Recovered Paper Yield Estimate Using Laboratory and Mill Accounting Data

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ABSTRACT

Yield is an important process parameter with serious economic and environmental consequences. Precise calculation of yield is not easy. Mills use various approaches to estimate yield. The objective of this paper is to compare the yield for each furnish component with adjustment for actual process losses by combining paper machine product data, monthly mill accounting data, and data for each furnish component. Laboratory data for % moisture, 6 cut rejects, solubles, fines + ash are included in an example for a furnish of Newsprint, Sorted White Ledger, Coated Book, wet lap DIP, and mill broke. The model can be expanded to assign bleach chemicals and residue disposal tons to the appropriate furnish component. Tracking yield results will help identify economically and environmentally attractive furnish components for the mill.

INTRODUCTION

When recovered paper is received by the mill, their objective is to get as much of it as possible to the paper machine headbox without affecting product quality. However, certain losses are inevitable. Components of the furnish which contribute to a decrease in yield include:

- Contaminants such as staples, paper clips, plastics, wet strength paper, stickies, etc.
- Fillers and coatings such as clay, calcium carbonate and latex.
- Soluble material like starch.
- Fines and good fibers lost during processing

Although recycle paper processing systems are designed to remove detrimental contaminants without significant loss of desirable material, the rejects from screens, cleaners, flotation cells and washers usually contribute to the process loss of some good fibers. Frequent checks of the rejects to determine the amount of desirable material in the rejects is necessary to maintain a high yield. The yield should be kept as high as possible to reduce furnish cost and to avoid any unnecessary fiber losses, which will contribute to higher residue disposal costs. Therefore, yield calculation plays a major role in the economic viability of a mill.

The most important yield calculation is based on figures produced by accounting each month. Mill management uses these figures to evaluate plant performance and to compare yield with other mills using the same accounting system. This is often based on the total weight of the raw materials used in “as is” tons and on the net tons of paper produced on the paper machines as reported by production. The yield is determined by dividing output tons by input tons; however these figures are subject to frequent accounting adjustments due to for example:

- Incorrect scale weights
- Differences in monthly inventory of raw materials
- Discrepancies in accounting of paper machine broke, converting broke, rejected reels.

The accounting data does not show which raw material has the best yield to the paper machine head box. By combining laboratory data with accounting data it is possible to calculate the yield of each furnish component. The method will be described by calculating the yield of each furnish component in a hypothetical mill which uses 20% Sorted White Ledger (SWL), 20% Coated Book (CBK), 20% Newsprint (ONP) in the Deinking Plant plus 20% Wetlap pulp and 20% Broke at the papermachine. This hypothetical mill uses 30,000 “as is” tons of furnish per month and produces 21,000 “as is” tons per month As a result the losses are 9,000 tons per month and the yield becomes 70% as shown in Table 1, (which is part of an Excel spreadsheet designed for the hypothetical mill).

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Table 1: Yield based on "as is" tons in hypothetical mill (with spreadsheet variables in italics)

ATTRIBUTE	INPUT						OUTPUT	
	Deink Plant			Papermachine		Furnish	PM	
	SWL	CBK	ONP	Wetlap	Broke	Total	Prod.	Yield
"As is" Furnish Comp.	*20%*	*20%*	*20%*	*20%*	*20%*	*100%*		
"As is" Tons/month	6,000	6,000	6,000	6,000	6,000	*30,000*	*21,000*	
						"As is"Losses 9,000		70.0%

The 50% moisture content of the Wetlap pulp is lowering the yield results. When the results are recalculated on a bone dry basis in Table 2 (assuming 6% moisture content for SWL and CBK, 9% for ONP and 7% for broke + production tons) the BD losses are 5,790 tons and the BD yield becomes 77.1%.

Table 2: Yield based on bone dry tons in hypothetical mill (with spreadsheet variables in italics)

ATTRIBUTE	INPUT						OUTPUT	
	Deink Plant			Papermachine		Furnish	PM	
	SWL	CBK	ONP	Wetlap	Broke	Total	Prod.	Yield
Moisture Content of "as is"	*6%*	*6%*	*9%*	*50%*	*7%*		*7%*	
Tons In	360	360	540	3,000	420	4,680		
Out	327	327	317	174	324	1,470	1,470	
Losses	33	33	223	2,826	96	3,210		
BD Furnish Composition	22.3%	22.3%	21.6%	11.8%	22.0%	100%		
BD Tons/month	5,640	5,640	5,460	3,000	5,580	25,320	19,530	
						BD Losses 5,790		77.1%

Calculating yield on a bone dry basis has eliminated 3,210 tons of moisture and reduced the losses from 9,000 to 5,790 tons per month. This improves the yield form 70% to 77.1%. The yield of each furnish component can be calculated by allocating losses using laboratory data.

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LABORATORY DATA FOR YIELD CALCULATION

In order to calculate the yield per grade, the laboratory data is needed on the following attributes of each furnish grade:

- 6 Cut Rejects or out throws from bale audits
- Solubles
- Britt Jar Fines & Ash (or Length weighted fines + ash at 550 C)

Normally these figures would be based on several samples from each furnish or even from each source. It will be necessary to assume some typical values for the hypothetical mill.

Table 3: Assumed Laboratory Data for Furnish and Product (with spreadsheet variables in italics)

ATTRIBUTE	INPUT					OUTPUT
	Deink Plant			Papermachine		PM
	SWL	CBK	ONP	Wetlap	Broke	Prod.
6 Cut Rejects	***0.2%***	***0.4%***	***1.4%***	***0%***	***0.1%***	***0%***
Solubles	***4%***	***6%***	***1%***	***2.5%***	***1%***	***1%***
Britt Jar Fines&Ash	***26%***	***33%***	***27%***	***20%***	***11%***	***11%***

It is also necessary to assume some arbitrary accounting data for residue disposal to landfill:

- *180* tons of bone dry coarse rejects (containing *30%* good fiber from coarse screens).
- *4900* tons of bone dry residue (containing *20%* good fiber from screens, cleaners, drains).
- Biological sludge is kept separate.

CALCULATION OF BD LOSSES USING LAB DATA (6 cut Rejects + Solubles)

The amount of losses for each furnish component is calculated by multiplying the bone dry tons in Table 2 with the corresponding lab figure for each furnish component as shown in Table 3. For instance 5,640 tons of SWL contains 5,460 x 0.2% = 11 tons of 6 cut rejects + 3 tons fiber (due to 30% good fiber in coarse reject samples) = 15 tons of coarse rejects after rounding. The Wetlap pulp and PM Product contain no coarse rejects, so that no adjustment for coarse rejects in the finished product is required. The results calculated for coarse rejects and solubles based on laboratory results are shown in Table 4 and they are subsequently corrected for *180* tons "reported" losses in Table 5.

The solubles in the furnish minus the solubles in the finished product are assumed to go to the effluent plant. The solubles in the finished product are allocated according to bone dry furnish composition and are deducted from the solubles in each furnish component. The biological sludge produced from the solubles is kept separate in this example so that no adjustment in residue tons is needed for this example.

Table 4: Calculation of Losses for 6 Cut Rejects and Solubles Using Arbitrary Lab Data.

ATTRIBUTE		INPUT						OUTPUT
		Deink Plant			Papermachine		Net	PM
		SWL	CBK	ONP	Wetlap	Broke	Losses	Prod.
6 Cut Rejects	**In**	11	23	76	-	6		
	Out	-	-	-	-	-		-
	Losses	11	23	76	-	6	116	
Fiber in 6 Cut Rej.	***30%***	3	7	23	-	2	35	
	Total	**15**	**29**	**99**	**-**	**7**	**151**	
Solubles	**In**	226	338	55	75	56		
	Out	44	44	42	23	43		195
	Losses	**182**	**295**	**12**	**52**	**13**	**554**	

Table 5: Losses for 6 Cut Rejects and Solubles after Adjustment for *180* BD Tons "Reported" Losses

ATTRIBUTE		INPUT						OUTPUT
		Deink Plant			Papermachine		Net	Residue
		SWL	CBK	ONP	Wetlap	Broke	Losses	BD Tons
6 Cut Rejects+Fiber		15	29	99	-	7	151	
Unaccounted	20%	3	6	19	-	1	29	
	Total	**18**	**35**	**119**	**-**	**9**	**180**	***180***
Solubles		**182**	**295**	**12**	**52**	**13**	**554**	

Note: Figures in italics are normally based on laboratory and accounting data.

CALCULATION OF BD LOSSES USING LAB DATA (BJ Fines & Ash)

The amount of BJ Fines & Ash in each furnish component is again calculated by multiplying the bone dry tons in Table 2 with the corresponding assumed or measured laboratory figure for each furnish component from Table 3. Some example calculations are shown below with the results summarized in Table 6:

- 5,640 BD tons of SWL x 26% = 1,466 tons BJ Fines & Ash
- 3,000 BD tons of Wetlap pulp x 20% = 600 tons of BJ Fines & Ash.
- 19,530 BD tons of finished product x 11% = 2,148 tons BJ Fines & Ash.

Since the Wetlap Pulp and Broke are added at the papermachine, it is necessary to assume 90% of the fines and ash will be retained in the product for this hypothetical example. (Normally this could be determined experimentally when the papermachine is running without any deinking plant furnish.) Since there are 2,148 tons of BJ Fines & Ash in the finished product, Table 6 shows that 1,092 tons came from the Wetlap Pulp + Broke, so that only 1,056 tons can come from the Deink Plant.

The 1056 BD tons of BJ Fines & Ash from the Deink Plant can now be allocated according to the bone dry furnish composition of the Deink Plant shown in Table 6 (33.7% SWL, 33.7% CBK + 32.6% ONP).

- 1,466 BD tons in SWL – 356 tons in finished product = 1,111 tons of BJ Fines & Ash losses + 20% good fiber in the residue (222 tons) = 1,333 BD tons.
- 1861 BD tons in CBK – 356 + 301 = 1807 BD tons
- 1474 BD tons in ONP – 345 + 226 = 1356 BD tons

The results calculated for each furnish component in Table 6 (using assumed laboratory data) account for 4,641 tons of residue. Since the "reported" amount of residue determined by accounting equals *4,900* tons after moisture correction, the missing tons can be allocated proportionally to the amount of residue in each furnish component. This is done in Table 7.

Table 6: Calculation of Losses for BJ Fines & Ash

ATTRIBUTE		INPUT						OUTPUT
		Deink Plant			Papermachine		Net	PM
		SWL	CBK	ONP	Wetlap	Broke	Losses	Prod.
Deink Furnish Comp.		33.7%	33.7%	32.6%				
BJ Fines&Ash	**In**	1,466	1,861	1,474	600	614		
	Out:							
Deink Out	**Alloc.**	356	356	344	-	-		1,056
PM Retention	***90%***				540	552		1,092
								2,148
	Losses	1,111	1,505	1,130	60	61	3,867	
Fiber in Residue	***20%***	222	301	226	12	12	773	
	Total	**1,333**	**1,807**	**1,356**	**72**	**74**	**4,641**	

Table 7: Losses for BJ Fines & Ash after Adjustment for *4900* BD Tons "Reported" Residue

ATTRIBUTE		INPUT						OUTPUT
		Deink Plant			Papermachine		Net	Residue
		SWL	CBK	ONP	Wetlap	Broke	Losses	BD Tons
BJ Residue + Fiber		1,333	1,807	1,356	72	74	4,641	
Unaccounted	6%	74	101	76	4	4	259	
	Total	**1,407**	**1,907**	**1,432**	**76**	**78**	**4,900**	***4,900***

Note: Figures in italics are normally based on laboratory and accounting data.

SUMMARY OF BD LOSSES AND YIELD CALCULATION

The losses calculated in Table 5 for coarse rejects and solubles and the losses calculated in Table 7 for BJ Fines & Ash residue are combined in Table 8. The total losses have to equal the bone dry losses of 5,790 tons per month calculated in Table 2. As a result the unaccounted difference of 156 tons is distributed in proportion to the amount of losses for each furnish component in Table 8.

Table 8: Summary of BD Losses and Adjustments per Furnish Component.

ATTRIBUTE		INPUT						OUTPUT
		Deink Plant			Papermachine		Net	Residue
		SWL	CBK	ONP	Wetlap	Broke	Losses	BD Tons
6 Cut Rejects+Fiber		15	29	99	-	7	151	
Unaccounted	20%	3	6	19	-	1	29	
	Total	**18**	**35**	**119**	**-**	**9**	**180**	***180***
Solubles		**182**	**295**	**12**	**52**	**13**	**554**	
BJ Residue + Fiber		1,333	1,807	1,356	72	74	4,641	
Unaccounted	6%	74	101	76	4	4	259	
	Total	**1,407**	**1,907**	**1,432**	**76**	**78**	**4,900**	***4,900***
Losses accounted for		**1,607**	**2,237**	**1,563**	**128**	**99**	**5,634**	
Unaccounted	3%	44	62	43	4	3	156	
ACTUAL LOSSES	**Total**	**1,651**	**2,299**	**1,606**	**131**	**102**	**5,790**	**5,790**

Note: Figures in italics are normally based on accounting data.

It is now possible to calculate the bone dry yield per grade for each furnish component in Table 9 by deducting the grade losses from the input tons. The actual losses from Table 8 are subtracted from the BD furnish calculated in Table 2 to obtain the amount of good fiber. The bone dry yields become:

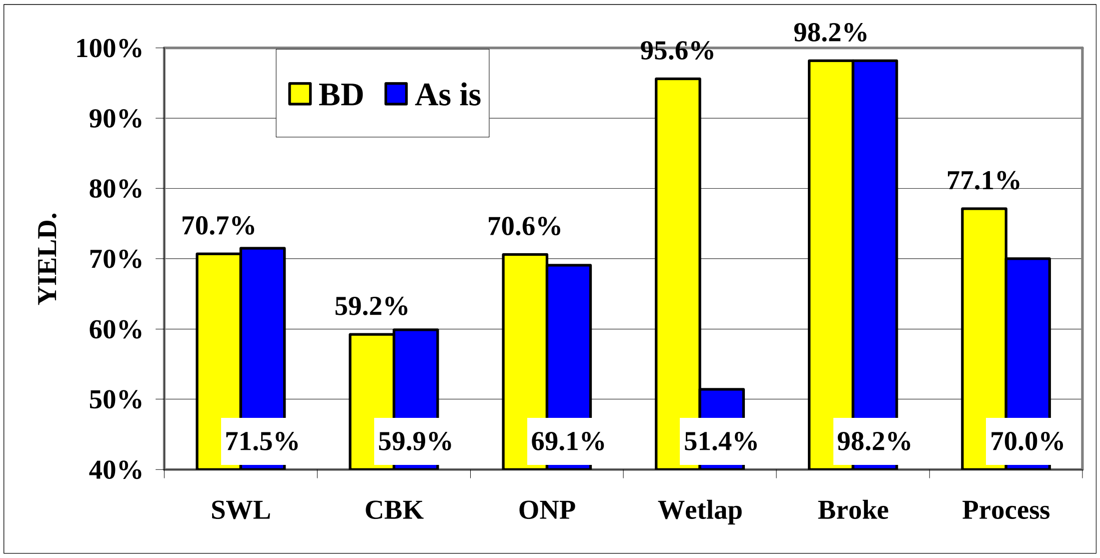
- SWL BD yield = 3,989 BD tons of good fiber / 5,640 BD tons input = 70.7%.
- CBK BD yield = 3,341 / 5,640 = 59.2%
- ONP BD yield = 3,854 / 5,460 = 70.6%.
- Wetlap pulp BD yield = 3,000 / 2,869 = 95.6%
- Broke BD yield = 5,478 / 5,580 = 98.2%
- Process BD Yield = 19,530 / 25,320 = 77.1%

Table 9: Yield Calculation per Furnish Component.

ATTRIBUTE		INPUT						OUTPUT
		Deink Plant			Papermachine			BD
		SWL	CBK	ONP	Wetlap	Broke	Total	Tons/mo
FURNISH	**As is**	6,000	6,000	6,000	6,000	6,000	30,000	
	BD	5,640	5,640	5,460	3,000	5,580	25,320	
ACTUAL BD LOSSES		1,651	2,299	1,606	131	102		5,790
GOOD FIBER	**BD**	3,989	3,341	3,854	2,869	5,478		19,530
	As is	4,289	3,592	4,144	3,084	5,890		21,000
BD YIELD		**70.7%**	**59.2%**	**70.6%**	**95.6%**	**98.2%**		**77.1%**
As is YIELD		**71.5%**	**59.9%**	**69.1%**	**51.4%**	**98.2%**		**70.0%**

The "as is" yield is calculated by adding the 7% moisture in the finished product to the good fiber BD tons and dividing by the "as is" tons input. The results are shown in Table 9 and in Diagram 1.

Diagram 1: BD and "As is" Yield Comparison for Each Furnish Component



GRADE COST TO THE HEADBOX

The cost data presented in this section are for illustration purposes only. Actual cost values depend on mill location as well as overall global economic climate. This illustration shows how e.g. furnish costs, residue disposal costs and bleach costs can be allocated to the furnish component in proportion to the amount of costs each furnish component is contributing per ton of good fiber at the headbox. Other costs such as additive costs, effluent costs, energy costs, labor costs and fixed costs are usually kept the same for each grade, but could be allocated if there is sufficient information available to adjust the model spreadsheet.

The information on "as is" yield and losses per grade can be used to calculate the cost to the headbox of SWL, CBK and ONP, if one assumes the following delivered costs in US$ per short ton of these furnishes, which depends on the distance of the source to the hypothetical mill:

- $270/ton SWL + $20/ton freight + $10/ ton Mill Storage + Handling = $300 / as is ton
- $170/ton CBK + $20/ton + $10= $200 / as is ton
- $130/ton ONP + $20/ton + $10= $160 / as is ton

The shrink cost can be calculated by dividing the above figures by the "as is" yield % - the above furnish cost per "as is" ton delivered to the Deink Plant conveyor belt:

- SWL: $300 / 71.5% - $300 = $116 / as is ton at PM
- CBK: $200 / 59.9% - $200 = $127 / as is ton at PM
- ONP: $160 / 69.9% - $160 = $ 67 / as is ton at PM

Residue costs include the chemical cost of clarification, transport cost and disposal fee of the wet residue. Residue disposal costs can be determined by multiplying the allocated BD residue quantity in Table 8 (*4,900* BD tons + *180* BD tons) per 21,000 PM tons by e.g. $100 per BD residue ton disposal cost as follows:

- Process: $100 x (5,080 / 21,000 = 0.24) = $24 / PM ton
- SWL: $100 x 0.33 = $33 / as is ton at PM
- CBK: $100 x 0.54 = $54 / as is ton at PM
- ONP: $100 x 0.37 = $37 / as is ton at PM

Bleach costs per PM ton can be allocated on the basis of total bleach costs divided by brightness tons. Brightness tons can be determined by subtracting furnish brightness from the CBK furnish brightness multiplied by the number of BD tons to be bleached. For simplicity assume the following brightness tons per grade and total bleach cost of $3 per brightness ton:

- Process: 120,000 brightness tons x $3 / brightness ton = $360,000 or $17 / PM ton
- SWL portion: 20,000 brightness tons x $3 = $60,000 /month or $14 /as is ton at PM
- CBK portion: 0 brightness tons x $3 = $0 / month
- ONP portion: 100,000 brightness tons x $3 = $300,000 / month or $72 /as is ton at PM

The above allocated costs for the Deinking Plant are shown in Diagram 2 in US$ per as is ton at the PM.

Diagram 2: Allocated Grade Costs for the Deink Plant (Using above arbitrary costs**)**

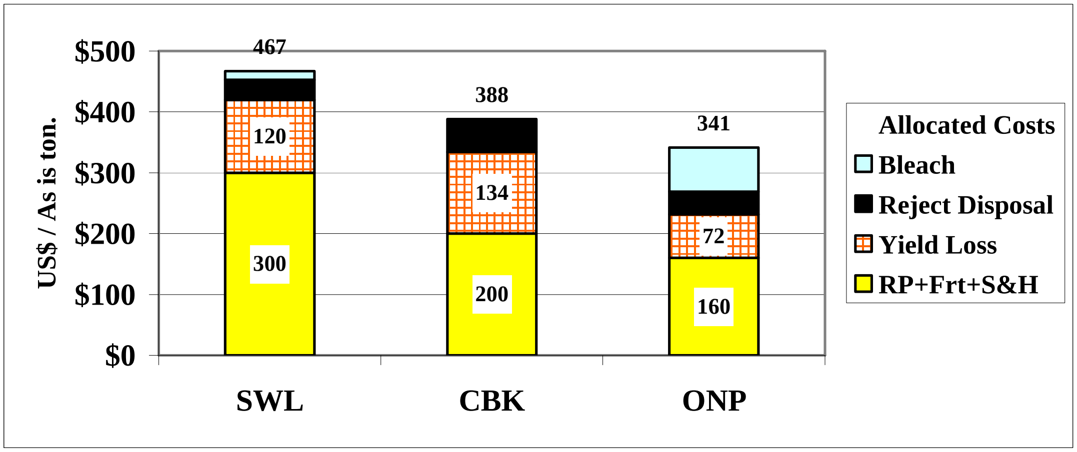


Diagram 2 shows the following increases in furnish cost to the headbox due to yield loss, allocated reject disposal costs and allocated bleach costs:

- SWL increases $167: from $300 per "as is" ton to $467 or 56%
- CBK increases $188: from $200 per "as is" ton to $388 or 94%
- ONP increases $181: from $100 per "as is" ton to $341 or 113%

CONCLUSION

Combining average laboratory data for each furnish component with monthly accounting data can provide a much better indication of the true yield to the headbox for each furnish. The information is converted to a bone dry basis so that it can be used to allocate cost data to the appropriate furnish component. By using a model spreadsheet for each application it is possible to calculate the actual grade cost to the headbox on an "as is" basis.

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