

OPERATING EXPERIENCES WITH THE LO-SOLIDS™ PULPING PROCESS AT WILLAMETTE INDUSTRIES' JOHNSONBURG MILL

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ABSTRACT

In 1994 Willamette Industries' Johnsonburg mill underwent a major, mill wide expansion and modernization. As part of the new fiberline a single vessel hydraulic digester was commissioned and then shortly afterwards converted to Lo-Solids cooking operations. This paper describes the long term operating experiences with the Lo-Solids pulping process. Compared to earlier batch and earlier modified continuous operations, the Lo-Solids cooking operation resulted in improved yield, washing, bleachability, pulp viscosity and paper machine runnability. Pulp yield was measured based on long term production and accounting data, and also by using laboratory methods. The production and accounting data indicate a bleached yield of 48.2%, while the laboratory based method indicates a bleached yield of 49.7%, both expressed as bone dry tons bleached pulp per bone dry ton of wood to the digester.

INTRODUCTION

In 1990 Willamette Industries, Inc. purchased the Penntech Papers Inc. facility located in Johnsonburg, Pennsylvania. Willamette Industries has since made extensive capital investments in order to modernize and expand this specialty and commodity paper making facility. In addition to the new No. 5 paper machine, the expansion included new, state-of-the-art woodyard, fiberline, recovery boiler, lime kiln, recaust, evaporator, and waste water treatment facilities. At the same time, a major investment in workforce training was made. As a result, the facility now produces over 1,300 tons of paper per day using three of the four original paper machines and the new No. 5 paper machine. This figure is up from approximately 400 tons per day prior to the expansion.

Figure 1 shows the layout for the woodyard and fiberline areas. Start-up for the new fiberline was May of 1994.

Approximately 50% of the wood supply are from two satellite chip plants while the remaining 50% are residual chips from some 120 area sawmills. Chip screening is accomplished in an

Acrowood system. All screen rejects (i.e. pins, fines, and gross overs) are weighed and then land filled. The furnish is 100% hardwood. While wood species distribution varies slightly the average furnish composition is 32% Maple, 30% Oak, 13% Cherry, 7% Beech, 3% Ash, and approximately 15% other (Hickory, Birch, and Poplar). A 10 to 12 day inventory of chips is maintained and material flows through the wood yard on a first-in-first-out basis.

The pulping system consists of an Ahlstrom-Kamyr single vessel hydraulic digester coupled with a blowline pressure diffuser. The digester's design capacity is 700 BDST/D. The digester was originally designed for Extended Modified Continuous Cooking (EMCC™), but was converted to Lo-Solids® cooking by October of 1994 (i.e. within 6 months of start-up). As such, this digester was the 4th cooking system in the world to operate with the Lo-Solids process. A more detailed description of the pulping system design and operation will be given below.

Following the pressure diffuser washer and brownstock HD storage are an Impco knotter, Black Clawson screens, and a single stage Impco washer/decker. The bleach plant consists of an Impco three stage D₁₀₀E_{op}D system. For normal operation peroxide is not used in the second stage. Peroxide is only used in the bleaching sequence for start-ups and when ClO₂ inventory is low. Not shown in Figure 1 is the chlorine dioxide plant, which is an Eka Nobel SVP-HP with 15 TPD original design capacity. This unit was the first ever greenfield plant of its kind.

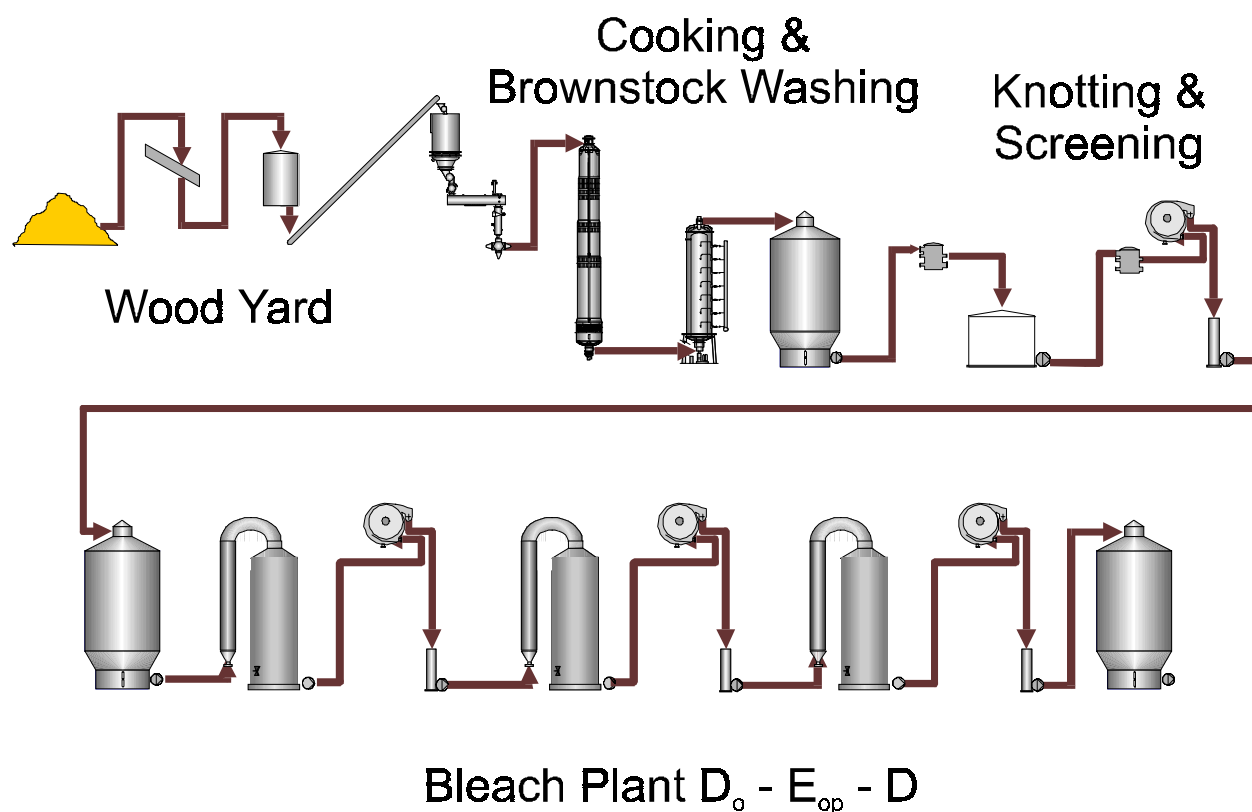


Figure 1. *Woodyard and fiberline flowsheet for Willamette Industries, Inc. Johnsonburg Mill.*

Digester Design and Operation Parameters

The Johnsonburg digester was designed as a single vessel hydraulic with EMCC cooking. Design capacity is 700 BDST/D. A schematic of the process is given in **Figure 2**. The system is equipped for 30 minutes of atmospheric pre-steaming and 1.5 minutes of pressurized steaming at 14 to 18 psig (i.e. at design rates). The digester vessel itself has five screen sections which delineate four different zones within the cooking process: an impregnation zone, a con-current cooking zone, a counter-current cooking zone, and a final counter-current cooking zone with Hi-Heat™ Washing.

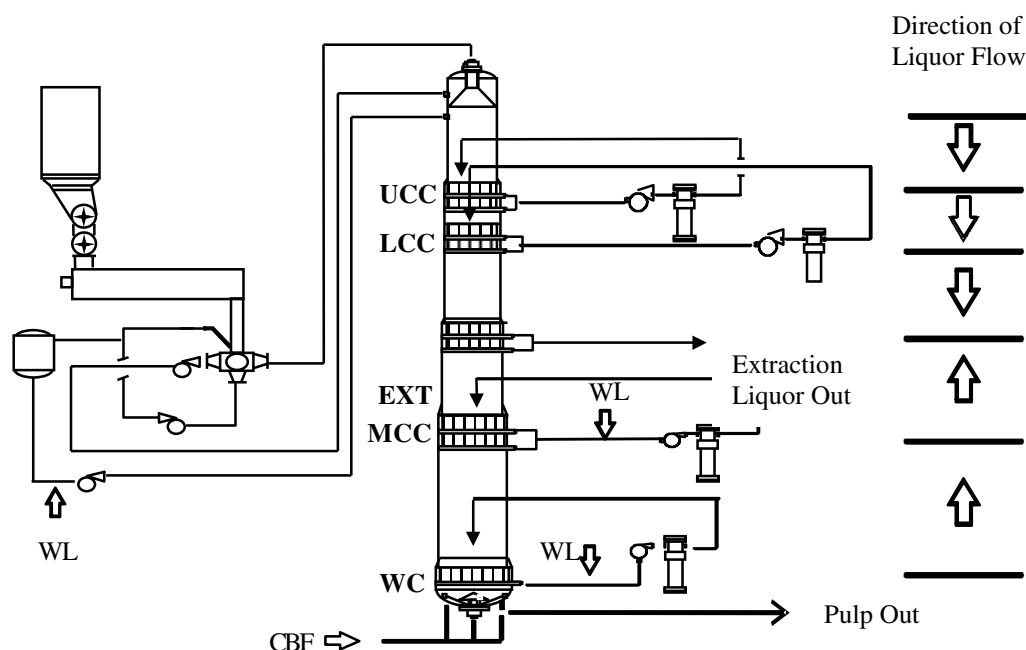


Figure 2. Process Layout for EMCC Cooking at Johnsonburg. Legend: WL denotes white liquor; CBF denotes cold-blow filtrate; UCC denotes upper cook circulation; LCC denotes lower cooking circulation; EXT denotes extraction screens; MCC denotes modified cooking circulation s, WC denotes wash circulation.

The top of the vessel serves as the impregnation zone with approximately 45 minutes chip retention time at design rates. Beneath the impregnation zone are the upper and lower cooking screen and circulation systems. These external circulation systems serve as the primary heating system for bringing the chip/liquor reaction mixture up to full cooking temperature. As chips proceed vertically downward they pass through the first, con-current cook zone. The con-current cook zone is terminated at the extraction screens where spent cooking liquor is withdrawn from the system. Enough liquor is extracted here to generate a liquor upflow beneath these screens, i.e. a counter current flow between (chips & chip-bound-liquor) and (unbound liquor). After passing by the extraction screens, chips proceed through the next, counter-current cook zone, which is typically described as the MCC cook zone. Design chip retention times for both the con current and the counter current (MCC) cook zones are approximately one hour each at design rates. Another heating circulation is located between the counter-current MCC and the counter current wash-cook zones. This circulation is referred to as the MCC circulation. The wash-

cook zone has three hours of retention time at design rates and is terminated at the wash circulation screens. Finally, the dilution/cold-blow zone is located beneath the wash screens and is used to discharge fully cooked pulp from the bottom of the vessel.

For EMCC operation white liquor is added to the feed, the MCC circulation, and the wash circulation. All spent cooking liquor is extracted from the extraction screens and all cold-blow filtrate (i.e. washer filtrate from the blowline pressure diffuser) is added at the bottom of the digester vessel. The Johnsonburg digester was commissioned as an EMCC system but converted to Lo-Solids pulping within six months of start-up.

The equipment modifications required to convert the Johnsonburg digester to Lo-Solids pulping were relatively minor. These are illustrated in **Figure 3** below. Two additional extraction lines were added; one at the upper cook circulation (UCC) header and the other at the modified cook circulation (MCC) header. Also, additional white liquor (WL) and cold-blow filtrate (CBF) lines were added to both the lower cook circulation (LCC) and MCC lines. The WL and CBF lines were introduced upstream of the respective pumps and heaters but, in the case of the MCC, downstream of the new extraction line. Each of these new lines were equipped with flow indicator-control valves and instrumentation.

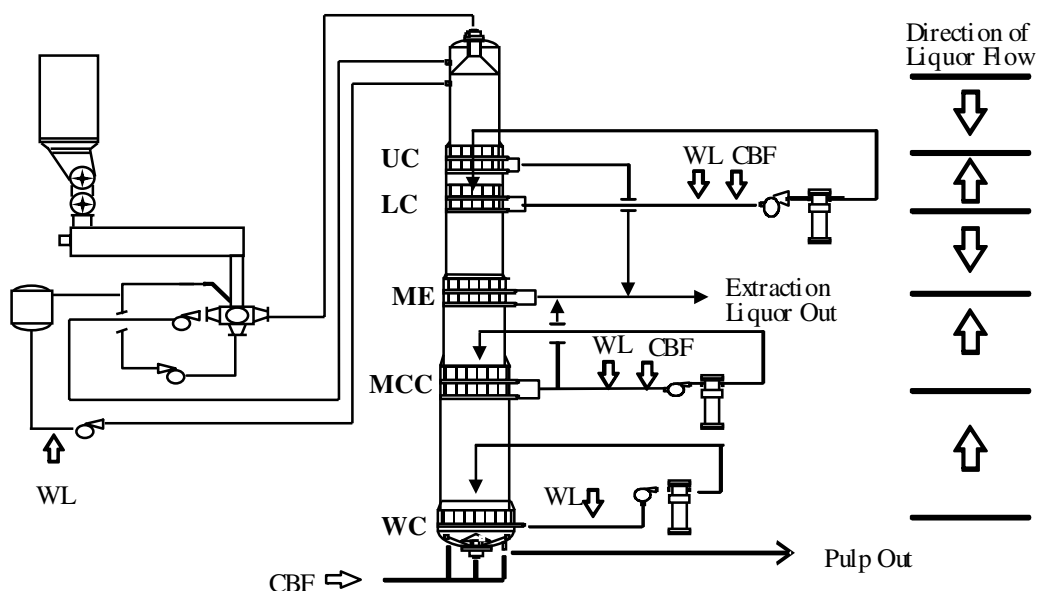


Figure 3. Process Layout for Lo-Solids Cooking at Johnsonburg. Legend: WL denotes white liquor; CBF denotes cold-blow filtrate; UCC denotes upper cook circulation; LCC denotes lower cooking circulation; ME denotes main extraction screens; MCC denotes modified cooking circulation s, WC denotes wash circulation.

For the Lo-Solids process spent cooking liquor is extracted at three locations: the UCC screen header, the extraction screens, and the MCC screen header. Washer filtrate (CBF) is added at three locations: the LCC circulation, the MCC circulation, and the bottom of the digester. White liquor is added at four locations: the feed, the LCC, the MCC, and the wash circulation. Thus compared to EMCC operations the Lo-Solids process utilizes more extraction, WL addition, and CBF addition points.

The WL distribution and, to a lesser degree, the CBF and temperature distributions are set so as to achieve alkali concentration minima at each of the three extraction points. Target residual alkali concentrations of between 5 and 8 g/L Effective Alkali (EA) as Na₂O are set for each of the three extractions. Both extraction flow setpoints and CBF addition flow set points are adjusted to achieve a minimum time-concentration profile of dissolved organics within the cooking liquor and, at the same time, achieve a desirable “hydraulic balance”. As Figure 3 indicates, the direction of liquor flow within different zones of the Lo-Solids cooking process are similar to that of the EMCC process with the exception of the upflow generated between the UCC and LCC screens. The magnitude of flows within the different zones can, however, differ significantly. With the Lo-Solids process the following variables can be manipulated independently: the direction of unbound liquor flow, the magnitude of unbound liquor flow, the EA profile, and the dissolved solids profile. For a detailed description of the theory and application of this process the reader is referred to Marcoccia *et al.* [1,2].

Table 1 gives typical operating conditions for the Lo-Solids cooking process. Conditions cited are for a 700 BDST/D rate. Total WL applied varies from 15.4 and 15.8% EA on wood as Na₂O. Once again, individual WL flows are adjusted to achieve target residuals of 5 to 8 g/L EA as Na₂O at each of the three extraction sites. Energy balance calculations around the wash circulation system shows that the average wash zone temperature is between 295 and 298°F. Total extraction factor ranges from a 1.90 to 2.10 GPM per BDST/D. This corresponds to a global dilution factor of between 2.5 and 3.5 tons filtrate per ADT pulp. In practice, considerably more filtrate can be added to and extracted from the vessel. A nominal extraction factor target of 1.95 GPM per BDST/D is the typical set point: this value is felt to give the optimum performance with respect to brownstock washing and evaporator energy requirements. All brownstock wash water runs completely counter-currently through the screen room, pressure diffuser, and digester. No filtrate is by-passed across any stage in the brownstock washing area. Brownstock washing is reliable and extremely efficient with minimal carryover into the bleach plant.

	<u>Feed</u>	<u>UCC</u>	<u>LCC</u>	<u>ME</u>	<u>MCC</u>	<u>WC</u>
Temperature °F						
(Cold/hot pens)	256	277/279	294/296	302	301/303	295/309
WL Distribution						
(% of total applied)	53	0	24	0	14	9

Table 1. Operating Conditions for Lo-Solids Pulping at the Johnsonburg Mill. Conditions based on a 700 BDST/D rate. Total WL applied is between 15.4 and 15.8% EA on wood as Na₂O. Actual WL flows and temperature set points adjusted to maintain target residuals and target kappa/viscosity numbers respectively.

Digester Performance and Operating Experience

The digester operation is exceedingly stable and well controlled. System availability exceeds 98% and is in fact close to 99%. **Table 2** shows monthly averages and standard deviations for brownstock kappa and viscosity testing. Statistics are based on 6 tests per day, every day of the

month with no exceptions (i.e. all data included). On occasion (e.g. shut-ins and start-ups) testing will not be performed but this is quite rare.

	Month (1999)	Average	Standard Deviation
Brownstock Kappa	January	14.8	0.48
	February	15.1	0.50
	March	15.8	0.59
	April	16.6	0.89
	May	16.2	0.78
	Average	15.7	0.65 (4.1%)
Brownstock Viscosity (Tappi T-230, cp)	January	72.6	6.1
	February	73.7	4.1
	March	73.9	4.2
	April	77.1	3.7
	May	70.0	7.3
	Average	73.5	5.1 (6.9%)

Table 2. Brownstock kappa and viscosity monthly averages and standard deviations.

The target brownstock kappa is between 14 and 16 and is allowed to swing slightly in order to achieve target brownstock viscosity, which is 70 cp. Viscosity is controlled by adjusting cooking temperature(s). In other words, primary control is on brownstock viscosity (via temperature) so long as brownstock kappa is within +/- 1.5 units of target. This strategy prevents the use of excess temperature and subsequent viscosity loss. Brownstock viscosity and, more specifically, bleached viscosity are very important quality parameters at the Johnsonburg mill as the papermakers have determined that machine runnability and performance are directly influenced by them.

Table 3 summarizes the key performance parameters of the fiberline area, comparing Lo-Solids pulping to EMCC and conventional batch operations. It was found that Lo-Solids cooking resulted in improved selectivity (i.e. higher viscosity-to-kappa ratios at all kappa numbers within the 10 to 18 range) and improved bleachability. Improved bleachability allowed for an increase in brownstock kappa (and thus viscosity) while applying less bleaching chemicals and achieving higher final brightness. It should be noted that at the same time the Lo-Solids process was commissioned bleach plant operations were being optimized. Specifically, the distribution of ClO₂ was optimized to a 70/30% split between the 1st and 3rd stages and sulfuric acid was added prior to the D₁₀₀ chemical mixer. It is not possible to quantitatively determine how much of the improved bleachability was due to the new cooking process and how much was due to changes in bleach plant operations. Earlier theoretical work suggests, however, that a 5% decrease in kappa factor and a 1 to 2 point increase in brightness ceiling should have resulted from the changes in cooking chemistry [1,2]. Overall, the kappa factor decreased by 36%. Finally, bleached viscosity increased nearly two-fold. Within a week of the cooking process change to Lo-solids cooking the paper machines at Johnsonburg began to consistently run faster and better, breaking both speed and production records.

Parameter	Before Lo-Solids Cooking	After Lo-Solids Cooking
Brownstock Kappa	11.0	15.0
Brownstock Viscosity	40 cp	> 70 cp
Bleached Viscosity	22 cp	41 cp
Final Brightness	86.0 GEB	88.0 GEB
ClO ₂ Usage	2.8% applied	2.5% applied

Table 3. Key performance parameters for the Johnsonburg fiberline.

In addition to improved pulp quality and bleachability, improvements in washing and apparent yield were noted almost immediately after the conversion to Lo-Solids pulping. Mill production personnel noted that the ratio of bleached pulp and brownstock pulp production increased after the conversion. Their observations suggests that either: (1) there was less “shrinkage” across the bleach plant for the new cooking process, and/or (2) brownstock pulp production increased relative to their method of measuring production (i.e. chip meter rate). **Figure 4** gives weekly wood usage data for 8 weeks prior and 8 weeks after conversion to the new process. In this case the data is based on weightometer measurements of wood feed, blowline flowrates, and estimates of blowline consistency.

The data in Figure 4 clearly shows a stepwise decrease of approximately 10% as a result of the transition from EMCC to Lo-Solids Pulping. Here, the average wood usage for the EMCC base case was arbitrarily set as 100%. Base case wood usage values were comparable to long term values for the conventional batch system used earlier at the mill.

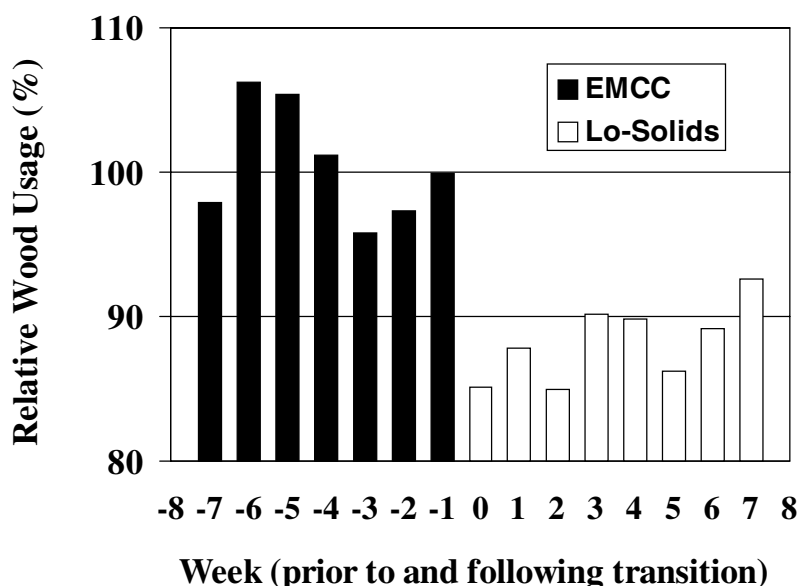


Figure 4. Stepwise decrease in hardwood usage at the Johnsonburg Mill. Average wood usage for EMCC base case arbitrarily set as 100%.

While the results in Figure 4 are quite convincing, the authors recognize that yield measurements based on weightometer and blowflow observations are subject to large inaccuracies and imprecision. Specifically, variations in wood moisture, chip meter fill factor, and blowline consistency (as well as inaccuracies in the weightometer and blowline consistency measurements) renders this observation qualitative or semi-quantitative at best. As a result, a major effort was made to quantify both brownstock and bleached yield.

Table 4 summarizes results from long term production and accounting data. In addition to brownstock and bleached pulp flow meter measurements, wood receipts, quarterly aerial photographs of chip pile inventory, purchased pulp receipts, and paper production values were used to compile the results given in Table 4. The new chip screening system alone resulted in decrease wood usage of approximately 3%. Factoring out wood savings from the screen room by considering yield based on wood feed to the digester, the new cooking process resulted in a 4.6 Yield percentage increase in screened brownstock yield. This value corresponds to a 9% decrease in wood usage across the digester, which is consistent with the results in Figure 4. A parallel calculation based on aerial photography results, wood receipts, and pulp receipts alone result in an average wood usage value of 3.45 Green T per BD bleached ton for present operations. This is within 1.5% of the value calculated in Table 4 (i.e. easily within the range of precision of these measurements).

Basis: 100 Tons of Purchased Green Chips

	Before Lo-Solids Pulping	After New Chip Screens & Lo-Solids Pulping
Green Wood After Chip Screening	94.0 Tons	96.5 Tons
Bone Dry Wood After Screening	56.4 BDT	57.3 BDT
Bone Dry Unbleached Pulp	26.5 BDT	29.5 BDT
Bone Dry Pulp after Knotters and Screens	25.45 BDT	29.45 BDT
Bone Dry Bleached Pulp	24.7 BDT	28.6 BDT
 Wood Usage (Tons Green Chips Per Ton Bleached Pulp)	 4.04 Green T/BDT*	 3.50 Green T/BDT**
 Screened Brown Pulp Yield (BDT Brown Pulp BDT screened wood)	 45.1% BDT/BDT*	 49.7 BDT/BDT **
 Fully Bleached Yield (BDT Bleached Pulp BDT screened wood)	 43.8% BDT/BDT*	 48.2 BDT/BDT **

* Based on average of 40.0% wood moisture

** Based on average of 40.6% wood moisture

Table 4. Summary of wood usage, brownstock yield, and bleached yield based on production and accounting data.

The yield measurements reported above have been confirmed using the direct, laboratory based method described elsewhere by Marcoccia, Prough, and Stromberg [3]. This method involves the collection of representative chip samples (i.e. digester feed) for use in 8 to 10 laboratory

cooking simulations. The lab cooking simulations are performed with varying EA charge, H-factor, and target kappa. In addition, cooks with substantially different chemistry are also performed: e.g. soda based cooks and kraft-anthraquinone cooks. The resultant pulp series' have varying Yield vs. Kappa relationships as well as a wide range of yields. From this, a universal yield calibration curve for the chips in question is developed. The calibration curve consist of plotting lignin-free (or kappa corrected) brownstock yield against the parameter $\log_{10}(V)/G'^2$ where V denotes brownstock pulp viscosity (Tappi T-230, cp) and G' denotes the mass fraction of cellulose in lignin-free brownstock pulp. The term G' is measured via monosaccharide component analysis. The calibration curve is independent of cooking chemistry and brownstock kappa number. Thus, once developed it can be used to infer the yield of corresponding mill brownstock samples simply by measuring their $\log_{10}(V)/G'^2$ values. Finally, and indirect estimate of bleach shrinkage and final bleached yield is obtained by bleaching both a lab and mill brownstock (with comparable kappa numbers) using a standard DED lab bleaching sequence. Final shrinkage and brightness developed are measured.

Table 5 is a summary of the laboratory cooking conditions used for the Johnsonburg chip samples. **Table 6** gives the composition analysis of the resultant laboratory pulps.

Cook ID	S1112	S4194	S1108	S4182	S1131	S4180	S1116	S4184
Cook Type	CK ^a	CK	CK	CK	CK	CK	CK w/PS ^b , AQ ^c	SODA ^d
Presteam:								
Temperature (°C)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Time (min)	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Impregnation:								
EA Charge (% on wood NaOH)	17.0	17.0	18.0	18.0	21.0	21.0	23.0	23.0
WL Sulfidity (% AA)	29.6	27.3	29.8	29.8	27.3	29.6	29.4	0.0
AQ (% on wood)	—	—	—	—	—	—	0.1	—
Polysulfide (% on wood)	—	—	—	—	—	—	3.0	—
L/W Ratio (L/kg)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Temperature (°C)	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0
Time to Temperature (min)	16.0	15.0	16.0	16.0	15.0	16.0	16.0	16.0
Time at Temperature (min)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Cooking								
Temperature (°C)	158.8	164.0	160.8	164.0	163.2	164.0	164.0	164.0
Time to Temperature (min)	17.0	15.0	16.0	15.0	15.0	16.0	18.0	16.0
Time at Temperature (min)	86.5	153.5	84.8	189.3	85.0	186.8	184.5	185.8
Final Cooking Results:								
Residual pH	12.6	12.0	12.7	12.1	13.0	12.8	11.6	13.1
H-Factor	550	1494	639	1805	796	1804	1797	1790
Screened Kappa Number	17.5	13.1	14.6	12.4	11.6	9.7	10.4	14.1
Screened Viscosity (mPa-s)	61.4	49.2	54.1	37.2	33.4	25.2	33.1	23.5
Total Yield (% on wood)	51.8	50.3	51.1	50.2	48.8	48.2	51.0	48.0
Total Rejects (% on wood)	0.9	0.1	0.4	0.2	0.0	0.0	0.0	0.1
Screened Yield (% on wood)	51.0	50.2	50.7	50.1	48.8	48.2	51.0	47.9
Knots >13 mm (% on wood)	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.1

^aCK=Conventional Kraft Process ^bPS=Polysulfide ^cAQ=Anthraquinone

^dSODA=Soda Process

Table 5. Laboratory cooking conditions and results (Johnsonburg Chips).

Descriptive ID	Kappa Number	Viscosity (mPa·s)	Aarabinan (% ^a)	Galactan (%)	Glucan (%)	Xylan (%)	Mannan (%)	Lignin Free Cellulose Content of Pulp	
								G'	log(V)/G' ² ^b
Mill Brownstock	12.9	63.7	<0.1	<0.1	74.84	19.67	0.40	0.69	3.77
S1112	17.5	61.4	0.06	0.08	72.74	20.26	0.35	0.68	3.86
S4194	13.1	49.2	0.03	0.04	75.13	20.09	0.36	0.69	3.58
S1108	14.6	54.1	0.04	0.06	73.66	20.29	0.38	0.68	3.72
S4182	12.4	37.2	0.03	0.04	73.90	20.31	0.35	0.68	3.36
S1131	11.6	33.4	0.03	0.02	76.56	19.40	0.44	0.70	3.12
S4180	9.7	25.2	0.03	0.02	75.95	20.11	0.37	0.69	2.94
S1116	10.4	33.1	<0.1	<0.1	73.2	21.1	0.82	0.67	3.42
S4184	14.1	23.5	<0.1	<0.1	76.4	18.9	0.39	0.70	2.76

^a% sugar on OD pulp ^bbased on glucan content that has been corrected for percent recovery

Table 6. Composition analysis for laboratory pulps from Johnsonburg chips.

The yield calibration curve is shown in **Figure 5** and is described by:

$$Y' = 3.24 * (\log_{10}(V)/G'^2) + 38.1, R^2 = 0.89 \quad (1)$$

Where Y' denotes lignin-free brownstock yield. Both the slope and intercept of this calibration curve are consistent with those observed in earlier studies with similar furnish [3]. The precision of the calibration curve is felt to be reasonably good. Note that the reproducibility of yield measurements for laboratory cooks was measured to be +/- 0.45 yield points at the 95% confidence interval. The vertical error bars on Figure 5 indicate this level precision.

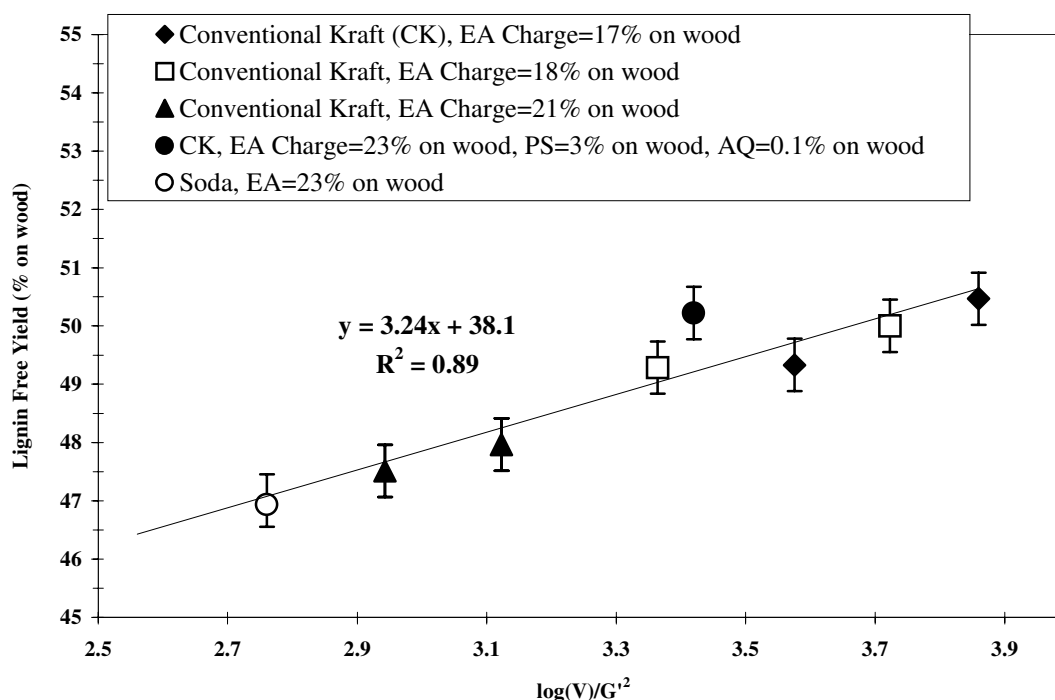


Figure 5. Yield calibration curve for Johnsonburg hardwood furnish (digester feed).

Table 7 shows the composition analysis and inferred yield for a series of mill brownstock pulps sampled during May of 1999. The mill brownstock samples were produced from chips, which were determined to be similar to those used for the laboratory pulping studies. Yield values for the mill brownstocks ranged from 51.8 to 52.7%. The yield vs. kappa relationship is plotted in **Figure 6** where mill and lab brownstocks are compared. The mill, Lo-Solids brownstock has a total yield, which is between 1.8, and 2.0 yield % points higher than corresponding lab conventional cooked pulps of similar kappa. The laboratory results show higher brownstock yield than did mill production and accounting data: i.e. approximately 52.0% versus 49.7% as BDT/BDT within a similar kappa range. At the same time, lab results for pulp shrinkage after bleaching were found to be higher than the results based on mill production and accounting data.

Descriptive ID	Kappa Number	Viscosity (mPa·s)	Arabinan (% ^a)	Galactan (%)	Glucan (%)	Xylan (%)	Mannan G'	log(V)/G ^{2b}	Calculated BS Yield (%)**
5/2/99	12.9	63.7	<0.1	74.84	19.67	0.40	0.69	3.77	52.2
5/3/99	13.7	56.8	<0.1	75.30	19.60	0.41	0.69	3.65	51.8
5/4/99	13.9	61.4	<0.1	75.10	19.60	0.42	0.69	3.73	52.1
5/5/99	15.1	65.6	<0.1	74.30	19.50	0.42	0.69	3.79	52.3
5/6/99	13.9	55.7	<0.1	75.20	19.80	0.40	0.69	3.66	51.9
5/7/99	13.7	57.0	<0.1	74.60	20.20	0.39	0.68	3.75	52.2
5/10/99	13.7	68.4	<0.1	74.90	19.80	0.36	0.69	3.85	52.5
5/11/99	12.2	59.3	<0.1	75.90	19.40	0.39	0.70	3.65	51.8
5/12/99	12.4	55.8	<0.1	75.10	19.80	0.39	0.69	3.66	51.9
5/14/99	13.7	72.0	<0.1	74.20	19.90	0.35	0.69	3.93	52.7
5/17/99	13.1	58.6	<0.1	74.80	19.80	0.38	0.69	3.71	52.0

** Lignin free yield calculated using Equation [1]. Total Brownstock yield calculated using:
Total Brownstock Yield = Lignin Free Brownstock Yield + 0.147*kappa/100

Table 7. Composition analysis and yield for Mill Brownstock pulps from Johnsonburg.

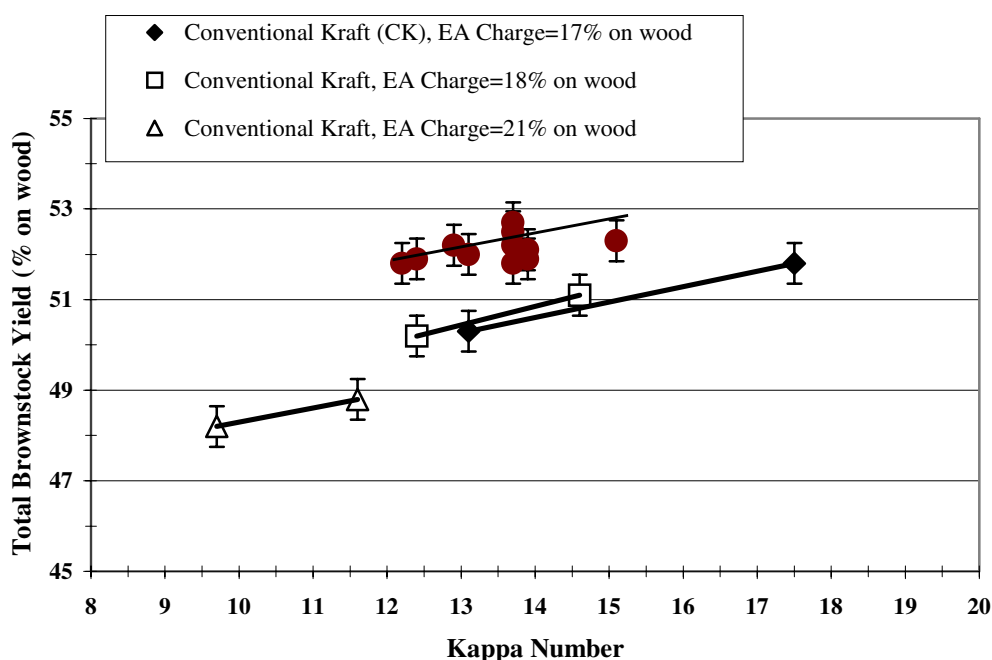


Figure 6. The yield vs. kappa relationship for Johnsonburg Mill and Lab Brownstocks.

Table 8 shows the conditions and results from lab bleaching of a mill and a lab brownstock. First stage kappa factors were normalized so that conditions were as comparable as possible. Compared to the lab conventional pulp, mill achieved a slightly higher final brightness and shrank considerably less (i.e. 4.8% shrinkage versus 6.2% shrinkage). Again, the shrinkage measured using the laboratory methods was greater than that measured with production and accounting data (3.1% for lo-solids pulp). However, the discrepancies between lab and production brown and bleach data counter-act one another.

<u>Brownstock Description:</u>	Mill Lo-Solids Pulp	Lab Conventional Pulp
Kappa Number	12.9	12.4
Viscosity, mPa·s	63.7	37.2
Brightness, % ISO	36.9	36.4
Brownstock Yield (% as BDT/BDT)	52.2	50.2
<u>Do – Stage: 60 min., 70°C, 10% consistency</u>		
ClO ₂ , % as ClO ₂	1.47	1.41
Kappa Factor	0.30	0.30
Final pH	2.1	2.0
Consumed ClO ₂ , %ClO ₂	1.47	1.41
<u>E - Stage: 60 min., 70°C, 10% consistency</u>		
NaOH, %	0.80	0.80
Final pH	11.4	11.5
<u>D – Stage: 180 min., 70°C, 10% consistency</u>		
ClO ₂ , % as ClO ₂	1.20	1.20
NaOH, %	0.35	0.35
Final pH	3.1	3.3
Consumed ClO ₂ , %ClO ₂	1.07	1.02
<u>Final Bleached Results</u>		
Viscosity, mPa·s	39.3	27.8
Brightness, %ISO	88.7	88.6
Shrinkage, % as T/T	4.8	6.2
Final Bleached Yield (% as BDT/BDT)	49.7	47.1

Table 8. Lab bleaching conditions and results for Johnsonburg Mill and Lab Brownstocks.

Expressed on a fully bleached basis, the lab measurement of bleached pulp yield is 49.7% as BDT/BDT for lo-solids pulp versus the production data calculated value of 48.2% as BDT/BDT. These values are felt to be comparable and in confirmation of one another. It is not exactly known why the two methods differ in brownstock yield and bleach shrinkage, but the most likely explanation for this is inaccuracy in bleach feed pulp flowrate measurements at the mill. This issue is being investigated further.

Finally, the laboratory studies show that mill Lo-solids pulps have a final bleached yield, which is approximately 2.7 yield % points higher than corresponding lab conventional cooked pulps. This compares relatively well to the observations and calculations based on production data (Table 4). The results in Table 4 show that the mill Lo-Solids pulp has a final bleached yield which is 4.4% higher than earlier EMCC and conventional batch bleached yields. It was not

possible to use the laboratory method to measure EMCC and conventional batch yield since those operations pre-date the development of the yield measurement method utilized here. It is speculated that earlier mill pulping and bleaching operations gave brownstock and bleached yields which would have been slightly lower than those of lab simulations.

SUMMARY

The Lo-Solids Pulping operation at Willamette Industries' Johnsonburg mill has been in operation for nearly five years. Overall digester operation, control, and reliability are excellent. Conversion to Lo-Solids pulping has resulted in pulp which is easier to bleach, runs consistently better on the paper machines, and has significantly higher brown and bleached yield.

Various sources of long-term, mill production and accounting data show that the bleached yield is approximately 48.2% (as BDT bleached pulp per BDT wood feed to digester) and that this is approximately 4.4 yield % points higher than earlier EMCC and conventional batch operations.

Direct measurement of yield based on laboratory methods indicates a bleached yield of 49.7% (as BDT bleached pulp per BDT wood feed to digester) on a single grab sample of Lo-Solids pulp. Laboratory studies also show that the mill Lo-Solids pulp bleached yield is approximately 2.7 yield % points higher than that of corresponding lab conventional batch.

While the mill and lab based results for bleached yield correspond well, it was found that the mill-data based estimates of both brownstock yield and bleach shrinkage were lower than the lab based measurements. It is felt that the source of this discrepancy is inaccuracy in the measurement of pulp flowrates between the brownstock and bleach plant areas.

Further work in the area of yield measurement and optimization is ongoing.

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