Efficient Depithing of Bagasse for Reduction of Water Requirement in Pulp Mill

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***Abstract*— Paper making process demands large amount of fresh water and produces enormous quantities of wastewater. The amount of water depends upon raw materials, scale of operation used and the process employed. More than 120 m3 of water used for every ton of pulp produced and so the pulp and paper sector is one of the largest users of industrial process water. Worldwide bagasse has established itself as a very useful non- woody fibrous raw material for pulp and paper industry. Though it is superior to other agricultural residues in its properties for pulp and paper manufacture, the innate deficiency of bagasse is the presence of pith cells. Since this non-fibrous material (pith) does not give any desired properties in pulp and paper production, it remarks the importance of its maximum removal. A well-depithed bagasse not only provides better pulp and paper quality, it also improves process efficiency and properties of black liquor compared to without depith bagasse. Proper depithing of bagasse increase pulp yield, brightness, and strength properties of the pulps and also requires fewer chemicals in cooking and bleaching.**

Research work has been going on for producing efficiently depithed bagasse since the early 1900. Depithing may be conducted using moist/ wet or dry conditions. In both processes, bagasse is mechanically abraded to break the clusters of pith away from the fibrous portion of bagasse. However, even by the best available methods, there is still some residual pith left in the bagasse (nearly about 18-20%).

If we compare the two most commonly used depithing processes in pulp mill wet depithing shows higher depithing efficiency. Initial pith level in bagasse is around 36-38% which is reduced to 25% in dry depithing and to 18% by using wet depithing.

In the wet depithing, bagasse to which water has been added is treated in a hydrapulper or in a vertical wet aeration mill, wherein the pith passes through a screen and separated from fibre. But, in the wet depithing operations there are a couple of difficulties appear; these are-

- **A large amount of water is consumed during the process (5000 tons of water in 500 tpd mill),**
- **This high amount of water is discharged in to recipient stream as an effluent.**
- **Problem of disposing of wet pith and waste and**
- **Extra water accompanying the bagasse fibre. Though most of the paper mills are using wet depithing process but due to above explained problems they always in demand to develop an efficient depithing process which may overcome these problems.**

Keeping the above scenario in mind, efforts were initiated in Central Pulp & Paper Research Institute (CPPRI), Saharanpur, India to develop a depithing process which can remove the pith efficiently without use of water. The institute finally has come up with a novel process of efficient dry depithing of bagasse. The study explains an efficient depithing process that upgrades the quality of the bagasse by efficiently removing the pith content without the use of any water.. Dry depithing was performed with air dried bagasse using the technology developed and patented by Central Pulp and Paper Research Institute (CPPRI) at plant scale. The results concluded that the depithed bagasse contains only 5% pith and the results were superior of those reached by most of the wet depithers using in the paper mills presently. Thus the technology will provide a possible way to mitigate fresh water consumption and waste water pollution in pulp and paper industry.The present paper highlights the efforts made by Central Pulp & Paper Research Institute (CPPRI) in developing the efficient novel bagasse depithing process which not only depith bagasse efficiently but at the same time saves water consumption in the process of paper making to the tune of around 5000 m3 in a 500 ton per day bagasse based mill. It also reduces waste water generated in the pulp mill during wet depithing.

Keywords- Pith, Depithing, Effluent, water conservation, pith to fibre ratio

I. INTRODUCTION

A. Pulp & Paper Industry

Nowadays, by rapid economic development and population growth the demand for paper also increased worldwide .World paper and paperboard demand is expected to grow by about 2.1% till year 2020 and the growth will be fastest in Eastern Europe, Asia (except Japan) and Latin America [1]. Throughout the world, paper industry has made a revolution in technology development and today; the paper industry is glamorous and high tech industry. The industry has made remarkable achievements in improving the quality standards, cost effective production and effective energy and environmental management at the international level but still it is at the crossroads faced with number of challenges and one of the key challenges for pulp and paper mills is to control on its fresh water consumption and waste water quality.

B. Water Issues to Paper Industry

Water issues have been identified as the most serious sustainability challenges facing the planet, partly due to the impacts of climate change [2, 3]. Less than 1% of the world's water is easily accessible fresh water and increasing population, urbanization, per capita demand, and pollution damage to supplies will put even greater pressure on these limited resources [4]. Pulp and paper industry is one of the most water and energy consuming industry in the world. Paper making process demands large amount of fresh water and produces enormous quantities of waste water. It has been

estimated that 500 million tons of paper and paper board per year will be produced by 2020. Pulp and paper operations are highly dependent on the use and responsible management of water resources. Water is used in all major process stages, including raw materials preparation (e.g., raw material washing), pulp washing and screening, and paper machines. Water is also used, for process cooling, materials transport, equipment cleaning, general facilities operations, and to generate steam for use in processes and on-site power generation [5]. The consumption of water as well as production of waste water depends upon raw materials, scale of operation used and the process employed. In a virgin pulp mill approximately 100-120 m^3 water is used for every ton of pulp produced and so the pulp and paper sector is one of the largest users of industrial process water. Researchers in the past [6-9] have shown that among the various practices which can lead to water reduction, reduced effluent generation, energy savings and regulatory compliance at pulp and paper mills, one is to adopt the dry processes instead of wet processes.

C. Bagasse: An Alternative Raw Material for Paper Industry

Due to scarce availability of forest based raw material (wood), the paper industry is looking for alternate renewable fibre raw material. Bagasse, a sugar mill by-product is a potential raw material for paper industry due to its fibre nature [10, 11].

Toward the beginning of the 21st century, it was almost well established by paper experts throughout the world that bagasse, after proper depithing, was an ideal raw material for the manufacture of different kinds of paper, newsprint etc. [12].

D. Pith: A Major Problem with Bagasse

Till recently bagasse is superior to other agricultural residues in its properties for pulp and paper manufacture, the innate deficiency of bagasse is the presence of pith cells [13, 14]. In a sugarcane plant the 'bast' is the external part and the 'pith' is the internal part of the plant. A good paper making fibre from bagasse is mainly derived from bast portion of the sugar cane plant. Bagasse pulp quality is believed to be detrimentally affected by short pith material. Therefore for efficient use of bagasse in paper making removal of pith is a pre requisite. The process of removal of pith from bagasse is known as depithing.

E. Depithing Methods

Depithing is an important and necessary step to upgrade quality of bagasse for the production of high-grade cellulose pulps [15, 16]. Conventially, dry depithing, moist depithing and wet depithing processes are used by paper industry for pith removal. However, in all processes, bagasse is mechanically abraded to break the clusters of pith away from the remaining fibrous portion of bagasse. In wet depithing huge amount of water and energy is consumed. However, even by the best available method (wet depithing), there is still substantial percentage of residual pith left in the bagasse (nearly about 18-20%).

F. Wet Depithing Process

Initial pith level in bagasse is around 36-38% which is reduced to 25% in dry depithing and to 18-20% by using wet depithing process [17]. In the wet depithing, a suspension of 4-5% previously moist depithed bagasse is made in water, wherein after the pith is separated by utilizing the difference in the densities of the fibre and pith or this moist bagasse is treated in a hydrapulper or in a vertical wet aeration mill, wherein the pith passes through a screen and separated from fibre.

In wet depithing operations following problems are associated.

- A large amount of fresh water is consumed during the process (5000 tons of water in 500 tpd mill)
- The high amount of water is discharged in to recipient stream as an effluent
- Problem of handling of wet pith and
- Extra water accompanying the bagasse fibre.

Nearly 2000 M^3 effluent is generated in a 500 tpd paper mill in bagasse wet depithing. This water is laden with high effluent characteristics. Table 1 shows the pollution load in this effluent generated.

Table 1: Pollution load in Wet depithing Effluent

S. No.	Parameter	Value
1	COD, mg/litre	2200-2500
2	BOD, mg/litre	1200-1400
3.	Suspended solids, ppm	1000-1200
4.	Colour, PCU	1200-1500

Though wet depithing process has been adopted by most of the large paper mills based on bagasse but due to above explained problems, mainly the requirement of high amount of fresh water and effluent generated, the efforts on the improvement of the design and processes of depithing have continued in the line of obtaining a process which yields efficiently depithed bagasse with a better quality of fibre.

G. CPPRI Process

Looking in to this CPPRI has initiated work to develop a depithing process which can remove the pith efficiently without use of water. The institute has come up with a novel process of efficient depithing of bagasse. The results concluded that the depithed bagasse contains less than 7% pith and the quality of paper produced from this bagasse is superior. Thus the technology will provide a possible way to mitigate fresh water consumption and waste water pollution in processing of bagasse in paper making.

The present paper highlights the efforts made by Central Pulp & Paper Research Institute (CPPRI) in developing the efficient novel bagasse depithing process which not only depith bagasse efficiently but at the same time saves water to the tune of around 5000 m3 in a 500 ton per

day bagasse based mill. It also reduces waste water generated in the pulp mill during wet depithing. The pulp produced from bagasse depithed by this process is far superior to wet depithed bagasse.

II. MATERIALS AND METHODS

Bagasse samples were collected from a mill located in western UP, India. All testing/ analysis were carried out according to TAPPI/ CPPRI standard methods.

A. Efficient Depithing Method-A Novel Process Developed by CPPRI

A novel process for efficient depithing of bagasse was developed. The conveyor belt leads the whole bagasse in to a screw conveyer. On top of the conveyor belt, an electromagnetic system is provided to remove any metallic impurities that normally come with the 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 process involves a mechanical action to separate bonded pith from bagasse. The mechanical action is introduced through a disc having special pattern which gives a brushing action on bagasse rather than cut. Mixture of pith and bagasse is send to a screen through a spherically designed cyclone. Pith and depithed bagasse is separated by the screen. The process has been up scaled upto a scale of 5 tons per day.

III. RESULT AND DISCUSSION

Proximate Analysis of Bagasse

Proximate chemical analysis of raw material gives a lead in accessing its suitability in pulp and paper making. Dust for chemical analysis of Bagasse was prepared using Wiley Mill (make: Thomas), after passing through 40 mesh and was collected in a polythene bag. The results of proximate chemical analysis of all the samples of bagasse i.e. whole bagasse, the wet depithed bagasse collected from the mill and the depihted bagasse obtained by CPPRI depithing procedure as employed in the present study are shown in Table 2.

Table-2: Comparison of Proximate Chemical Analysis of various depithed bagasse Samples

S. No.	Parameters	Unit	Whole Bagasse	Dry/Moist Depithed bagasse	Wet Depithed bagasse	Bagasse Depithed by CPPRI method
1.	Residual Pith Content	%	36.78	25.60	7.94	4.89
2.	Ash Content	%	3.89	2.35	2.10	1.52
3.	Cold Water Solubility	%	4.53	4.03	2.56	2.98
4.	Hot Water Solubility	%	7.97	7.78	5.05	6.2
5.	1/10 N NaOH Solubility	%	29.95	29.89	27.78	25.98
6.	Pentosan	%	27.68	26.1	26.3	26.10
7.	Holocellulose	%	73.61	75.7	78.4	79.45
8.	Alpha Cellulose	%	38.21	40.8	42.6	43.7
9.	Beta Cellulose	%	24.97	24.45	24.5	24.8
10.	Gamma Cellulose	%	11.53	10.42	11.2	11.4
11.	Acid Insoluble Lignin	%	21.80	18.00	17.93	19.2
12.	Acid Soluble Lignin	%	1.41	0.92	1.10	1.30

The above results go to indicate that the quality of the bagasse depithed using the CPPRI depithing process is better. Ash content is lowered by 40% which is a sign of better pulpability, pith content is reduced to around 5% which shows that this bagasse can be used for high quality paper production.

While processing the bagasse in pulping fibre to pith ratio is an important parameter. Higher the pith, lower is the yield and demand of chemicals is high. Fibre to pith ratio of bagasse depithed by various depithing processes is shown in figure 1.

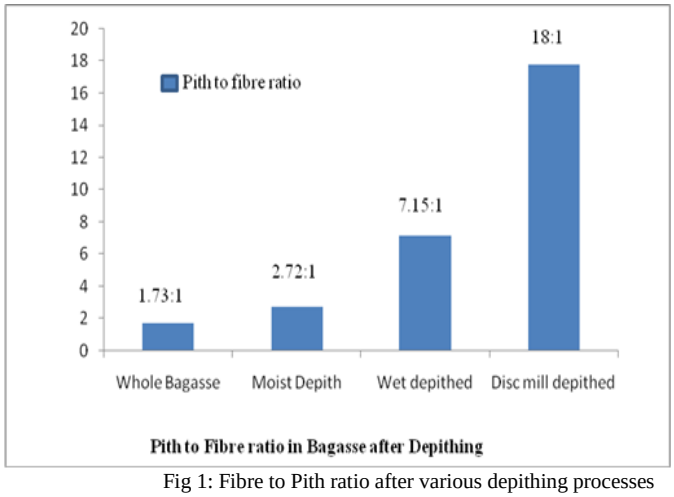

Fig 1: Fibre to Pith ratio after various depithing processes

The above figure shows that bagasse depithed by employing proposed process has higher fibre to pith ratio which leads to high quqlity paper production.

Water Conservation & Effluent Management by CPPRI Novel Depithing Method

The process developed by CPPRI required no water for depithing process whereas depithing efficiency is far better as compared to water intensive conventional wet depithing process. About 4M3 water per ton of bagasse processed (5000 M3 in a 500 tpd mill per day) is saved by employing this new depithing process.Since no water is used in the process this leads to zero water pollution generated in the depithing process. The nearly 2000 M3 effluent generated with high pollution load by the wet depithing is reduced by the new process developed by CPPRI.

IV. CONCLUSION

The novel depithing developed by Central Pulp & Paper Research Institute, Saharanpur has a depithing efficiency more than 85% which residual pith content around 7% as against 16% in wet depithing process being used by mill. It also saves nearly 5000M3 water per day in a 500 tpd mill and around 2000 M3 waste water generated in the mill.

REFERENCES

[1] V. Honnold, "Developments in the Sourcing of Raw Materials for the Production of Paper. United States International Trade Commission", J. of Int. Commerce and Economics, 2009.

[2] United Nations Global Compact, "Fresh Water Resources and Related Services", IV UN Conference on the Least Developed Countries, Private Sector Track, 2011. http://www.unglobalcompact.org/docs/issues _doc/Environment/LDC_Water_Final.pdf

[3] B.C. Bates, Z.W. Kundzewicz, S. Wu, and J.P. Palutikof, "Climate Change and Water: Technical Paper of the Intergovernmental Panel on Climate Change", IPCC Secretariat, Geneva 2008.

[4] WBCSD, "Facts and Trends-Water, Version 2", World Business Council for Sustainable Development, 2009.

[5] UPM-Kymmene, "From Forest to Paper, the story of our water footprint" August 2011. http://www.waterfootprint.org/Reports/UPM-2011.pdf

[6] K. Kramer, et al., "Energy Efficiency Improvement and Cost Saving Opportunities for the Pulp and Paper Industry", Report No. LBNL-2268E, Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA, October 2009. http://www.energystar.gov/ia/business/industry/downloads/Pulp_and_Paper_Energy_Guide.pdf

[7] European Commission, "Integrated Pollution Prevention and Control (IPPC)", Reference Document on Best Available Techniques in the Pulp and Paper Industry, December 2001

[8] WBG, UN Environment Programme and the UN Industrial Development Organization, "Pollution Prevention and Abatement Handbook 1999- Toward Cleaner Production", Industry Sector Guidelines, Pulp and Paper Mills, World Bank Group, Washington, DC, 1999, pp. 395-400.

[9] U.S. EPA, Office of Air and Radiation, "Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Pulp and Paper Manufacturing Industry", Prepared by the Sector Policies and Programs Division, Office of Air Quality Planning and Standards, U.S. EPA, Research Triangle Park, N.C., October 2010.

[10] Malaysian Newsprint Industries, "Paper Recycling Report", http://www.newsprint.com.my, 2007.

[11] Waste Cap- 2008, "Waste Cap of Massachusetts", 68 Hopkinton Road/ Westboro/MA 01581, http://www.WasteCap.Org/WasteCap/Commodities/Paper/Paper.htm., March 2008.

[12] T. Gupta & V. Ahuja, "Bagasse based Paper & newsprint in India: Economics and policy Issues", vol 14 (3) July- September 1989.

[13] H.W. Giertz, and R.S. Varma, "Studies on the pulping of bagasse and the influence of pith on paper properties", Non-wood plant fibre pulping progress report, Tappi Press: Atlanta, 1979, pp. 53-69.

[14] M. Zanuttini, "Factors determining the quality of bagasse mechanical pulps", Cellulose Chem. Technol, vol. **31**, 1997, pp. 381-390.

[15] G. Covey, T.J. Rainey, and D. Shore, "The potential for bagasse pulping in Australia", Appita Conference Proceedings, Auckland, New Zealand, 2005.

[16] J.E. Atchison, "Bagasse becoming a major raw material for manufacture of pulp and paper- Background, present status, and future possibilities", Proc. Int. Soc. Sugar Cane Technol., 1962, pp. 1185-1211.

[17] Lois, J.A. Correa, "Depithers for Efficient Preparation of Sugarcane Bagasse Fibers in Pulp and Paper Industry", Ingenieria Investigation & Technologia, volume12 (4), October- December 2012, pp 417-424.