REPORT

ON

Water Conservation in Pulp & Paper Industry

Submitted to

Cess Grant Authority

(Development Council for Pulp, Paper & Allied Industries)

By

Central Pulp & Paper Research Institute

Saharanpur, (UP), India

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CONTENTS

OBJECTIVE AND TECHNICAL PROGRAMME

OBJECTIVE AND TECHNICAL PROGRAME:

In recent times, due to scarcity and relatively high cost of water treatment , the mill have made efforts to minimize the consumption of fresh water through efficient use, increased reuse / recycling of waste water and adoption of modified / state of art process technologies. Recycling concept is going to be a long-term strategy for the Indian paper industry. To conserve natural resources and also to achieve cost effective production, there is a need for practicing the recycle concept in the area of basic utilities such as water, fibers, chemicals and energy. Water being one of the natural resources requires to be recycled efficiently during the various paper making unit operations. The pulp & paper industries in developed countries are practicing the recycle concept with a greater degree of success, which has resulted in lower consumption of water to the tune of 50-100m^3/ton of paper. In Indian paper industry, though the efforts have been taken to bring down the water requirements, but still the water consumption figures are high ranging from 150-250 m^3/ ton of product. With the increased concern for improved and cost effective use of available natural resources coupled with greater emphasis on pollution control, more attention is required to be given to cut down the fresh water usage and recycling of paper mill waste water.

The major advantages of water recycling primarily leads to less water requirement depending on degree of back water recycling in the various mill

operations, savings in energy, reduced waste water load on environment and simultaneous reduction in effluent treatment cost due to lower effluent discharges.

The driving forces responsible for water recycling in pulp and paper industry are; the high cost of fresh water, inclination of the industry towards environment friendly process, laid down discharge norms by regulatory authorities, community perception and high cost of secondary effluent treatment processes.

Besides having several advantages, the complete water recycling often leads to increasing operating problems of change in water quality because of the accumulation of various inorganic and organic components, odor and corrosion problem due to increased levels of calcium, chlorides, sulphates and suspended matter etc. This also affects the product quality due to lower retention and drainage of the additives. In tropical countries, one of the major problem may arise due to the increased levels of microbial population with rise in temperature by water recycling which might affect the run-ability of the paper machines.

In view of the problems associated with water recycling due to build up of suspended matter and total dissolved organic & inorganic components, there is a need to carry out systematic studies in individual sections of the paper

industry. Special emphasis will be given on streams resulting from bleach plant section, paper machine and chemical recovery, which are required to be thoroughly studied and treated. Section wise fresh water usage, possible quantity of water recycling in each section and its impact on system performance will be looked into. Impact of recycling on product quality, machine run ability, volume of effluent generated and its treatability will also be taken up during the course of studies. Process Integration Approach will be adopted for reuse of process water by using water pinch technology. One inception workshop is to be organized by inviting mill officials to highlight the objective and targeted output of the project and also to incorporate the recommendation and suggestions of the industry representatives in project activities.

TECHNICAL PROGRAMME:

1) Organization of inception workshop to highlight the objective and targeted output of the project.

2) Selection of mills and preliminary mill visits.

3) Collection of general and technical data related to process.

4) Collection of secondary data on water consumption in the various unit operation of the mills.

5) Identification of various effluent streams in the mills and preparation of lay out on water usages, recycling, sampling points etc. for further detailed study.

6) Collection and characterization of individual streams for various pollutional parameters.

7) Water balancing and options for recycling and reuse of back water.

8) Potential of water pinch analysis (software) for formulation of modules for efficient water usages and reuse of back water to the process in the mills.

9) Report preparation along with recommendation.

INTRODUCTION

INTRODUCTION:

Water is a key element in the production of paper. Pulp and paper mill use water as a medium to transport fibers, energy and chemicals during the production of paper. The major areas of water consumption in a pulp and paper mill include raw material cleaning, pulp mill, showers on washers, paper machine and boilers. Over the years the mills abroad through adoption of modern fiber line technologies have been successful in reducing the consumption of water in paper making process through adoption of modern fiber line technologies as well as techniques for increased recycling leading to minimal discharge of effluent. .However this has not been so in case of Indian pulp & paper mills as a result compared to developed countries the water consumption in Indian paper industry is significantly higher .

Particulars	**Water Consumption , m^3 / t_{paper}**	
Pulping Process	**Indian Mills**	**Mills with BAT (Abroad)**
Kraft	**110-220**	**42**
Rayon grade	**130-180**	**36**
RCF	**25-75**	**8**
End Products		
Newsprint	**90-160**	**11 m^3 / t_{paper}**
Writing & Printing	**100-220**	**38 m^3 / t_{paper}**
Industrial & packaging	**60-150**	**15 m^3 / t_{paper}**

As indicated above Indian mills lag far behind to their counterparts abroad in terms of water consumption. The major reasons for this high water consumption in Indian mills in have been :

- Lower level of technologies & process employed
- Use of mixed raw material
- Low cost of water
- Easy availability of water

Further , the water consumption varies from mill to mill depending upon the raw material used and end product as well as level of technologies / equipments used. A comparative data of water consumption trends in various categories of Indian paper mills is summarized below:

	Water Consumption in Various Process Operations				
	R/M : 100 % Bamboo Product : 100% Bld	**R/M : Wood & Bamboo Product : 100% Bld**	**R/M : Wood & Bamboo Product : Bld & Unbld**	**R/M : Wood , Bamboo ,RCF & Bagasse Product : Newsprint**	**R/M : Agro residue & RCF Product : Blaeched**
Water Consumption m^3/t paper	**118**	**124**	**143**	**74**	**118**
Raw material Handling	**3%**	**-**	**-**	**3 %**	**-**
Pulping	**14%**	**6%**	**5%**	**10 %(CMP) 11 % (CP)**	**26%**
Bleaching	**28%**	**40%**	**28%**	**-**	
Stock Preparation	**2%**	**4%**	**27%**	**28%**	**45**
Paper Machine	**34%**	**25%**			**52%**
Chemical recovery	**5%**	**12%**	**27%**	**19%**	**8%**
Boiler	**4%**	**6%**	**9 5**	**29%**	**7%**
Others	**10%**	**7%**	**4%**	**-**	**35**

EXISTING WATER CONSUMPTION NORMS / STANDARD; WORLD

In developed countries, most of the pulp and paper manufacturing mills are wood based, however, due to environmental implications, trend is changing towards use of recycled fiber as is the case with Indian paper industry

The average water consumption for wood based large pulp and paper industries primarily producing paper and paper board products from six countries is given below;

S. No.	Region / Country	Average specific water consumption (m^3 / $t_{product}$)
1.	United States	64 (Average value in year 2000)
2.	Australia	28.7 (Average value in year 2003)
3.	Europe	40
4.	Canada	67
5.	Finland	40
6.	Spain	30

IMPACT OF HIGH WATER CONSUMPTION

High level of water consumption in turn results in high consumption of energy as well as generation of high volume of effluent as 90% of the water intake is discharged as effluent in pulp & paper making process. Consequently high level of effluent require adequate ETPs for treatment to stipulated discharge norms. In Indian scenario, since the mills have gradually increased the production capacity without corresponding increase in effluent handling capacity, most of these ETP are overloaded and most of these mills find hard in treating their effluent to stipulated discharge norms.

NEED FOR WATER CONSERVATION:

In recent times factors like ***low ground water level as well as decreased flow in receiving streams coupled with issues of public resentment , regulatory pressure as well as awareness of the impact on over all economics of paper production*** have made **Water Conservation** a priority agenda before all the pulp & paper mills. Over the years the mills have been able to reduce to great extent the water consumption to the existing level mentioned earlier still there is a lot of potential / scope to reduce it further . Acknowledging this fact, **Ministry of Environment & Forests (MoEF)** has recently finalized and imposed **Charter on Corporate Responsibility for Environment Protection (CREP)**. Where in its mandatory for reducing the

waste water discharge level to less than 100 m^3 /t_{paper} & 150 m^3 /t_{paper} by large and small mills respectively.

It is in this perspective the Project on **"Water Conservation in Pulp & Paper Industry"** was undertaken by CPPRI with focus on reducing the water consumption through re-use and recycle of treated waste water . Water being one of the natural resources requires being recycled efficiently during the various paper making unit operations. Recycling not only helps in reducing the water consumption but also leads to savings in energy, reduction in volume of waste water generated as well as the subsequent treatment cost leading to beneficial impact on over all production cost. . however recycling has certain bottlenecks like build up of non process elements like silica, etc leading to scaling of the equipments and machinery as well as affecting product quality. The scope of work covers these issues also .

CASE STUDIES

CASE STUDY:

(I) SEHASAYEE PAPER & BOARDS LTD (SPBL), ERODE

The pulp and paper mill is one of the oldest mills in India. Set up in 1962, it is located on the bank of Cauvery river and is one of the premier paper mill in southern India with over 300 TPD of paper production capacity. The mill produces 1,15,000 tpa paper and board utilizing bagasse, Casurina, E. hybrid, waste paper and imported pulp as main raw materials. Mill produces a wide range of products with 5 machine viz. Printing and writing papers, Multi layer duplex, boards, packaging papers etc. The bagasse and wood pulp is bleached by using CEpHH bleaching sequence. It is also one of the model unit demonstrating reuse of treated effluent for irrigating agricultural fields thereby benefiting the local community in a water scarcer area.

The overall flow diagram of Paper making process is shown in **Figure 1.** The paper manufacturing process is divided into following steps:

⇒ Raw material preparation

⇒ Pulping process

⇒ Paper making

Raw Material Preparation:

Wood logs are washed, chipped and fed to the stationary digester for cooking **Figure -2** whereas Bagasse after dry pithing is washed in slush tank and the and the pith is removed by dewatering in aqua separator and screw press before

Fig 1 Process Layout at SPBL, Erode

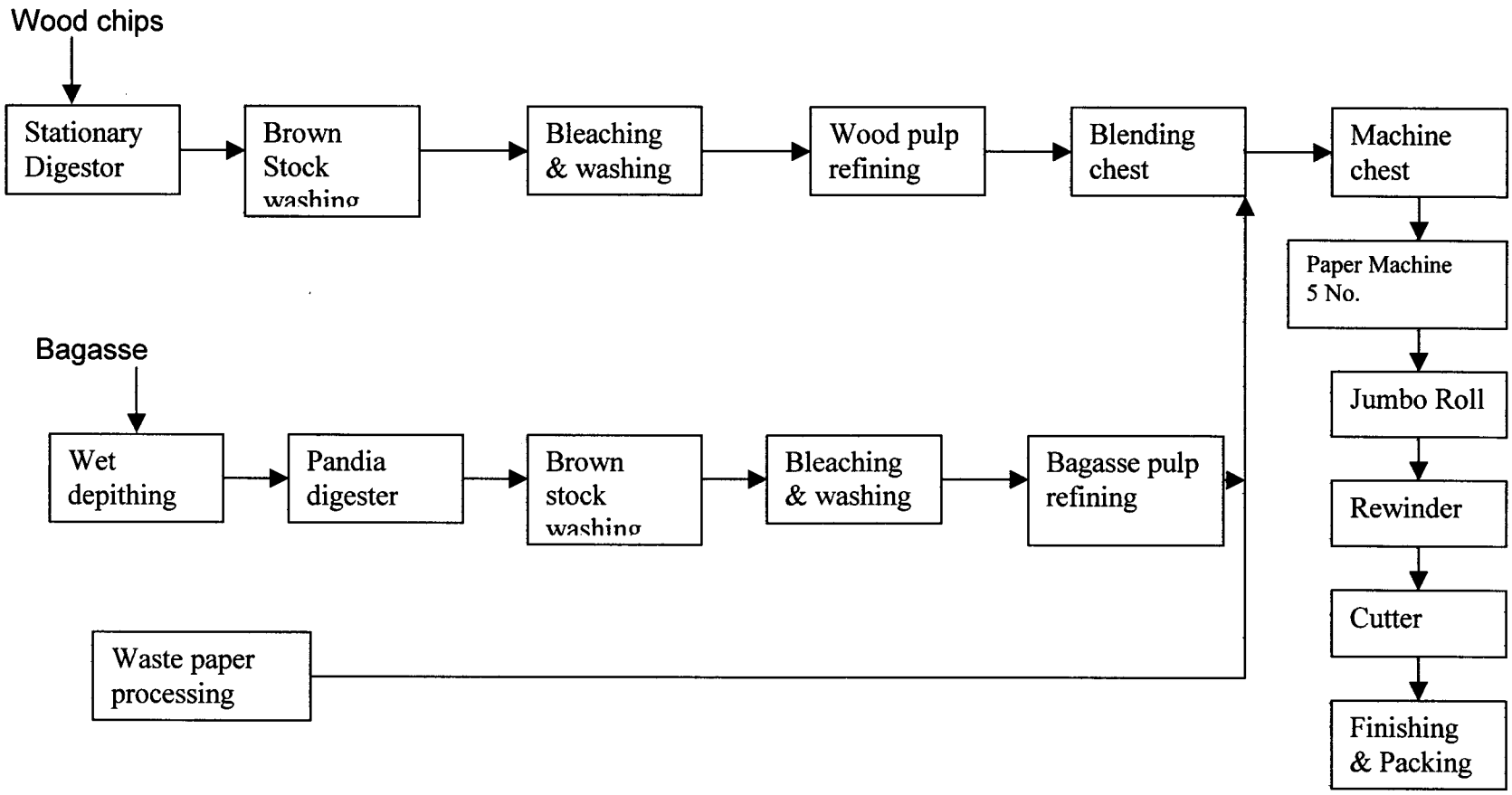
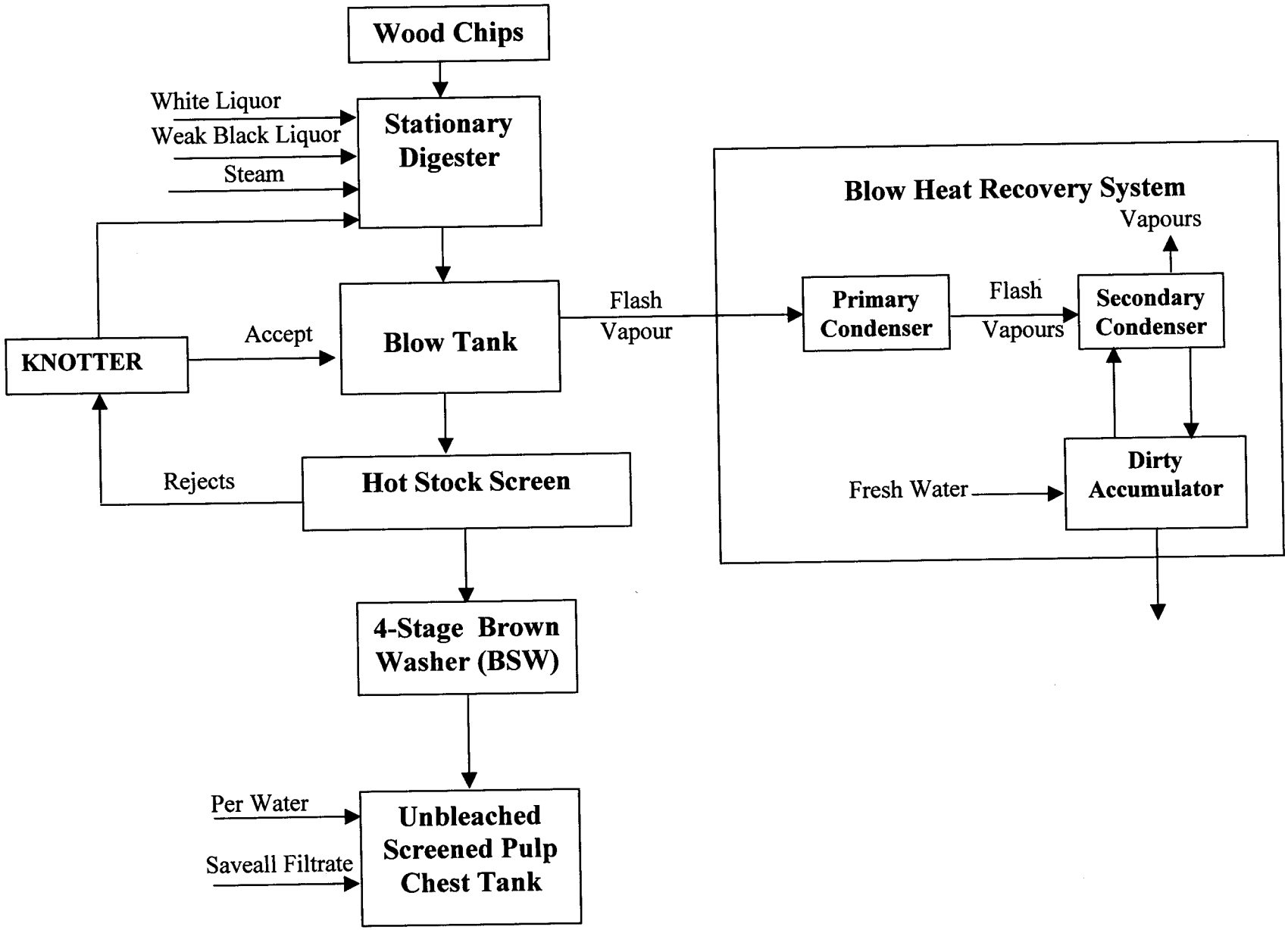


Fig. - 2, Pulping Process for Wood , Crude



feeding to the continuous pandia digester as shown in **Figure-**3 . The filtrate of aqua separator and screw press is fed to the pith press where the pith is removed and sold off to local market. Part of pith filtrate is recycled back to the slush tank and remaining goes to anaerobic lagoon.

Pulping Process:

Pulping process includes cooking of raw material, brown – stock washing and bleaching. Wood based pulping process is shown in **Figure 2** and bagasse based pulping process is shown in **Figure 3** . Cooked raw material from Wood and Bagasse digester is blow down in blow tank, separated from knots in the knotter and is washed in four stage counter current brown stock washer (BSW). Heat from blow tank is recovered by allowing the vapors to condensate in primary and secondary condenser. Fresh water is used in dirty accumulator to cool the condensate. The hot water from blow heat recovery is used in brown stock washer for both the street (wood and Bagasse). The black liquor generated from counter current brown stock washing is goes to soda recovery process. The mill uses chlorination, alkali with peroxide and hypochlorite (CEpHH) sequence to bleach the pulp. Flow sheet of bleaching process for wood and Bagasse is shown in **Figure - 4 & 5** respectively. The bleach filtrate from different bleaching sequences is used for pulp dilution and the excess is discharged to ETP for further treatment. The bleached pulp is stored in bleached tower at 8-10% consistency. The bleached pulp form the storage tank is diluted to ~3.5% consistency using paper machines back water and sent to stock preparation and paper machines.

Fig.- 3, Pulping Process for Bagasse, Erode

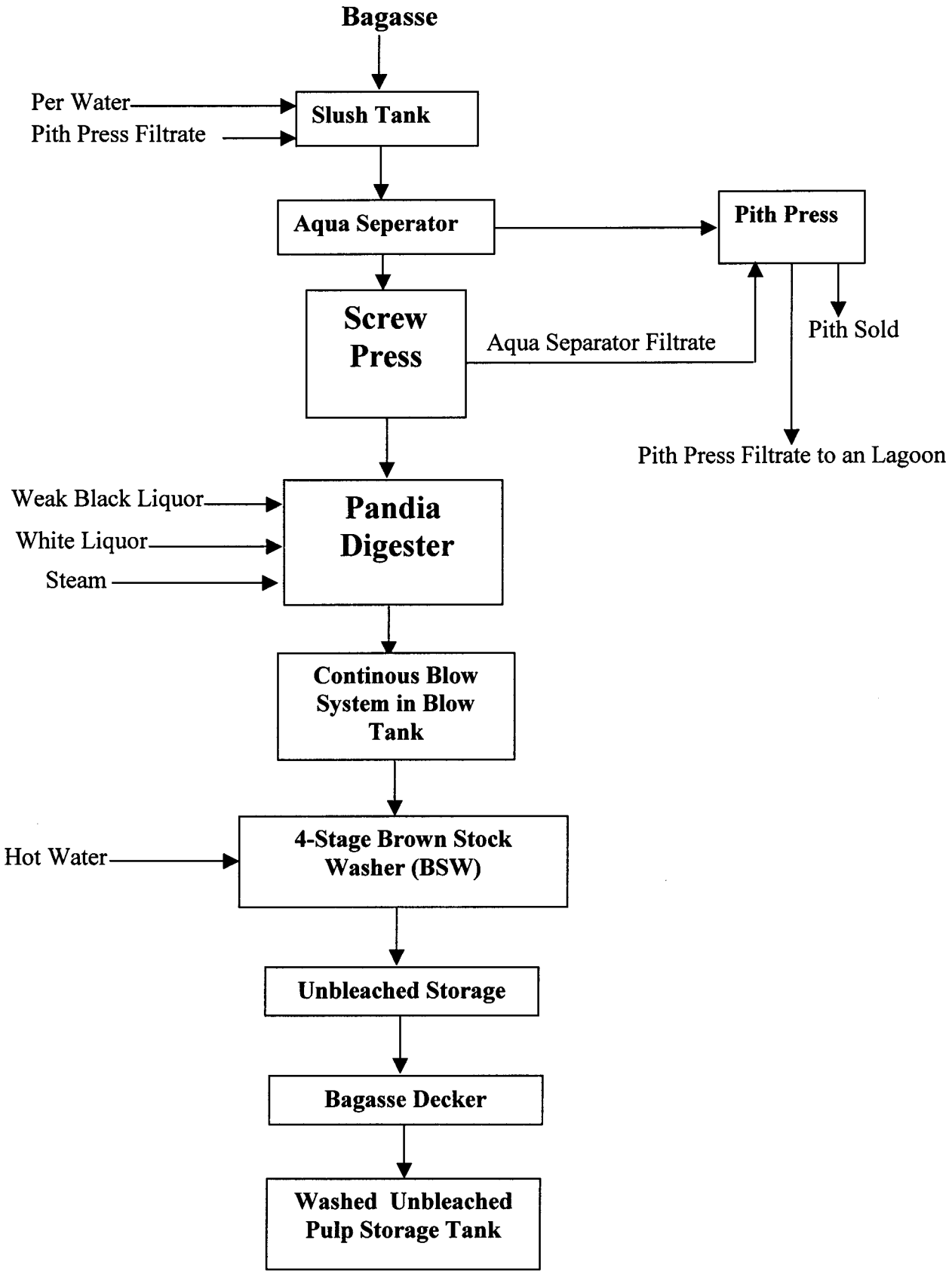


Figure – 4, Flow Sheet of Wood Bleaching process, Erode

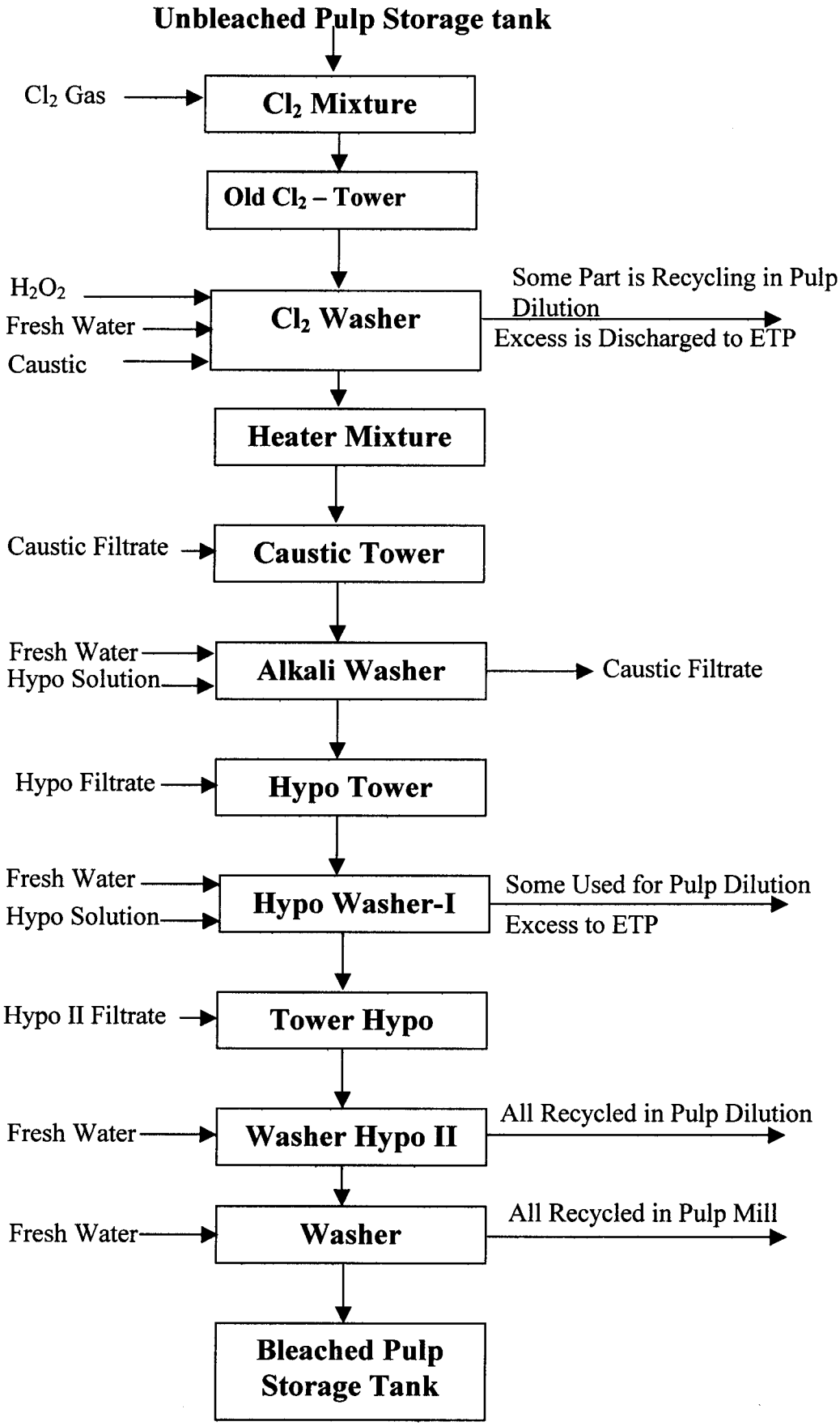
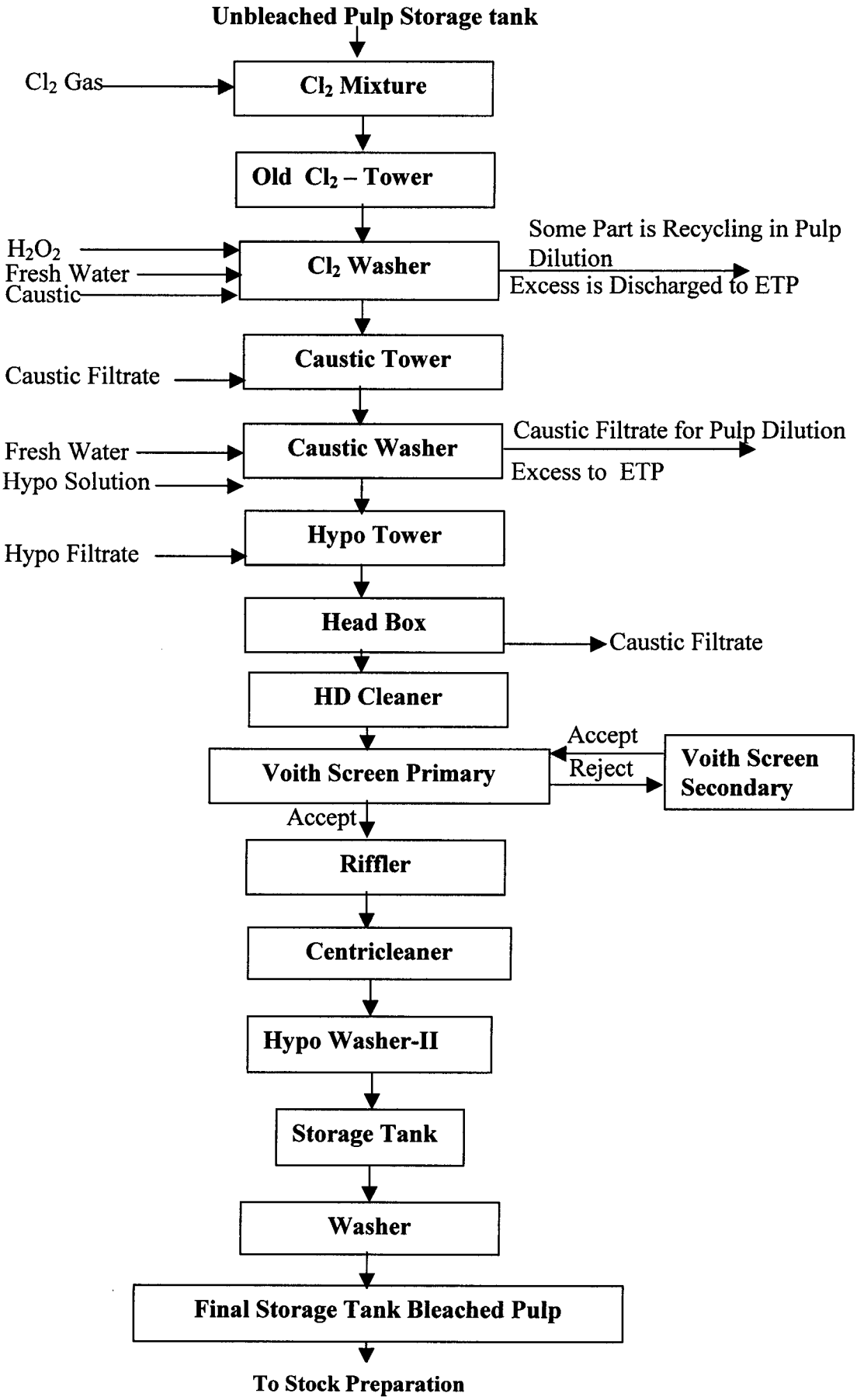


Figure – 5, Flow Sheet of Bagasse Bleaching Process, Erode



Paper making:

This process essentially involves stock preparation and paper forming process. There are five paper machines in Mill A manufacturing different types of paper like Map litho / bristle paper, duplicating paper, superfine paper and paper board. Bleached pulp from wood and bagasse street is blended in a blending chest where desired dye and rosin solution is added. The bleached pulp is refined before stored in machine chest. The refined pulp is drawn by the fan pump along with the back water from wire part of the paper machine. The diluted pulp is cleaned in pressure screen, followed by three stage centricleaner and is finally pump to the head box. From the head box the pulp solution passes through different sections of paper machines and finally paper is formed having 5.0 – 6.0 % moisture.

In the wire section of paper machine natural drainage of water takes place by gravity which is collected in rich wire tank and recirculated back to head box via fan pump. The vacuum pump present in the wire section as well as press section removes water from the sheet which is collected in seal pit. Seal pit tank and rich water tank is connected to each other. The shower water and excess seal pit water is pumped to krofta save-all and Polly disc save-all. The recovered fiber from save-all is reused and the filtrate is recycled for dilution of pulp in stock preparation etc. The waste water generated from the OD thickener filtrate, save all filtrate, tertiary centricleaner rejects, pressure screen rejects, vacuum pump sealing waste water, floor washing and equipment washing waste water etc. is collected in a common channel and is sent to the Per Water System (PER).

Along with paper machine waste water and some part of the pulp mill waste water is also sent to PER system. The clarified water from PER system is recycled back to vacuum pump sealing in paper machines, gland sealing/cooling in pulp mill etc. The weak black liquor having ~12.5 % solids from the pulp mill is passes through five stage multiple evaporator to a solid level of ~ 50% and finally 65% solid after cascade evaporator where heat from the flue gas of recovery boiler is used. The concentrated liquor is then sprayed in to the recovery furnace having temperature more than 850 °C

Water Consumption Pattern at SPBL:

The fresh water consumption in various sections of the mill was critically monitored using (ultrasonic ESSIFLIO 6000 SERIES flow meter) the results of which are indicated as under :

S.No.	Particulars	Quantity of fresh water used m3/d
1.	Pulp Mill	**9,000**
2.	Paper Machine 1-4	**7,000**
3.	Paper Machine 5	**2,200**
4.	Soda Recovery Process & Boiler House	**500**
5.	D M Plant	**2,000**
6.	Drinking Water Plant	**2,000**
7.	Water Treatment Plant	**600**
8.	Hypo preparation (direct river water)	**500**
9.	Cooling tower (direct river water)	**500**
	Total	**24,300**

Water Balance Study at SPBL

The total raw water drawn from the river on average is 25,500 m^3/d. Out of total, 24,500 m^3/d goes to water treatment plant via turbo generator / compressor (as cooled media). Under sludge from the clariflocculator around 500 m^3/d goes directly to effluent treatment plant. Around 24,300 m^3/d is distributed in different paper making process. Around 1000 m^3/d direct river water is used for Hypo solution preparation and for cooling tower make up. Water balance across the paper mill are depicted in **Figure – 6** and Water balance across the pulp mill are depicted in **Figure – 7** respectively. Fresh water used across individual section are given below:

Pulp mill:

- Blow heat recovery system
- Pump gland sealing / cooling
- Bleach chemical preparation
- Pulp dilution

Stock preparation:

- Dye preparation
- Starch solution preparation
- Size solution preparation
- Color floor washing

FIGURE- 6, WA TER BALANCE AT M/s SESHASAYEE PAPER AND BOARDS LIMITED, ERODE

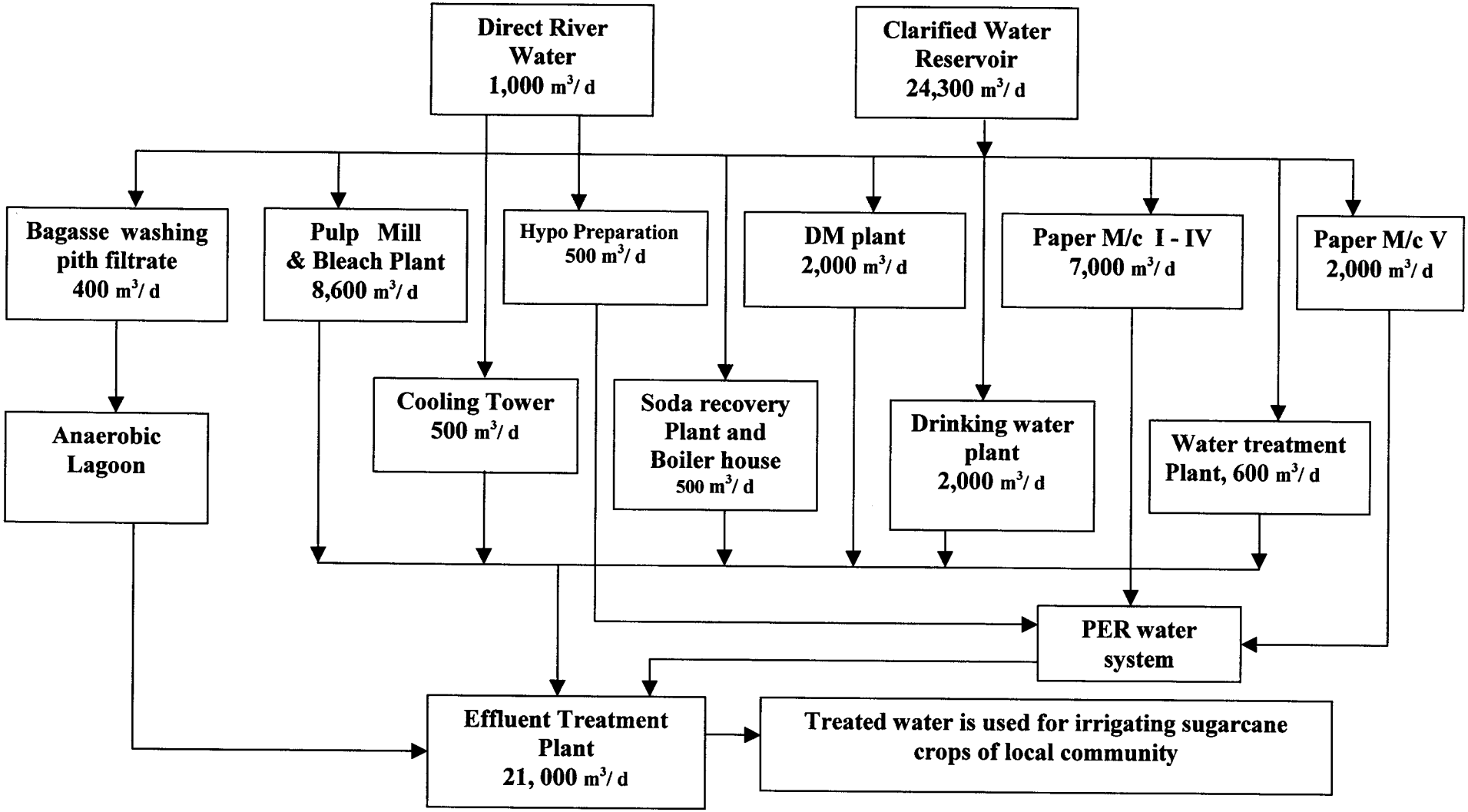
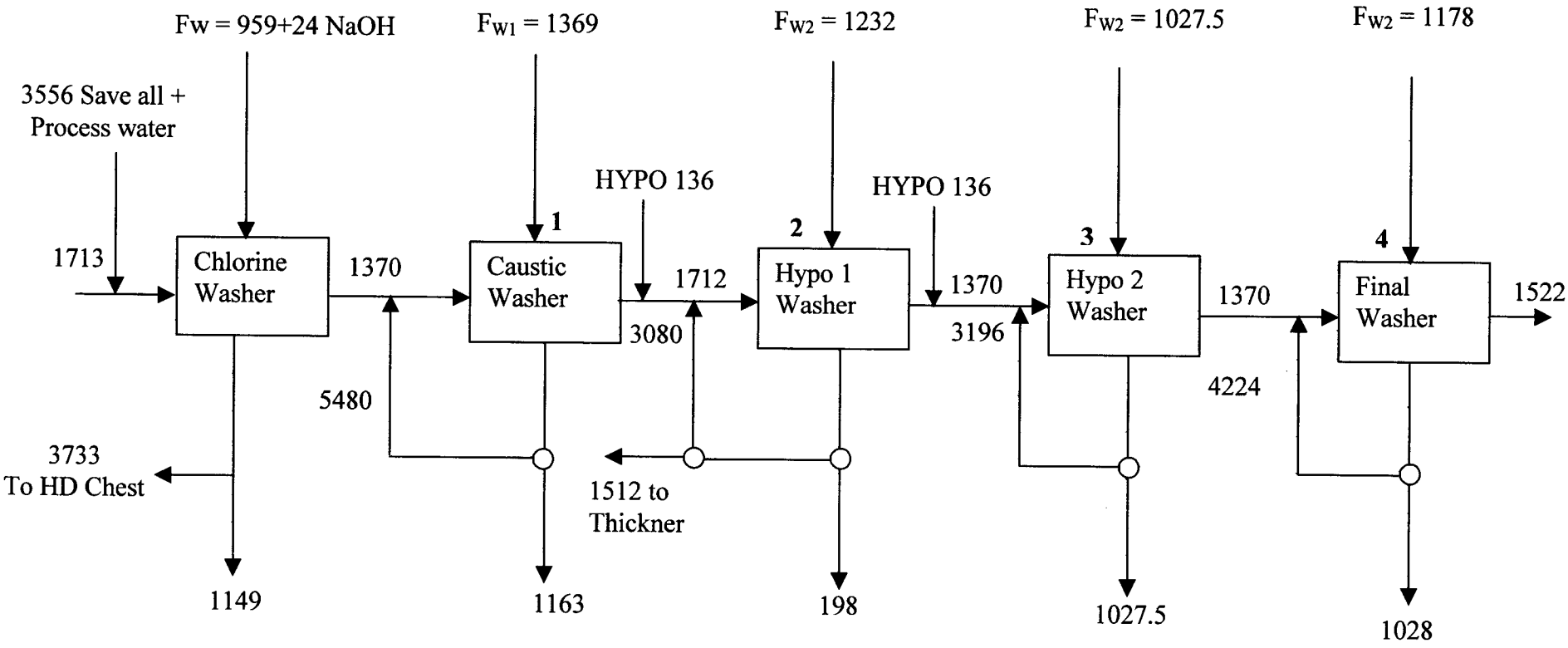


Fig. 7, Water Balance Flow Diagram for SBPL, Erode (All Figures in m^3/day)



- Refiner and gland cooling
- Pump suction
- Coagulant dilution

Paper machines:

Wire Part:

- Low pressure wire shower
- Lump breaker shower
- Floor washing
- Decker washer
- Dandy cleaning showers
- Gear box of couch roll
- Yankee hot press cooling water
- Make up to warm water tank

Press Part:

- H.P. showers in press felt (1.0 – 2.0 hr/day)
- Suction press sealing water
- Doctor blade
- Floor washing
- Gear box at presses

Dry End:

- Drum Reels & gear box
- Size press cleaning showers

Soda Recovery Plant:

- Cooling tower make up
- F.C. pump
- Milk of lime preparation
- Slurry pump gland cooling

Water Conservation Measures Implemented by SPBL :

Process back water available for reuse and their characteristics in the different section of the paper mill were determined. Based on their characteristics and availability several conservation measures were implemented. Before implementation, it was assured that replacing fresh water in specific area should not affect the final paper quality. During the water crisis period in summer season some stream measures had to be taken, keeping in mind the after affect, so as to keep the mill running without stoppage. During the water crisis period the recycling of PER and Disc-save all increased ultimately affecting the process and final product to the some extent.

Following are the water conservation measures already implemented by the SPBL.

- Counter current brown stock washing is used in the mill which reduces fresh water consumption as well as increase the toddle value of black liquor generated. As a result energy consumption in soda recovery plant is also reduced.

- Bleach filtrate except chlorine back water is partly reused for tower dilution.
- Use of PER water (recycled water) for non contact, non process operations where quality of water is not important as it does not effect the quality of final finish product:
  a) pump gland / sealing cooling
  b) vacuum pump sealing
  c) Floor washing
- PER water is used for wet depithing of bagasse.
- PER water is used for pulp dilution before bleaching
- Save-all filtrate, waste cooling water from surface condenser from paper machine 1 – 4 is used for pulp dilution before bleaching.
- Surface condensates from dryers from paper machines 1 – 4 is used as high pressure showers of paper machines 1-4.
- Back water from disc save – all installed in paper machine 5 is used in showers, vacuum pump sealing, decollators cooling etc. of paper machine 5.
- Back water from disc save – all installed in paper machine 5 is used for waste paper processing.
- All pulp dilution in centricleaner is being done by seal pit water of the same machine.
- Back water from disc save – all is used for couch pit and pulper dilution in paper making process.

As a result of implementation of above said options, the SPBL, Mill has been able to reduce fresh water consumption by ~ 30-45% with increase in paper production capacity. **Further the treated effluent is being used for irrigation of sugarcane fields of the local community.**

CASE STUDY:

(II) Ballarpur Industries Ltd (BILT), (Unit Shree Gopal), Yamunanagar

This pulp and paper mills is also one of the oldest mill of country (established in 1936) with an installed capacity of 70,000 tonnes per annum approximately. The average production of the mill is 240-250 TPD. The main raw material is hardwood and bamboo in the ratio of 84:16. Mill produces writing & printing paper as well as specialty grades like tissue paper, electrical grade etc. on six paper machines. Depending upon the quality and grade of paper, mill also use some portion of imported wood pulp in the fiber furnishes. The mill has 3 stationary batch digesters, Brown stock washers, Bleaching section ($C/DEopD_1D_2$), five power boilers (three running) and two turbines. The treated waste water is discharged to a canal which ultimately meets to yamuna river. The overall flow diagram of Paper making process is shown in **Figure 8.**

The paper manufacturing process is divided into following steps:

⇒ Raw material preparation

⇒ Pulping process

⇒ Paper making

Raw Material Preparation:

Wood logs are washed, chipped in drum and fed to indirect heated stationary digester for cooking **Figure -8.**

Pulping Process:

Pulping process includes cooking of raw material, brown – stock washing and bleaching. Flow sheet of pulping process is shown in **Figure 9.** Cooked raw material from digester is blow down in blow tank, separated from knots in the knotter and is washed in four stage counter current brown stock washer (BSW). Heat from blow tank is recovered by allowing the vapors to condensate in primary and secondary condenser. Fresh water is used in dirty accumulator to cool the condensate. The hot water from blow heat recovery is used in 4^{th} stage brown stock washer. The black liquor generated from counter current brown stock washing is goes to soda recovery process. The mill uses chlorine dioxide, alkali with peroxide ($C/DEopD_1D_2$) sequence to bleach the pulp. Flow sheet of bleaching process is shown in **Figure 10**. The bleach filtrate from C/D and Eop washer is used for pulp dilution and the excess is being discharged to ETP for further treatment. The back water from D1 and D2 washer is used for pulp dilution. The bleached pulp is stored in two no. bleached tower at 8-10% consistency. The bleached pulp form the 1000 M3 storage tank is diluted to 2.0-2.5% consistency using paper machines back water and sent to paper machines 1,2 & 4 and pulp form the 500 M3 storage tank is diluted to 4.0-5.0% consistency using paper machines back water and sent to paper machines 3, 5&6 respectively.

Figure- 8, Flow Diagram of Paper Manufacturing process at M/s BILT, Yamunanagar

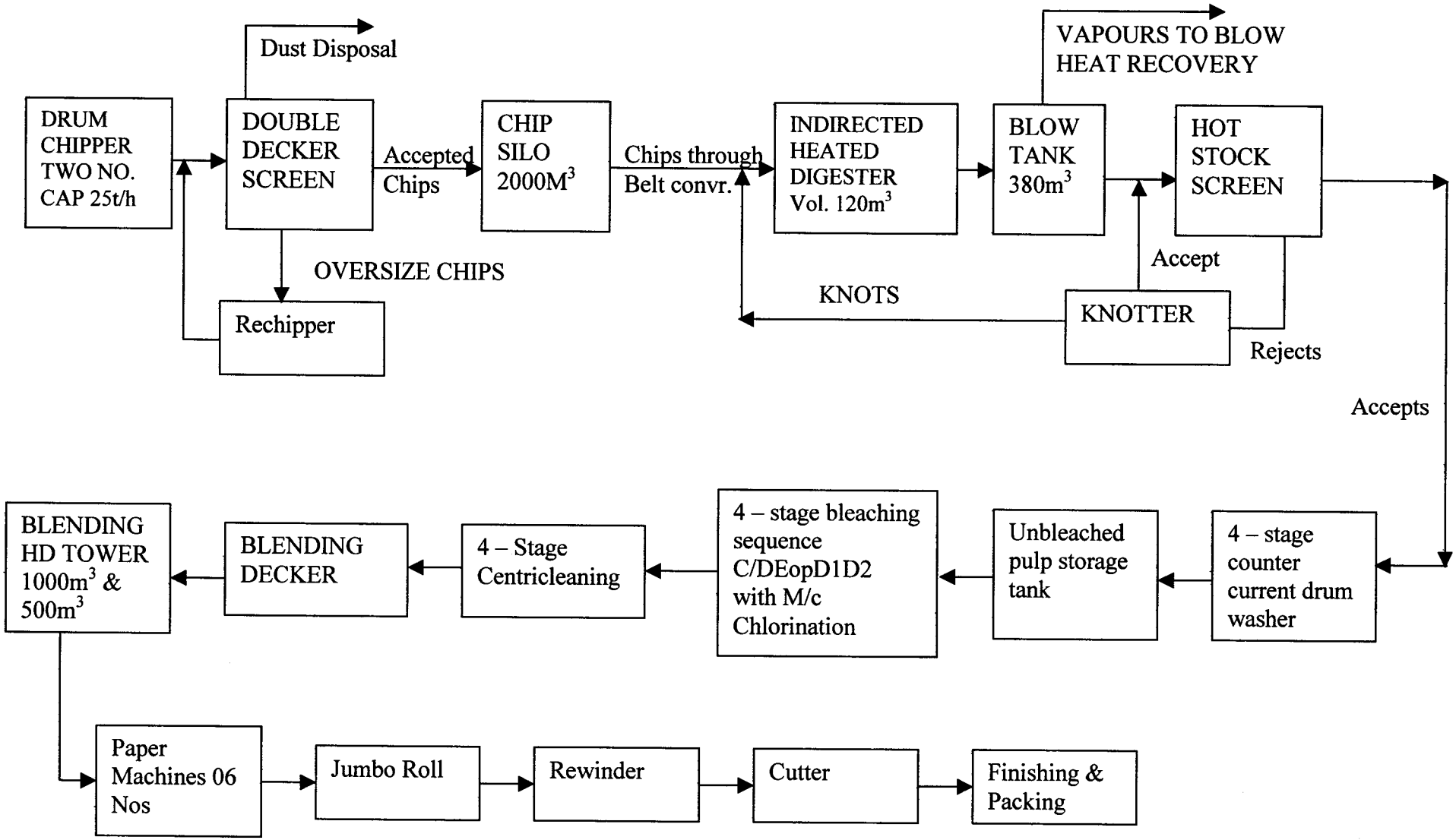


Fig. 9 Pulping Process, BLEYMinal Layout

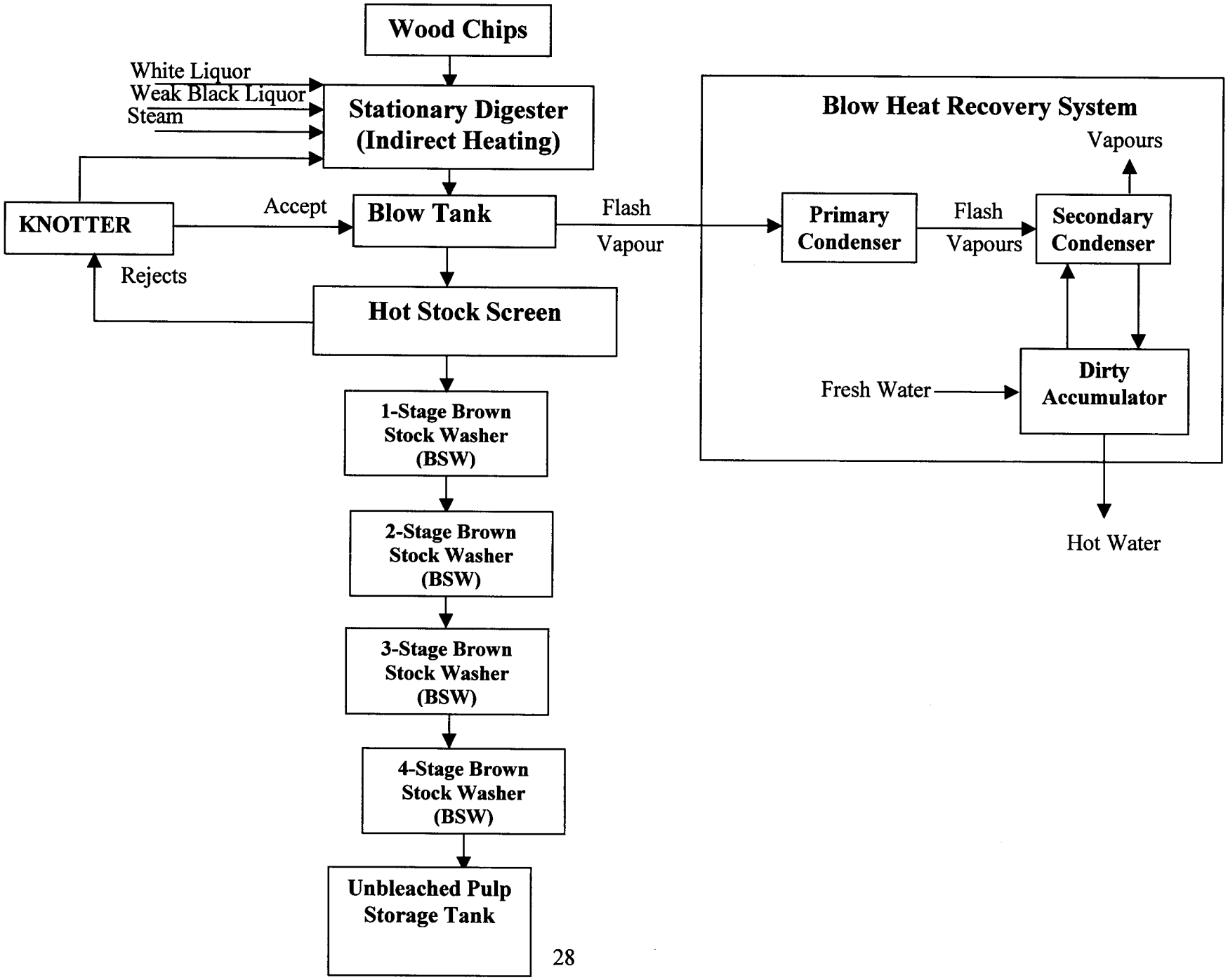
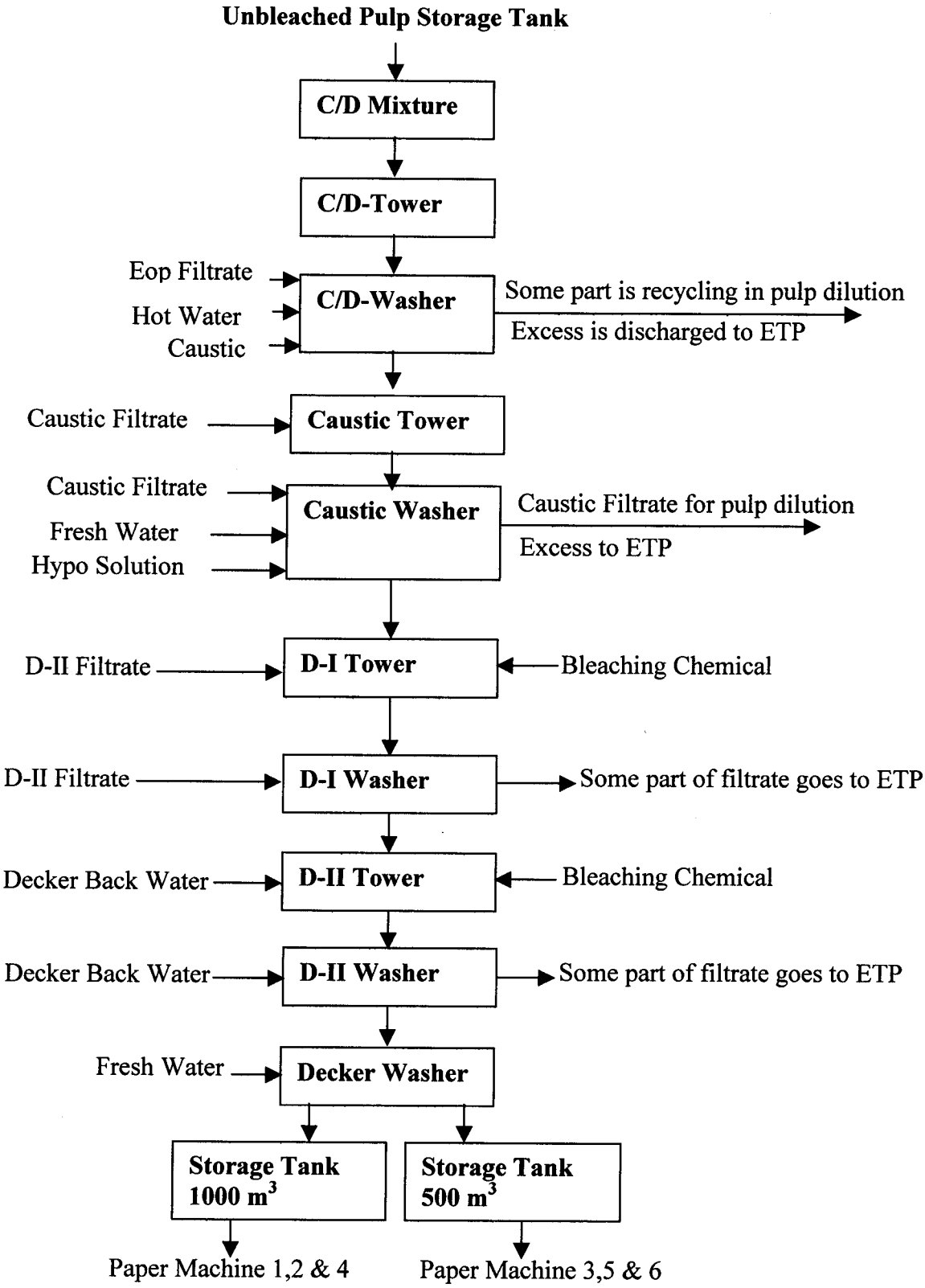


Figure- 10, Flow sheet of Bleaching Process, Yamunanagar



Fresh water consumption was monitored for 24 hrs through flow meter installed in fresh water storage tank for supply to different sections of paper making process.

Paper making:

There are six no. of paper machines and a blade coater of 75 TPD capacity in BILT Yamunanagar manufacturing different types of writing and printing paper, industrial paper, coated papers & boards and water marked paper. Bleached pulp from wood is blended in a blending chest where desired dye and rosin solution is added. The bleached pulp is refined before stored in machine chest. The refined pulp is drawn by the fan pump along with the back water from wire part of the paper machine. The diluted pulp is cleaned in pressure screen, followed by three stage centricleaner and is finally pump to the head box. From the head box the pulp solution passes through different sections of paper machines and finally paper is formed having 5.0 – 6.0 % moisture.

In the wire section of paper machine natural drainage of water takes place by gravity which is collected in rich wire tank and recirculated back to head box via fan pump. The vacuum pump present in the wire section as well as press section removes water from the sheet which is collected in seal pit. Seal pit tank and rich water tank is connected to each other. The shower water and excess seal pit water is pumped to krofta save-all and back water storage tank. The recovered fiber from save-all is reused and the filtrate is recycled for dilution of pulp in stock preparation etc. The back water from storage tank is used for pulp dilution in pulp mill and the overflow from storage tank goes to effluent treatment plant for

further treatment. The weak black liquor having ~12.5 % solids from the pulp mill is passes through five stage multiple evaporator to a solid level of ~ 50% and finally 65% solid after cascade evaporator where heat from the flue gas of recovery boiler is used. The concentrated liquor is then sprayed in to the recovery furnace having temperature more than 850 oC

Water Consumption Pattern at Bilt Yamunanagar

The fresh water consumption in various sections of the mill was critically monitored using (ultrasonic ESSIFLIO 6000 SERIES flow meter) the results of which are indicated as under :

S.No.	Particulars	Quantity of fresh water used m3/d
1.	Pulp Mill	**8,592**
2.	Paper Machine I	**1,992**
3.	Paper Machine II	**2,328**
4.	Paper Machine IV	**3,792**
5.	Paper Machine V	**3,408**
6.	Paper Machine VI	**3,12**
7.	Paper Machine VII	**2,208**
8.	Soda Recovery Process	**1,560**
9.	D M Plant	**3,768**
10.	CLO2 Preparation	**432**
11.	Blade Coater	**744**
12.	Mill Colony & other Miscellaneous	**4,128**
	Total	**33,264**

Water Balance study at Bilt Yamunanagar

The mill has 17 numbers of tube wells for fresh water intake from the ground. The total raw water drawn on average is 33,264 m3/d. The mill has a fresh water reservoir tank where all the tube wells out let is connected. Out of total, 3,768 m^3/d goes to water treatment plant including power generation. Around 29,496 m^3/d is distributed in different paper making process including mill colony water supply and miscellaneous as indicated above. Around 750 m^3/d fresh water is used for Blade coating plant. Water balance across the Paper mill is depicted in **Figure- 11** and Water balance across the pulp mill is depicted in **Figure- 12**. Fresh water used across individual section are given below:

Pulp mill:

- Blow heat recovery system
- Shower spray and pulp dilution
- Cooling / sealing of pump gland
- Bleach chemical preparation

Stock preparation:

- Dye preparation
- Super clear water make up
- Consistancy regulators
- Starch solution preparation
- Size solution preparation
- Floor washing

Fig. 11, WATER BALANCE AT M/s BALLARPUR IMNDUSTRIES LIMITED, YAMUNANAGAR, HARYANA

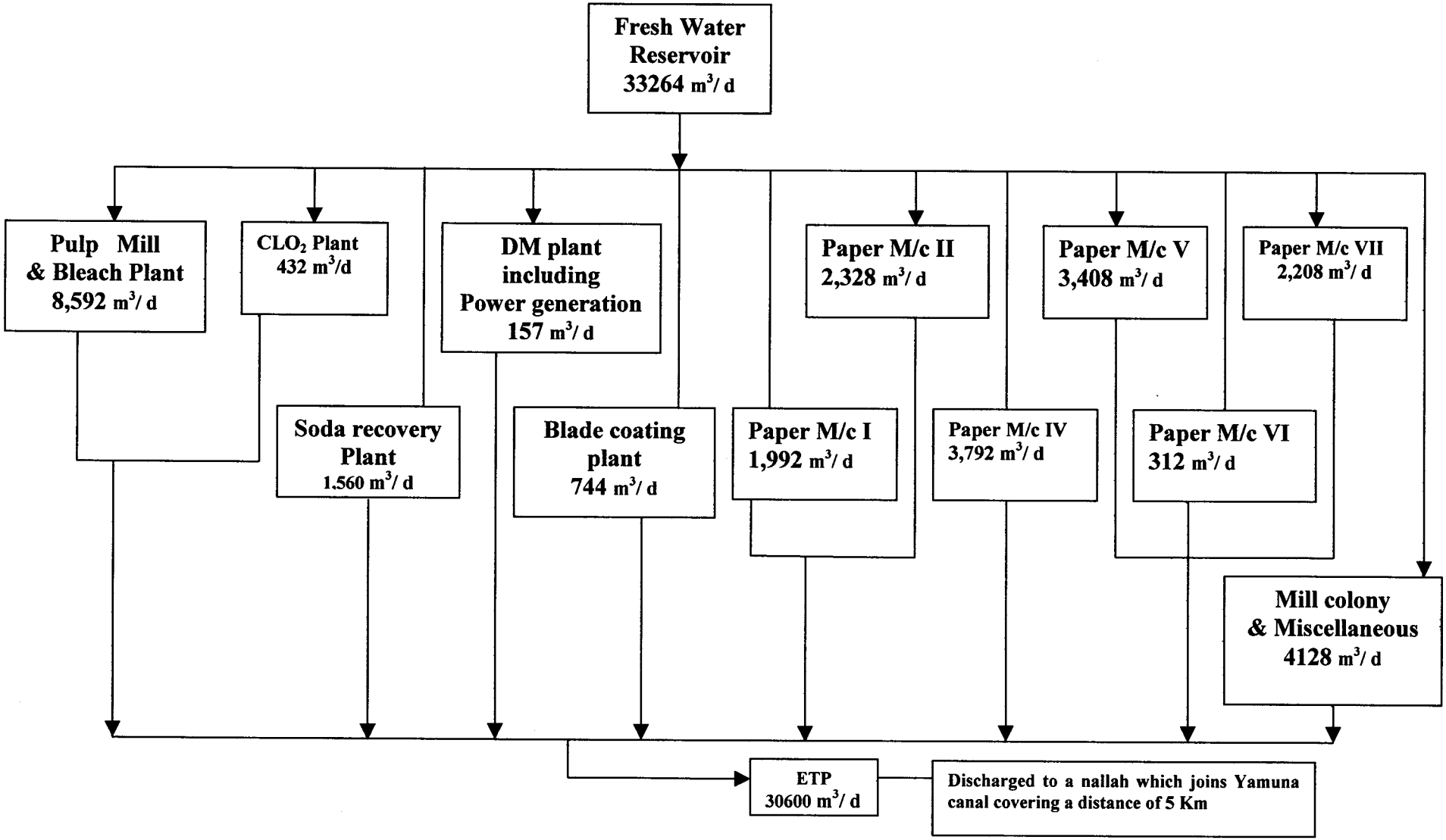
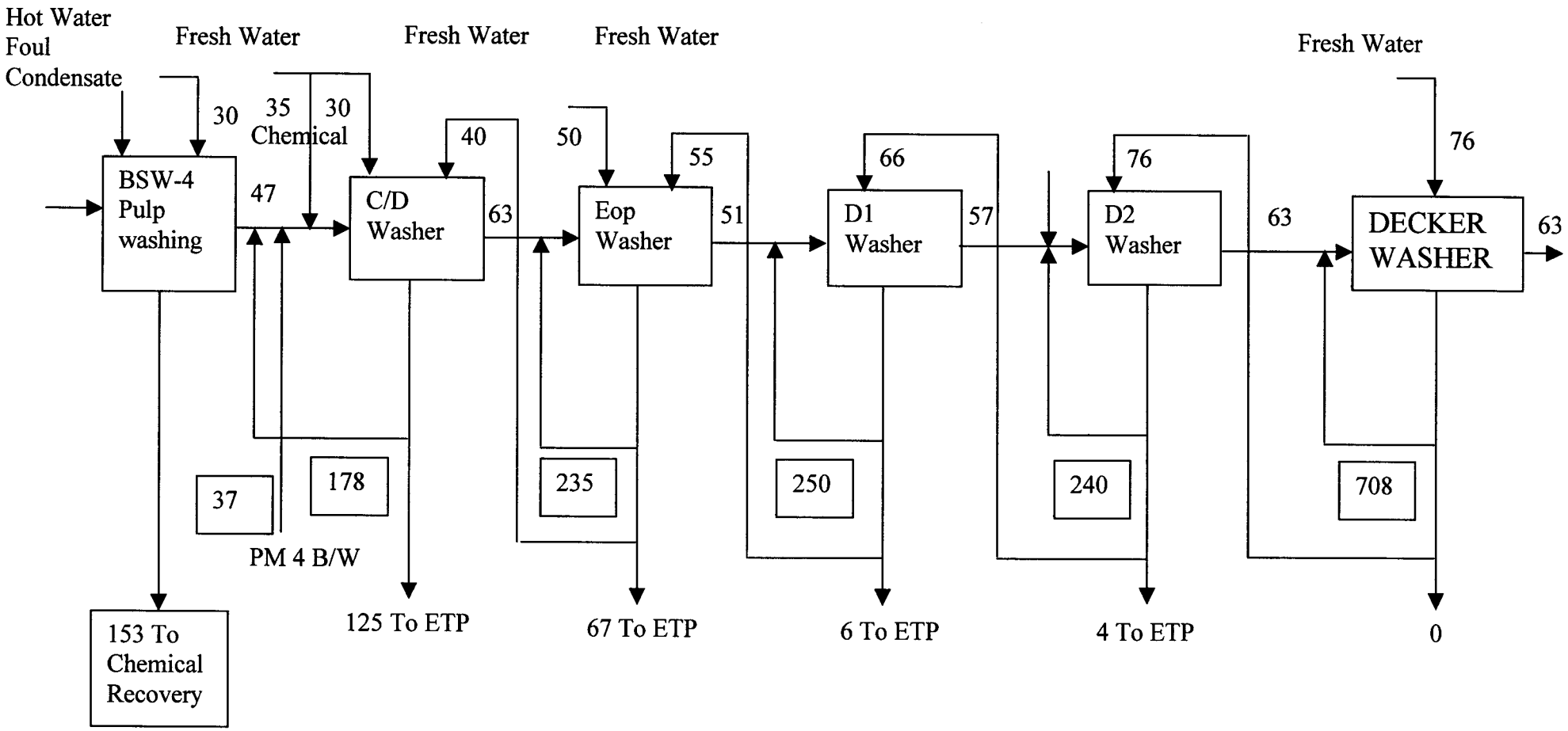


Fig. 12, Water Balance Flow Diagram for BILT, Yamunanagar (All Figures in m^3/hr)



- Refiner and gland cooling
- Pump suction
- Coagulant dilution

Paper machines:

Wire Part:

- H.P. showers
- Couch sealing water
- Floor cleaning
- Decker washer
- Dandy cleaning showers (2 nos.)
- Gear box of couch roll
- Squire nozzle water
- Make up for silo at the time of wash up

Press Part:

- H.P. showers in press felt (2.0 hr/day)
- Suction press sealing water
- Doctor blade
- Floor cleaning
- Gear box at presses

Dry End:

- Gear box for all gears
- Size press cleaning showers
- Drum reels

Soda Recovery Plant:

- Cooling tower make up
- F.C. pump
- Milk of lime preparation
- Slurry pump gland cooling

Water Conservation Measures Implemented by Bilt Yamunanagar:

In the washing, screening, bleaching and dilution of pulp and paper stock section the reuse of white water can lead great shaving of fresh water consumption. Waste water discharged from different paper making processes were characteristics for different parameters. The white water from paper M/c - 4 is stored in a silo and is recycled to pulp mill for pulp dilution, etc. Based on their characteristics and availability several conservation measures were implemented. Before implementation, it was assured that replacing fresh water in specific area should not affect the final paper quality. Following are the water conservation measures already implemented in BILT Yamunanagar.

- Counter current brown stock washing is used in the mill which reduces fresh water consumption.
- Back water from **C/D** washer is partly reused for tower dilution and rest discharged to Effluent Treatment Plant.
- Back water from **Eop** washer is partly reused for tower dilution and rest discharged to Effluent Treatment Plant.

- Back water from excess water chest is reused in the following operations:
  d) Pulp dilution in New Pulp Mill
  e) Paper M/c showers after passing through super clear filter
  f) Consistency regulator pump
  g) Couch pit dilution
  h) UTM pulper dilution
- ETP treated water is used for wetting of wood , gardening purpose and ash quenching ultimately reducing the fresh water consumption by 1000 m^3/day.
- Lean water from Krofta filtrate of Paper machine 1 & 2 is used for pulp dilution in new pulp mill.
- Surface condensates from dryers from paper machines 1, 2 & 4 is used as couch pit dilution.
- Back water from krofta in paper machine 1 & 2 is used for waste paper processing.
- ETP treated effluent and paper machines Krofta filtrate is recycled for non contact, non process operations where quality of water is not important as does not effect the quality of paper production ultimately reducing the fresh water consumption by 2000 m^3/day.

As a result of implementation of above said options, the mill has been able to reduce fresh water consumption by ~ 10-20%.

Sources of Waste Water in M/s Sesashayee Paper & Boards Limited, Erode and M/s BILT, Yamunanagar:

In general the sources of waste water are common in both the mills except for the fact that like in SPBL, the pith filtrate is not generated in BILT Yamunanagar as the mill is not using bagasse as raw material The sources of waste water are indicated below.

Sources	Discharges	Intensity of pollution	Effluent sent to
Raw material washing	Pith filtrate	Small volume with low level of pollutants.	ETP (anaerobic lagoon)
Digester House	Spills & leakages of black liquor & gland cooling water	Small volume but high concentration of pollutants	Chemical recovery
Unbleached pulp washing	Wash water	Small volume with moderate level of pollutant	ETP
Bleaching and Screening	Wastewater from chlorination stage having low pH and high chlorolignins, from caustic extraction stage with dark brown colour & high pH as well as chlorolignins from hypochlorite stage	Large volume with high level of pollutants. Waste water contains high amount of non process elements and toxic chloro-organic compounds.	Some part of filtrate is used for pulp dilution and rest going to ETP
Soda recovery plant	Spills of black liquor in the evaporators, foul condensates and washings of the causticiser	Small volumes, but high pollutants.	ETP
Paper machine	Often referred to as white water.	Volume depending upon the extent of recycling as major part of it is recycled	Some part of white waste water going to ETP
Utilities	DM Plant, Boiler House etc	Small volume & low pollution load	ETP

Characterization of the effluent streams:

The composite samples collected from both the selected mills were characterized for different pollutional parameters. The characteristics of effluent generated from various sections are indicated as under:

EFFLUENT CHARACTERISTICS OF SAMPLES COLLECTED FROM PULP MILL (M/s Sesashyee Paper & Boards Limited, Erode)

S.No.	Parameters	C washer Filtrate wood	Ep - I washer filtrate wood	Ep - II washer filtrate wood	H washer filtrate wood	Pulp Mill Drain Wood
1.	pH	2.2	8.0	7.5	3.2	6.5
2.	T.S., mg/l	1440	1592	1952	3828	4218
3.	T.D.S., mg/l	1410	1552	1849	3771	2679
4.	T.S.S., mg/l	30	40	103	57	1528
5.	C.O.D., mg/l	479	730	787	347	263
6.	Na, mg/l	80	421	59	182	210
7.	K, mg/l	7	13	15	5	9
8.	Ca, mg/l	234	84	53	786	200
9.	Mg, mg/l	16	16	23	28	21
10.	Organic, %	50	47	48	45	45
11.	Hardness, mg/l	583	210	132	1961	412

CHARACTERISTICS OF EFFLUENT SAMPLES COLLECTED FROM PULP MILL
(M/s Sesashyee Paper & Boards Limited, Erode)

S.No.	Parameters	C/H washer Filtrate bagasse	H-II washer filtrate bagasse	Combined bleach Effluent bagasse	High BOD drain bagasse clarifier In	High BOD drain bagasse clarifier out
1.	pH	4.0	4.0	4.0	5.0	5.5
2.	T.S., mg/l	2564	4800	2472	4248	4218
3.	T.D.S., mg/l	2238	3180	1676	2664	3642
4.	T.S.S., mg/l	326	1620	796	1584	576
5.	C.O.D., mg/l	840	3424	1141	3750	966
6.	Na, mg/l	255	80	210	104	124
7.	K, mg/l	23	8	8	28	80
8.	Ca, mg/l	374	513	332	53	267
9.	Mg, mg/l	11	24	10	30	23
10.	Organic, %	45	70	45	65	64
11.	Hardness, mg/l	934	1279	829	129	666

EFFLUENT CHARACTERISTICS OF SAMPLES COLLECTED FROM ETP
(M/s Sesashyee Paper & Boards Limited, Erode)

S.No.	Parameters	Combined effluent P/C inlet	Final Discharge
1.	pH	7.5	7.1
2.	T.S., mg/l	2270	743
3.	T.D.S., mg/l	860	733
4.	T.S.S., mg/l	1410	10
5.	C.O.D., mg/l	1752	112
6.	Na, mg/l	174	128
7.	K, mg/l	16	17
8.	Ca, mg/l	222	150
9.	Mg, mg/l	46	43
10.	Organic, %	75.6	57.2
11.	Hardness, mg/l	554	374

EFFLUENT CHARACTERISTICS OF SAMPLES COLLECTED FROM DIFFERENT SECTION
(M/s Ballarpur Industries Limited, Yamunanagar, Haryana)

S.No.	Parameters	Surface evaporator condensate	Common drain from evaporator section	Back water from Paper M/c IV Silo	Final drain from Paper M/c I,II & IV	Final drain from Paper M/c V ,VI & VII
1.	pH	8.9	9.9	6.2	6.4	6.9
2.	T.S., mg/l	523	610	505	1023	1288
3.	T.D.S., mg/l	520	602	351	544	661
4.	T.S.S., mg/l	03	08	154	479	627
5.	C.O.D., mg/l	1032	752	240	616	328
6.	Na, mg/l	Nil	40	24	32	40
7.	K, mg/l	Nil	9	2	3	2
8.	Ca, mg/l	38	42	64	50	102
9.	Mg, mg/l	10	15	32	29	35
10.	Organic, %	29	32	27	60	31
11.	Hardness, mg/l	135	165	290	245	400

EFFLUENT CHARACTERISTICS OF SAMPLES COLLECTED FROM PULP MILL
(M/s Ballarpur Industries Limited, Yamunanagar, Haryana)

S.No.	Parameters	C/D washer Filtrate	Eop washer filtrate	D1 washer filtrate	D2 washer filtrate	Combined acid drain
1.	pH	2.2	7.1	3.3	3.0	3.0
2.	T.S., mg/l	3228	3050	3025	2495	3125
3.	T.D.S., mg/l	2977	2976	2859	2272	2956
4.	T.S.S., mg/l	251	74	166	223	169
5.	C.O.D., mg/l	1472	960	800	816	1240
6.	Na, mg/l	75	432	45	11	50
7.	K, mg/l	6.0	17	7.0	5.0	12
8.	Ca, mg/l	391	88	293	220	380
9.	Mg, mg/l	91	35	57	64	73
10.	Organic, %	46	27	43	49	46.5
11.	Hardness, mg/l	270	365	965	812	850

EFFLUENT CHARACTERISTICS OF SAMPLES COLLECTED FROM ETP
(M/s Ballarpur Industries Limited, Yamunanagar, Haryana)

S.No.	Parameters	Combined effluent P/C inlet	Final Discharge
1.	pH	8.5	7.1
2.	T.S., mg/l	1642	988
3.	T.D.S., mg/l	1056	976
4.	T.S.S., mg/l	586	12
5.	C.O.D., mg/l	618	168
6.	Na, mg/l	117	102
7.	K, mg/l	19	17
8.	Ca, mg/l	165	144
9.	Mg, mg/l	26	18
10.	Organic, %	48	16
11.	Hardness, mg/l	460	435

WATER CONSERVATION THROUGH INNOVATIVE WATER MANAGEMENT MODELING (PINCH ANALYSIS)

INTRODUCTION:

The pulp and paper industry is one of the major water consuming industries. Water is used for a variety of processes such as raw material cleaning, pulping, bleaching, washing, screening & papermaking and gets contaminated during processing with raw materials, by – products & residues. Treatment of contaminated wastewater has always been an expensive & technically challenging subject. Since water and energy are closely integrated as 98% of the streams have water content higher than 50%, therefore water conservation has gained significant importance. Water management techniques can prove to be highly effective in this case as they enable efficient usage of water with considerations of reuse, recycle and regeneration opportunities. **The process integration approaches** for water management available in literature can be broadly classified as either **pinch based methods** or the methods based on **mathematical programming.** Among the analytical or pinch based approaches, graphical technique to minimize fresh water flow rates is based on an extension of the pinch analysis technique for heat integration. In water integration problems like Thermal Pinch concept, the water surplus diagrams are utilized. Several pinch based analytical methods have been adopted to target water requirement for fixed contaminant (FC), fixed flow rate (FF) as well as for the mixed kind of water allocation problems (FF & FC) but none of them present a methodology for multiple contaminant system, very common in pulp & paper mill waste water.

Apart from pinch based methods, mathematical programming based approach has been adopted to minimize water consumption. In this kind of

approach a network of all possible matches is created and subsequently the system is optimized for minimum utility requirement based on the capital or operating expenses of the network. The advantage of this method is that it provides a robust way of network design and application of these tools based on mathematical programming , to provide insight into water targeting with a consideration of recycle, reuse & regeneration.

Wang and Smith have introduced the concept of source and sink analysis in water minimization known as water pinch analysis. This is a graphical approach for water network and reducing water costs for processes.

METHODOLOGY

The methodology for pinch analysis basically involves following steps:

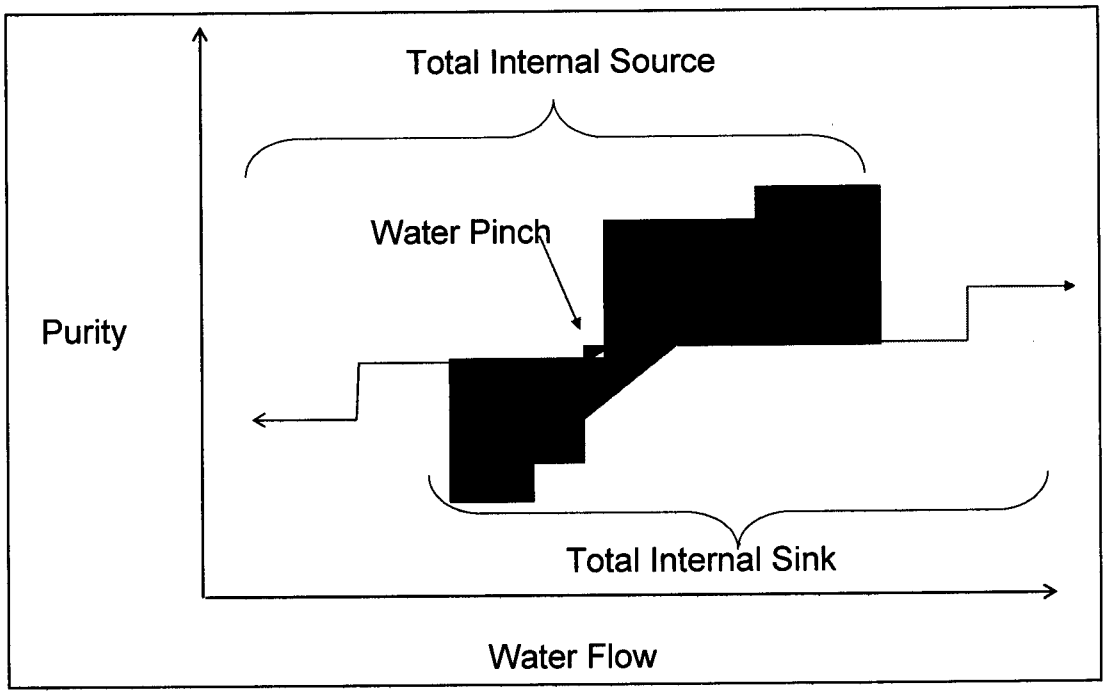
Flow sheet

A simple flow sheet model of water system is developed which shows where water is used (source) and water is generated (sink) e.g water sources might be showers on the paper machine and for sinks one might be consider the white water.

Contaminant Data

The key contaminates are selected for e. g. COD, suspended solids etc . A **key contaminant** is defined as " any property that prevents the direct reuse of the waste water stream". These data can be used for setting up of permissible limit in deferent section. The graphical representation of water

flow (quantity) on horizontal axis and water purity (quality) on vertical axis, isindicated below. Hence the source and sink are also referred as purity profile or composite curve.



Analysis of the water balance

The water balance is critically analyzed & multidimensional water pinch analysis is carried out to determine the optimum matches between source and sinks. Graphical representation of water flow (quantity) on horizontal axis and water purity (quality) on vertical axis, hence the source and sink are also referred as purity profile or composite curve.

Review Design

Examine the resulting network design is examined and the pinches are identified for the selected contaminants. This procedure might also include process modification and "regeneration" options that would result in lower targets.

CASE STUDIES

SPBL, Erode

Mill produces 1,15,000 tpa paper and board utilizing bagasse, Casurina, E. hybrid, waste paper and imported pulp as main raw materials. Mill produces a wide range of products with 5 machine viz. Printing and writing papers, Multi layer duplex, boards, packaging papers etc. The bagasse and wood pulp is bleached by using CEpHH bleaching sequence.

BILT, Yamunanagar

The average production of the mill is 75,000 tonnes/annum against the installed capacity of 53,000 tonnes per annum. The main raw material is hardwood and bamboo in the ratio of 84:16, Mill produces writing & printing paper of different grades and quality on six paper machines. The mill has 3 stationary batch digesters, Brown stock washers, Bleaching section ($C/DEopD_1D_2$), five power boilers (three running) and two turbines. Present water consumption of the mill is 145 m^3 /t paper

Water minimization study was conducted in the above mills using GAMS Development Corporation software for mathematical programming. The mathematical programming was carried out for two contaminants (TS & COD) in the bleach plant for reuse & recycle options. A complete water balance of the pulp mills was prepared using online & portable flow meter and same is shown in Fig –1 & 2. The water samples from various streams were characterized with respect to their pollution load.

Data Extraction

The water balance in **Fig 1 & 2** show that the contaminated streams are mainly the various outlets of the washing operations, therefore, the scope of analysis for water conservation in bleach plant is limited to washing operations only. The assumption made for data extraction are;

I. For mills SPBL, Erode all operations are assumed to be fixed contaminant load type. In this case, however the flow rates through the operation are fixed. The limiting contaminant levels are fixed at 10 % above the current values.

II. For mills BILT, Yamunanagar all processes are assumed to be fixed flow rate operations with upper limits on contaminants fixed at 10 % above the current values.

Restriction on re use of water streams is considered before the analysis. This implies that all matches prohibited by pH are disallowed at the beginning.

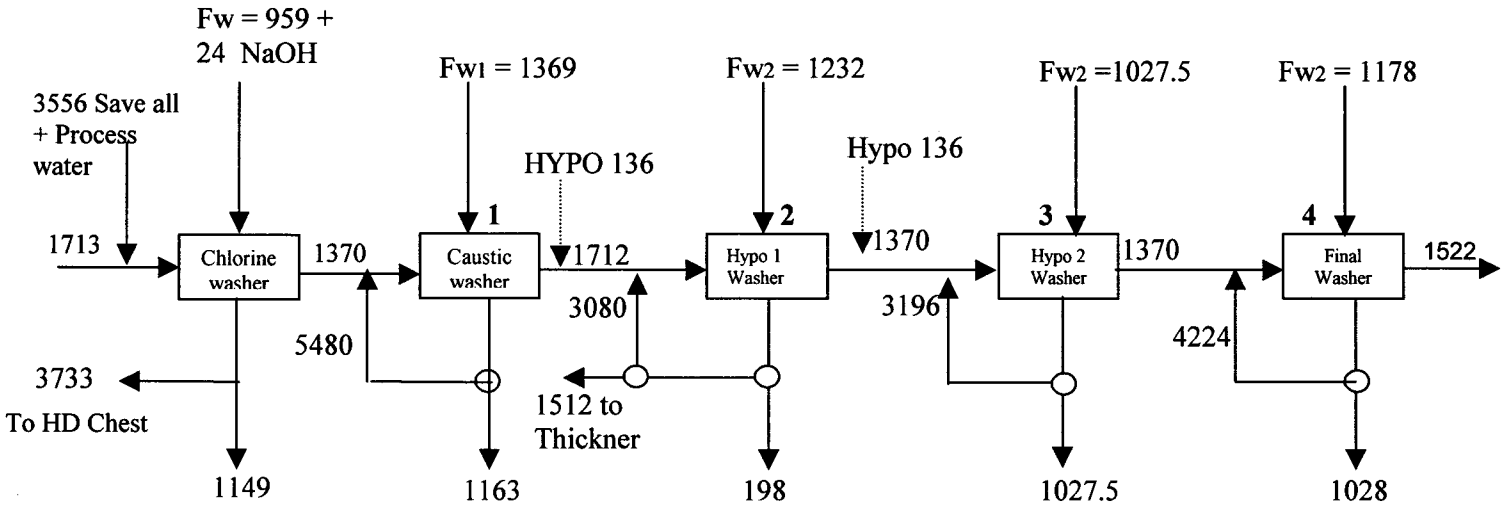


Fig 1 Water Balance Flow Diagram SPBL, Erode (All values in m^3 / day)

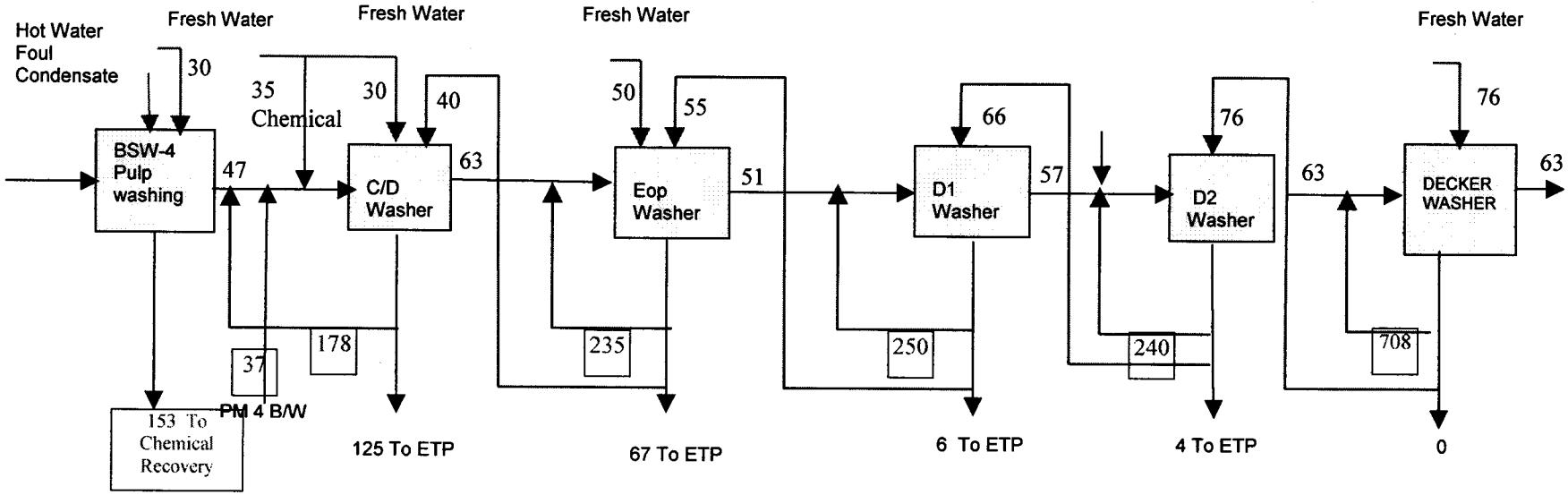


Fig 1 Water Balance Flow Diagram for BILT, Yamunanagr (All values in m^3 / day)

The order and flow rate from one process to another is maintained in process. This implies that the same amount of water flows from process 1 to process 2 as before and so on.. Current internal recycles can not be removed. The flow rates can only be increased and not decreased.

The flow rate and contaminants data obtained for Mills SPBL, Erode is shown in **Table - 1 and 2.**

Table : 1 Flow rate data for SPBL, Erode

S.No	Details of Streams	Flow in (F_{in}) m3/hr	Water added m3/hr	Flow out(F_{out}) m3/hr
1	Caustic Washer	285.4	62.7	348.1
2	Hypo Washer 1	205.3	51.3	256.6
3	Hypo Washer 2	195.9	42.8	238.7
4	Final Washer	233.1	49.1	282.2

Table 2: Contamination and Contaminants Load Data for SPBL, Erode

S.No	Details of Streams	Inlet Stream (C_{in}^{max})		Outlet Stream (C_{out}^{max})		Contaminant Load	
		TS ppm	COD ppm	TS ppm	COD ppm	TS kg/hr	COD kg/hr
1	Caustic washer	2927	974	3355	1056	138.5	28.6
2	Hypo Washer 1	2776	750	3327	880	141.4	33.4
3	Hypo Washer 2	2492	728	2744	898	60.1	40.3
4	Final Washer	2290	590	2616	654	91.9	18.3

For Mills BILT, Yamunanagar the flow-rate and contaminants data extracted is shown in **Table- 3:**

Table 3 : Flow rate and contamination data for BILT, Yamunanagr

S.No	Detail of Streams	F_{in} m3/hr	C_{in}^{max}		F_{out} m3/hr	C_{in}^{max}		Loss m3/hr
			TS ppm	COD ppm		TS ppm	COD ppm	
1	C/D Washer	368	4457	1854	63	8797	2970	305
2	EOP Washer	403	3827	1190	51	6982	2081	352
3	D1 Washer	367	3683	1037	57	5674	1910	310
4	D2 Washer	373	3134	990	63	5063	1447	310
5	Decker washer	847	2617	656	63	2617	656	784

Results and Discussion:

The results shown for mills are calculated for two contaminants primarily because consideration of two contaminants makes the network easily implementable as it is closer to the real scenario.

The results for mills SPBL, Erode obtained by performing the GAMS program run are shown in **Table 4.** It indicates a 15 % possible reduction in fresh water consumption from the current levels. Results were calculated for the cases of multiple contaminants (TS & COD).

Table 4: Results for SPBL, Erode

Results	Min. FW	Units
Current FW consumption	200.3	m3/hr
Min FW. (Considering TS and COD contaminants)	171.3	m3/hr

The network for minimum fresh water usage considering both TS and COD as contaminants are shown in **Fig – 3**

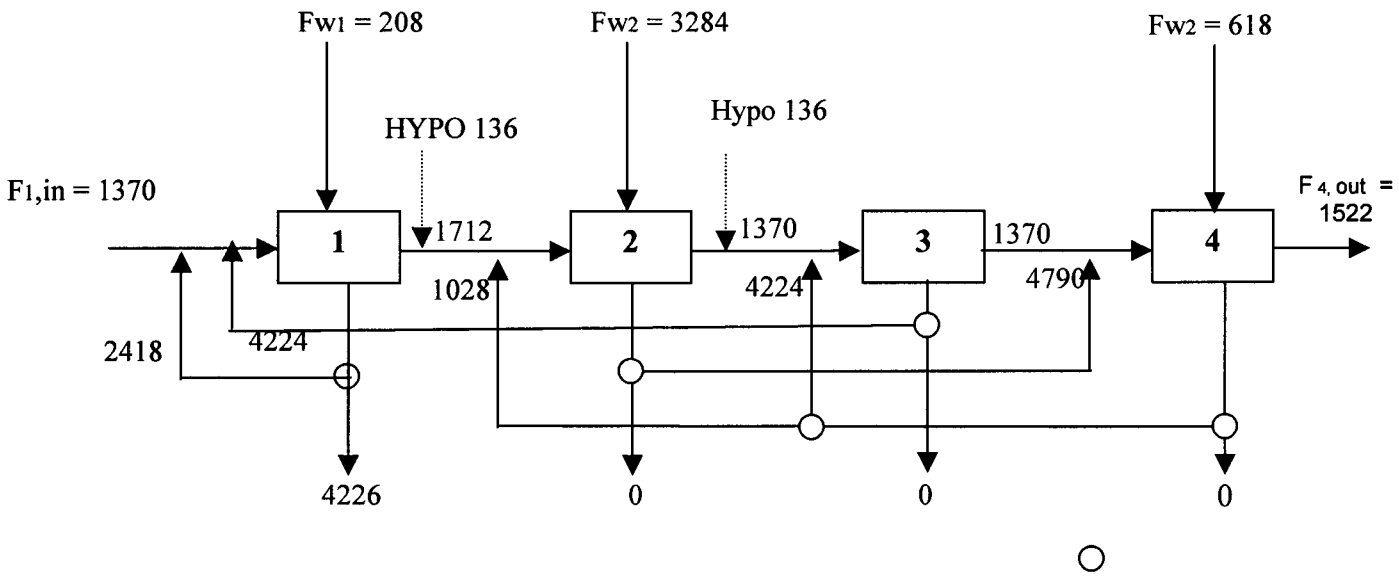


Fig. 3 Final Network design for SPBL, Erode

Note: All figures shown are in m3/ day

The network of the cases of single and multiple contaminants are very different even though the fresh water target is the same. There is a decrease of about 15 % in the amount of fresh water used in the operations without any reduction in effluent volume.

For mills BILT, Yamunanagar the fresh water target obtained is 121 m3/hr as compared to the current requirement of 191 m3/hr. This indicates savings of approximately 35%. The current fresh water network is represented in a matching matrix form in **Table-5.** The fresh water network obtained to satisfy this requirement is shown in **Table- 6.**

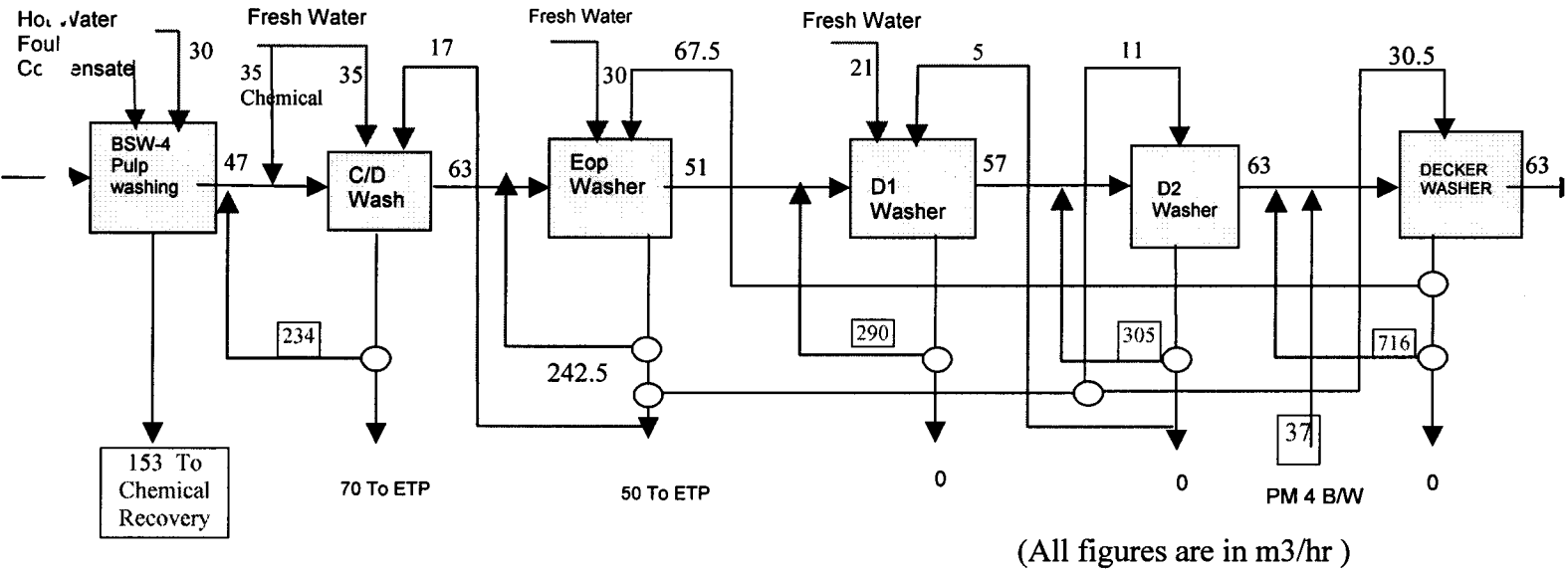
Table 5: Current fresh water Network for BILT, Yamunanagar

No.	Streams	F (m3/hr)		C/D Washer	EOP Washer	D1 Washer	D2 Washer	Decker Washer	Extra
	Name	Available	Used	D1 {368}	D2 {403}	D3 {367}	D4 {373}	D5 {847}	
S1	Freshwater	191	191.0	65.0	50.0			76.0	0.0
S2	B/W from PM 4	37	37.0	37.0					0.0
S3	Feed from BSW	47	47.0	47.0					0.0
S4	C/D Washer B/W	304	179.0	179.0					125.0
S5	EOP Washer B/W	351	275.0	40.0	235.0				76.0
S6	D1 Washer B/W	311	305.0		55.0	250.0			6.0
S7	D2 Washer B/W	310	306.0			66.0	240.0		4.0
S8	D.W. B/W	784	784.0				76.0	708.0	0.0
P1	C/D Washer o/l	63.0	63.0		63.0				0.0
P2	EOP Washer o/l	51.0	51.0			51.0			0.0
P3	D1 Washer o/l	57.0	57.0				57.0		0.0
P4	D2 Washer o/l	63.0	63.0					63.0	0.0
P5	Decker Washer o/l	63	0.0						63.0

Table- 6: Fresh Water network for BILT, Yamunanagar

No.	Streams	F (m3/hr)		C/D Washer	EOP Washer	D1 Washer	D2 Washer	Decker Washer	Extra
	Name	Available	Used	D1 {368}	D2 {403}	D3 {367}	D4 {373}	D5 {847}	
S1	Freshwater	191	121.0	70.0	30.0	21.0			70.0
S2	B/W from PM 4	37	37.0					37.0	0.0
S3	Feed from BSW	47	47.0	47.0					0.0
S4	C/D Washer B/W	304	234.0	234.0					70.0
S5	EOP Washer B/W	351	301.0	17.0	242.5		11.0	30.5	50.0
S6	D1 Washer B/W	311	290.0			290.0			21.0
S7	D2 Washer B/W	310	310.0			5.0	305.0		0.0
S8	D.W. B/W	784	784.0		67.5			716.5	0.0
P1	C/D Washer o/l	63	63.0		63.0				0.0
P2	EOP Washer o/l	51	51.0			51.0			0.0
P3	D1 Washer o/l	57	57.0				57.0		0.0
P4	D2 Washer o/l	63	63.0					63.0	0.0
P5	Decker Washer o/l	63	0.0						63.0

The shaded boxes here represent restricted matches. The network for minimum fresh water usage considering both TS and COD as contaminants are shown in **Fig – 4,** showing new matches that need to be added to the system to achieve the water savings.



(All figures are in m3/hr)

Fig. 4 Final Water Balance Network for BILT, Yamunanagar

Various other alternative networks and targets were also obtained as a result of the computational analysis. In one of the analysis, the recycle of EOP washer backwater, which is highly colored and may create a problem in recycle, was eliminated. Therefore in an alternative network, the matches between EOP washer backwater to D2 Washer and Decker Washer were considered as infeasible. As an illustration, this alternate network is reported in **Table -7** in order to obtain the fresh water target of 10 m3/hr. This alternate network has only three new connections with remarkably low fresh water target. It also solves the problem of the EOP stream being re-used in D2 and Decker washer.

Table 7: Alternate Fresh water network for Mill -2

No.	Streams	F (m3/hr)		C/D Washer	EOP Washer	D1 Washer	D2 washer	Decker washer	Extra
	Names	Available	Used	D1(368)	D2(403)	D3(367)	D4(373)	D5(847)	
S1	Fresh water	191	9.7		6.3			3.4	181.3
S2	B/W from PM-4	37	37.0		*37.0*				0.0
S3	Feed from BSW	47	47.0	47.0					0.0
S4	C/D WasherB/W	304	304.0	304.0					0.0
S5	EOP Washer B/W	351	321.3		293.3	28.0			29.7
S6	D1 washer B/w	311	311.0	*17.0*		288.0	6.0		0.0
S7	D2 Washer B/w	310	310.0				310.0		0.0
S8	D.W.B/W	784	784.0		*3.4*			780.6	0.0
P1	C/D Washer O/l	63	63.0		63.0				0.0
P2	EOP washer O/l	51	51.0			51.0			0.0
P3	D1 washer O/l	57	57.0				57.0		0.0
P4	D2 washer O/l	63	63.0					63.0	0.0
P5	Decker washer o/l	63	0.0						63.0

Since this network and target is based on theoretical calculations taking into account only TS and COD, therefore, for practical application the suggested network and concept needs to be verified considering impact of all other contaminants and various other process constraints.

OBSERVATIONS

OBSERVATIONS

Based on the mill visits as well as data on general and technical information collected from both selected mills under the water conservation project, following are the observation made by Central Pulp and Paper Research Institute (CPPRI) with respect to water conservation in both the selected mills. The major technological and environmental challenges before the large mills are;

TECHNOLOGICAL ISSUE;

- High water consumption per ton of paper
- Raw material availability
- High cost of basic inputs
- Uneconomic scale of operation
- Ecofriendly "State of Art" processing technologies
- High energy consumption

ENVIRONMENTAL CHALLENGES;

- High volume of effluent
- High color in effluents
- Handling and disposal of solid wastes
- Control of Odorous emission

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- Continuous and sustained supply of raw material is still a major problem before large scale integrated paper mill. The mill meets their raw material requirement by use of mixed raw materials like hard wood and agro residue (Bagasse)

- The mill is a large scale wood & agro residue based mill producing about 300 tpd of various grades of paper like Printing and writing papers, Multi layer duplex, boards, packaging papers etc.

- The long period of storage of wood and bagasse and that too in open atmosphere results in degradation of raw materials and moreover it has a risk of being a potential fire hazard.

- The mills also using bagasse, store it in bales stacked one over the other. The mill is taking more precaution due to possibility of auto combustion. As a result continuous water spray is carried out to keep the bagasse wet. The mills is using treated effluent for this purpose to reduce the fresh water consumption.

- The mill is using drum / disc chipper for chipping of wood and drum pith remover for bagasse followed by wet washing. The chipped and

wet washed materials are stored in a silo and sent to digester by conveyer as per requirement.

- The wood chips are cooked in stationary digester and bagasse is cooked in continuous Pandia digester.

- The mill draws ~ 24300 m3/d fresh water from nearby Kauvery River. The average water consumption varies between 90 - 95 m3/t paper.

- The study conducted has revealed that maximum water consumption is in stock preparation paper machine section due to multiple number of paper machines.

- Counter current brown stock washing is used in the mill which reduces fresh water consumption as well as increase the toddle value of black liquor generated. As a result energy consumption in soda recovery plant is also reduced.

- The kappa of unbleached pulp produced from wood raw materials varies from 17- 20. In case of bagasse, kappa number varies between 12 -14.

- The chlorine and chlorine based bleaching chemicals are still the dominating chemicals used by the mills in multi stage bleaching sequences. The mill uses chlorination, alkali with peroxide and hypochlorite (CEpHH) sequence to bleach the pulp up to brightness level 80-85% ISO.

- Bleach filtrate fro chlorine washer and Ep washer is partly used for pulp dilution and rest is sent to ETP for further treatment.

- By performing the GAMS program on the water flow in pulp mill of SPBL, Erode it was observed that ~15 % possible reduction in fresh water consumption from the current labels can be obtained.

- PER water is used for wet depithing of bagasse and also in pump gland / sealing cooling, vacuum pump sealing & Floor washing.

- PER water and Save-all filtrate is used for pulp dilution before bleaching.

- Surface condensates from dryers from paper machines 1 – 4 is used as high pressure showers of paper machines 1-4.

- Back water from disc save – all installed in paper machine 5 is used for waste paper processing.

- All pulp dilution in centricleaner is being done by seal pit water of the same machine.

- Back water from disc save – all is used for couch pit and pulper dilution in paper making process.

- As a result of implementation of above said options, the SPBL, Mill has been able to reduce fresh water consumption by ~ 30-45%.

- Due to scarcity of water in summer season the mill is giving top priority for further reduction in fresh water consumption through efficient use and increased recycling / reuse of back water.

(II) Ballarpur Industries Ltd (BILT), (Unit Shree Gopal), Yamunanagar

- The mill produces various grades of writing and printing paper as well as specialty grade like tissue paper, electrical grade paper, etc. by using bamboo, eucalyptus, poplar, wood wastes (procured from near by saw mills). The mill also use some fraction of imported wood pulp in fiber furnish depending upon the quality and grade of paper.

- The main source of water is bore well. The mill has 17 numbers of bore well. The fresh water is collected in a reservoir and distributed to the different section by separate pump.

- Fresh water consumption to the mill is ~ 33264 m3/d. The average water consumption varies between 135 - 138 m3/t paper.

- The chipped raw material is kraft cooked in stationary digester. The mill also have heat recovery system in digester blow. The mill has Counter current brown stock washing system which reduces fresh water consumption. Hot water received from blow heat recovery system is used at 4^{th} stage of BSW.

- The kappa of unbleached pulp produced from wood raw materials varies from 16- 18.

- The mill use chlorine dioxide, oxygen and peroxide reinforced alkali extraction during pulp bleaching to improve the pulp brightness - !SO 88%.

- Back water from **C/D** washer is partly reused for tower dilution and rest discharged to Effluent Treatment Plant.

- Back water from **Eop** washer is partly reused for tower dilution and rest discharged to Effluent Treatment Plant.

- By performing the GAMS program on the water flow in pulp mill of BILT, Yamunanagar it was observed that ~35 % possible reduction in fresh water consumption from the current labels can be obtained.

- Back water from excess water chest is reused in the following operations:

  a) Pulp dilution in New Pulp Mill

  b) Paper M/c showers after passing through super clear filter

  c) Consistency regulator pump

  d) Couch pit dilution

  e) UTM pulper dilution

- Part of ETP treated water is used as:
  - Gardening
  - Soda recovery process
  - Ash handling yard
  - Chipper house

- Lean water from Krofta filtrate of Paper machine 1 & 2 is used for pulp dilution in new pulp mill.
- Surface condensates from dryers from paper machines 1, 2 & 4 is used as couch pit dilution.
- Back water from krofta in paper machine 1 & 2 is used for waste paper processing.

- Measures taken by mills have resulted in reducing fresh water consumption from 140-150 m3/h (some years back) to around 125 – 130 m3/h at present. As a result of implementation of above said options, the mill has been able to reduce fresh water consumption by ~ 10-20%.

- The mill is making continuous effort to reduce further the water consumption through increased recycling of waste water, regular water auditing , etc. to achieve the targets set for individual unit operation involved in manufacturing of paper.

CONCLUSSION AND RECOMMENDATIONS

CONCLUSION AND RECOMMENDATION:

Based on the studies conducted in selected mills and other technical and general information collected in other R & D projects, the following are the conclusion with respect to water conservation in pulp and paper industry;

CONCLUSION:

- The pulp and paper making process is highly water intensive and requires huge amount of water in each and every stage of process.
- The pulp and paper mills are aware and has been taking the all possible measures to reduce the water consumption.
- In last decade, the remarkable efforts have been made by mills to reduce fresh water consumption which result in reduction of water consumption from 250 – 300 m3/t to about 100 – 150 m3/t paper.
- The high level of water consumption in Indian mills compared to mills operated abroad , is mainly due to application of multiple number of paper machine, use of mixed fibrous raw materials in absence of good

quality forest based raw materials, use of conventional technology & equipments as well as low level of operation.

- The application of multiple paper machine and other equipments added in batches for capacity expansion require lot of fresh water particularly for cleaning, washing of, machine wire, felt etc. and generate same quantity of back water which has limitation in its reuse / recycle not only due to its quality but also availability of excess back water.
- Most of the mills use multi stage of brown stock washer for washing of unbleached and bleached pulp which also consumes huge amount of fresh water in showers. However, some of the mills have adopted new generation of washer like twin press role and chemi washers which consumes less water.
- Mills are taking all possible measures to reduce water consumption through efficient use of water, water auditing as well as setting target in individual section of paper making.

- Some of the mills have been able to reduce their water consumption between 75 – 90 m3/t papers through efficient recycle of back waters, regular monitoring to achieve the target set under internal strategies.
- The further reduction in water consumption in those mills consuming water below 100 m3/t need to adopt state of art technology which depends upon scale of operation of mills.
- The level of recycle / reuse of back water in Indian Mills are still low as compared to the mills operating abroad.
- The low level of recycle / reuse of back water in Indian Mills may be due to;
  - Excess generation of paper machine back water due to multiple use of paper machines of low capacity.
  - High level of TDS, color & turbidity which restricts its reuse / recycle.
  - Improper segregation of effluent streams.

- High cost of treatment of back water to make it suitable for further reuse in comparison to water cess.
- To some extent, easy access of water.

- Most of the mills use fresh water for pump / vacuum pump cooling / sealing, though some of the mills have started use of clarified back water to some extent. The use of new mechanical seal pumps or ceramic based pumps can reduce the fresh water requirement.
- Though the mills have number of variables, but Pinch based techniques / software available in market have been found useful for water management in section wise and has potential to reduce water consumption to a great extent.
- In nut shell, the water conservation in a pulp and paper mill can be achieved through **3 R approach i.e. Reduce, Reuse and Recycle.** The major focused areas are;
  - A water balance study is essential in the very beginning to know the section and stage wise water

consumption and existing mode of recycling and drainage.

- Improvement in pulp washing and screening equipments.
- Maximum recycling of back water and condensate in various stages.
- Prevention of accidental leakages and collection of spillages.
- Efficient metering and monitoring of water consumption of every unit.

RECOMMENDATIONS:

Based on studies conducted, the following are the recommendations with respect to water conservation:

- The major areas of fresh water consumption are showers on paper machines & brown stock washers. The Mills must use appropriate techniques to clarify Paper Machines back water suitable for further reuse to the possible extent in showers.

- Use of high consistency pumps to avoid unnecessary pulp dilution.
- Optimum use of equipments, machines to avoid over loading which may affect the performance efficiency of the system.
- Segregation of colorless effluent streams and should reuse / recycle with or without treatment to the process to the maximum possible extent.
- Mills may also think of going mechanical seal pump or ceramic based pumps where water requirement is very less, or even mechanical face and lip seal where water requirement is almost nil.
- Use of new generation pulp washer to minimise the water requirement which ultimately improve the economics of multiple effect evaporators.
- In view of scarcity of water, the use of membrane filtration for selected effluent stream will be useful in achieving system closure. The mills or association should promote R & D studies to assess techno-economic viability of these technologies.

- Pinch based technologies is useful tool which can help the mills in establishing detailed water networking / auditing in implementation of effective management strategies to minimize water consumption in particular section and as a whole process.
- Regular water auditing is an important tool which helps industry know the status and also to explore possibility for minimizing water consumption by setting target / benchmark for individual section.
- Mills should also conduct awareness programme to mill staff working on Flore and involve them to participate in giving suggestion to improve the water conservation in particular section.
- **The water consumption leads to saving energy in pumping and handling of relatively smaller volume, lesser material loss, lesser effluent treatment cost due to reduction in volume and eventually lower cost of production in an environmentally sustainable manner.**