

Effect of Hot-Water Extraction on Alkaline Pulping of Bagasse

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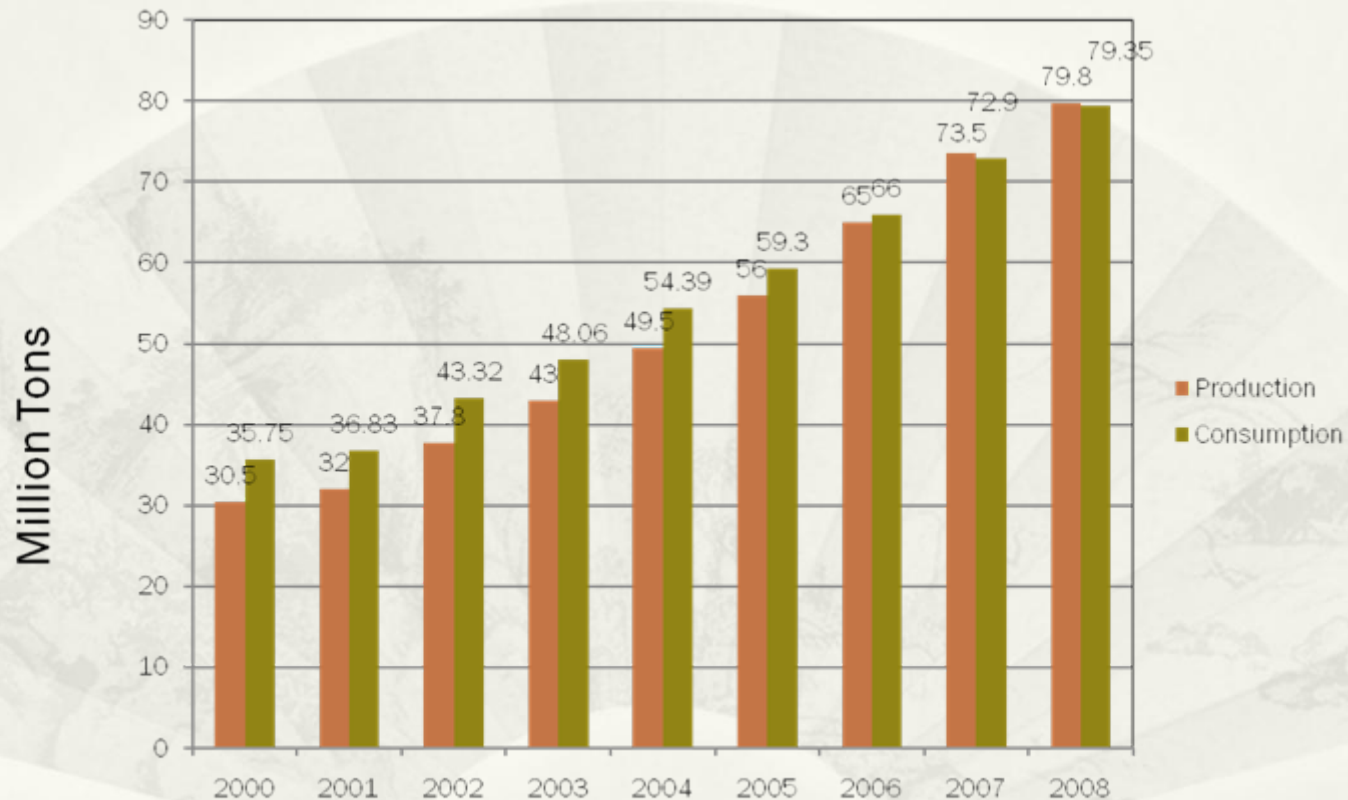
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Outline

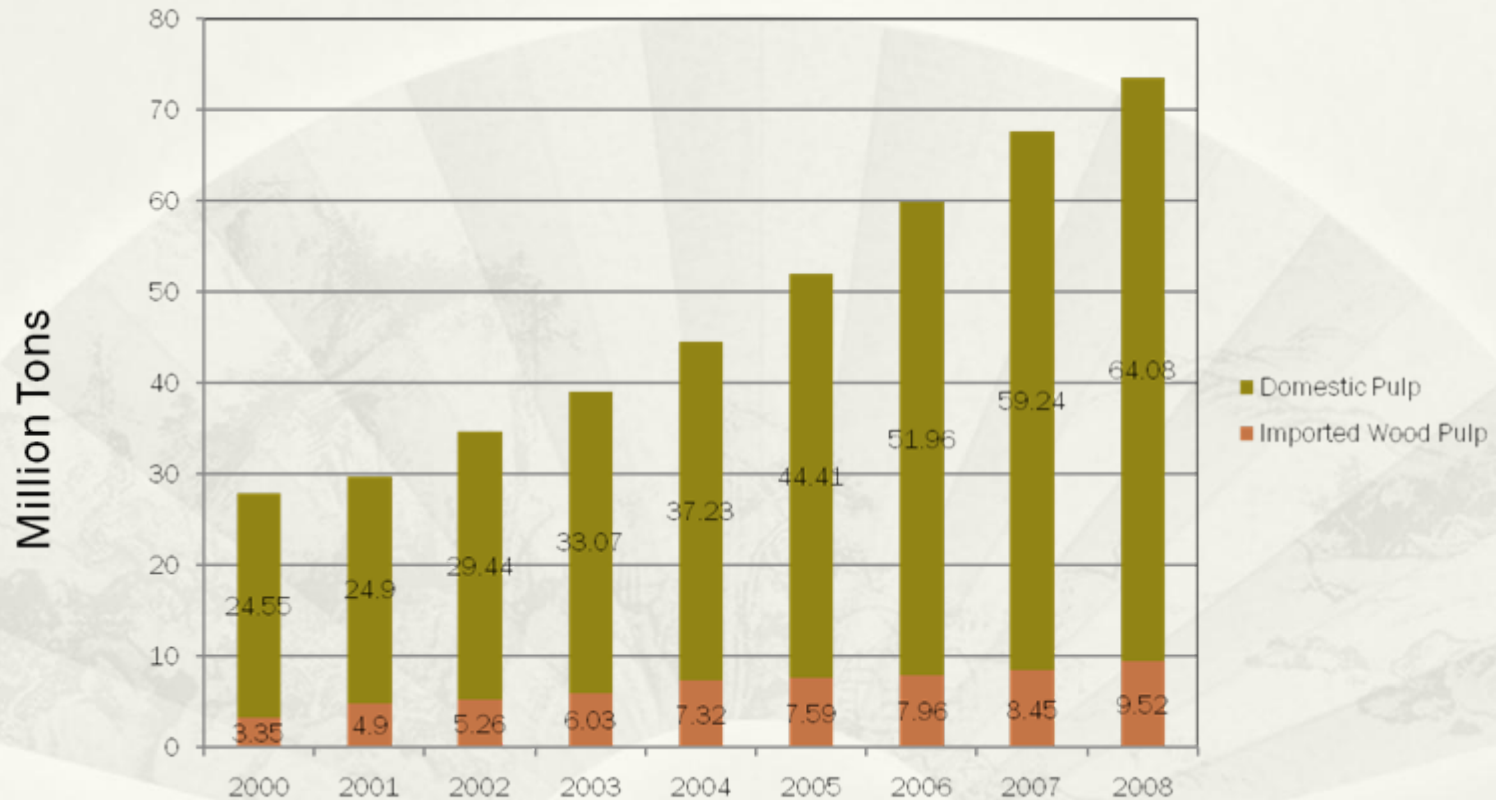
- * Introduction
- * Hot water extraction of bagasse
- * Pulping of bagasse
- * Properties of black liquor
- * ECF bleaching and pulp properties
- * Conclusion

China's Paper and Paperboard Production and Consumption



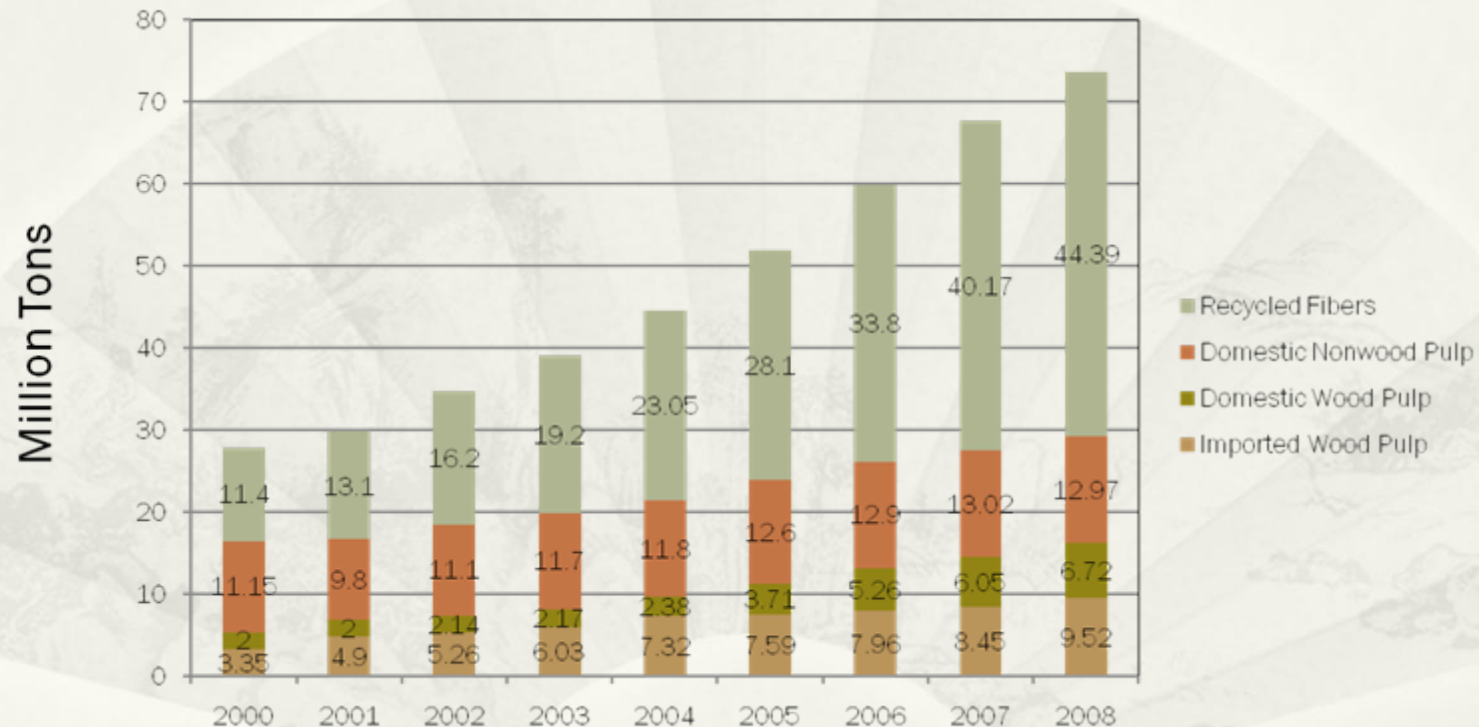
Source: The Annual Report of China's Paper Industry in 2008

Pulp Consumption in China



Source: The Annual Report of China's Paper Industry in 2008

More Detail about Pulp Consumption



Source: The Annual Report of China's Paper Industry in 2008

The Situation of China's Paper Industry

- * Paper Production and Consumption are fast growing. From 2000 to 2008, the average annual growth rate is 12.78% and 10.48% for production and consumption respectively.
- * Lack of forest resource, wood fiber mainly relies on import.
- * Nonwood fiber has high proportion.
- * More environmental pressure.

Nonwood Pulping in China

- * Abundant Non-wood materials, such as reed, bamboo, bagasse and wheat straw.
- * Pulping processes, Soda or Soda-AQ or Kraft
- * Bleaching processes, single Hypochlorite bleaching (H) or HH or CEH bleaching
- * Pulp capacity, 30000-100000 T/Y
- * Small pulp mills, old equipment and obsolete processes, high water consumption (130 m³/t of pulp), high cost effluent treatment

Biorefinery for Bagasse

- * Bagasse is widely used for papermaking. 9 million tons of bagasse produced annually in China, only 40% was used in paper industry.
- * Bagasse contains 30% of pith. Depith is very important for bagasse pulping.
- * Because of pith and high hemicelluloses content, bagasse pulp has poor drainage.
- * Hot water extraction was introduced prior to pulping.

Hemicelluloses of bagasse

- * About 30% content of hemicelluloses in bagasse
- * Main component , O-acetyl-4-O-methyl-glucurono-xylan and arabino-glucurono-xylan
- * Easy to degrade in hot alkali
- * Hemicelluloses can be extracted by hot water and as a potential raw material for biorefinery

Objective of this study

- * Research the hot water extraction technology for bagasse
- * Compare the standard bagasse and extracted bagasse's pulping behavior
- * Compare the two pulps' black liquor properties
- * Use ECF bleaching process to bleach the two pulps and compare their strength properties

Raw Materials

- * Bagasse, collected from Jiangmen Sugarcane Chemical Plant, Guangdong Province, China.
- * Two steps depith. In sugar manufacture depithed by $\Phi 2\text{cm}$ screen, before pulping depithed by 12 mesh screen. About 80% of total pith was removed.
- * Bagasse storage time, 10 months

Experimental Equipment

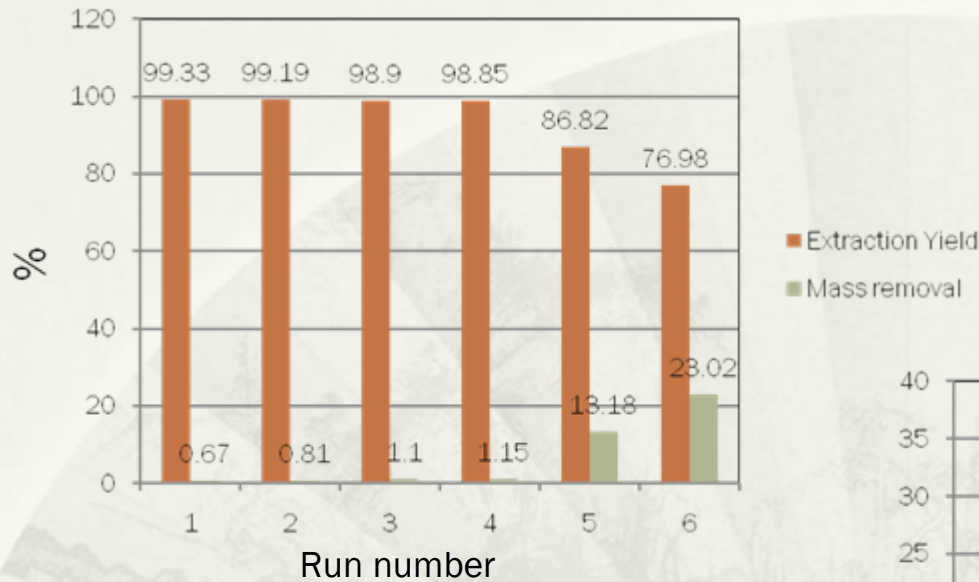
- * M/K circulation digester, hot water extraction
- * Rotary autoclave, 0.4 m³, Pulping
- * Somerville screen, slot, 0.15mm,
- * Pulp viscometer, pulp viscosity
- * Brookfield Viscometer, black liquor viscosity
- * PFI mill, pulp refining
- * Handsheet former, tensile strength tester, tearing tester, burst tester, brightness tester

Hot Water Extraction of Bagasse

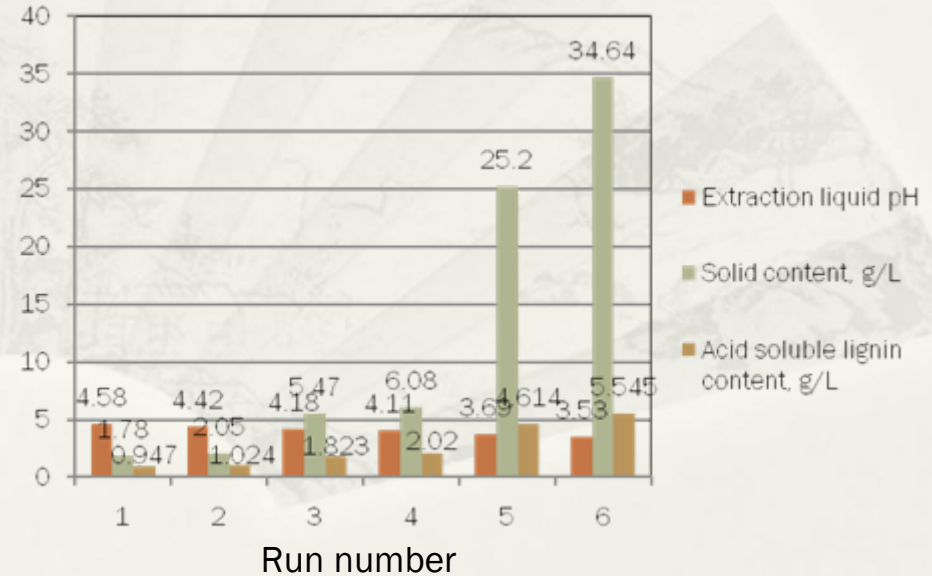
Details of Extraction Schemes

Run number	1	2	2	4	5	6
The charge of bagasse, OD, g	560					
Liquor to bagasse ratio, on OD bagasse	8:1					
Temperature of extraction, °C	80	80	120	120	160	160
Time to temperature of extraction, min	17	17	32	32	54	54
Time at temperature of extraction, min	30	60	30	60	30	60

Hot Water Extraction Results



Hot water extraction yield and mass removal



Extraction liquid properties

Summary

- * The mass removal from the hot-water extraction, the solid content and acid soluble lignin content of the extraction liquid increased with increasing extraction temperature and time. On the contrary, the extraction liquor pH value and yield decreased.
- * The mass removal was very low when the extraction temperature is below 120°C.

- * Hemicelluloses play an important role in developing sheet forming properties of fibers.
- * Hot water extraction can't affect the present pulp mill operation.
- * The mass removal needs to be modest.
- * It is better just to remove those hemicelluloses which dissolve in pulping process.
- * Run No. 5 was chosen for the later experiments.

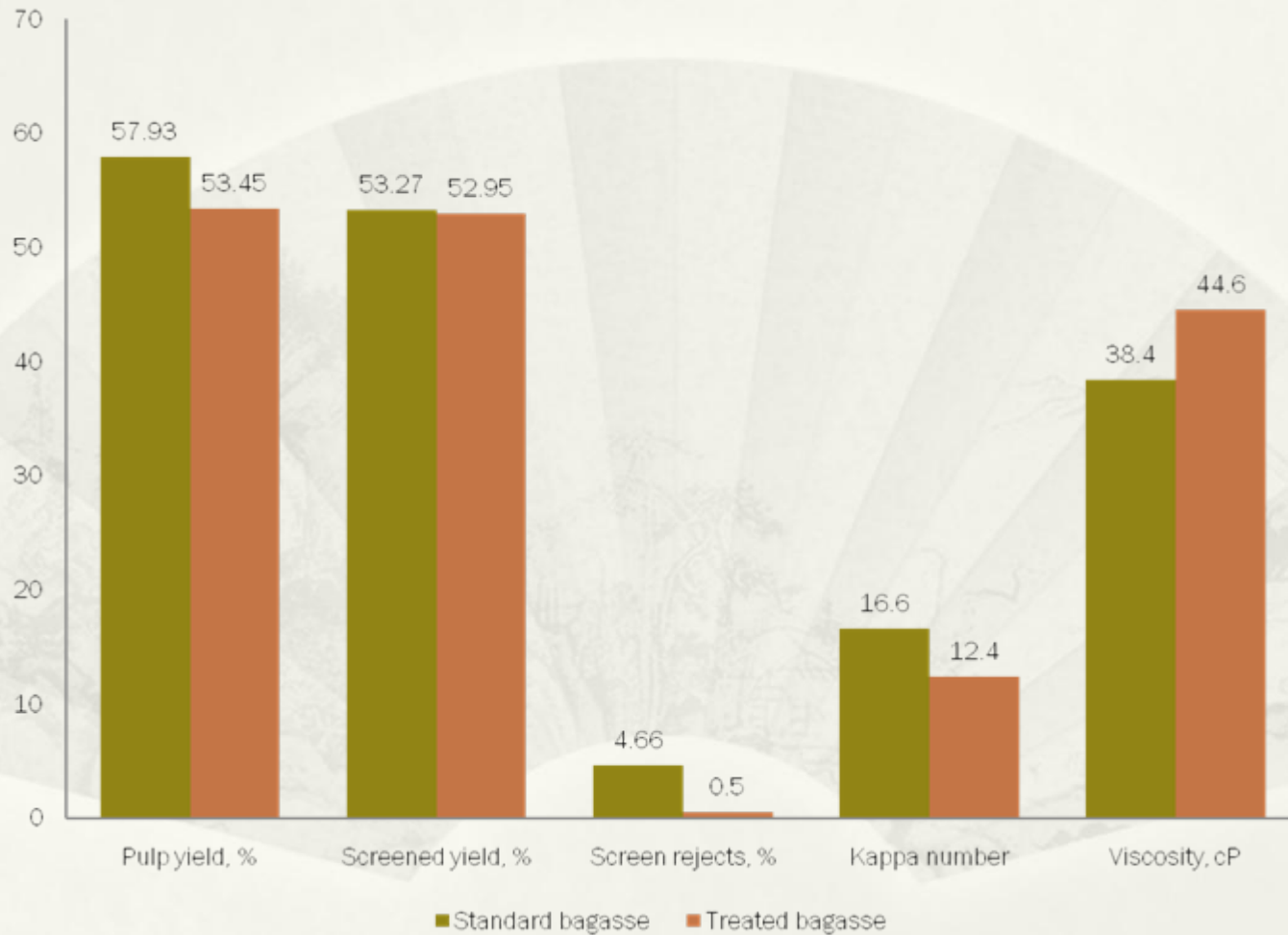
Pulping of Bagasse

Details of Pulping Schemes

	Standard bagasse*	Extracted bagasse
Pulping process	Soda	Soda AQ
The charge of bagasse, OD, g	280	280
Alkali charge, %, NaOH (on OD bagasse)	17	15.5
AQ dosage, % (on OD bagasse)	--	0.1
Liquor to bagasse ratio (on OD bagasse)	5.5	5.5
Cooking temperature, °C	160	155
Time to 110 °C, min	30	30
Time at 110 °C, min	15	15
From 110 °C to Cooking temperature, min	45	45
Time at cooking temperature, min	30	30

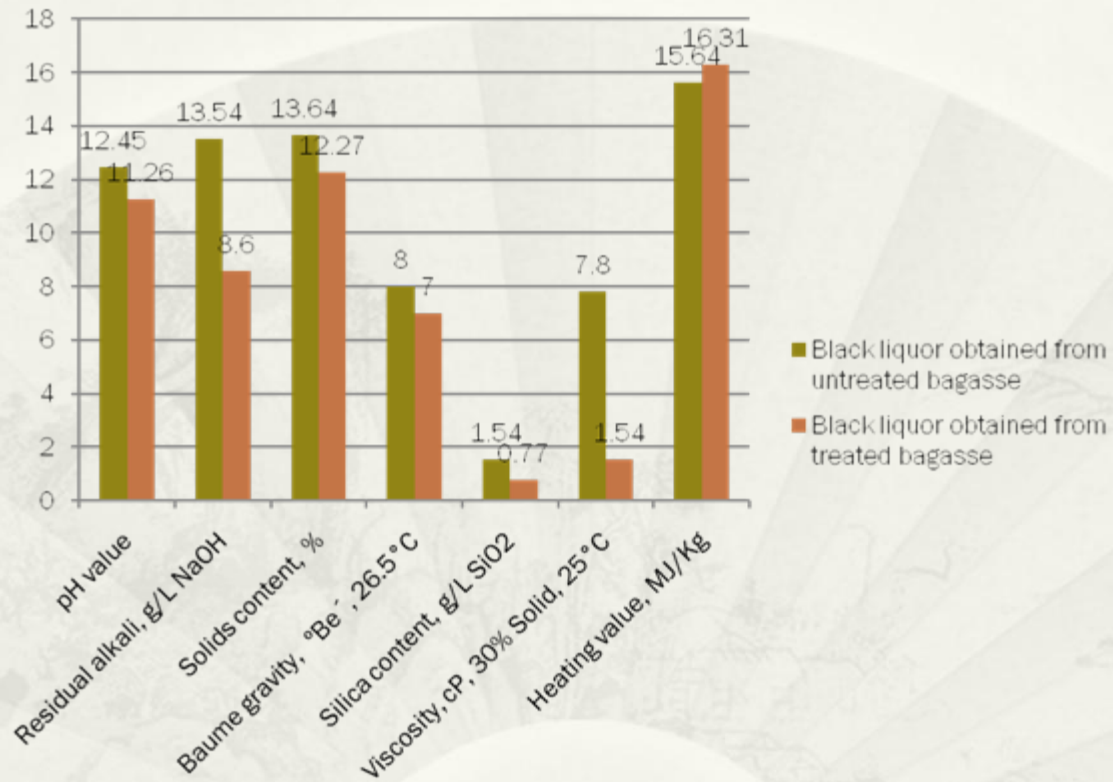
* The standard bagasse pulping conditions were provided by a bagasse pulp mill

Pulping Results



- * The pulp from treated bagasse has much lower Kappa number and screen rejects.
- * The pulp from treated bagasse has higher viscosity
- * Both bagasse have very close cooking screen yield.
- * Suppose cooking the standard bagasse to the same Kappa number as treated bagasse, it means more cooking time, lower cooking yield and lower production.

Properties of black liquor



Summary

- * Higher residual alkali of black liquor means more washing water is needed. More steam consumption is needed to concentrate the weak black liquor.
- * Lower solids content of black liquor, the same recovery boiler can tolerate more pulp production.
- * More silica content of black liquor, scaling problem, lower heat transfer efficiency.

- * Higher viscosity of black liquor means lower washing efficiency and lower heat transfer efficiency.
- * Higher heating value is always welcome.
- * In China, Nonwood pulp mills have the following problems, low heating value of BL, Low extraction rate of BL, high silica content of BL, high cost effluent treatment.
- * Hot water extraction prior to pulping has positive effects to the alkali recovery system.

ECF bleaching and pulp properties

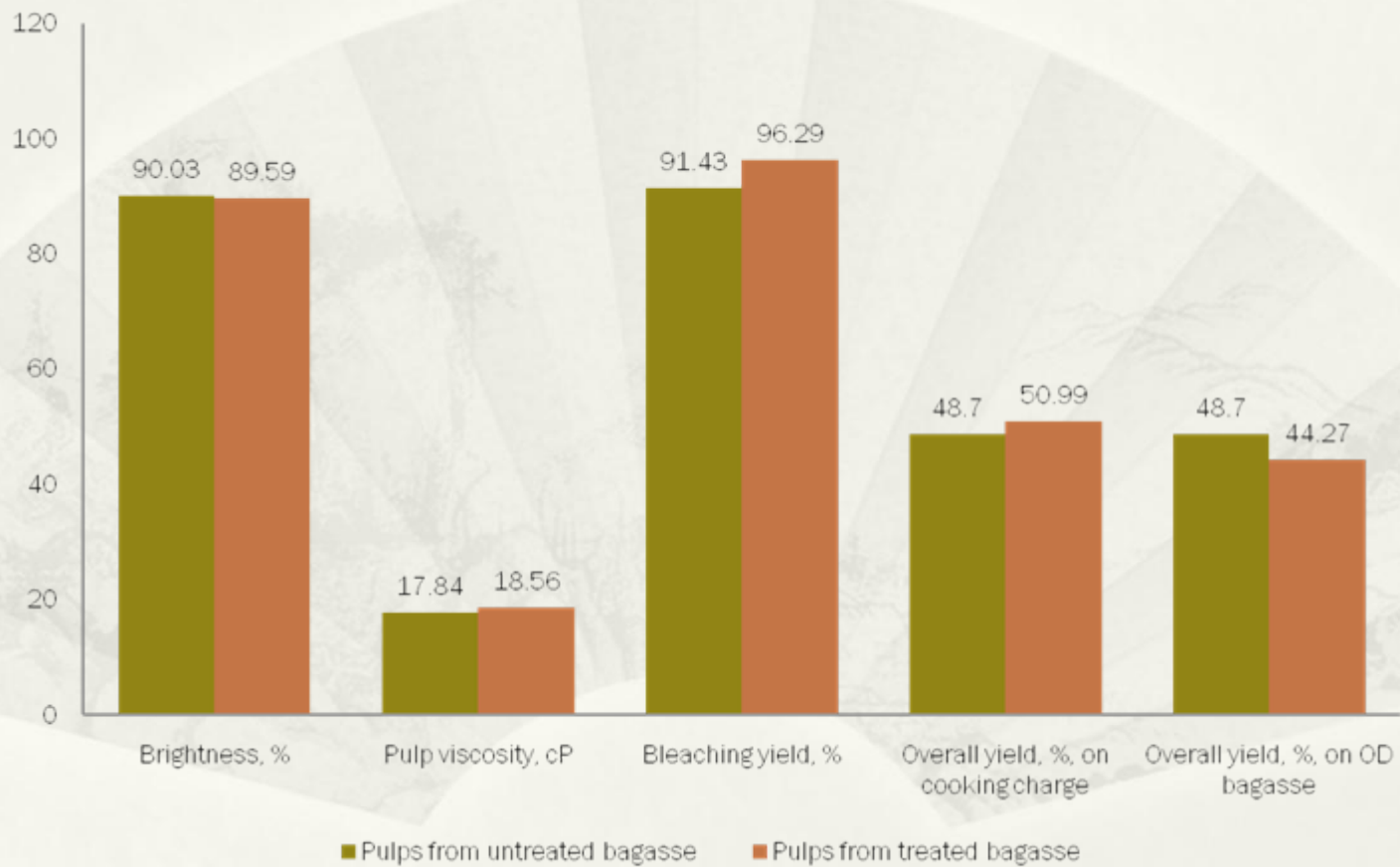
- * In China most bagasse pulp mills use soda pulping and CEH bleaching sequence or hypochlorite bleaching.
- * Serious pollution problem
- * The environmental regulations are getting tighter. The bleaching with elemental chlorine or hypochlorite must be replaced with ECF or TCF bleaching sequence.

ECF Bleaching Conditions

Details of Bleaching Schemes

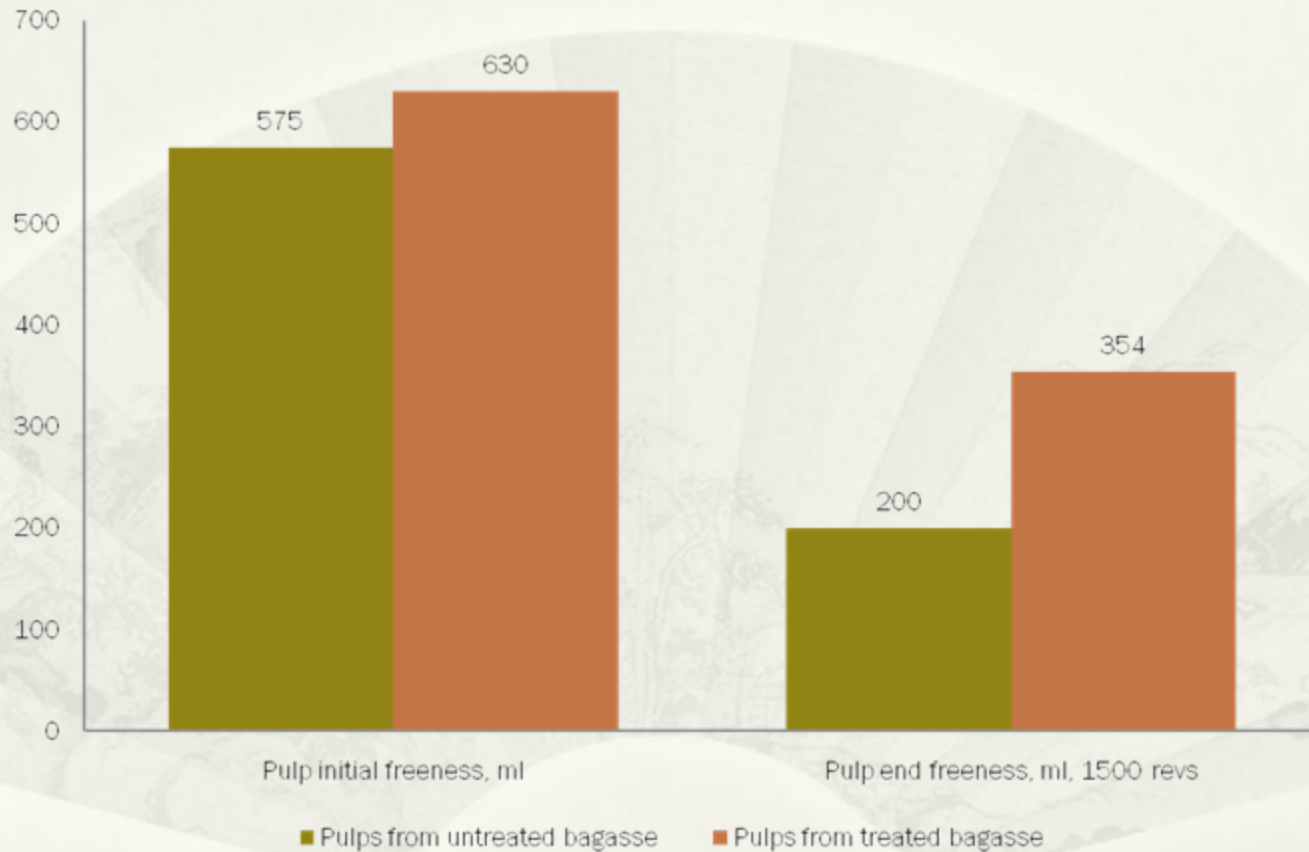
	Untreated	Treated
Kappa number	16.6	12.4
D₀ Stage: 60 min., 60°C		
Consistence, %	10.0	10.0
Kappa factor, %	0.23	0.23
ClO₂ charge, %	1.45	1.08
initial pH	4.30	4.30
Ep Stage: 10% Consistency, 60 min., 75°C		
NaOH charge, %	1.16	0.87
H₂O₂ charge, %	0.30	0.30
D₁ Stage: 10% Consistency, 150 min., 75°C		
Kappa factor, %	0.11	0.11
ClO₂ charge, %	0.69	0.52
NaOH charge, %	0.35	0.26

ECF Bleaching Results



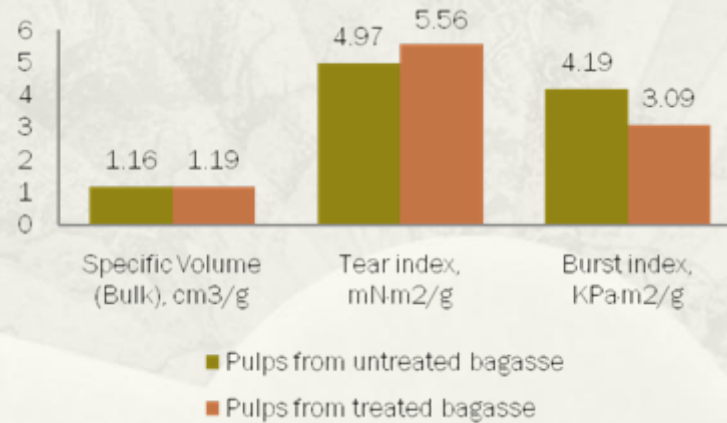
- * At the same Kappa factor, both pulps can be bleached to high brightness easily.
- * The treated pulp has higher bleaching yield and higher viscosity.
- * For bleaching treated pulp, the less ClO₂ charge and high bleaching yield means low bleaching cost and low effluent pollution.
- * The overall pulp yield for treated pulp is lower than untreated pulp due to hemicelluloses extraction.

Pulp Refining Properties



- * The pulp from treated bagasse has higher initial Canadian Standard Freeness (CSF) than the pulp from untreated bagasse.
- * After 1500 revolutions refining, the CSF of the pulp from untreated bagasse drops rapidly.
- * Low CSF will affect the runnability of high speed paper machine.
- * Hot water extraction can improve the runnability of paper machine when bagasse pulp as the main furnish.

Pulp Properties



Summary

- * The pulp from treated bagasse has lower tensile index and burst index, but higher bulk, tear index, and opacity as compared to the pulp from untreated bagasse.
- * Higher bulk and opacity will improve paper's printability.
- * The strength properties were still acceptable when the mass removal was about 10-15%.

Conclusion

- * Hot water extraction of bagasse prior to soda pulping can separate hemicelluloses from bagasse.
- * The mass removal from the hot-water extraction, the solid content and acid soluble lignin content of the extraction liquid increased with increasing extraction temperature and time.
- * The mass removal is very low when the extraction temperature is below 120 °C

- * The mass removal in the hot-water extraction for bagasse was about 13% when extracted at 160°C for 30 minutes.
- * The treated bagasse is easy to pulp, the pulp from treated bagasse has much lower kappa number and lower yield and higher viscosity.
- * The black liquor from treated bagasse has lower residual alkali, lower solid content, lower viscosity, lower silica content and higher heating value.
- * Hot water extraction prior to pulping has positive effects to alkali recovery.

- * With hot-water extraction, the bleaching chemical consumption was lower.
- * Hot water extraction can improve the runnability of paper machine when bagasse pulp as the main furnish.
- * The pulp from treated bagasse has lower tensile index and burst index, but higher bulk, tear index, and opacity as compared to the pulp from untreated bagasse.
- * The strength properties were still acceptable when the mass removal was about 10-15%.

Acknowledgements

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Thank You!