipper house was of 50 mm size. Normally the hole diameter of upper screen of the chips classifier is recommended up to 30 mm for uniform cooking, minimum pulp rejects and higher unbleached pulp yield. It was suggested to replace existing 50 mm hole screen with 30 mm hole screen in oscillating chip screen.

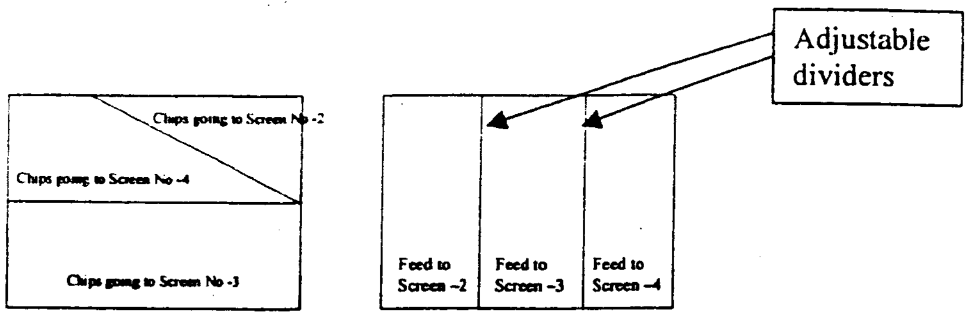
7. **Cleanliness of Purchased Chips and Other Raw Materials by ScreeningThrough Oscillating Chip Screen Before Processing:**

The raw material being fed to the digester is an important input for assessing the product quality. The cleanliness of material before feeding to digester must be ascertained to ensure that no additional cleaning is required in the processing steps and to avoid unnecessary contaminants in the stock and final product. During the audit in one of the mill, it was observed that the purchased eucalyptus chips are fed to digester directly i.e. without screening and the chips contain lot of dust (3-4%) and oversize/ over-thick chips (2-3 %) also. It was suggested that purchased eucalyptus chips may be passed through oscillating chip screen prior to feed the digester by increasing the length of conveyer belt (new) by 3 meter approximately.



8. **Proper Utilization of Equipment by Distributing the Equal Loading on Oscillating Chip Screens:**

The equipment utilization should be judiciously performed to ensure their proper utilization. During audit in a mill, it was observed that out of the three oscillating chip screens, the chips distribution in all the three oscillating chip screens was not equal. Almost all of the time the screen no. -3 was running with full load, screen no.–2 on 50 % load and screen no.–4 on 25 % load or less only. Mill was recommended to modify the distribution system (distribution box) for chips coming from chipper to screen by making some minor changes as proposed by CPPRI energy team.



Present shape of distribution box

Proposed shape of distribution box

9. **Separate Chipping and Pulping of Different Types of Raw Materials:**

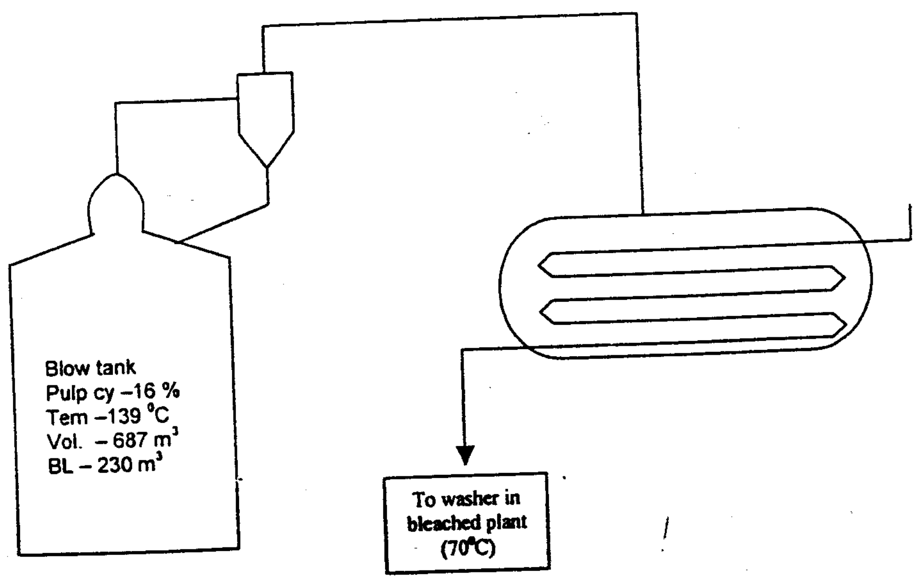
As a common practice, most of the hardwood based mills in India carryout mixed cooking for different types of hardwood. During audit in a mill, it was observed that the mill was practicing mixed cooking of mango with eucalyptus and subabul chips. All the three raw material have different pulping characteristics. Mango requires much more cooking chemical and longer cooking time in comparison to eucalyptus and subabul in order to produce same kappa pulp, therefore mixed pulping of these raw materials resulted in higher reject content, variation in kappa number and non-uniform pulp quality. It was recommended that mill should adopt separate pulping of mango by separately chipping and storing the chips in one or two chip silo above the digester. After separate pulping mill can mix mango pulp with mixed hardwood pulp in the same blow tank.

II. Pulp Mill Section:

1. **Utilization of Flash Steam of Pandia Digester Through Blow Heat Recovery for Water Heating and Replacing Live Steam in the Bleach Plant Washer:**

Utilization of flash steam from blow tank is an important energy saving option. Most of the large mills using batch digesters utilize the flash steam from blow tank for generation of hot water. However some of the mills producing the chemical pulp from hard wood and bagasse have installed pandia digester for pulping of bagasse. In one of the mill covered under the project study bagasse pulp from Pandia Digester blown along with the weak black liquor was collected in the blow tank. The blowing was controlled by maintaining the black liquor level by opening the blow valve so that sufficient black liquor was mixed with pulp to avoid fiber degradation on account of high shear forces generated during the blowing at high pressure & temperature. The flash steam from blow tank was vented into the atmosphere and therefore was not properly utilized.

It was proposed that a heat exchanger may be put up to heat the water by utilizing the flash steam generated in the blow tank and used in no. 1 washer of bleach plant. At present, mill is utilizing live steam to heat the pulp from chlorine washer and approximate 30-t/d steam is used. This hot water could result in significant saving of the live steam.



2. Insulation of Batch Digesters, Black Liquor Sump Chest, Steam Pipelines, Hot Black Liquor and Pulp Lines in Pulp Mill:

A large quantity of heat is wasted due to improper insulation in mills. During study it was observed that many areas need proper insulation in the mills. In many mills, which have stationary batch digesters, some of the digesters were found to have improper insulation. Similarly insulation was not provided at black liquor seal tanks, various steam pipe lines to the stationery digesters, blow pipe lines, pulp pipe lines up to washers and hot black liquor / white liquor lines and this was resulting in considerable heat losses.

It was informed that in most of the cases the insulation in digester house does not stand longer due to handling of corrosive materials. It was suggested to plan a preventive maintenance schedule for insulation in pulp mill to avoid the radiation losses. A monthly check up of insulation in pulp mill and corrective measures taken up immediately would yield significant savings to the mills.

3. Installation of Indirect Liquor Heating System and Recirculation of Liquor During Cooking in Stationary Batch Digesters:

The batch digesters used in large mills utilize medium pressure steam to heat the content in digester to pulping temperature by using preheaters. The sensible latent heat of steam is utilized for heating. The condensate is recovered and taken back to boiler house in a closed system. This results in considerable energy saving. Many mills still use direct heating system in the stationary batch digesters for cooking of casurina and eucalyptus hybrid chips. The bath ratio is maintained at 1:3.5, however due to direct steaming actual bath ratio is raised up to 1:4.25. In one of the mill it was informed that earlier the mill was heating the liquor by indirect steaming and recirculating it for cooking the hardwood chips. But due to problems faced by mills during cooking due to frequent jamming of the strainers it was discontinued. For stationary batch digesters indirect heating is an energy efficient method of cooking, resulting in lower bath ratio during cooking due to non-condensation of steam, utilization of condensate by returning it to boiler house and uniform & better cooking due to re-circulation of hot liquor.

In this case it was proposed that following suggestions could considerably reduce the frequent strainers choking:

1. Debarking of casurina
2. Reducing white liquor suspended solids with better settling.

The indirect steaming system was suggested to put back into operation after incorporating the above measures and resultant savings were highlighted.

4. **Optimization of Bagasse Pulping for Reducing the RAA Requirement for Processing of Weak Black Liquor:**

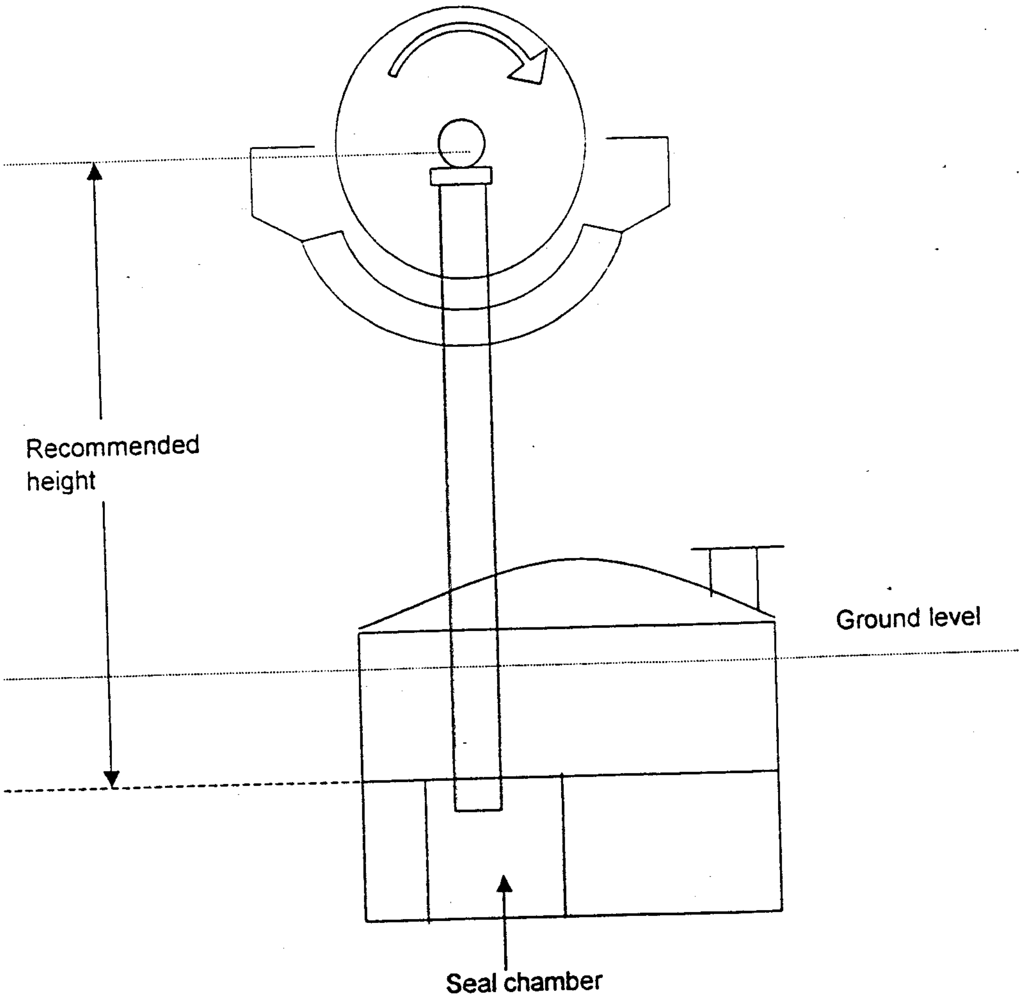
In one of the mills it was observed that in the combined weak black liquor, RAA of 10-12 g/l as Na_2O is maintained which is on much higher side. It is possible that the mill is forced to maintain high RAA because of black liquor instability i.e. the tendency of black liquor constituents to precipitate at higher solids concentration and high viscosity of bagasse black liquor. It was suggested to conduct laboratory scale studies on bagasse pulping to optimize the cooking conditions and study the bagasse black liquor properties at different RAA levels.

5. **Installation of Barometric Leg on Brown Stock Washers:**

In most of the mills, vacuum required for BSW is developed by installing barometric leg. This is an energy efficient method and results in significant energy savings in the mill. In one of the mills, in two streets of BSW's for unbleached bagasse pulp and hardwood unbleached pulp washing, vacuum pumps were being utilized for washing pulp in both the washing streets. The barometric legs were not used as the height of bagasse BSW's was approximately 7 meters and further increase in height was not possible. The wood pulp street BSW's earlier had barometric legs and was replaced with vacuum pump on account of inadequate vacuum.

It was proposed that mill should use barometric legs for displacement of liquor in 3rd & 4th stages of wood washing street where as in stage 1st & 2nd washing may be continued by developing vacuum through vacuum pumps. In this way, mill could reduce its electrical consumption in washing by replacing existing vacuum pump with a lower capacity pump.

In Bagasse Street, the barometric leg could be installed by placing the liquor seal tanks in underground pits and the required height could be achieved, as per requirement.



Recommended drop leg setup

6. **Reduction in Hydrogen Peroxide Addition at Extraction Stage:**

In one of the mills CEpHH bleaching sequence was employed for hard wood bleaching and CEpH sequence for bagasse chemical pulp to get a final brightness of pulp at around 82 % ISO. At the time of audit mill was using 1.0% hydrogen peroxide in the extraction stage, which was found to be on higher side.

It was suggested to reduce the dosage of hydrogen peroxide from 1.0% to 0.5 %, which would not adversely affect the final pulp brightness as well as pulp quality. Mill was suggested to conduct laboratory trials before implementing the proposal.

7. **Adoption of Oxidative Extraction (Eo):**

Use of gaseous oxygen in the extraction stage of bleaching enhances the removal of lignin present in the pulp. By adoption of oxidative extraction (Eo) in the existing CEpHH/CEpH sequence, 25-30 % reduction in kappa number can be achieved without affecting the pulp qualities, like freeness, viscosity etc. The effluent from bleaching sequences containing oxidant in the extraction stage applied on chlorinated pulp showed decrease in color substantially.

It was suggested to use oxygen at extraction stage to lower the kappa number and increase brightness of pulp. The existing CEpHH and CEpH sequence of bleaching can be converted in to CEopHH and CEopH bleaching sequence by putting up an oxygen mixer in place of existing alkali mixer.

8. **Pumping of Bleached Pulp from Pulp Mill to Stock Preparation Through Medium Consistency Pumps Instead of Low Consistency Pumps:**

In most of the mills the bleached bagasse and hard wood pulp is stored in high-density storage tower. From this tower the pulp is pumped to stock preparation by diluting with machine backwater. The consistency in the high-density tower is around 8-10 % in the upper portion and 3- 4 % in the lower portion. Machine backwater is pumped from paper machine to the high-density tower and pulp at 3- 4 % consistency is taken to the stock preparation. In one of the mill it was observed that the distance between high-density tower (old pulp mill) and stock preparation was approximately 100 meters, where as the distance between HD tower (new pulp mill) and stock preparation was more than 500 meters. This requires huge amount of pumping energy to transfer stock at 3 % consistency and to pump machine backwater from paper machine to HD tower.

It was suggested to utilize medium consistency pumps for transfer of stock at around 8 % consistency from HD tower to the stock preparation. This would result in considerable saving in the pumping energy.

9. **Replacement of Seal Tank pump in Pulp Mill:**

During audit studies in pulp mill section of one mill, seal tank pump discharge was measured by flow meter. The flow of the seal tank pump was recorded as 140 m^3/hr. The head developed by pump was 22 meters with power consumption of 22 kW. During discussion it was informed by the mill personnel that impeller was already trimmed by 10%. It was suggested to replace the existing seal tank pumps with higher efficient pump of 75 - 80% efficiency.

10. **Use of Hot Water in Place of Fresh Water at Malone Filter Installed at Blow Heat Recovery System in Pulp Mill:**

During audit in one of the mills, it was observed that the hot water recovered from blow heat recovery system contains some amount of fiber because there was no fiber separator at the top of the blow tank. To remove this fiber from hot water, mill was using malone filter. For washing of the wire of malone filter, mill was using fresh water showers, which reduces the temperature of hot water from 84 –85 ^{0}C to 74 -75 ^{0}C. It was suggested that mill could use hot water in place of fresh water at malone filter. Supply line of the hot water may be taken from the outlet of supply pump of the hot water tank.

11. **Installation of Slotted Centrifugal Screen after Brown Stock Washing:**

During the audit in one of the mills, it was observed that for the removal of debris contents present in the pulp, mill uses Johnson knotter screen before the brown stock washing which has 8 mm round hole. Sieves and small semi cooked chips pass through the screen, which was visible at brown stock washers. After washing, the pulp was diluted and passed through centisorter with round hole screen. At the centisorter small semi-cooked chips were separated out, but sieves still remained with pulp and were taken to the bleach plant as such, where they consumed more bleaching chemicals. Mill was suggested to either install centricleaners after centisorter or slotted centrifugal screen instead of centisorter for proper screening of pulp.

12. **Utilization of Old and Redundant Equipments:**

It was observed in one of the mill that it was using four stage brown stock washing system, which has washing capacity around 160 tones/day. As mill has increased its production up to 200 – 210 tonnes /day, these washers were overloaded and resulted in poor washing efficiency (soda loss ~ 40-45 kg/ton of pulp as Na_2SO_4). It was suggested that mill should use their old redundant bleach line washers as brown stock washers for proper washing of unbleached pulp. 70 % of the pulp could be washed through existing brown stock washers and rest 30 % of pulp could be washed through three of the old bleach line washers (as 4^{th} washer i.e. former hypo-2 washer was of lower capacity)

13. **Use of Chlorine Washer Filtrate for Dilution of Unbleached Pulp Before Suction Filter:**

During the audit, it was observed in one of the mills that for the dilution of the pulp before suction filter in the pulp mill it was using machine backwater as well as fresh water sometimes. As the residual chlorine level in the filtrate of the chlorine washer was on higher side (0.0137 – 0.0355 g/l), it was recommended that mill should use chlorine washer filtrate for dilution of unbleached pulp. This will also lead to reduction of overall chlorine consumption in the bleach plant.

III. Chemical Recovery Section:

1. Indirect Steaming of Concentrated Black Liquor in the Mixing Tank, Prior to Firing:

It is a prime goal of chemical recovery section of a mill to fire black liquor at highest possible concentration. In one of the study it was observed that black liquor from cascade evaporator was received in the mixing tank at a concentration of 70% solids and a temperature of 87°C. Prior to firing in the boilers, this concentrated black liquor was mixed with hopper ash from the recovery boilers and heated to a temperature of 110°C. Heating of concentrated black liquor was done by direct steaming with 30 psi steam for control of firing liquor temperature.

It was proposed to replace the direct heating system with indirect heating system. Indirect steam heating of concentrated black liquor in the mixing tank would provide the following benefits:

- Improve recovery of condensate to power boiler.
- Save fuel.
- Save make-up water and its treatment cost.
- Improve thermal efficiency of recovery boilers.

2. **Replacing the Steam Driven Ejector Sets with Vacuum Pumps in Evaporator Plant:**

   In one of the mills it was observed that steam ejector sets used in the multiple effect evaporation plant consumed steam at the rate of 170 kg/hr. It was suggested that by replacing the steam ejector set with vacuum pump (of liquid ring type), lower operating cost could be acheved incurred. It was proposed that ejector set should be replaced by vacuum pump operating with a 20 hp, high efficiency motor.

3. **Thermal Treatment of Bagasse Black Liquor for Viscosity Reduction:**

   Bagasse black liquor has inherent problem of high viscosity at high solids concentration. This is due to lignin-carbohydrate complexes (LCC) present in bagasse black liquor. The LCC can be easily broken down by using thermal treatment option, where the liquor is subjected to a thermal shock at temperature higher than the pulping temperature to disrupt the lignin and carbohydrate linkage. In one of the mill it was suggested that mill should go for Thermal Treatment of bagasse black liquor, if no substantial reduction in RAA is achieved after optimization of bagasse black liquor properties. Thermal treatment involves heating of semi concentrated black liquor (35 to 40 % solids) to 180-185^{0}C and maintaining the black liquor at the temperature for about half hour. This can result in substantial reduction of auxiliary fuel and also produce steam at higher economy from back liquor. Low viscosity would result in low power consumption also.

4. **Installation of External Pre Heaters in the Evaporation Plant:**

   The old Multiple Effect Evaporation Plant in one of the mill was of LTV type with forced circulation and consists of 6 Effect bodies and one forced circulation body. Of these. 4 effects were in operation. Liquor flow sequence was E4 – E5 – E3 – E2 – E1 – F.C. There were no preheaters and the Steam economy was low i.e. 2.8 – 3.0. It was suggested that external preheaters should be incorporated in the plant before E1, E2 and E3.

5. **Efficiency Improvement of Lime Mud Filter:**

   During the audit in a mill, it was observed that dryness of lime sludge cake is on lower side i.e. only 38%. To improve the dryness & efficiency of mud filter, following points were suggested;

   - Wire cloth must be stiff on the circumference of the drum.
   - Leakages at the sealing plate at both the ends to be arrested.
   - The pipe containing spray nozzles to be shifted towards feed side and spray nozzles to be modified to spray the hot wash water properly.
   - Replace 3 stages washing with single stage.
   - Check the rotor of the vacuum pump for any scale build up.

6. **Insulation of Bare Pipes & Vessels in Evaporator Section:**

   During an audit it was observed that pipelines are not properly insulated in evaporators (MEE I, MEE II and MEE III) of chemical recovery section. The surface temperature when measured by CPPRI team was found to be as high as 80-120^{o}C. This resulted in high energy loss through these uninsulated surfaces in the form of radiation. It was suggested to put proper insulation on the uninsulated surfaces of pipelines in evaporator section to reduce the heat loss through radiation.

7. **Re-use of Pump Sealing Water in Evaporator Section:**

   During the audit in a mill, it was observed that sealing water of 12 labour pumps in the evaporator section of chemical recovery was going to drain. The quantity estimated was around 100 m^3 / day. It was suggested that the water should be collected in an under ground tank and recirculated with the help of pump of required capacity.

8. **Optimization of Excess Air in Recovery Boiler:**

Monitoring and control of recovery boiler flue gas parameters is an important study for energy audit. During the audit studies in one of the mill, flue gas analysis was made at boiler-bank outlet and ESP inlet. The O_2 percentage at boiler bank outlet was 5.2% whereas at ESP inlet O_2 was 9.3% & 8.0%. That clearly indicated that there was some infiltration of air between boiler bank and ESP. Based on measurement taken by audit team, mill personnel blocked some visible holes to arrest the infiltration. Again the measurement of O_2 was taken after arresting the infiltration of air, which was found 7.5%. Now the reading was found within controllable limit. It was recommended to control the carbon monoxide by preventing the carryover & by proper combustion, which could be done by proper distribution of air at primary, secondary & tertiary zone and also to maintain the bed temperature at optimum level so that combustion may take place properly.

9. **Condensate Recovery from Recovery Boiler:**

Condensate is a valuable energy source and should not be wasted anywhere. During audit study in one of the mills it was observed that lot of condensate was going to drain. Mill has provided a condensate-collecting tank, where condensate was collected from various areas, D.M. water was sprayed in the collecting tank and finally it was pumped to feed water tank. A lot of vapor was venting out from the collecting tank, resulting in huge loss of heat & condensate and system was found to be inefficient. Firstly it was recommended to relocate the condensate tank so that 100% condensate recovery could be achieved. Further it was suggested to relocate the existing collecting tank & erect this tank 2 feet below the existing floor. Collect all the condensate from above areas in a common header by laying a proper pipeline and to connect common header to condensate tank just one inch below the center of the tank. It was also suggested to provide 3" diameter instead of existing 6" diameter of vent pipe to reduce the vapors carryover. Mill should also provide two D.M. water shower pipes, first one just 400 mm below the vent pipe and second one 600 mm below the vent pipe, so that maximum condensate recovery could be achieved. Existing pump may be used to deliver the hot water to feed water tank or polishing tank.

10. Installation of Heat Recovery System to Recover Waste Heat from CBD:

During the audit studies in one of the mills, it was observed that mill was operating continuous blow down (CBD) system for FBC & soda recovery boilers and this CBD was going to drain. It was suggested to install heat recovery system to recover waste heat from CBD by;

i. Installation of flash tank (operating at 3.5 to 4 bar) for collecting the blow down water from all the 4 boilers.

ii. Flash the blow down water in flash tank to a pressure of 2.5 kg/cm^2 and feed the flash to deaerator.

iii. Send the remaining condensate to pulp mill or mix with foul condensate of evaporator.

11. Installation of Steam Traps for Condensate Removal:

Steam traps are common device used to remove condensate from the steam line. Many mills continuously discharge the condensate without using traps. During audit studies in one of the mills, it was observed that turbo feed pump was always in ready mode for instant stating, due to which steam was getting drained continuously from governor head, exhaust line and main chamber.

Approximately 4 kg/hr of steam was going to drain per hour. It was suggested to install steam trap at the above locations i.e. at governor head, exhaust line and main chamber, so that only condensate could be drained instead of steam. The condensate coming from the trap can be collected in R/B cooling/collecting water pit.

12. **Replacement of Feed Liquor Pump in the Evaporator street:**

During audit studies in a mill, flow of feed liquor pump of evaporator was measured by flow meter to check the efficiency of the pump. The measured, efficiency of the operating pump was very low. Pump efficiency was calculated on design parameters, which was only 37%. So the pump was inefficient in both the cases. It was suggested to isolate the feed pump and to feed the liquor with the help of vacuum in the system i.e. 600 mm Hg. Due to vacuum, liquor would be sucked inside the system, since the head was 8-9 meters. It was suggested to utilize the pump only during startup, once the system is stabilized the pump could be isolated. Flow control could be done with the help of control valve. Secondly the pump was very inefficient, and it was recommended to go for a new pump or with the help manufacturer, impeller trimming could be done up to 10% of the total diameter. It was suggested to study the pump characteristics curve before trimming the impeller. Impeller trimming could also result in energy saving but increase in efficiency of the pump would be very marginal, since the design efficiency itself was on lower side.

13. **Optimization of Causticization by Using Good Quality Lime:**

Quality of white liquor from caustisization section depends to a large extent on quality of lime used. During audit study in one of the mill, it was observed that mill was producing 60 m^3/hr Green Liquor of 75 gpl. The Green Liquor was treated with lime having 48% - 50% Available Lime Index (ALI) which resulted in White Liquor production of only 60 gpl concentration.

In the slacker, mill was using live steam of 0.5 kg/cm^2 pressure and temperature 135-140^oC for raising reaction temperature from 70 to 80^oC. It was suggested to use good quality lime of 60% Available Lime Index (ALI). By using high purity lime mill would be benefited by raising the concentration of white liquor from 60 gpl to 100 gpl also no steam would be required for slacking.

14. Insulation of Bare Pipes & Tank in Chemical Recovery Section:

During the audit studies in one of the mills, it was observed that in chemical recovery section some pipelines and tanks were not properly insulated. The surface temperature when measured by audit team was found to be high and ranging between 80 - 160 ^oC. This resulted in high-energy losses through these uninsulated surfaces in the form of radiation. It was suggested to put proper insulation on the uninsulated surfaces of pipelines and tanks in chemical recovery section to reduce the heat losses through radiation.

15. Increasing the Temperature of the Flue Gas in Boiler to Increase the Service Life of the ESP:

In one of the mills, semi concentrated black liquor (SCBL) at a concentration of 45% TDS from the evaporators was further concentrated in the direct contact cascade evaporator using the flue gases from the recovery boiler. It was observed that the flue gas temperature after the cascade 1 & 2 units, in the MHI boiler, was only 110^o and 119^o C respectively. It was suggested that the exit gas temperature from the cascade evaporation must be maintained above the dew point of SO_2 i.e. above 149° C. The flue gas temperature could be increased by reducing the energy demand of the cascade evaporators by raising the MEE outlet concentration from 45% TDS to 50% TDS. It was proposed that by retrofitting a 3-section plate type concentrator prior to the existing effects, the outlet concentration of FF MEE could be raised. Higher product liquor concentration could be achieved in the LTV design evaporator by incorporating two additional falling film effects after the forced concentrator body.

16. Replacing the Steam Driven Ejector Sets with Vacuum Pumps in Multiple Effect Evaporator:

Steam ejector sets were used in the MEE for evolution of non-condensible gases from the evaporation plant in one of the mills audited. It was suggested that the lower operating costs could be incurred by replacing the steam ejector sets with vacuum pumps.

17. Installation of Secondary Surface Condenser and Stripping Column to Purify the Foul or Contaminated Condensate Generated from the Evaporation Plant:

In one of the mills, the secondary condensate at the rate of 230 m^3/hr. was generated from falling film & LTV Evaporators. This secondary condensate reportedly has black liquor entrainment. As a result of which, only 100-m^3/hr condensate is being utilized in the recausticization plant while the remaining condensate i.e. about 130 m^3/hr at 60° C was diverted to the E.T.P. It was suggested that the mill should install a stripping column to purify the foul condensate in order to facilitate the condensate return to power boiler. It was also suggested that a secondary condenser should be installed in series with existing surface condenser. The primary and secondary condenser should be so designed that the primary unit condenses approximately 85% of the vapor which contains only small amount of odorous & BOD producing compounds. The secondary unit condenses the remaining 15% of the vapor containing major quantities of these objectionable compounds. This arrangement permits separation & concentration of foul condensates and in turn would reduce the condensate stripping steam requirement.

IV. Stock Preparation and Paper Machine Section:

1. Use of Ferric Alum in Place of Non-Ferric Alum in Unbleached and Coloured Varieties of Papers:

The paper mills in India produce multiple varieties of paper. In one of the study it was observed that the mill apart from producing bleached grades, was also producing unbleached board and coloured varieties. Out of the total paper production of 77,974 tons per annum, the unbleached and coloured varieties account for 27,609 tons of paper per annum, which was about 35% of total production. For sizing the paper, the mill was using fortified rosin size and non – ferric alum/gum rosin at the rate of 1.2 – 1.5% and 7 to 8% respectively. The non-ferric alum was received in solid form by the mill. It was recommended to discontinue the use of non-ferric alum in unbleached and coloured verities. Non –ferric alum is generally used in bleached grades where brightness is an important parameter. Since brightness is not an important parameter in case of unbleached and colored varieties a rather cheap alternative of use of ferric – alum was suggested.

2. Replacing the Exhaust Fan in Paper Machines Hood:

In one of the mills, the dryer part of MF-1 & MF-2 paper machines were partly covered with hoods. The hood has ducts fitted with exhaust fan to draw the moisture laden air from inside the hood to atmosphere resulting from the evaporation from dryer surface on backside. On careful examination of duct, it was observed that design of exhaust fan in duct was not correct. In case of PM 1, the exhaust fan was attached to the shaft.

It was suggested that the design of existing exhaust fans should be changed. The electric motor, which was placed outside, should be removed and circular hole should be closed.

3. **Insulation of Steam and Condensate Pipelines in Paper Machines:**
During the visit the mills, it was observed that maximum number of steam, flash steam and condensate pipe lines coming in the dryer section of paper machine were not insulated. The surface temperature of these pipelines was as high as 110^0 C to 150^0 C. This indicated the high-energy loss in the form of radiation. This situation should be avoided because it results not only in energy losses but also increases the ambient temperature of working place causing problem for the persons working there.

It was recommended to put the proper insulation (asbestos rope type) on the bare pipes to reduce the heat losses through radiation and to save the energy.

4. **Installation of On -Line Streaming Current Titrator for Wet End Charge Measurement:**
In one of the mills, it was found that paper machines were not equipped with any on-line wet end charge-measuring instrument. Now- a-days, most of the high-speed machines are going for on line wet end charge measurements. This is necessary to manage the complex wet end chemistry more scientifically and with increasing flexibility. To-date, manufacturers have installed on line streaming current titrator on numerous paper and board machines throughout the world. These installations have shown that stabilization of wet end chemistry and control of the system cationic demand

and charge is the base for all benefits possible from the technology. The instrument provides an easy-to-use simple and practical approach for monitoring and control of paper machine wet end.

5. **Installation of On-Line Wire and Felt Cleaning System on Paper Machines;**

During the visit to the mills, it was found that paper machines wire and felt cleaning practice existing in mills was of conventional type i.e. the machine was shut for cleaning the wire and felts. It was suggested to install on-line wire & felt cleaning system on paper machines to reduce the downtime due to cleaning of wire and felts. Various on-line cleaning systems are available and details can be taken from the suppliers in this regard.

6. **Insulation of Sides of Dryers and M. G. of Paper Machines:**

The sides of the drying cylinders and M.G. dryers are generally not insulated which results in losses through these open sides in the form of radiation. The loss of heat from dryers sides resulted in lower drying capacity, more energy consumption or low speed of machine leading to production loss. During the audit studies, the CPPRI audit team suggested to insulate the sides of the drying cylinders/ M.G. of paper machines to reduce the heat losses through radiation.

7. **Proper Utilization of Cooling Tower in Paper Machines:**

Cooling towers installed in most of the mills were found to be under utilized During one of the study it was observed that 80% of total water being used in the cooling water (20m^3/hr) was being recirculated through overflow tank of cooling tower. It was also observed that the cooling tower fan was not running and as a result the temperature difference found was marginal. The close study revealed that fines coming with backwater blocked the cooling tower fins resulting in efficiency losses. It was recommended that the on line filters should be installed to separate the fines coming from machine backwater. The cooling tower fan should be repaired and started to get best efficiency of cooling tower (In winter season the fan was suggested to be stopped). Suggestions were given to utilize 100% water in all the vacuum pumps and other pumps in paper machines for avoiding use of fresh water.

8. **Use of Machine Back Water in Place of Fresh Water in Paper Machines:**
Paper machine is the area where maximum recycling of machine backwater takes place. In one of the mill it was observed that fresh water is being used at couch pit, thickner and Johnson screen in five paper machines. It was recommended that at these points, machine back water should be used which would not affect the paper quality.

9. **Recovery of Condensate from Paper Machines:**
Condensate is a valuable energy source and should not be wasted anywhere. During audit study in one of the mill it was observed that condensate in one of the paper machine was going to drain. The volume measured by audit team was approximately 60 LPM at temperature of 90°C. It was recommended that the condensate of paper machine be pumped to power boiler / D. M. Plant for its best utilization.

10. **Replacement of Defective Steam Trap at Paper Machines:**
Steam traps are provided in the steam pipelines to remove pipeline condensate without steam losses. However the leakage in traps results in major steam losses. During the studies made in plants, special attention was paid to trap monitoring and in most of the cases along with quantitative analysis of losses, it was observed that steam traps fitted at the steam line were not working properly. Suggestions were given to follow a regular

maintenance schedule for steam traps. In one case it was observed that the trap by-pass valve was kept open, and as a result the steam was being drained at the rate of 20 kg/hr. it was suggested to replace the existing steam trap with new efficient steam trap.

11. **Installation of VFD in Back Water Pump at Paper Machines:**

Variable frequency drives (VFD's) provide significant energy savings by regulating the motor speed and there by the flow from the pumps. This is a significant energy saving measure in cases where pumps are operating under capacity and the valves are throttled to regulate the water flow. During the audit study in one of the mills, it was observed that the backwater pump was running only with 25% valve opening. The matter was discussed with mill officials and they informed that the valve was adjusted according to grammage of paper and it varied from 120 m^3/hr to 250 m^3/hr. During the 25% valve opening the flow was 120 m^3/h and at this operating condition the efficiency of pump work out to 17.8%. Accordingly the pump efficiency would be 20% at 250 m^3/hr. flow for actual developed head of 10 meters. It was proposed to replace the existing pump with new pump of high efficiency (75%- 80%) and to regulate the flow with VFD, to control the flow precisely as per the requirement.

12. **Cascading the Steam & Condensate System Arrangement in Drying Cylinders of Paper Machines:**

Condensate is expensive with regards to its heat content and the water purification cost, therefore its wastage is considered as significant loss. All efforts should be made to recover the flash steam from condensate in processes wherever indirect heating/ drying takes place. Paper machine condensate is flashed in condensate tank and the flash steam is available for utilization. The available flash steam can be utilized by cascading the condensates flash steam in first group dryers. During the audit in one of the mill it was noticed, that the condensate generated from dryers, collected in condensate tank and pumped to Boiler House and the flash steam from the condensate was not utilized. It was proposed to flash the condensate in flash tank and use the flash steam in other groups of dryers using cascade system.

13. **Removal of Backwater Pump at Paper Machines:**

During an audit, it was observed that backwater generated from machine No. 6 was collected in an intermediate tank and then pumped to backwater storage tank at ground floor through a pump connected with 15 kW motor which was consuming 12 kW power. Detailed study revealed that pump was not required and could be by passed by laying straight pipe to backwater tank; as the water can flow through gravity. Therefore it was recommended that the back water collected in the side tank at back side of paper machine can go easily to backwater storage tank at ground level by gravity and there is no need to pump the backwater from first floor to ground floor.

14. **Increase the Capacity of Primary Centricleaner Reject Tank Installed at Paper Machines:**

During one of the studies, it was observed that centricleaners in the approach flow of paper machine were not functioning properly. The machine has two stage centricleaners. The reject of primary was passed through secondary stage and reject of secondary was going to drain. It was observed that the overflow of primary centricleaners mixing directly with the secondary reject was going to drain. This was due to low capacity of primary reject pit. It was recommended that primary centricleaner reject overflow to secondary reject should be stopped, by increasing the primary reject tank capacity.

15. **Use of Paper Machine Backwater In Place of Fresh Water at Couch Pit of Paper Machines:**

In one of the mills, fresh water was found to be used in the knock down shower of couch pit for removing the paper web from the wire. Fresh water was also used for dilution of pulp before pumping it to the chest. The shower was running most of time with an average flow rate of water about 80 liter/min. Use of paper machine back water was suggested in place of fresh water for the dilution of pulp at couch pit.

16. **Installation of Deckle Strip on the Sides of Wire Table near Slice Opening of Paper Machines:**

The studies in one of the mills, it was found that stock from the head box slice, spread all around the machine edges near breast roll, which resulted in the spillage of stock on floor and machine moving parts like table roll etc. This being direct loss of pulp and other additives, also spoiled the shop floor area resulting in bad house keeping. Deckle strip was suggested for installation on both sides of all 6 machines in the mill.

17. **Reusing of Cooling Water of Hydraulic Loading Unit of Refiner at Paper Machine:**

During audit study in one of the mills, it was noticed that about 80 LPM cooling water from hydrodynamic loading system of refiner at PM -I was going to drain. It was suggested to reuse this water in system itself by connecting the outlet pipe to incoming line.

18. **Installation of Horizontal Agitator at Couch Pit of Paper Machines:**

It was noticed that the couch pits of 6 paper machines were found not to be equipped with any agitator. During the time of break, paper web collected in couch pit was pumped to chest for mixing with machine stock. The paper web was diluted with fresh water. Due to lack of proper mixing of paper with water, the stock could not get homogenized and resulted in unnecessary load on the pump. Also the stock received at chest was not found to be uniform which ultimately disturbs the chest consistency and resulted in grammage variation of paper. It was proposed that mill should install proper agitators of horizontal type in the couch pits. This would result in proper mixing of stock and produce homogeneous stock as well as result in low load on pump. This would also reduce grammage variation and improve the paper quality.

19. **Proper Cleaning /Thickening at Hill Screen of Stock Preparation Plant:**
During the visit to one of the mills, it was observed that hill screen installed at stock preparation plant was not functioning properly. The inlet distribution pipe of hill screen was damaged from many places resulting in heavy stock flow from pipe. The most of the nozzles of pipe were also jammed. Most of the stock was going down the chest without any dewatering because of insufficient retention time to stock. It was proposed that inlet distribution stock pipe should be changed/repaired so that stock should flow across the full width of hill screen with enough retention time on screen and result in proper dewatering.

20. **Installation of Enclosed Hood at Dryer Sections on Paper Machines:**
In India many mills are using second hand paper machines and the machines are not equipped with enclosed hood. In one of the mills, it was found that the dryer section of 6 Nos. paper machines do not have any hood. Only machine No. 5 has open canopy over top of dryers, which was also not functioning properly. In absence of the hood in paper machine dryer, moisture evaporated from the paper surface can not be removed efficiently from machine house, which results in dripping problem especially in the rainy and winter season. It was recommended to place enclosed hoods on the

dryer section of paper machines. It should consist of an insulated enclosure above the operating floor. Front lifting panels and rear-sliding panels are used to provide access to the dryer above the operating floor.

V. Electrical and Utility Section:

1. Preheating the Combustion Air to 150°C in the Boiler:

In one of the mills, combustion air temperature in boiler was found to be maintained lower than the designed values. It was proposed that in order to attain better combustion efficiency, the combustion air must be preheated to 150°C.

2. Replacement of Oversized/ Under Loaded Motors with Small Sized Motors:

During the audit studies measurements were taken wherever possible, to ascertain loading of major LT induction motors in the plant with the objective of analyzing this data for identifying underloaded motors. It was pointed out that the operating efficiency and power factor of underloaded motors is lower resulting in wastage of energy. The motors, which are less than 60% loaded, are considered to be underloaded as there is more scope for saving through replacement or reshuffling of these motors. Suggestions were given to the mills for replacement of these motors considering the type of application that the motor had been put to, before trying to replace it with smaller motor of optimum rating. In this regard, high starting torque requirements, frequent process control variations, frequent emergency load - increase requirements, and future plans for capacity hike/modifications were taken into account. Considering these aspects and undertaking regular monitoring of underloaded motors, specific case-to-case decision were taken to replace them with smaller motors.

3. **Optimization of Fuel Combustion in Boilers:**

Energy audit team conducted measurements of excess air by using portable flue gas analyzer. In one of the mill the oxygen level in flue gases varied from 8.0 – 9.0 % in boiler No. 6 and 5.5 – 9.0 % in boiler No. 7. The high oxygen level in flue gases indicated excess air during combustion. The excess air was 63 – 69 % in boiler No. 6 and 47 – 68 % in boiler No. 7. The high amount of excess air takes away large amount of usable heat with it and results in higher losses through flue gas exit. Audit team suggested proper balance of ID and FD fans to maintain the oxygen level in flue gas between 5.0 – 5.5 % by proper damper opening or by installation of VFD.

4. **Maintain Uniform Ratio of Mixed Fuel in Boilers:**

Mills use mixed fuel like imported coal, raw lignite, pith, coconut shell and wood dust in Boiler No. 6 and 7 in different ratio. The variation was found in fuel feed rate and ratio for 6 days of the study period. It was suggested that the wide variation in fuel mix resulted in significant variation of calorific value and moisture in the fuel. As a result boiler-operating conditions were disturbed very frequently. This ultimately lead to variation in performance of boiler efficiency. The calculation conducted with operating parameter indicated that with in a period of 6 days, there was a variation of 1 – 2% in boiler performance efficiency, only due to variation in fuel mix. The moisture variation with feed variation disturbs the operation and efficiency of ESP's also.

5. **Reuse of Caustic Used in Regeneration in Strong Based Anions Cell of D.M. Plant:**

During the visit to one of the mills, it was noticed that 200 kg (solid basis) of caustic soda was being used for regeneration in strong base anion cell of DM Plant twice a day. Prior to feeding into the resin column, caustic was dissolved in water to make a solution of 60-70 gpl. The caustic supplied for regeneration was not used completely and about 35-40 % of caustic remain unused and was going to the drain. Out of two charges in strong base anion cell one wash was used to charge weak base anion and wash of another charge was going to drain. It was suggested that wash of another charge presently which was going to drain should be collected in a tank and can be use for caustic dilution / chemical recovery / pulp mill.

6. **Installation of Isolation Valve at D. M. Plant Vessels:**

In one of the mills, it was observed that anion / cation / mixed bed / filters vent lines were kept open continuously after venting the air, which was done mainly for easy operation of the plant and also there was no isolation valve. On an average approximately 180 LPM of water was going to drain continuously. It was recommended to provide isolation valve for the vessel vent pipe, so that valve can be opened and closed after venting the vessel.

7. **Installation of Permanent Pipeline with Shut Off Valve in Sampling Line at D. M. Plant:**

During the audit study in one of the mills, it was observed, that sampling line of polished water of ammonia dozing was continuously kept open and this polished water was going to drain through a hosepipe. Almost 20 LPM polished water (1.2 m^3 / hr) was going to drain through hosepipe. It was recommended that a permanent pipeline with a shut off valve can be installed in place of hosepipe from the main line and the sample should be drawn by opening the valve whenever required.

8. **By passing of Intermediate Screw Conveyor in Power Boiler:**

In one of the mills, it was observed that mill was using 3 nos. of screw conveyor to discharge the ESP ash. It was proposed to by pass intermediate screw conveyor by extending the Ist conveyor by about 2 meters.

9. Optimization of Fresh Water Consumption in Mill:

During the audit study in one of the mills, it was observed that in each section the fresh water taping of size 1" & 2" were provided for general purpose. These fresh water taps were noticed continuously kept open during audit studies as a result approximately 600 LPM fresh water was going to drain. It was proposed to provide 1/4" or maximum 1/2" taping in place of existing 1"/ 2" size of fresh water and also to provide plunger type valve to avoid wastage of fresh water.

10. Provide Local Electrical Switches in place of Common Switches:

It was observed that for general lightning purpose common switches were provided in many places i.e. mainly in Recovery Boiler & Finishing House Sections in one of the mills. Therefore all lights were in on condition in daytime because light was needed at a particular place. It was suggested to provide local electrical switches in place of common switches to avoid lighting during daytime wherever it was not needed.

11. Motor Efficiency Testing & Saving Potential by Replacing with Energy Efficient Motors:

In one of the mills, some selected motors were tested under load conditions as per IEEE specifications. The motors, which were running below the required efficiency level, were suggested to replaced by energy efficient motors.

VI. Others:

1. Collection of Over-Flow Water from High Pressure Cleaning Pump of Evaporator & Pulp Mill Section:

The overflow water of service tank provided with high-pressure machine was going to drain (Approximately 7.2 m^3/hr) in one of the mills, when studies were conducted. It is suggested to provide a service tank of MS/Concrete with high pressure pumps of capacity about 3-5 m^3 with control valves to re-use the overflow water which was going to drain.

2. Replacement of V-Belt by Flat Belt of Vacuum Pumps, Agitators and Air Blowers:

During the audit in many mills, it was observed that multi grooves V-Belt drives were in operation to run the vacuum pump and agitators. Flat belts being much more flexible than the V-belts and also requires less energy for traveling around the pulleys, friction losses are less compared to V-belts. Flat belt is free on the pulley since there is no wedging into the grooves and thus over all energy saving occurs. It was suggested that vacuum pumps and agitators should have flat belt type drive systems.

3. To By-pass the Mechanical Bar- Screen at E. T. Plant:

During audit studies in one of the mills, it was observed that mechanical bar screen installed in the main drain which was going to primary clarifier at ETP was not properly designed. The big size particles were going back to the drain instead of removing. Mechanical bar screens were installed after conventional bar screen and the big particles have already been arrested by these screens. Only few particles were going to mechanical bar screen (2 nos.), which were running with the help of 2 motors of 2 HP each. It was proposed that either mechanical bar screen should be properly designed to remove all foreign material or stop them. One person may remove these foreign particles twice in a shift.

4. To Use Single Super Phosphate in place of DAP as Nutrients in ETP:

In one of the mills, it was observed that mill was using Urea and DAP as nutrients for bacteria in the aeration tank at effluent treatment plant. About 850 kg urea and 300 kg DAP were being used every day. It was proposed that mill should use Single Super Phosphate in place of DAP. To maintain the same dosing of nitrogen and phosphorous, mill has to increase the quantity of urea to 971 kg per day from 850 kg per day, But the quantity of Single Supper Phosphate would be required only 225 kg/ day in place of DAP (300 kg/day).

AGRO BASED PULP AND PAPER MILLS:

I. Raw Material Preparation and Handling:

1. Washing of Bagasse Before Feeding to Digester:

The bagasse contains large amount of free sugars, water soluble components etc. During storage, these sugars convert in to alcohols, acetic acid, lactic acid etc., which ultimately consume some amount of cooking chemical. In one of the mills the depithed bagasse was going directly to the digesters for cooking. In case bagasse is processed through existing hydra pulper drainer washing system, it can remove a portion of the pith and large portion of the fine dirt, sugars and acids. It was suggested that the mill should use the existing hydra pulper drainer washing system normally used for straw washing to wash the depithed bagasse depending upon the availability of the washing system. Mill can save up to 2.0 % of cooking chemical to produce same kappa pulp with improvement in unbleached pulp yield by 3.0 % and bleached pulp yield by 2.0 %.

2. Connect Raw Material Washing System with Continuous Digester through Belt Conveyor:

In one of the mills, wheat straw coming out of hydra pulper drainer washing system has temperature around 45 – 51 ^{0}C. The washed wheat straw was first dumped on ground and then sent to continuous digester through belt conveyor. In this process the temperature of wheat straw came down to 25 – 35 ^{0}C in summer, in winter season the temperature may come down to 15 - 20 ^{0}C. By connecting the washing system to continuous digester with a conveyor belt, the temperature of washed wheat straw could be maintained on relatively higher side, before feeding to continuous digester. It would save huge amount of steam used to increase the raw material temperature from

25 ^{0}C to 45 ^{0}C. It was suggested that a covered conveyor belt system should be installed between hydra pulper drainer washing system to the existing conveyor for continuous digester for transferring the hot wheat straw discharged from washing system to the continuous digester. This would prevent the heat losses occurring in dumping and transportation of wheat straw.

3. **Proper Stacking of Bagasse and Wheat Straw:**

During the visit to one of the mills, it was noticed that bagasse and wheat straw was not stacked properly and raw material was falling down in the side drains, thus chocking the drain lines. It also deteriorates the raw material quality, which ultimately affect the final product i.e. paper. It was suggested that mill should stack bagasse and wheat straw properly. The proper stacking of bagasse / wheat straw would help in conservation of raw material.

4. **Covering of Bagasse and Wheat Straw Conveyor Belts:**

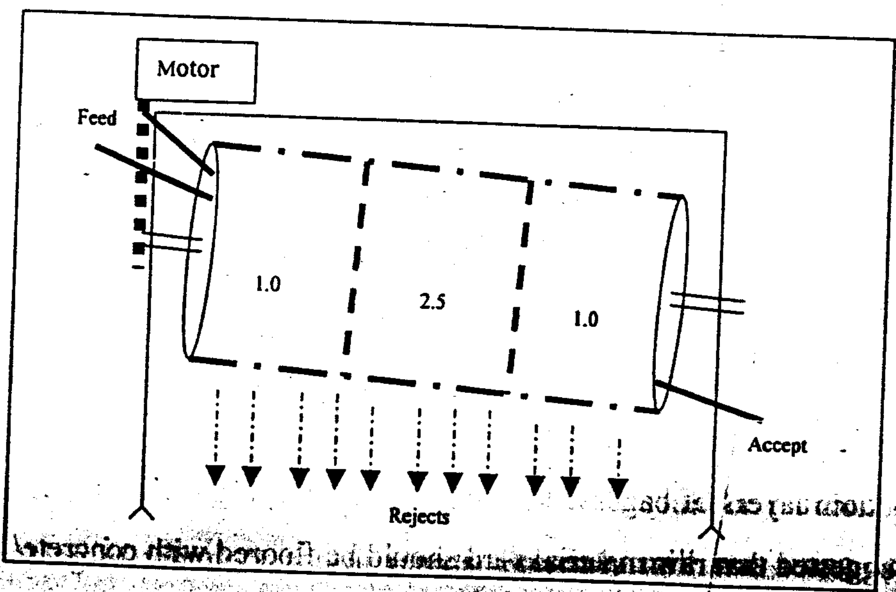
In one of the mills, it was observed that the conveyor belts conveying bagasse and wheat straw to depither and then to digester were not covered resulted in poor house keeping and loss of raw material due to removal of raw material during strong wind or on rainy days. It was suggested that mill should cover all the conveyor belts from the top to reduce the loss of raw material in rainy season. It would also save the falling of wet raw material during rains on the moving part of conveyor belt, thus reducing the maintenance cost.

5. **Use of Fresh Wheat Straw in Place of Stored Wheat Straw as Furnish:**

It was observed that a mill was using about 42% of wheat straw as a raw material in its furnish with an annual consumption of 12000t/annum. Mill stored a good amount of wheat straw for its use during off seasons. Mill was using the stored wheat straw first and fresh straw was stored. It was suggested that mill should use the fresh wheat straw directly and store the rest incoming wheat straw to save the transportation cost incurred during the handling of raw material inside the mill.

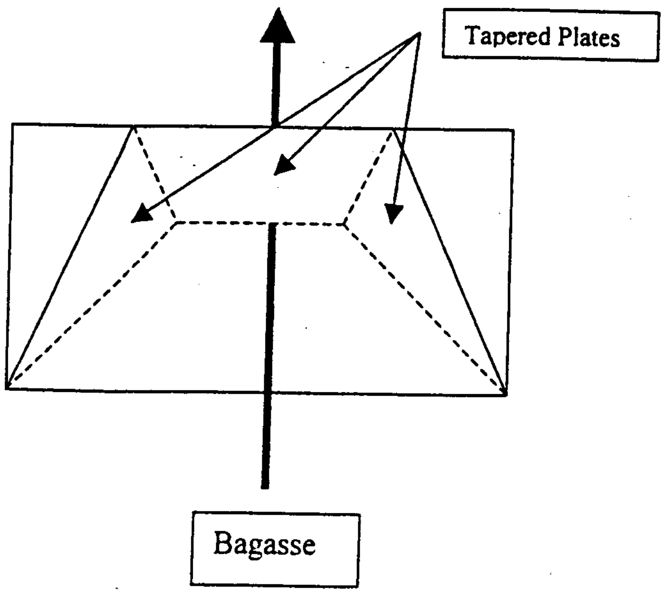
6. **Installation of Drum Cleaner for the Cleaning of Wheat Straw:**

   One of the mills using wheat straw and bagasse as a main raw material did not have any system for cleaning of wheat straw. Both bagasse and wheat straw were mixed at the beginning of the conveyor belt and fed to depither. The depithed bagasse and wheat straw were then fed to digester. The feeding of wheat straw without cleaning resulted in the entry of lot of dirt, grains, shives and unwanted material in the system increasing the load on cleaning equipment on one side and deteriorating the paper quality on other side. It was suggested that mill should install a drum type cleaning system to clean the wheat straw from any shives, dirt, grains, particles, stone etc.



7. **Installation of Feed Controller at Baggase Conveyor:**

During the visit to one of the mills, it was observed that the raw material (loose bagasse) was being put on conveyor belt manually, which was fed to depither for dephithing. The bagasse feeding was not controlled by any control device resulted in overloading/idle running of depither with 100 HP motor, therefore the operator deputed at depither had to stop the whole bagasse feed conveyor. It was suggested that a feed controller should be installed for constant feeding to depither. The feed controller may be fabricated locally as per the requirement.



8. **Raw Material Yard Flooring with Concrete/Bricks:**

It was observed during visit to one mill that raw material (Bagasse) procured from near by sugar mills was stored in open area (Approximately 100 stacks). Only 50 stacks have flooring with Concrete/bricks, rest stack do not have proper flooring resulted in the deterioration of raw material in the 2 or 3 bottom layers of bagasse bales as the material is stored for 8 months. It was suggested that raw material yard should be floored with concrete/bricks along with proper drainage system.

9. **Installation of Side Guard on Wastepaper Conveyor:**

It was observed in one of the mills, that the side guard was not provided for waste paper/KCB conveyor system resulting in poor housekeeping and wastage of raw material due to falling of waste paper from sides. It was suggested that side guard should be installed at waste paper conveyor.

II. Pulp Mill Section;

1. **Increase the Bath Ratio in the Continuous Digester:**

Generally continuous digesters are known to produce uniform pulp, however during the audit in one of the mill the Permanganate number of unbleached pulp produced from continuous digester varied from 12–19 (in terms of kappa number, the variation is ≈ 18-30). It was suggested that the bath ratio should be increased from 1:2 to 1:3.5 for proper liquor penetration and digestion. The desired bath ratio can be attained by addition of appropriate quantity of weak black liquor.

2. **Re-cooking of the Rejects of Vibrating Screen:**

It was observed in one of mills, that mill was screening their pulp by using Vibratory screen, Centrifugal screen and centricleaners. The rejects coming out from these cleaning equipments were estimated as given below:

Vibratory screen rejects (0.5 tonnes/ day)

Centrifugal screen rejects (2.0 tonnes/day)

TCC rejects (2.0 tonnes/day)

Thus approximately 4.5-tonnes/day roughly equivalent to 7.0 % of the total pulp produced was being lost. A portion of this could be reduced through re-cooking of vibratory screen rejects. Presently mill was using screen plate with 14 mm diameter holes in vibratory screen of unbleached pulp. It was suggested to reduce the screen diameter of plate from 14 mm to 8-10 mm. This would result in reduction of centrifugal screen rejects and tertiary centricleaner rejects. By reducing the screen diameter of plate from 14 mm to 8-10 mm, the major portion of uncooked raw material/pulp can be retained on vibratory screen, and can be re-cooked with the raw material.

3. **Utilization of Flash Steam of Blow Tank for Heating Water:**

In one of the mills, the wheat straw pulp from continuous digester blown along with the weak black liquor was collected in the blow tank. The bagasse/sarkanda pulp from batch digesters was also blown to blow tank. The flash steam from blow tank was vented into atmosphere without blow heat recovery. It was suggested that the existing heat exchanger may be utilized to heat the water by utilizing the flesh steam generated in the blow tank. This hot water can be used at the washers of bleach plant or in felt washing of paper machine.

4. **Insulation of Rotary Digesters, Blow Tank, Steam Pipelines, Hot Black Liquor and Pulp Lines in Pulp Mill:**

During the audit in one of the mills, it was observed that mill has 10 rotary spherical digesters and some of them were found to have improper insulation. Similarly insulation was not provided at blow tank, blowpipe lines, pulp pipelines up to washers and hot black liquor lines, and these resulted in considerable heat losses.

It was observed that in most of the cases that the insulation in digester house does not stand longer due to handling of corrosive materials. It was suggested to plan a preventive maintenance schedule for insulation in pulp mill to avoid the heat losses. A monthly check up of insulation in pulp mill and corrective measures taken up immediately would yield significant savings to the mills.

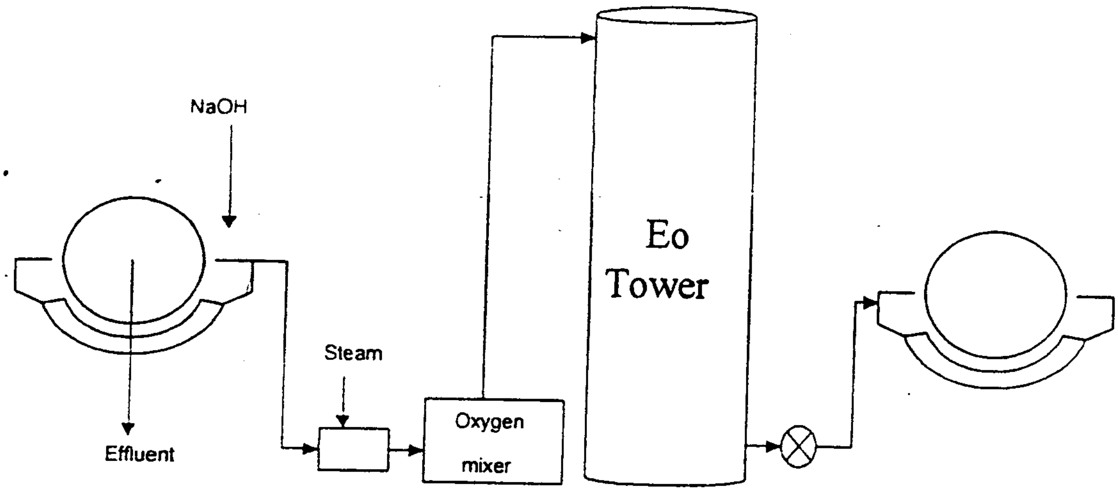
5. **Installation of Barometric Leg on Brown Stock Washer No. -1& 2 and at Alkali Washer:**

The mill audited has 4– stage brown stock washing system and at BSW No. 1, BSW No. 2 and at alkali washer, vacuum pumps were used.

It was suggested that the mill should use barometric legs for displacement of liquor in 1st & 2nd stages of pulp washing and at alkali washer. In this way, mill can reduce its electrical consumption by replacing existing vacuum pumps with barometric legs.

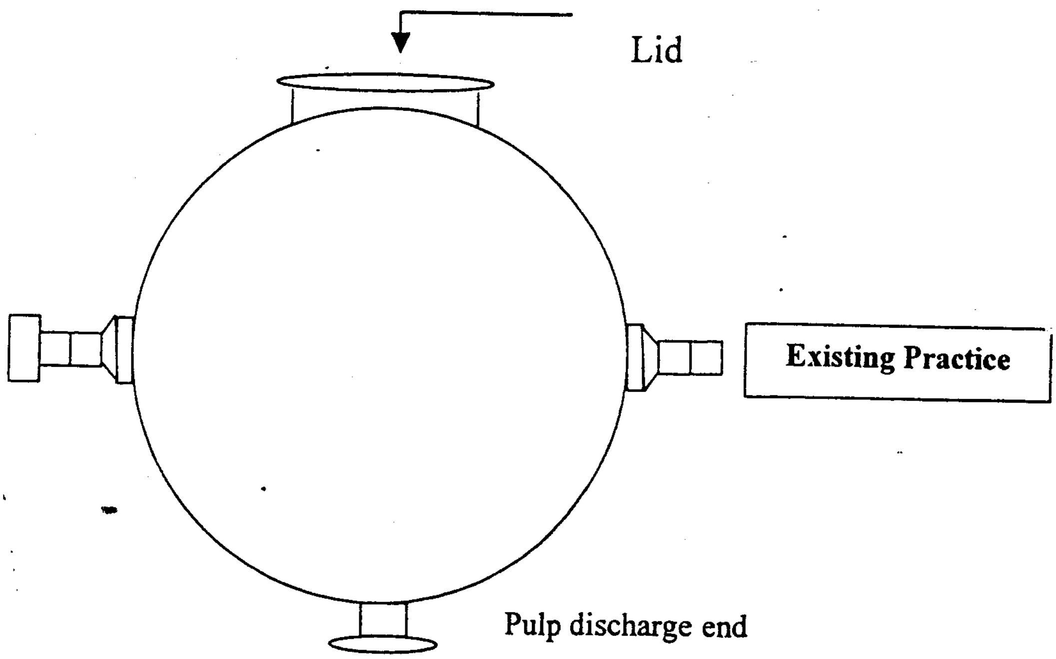
6. **Adoption of Oxidative Extraction (Eo):**

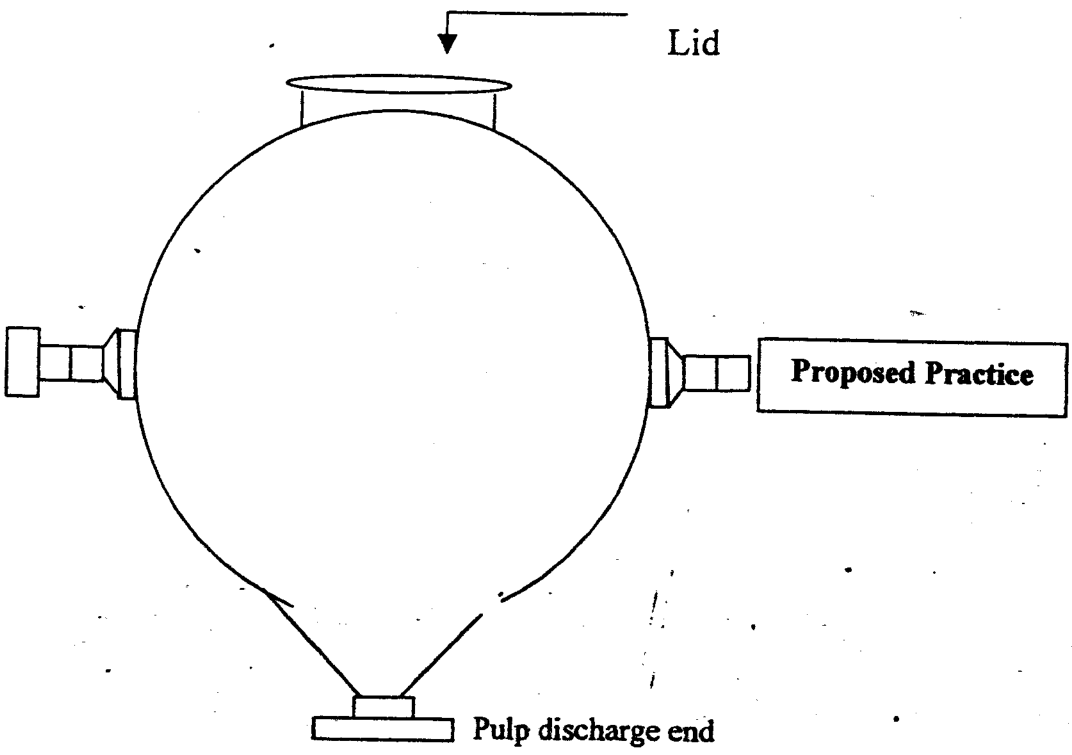
Use of gaseous oxygen in the extraction stage of bleaching enhances the removal of lignin present in the pulp. In one of the mills, it was observed that by adoption of oxidative extraction (Eo) in the existing CEHH sequence, 25-30% more Kappa-number can be reduced without affecting the pulp qualities, like freeness, viscosity etc. The effluent from bleaching sequence containing oxidant in the extraction stage applied on chlorinated pulp shows 27-70% decrease in colour. It is possible to lower kappa number of pulp and increase brightness by using oxygen at extraction stage. The existing CEHH sequence of bleaching can be converted in to CEoHH bleaching sequence by putting up an oxygen mixer in place of existing alkali mixer.



7. **Modification in the Design of Spherical Rotary Digester for Complete Blow Down of Cooked Pulp:**

During the audit in one of the mills, it was noticed that the mill was using spherical rotary digesters for cooking the raw material and the pulp was not completely blown down in blow tank after cooking. Some amount of cooked pulp always left in the digester. This left over was blown down on the floor and was cooled down and after dilution by paper machine backwater pulp was pumped to the chest. The above procedure indicates that the design of the spherical rotary digester was not proper. There should be no pulp left in the digester after blowing. The practice of dumping the pulp on the floor and diluting it with machine backwater resulted in excessive heat loss that could be otherwise recovered in blow tank. Beside this it also accounted for increasing pumping cost incurred during the pumping of the pulp. It was suggested to modify the design of the digesters as per the proposed design of CPPRI audit team.


Lid
Existing Practice
Pulp discharge end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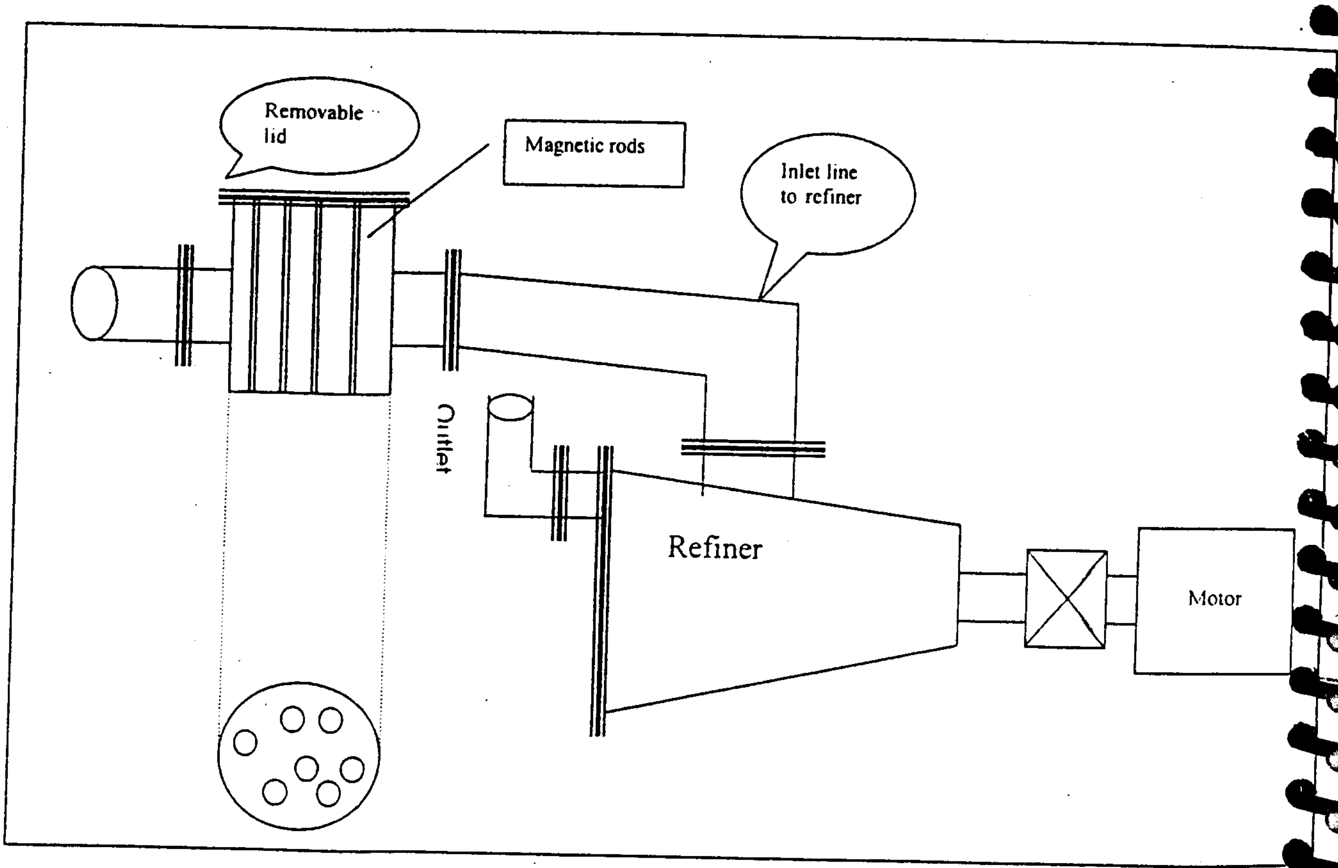
Proposed Practice
Pulp discharge end

8. Installation of Magnetic Traps before Refiners in Pulp Mill:

In one of the mills, it was observed that mill was using waste paper as raw material and there was chance of having metallic contaminants / impurities in the form of nails, pins etc. in spite of good sorting practice carried out at mill. There might be a chance of carryover of small iron pieces in the fibre line, which could reduce the life of refiner plates. A magnetic trap should be installed in the inlet line of refining. The magnetic trap has magnetic bars inside, which can trap the metallic pieces and would not let the iron particles to go in the refiner. The trap is cleaned periodically for removing the contents.



9. **Insulation of Blow Tank Pipelines in Pulp Mill:**

During the visit to one of the mills, it was noticed that blow tank pipelines taking pulp to blow tank and recovered steam for water heating were not insulated. This resulted in high-energy loss through these uninsulated surfaces in the form of radiations. The loss of heat resulted in the poor heat recovery from blow tank. It was suggested to put proper insulation on the uninsulated pipes to reduce the heat loss through radiation.

10. **Replacement of SDR by TDR in Pulp Mill:**

The mill audited has installed one single disc refiner for refining its pulp after washing in potcher in unit - I before pumping it to the vibratory (Johnson) screen. The refiner was running continuously by a motor of 100 HP. It was suggested that the SDR should be replaced by TDR as it is more energy efficient. A TDR consumes 20% less energy to maintain the same properties as SDR. This is due to the decrease in the size of TDR and increasing refining surface (two disc surface as compared to single disc in SDR). Besides the energy, the TDR action results in greater bonding strength development, less cutting, more fibrillation and less damage to the fiber.

III. Chemical Recovery Section:

1. **Indirect Steam Heating of Strong Black Liquor Feed to Venturi Cyclone:**

In one of the mills, strong black liquor from the evaporator at 25% solids was further concentrated to 40-45% solids by direct contact with the flue gases (from the Fluidized bed reactor) in the venturi cyclone. The strong black liquor feed temperature of 90^0C to the venturi cyclone was maintained through line heating utilizing 2 tonnes/ day of live steam of 10 Kg/ cm^2

pressure. It was suggested that indirect heating of strong black liquor should be adopted to maintain strong black liquor feed to venturi at 90^0C.

2. Insulation of Weak Black Liquor Storage Tanks:

In a mill the chemical recovery section of mill was receiving over 900 m^3/ day of weak black liquor from the pulp mill at a temperature of 65^0C. The weak black liquor was stored in two weak black liquor storage tanks before feeding in the evaporation plant. It was observed that the weak black liquor storage tanks were uninsulated and as a result the temperature of the weak black liquor dropped down to 58^0C from 65^0C. It was suggested that weak black liquor storage tanks be provided with a lining of heat insulating material so as to reduce the heat loss through radiation.

3. Installation of Pre-heaters in the LTV Evaporator:

During the study in one of the mills, it was observed that mill was equipped with a 7 body, 6 effects LTV evaporator with the following liquor flow sequence E6 – E7- E5- E4 – E3- E1. There were no preheaters in the evaporation plant and the steam economy was low ie 3.2. It was suggested that preheater bodies be incorporated in the plant with the following liquor flow sequence E6 - PH6 - PH7- E7 – PH5- E5 –E4 - PH3 – E3 – E1.

IV. Stock Preparation and Paper Machine Section:

1. Installation of Enclosed Hood on Paper Machine Dryer Section:

In one of the mills, the dryer section of the paper machine did not have enclosed hood. The dryers were covered only on topside. The side panels were not fitted along the full length of dryers. The exhaust fans of the hood were also not in running condition. As such the moisture evaporated from the paper surface at dryer section was not removed completely from machine house, which resulted in dripping problem especially in the rainy and winter seasons. It was recommended to place an enclosed hood on the dryer section of paper machine. It consists of an insulated enclosure above the operating floor. Front lifting panels and rear sliding panels are used to provide access to the dryer above the operating floor. The purpose of basement enclosure is to provide the control of air infiltration from the basement enclosure. This type of hood would increase the drying capacity of machine result in an increase in the speed of machine. An increase in speed of machine by 15 meter/ minute to 20 meter/ minute would result on an average about 1650 tons more production annually.

2. **Cascading the Steam and Condensate System Arrangement in Drying Cylinders of Paper Machine:**

In a mill the paper machine dryer section had overall 28 number of dryers divided into six groups. The dryers were heated by steam supplied from power house at a pressure of 3.5 kg/cm^2. One line of steam was also coming from power house at a pressure of 9.00 kg/cm^2. The condensate collected from the dryers was taken into a condensate-collecting tank from where it was pumped back to boiler house. The flash steam collected from condensate was used to heat the zero group dryers having six numbers of drying cylinders. Other dryers were heated with live steam. It was proposed that flash steam should be used in some other groups of dryers by using cascade system. It was also suggested that differential pressure and blow through steam must be created to drain the dryers. The steam and condensate handling system outside the dryers is responsible for creating the differential pressure and handling the blow through steam in an efficient manner.

3. **Insulation of Steam and Condensate Pipelines, Drying Cylinders Side Faces at Paper Machines:**

Like wood based mills, in agro residue based mills also steam, flash steam and condensate pipelines in the dryer section of paper machines were not found insulated properly. It was recommended to put a proper insulation on the bare surfaces to reduce heat loss through radiation.

4. **Putting Up of Exhaust Fan/ Blower in the Area between Size Press and First Dryer of Fourth Dryer Group:**

During the audit in one of the mills, it was noticed that the gap between the size press and first dryer of the fourth dryer group was large. Since there was no dryer in this space, the ambient temperature in this region would remain low in comparison to other dryers. In winter season, the water vapors evaporated from the web condense quickly in this region as compared to other part of dryers causing dripping on the paper. Since paper runs without any support in this region, paper easily get broken causing poor machine runnability and loss in production. It was recommended that there should be a proper exhaust of moisture-laden air from this region either by exhaust fan or pocket ventilation system. This will help in reducing the paper breaks in dryer section and hence improve the machine runnability. An average break, if consume 10 minutes in rethreading of sheet and four breaks per day due to dripping in this particular section will result in the loss of 2.5 T of paper per day.

5. **Fiber Recovery from Paper Machine White Water:**

During the study in one of the mills, it was observed that there was no fiber recovery system on paper machine to recover the fibers and chemicals from the paper machine backwater. The machine backwater was used in various sections in pulp mill and paper machine for dilution purpose without any fiber recovery. From many points, in pulp mill these fibers and chemicals went to ETP through various drain lines. It was recommended that mill should install proper fiber recovery system either sedimentation type conical (Mark) saveall or flotation type Krofta Saveall.

6. **Improvement of Glaze in Paper:**

   Glaze on Paper surface is an important surface property of a paper manufactured on MG machines. During the visit in one of the mills, it was found that the glaze of the paper was not very satisfactory. It was recommended that mill should take proper care to improve its quality. Some of the suggestions are listed below:

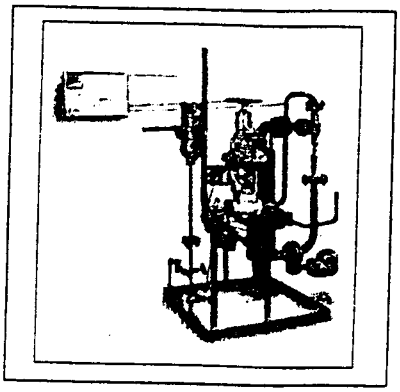
   - Installation of doctor blades on dryer surface to clean the dryers properly.
   - Gradual increase in dryers temperature especially at wet end dryers.
   - Regular monitoring of dryer temperature profile.
   - Use of chemicals like cartaflex etc. for the improvement of glaze.

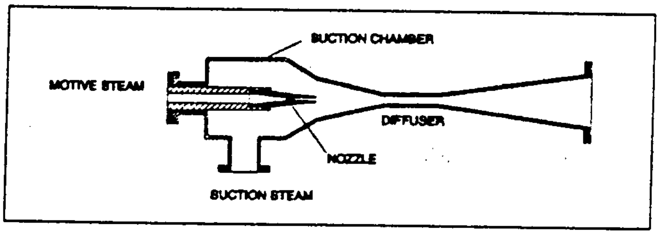
7. **Recirculation of Vacuum Pumps Sealing Water:**

   In this mill, fresh water was being used for the sealing of vacuum pumps. This fresh water was not recycled and was continuously drained to effluent plant. On taking the measurement, roughly 3-4 m^3 of fresh water was used per hour in vacuum pumps for sealing purpose. It was suggested that sealing water used in vacuum pumps should be recirculated. For this purpose a small pit may to be constructed to collect pump sealing water and can be recirculated through a small pump to all vacuum pumps.

8. **Use of Flash Steam in Wet End Dryer Group Using Thermo-Compressor:**

In a mill, the flash steam generated from the condensate collected from the dryer groups was used for heating the backwater in paper machine silo and condensate was pumped back to boiler. In paper machine there was no flash steam recovery system and condensate along with flash steam was pumped directly to boiler. Thus the mill was neither recovering flash steam from the condensate system, nor utilizing it properly, thus loosing a good quantity of heat energy. The flash steam if recovered properly from the dryer's condensate; can be used in wet end dryer group where temperature requirement is less. This will save the live steam and hence reduce load on boiler house. It was suggested that mill should use thermo-compressor to reclaim low pressure flash steam that is otherwise vented or go waste. Small quantities of low-pressure flash steam are compressed to a reusable pressure using thermal vapour recompression technology.





Thermo compressor

9. **Recovery of Fiber from the Tertiary Centricleaners Rejects:**

During the audit in one of the mills, it was observed that valuable fibers were also coming out in the rejects of tertiary centricleaner. A sample of these rejects was collected and analyzed in CPPRI laboratory for fibre classification. The Baur McNett result of tertiary centricleaners reject sample indicated that sample has more than 50% of long fiber content. This long fiber (+50) content should be recovered for paper making after separating it from –200 fraction (i.e. dirt particles, sand particles etc.). It was recommended that mill should clean its reject from sand and dirt particles after passing it through the raffler. The cleaned fiber portion should be thickened either by passing it through decker or hill screen before being fed back into the system.

10. Improving the Condensate Recovery from Paper Machine Drying Cylinders:

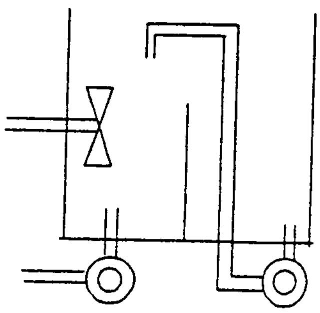
Mills should try to recover most of the condensate generated in different sections during various operations. In one of the mills, it was found that the condensate recovery from the dryer section was on lower side i.e. only 60%. Due to the lack of installation of proper monitoring device in the boiler house, actual amount of recovery could not be measured. During the visit to the paper machine, many leakages and uninsulated condensate line were found. Mill was advised to take necessary action.

11. Removal of J. Screen Pump:

During the audit in one of the mills, it was observed that the stock after SDR was collected in S. S. tank and then pumped to the dilution box of J. Screen by a pump attached with 20 HP motor in pulp mill -I. Normally SDR/TDR has sufficient pumping capacity at delivery end, therefore it was suggested that mill can take a trial by making a direct pipe line from SDR to dilution box of J. Screen and by passing the existing S. S. tank and J. Screen pump.

12. Modification in Machine Chest of Paper Machines:

In one of the mills, it was observed that machine chests of both the paper machines were divided into two chambers and equipped with one agitator and two pumps. The over flow of SR Box and chamber No.1 came into chamber No 2. and again it was being pumped to chamber No. 1 by 7.5 HP pump. It was suggested that a rectangle hole or passage can be made at the bottom of partition wall of machine chest as shown in the diagram below.



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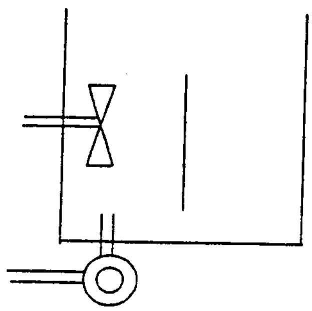


Proposed

V. Utility Section:

1. Optimization of Fuel Combustion in Boilers:

Like wood based mills, in some agro based mills also the oxygen % in flue gases was found on higher side. The high oxygen level in flue gases indicates excess air during combustion. The high amount of excess air carries away with it large amount of usable heat and results in higher losses through the flue gas exit. It was suggested that ID and FD fans may be properly balanced to maintain the oxygen level in flue gas between 5.0-5.5% by proper control of dampers or by installation of VFD.

2. **Feeding of Fuel With Uniform Moisture in Boilers:**

   During the audit study period of four days in one of the mills, it was observed that mill was using rice husk as a fuel in boiler and a lot of variation was found in the moisture level in the fuel being fed to the boiler no. 4. As a result the boiler operating conditions were disturbed which ultimately led to variation in efficiency. The observations made by the study team revealed that with in a period of 4 days, there was a variation of 1-2% in boiler performance efficiency only due to variation in fuel moisture. The moisture variation disturbs the operation and efficiency of dedusting devices also.

3. **Replacement of Oversized / Under Loaded Motors with Small Sized Motors:**

   Measurements were taken wherever possible, to ascertain loading of major LT induction motors in the plant with the objective of analyzing this data for identifying under loaded motors. It was pointed out here that the operating efficiency and power factor of under loaded motors comes down resulting in wastage of energy. The motors, which were less than 60% loaded, had been considered to be under loaded as in this case there is scopes for saving through replacement or reshuffling. However, it is essential to consider the type of application that the motor has been put to, before trying to replace it with smaller motor of optimum rating. In this regard, high starting torque requirements, frequent process control variations; frequent emergency load-increase requirements, and future plans for capacity hike/ modifications should be taken into account. Considering these aspects, and undertaking regular monitoring of under loaded motors, specific case-to-case decision should be taken to replace them with smaller motors.

4. **Insulation of Steam and Mud Drums of Boiler:**

During the visit in one of the mills, it was noticed that steam and mud drums of boiler were not insulated. The surface temperature when measured by CPPRI team was found to be as high as 125°C. This results in high-energy loss through/these uninsulated surfaces in the form of radiation. It was suggested to put proper insulation on the uninsulated areas to reduce the heat loss through radiation.

5. **Increasing the Height of Stack Attached with D.G. Sets:**

The height of stacks attached with all the three D.G. sets was found nearly at the same level of the roof of D.G. rooms when studies were conducted in this mill. The exit gases coming out from the stack could not raise to proper elevation to dispersed in atmosphere. As per the rule the minimum stack height should be 7 meters and 4.5 meters above the roof of D. G. rooms for the D.G. sets of 1250 KVA and 500 KVA respectively. It was recommended that the height of stack should be raised to proper level to control the air pollution.

6. **Insulation of Condensate Returns Line and Feed Water Line of Boilers:**

In agro residue based mills also, it was observed that in some of the mills condensate return line and Feed water line were not insulated.

It was suggested to put proper insulation on all the mentioned surfaces to reduce the heat losses through radiation.

7. **Reuse of Caustic Used in Regeneration of D.M. Plant:**

During the visit in one of the mills, it was noticed that 25 kg of caustic flakes were being used for regeneration of D.M. plant per day. This caustic was dissolved in 200 liters of water prior to feeding into the resin column. Caustic used for regeneration was not consumed completely and about 30% caustic remains in the drain water, which was tested and confirmed in mill's laboratory during visit. It was suggested that drain water after regeneration, presently, which was going to drain (200 liters) should be collected in a drum/tank and be used in digester.

8. **To Stop One Rice Husk Feed Conveyor of Boilers;**
   In one of the mills, it was observed that fuel (Rice husk) was being fed to hopper of boiler no. 4 by two belt conveyors simultaneously. Both the conveyors were running at just half of its capacity i.e. approximately 2.5 t/hr, and total running hrs. of each conveyor was approximately 15 hr/day. It was recommended to stop one conveyor belt and double the load on the other conveyor.

9. **Optimization of Excess Air in FBC Boilers:**
   It was observed that oxygen percentage in Boiler No. 4 was on higher side i.e. 11.1% in this mill resulting in excess air of 114%. It was recommended to optimize excess air by proper controlling the damper of I. D. fan & F. D. fan and accordingly changing feeding parts & to arrest free air entering into the furnace or duct. For this, mill has to install close loop combustion control system in the online O_2 sensor system.

VI. Others:

1. **Use of Treated Effluent in Place of Fresh Water for the Preparation of Milk of Lime (MOL) in Effluent Treatment Plant:**
   During the audit in one of the mills, it was observed that to increase the pH of effluent generated from chlorination washer of bleach plant (pulp mill), prior to addition with the effluent generated from other sections of the mill in equalization tank and to further maintain the pH in reaction tank, milk of lime (MOL) is used. To prepare this milk of lime (MOL) around 2-3 tonnes

of lime and 100 m^3 fresh water were being used every day. It was suggested that mill can use treated effluent in place of fresh water for the preparation of milk of lime. However, the requirement of the lime may be higher marginally i.e. 2-3% due to low pH of treated effluent than fresh water.

2. **Slogans for Energy Savings:**

   In most of the mills, it was observed that slogans regarding energy conservation were not displayed properly. As the slogans are important tools to create awareness among the staff members and workers in the industry, it was suggested that energy saving slogans should be written in different areas of plant (especially in the areas of high energy consumption) in simple and in attractive manner. This will motivate the people at grass root level to save energy.

3. **Installation of Proper Monitoring Devices to Monitor Section Wise Steam Consumption:**

   During the audit in many mills, it was observed that section wise monitoring system for steam consumption was not in practice due to which it is very difficult to know the area of high consumption. It was recommended that mill should install proper monitoring devices for proper monitoring of steam flow rate in various sections. This will help in root cause analysis for the high consumption of steam in the particular section.

4. **Installation of Water Flow Meter in Feed Water Main Line Instead of Bypass Line:**

   In this mill, it was observed that water flow meter was installed in the bypass line of main feed water line instead of main line in power boiler section. That was entirely wrong. For the correct measurement of incoming water to the boiler, flow meter should be placed in main line and not in bypass line, which remains shut for most of the time. It was recommended to change the flow meter position.

5. **Replacement of V-Belt Drive of Vacuum Pump by Flat Belt:**
As a general practice, in some of the mills of agro sector are also using multi grooves V belts drives to run the vacuum pumps. The major disadvantage of V-belt is that these absorbs a great deal of useful power and adds running costs. These power losses are typically dissipated in the form of heat, which in tern has a deteriorative effect on the belt life. It was recommended that vacuum pumps should have flat belt type drive system in place of multi grooves V belts drives.

6. **To Stop Water Leakages in Mill Colony at Different Points:**
During the audit in one of the mills, it was observed that there were several leakages through water supply line, tanks and valves in the paper mill colony. It was suggested that these leakages should be stopped on priority by repairing all the leakage points. Meanwhile mill can go for rostering the water supply to the colony to minimize the wastage of water.

7. **Use of Fresh Wheat Straw in Place of Stored Wheat Straw in Furnish:**
This mill was using 42% of wheat straw as a raw material in its furnish with an annual consumption of 12,000 t/annum. Mill stored a substantial amount of wheat straw for its use during off-season. It was also observed that mill always use the stored wheat straw first and store rest of the incoming wheat straw. It was suggested that during the season, mill should use the fresh wheat straw directly and store the rest incoming wheat straw.

9. **Recycling of Waste Water Generated from Potchers:**

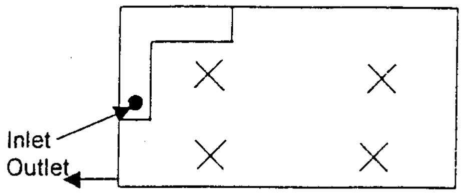
   It was observed in one of the mills that in pulp mill, fresh water/back water was being used to wash the pulp in all four potchers. The estimated quantity of water was 190 m^3/hr, which was going to the anaerobic lagoon at ETP. It was suggested to recycle at least 50% of the waste water from potchers in other areas of pulp mill after discarding first 90 minutes water to anaerobic lagoon.

10. **Optimization of Nutrients Dozing at ETP:**

    During the audit in one of the mills, it was observed that as nutrients 300 kg single super phosphate and 200 kg urea were added to aeration tank directly once in a day. As the nutrients were being fed directly in the aeration tank, the doze will not remain same throughout the day resulting in an unbalanced nutrition to the microbes. Therefore it was recommended to dissolve the single super phosphate and urea in the separate dissolving tanks prior to addition in the inlet of aeration tank after adjusting the flow as per the requirement.

11. **Modification of Outlet line in Aeration Tank at ETP:**

    In one of the mills, it was observed that in aeration tank at Effluent Treatment Plant, inlet and outlet lines were installed at the same side and were very close to each other resulting in improper aeration of effluent. The inlet and outlet lines should be on opposite side to get maximum efficiency of aerators. Therefore it was recommended to shift outlet point accordingly.



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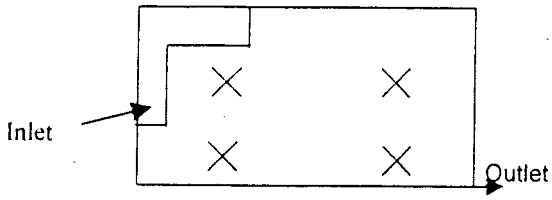


Proposed

12. **Replacement of Existing Pumps at E. T. Plant:**

During the visit in one of the mills, it was observed that two pumps were under operation for pumping the wastewater (from sump pit to anaerobic lagoon -10 H P & 7.5 H P and from sump pit to primary clarifier). It was suggested to install or operate the single pump of better efficiency. Also the weak black liquor coming from potcher was being pumped to anaerobic lagoon by two pumps (10 HP & 7.5 HP). The same quantity of liquor can be pumped by single better efficiency pump of 10 H P. Similarly same type of pump can be used to pump liquor from sump pit to primary clarifier.

WASTE PAPER BASED PAPER MILLS:

I. Raw Material Preparation and Handling:

1. **Manual Sorting of Raw Material for Cleaning Waste Paper:**
   During the visit in one of the mills, it was observed that the mill has no specific department / persons for sorting of waste paper. Large contaminants like Iron Wires, Stones, Plastic sheets etc. were sorted out manually at the time of loading the material on the conveyer belt. It was recommended to provide a raised perforated platform at a height of 4 feet, where the loose paper cuttings, which are likely to have more dirt, are cleaned by manual shaking, so that the dirt will be collected down and cleaned paper will go for pulping.

2. **Raw Material Yard Flooring with Concrete/Brick:**
   In one mill it was observed that raw material (Waste paper) procured from out side agencies for making the paper was partially stored in covered area and partially in open area and these areas were not floored with brick or concrete resulted in increased load on cleaning equipments and poor quality of final product due to dirt. It was recommended that raw material yard should be floored either by brick or concrete so that dirt / sand should not enter along with waste paper.

3. **Raising the Height of Wall Separating Raw Material Yard and Boiler Fuel Yard:**
   In one of the mills, it was observed that the height of the wall, separating raw material yard and boiler fuel yard (saw mill waste) was of low height resulting in contamination of dirt in wastepaper. The dirt in raw material

increases the load on cleaning equipments (centricleaners, screens etc.). It was recommended that the height of the wall separating raw material yard and boiler fuel yard should be raised, so that the dirt in the form of the sand, soil, fly ash etc. should not enter along with raw material.

4. **Setting up of Permanent Platform on the Side of Waste Paper Feeding Conveyor:**

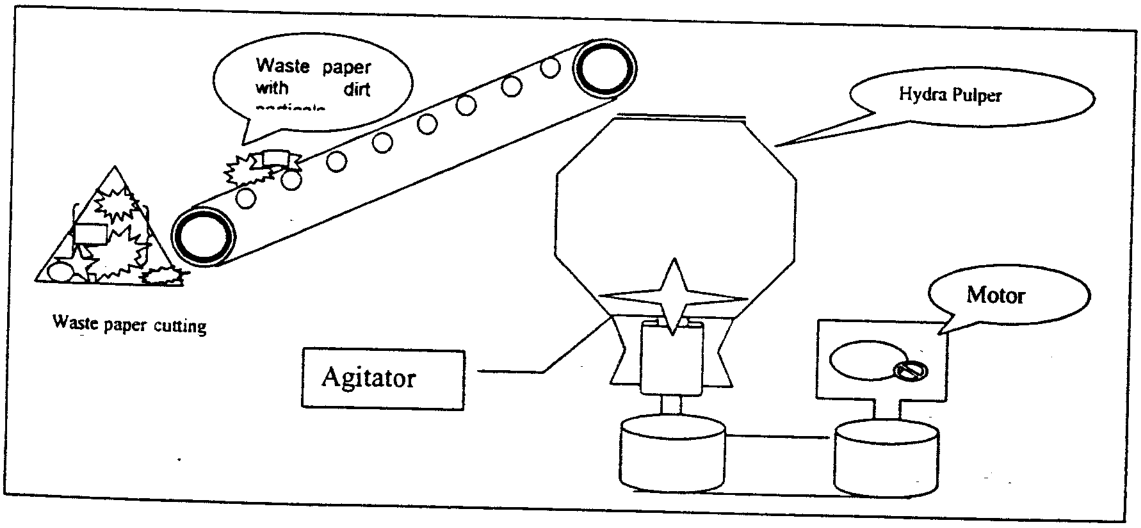
   It was observed that bales of waste paper were piled on the one side of waste paper feeding conveyor and used as elevated floor to load waste paper on conveyor during the visit to one of the mills. It was recommended that there should be a permanent structure (stair case) for loading the waste paper. Uses of raw material pile as a raised platform for loading the waste paper on conveyor not only damages and deteriorates the raw material for subsequent paper making operation but also leads to safety hazards and may result in accidents.

5. **Bypassing the First Feed Conveyor for the Boiler:**

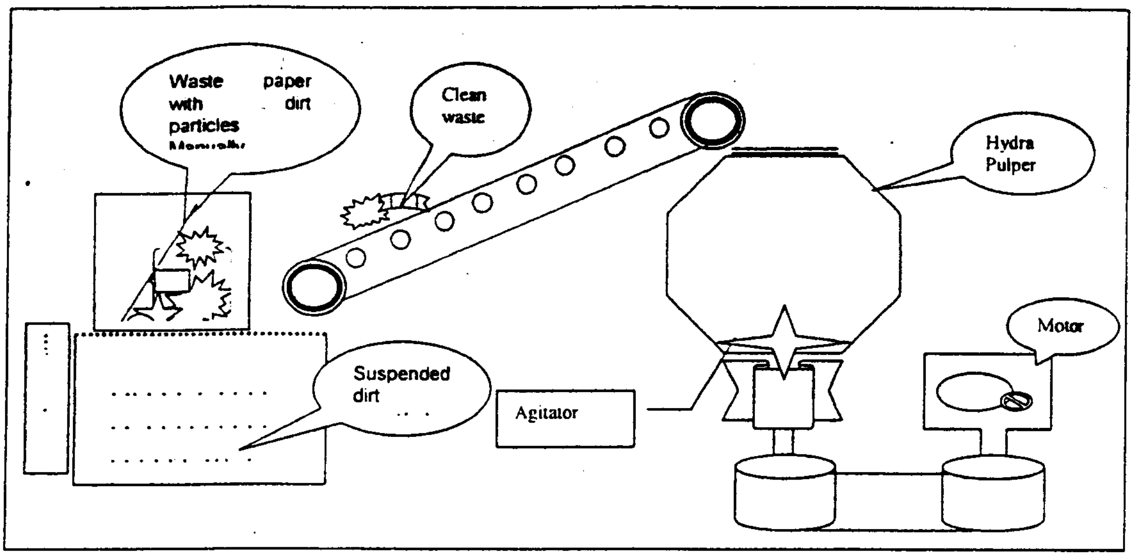
   Two conveyor belts were in operation to feed the fuel in the boiler of a mill. The operation of first stage belt conveyor was of no use. It should be stopped immediately as it was consuming electric energy to drive the conveyor and increasing the wear and tear of belt conveyor without giving any benefit. It was recommended that saw dust feeding point should be brought near to the second conveyor and fuel should go through second belt conveyor only for feeding to boiler hopper.

6. **Introduction of Perforated Platform Before the Waste Paper Conveyor:**

   CPPRI audit team observed that large contaminants like iron wires, stones, plastic sheets etc. were sorted out manually at the time of loading the material on the conveyor belt in one of the mill visited. As such large amount of small contaminants in the form of dirt, sand, plastic chips, small iron pieces etc. were going with the waste paper in the pulping street resulting in poor product quality. It was suggested that a de duster (perforated platform) should be introduced before the conveyor belt having appropriate perforation, which will remove some of the dirt and other external contaminants from the waste paper stock thereby improving the quality of incoming waste paper to hydra pulper.



Existing Practice



Proposed practice

7. Replacement of Air Blows System with Belt Conveyor:

It was observed during audit study that the fuel (saw dust) was fed to boiler through air blower which was equipped with 7.5 HP motor. It was suggested that a belt conveyor may be installed in place of air blower as the electrical power consumption in belt conveyor is much less than air blower. 5 HP motor will be sufficient to convey the fuel to boiler through conveyor belt. To stop the sweeping of saw dust by wind, conveyor belt may be covered by half portion of waste drums.

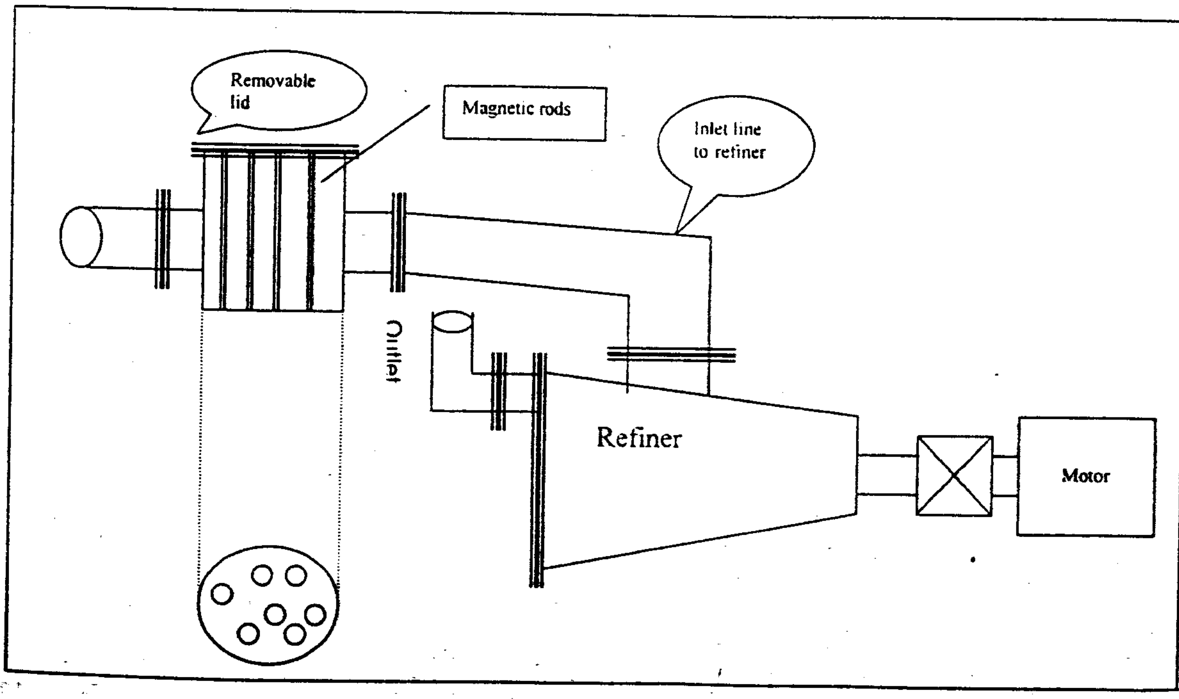
8. Replacement of Existing Belt with New Belt of 78 cm Width at Waste Paper Street:

During the visit to one of the mills, it was observed that rollers of hydra-pulper belt conveyor were jammed and loaded belt just slides over them. Besides this the width of belt was less (55 cm against the 78 cm side guard distance). This resulted in the gap on both sides of belt resulting in the falling of raw material from the sides of the belt. Some paper got stuck between rollers resulting in jamming of rollers. The waste paper falling down was again collected manually and reloaded on conveyor belt. This unnecessary material handling resulted in time and manpower wastage along with poor housekeeping. It was suggested that belt width should be increased to 78 cm so that the gap on both sides could be covered and prevent the falling down of waste paper. The jammed rollers should be made movable after proper greasing. This would result in less load on conveyor motor.

II. Pulp Mill Section:

1. Installation of Magnetic Traps before Refiners in Pulp Mill:

To increase the life of refiner plates the incoming stock should be free from iron particles otherwise these particles may damage the bars of plates. during the visit in one of the mills, it was observed that mill was using waste paper as raw material and there was chance of having large metallic contaminants / impurities in the form of nails, pins etc. It was recommended that a magnetic trap may be installed in the inlet line of refiner. The magnetic trap has magnetic bars inside which can trap the metallic pieces. The magnetic trap is cleaned periodically for removing the contents. This will not let the iron particles to go in the refiner plant.



2. **Insulation of Spherical Rotary Digester:**

   During the visit to one of the mills, it was observed that mill has one spherical rotary digester for cooking of high wet strength waste paper. The digester was not insulated and this resulted in considerable heat loss. It was suggested to put proper insulation on the digester to reduce the heat loss through radiation.

III. Stock Preparation and Paper Machine Section:

1. **Convert V-belt Drives to Flat Belt Drives in the Chest Agitator Drives of Paper Machines:**

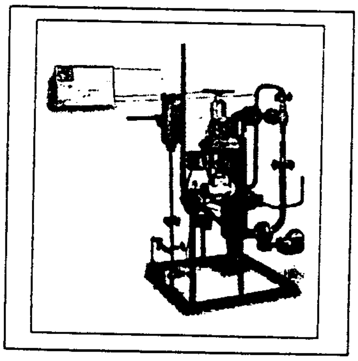
   During the visit to one of the mills, it was observed that chest agitators running in different chests were driven by V-belt drive. Flat belts being much more flexible than the v-belts they require less energy for travel around the pulleys and thus overall energy saving occurs. It was recommended that chest agitator's drive be modified to flat belt drive system.

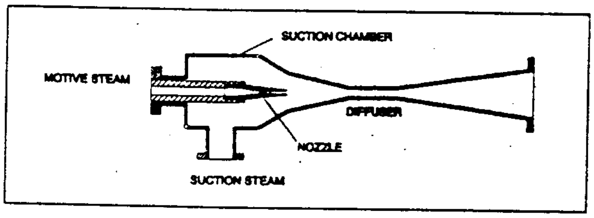
2. **Increasing the Life of Triple Disc Refiner (TDR) Plate:**

   It was observed that dirt, sand particles etc. coming with the pulp are going to refiner in this mill. The mill was using triple disc refiner (TDR) for refining its pulp. It was recommended that mill should have a proper sorting system of raw material or should have proper cleaning equipment (like centricleaners) capable of removing dirt and sand particles, before refiner resulting in increase in the life of TDR plate.

3. **Use of Thermo-Compressor to Utilize Flash Steam in Proper Manner:**

   During the audit study in one of the mill, it was observed that in paper machine there was no flash steam recovery system and condensate along with flash steam was pumped directly to boiler. The flash steam if recovered properly from the dryer's condensate; can be used in wet end dryer group, where temperature requirement is less. This will save the live steam and hence reduce load on boiler house. It was recommended that mill should use thermo-compressor to reclaim low pressure flash steam that is otherwise vented or go waste.





Thermo compressor

4. **Insulation of Uninsulated Condensate Tank and Flash Steam Line of Paper Machines:**

Condensate tank and flash steam line meant for the collection of condensate from the dryers were not found insulated in this mill. It was recommended to put a proper insulation on the condensate tank and pipeline to reduce heat loss through radiation.

5. **Condensate Recovery from the Steam Shower Pipe Installed for Dandy Roll Cleaning at Paper Machines:**

During the audit to one of the mills, it was observed that there was a steam shower installed for cleaning the dandy roll. Steam after condensing in shower pipe was coming out from another end of the pipe in the form of condensate through a small piece of hosepipe. There was no recovery system for such condensate and condensate was falling directly to drain in the form of continuous drops. It was recommended that this condensate should be collected and reused in boiler house or any other suitable place.

6. **Improving the Efficiencies of Centricleaners to Improve the Paper Quality:**

   In one of the mills, it was observed that a three stage centricleaning system has been installed in the paper machine section but only two stages were found in operation resulting in improper cleaning of stock. Also the pressure gauges installed on the centricleaners were out of the order. Therefore it was recommended that mill should operate all its three stages of centricleaners. Pressure gauges should be installed at all stages so that proper pressure difference is maintained to get required cleaning. Also maintaining the consistency of feedstock is necessary at desired level. The rejects of primary stage should be cleaned through secondary centricleaners and rejects of secondary centricleaners should be cleaned through tertiary stage. The final rejects from tertiary stage should pass through raffler or sand trap to remove sand and dirt impurities and to recover fiber.

7. **Raising the Height of Hood above M.G. Cylinder:**

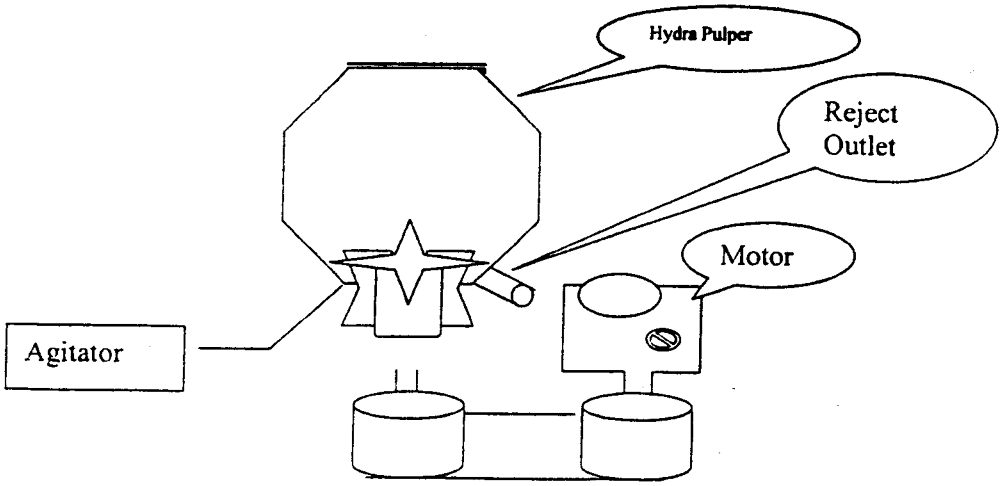
   The gap between hood above M.G. and M.G. of paper machine was not found sufficient. The vapours raised as a result of evaporation from the paper sheet were brought out through the duct, which was fitted with the fans. In this mill, it was recommended that the height of the M.G. hood should be raised to a proper level so that the exhaust of humid air from the hood can be removed easily. The improper ventilation of vapours from the dryer hood will result in sheet rewetting and non-uniform moisture profile. This will result in higher breakage of paper web and production loss. Mill was also advised to take suggestion from the hood suppliers regarding appropriate design.

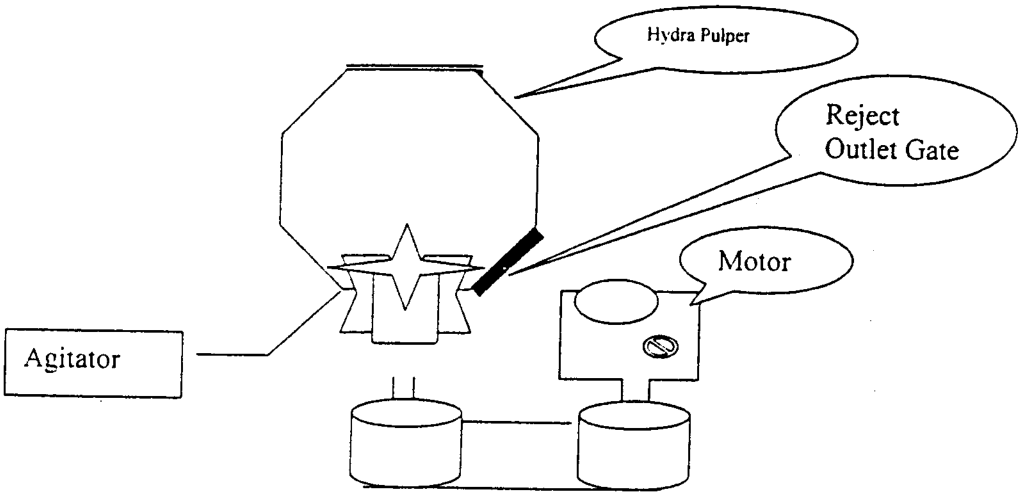
8. **Installation of Pressure Screen in Paper Machine Approach Flow:**

During the audit in one of the mills, it was observed that pressure screen was not provided in the approach flow of paper machine and the mill was advised to provide the same. This will help in the removal of flakes, plastics in the form of film polyethylene etc. coming from bags or wrappers, adhesives including hot melts, pressure sensitive and latex based sticky materials, debris, dirt, shives, etc. from the stock, which are not removed from the centricleaners. It is also helpful in the removal of stickies to some extent from which mill was facing lot of problems.

9. **Manual handling of Hydra-pulper Rejects:**

In one of the mills, it was observed that the rejects collected in the hydra-pulper were removed manually. It was recommended that mill should make a provision of bigger reject outlet on the side of pulper, extended towards the bottom with an hinged door which can be easily opened for taking out the rejects.





10. Insulation of Sides of Pre, Post & M.G. Dryers and condensate lines:

Like wood and agro residue based mills, in recycled fiber based mills also sides of the drying cylinders of pre dryers, M.G. dryer & post dryers and condensate lines were not found insulated in some of the mills. It was recommended to put proper insulation on the sides of the drying cylinders of pre, post & MG dryer and condensate lines to reduce the heat loss through radiation.

11. **Installation of Water Deflectors on Table Rolls:**
During the audit to one of the mills, it was observed that no deflectors were provided on the table rolls to deflect the rimming water from the out going nip. As such, the water reamed round the circumference of the roll and rewet the web, thus again increasing the paper web moisture. This increases the load on vacuum element of wire table and suction couch and consequently on presses and dryers. It was recommended that mill should install proper deflectors on table rolls so that rimming water falls down and should not rewet the paper web.

12. **Split Sizing in Different layers of Duplex/Triplex Boards:**
It was observed that this mill was adding its sizing chemicals in chemical chest, which is old and conventional method. Now a days many mills have started split dosing of alum i.e. part of alum is dosed in chemical chest and part of it at some other point in approach flow system to get better sizing with less chemical consumption. Therefore it was recommended that mill should follow split alum dosing to reduce consumption of rosin size and alum.

13. **Reduction in the Consumption of Ranipal (OBA) by Split Dosing:**
As a normal practice in this mill also total quantity of optical brightening agent (OBA) was being added in chemical chest. It was recommended that mill should perform split dosing of Ranipal (OBA). This will bring about 20% saving of OBA without affecting the paper quality.

14. Adoption of Enzymatic De-inking instead of Chemical De-inking:

During the audit to one of the mills, it was observed that mill was performing chemical de-inking using various chemicals. These de-inking chemicals are not only environmentally unfriendly but they also affect adversely the fiber strength. Enzymatic de-inking is an excellent substitution of chemical de-inking. Therefore it was recommended that mill should explore the possibility of using the same. Help of CPPRI could be sought for the same.

15. Setting up of Reverse Centricleaner in Approach Flow System:

It was observed during audit in this mill that particles of thermocoal passed through installed cleaning system which were deteriorating the quality of paper and increasing the down time of machine. Since thermocoal is a low density particle, it cannot be removed by forward cleaner as it passes with accept pulp. It was recommended that mill should install one leg of reverse centricleaner for recovery of low density impurities like plastic and thermocoal. These impurities give sticky problem in dryer section causing paper breakage.

16. Separate Refining of Imported and Indigenous Waste Paper:

It was observed during mill audit that different grades of wastepaper like imported OCC, Indian OCC, sack Kraft and NDLKC were used to make M.G. Kraft Paper. Presently mill is using approximately 50% imported wastepaper (Imported OCC) having long fibres and 50% Indigenous wastepaper with mixed refining system. It was suggested that during the manufacturing of unbleached varieties, imported and Indigenous wastepaper may be refined separately. To get required strength properties in paper, indigenous waste paper grades requires little refining while imported grades (having soft wood fibres) need more refining. When two grades are refined together refining leads to deterioration of indigenous fibers results in incomplete refining of imported waste paper. In both cases, quality of paper will suffer and energy is wasted. It was recommended that separate refining of two grades must be carried out.

IV. Utility Section:

1. Optimization of Fuel Combustion in Boilers:

During the audit in one of the mills, it was observed that the oxygen percentage in flue gases of both the boilers was on higher side. The high oxygen level in flue gases indicated excess air during combustion. It was recommended that ID and FD fans may be properly balanced to maintain the oxygen level in flue gas between 5.0 – 6.0 % by proper control of dampers.

2. Installation of Economizer in Boilers:

It was observed that the temperature of flue gas at boiler outlet was very high i.e. 355^0 C and 228^0 C in two boilers of this mill. The high temperature of flue gases indicated excessive heat loss along with flue gases. Therefore it was recommended that economizer/air preheater may be installed to preheat the water/air going to boiler. The temperature of flue gas going to stack should be around 150^0 C.

3. Replacement of Motors Running below the Required Efficiency Level:

In one of the mills, measurements were taken where ever possible, to ascertain efficiency of major LT induction motors in the plant with the objective of analyzing this data for identifying efficiency of motor at no-load and with load. All the motors tested were found running below the required efficiency level. It was suggested that these motor be replaced with energy efficient motors at the earliest.

7. **Removal of Canopy from Stack Attached with Boiler:**

It was observed in a mill that the canopy was placed at the top of stack attached with boiler. It was suggested that the canopy may be removed from the top of stack because canopy prevents proper dispersion of flue gas in the atmosphere and also retards the flue gas draft height.

8. **Installation of Automatic Tap at Tube Well Line:**

It was observed in one of the audits that a tap was provided in the tube well line near the boiler. Most of the time the tap remained open while not in use, due to negligence of workers or some fault in the tap. The quantity of fresh water estimated was around 6 m^3/day. It was suggested that the tap provided in the line of tube well should be changed with automatic tap to save the fresh water.

9. **To Increase the Height of Stacks Attached with D. G. Sets:**

It was observed in one of the mills that the stacks attached with both the D. G. sets i. e. 380 KVA and 320 KVA open at the height of D. G. sets. The running hours for 380 KVA and 320 KVA D. G. sets were 150 hrs/month and 100 hrs/month respectively. The Diesel consumption was 52 liters/hrs in 380 KVA D. G. set and 48 lit/hr in 320 KVA D. G. set. As per norms. the stack height for 380 KVA D. G. set should be 3.9 meter above the roof of D. G. Room and for 320 KVA D. G. set it should be 3.6 meter above the roof of D. G. Room. By increasing the height of stack, proper dispersion of flue gas would result in less fugitive pollution. Additionally the efficiency of D. G. sets will beimproved resulting in saving of approximately 2 % in fuel consumption due to better draft.

10. **Installation of Limit Switch at Feed Water Tank of Boiler:**

During the audit in one of the mills, it was observed that feed water (Soft water + Condensate) from feed tank of boiler was going to drain through over flow line. It was suggested that over flow of boiler feed water from feed tank should be stopped since condensate coming from paper machine has high temp (approximately 100° C), which get mixed with make up soft water (ambient temperature) in feed water tank resulting a final temperature of 60 - 65° C. By stopping the overflow, about 5° C temperature may be increased resulting in saving of fuel in boiler as well as treated water.

11. **Optimization of Excess Air in Boiler:**

It was observed during an audit that oxygen percentage in boiler was on higher side, i.e. 11.1% resulted in excess air of about 114%. It was recommended to optimize combustion air by proper controlling the damper of I.D. fan and changing feeding parts accordingly. To arrest free air entering into the furnace or duct it was also recommended to use a close feeding system by installing fuel feeder. Mill was advised to contact boiler supplier for installation of closed feeding system.

V. Others:

1. **Installation of Agitator at Couch Pit:**

During the audit in one of the mills, it was observed that no agitator was provided in the couch pit of paper machine. As such the paper falling in couch pit (at the time of paper break on machine) cannot be disintegrated and causes high load on pump. It was recommended that mill should install a horizontal agitator in the couch pit which would disintegrate the pulp uniformly. A uniformly disintegrated pulp is easy to pump and will cause less consistency fluctuation.

2. **Installation of Section Wise Energy Monitoring System:**

   During the audit in one of the mills, it was observed that no energy meters had been installed to monitor section wise electrical consumption. As without section wise monitoring, it is not possible to find out the area of high electricity consumption. Therefore it is suggested that mill should install energy meters in Pulp Mill (Pulper and refiners), Paper machine and Boiler house

3. **The Steam Generation should be Properly Monitored:**

   To find out the efficiency of boiler it is must to know the quantity of steam generated by boiler. During the audit in one of the mills, it was observed that there was no metering device provided in the feed water line as well as in steam out let line, due to which it was not possible to know the actual steam production. It was suggested that a flow meter at feed water be installed in the boiler house. This will help to calculate the efficiency of boiler.

4. **Installation of Hot Water Circulation Pump:**

   In one of the mills, it was observed that condensate coming from paper machine dryers was collected in condensate tank and pumped back to boiler house with air pressure from air compressor. This resulted in lowering of condensate temperature and inclusion of air in the condensate, which may lead to corrosion in the boiler tubes at high temperature. It was suggested that this arrangement should be replaced with hot water circulation pump.

CHAPTER – 4

CHAPTER - 4

Conclusion:

The study has covered a large cross section of the industry and indicated many areas where energy saving potential exists. The findings of the study would serve as a guideline for the pulp & paper industry to plan their energy efficiency drive to achieve cost effective production as well as the strict energy norms to be notified by Govt. of India under Energy Conservation Act – 2001. Study has revealed that by focusing on process optimization the mills can easily achieve these targets for energy efficiency. The studies have shown that largest savings are possible through regular process monitoring, optimization and timely maintenance & upgradation of process equipments. A well-planed energy efficiency drive should be initiated by the mills to achieve efficiency targets in a phase wise manner.

The improvements suggested in the study may be specific to the mills, however they represent the overall working of the mills in India. Mills have to devise strategies for their energy management activities and these studies can help them to understand energy saving potential and identify areas where they need to work immediately. In house energy conservation efforts made by the mills should also be evaluated for understanding their impact on overall energy consumption. Outside agencies, accredited by Ministry of Power, Govt. of India should be entrusted the task to take up the energy audit and propose efficiency improvement measures.

For implementation of Energy Conservation Act-2001, it is necessary that process should be audited by the energy auditors as with out process audits, it is difficult to achieve the suggested energy saving targets. Most of the energy

audit agencies make their efforts on the utilities area, pump and motors, which cannot give substantial energy saving options. Mill should find out such energy auditors who have ample experience in the process auditing in pulp & paper industry.

Following process must be covered during future energy management and efficiency improvement plan by the mills.

- Raw material preparation
- Digester house
- Washing, screening and centricleaning operations
- Bleaching
- Stock preparation
- Paper machine
- Chemical recovery
- Effluent treatment
- Powerhouse
- Other utilities like compressors, vacuum pumps, D. M. Plant etc.

Process simulation & process integration within the mill can explore many areas where savings are possible. Process integration is very useful particularly when mills go for expansion. This exercise can give the details of total hot & cold utilities required in the new setup. Therefore the mills after understanding their process requirements can plan the optimum sized equipments. Process simulation is another area, which offers significant saving opportunities. With the introduction of computer controls in the mills, these tools can be very useful to identify the energy saving areas.

An analysis of energy performance by different mills has shown that in wood based mills there is potential of significant savings in raw material preparation & handling section, pulp mill, stock preparation and chemical recovery sections without making major changes in process & equipments. Similarly in Agro based mills there is large potential in pulp mill section and stock preparation & paper machines. In the waste paper based mills stock preparation & paper machines require most of the efforts. Apart from these electrical. Utilities and power house also offer significant savings. The studies conducted in this project have given an overview of the energy performance in mills and highlighted the areas of requiring attention. Since no two mills are identical in process layout and technological studies, therefore no common strategies can be adopted for improvement of energy efficiency, however the experience and efforts made in one mill can form a guide line to be followed as per the requirement & mill conditions. Section wise saving potential carried out at different mills is enclosed as annexure - II

ANNEXURE

Annexure – I

List of mills;

LARGE WOOD BASED PULP AND PAPER MILLS;

1. M/s Seshasayee Paper & Boards Ltd. Erode (T.N.)

2. M/s Tamil Nadu Newsprint & Paper Ltd., Distt. Karur, (T.N.)

3. M/s Ballarpur Industries Ltd. (BILT). Unit: Ballarpur, Distt. Chandrapur (Maharashtra)

4. M/s Ballarpur Industries Ltd. (BILT). Unit: Shree Gopal, Yamuna Nagar (Haryana)

5. M/s The Sirpur Paper Mills Ltd., Sirpur – Kaghaznagar (A.P.)

AGRO BASED PULP AND PAPER MILLS;

6. M/s Shreyans Industries Ltd., Ahemadgarh (Punjab)

7. M/s Kailash papers, Aghwanpur, Distt. Moradabad (U.P.)

8. M/s Yash Papers Ltd., Darshannagar. Faizabad (U.P.)

WASTE PAPER BASED PAPER MILLS;

9. M/s Kalptaru Papers Limited, Tal. Kalol, Gandhinagar, Gujarat

10. M/s Well Pack Papers & containers Ltd., Vamaj, Tal. Kalol, Gujarat

11. M/s Rainbow Papers Limited, Ahmedabad, Gujarat

12. M/s Karan Paper Mills, Chhatral, District - Mehsana, Gujarat

13. M/s Shelavi Pulp & Paper Mills Pvt. Ltd., Chhatral, District - Mehsana, Gujarat

14. M/s Plaza Papers Pvt. Ltd., Village Ghunna, Behat Road, Distt. Saharanpur (U.P.)

Annexure -II

Section wise saving potential carried out at different mills;

LARGE WOOD BASED PULP AND PAPER MILLS

Sl No.	Raw Material Preparation and Handling *	Pulp Mill*	Stock Preparation and Paper Machine*	Chemical Recovery *	Electrical *	Effluent Treatment *	Others*	Total (Rs. in Lacs)
1.	328.00	410.0	59.20	323.05	18.87	-	47.50	1187
2.	46.60	224.4	-	1.15	24.08	-	252.00	548
3.	220.00	0.25	6.66	32.82	-	0.50	14.16	274
4.	13.12	1.37	64.71	116.73	6.67	-	117.57	320
5.	8.93	248.0	226.0	181.00	9.63	5.13	30.00	709

AGRO BASED PULP AND PAPER MILLS

Sl No.	Raw Material Preparation and Handling *	Pulp Mill*	Stock Preparation and Paper Machine*	Chemical Recovery *	Electrical *	Effluent Treatment *	Others*	Total (Rs. in Lacs)
1.	41.07	79.63	17.51	34.24	16.37	-	31.45	237
2.	33.00	1.92	18.81	-	0.82	-	11.82	66
3.	24.53	35.10	2.50	-	6.69	3.72	6.50	79

WASTE PAPER BASED PAPER MILLS

Sl No.	Raw Material Preparation and Handling *	Pulp Mill*	Stock Preparation and Paper Machine*	Electrical *	Effluent Treatment *	Others*	Total (Rs. in Lacs)
1.	1.00	-	13.26	329.00	-	88.21	431
2.	18.87	-	50.76	5.65	-	14.30	90
3.	-	1.00	25.32	9.03	-	13.48	49
4.	-	19.40	33.57	-	-	3.65	57
5.	3.30	0.50	13.25	-	-	8.08	25
6.	0.96	0.98	0.56	2.08	-	19.07	24

***All figure indicating Rs. Lacs per annum**
SL No: Indicating Mill as per listed in annexure-I
Others: Inc. Power Boiler, DM plant, process improvement etc

Annexure - III

COMPREHENSIVE QUESTIONNAIRE FOR MILL DATA & INFORMATION

For

ENERGY PERFORMANCE EVALUATION AND OPTIMIZATION IN PULP & PAPER INDUSTRY

BY

CENTRAL PULP AND PAPER RESEARCH INSTITUTE
SAHARANPUR, U. P., INDIA
www.cppri.org.in

Project Specification
(To be filled by CPPRI)

A. GENERAL INFORMATION

1. Name of the mill:

2. Address:

   PIN

3. Year of establishment:

4. Address of Head/ Corporate Office:

   PIN

5. Contact person

Name		Designation	
Phone No.	Fax No.	Mobile No.	E-mail

6. No. of employees (including mill) :

Technical,	Non Technical	Ministerial

7. Annual turn over (last three years):

Year			
Rs. in Lacs			

8. No. of working days:

B. MILL DATA

1. Installed capacity, t/a :
2. Actual production, t/a :
3. Capacity utilisation, % :
4. Raw material furnish ,% :

Grade of Paper	Raw material furnish , %				

5. Raw material consumption, t/a:

	1	2	3	4	5
Raw Material					
t/a					

6. Quality / grades of paper produced, t/a:

Sl. No.	Grade/ Quality	t/a
1		
2		
3		
4		
5		
6		

7. Energy consumption :

Particulars	Max.	Min.	Avg.
Water consumption, m^3/t_p :			
Steam consumption, t/t_p :			
Electricity consumption ,kWh $/t_p$:			

8. Sources of Energy :

Purchased Power, MWh/a	
Co-generation of Electricity, MWh/a	
Black Liquor solids, t/t_p	
Coal Consumption, t/t_p	
Others	

C. TECHNICAL INFORMATION:

1. RAW MATERIAL STORAGE & HANDLING :

I STORAGE YARD:

a. Bagasse Storage:

Storage Capacity, MT	
Area of Storage Yard, m^2	
Storage, Wet / Dry	
Moisture in stored Bagasse, %	
Storage in Bales / Loose form	
Storage Period , days	
Storage Yard Floored / Unfloored	
Stack Dimensions, m (L x H x W)	
Quantity and name of Enzyme used during Storage (if any)	
Mode of cleaning	
Quantity of rejects, %	
Water consumption in raw material cleaning, m^3/d	
Effluent generated, m^3/d	

b. Other Agro Residues:

Name of the raw material used				
Storage capacity, M/T				
Area of storage, m^2				
Storage period, months				

c. Hard Wood / Bamboo Storage:

Name of the raw material			
Quantity of raw material processed, t/d			
Storage Capacity, MT			
Area of Storage Yard, m^2			
Wood Storage with / without bark			
Mode of Transportation up to Chipper House			
Storage period, months			

d. Recycled Fiber (RCF) /Waste Paper:

i. Source of RCF: Indigenous Imported

ii. Quantity of RCF used, t/a :

iii. Grades of RCF used:

Grade	Ash,%	Quantity, t/d

iv. Sorting practice at source or at mill : At source At Mill

v. Method used to remove contaminants:

e. Any Other Raw Material (pl. give details)

2. RAW MATERIAL PREPARATION:

a. Bagasse

i. Whether Depithing at Mill site — Yes / No / Partial

ii. Depither Details

Make	
No. of Depithers	
Capacity of each Depither, t/d	
Mode of Depithing ,Wet / dry	
Moisture during depithing , %	
Quantity of bagasse, depithed, t/d	
Pith, %	
Screen size (diameter) ,mm	
Energy Consumption kWh / t for depithing Bagasse	
Stack Dimensions, m (L x H x W)	
Quantity and name of Enzyme used during Storage	
Mode of Transportation up to Pulp Mill	
Energy Consumption, kWh/t for Handling of Bagasse	
Mode of disposal / utilisation of pith	

b. Straw :

Type of straw used		
Quantity of straw processed, t/d		
Type of cutters		
No. of cutters		
Through put of cutters		
Energy consumption during cutting,kWh/t straw		
Mode of cleaning		
Quantity of rejects, %		
Water consumption in raw material cleaning, m^3/d		
Effluent generated, m^3/d		
Recirculation of effluent, Yes/ No (If yes, % recirculation)		
Energy consumption during cleaning, kWh/t straw		
Mode of disposal/ utilisation of rejects.		

c. Other Agro Residues :

Name of the raw material used				
Quantity of raw material processed, t/d				
Type of cutters				
No. of cutters				
Mode of cleaning				
Effluent generated during raw material cleaning, m^3/d				
Recirculation of effluent, Yes/ No (If yes, % recirculation)				
Mode of conveying raw material to digester				
Qty of rejects generated , %				
Mode of disposal/utilization of rejects				

d. Wood / Bamboo

i. Details of chipper house

Name of the raw material used			
Quantity of raw material processed, t/d			
Moisture content in raw material,%			
Type of Chipper			
Make			
No. of Chippers			
Chipper Capacity t/h			
Total chip production, t/d			
Mode of Feeding			
Total Running hours, hrs./ d			
Electrical Consumption kWh/t wood			
Dust generation, %			
Mode of disposal / utilization of chipper dust			

ii. Chip screening

Type of screen	
Make	
Accept Chip dimensions	
Length, mm	
Width, mm	
Thickness, mm	
Chip Accept, %	

3. PULP MILL

I. Pulping process employed: Mechanical Chemical

a. Mechanical Pulping

i. Refining Details

Name of the raw material refined	
Quantity of raw material processed, t/d	
No. of refiners	
Make/type of refiner,	
Electrical consumption, kWh/t pulp	
Presteaming temp., ^{0}C and time , hr.	
Chemical applied, %	
White liquor temp. ^{0}C,	
Sharpness and pattern of refiner plates	
Temperature of refining, . ^{0}C	
Gap between refiner plates, mm	
Rate of feeding through refiner, t/hr	
Speed of refiner plates, rpm	
Stages of refining (two/three stage)	
Refining - Atmospheric / Pressurized	
Pulp consistency, %	
Freeness rise, . ^{0} SR/ CSF	
Screening pattern	
Cleaning pattern	
Bleaching Sequence	

ii. Details of Bleaching Stages

Bleaching stage				
% Chemical addition on pulp				
pH				
Temperature, °C				
Time, hrs.				
Consistency, %				

iii. Pulp Characteristics & Energy Consumption in Bleaching

Initial Pulp Brightness , %	
Final Pulp Brightness, %	
Bleached pulp yield ,%	
Steam Consumption in bleaching section, t/t_{pulp}	
Electrical consumption, kWh/t_{pulp}	

b. Chemical Pulping

i. Pulping process employed — Soda / Kraft

ii. Raw material used

Raw Material	Quantity t/d

iii. Type of digester used — Batch / Continuous

a. Batch Digester Details:

Type of digester			
No. of digesters			
Capacity, m^3			
Loading capacity ,%			
Chip Feeding Mode			

Chip Reject, %	
Chip Dust, %	

e. Waste Paper

i. Sorting — By hand | Shredded | As such

ii. Method used for removing contaminants — Manual | Mechanical | As such

f. Others

i. Mode of cleaning — Manual | Mechanical | As such

ii. If by mechanical means

Make and type of equipment			
Capacity , t/ hr.			
Material processed, t/d			
Rejects , %			

i. Batch Cooking Details:

Digester type & capacity, m^3				
Name of the raw materials used				
Quantity of raw material processed, t/d				
Raw material to digester (o.d) t/batch				
Active alkali charge, Kg/batch				
White liquor charge, m^3				
Active alkali in white liquor, g/l				
Liquor fill to digester, m^3				
Direct/ Indirect steaming				
Chip moisture, %				
Bath ratio				
Black liquor fill, m^3				
Effective Alkali charge (as NaOH)%				
Chip filling time, minutes.				
Steaming time to temperature				
Total cooking time				
H factor				
Initial temperature °C				
Cooking temp. °C				
Retention at maximum temperature , minutes				
Pulp Yield, %				
Kappa No.				
Blow temperature (batch) °C				
Blowing time				
Steam requirement, LP, t/t_{pulp}				
Steam requirement, MP t/t_{pulp}				
Electrical consumption, kwh/t_{pulp}				
Mode of Blow Down (open tank/ blow tank)				

ii. Blow heat recovery — Yes / No

If yes,

Volume of water, m^3/d			
Temp., °C			

b. Continuous Digester Details :

Name of the Digester	
Number of digesters	
Capacity, t	
Loading capacity, %	
Dimensions	
No. of tubes	
Length, m	
Diameter, m	

i. Continuos digester cooking details:

a. Raw material used

Raw Material	Quantity, t/d

b. Cooking conditions

Street	1	2
Raw material moisture ,%		
White liquor charge t/ hr.		
White Liquor active alkali, g/l		
Black liquor charged t / hr.		
Black Liquor residual active alkali, g/l		
Retention time, min.		
Temp. °C		
Liquor to raw material ratio		
H factor		
Kappa no.		
Pulp yield unbleached, %		
L P Steam flow, t/hr.		
MP steam flow. t/hr.		
Electrical consumption KWh/ day		
Type of blow down		

c. Blow heat recovery

Yes	No

If yes,

Volume of hot water generated, m^3/d		
Temp., °C		

II. Waste Paper / Secondary Fibre Processing

a. Source of RCF : Indigenous Imported

b. Quantity of RCF used, t/a :

c. Grades of RCF used :

Grade	Ash%	Qty. t/d

d. Sorting practice : At source At mill site

e. Method used to remove contaminants:

Parameters	Pulper, HC/LC	H D Cleaning	Deflaker	Turbo separator	Coarse screening	Fine screening
No. of units						
Capacity, t/hr.						
Operating cy. %						
Opening size, mm of HD Cleaner						
Pressure drop in HD cleaner, mm						
Screen Perforation, mm						
Nature of rejects & their, %						
Rejects, %						
Energy consumption, kWh/t pulp						

f. Deinking Process

Type of cell	
Make	
Capacity t/d	
Feed consistency, %	
Stock feed rate, lt/min	
Retention time, min.	
Temperature of stock, °C	
pH	

i. Chemical addition

Name of chemical		% chemical on pulp	
At Pulper	At Floatation Cell	At Pulper	At Floatation Cell

ii. General Information on Deinking Process & Deinked Pulp

Pulp yield, %	
Fibre loss %	
Ink removal efficiency, %	
Post floatation brightness gain, points	
Deinking sludge generation, t/d	
Water consumption, m^3/t_{pulp}	
Electrical consumption, kWh/t_{pulp}	
Disposal or recycling of waste water, %	
Deinking sludge disposal practice.	

4. WASHING / SCREENING / CENTRI -CLEANING AND REFINING OF UNBLEACHED PULP

I Brown stock washing:

Type & no	
Drum speed:	
Stock inlet flow rate,t/hr	
Stock consistency,%	
Dilution factor	
Hot/ cold water washing	
Soda loss at BSW - 3/4	
Energy consumption, kWh/t pulp	

II Pulp Screening

Number of vibratory screens	
Screen hole diameter, mm	
Consistency of feed pulp %	
Quantity of rejects t/day	
Reject ash %	
Rejects re-cooked/sold	
Number of centrifugal/ pressure screens	
Screen hole dia/ slot width mm	
Consistency of feed pulp	
Quantity of rejects t/day	
Re-cooked / recycled/ sold	

III Centricleaning

No. of centicleaning stages 3/ 4 stage	
Consistency of feed pulp	
Quantity of rejects t/day	
Re-cycled/sold	
Any other type of screening/cleaning	

IV Pulp refining

Type of refiner	
Make	
Number of refiner	
Refining consistency	
Initial/final freenes	
Refining power	

5. PULP BLEACHING:

I. Bleaching process/sequence employed:

II. Bleaching chemical applied, kg/t $_{pulp}$:

Cl_2	NaOH	Hypo	Others

III. Bleaching Conditions:

Bleaching Stage	Chemical, %	pH	Temp, ^oC	Retention Time, hrs	Consistency, %

IV. Bleached Pulp Characteristics & Energy consumption In Bleaching

Brightness of bleached pulp ,%ISO	
Viscosity of bleached pulp, g/cm^3	
Bleaching loss (pulp shrinkage),%	
Quantity of bleach plant effluent generated ,m^3/t_{pulp}	
Recycling/reuse of bleach plant effluent, %	
Steam consumption in bleaching section, t/t $_{pulp}$	
Electrical consumption ,kWh/t $_{pulp}$	

V. Characteristics of bleach plant effluent, if available:
(if possible give for individual bleaching stage)

Parameters	Bleaching Sequence. stages				
Volume . m^3/t pulp					
pH					
COD, mg/l					
BOD, mg/l					
TSS, mg/l					
AOX, mg/l					

VI. Hypo Preparation Plant

Bleach liquor produced, m^3/d	
Lime used for preparation of bleach liquor , t/d	
Available chlorine in bleach liquor, %	
Amount of sludge produced, t / d	
Moisture in sludge, %	
Mode of disposal of sludge	

6. STOCK PREPARATION & PAPER MACHINE

I. Refining

Particulars	1	2	3	4
Type of refiners				
Make				
No. of refiners				
Bar shape & size				
Presence or absence of dams				
Metal of refiner plate				
Life of refiner plate				
% Wear of refiner plate				
Refining consistency, %				
Temperature, °C				
pH				
Initial pulp freeness , °SR or CSF				
Final pulp freeness, °SR or CSF				
Refining power kWh/t or hp-day/ton				

II. Major furnish Components :

Name of the furnish				
%				

III. Chemical additives in Stock Preparation

Major Chemicals

Chemical	Type	Amount used (Kg/t $_p$)	Point of addition
Fillers			
Rosin size			
Alum			
Wet strength agent			
Dry strength agent			
Optical brighteners			
Retention aid			
Dye			
Any other			

IV. Details of centricleaner

Type of centricleaners	
No. of cleaning stages	
Cleaning consistency, %	
Inlet pressure differential designed/operating, Kg/cm2	
Outlet pressure differential designed/operating,Kg/cm2	
Leg diameter , mm	
Reject flow rate , m^3 / d	
Reject consistency , %	
Type of contaminant removed	
Mode of disposal of centricleaner rejects	

V. Pressure Screening

Type of screen	
Type of perforation	
Cleaning consistency, %	
Size of hole/slot, mm	
Rate of reject from screen ,%	
Type of reject	
Energy consumption, kWh/d	

PAPER MACHINE SECTION:

I. Details of Paper Machines

Paper Machine No./ Name	1	2	3	4	5
Type of M/c					
Make					
Capacity, t/d (Designed)					
Production, t/d (actual)					
Product/ gsm					
Deckle,m					
Speed, m/min					

Electricity consumption, kWh/t					
Steam, t/t_p					
Quantity of machine back water, m^3/t_p.					
Points of use of paper machine back water					
Quantity of back water used at each point					
Type of water used in sealing of vacuum pumps & extent of recirculation of sealing water					
Type of inplant filtration/purification system for paper machine back water					
Fiber loss, kg / t_p					
Type of save all used for fiber recovery					
% of fibre recovered from the save all					
Point of use of clarified water from save all					
Energy consumption in running save all, kWh/d					
Recycling of paper machine back water, %					

a. Head Box

Paper Machine No.	1	2	3	4	5
Type of head box					
Consistency range in head box , %					
Consistency regulation (Manual/Auto)					
Slice opening ,mm					
Head of stock , mm					

b. Wire Part

Paper Machine No.	1	2	3	4	5
Type of wire used					
Shake mechanism, if any					
No. of elements					
Width of wire ,mm					
Type of couch roll					
Dryness after couch roll ,%					
Consistency of white water,%					
Type of drive					
Drive energy consumption in running wire ,kWh/ t_p					
Fiber recovery system					
1st Pass Retention,%					

i. Type and number of dewatering elements on wire table

Paper Machine No.	1	2	3	4	5
Hydrafoils					
Vacuum aided					
Vacuum boxes					
Hydrafoils					
Table rolls					

c. Press part:

Paper Machine No.					
No. of presses					
Type of press					
Vacuum in suction press,mm hg					
Nip load at press ,Kg/cm					
Material of press rolls					
Type of felt used					
Dryness after each press, %					
Electrical energy consumption, kWh/t_p					

d. Dryer Part:

Paper Machine No.	1	2	3	4	5
Type of drying cylinders					
No. of dryers					
Drying capacity of dryer cylinders, kg water removed /hr					
Steam pressure ,kg/cm^2					
Type of dryer fabric used					
Whether equipped with heat recovery System, Yes/No If yes, type of hood					
Dryness of web before entering the dryer, %					
Final dryness of web ,%					
Type of condensate removal system					
Overall condensate recovery, %					
Power requirement, kWh/t_p					

e. Size Press:

Paper Machine No.	1	2	3	4	5
Type of size press					
Position of size press (after which dryer group)					
Dryness of web before size press,%					
Size pick up, g/m					
Dryness of web after size press ,%					
Power requirement, kWh/t_p					

f. Calendar :

Paper Machine No.	1	2	3	4	5
Type of calender					
No. of calender rolls					
Working nip load					
Power requirement, kWh/t $_p$					

g. Pope Reel

Paper Machine No.	1	2	3	4	5
Type of pope reel					

h. Rewinder

Paper Machine No.	1	2	3	4	5
Type of rewinder					
Power requirement, kWh/t $_p$					

7. CHEMICAL RECOVERY SECTION

I. Characteristics of black liquor

Type of Black Liquor			
Vol. of Black Liquor . m^3/day			
Solids. % (w/w)			
Inorganic /organic ratio			
Temp. of black liquor.°C			
RAA. g/l as NaOH			
TTA. g/l as NaOH			
PH			
Silica. %			

II. Multiple Effect Evaporators (Evaporation Plant)

Type of Evaporator (LTV/FF)		
Street No.		
Make		
No. of Effects		
Liquor flow pattern		
Evaporation capacity ,Kg/hr.		
Dry solid flow Kg/hr.		
Feed black liquor concentration , %		
Black liquor outlet concentration, %		
Live steam flow , t/hr		
Live steam pressure. kg/cm^2 & temp. °C		
Steam economy		
Frequency of cleaning		
Volume of evaporator secondary condensate, m^3/d		

III Recovery Boiler

a. Boiler Design Parameters

Boiler No.	1	2
Make		
Designed dry solid Capacity, tds/d		
Design black liquor solids, %		
Designed steam temperature, °C		
Design steam pressure, kg./cm^2		
Steam production ,t/t BLS		

b. Boiler Operating Parameter

Boiler No.	1	2
Black liquor firing, tds/d		
Steam pressure ,kg/cm^2		
Steam temperature ,°C		
Steam flow ,t/hr.		
Primary air, %		
Primary air temp ,°C		
Secondary air ,%		
Secondary air temperature ,°C		
Tertiary air ,%		
Tertiary air temperature ,°C		
Flue gas temp after economizer, °C		
Higher heating value of black liquor solids, KCal/ Kg		
Black liquor solid before mixing tank, %		
Chemical losses to stack ,kg/t		
Reduction % ds		
Smelt from the boiler, t Na_2O/d		

IV. Causticisation

Lime requirement t/day	
Smelt from the boiler, t Na_2O/d	
Green liquor from dissolver, , m^3/d	
TTA of green liquor g/l as Na_2O	
Type of slaker	
Capacity, t/d	
Weak white liquor, m^3/d	
White liquor to storage , m^3/d	
Total active alkali of White liquor , g/l as Na_2O	
Quantity of lime sludge produced, t/d	
Moisture content in lime sludge, %	
Mode of disposal of lime sludge	

V. Lime Kiln

Lime kiln design capacity, t/hr	
Length, m	
Diameter . m	
Type of Cooling for Lime.	
No. of coolers	
Lime sludge feed, t/hr	
Temperature of lime sludge, °C	
$CaCO_3$ in lime sludge, %	
Loss on Ignition (LOI)of lime sludge,%	
Lime stone or lake shell feed, t/hr	
Moisture in lime stone, %	
Furnace oil, feed, l/t (lime produced)	
LOI of SPM, %	
Lime produced; t/hr.	
Temperature of lime, °C	

VIII. ETP sludge generated t/d: Primary [ ] Secondary [ ]

a. Sludge characteristics:

Sludge dewatering device, if any	
Consistency of dewatered sludge, %	
Mode of disposal of ETP Sludge	

8. EFFLUENT TREATMENT PLANT

I. Quantity of effluent discharged, m^3/d:

Min	Max	Avg

II. Source of waste water generated:

a.	e
b	f
c	g
d	h

III Flow rate measurement device:

IV. Brief details of Pretreatment facilities available ,if any:

V. ETP details:

Particulars	Type	Dimensions, m	Capacity , m^3	Retention Time, hr.	Performance Efficiency, %
Primary Clarifier					
Anaerobic/ Aerobic Pond/ Lagoon					
Aeration Tank (ASP)					
Secondary Clarifier					
Polishing Pond					
Other treatment facilities , if any					

**Please attach flow sheet of ETP system*

VI. General Characteristics of Influent and Effluent :

Characteristics	Influent	Effluent
Temp, ^0C		
pH		
TSS, mg/l		
TDS, mg/l		
Chlorides, mg/l		
BOD, mg/l		
COD, mg/l		
AOX,mg/l		
SAR,		
Colour, Pt.Co unit		
Phosphates,mg/l		
Nitrogen,mg/l		

VII. Mode of Discharge of treated effluent: Inland (canal or river) Onland discharge

a. On land discharge:

Area of land irrigated with treated effluent, hectares	
Crops grown in effluent irrigated area	
No. of years the land has been used for irrigation	

i. Soil characteristics before and after irrigation with effluent

Characteristics	Before Irrigation	After Irrigation

9. POWER HOUSE

I. Boilers:

a. Boiler Details:

Boiler No.	1	2	3	4
Type of boiler				
Make				
Capacity, t/hr.				
Designed efficiency, %				
Operating efficiency, %				
Fuel used				
Pollution control device used (ESP, Cyclone etc.)				

b. Boiler Operating Parameters:

Boiler No.	1	2	3	4
Feed water flow rate, t/hr				
Feed water temp., °C				
Feed water TDS, ppm				
Blowdown TDS, ppm				
Blow down, %				
Fuel feed rate, t/hr				
Steam pressure, $kg/cm.^2$				
Steam flow, t/hr.				
Steam temp., °C				
Surface radiation loss, %				
Bottom Ash Analysis				
Quantity t/d				
Carbon %				
Ash, %				

Fly Ash Analysis				
Quantity t/d				
Carbon %				
Ash, %				
SPM, mg/Nm^3 (at stack)				

c. Flue Gas Analysis

Oxygen,%				
Carbon Mono oxide, %				
Carbon dioxide,%				
Temp. °C				

d. Fuel analysis

Name of the fuel			
Carbon, %			
Hydrogen, %			
Oxygen, %			
Sulfur , %			
Volatile matter, %			
Ash, %			
Moisture, %			
Gross Cal. Value, Kcal/kg			

II. Co-Generation:

a. Total Co-generation, MW

c. No. of turbines

c. Details of turbines

Turbine No.	1	2	3
Type			
Make			
Year of installation			
Capacity, MW/d			
Production, MW/d			
Inlet steam presure, kg/cm^2			
Inlet steam temp. °C			
Inlet steam flow, t/hr.			
Outlet steam pressure, kg/cm^2			
Outlet steam temp. °C			
Outlet steam flow, t/hr.			
Condensate flow, t/hr.			