Efficient Depithing of Bagasse- A Step towards Sustained Availability of Raw Material for Paper Industry to Produce High Quality Paper

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ABSTRACT

Scarce availability of forest based raw material has forced the Indian Paper Industry to look out for alternate fibrous resources for making paper. Out of the total 715 number of paper mills in India nearly 165 number of mills are based on agro residue as primary source of raw material mainly bagasse and straws. Till recently the bagasse generated in a sugar mill was mainly utilized as fuel for generation of steam and power by sugar mill itself and only a small portion was available for other uses mainly papermaking. With the advent of new generation boiler and bagasse drying technologies, the utilization of bagasse as a source of energy has been reduced in sugar mill thereby making more quantity of bagasse available for cogeneration and/or papermaking.

One of the major impediment in utilization of bagasse in papermaking is the presence of higher percentage of pith (of 35-40%) along with fibre. Pith being non fibrous in nature and rich in juice, contributes to various problems during papermaking like requirement of high cooking chemicals, increased foam, inferior quality of pulp and poor black liquor properties. In order to make quality paper from bagasse efficient removal of pith is a prerequisite. Conventional depithing methods including dry depithing followed by wet cleaning result in removal of only 50% of the pith associated with bagasse thereby resulting around 15% pith in depithed bagasse.

With the efficient depithing process developed byCentral Pulp & Paper Research Institute (CPPRI) achieving a depithing efficiency more than 75% resulting in a depithed bagasse having 5-7%residual pith content, it has been possible to produce high quality pulp suitable for high grade paper with excellent optical and strength properties alongwith improved properties of black liquor.

The present paper highlights the results of the pilot plant trials carried out at CPPRI on depithing of bagasse and producing high quality pulp from this efficiently depithed bagasse thereby providing a sustainable source of alternate raw material for quality papermaking while meeting the energy requirement of the sugar mill.

Introduction

Paper industry is always on the look out for alternative materials that can be used as a source of fiber. Bagasse, which is a waste material left after the crushing operations in the sugar mills producing sugar from sugar cane has great potential as a fibrous raw material for papermaking and in countries where wood is scarce, this can be a good substitute of fibrous raw material as its pulp properties are comparable with hardwood. In India where nearly 5.0 million hectare farmland was under Sugar Cane plantation in the year 2007-08 and total sugar cane production was 345.6 million tons, this can be a rich source of raw material for paper industry. Although only 40% of the sugar cane produced in India reaches sugar mill even then a huge quantity of sugar cane around 40 million tons is generated as bagasse by Indian sugar industry.

Table -1 shows fiber dimensions of various raw material as compared to bagasse.

Though bagasse is a potential raw material for the paper industry, it has one of the serious drawback of pith associated with the fibrous portion which is undesirable from the point of view of paper making (1).The presence of pith in bagasse has adverse effect in respect of lower pulp yield, high chemical consumption, strength and optical properties, besides exhibiting runnability problems on the paper machine. Thus, there has always been interest in the efficient removal of pith from the fibrous portion of bagasse so that the same can be used for pulp and paper making efficiently.

Research work has been going on for producing efficiently depithed bagasse since the early 1900s mainly on methods which have used the dry/moist depithing or a combination of the moist and the wet depithing. In both processes, bagasse is mechanically abraded to break the clusters of pith

Table- 1
Fibre Dimensions of Non- Wood Plant Fibers

Fibers	Average length (mm)	Average diameter (microns)
	Non-wood Fibers	
Manila hemp	6.0	24.0
Bagasse (depithed)	1.0-1.5	20
Bamboo	2.0-2.5	15
Jute	2.5	20
Kenaf (bast fiber)	2.6	20
Kenaf (Core fiber)	0.6	30
Rice Straw	0.5-1.0	8-10
Wheat Straw	1.5	15
	Wood fibers	
Temperate zone coniferous woods	2.7-4.6	32-43
Temperate zone hardwoods	0.7-1.6	20-40
Mixed tropical hardwoods	0.7-3.0	20-40
Eucalyptus sp.	0.7-1.3	20-30

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away from the fibrous portion of bagasse. Dry depithing has been accomplished by using a hammer mill followed by dry screening. In the wet depithing, a suspension of previously moist depithed bagasse is made in water, wherein pith is separated by utilizing the difference in the densities of the fiber and pith. Moist depithing involves direct depithing of bagasse after crushing at a moisture of around 50%. However, even by employing the best available methods, there is still some residual pith left in the bagasse (of the order of more than 15%). Moreover, in wet depithing operations there is associated problem of a negative environmental impact as the pith is obtained in a slurry form which poses disposal problems besides huge capital and operational expenses in the process. Thus there is a demand from the industry to develop an efficient, depithing process which does not have the problem from an environmental standpoint.

In the present paper a new and efficient depithing process to upgrade the quality of bagasse by efficiently removing the pith content is discussed. The process removes pith to the tune of 80% against nearly 60% in the prevalent most efficient depithing processes including the wet depithing process. Further the properties of the pulp produced from this efficiently depithed bagasse under optimized pulping and bleaching conditions are also discussed.

Material And Method

Material

The whole bagasse used for experiments was procured from nearby paper mill. Moist and wet depithed bagasse was also collected from the mill to compare the depithing efficiency and pulp quality.

Brief Description of the Depithing Process developed by CPPRI

Bagasse as received from the sugar mill after crushing operation is fed to the system through a conveyer belt. On top of the conveyor belt, an electromagnetic system is provided to remove any metallic impurities that normally come with bagasse, specially when it is shipped in the bale form. The function is important as no metallic impurity should be allowed to enter the system. The screw conveyor is used to lead the whole bagasse in to the treatment chamber. Controlled mechanical action is given to bagasse to physically separate the pith from fibres. Subsequently, the treated raw material is made to fall in to a specially designed equipment which separates the pith from the fibrous portion of the bagasse. In this equipment, treated bagasse is made to pass over a series of sieves with the help of an endless rotating brush, which also cleans the sieves as it removes the treated material above them, thereby aiding effective separation of the pith and the fiber. The separated pith and fibrous material falls though the sieves by gravity and is collected separately with the help of hoppers at the bottom of the sieves.

Methods

Following standard methods were applied for different analysis.

Pith and fiber analysis	TAPPI UM-3
Proximate chemical analysis	TAPPI Standard methods
Kappa number,	TAPPI T: 236 OS 76

Result And Discussion:

Comparison of depithing efficiency of process developed by CPPRI with conventional process

Table 2 gives a comparative statement of the analysis of samples of bagasse obtained by conventional depithing process vis-a-vis proposed methodology. The composite samples of the moist and combination of moist and wet depithed bagasse were collected from a paper mill which were analyzed for characteristics of interest with the least possible lag time. The determinations were carried out in triplicate and the values obtained are presented in the table

This table compares the characteristics of bagasse samples obtained after depithing by best available conventional methods with the depithed bagasse using the modified technique. The lowest values of useful fiber to pith ratio obtained by the proposed technique are substantially higher at around 18:1 as compared with the best value of 8:1 obtained for depithed bagasse by the conventional methods, by virtue reduction in paranchymetous material (pith).

Comparison of proximate chemical analysis of various depithed bagasse samples

The results of Proximate Chemical Analysis of various depithed bagasse Samples are given in table 3.

The above results show that there is a substantial increase in hollocellulose and alpha cellulose content in bagasse treated with CPPRI depithing oprocess as compared to conventional depithing process. Ash content has also been reduced.

Characterization and Comparison of Pulp Quality of Depithed Bagasse From Conventional Means and by CPPRI Merhod

In order to compare the pulping characteristics of depithed bagasse obtained from conventional methods and by the proposed new method, lab scale pulping trials were performed under optimum conditions employed in pulping operations in order to ascertain the advantage of the efficient depithing by the proposed new methodology. The bagasse sample obtained by

Table- 2
Comparision of Depithing Efficierncies of Convention and New Proposed Depithing Process

S. No	Particulars	Moist depithed bagasse			Combination of Moist and Wet depithing			Depithing by the new proposed method		
	Exp. No.	I	II	III	I	II	III	I	II	III
1	Useful fiber, %	68	70	69	84.9	84.2	86.4	91.3	91.7	92.0
2	Residual Pith, %	25	24	23	12.0	13	11	5.3	4.8	5.2
3	Water Solubles in useful fiber, %	7	6	8	3.1	2.8	2.6	3.4	3.5	2.8
4	Useful Fiber to pith ratio	2.7:1	2.9:1	3.0:1	7.1:1	6.5:1	7.9:1	17.2:1	19:1	17.7:1

Table- 3
Comparison of Proximate Chemical Analysis of Various Depithed Bagasse Samples

Parameters	*Dry/Moist Depithed bagasse*	*Wet Depithed bagasse*	*bagasse depithed by CPPRI process*
Ash Content, %w/w	2.35	2.10	1.52
Cold Water Solubility, %w/w	4.03	2.56	2.98
Hot Water Solubility, %w/w	7.78	5.05	6.2
N/10 NaOH Solubility,%w/w	29.89	27.78	25.98
Pentosan, %w/w	26.1	26.3	26.10
Holocellulose, %w/w	75.7	78.4	79.45
Alpha Cellulose, %w/w	40.8	42.6	43.7
Beta Cellulose, %w/w	24.45	24.5	24.8
Gamma Cellulose, %w/w	10.42	11.2	11.4
Acid Insoluble Lignin, %w/w	18.00	17.93	21.6
Acid Soluble Lignin, %w/w	0.92	1.10	1.37

Table-4
Characterization & comparison of pulp quality of depithed bagasse from conventional means & new proposed process

Parameters	Dry/ Moist depithed bagasse (Pith 21%)	Combination of moist and Wet Depithed bagasse (Pith 17%)	Depithed bagasse from the prposed method (Pith 7%)
Screen yield, %w/w	51.5	50.7	52.6
Kappa Number	17.3	13.0	9.5
Cellulose, % w/w	70	75.2	78.5
Holocellulose, %w/w	95	96.2	97.6
Viscosity, cp	10.4	11.3	18.5

Table 6
Properties of Bleached pulp of Conventially depithed and efficiently depithed bagasse

	Unit	Bleached Pulp obtained by conventionally depithed bagasse (pith 12%)	Bleached Pulp obtained depithed by the new method (pith 5%)
Determination 2			
Pulp Yield	%	41.5	44.2
Alpha Cellulose	%	69.2	84.5
Viscosity	cps	12.5	20.4
Determination 3			
Pulp Yield	%	41.3	43.8
Alpha Cellulose	%	72.4	83.7
Viscosity	cps	10.6	18.3

Table -7
Improvement in Strength Properties of Bleached pulp

Sample	**Brust Index** kPa.m^2/g	**Tensile Index** Nm/g	**Tear Index** mN.m^2/g	**Brightness** %ISO
Pith 12% CEHH	3.2	63	3.5	82
Pith 5% CDED	4.7	73	5.8	85.2
Improvement %	46.9	16	65.7	3.5

Table 5
Enzyme pretreatment of pulp

Parameter	**Value**
Enzyme Dose, IU/g	7.0
Temperature, ^{0}C	50
Time, minutes	120
pH	8.5
Consistency, %	8.0

conventional dry/moist depithing, combination of moist and wet depithing and that obtained by the present method used for experiment had a residual pith content of 21%, 17% and nearly 7% respectively Pulping was carried out using kraft process. Following common conditions were applied to all samples.

Pulping conditions

Sulfidity : 17%
Bath Ratio : 1:3.5
Temperature : 160^{o}C
Time : 60 minutes
Alkali charge : 17%

Results are given in table 4.

From the above results it can be clearly seen that the pulp obtained from the modified depithing method, showed higher pulp viscosity values with a higher alpha cellulose content as well as higher screened pulp yields. The pulp thus obtained by the improved depithing operations could find better applications for value added products.

Upgradation of Bagasse Through Environment Friendly Bleaching Techniques

Various bleaching sequences were tried to see the effect of various bleaching chemicals on bleach pulp properties. Enzyme pretreatment of unbleached pulp was carried out under following conditions.

Results obtained from bleaching of Conventially depithed and efficiently depithed bagasse are shown in table 6. The results have clearly shown that efficiently depithed bagasse puklp have higher values of alpha cellulose and viscosity. Further strength propwerties of bleached pulp were also determined and are shown in table 7.It is evident from table that bagasse having less pith content and bleached under modified bleaching conditions have shown better strength properties as compared to conventially depithed high pith bagasse.

Table 8
Characterisation of Bagasse Black Liquor (4)

Parameter	Pith Content 20%	Pith Content 8%
pH	12	12.1
Total solid % w/w	9	9.2
Inorganics as NaOH % w/w	34	33.8
Organics% w/w	66	66.2
Chloride as NaCl% w/w	1.4	1.3
Silca as SiO_2% w/w	1.3	1.25
Residual Active Alkali as Na_2O	7.0	6.8
Swelling Value Ratio, ml/g	14	18
Calorific value	3300	3310

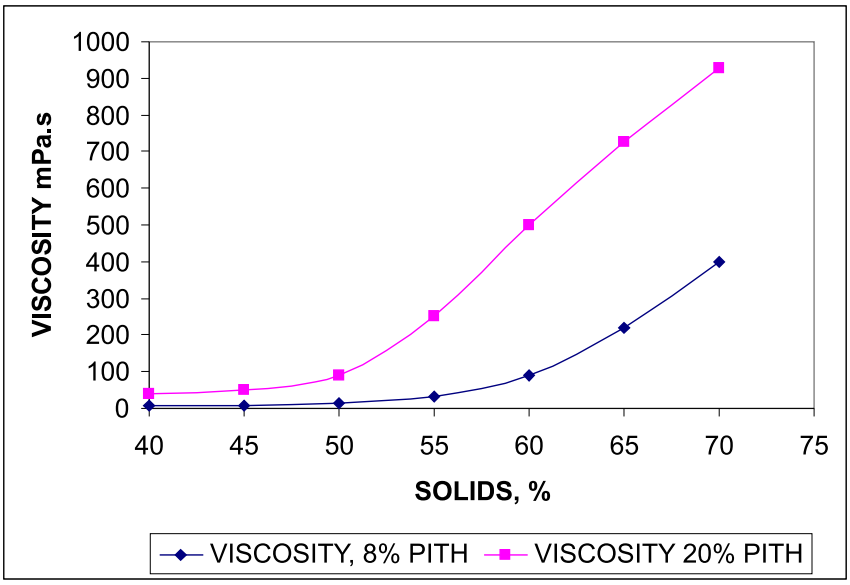

Fig. 1 Viscosity profile of Bagasse Black liquors

Effect Of Pith On Black Liquor Characteristic

Efficiency of Chemical recovery system plays an important role in the economy of a pulp mill. Nature of black liquor is important for smooth functioning of recovery system (2). Physico-chemical, combustion & rheological properties of black liquor generated from bagasse having varying pith content are shown in table 8. (3).

Bagasse black liquor exhibits higher viscosity as compared to other non-wood raw materials. Presence of higher amount of pith is also responsible for high viscosity of bagasse black liquor.

Viscosity profile of black liquor generated from pulping of conventionally moist depithed bagasse (Pith 20%) and bagasse depithed by CPPRI process(Pith 8%) is shown in the fig-1.

The above results indicate that black liquor generated from efficiently depithed bagasse shows improved swelling behavior. Other properties however remain almost same. Improvement in swelling volume ratio is a pointer towards better burning behaviour of black liquor.

The viscosity profile measured at 95^0 C of the two samples clearly depicts a marked improvement in the viscosity of the bagasse black liquor obtained from bagasse having low pith content. Lower viscosity of black liquor enables to dry it to higher dry solids thereby increasing energy efficiency in the chemical recovery system

Conclusions

1. Whole Bagasse or partially depithed bagasse can be used for making low-grade corrugating medium, insulating boards and similar varieties. Depithing is an important and necessary step to upgrade bagasse for the production of high-grade pulps.
2. Depithed bagasse requires significantly lower chemicals in cooking and bleaching. The pulp produced show higher yield with improved brightness and strength properties. However, chemical pulps from bagasse normally have low opacity and scattering co-efficient.

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3. The studies conducted on bleaching of efficiently depithed bagasse have shown that mills can achieve brightness level upto 86%ISO which is not possible with conventional bleaching sequences.
4. Lower pith content in bagasse is also helpful in high solid evaporation of black liquor
5. Thes studies have shown that bagasse can be a potential alternate of wood in making paper. This will not only solve raw material problem but at the same time will conserve our forest.

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