Reducing water consumption in the pulp and paper mills, Possibilities and Benefits

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ABSTRACT

Paper mills in India with a production capacity of around 50 tons per day are integrated and nonwood based using mainly rice straw, wheat straw, bagasse, sarkanda, waste paper, jute, hemp, rags etc , use relatively large amounts of fresh water and do not have chemical recovery An analysis of the data collected from the mills through a questionaire indicated that total fresh water consumption in Indian mills varies from around 100 to 350 M^3/tonne of paper depending upon the paper quality, manufacturing process and other facts like site of the mill, its age, availability of fresh water etc This amount is quite high when compared to that of modern mills in developed countries.

As the mills are quite liberal in using fresh water replacing existing uses of fresh water with recycled one is one way to bring down the water requirement. A well organised & relatively efficient mill producing 50 tonne/day kraft paper was studied & complete water balance in each section carried out This helped in identifying the areas where bulk of the water was being used & scope of recycling/reducing the requirement. Some changes in the pulp washing section resulted in 25-30% reduction of the fresh water requirement. This saved energy & reduced effluent volume. If this is taken as an example there is ample scope to reduce fresh water requirement per tonne of paper in most of the Indian pulp and paper mills small ones in particular. The first step should be complete water auditing of all the sections of the mill. The increasing concern about the preservation of the environment justifies a more concerted effort to reduce fresh water requirement in the manufacturing of paper.

Introduction

The pulp & paper mills use large quantities of water. Until fairly recently in the history of papermaking, the ingredient has been regarded as a cheap, if not a free raw material. This fact caused little attention to be paid to the way in which water was utilized in the mills, even if it was clear to many peop'e that this utilization had a crucial influence on the fibre losses to drain. Some how, it was agreed that to make a good sheet of paper a purge of the system was needed- the bigger the purge, the better paper in the end. In today's highly competitive market with continuing emphasis on more stringent effluent limits, it becomes increasingly important that water usage be closely monitored. Every drop of water that is mixed into a papermaking system incurs cost in one or several ways. First, it has to be pumped to the mill and often from a considerable distance or depth. If contaminated it is to be purified in a plant built for the purpose and operated at some expense. With the exception of few cubic meters of water which is evaporated in the dryer section, remaining has to be treated in waste water treatment plant at considerable capital and running cost for its reuse or disposal as effluent. Each drop of water leaving the process, contains some dissolved and dispersed solids which are lost from the process thus

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causing increased production cost and adverse effect on the environment. The environment and the economic considerations have made the reuse of process water a necessity in the operation of a pulp and paper mill. The present paper gives a general scenario of the water used per ton of paper by different pulp and paper mills in India, sectionwise water consumption in a typical paper mill producing kraft paper, few simple measures to reduce water requirement & the entailing benefits.

Water Consumption in the Indian Pulp & Paper Mills :

Literature survey and data received against the questionnaire sent to the Indian pulp and paper mills (1989) indicated that there was a wide variation in the water requirement per ton of paper in case of different mills which differ in installed capacity, types of fibrous raw material, and product range etc. The fresh water requirement ranges from about 100 to 350 m^3/tonne of paper (Table I, II).

Only in the paper machine area the fresh water requirement ranges from 50 M^3 to 150 M^3 per tonne of paper for Indian mills which is relatively much higher than 9-20 M^3/tonne of paper for developed countries (Fig. 1.)

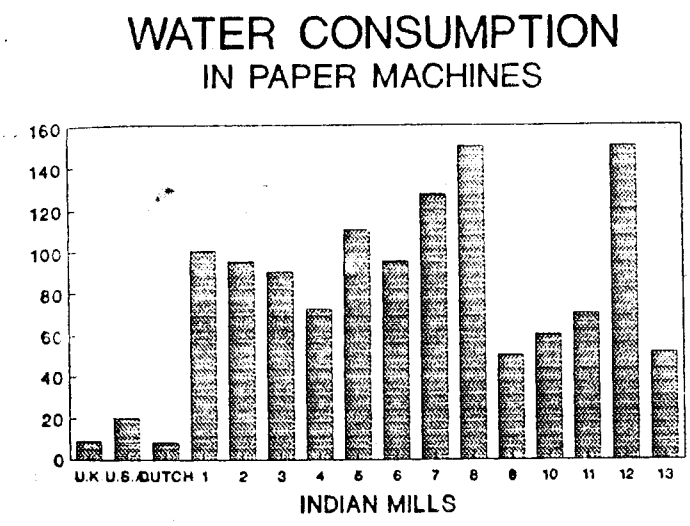

Fig. 1

The wide range & higher amounts of water requirement in the Indian mills indicate that sufficient efforts have not been put in to establish the controlled usage of water at individual points. Liberal use of water, open systems, wide variety of raw materials like mixed hardwoods, bamboo, bagasse, wheat & rice straw, waste paper etc., type of machinery and processing methods and multiple varieties of end products being manufactured turnwise on the same machine. The small paper mills which are mainly based on agricultural residues generally use more water than bigger ones. The high consumption affects the production cost as increased water usage relates directly to increase in energy and chemical usage, it also overloads the effluent treatment plant. The treatment itself is quite expensive (both capital and running costs). In the areas with limited water supply, the inability to use water efficiently could be a limiting factor in mill expansion plans. The cost of fresh water varies considerably from mill to mill and can not be considered insignificant even under most favourable conditions.

Case Study of an Agricultural Residues Raw Material Based Pulp And Paper Mill :

Small pulp and paper mills in India are generally quite open with few exceptions where reasonable degree of water recycling is practised. One of such mills was studied in detail with the aim to reduce fresh water consumption which was already on lower side due to various measures already taken. The salient features of the mill were—

Installed capacity	—	16600 tons per annum
Grade of paper	—	MG/MF kraft paper
Cellulosic raw material	—	Bagasse, Waste paper, Hession cuttings, Jute caddies
Pulping process	—	Mechano chemical & Soda pulping
Paper machine	—	One
Deckle (m)	—	2.18
Speed (m/min)	—	200
Grammage range (g/m^2)	—	90-205
Average capacity	—	50 TPD

Pulping processes employed were —

- Chemical pulping of bagasse, & jute caddies separately.
- Chemi Mechanical pulping of bagasse (CMP).
- Waste paper street (hydrapulper).

The paper furnish contained more than 80% bagasse & rest jute caddies & waste paper.

Water Usage System in the Mill :

For carrying out the complete water balance studies in different sections of the mill the following values of consistency etc. were employed.

Data used for water balance calculations :

1. Moisture Content in paper at pope reel = 8%
2. Dry content after presses = 36%
3. Dry content after couch = 22%
4. Dry content after suction boxes = 10%
5. Dry content before suction boxes = 3%
6. Consistency of stock in head box = 0 6%
7. Consistency of water from press =0.00 (assumed)
8. Consistency of water from suction boxes = 0 04%
9. Consistency of water from forming section = 0.05%
10. Consistency of suction couch water = 0 08%
11. Consistency at the inlet of primary centricleaner = 0 80%
12. Consistency of rejects from primary centricleaner = 1.7%
13. Consistency of rejects from secondary centricleaner = 2.4%
14. Consistency of rejects from tertiary centricleaner = 2 0%
15. Hill Screen accept consistency = 3%
16. Pressure screen rejects amount = 2%
17. Consistency of water from Hill = 0.05%
18. Trimmings at Couch = 0.18 m
19. Break time at Couch (assumed) = 30 min/day
20. Width of paper web coming from couch = 2.26 m
21. Fresh water added in Head box (foam killing showers) = 80 m^3/day
22. Fresh water used in boiler House = 360 m^3/day
23. Fresh water used in sealings of vacuum pumps and refiners
    = 5 to 6 m^3/tonne of paper i.e. approx. 250 m^3/day.

Fresh water being used in the mill was being drawn from tubewells.

Section wise water Usage in the Mill :

Fresh Water :

The calculated fresh water consumption in different sections is given in table 3.

TABLE—3
Amount of Fresh water being used in Different sections of the mill

Section	Water used M^3/day
Pulp mill	
Caustic dilution	110
Chemical pulping	
For dilution before 2nd stage washers	1649
Showers	472
CMP pulping	
Showers	1148
Waste paper	
Showers of mould	284
Jute caddies	
Showers of mould	284
Stock preparation	
Rosin preparation	1
Alum preparation	9
Paper machine	
Head box	80
Showers of paper machine*	1128
Miscellaneous	
Boiler	360
Vacuum pumps	250
Total	5775

* Amount of water used in different showers is given in Table IV.

TABLE—1

Water Consumption in Indian Paper Mills Having Capacity More Than 50,000 T/YR.

Mill No.	Raw Material	Water Consumption M^3/Tonne of Paper in the Mill	Water Consumption in Paper Machine Only M^3/Tonne of Paper
1	Hardwoods, Bamboo waste paper, imported pulp, bagasse	362	—
2	Hardwoods, Bamboo Straws Rags & bagasse	260	100
3	Hardwoods, Bamboo	202	95
4	Hardwoods, Bamboo & waste paper	350	90
5	Hardwoods, Bamboo & Imported pulp	190	72
6	Hardwoods, Bamboo & waste paper	353	110
7	Hardwoods, Bamboo & Sabai grass	260	95
8	Bamboo & Hardwoods	270	127

TABLE—2

Water Consumption in Indion Paper Mills Having Capacity Less Than 20,000 T/YR.

Mill No.	Raw Material	Water Consumption M^3/Tonne of Paper in the Mill	Water Consumption in Paper Machine Only M^3/Tonne of Paper
1	Waste paper, rags, wheat straw, Rice straw	350	150
2	Waste paper	175	50
3	Waste paper, Market pulp, Straw	160	60
4	Wood Pulp, Waste paper, Bagasse	185	70
5	Sarkanda, Rags, Cotton Linters, Rice & Wheat straw	350	150
6	Woodpulp, Waste paper, Cotton Linters Agricultural Residues	210	—
7	Rice Straw, Wheat Srtaw, Sarkanda, Imported pulp	250	51
8	Rice Strw, Wheat Straw Sarkanda, bagasse, Cotton Linters	240	—
9	Rice Straw, Wheat Straw, Bagasse, Sabai Grass, Sarkanda, Waste Paper	240	—
10	Wood pulp, Agricultural residues, Imported wood pulp	180	—
11	Wood pulp, Rags, Bagasse	85	

TABLE 4

Fresh Water Requirement in Various Showers of the Paper Machine

Section	Water pressure Kg/cm²,	Hole Size (mm)	Pitch (mm)	Pipe length (m	Water requirement M³/day
Trim squirts (2 Nos)	15	1	—	—	10
Wire Return Roll shower (1 No)	3 5	2	50	2.2	312
Knock off showers	10	2	50	—	11
Trim knock off showers (2 No)	10	2	—	—	24
Low pressure shower (1 No)	3.5	2	50	—	313
High pressure showers for felt Conditioning and cleaning (4 Nos)	15	1	100	2 2	458
				Total	1128

*—calculated on the basis of break time of 30 minutes per day.

TABLE—5

Amount of Water Being Recycled in Different Sections of the Mill

Section	Water recycled From	To	Amount M³/day
Chemical Pulping			
	Seal pit	Before Ist stage washer	1603
	Pulp mill B/W tank	Blow tank	311
	Pulp mill B/W tank	Digestor	69
Chemi-mechanical Pulping			
	Seal pit 1	Before IInd stage washer	1717
	Seal pit 2	Before IIIrd stage washer	1649
	Machine B/W tank	After IIIrd stage washer	174
	Pulp mill B/W tank	Riffler	550
	Pulp mill B/W tank	Riffler	1202
	Pulp mill B/W tank	Johnson Screen	962
	Pulp mill B/W tank	CMP hydrapulper	351
Waste Paper	Machine B/W tank	Hydrapulper	187
Jute caddies			
	Pulp mill B/W tank	Digestor	21
	Pulp mill B/W tank	Discharging the digestor	122
	Pulp mill B/W tank	Beater	108
Paper machine			
	Silo	Fan pump	2719
	Wire pit	Sec. Centricleaner	2918
	Wire pit	Ter. Centricleaner	1605
	Wire pit	Mixing chest	758
Pumps Sealing Water			
	Sump tank	Hydraulic oil cooler of DDR	130
	Sump tank	Compressors	10
	Sump tank	Air cooler	50
		Total	17216

Recycled water :

Water which is recycled at different points is :

— Pulp mill back water.

— Machine back water.

— Wire pit water.

— Silo water.

— Seal pit water.

— Sealing and cooling gland water of pumps.

The available sources of water for recycling to different sections & the amount of water coming in each tank is given in Table V, VI.

In the pulp mill back water tank, water mainly comes from mould of waste paper street and overflows from different seal pit tanks. The machine back water is comprised of water from presses and sealing and cooling water of vacuum pumps & refiners. The wire pit tank stores water from couch & hill screens. The water from wire pit tank is treated in krofta save all to recover fibres. Silo receives water from suction boxes and forming section. The water extracted on each washer is stored in the seal pit of individual washer before being used for dilution.

Out of the total fresh water consumption of 5775 M^3/day i.e. 129 M^3 tonne of paper the pulping section is consuming 3947 M^3/day in stock preparation and paper machine 1218 M^3/ day & the remaining 610 M^3/day is being used for Boiler, vacuum pumps and cooling/sealing etc. 17216 M^3/day of water being recycled in different sections is detailed in Table V. In pulping section 9026 M^3/day of water is recycled for dilution and washings, 8000 M^3/day is recycled in paper machine section & the remaining 190 M^3/day goes for cooling/sealing.

Effluent volume :

The main points of waste water drain are the riffler mould of CMP, first stage washers of chemical and chemi-mechanical pulp, mould washer of jute caddies, out of the total amount calculated i.e. 5737 M^3, 5297 M^3/day is going as effluent to the treatment plant & remaining with paper and evaporated in dryer section, steam & condensate losses etc. (Table VII).

TABLE—6

Back water/Recycled Water Quantity & Sources

Tank	Emanating from	Amount M^3/day
Pulp mill B/W	Mould (waste paper street)	255
Seal Pits (3)	IIIrd stage washer of CMP	2.92
(overflow to pulp	IInd stage washer of CMP	2124
mill B/W tank)	IInd stage washer of CP	1953
Machine B/W	Presses	538
(overflow to seal pits)	Seal water of vacuum pump & refiner	250
Wire pit	Showers of wire part	322
(overflow to	Couch	269
machine B/W tank)	Hill Screen I	145
	Hill Screen II	2.4
Silo	Suction Boxes	1161
(overflow to wire pit)	Forming Section	7212
Sump tank	DDR oil cooling	130
	Compressors	10
	Air cooler	50
	Total	16825

TABLE VII

Amount of waste water going to drains (effluent treatment plant) and losses from different sections of the Mill

Section	Amount M^3/day
Pulp mill	
Ist stage washer of CMP	1228
Riffler mould of CMP	1752
Ist stage washer of chemical pulping	1884
Mould of jute caddies	183
Water used for discharging jute caddies	122
Johnson Screen of waste paper	1
Stock preparation :	
Ter. centricleaner	127
Paper Machine :	
Evaporated to atmosphere from dryers	76
Going with paper	4
Misc.	
Boiler make up water	360
Total	5737

The degree of water recycling was calculated on the basis of :

— Fresh water being used.

— water being recycled at different stages.

The degree of water recycling in the mill was 74.8 (Table VIII).

TABLE–VIII

Water Consumption in the Mill

Water	M^3 /ton of paper
Fresh	129
Recycled water	383
Percentage of water being recycled	74 8

Fresh water consumption of 5775 M^3/day & effluent generation of 5737 M^3/day leaves a difference of 38 M^3/day which is very small & could be attributed to

— Atmospheric evaporation of water other than dryers.

— At some places the calculated figures may vary slightly from the actual ones.

For reducing fresh water consumption the recommended steps included :

— Low pressure showers on the wire return section should be fed by clarified save-all water.

— Clarified krofta water should be used for deckers & vacuum washers.

— Rejects from 3rd centricleaner stage should be sent over to sandtrap (riffler) for removal of nonfibrous solids & accepted water with fibers should be returned to hill screens for fiber reclaimation.

— Steps were already initiated for changing washing of CMP to pressure washing (diffusion/extraction) in place of deckers Dilution should use back water from paper machine.

— Sealing water in vacuum pump should be recirculated.

— Water temperature of back water should be maintained as high as possible for improving drainage on wire and for reducing volume of washing water (heat conservation).

— The pulps in mixing chest should be neturalized with dil. Sulphuric acid to pH 7-6 Alum addition should be reduced step by step down to approximately 1–1 5% preventing precipitation of salts and subsequent deposition due to enrichment by closure of circulation.

Feed back :

Few of the above measures at the first instance resulted in reduction of fresh water consumption to the extent of 25–30% i.e. 129 M^3 to around 90 M^3/ton of paper. When the systems were working efficiently (double wire washer) this figure further went down to around 60 M^3/ton of paper.

Benifits :

Reduced water consumption entailed.

— Reduction in Energy Consumption due to

— Running lesser number of tubewells

— Higher back water temperature resulting in better drainage due to which pulp washing efficiency improved substantially which reduced running period/number of washers.

— **Reduction in Effluent Volume**

— Reduced volume of total effluent prevented overloading of the effluent treatment plant.

Fresh Water Reduction in the Paper Machine Area :

In the paper machine area almost the entire fresh water consumption is in the showers of the machine wire and the press felts.

Not much experience has yet been gained regarding the use of white water in felt showers The only method of reducing the water consumption at the present time is to reduce the amount used in various positions. One factor which facilitates this, is the introduction of synthetic materials in the press felts, and this has led to a noticeable reduction of the quantity of shower water required.

In the paper machine wire part greatest reduction in fresh water consumption and the best continuity has been achieved by recirculation of the white water and a number of systems have been developed. The most common is the use of cleaned white water fr m the interal fibre recovery unit (eg. krofta save all). Thus treated white water can be used in the various showers of paper machine wire by employing proper shower design, for example self cleaning showers In a typical type of self cleaning shower reduction in the line pressure retracts a piston to purge fibres and other suspended solids from a clogged nozzle, which makes them particularly well suited for use white water. Typical application of these showers as claimed are for-

— Wire cleaning (return rolls)

— Knock off showers

— Pre wetting showers (Breast roll)

The amount of reduction in fresh water in paper machine section by using self cleaning showers in the low pressure showers only has been estimated to be around 55% to 60%. Preliminary laboratory scale studies with a typical imported self cleaning shower nozzle has given encouraging results. Details will be published after the trials on paper machine are completed.

Conclusions :

— There is good scope to reduce fresh water consumption in the pulp and paper mills, small ones in particular by improving the degree of recycling.

— Pulp washing & paper machine area where substantial proportion of fresh water is used need first consideration.

— Studies carried out in a typical mill, 25 to 30% reduction in fresh water requirement was achieved by carefully auditing the water usage at different points followed by simple & inexpensive measures.

— For initiating water saving measures the mill management should precisely & accurately know the total quantity of water in use. A material balance study therefore, is very essential in the very begining to know the section and stagewise water consumption and the existing mode of recycling and drainage.

— In the begining only simpler and cost effective methods to reduce fresh water consumption should be adopted.

— Reduced fresh water consumption means saving of energy in pumping & handling of relatively smaller volumes, lesser material losses, lesser effluent treatment cost (capital & running) due to reduction in volume. It will eventually prove to be one of the most effective means of preserving the environment as paper industry in developed countries has already started talking of zero effluent discharge.

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