ISSN: 0379-5462
IPPTA: Quarterly Journal of Indian Pulp and Paper Technical Association
Vol. 35, E1, 2023, p. 161-165

STATISTICAL VALIDATION OF MAKEUP WATER REQUIREMENT IN A RECYCLED FIBRE BASED KRAFT PAPER MILL OPERATING ON ZERO LIQUID DISCHARGE





Mohd Salim* ***Nitin Endlay**** ***Shivaker Mishra**** ***M. K. Gupta**** ***B. P. Thapliyal*****

**Scientist, Central Pulp & Paper Research institute (CPPRI), Saharanpur*
***Indian Agro& Recycled Paper Mills Association (IARPMA), New Delhi*

Abstract:

In recent times with emphasis on reduction in fresh water consumption and stringent effluent discharge norms many Recycled Fibre (RCF) based paper mills producing unbleached grade paper (kraft paper) have shifted to Zero Liquid Discharge (ZLD) through complete reuse/recycle of backwater into manufacturing process without major technological intervention for treatment of backwater generated. Fresh water is used as makeup water only to maintain the backwater volume circulating in closed circuit/loop [1].

In the present study, while evaluating the feasibility of ZLD status in a RCF based kraft paper mill, total water loss during paper making was estimated on the basis of moisture/water content present in waste paper, finished paper at intermediate stages, solid rejects and steam condensate loss. The study has established that at 95 % confidence level the fresh water ranges from 1.44 to 1.84 m^3/tonne of finished paper is required as makeup water for such RCF based kraft paper mills operating on ZLD. This can also be used as a benchmark to validate the ZLD status of similar category of paper mills.

Keywords: Zero liquid discharge (ZLD), Recycled fibre (RCF), Makeup water

Introduction:

In RCF based kraft paper mills, the general paper manufacturing process includes processing of waste paper through Hydra Pulper at 4 – 15 % consistency to produce pulp from waste paper. The slushed waste paper pulp at low consistency (~ 2 %) is screened through Poire, High Density Cleaner and Turbo Screenfor removal of plastics and other contaminants. Finally screened pulp's consistency is increased through Decker/Disc Thickener up to 4 – 4.5 % and sent to stock chest for storage. From stock chest, pulp is further cleaned / screened through Centri Cleaners followed by Pressure Screen at around 1 % consistency and forwarded to head box via SR box for paper sheet formation moving from wire part to press part, pre-dryer section, size press, post-dryer section and pope reel. In general, most of the RCF based paper mills use fresh water in pulp mill, paper machine section, chemical preparation, sealing & cooling, steam boiler etc. The combined effluent generated during paper making is treated through conventional Effluent Treatment Plant (ETP) and discharged into recipient drain.

In recent times with increased emphasis on reduction in fresh water consumption, wastewater discharge and proposed stringent norms likely to be implemented soon [2], many RCF based kraft paper mills have switched over to ZLD and discontinued ETP operation by complete reuse/recycle of backwater into manufacturing process using fibre recovery systems only. All the unit operations like pulp dilution, stock preparation, consistency levelling etc. are carried out mainly with backwater and fresh water is reported to be used as makeup water only for clearing of wire & felt at paper machine, sizing chemical preparation and boiler feed makeup water [3]. The backwater closed circuit of the RCF based kraft paper mill operating on ZLD is given in Fig.-1.

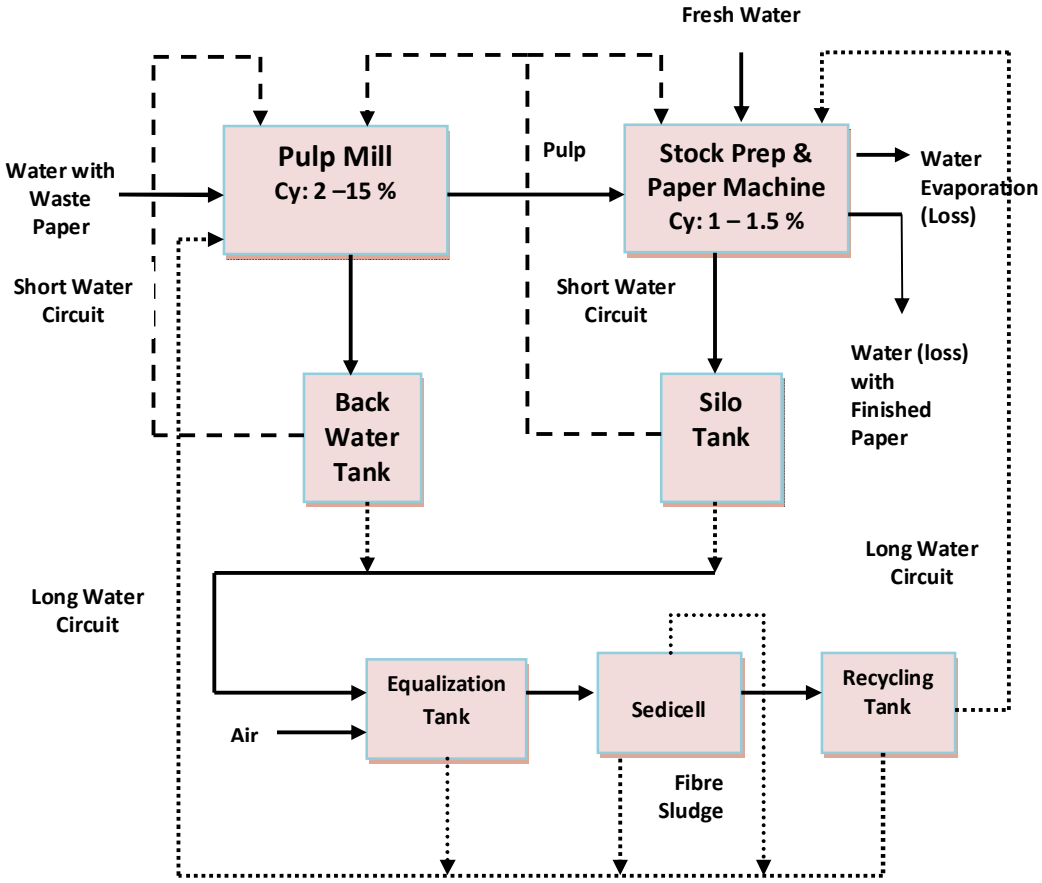

Fig.-1: Layout of backwater closed circuit in a RCF based kraft paper mill operating on ZLD

Case Study:

A RCF based kraft paper mill operating on ZLD since 2018 was taken up for the study. The mill produces around 120 tpd unbleached grade paper (kraft paper) in the grammage range 80 – 160 g/m^2 from indigenous & imported waste paper and maintains Zero Liquid Discharge (ZLD) by complete reuse/ recycle of backwater into paper making process. To estimate/ validate the makeup water requirement following methodology was adopted.

Methodology Adopted:

The selected mill was visited for three months on regular intervals for collection of samples and data/information related to starch consumption, filler consumption, solid waste generation, steam consumption and steam condensate recovery etc. Following samples were collected for analysis in Laboratory:

- ⊡ Waste paper used
- ⊡ Paper sheet after press part (Inlet to pre dryer section)
- ⊡ Paper sheet after pre dryer section (inlet to size press)
- ⊡ Paper sheet after pope reel (finished paper)
- ⊡ Paper machine backwater from wire tray
- ⊡ Starch solution used at size press
- ⊡ Solid waste generated

The major relevant data collected from the mill for estimation of makeup water requirement is summarized as under in Table-1.

Table-1: Major relevant data collected from the mill

Particulars/Variables	Unit	Range	Average Value	Denoted by
Starch consumption	% w/w of finished paper	4 - 7	5.5	X_1
Additives (filler etc.) consumption	% w/w of finished paper	2 – 4	3	X_2
Solid waste generation	% w/w of waste paper	4 – 6	5	X_3
Steam consumption	tonne/tonne of finished paper	1.5 – 2.0	1.75	X_4
Steam condensate recovery	w/w % of steam generated	80 – 90	85	X_5

Samples collected from the mill at different time intervals were analyzed for different parametersin order to estimate water losses during paper making. Waste paper, finished paper at intermediate stages and solid rejects samples were analyzed for moisture content/dryness. Results are summarized as under in Table-2.

Table-2: Moisture/dryness results of waste paper and finished paper at intermediate stages

Particulars/Variables	Unit	Sampling					
		I	II	III	IV	V	VI
Moisture in waste paper	% w/w	8.88	9.12	8.65	9.92	10.26	8.44
Dryness of paper sheet after press part (inlet to pre dryer section)	% w/w	48.62	47.54	46.66	48.92	49.32	48.44
Dryness of paper sheet after pre dryer section (inlet to size press)	% w/w	89.54	90.46	89.65	88.76	89.35	91.11
Moisture in paper sheet after pope reel (finished paper)	% w/w	6.22	6.76	7.13	7.04	6.88	6.49
Dryness of solid wastes generated	% w/w	27.74	34.56	32.5	31.1	21.34	29.12

Paper machine backwater and starch solution used at size press were analyzed for dissolved solids and total solids respectively. Results are summarized as under in Table-3.

Table-3: Results of solids in paper machine backwater and starch solution used at size press

Particulars/Variables	Unit	Sampling					
		I	II	III	IV	V	VI
Dissolved solids in paper machine backwater	% w/w	5.23	4.46	5.07	4.39	5.54	4.61
Total solids in starch solution	% w/w	12.56	13.31	11.86	11.27	12.98	13.64

The data generated in laboratory was statistically analyzed to determine the lower and upper confidence limits at 95 % confidence levelgiven as under in Table-4.

Table-4: Statistical analysis of data for estimation of makeup water requirement

Particulars/Variables	Unit	Average Value	Std. Dev.	Coef. Var.	Confidence Limit		Denoted By
					Lower	Upper	
Moisture in waste paper	% w/w	9.21	0.66	7.19	7.89	10.54	X_6
Dryness of paper sheet after press part (inlet to pre dryer section)	% w/w	48.25	0.89	1.85	46.46	50.04	X_7
Dryness of paper sheet after pre dryer section (inlet to size press)	% w/w	89.81	0.77	0.85	88.28	91.34	X_8
Moisture in paper sheet after pope reel (finished paper)	% w/w	6.75	0.31	4.66	6.12	7.38	X_9
Dissolved solids in paper machine backwater	% w/w	4.88	0.42	8.70	4.03	5.73	X_{10}
Starch solution concentration	% w/w	12.60	0.82	6.52	10.96	14.25	X_{11}
Dryness of solid wastes generated	% w/w	29.39	4.22	14.36	20.95	37.84	X_{12}

Table-5: Estimation of waste paper requirement per tonne of finished paper

Particulars/Variables	Calculation	Quantity (t/t finished paper)		Denoted by
		At lower Confidence Limit	At Higher Confidence Limit	
Moisture content in finished paper	$1 \times(X_9/100)$	0.061	0.074	Y_1
Starch carryover with finished paper	$1 \times(X_1/100)$	0.055	0.055	Y_2
TDS carryover with finished paper	$\{(1-Y_1-Y_2)/X_7 \times (100 - X_7)\} \times \{X_{10}/(100 - X_{10})\}$	0.043	0.053	Y_3
Filler in finished paper	$1 \times(X_2/100)$	0.030	0.030	Y_4
Pulp (fibre content) in finished paper	$1 - (Y_1 + Y_2 + Y_3 + Y_4)$	0.811	0.788	Y_5
Waste paper requirement	$\{(Y_3 + Y_5)/(100-X_3-X_6)\} \times 100$	0.980	0.996	Y_6

Table-6: Estimation of total water lossin RCF based kraft paper mill operating on ZLD

Particulars/Variables	Calculation	Quantity (t/t finished paper)		Denoted by
		At lower Confidence Limit	At Higher Confidence Limit	
Water evaporation(loss) from pre dryer section	$\{(1-Y_1-Y_2)/X_7 \times (100- X_7)\}-\{(1 - Y_1-Y_2)/X_8 \times (100- X_8)\}$	0.901	0.787	Z_1
Water evaporation (loss) from post dryer section	$\{(1 -Y_1-Y_2)/X_8 \times (100- X_8)\} + \{Y_2/X_{11}\times (100- X_{11})\} -Y_1$	0.503	0.340	Z_2
Water carryover (loss) with finished paper	Y_1	0.061	0.074	Z_3
Water carryover (loss) with solid rejects	$\{1\times(X_3/100)\}/X_{12} \times (100-X_{12})$	0.189	0.082	Z_4
Steam condensate loss	$(1 \times X_4) \times (100-X_5)/100$	0.263	0.263	Z_5
Total water loss during paper making	$Z_1 + Z_2 + Z_3 + Z_4 + Z_5$	1.916	1.545	Z_6
Water addition from waste paper	$Y_6 \times (X_6/100)$	0.077	0.105	Z_7
Nett water loss (Makeup water requirement)	**$Z_6 - Z_7$**	**1.839**	**1.440**	**--**

Results and Discussion

- The selected paper mill has been operating on ZLD for five years by complete reuse/recycle of backwater into manufacturing process without major technological intervention for backwater treatment.
- The excess backwater generated from pulp mill and paper machine is treated through Sedicell only (based on dissolved air floatation system) and reused/recycled back into process. The fresh water is used as makeup water onlyat paper machine high pressure showers, for sizing chemical preparation and as boiler feed makeup water.
- As indicated in Table-3, high level of TDS buildup in paper machine backwater may result in slime formation and potential paper breakage which may be controlled through maintaining continuous circulation of backwater in closed loop and regular monitoring of pH, temperature, COD, BOD and volatile fatty acids (VFA) in backwater.
- As indicated in Table-4, the moisture content in raw material (waste paper) and end product (finished paper) varies from 7.9% to 10.5% and 6.1% to 7.4 % respectively which shows 2 % recovery loss due to more moisture content in waste paper
- As indicated in Table-5, dissolved solids carried over with finished paper results in increase of pulp yield from 4.3 % to 5.3 % which compensates to the frequent paper breakage to a large extent.
- As indicated in Table-6, total water loss during paper making ranges from1.54 to 1.92 m^3/tonne of finished paper which

is shared as 47 %, 26 %, 14%, 10% and 3% by pre-dryer section, post dryer section, steam condensate loss, moisture carryover with solid rejects and moisture carryover with finished paper respectively. The percentage share of total water loss is indicated below in Fig.-2.

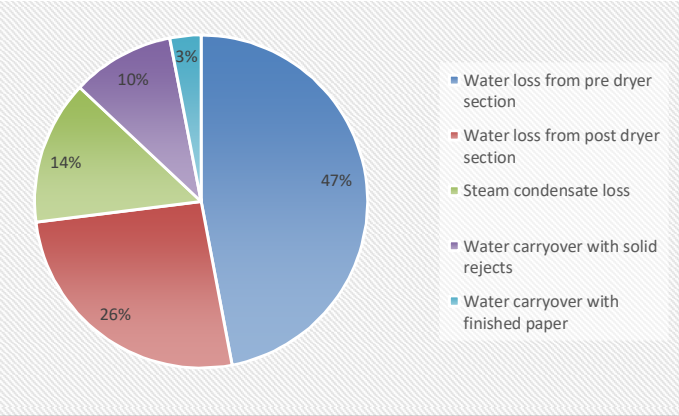

Fig.-2: % Share of water loss in RCF based kraft paper mill operating on ZLD

Conclusion:

The ZLD operation in pulp and paper mills is possible without major technological intervention in RCF based paper mills only producing unbleached grade paper [4].The study has established that the optimum fresh water ranges from 1.44 – 1.84 m^3/tonne of finished paper is required as makeup water for such RCF based kraft paper mills operating on ZLD at 95% confidence level. This study can also be used as a benchmark to validate the ZLD status of similar category of paper mills. However these mills have to compromise with product quality, process operations and odor issue while operating on ZLD. CPPRI is working to address these issues.

References:

1. Endlay, N; Mishra, Shivaker; Mohd, Salim; Thapliyal, B. P., Validation of Feasibility of Zero Liquid Discharge in RCF Based Kraft Paper Mill- A Case Study, IPPTA Journal, 30 (2), pp 129 -132, (2018)
2. Hima Jwala, V; Vidyarthi, A. K.; Singh, Kamlesh, Techno-Economic Sustainable Option Adopting Zero Liquid Discharge in Wastepaper Based Pulp & Paper Industries, International Journal of Engineering Technology Science and Research,Volume 4, Issue 9, pp 898-907, (2017)
3. Shammas, Nazih K; Wang, Lawrence K.; Selke, William A., Completely Closed Water Systems in Paper Mills, Handbook of Environmental Engineering, Volume 12, pp 40-426, (2010)
4. Edde, Howard; Techniques for Closing the Water Circuits in the Pulp and Paper Industry Wat. Sci. Tech., Vol. 29, No. 5-6, pp. 11-18, (1994).