REPORT

ON

UPGRADATION OF QUALITY OF BAGASSE THROUGH ADVANCE DEPITHING PROCESS

SUBMITTED

TO

CESS GRANT AUTHORITY

BY

CENTRAL PULP AND PAPER RESEARCH INSTITUTE
SAHARANPUR (U.P.)

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PROJECT TEAM

PROJECT COORDINATOR

Dr. R. M. Mathur

INVESTIGATORS

1.	Principal Investigator	:	Dr. R. K. Jain
2.	Co – Investigator	:	Dr. k. Singh
3.	Co – Investigator	:	Dr. A. K. Dixit
4.	Project Associate	:	Shri Krishna Rawat
5.	Project Associate	:	Shri Krishna Kant

OTHER PROJECT TEAM DURING THE TRIALS

1. Shri R. C. Sharma
2. Shri O.P. Kotnala
3. Shri
4. Shri Roop Singh
5. Shri Balbir
6. Sukh Lal, Helper

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DRAFT

PROJECT REPORT ON THE CESS FUNDED PROJECT ENTITLED "UPGRADATION OF QUALITY OF BAGASSE THROUGH ADVANCE DEPITHING PROCESS"

PREAMBLE

Paper industry is always on the look out for alternative materials that can be used as a source of fiber. Many countries have been using bagasse, which is a waste material left after the crushing operations in the sugar mills producing sugar from sugar cane. Though bagasse is a potential raw material for the paper industry, has one of the serious drawback of pith associated with the fibrous portion. Along with the fibrous portions of the bagasse, there is pith, which is undesirable from the point of view of paper making. The presence of pith in the bagasse has adverse effect in respect of lower pulp yield, high chemical consumption and quality related problems besides exhibiting runnability problems on the paper machine. Thus, there has always been interest in the efficient removal of this pith from the fibrous portion of bagasse so that the same can be used for pulp and paper making in an efficient and better manner. Research work has been going on for producing efficiently depithed bagasse since the early 1900. These depithing processes have been 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 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 after the 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% The previous 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 fiber which is more useful for paper making. However, even by the best available methods, there is still some residual pith left in the bagasse (of the order of more than 15%). Moreover, in the wet depithing operations there is the 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.

Keeping the above scenario in mind, efforts were initiated in the form of the present project to develop a novel process of efficient depithing of bagasse.

OBJECTIVE OF THE PROJECT

The project aims to develop on efficient depithing process that upgrades the quality of the bagasse by efficiently removing the pith content without the use of any wet operations. The objectives of the project include upgrading of the existing pilot machine to demonstrate efficient depithing process on continuous basis to obtain a depithing efficiency of more than 75-80%, wherein the residual pith content is less than 10%. The efficiently depithed bagasse thus obtained would be compared with ...when converted into depithed bagasse for the pulping to compare the quality of pulp and spent pulping ....from further process viewpoint while improving the throughout put of the machine.....compare ....he quality of the fibre/pulp. As per the original objectives of the project, based on the results of the study, a feasibility report would have been made for the design and operation of a 200 TPD full scale depiting plant. As explained in the subsequent pages, the results of the project were very important and therefore, have been protected through a patent. The technology has been transferred to a buyer, namely M/S Bajaj Eco Products Ltd., a subsidiary of the sugar major, M/S Bajaj Hindustan Ltd. As per the MoU with BEPL, the prototype pilot plant will be upscaled jointly by BEPL and CPPRI.

INTRODUCTION

Paper industry, throughout the world, particularly in developed countries, has made a revolution in technology development and today; the paper industry in these countries 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.

Paper industry in India, on the contrary, is at the crossroads faced with number of challenges. Availability of good quality raw materials is one of the major challenges. As a result, today, the industry continues to face stiff competition from imports, while trying to improve the profitability and productivity.

The Indian Pulp & Paper Industry is more than a century old industry. The first paper mill was established in the year 1832, based on imported raw materials. The number of mills has today grown to around 700.

Till early 70's industry was primarily depending on bamboo as a cellulosic raw material and subsequently it had switch over to hard woods like eucalyptus. In 1970's there was a severe shortage of paper in the country and Government of India decided to encourage setting up of small pulp & paper mills based on locally available agro residues such as rice straw, wheat straw and bagasse etc.

Paper industry in India produces nearly 5.9 million tons of paper and paper board and 0.91 million tons of newsprint. To date, the total installed capacity of the Indian paper industry is about 9.8 million tons. Out of this, nearly 1.2 million ton capacity is shut out of operations, leaving an operating installed capacity of about 8.5 million tons. At the present level of production, the capacity utilization works out to be in the range of 75-80%. The per capita consumption is about 6 kg ranking India behind Indonesia, China, and Thailand etc.

INDUSTRY STRUCTURE

The structure of paper industry in India is a mix of very small to large plants using diverse raw materials and technologies producing various grades of papers. The Indian paper industry is broadly categorized either based on size or on the fibrous raw materials used for pulp and papermaking.

Large Paper Mills

The mill having a capacity of 33,000 tpa (100tpd) is considered a large mill in India. These mills invariably are based on bamboo, wood and other forest based raw materials. These mills contribute to nearly 36% of the total national production.

Medium Paper Mills

These mills are primarily based on agro based raw materials like cereal straws, bagasse, sarkanda & animal grasses and indigenous/imported waste paper respectively. The annual installed capacities of these mills are between 16500-33000 tpa. (50-100tpd). These paper mills contribute to less than 30% of the total paper and paperboard production of the country. In recent years, agro based mills with higher capacity are being set up and several of the medium agro based mills are also gradually expanding their capacities from 15000 tp to more than 33,000 tpa while installing chemical recovery system in order to meet to CREP norms set by Central Pollution Control Board.

Small Paper Mills

Large number of small paper mills of capacity below 16500 tonnes/annum (below 50 tpd) are operating employing both indigenously available as well as imported waste paper and they contribute to nearly 34% of the paper production in the country.

THE PRODUCTION SCENARIO

Table 1, 2 and **Fig. 1** depict the distribution patter of production of paper with respect to the raw material, producing units as well as the total paper production.

TABLE- 1
Production of Paper and Paper Board in India

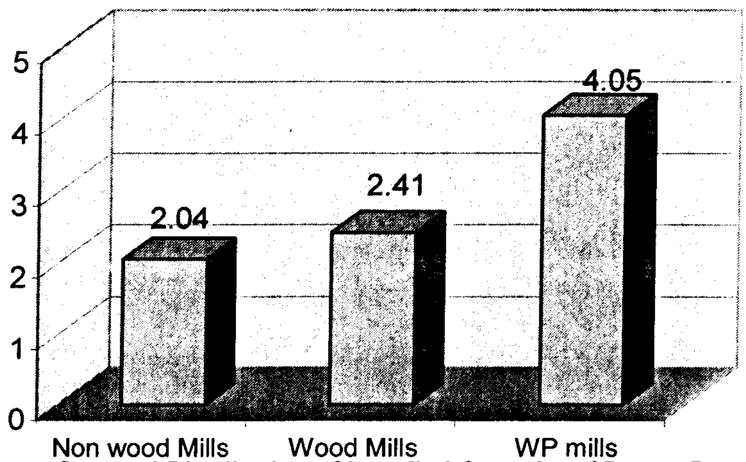
Type of Raw Material	**No. of Mills**	**Installed Capacity (Million Tons)**	**Production (Million Tons)**	**Production (% on total)**
Forest Based (Wood & Bamboo)	25	2.43		
Agro Based (Straw, Bagasse Etc.)	140	1.99		
Others (Waste Paper Etc.)	405	4.13		
TOTAL	**569**	**8.55**		**100**

Table 1.2 indicates the total availability of agro- fibers in India. However, not all of the available fiber is used for making paper pulp.

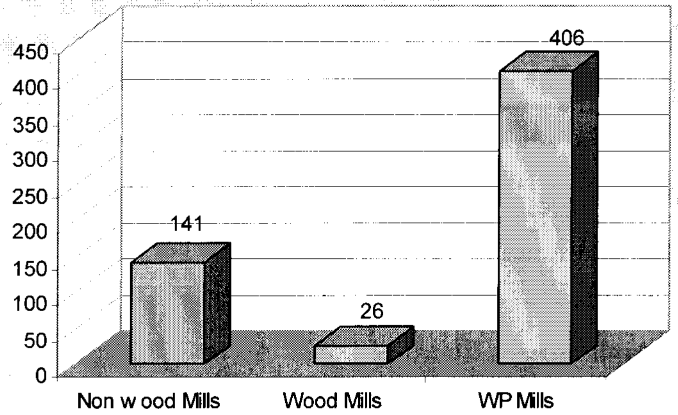
TABLE –2
Annual Potential of Agro Based Fibers in India 2001

Agro Residue	**Availability Mill. Tons**	**Tons needed for 1 Ton of pulp**
Wheat straw	**22**	**2.5-3.5**
Rice Straw	**15**	**2.5-3.5**
Bagasse	**10**	**5.0-6.0**
Jute, mesta, kenaf	**2**	
Total	49	-

The other salient features of the Indian pulp and paper industry are depicted in figures 2 – 6..

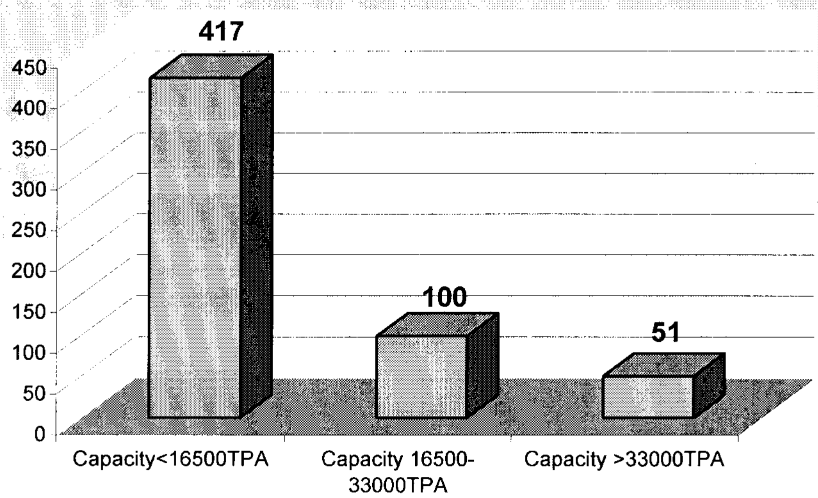


Sectoral Distribution of Installed Capacity of Paper, Paper Board and Newsprint grades
Fig.2



Sectoral Distribution of Mills

Fig.5



Capacity Distribution

Fig.6

Future Growth of the Paper Industry

The increase in the growth indicators such as literacy rate, industrialization, resurgent demand of quality packing and printing is sure to drive the demand scenario in the pulp and paper sector. However, the Industry must overcome many challenges on the road to become globally competitive. The major hurdle before the Indian paper industry is the quality fibre resource. With depleting forest resources, the wood based segment of the paper industry has considerably shrunk. In 1970s, nearly 84% of the mills were forest based in comparison to the recent figure of 36%. Around 30% of the mills are based on agro-based raw materials and the rest 34% of the mills are based on waste paper. The waste paper based segment of the industry is rapidly increasing with the basic import duty on paper and board being brought to a current level of about 12.50% in 2001-02 from a figure of 140% in 1990-91.

DEMAND FORECASTS

The total demand is expected to grow from 5.4 million ton per annum in year 2006 to further 8.3 million ton per annum by the year 2010. This corresponds to an annual growth of 6.2% during the period 2000-2010.

In India, the present growth rate is targeted as 7 – 8% per annum due to rapid economic growth, increasing purchase power, increased literacy rate, rapid development of retail market, fast development of computerization and emerging exports leading and increased use of packaging paper and board etc.

RESOURCES OF INDIAN PULP & PAPER INDUSTRY:

The fiber resources used by the Indian pulp and paper industry come from three sources. They are:

- Forests, including bamboos and mixed hardwoods from forest fallings and Eucalyptus wood from plantations (both organized plantations and farmer's fields/ agro forestry plots).
- Agricultural residues such as Bagasse, rice and wheat straw and cotton stalks.

- Recycled fiber, including both domestic and imported waste paper.

OVERVIEW OF THE AGRO-BASED FIBRES:

The main agricultural residues utilized by the paper industry include Bagasse, cereal straws (wheat and rice straw), kenaf, mesta, jute sticks, grasses and cotton stalks. The small agro based paper mills mostly use and cereal straws as raw materials.

Recent Situation on Global Scale:

Globally, non-wood fibers are a minor part of raw material supply to paper and paperboard manufacture. In many countries like PR China & India, however, they are still widely used and are of significant importance in terms of overall volume and as a percentage of total pulp supply. Table –3 gives an idea of current use of non-wood fibers in papermaking in the 18 countries that account for nearly 98 percent of world supply.

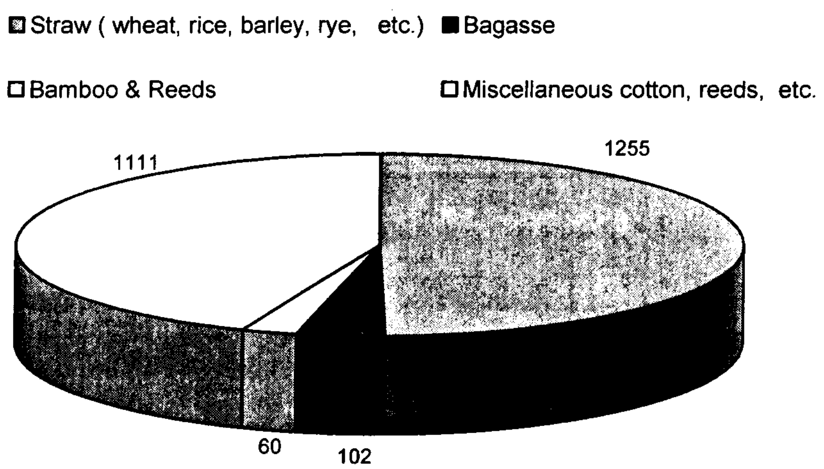
The region that has invested the most time and resources into the pulping of non-woods is Asia and the Pacific. In particular, China and India are leaders in the utilization of non-woods for papermaking in terms of volume. In North America, Latin America, Europe, the Russian Republics and Africa, the use of non-wood fiber sources has been relatively limited.

TABLE- 3
Leading Users of Non-Wood Fibers in Papermaking

Country	`2000 (Approx.)	Country	`2000 (Approx.)
China	84.3	Columbia	37.2
India	60.3	Thailand	100
Pakistan	100	Brazil	3.3
Mexico	29.3	Venezuela	75.4
Peru	95.2	United States	0.3
Indonesia	10.1	Greece	84.2
Spain	7.7	Italy	13.3
Argentina	12.8	Cuba	100
Egypt	100	Turkey	16.5

TABLE- 4
Leading Non-Wood Fibers
(Million Tonnes)

Raw Materials	Non-wood paper making pulp capacities
Straw (wheat, rice, barley, rye, etc.)	**1255**
Bagasse	**102**
Bamboo & Reeds	**60**
Miscellaneous cotton, reeds, sisal, jute, hemp, abaca, Kenaf, flax, stalks, etc.	**1111**
TOTAL	2528



Leading Non-Wood Fibres
(Million Tonnes)

Fig.7

Leading Sources of Non-Wood Fibers: Global

At the present time, the most commonly utilized non-wood fiber is straw (rice, wheat, barley, oat and rye, etc., which accounts for 49.7% of total productions. This is followed by bagasse (4%) and bamboo (1%). Other non-wood fibers such as cotton, hemp, jute and kenaf are also becoming more important in the manufacture of pulp & paper.

Characteristics of Non- wood Fibers

Some non- wood fibers used as raw materials for papermaking have high annual yields per hectare. The average annual yield per hectare of kenaf, a non- wood fiber is about twice that of fast growing softwoods. Table- 5 shows the annual fiber yield of different paper making raw materials.

TABLE – 5
Average Yield of Different Paper Making Raw Materials

Plant	Fiber yield **T/Yr/hectare**	Pulp Yield **T/Yr/hectare**	Pulp Yield, %
Scandinavian softwood	**1.5**	**0.7**	**46.66**
Fast growing softwood	**8.6**	**4.0**	**46.5**
Fast growing hardwood	**15**	**7.4**	**49.3**
Wheat straw	**4**	**1.9**	**47.5**
Rice straw	**3**	**1.26**	**42.0**
Bagasse	**9**	**4.55**	**50.5**
Bamboo	**4**	**2.0**	**50**
Kenaf	**15**	**7.05**	**47.0**
Hemp	**15**	**6.7**	**44.66**
Elephant grass	**12**	**5.7**	**47.5**
Canary grass	**8**	**4**	**50**

Non- woods have lower lignin content than woods and generally it is easier to delignify non- woods as they have lower Energies of Activation. Pulping of non- wood fibers would help in reducing the need to procure pulpwoods from natural forests and from large-scale plantations. Under certain climatic conditions, non- wood fiber production may be a reasonable alternative to tree plantations. Table-6 shows the proximate chemical composition of commonly used paper making fibrous raw materials.

TABLE – 6
Proximate Chemical Composition of Paper Making Raw Materials

Particulars	Depithed Bagasse	Rice Straw	Wheat Straw	Bamboo	Hard woods
Ash	**2.6**	**16.0**	**7.0**	**3.4**	**0.08**
Silica	**2.0**	**12.5**	**5.0**	**3.0**	**0.05**
Cold water solubility	**2.8**	-	**6.5**	**1.9**	-
Hot water solubility	**5.9**	**15.5**	**10.5**	**11.1**	**5.24**
1% NaOH solubility	**32**	**49.4**	**40.0**	**28.0**	**14.55**
Ethanol-Benzene solubility	**1.7**	**7.4**	**5.3**	**8.0**	**2.6**
Lignin	**23.9**	**12.6**	**17.0**	**32.0**	**29.9**
Holocellulose	**74.1**	**70.2**	**70.7**	**56.6**	**69.4**
Pentosans	**28.9**	**24.0**	**25.0**	**20.3**	**19.3**

* All values expressed on oven dry % w/w basis.

A high ash content in terms of silica is another problem with most non- wood fibers in general. Table 7 shows the silica content of various nonwoods and wood based fibrous raw materials.

TABLE – 7
Silica Content of Fibrous Raw Materials

Raw material	Ash, %	Silica, %
Bagasse	2-3	1.5-2.0
Rice Straw	**15-20**	**12-18**
Wheat Straw	**5-10**	**4-7**
Bamboo	**3-5**	**1.5-2.5**
Reed	**3-4**	1.5-2.5
Kenaf	**3-4**	1.5-2.5
Softwoods	**<1.0**	**Traces**
Hardwoods	**<1.0**	**Traces**

However, the availability per round year supply of fiber is a primary concern for paper mills. Given that most non- woods are annual plants, a large storage capacity must be developed to ensure a constant supply. This is further complicated by the fact that most non- wood fiber sources are high in volume and low in density when compared with woods. Further, high inputs are required for growth and harvesting of these annual crops.

Fiber Dimensions of Non- wood Plant Fibers:

Of the wide range of characteristics that will determine its potential use, the dimensions of the fiber provide a good pointer as to the likely suitability for a particular end use. Table- 8 provides the dimensions of a number of plant fibers. These are typical values, and individual variations may and do occur. The data show the wide variations in the fiber characteristics of non- wood fibers. Many of the non- wood fibers are similar to the short fiber hardwoods, while others are so long that they must be shortened to optimize their paper making values. In general the diameter of these non- wood fibers are small, resulting in lower coarseness from these pulps. These fiber dimensions provide an idea of the potential usefulness of these pulps when put to different usages. In fact any quality of paper can be produced by using the combination of non- wood plant fibers.

TABLE- 8

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	**2.7-4.0**	**15**
Corn Stalk (depithed)	**1.0-1.5**	**20**
Cotton fiber	**25**	**20**
Cotton stalks	**0.6-0.8**	**20-30**
Sun hemp	**3.7**	**25**
Esparto	**1.5**	**12**
Flax straw	**30**	**20**
Hemp	**20**	**22**
Jute	**2.5**	**20**
Kenaf (bast fiber)	**2.6**	**20**
Kenaf (Core fiber)	**0.6**	**30**
Rags	**25**	**20**
Reeds	**1.0-1.8**	**10-20**
Rice Straw	**0.5-1.0**	**8-10**
Sisal	**3.0**	**20**
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**

Table-9 provides the fiber classification of the bleached pulps from different raw materials. This data is also compared in figure 8

TABLE –9

Fiber Classification of Bleached Pulps From Different Raw Materials

Type of Pulp	Retained on			Passing through 100 mesh
	24 mesh	48 mesh	100 mesh	
Bagasse	**6.0**	**19.0**	**42**	**33**
Wheat Straw	**3.5**	**13.4**	**38.6**	**44.5**
Rice Straw	**2.7**	**18.0**	**25.3**	**54.0**
Bamboo	**43.8**	**3.6**	**16.5**	**36.1**
Softwoods	**82.5**	**6.5**	**5.0**	**6.0**
Hardwoods	**0.9**	**27.1**	**52.2**	**19.8**

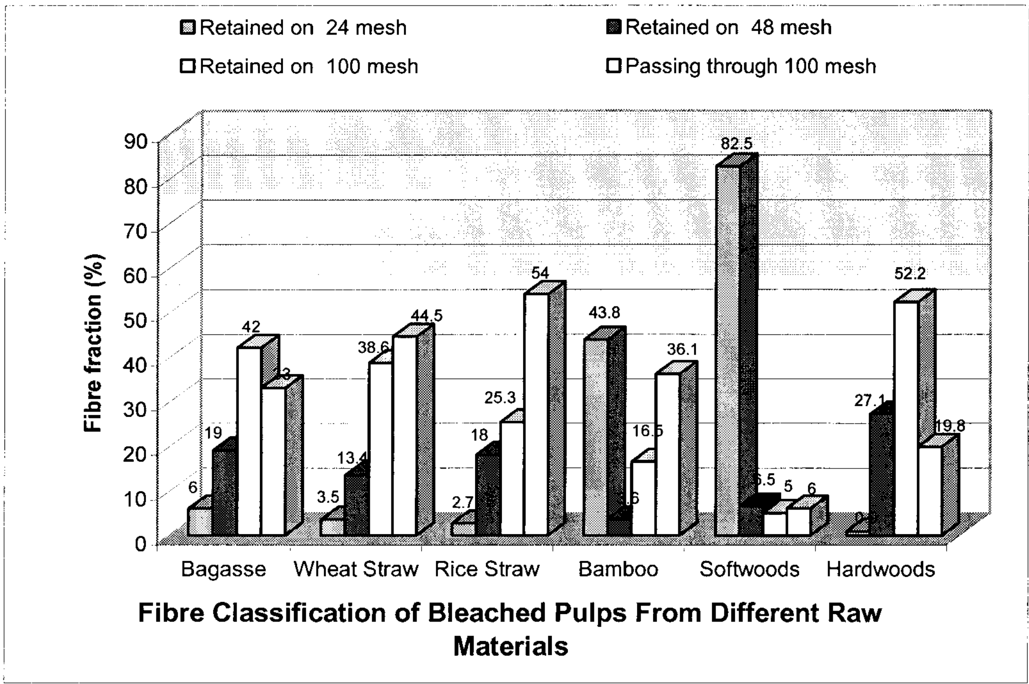
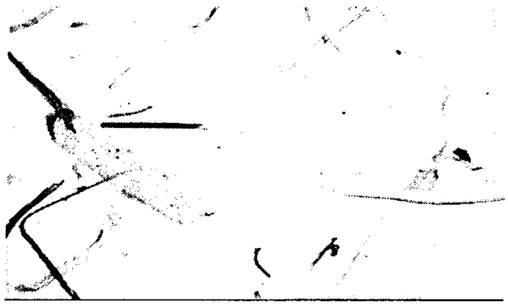


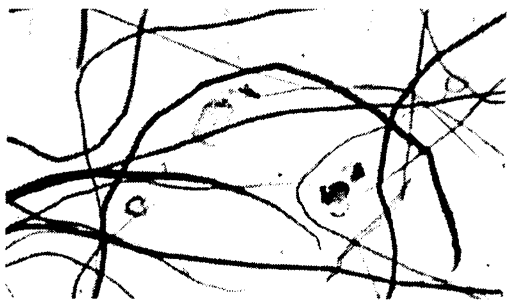
Fig.8

Fiber Types and Morphological Characteristics:

Anatomical examination of cross section of non- wood raw materials reveal that the fibers are located in two regions of the stalk, i.e. in the rind layer and in vascular bundles. Fibers located in the rind layer are all oriented parallel to the axis of the stalk. The fibers in the rind layer is larger than the scattered fiber elements in the interior of the stalk. The fibers in the vascular bundles are embedded in a relatively weak parenchymatous tissue. The rind fibers represent a superior raw material for pulp preparation.

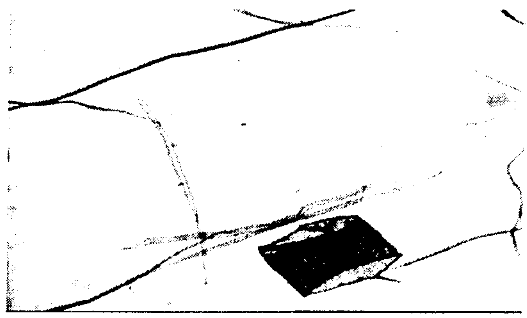


Bagasse fibers



Bamboo fibers

Wheat Straw



Eucalyptus

Fig. 9 Fiber Morphological Characteristics

Bagasse – A Potential Raw Material for Pulp Production

Bagasse (Saccharum officinarum) is the fibrous portion of the sugar cane from which juice has been extracted. Fresh bagasse, as obtained in the sugar mills contains around 50% moisture and is made up of fibrous and the pith portion. Sugar cane is grown on a commercial scale mainly in Southeast Asia, (Indonesia, Philippines, China, India) Egypt, West Indies etc. Bagasse is one of the prime raw materials for production of different grades of paper and pulp. About 4.25 million hectare of land is used for Sugar Cane cultivation in India, with an average yield of 70-ton/hectare. The crushing capacity of the sugar industry in India is 180 million tons, the average duration of season being 150 to 180 days. This translates to the availability of around 54 million tons of bagasse(at 30% of the total cane crushed.) Only about 7 million tons of this bagasse is diverted for the manufacture of pulp and paper production in India. The rest is being used for co-genration of energy by the sugar mills and the availability of bagasse is more in the major sugar cane growing states of Uttar Pradesh, Maharashtra, TamilNadu and Karnataka. Table......

Sugar Cane in the field

Fig.10

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 compared to undepithed bagasse or comparing inefficiently depithed bagasse. efficiently depithed bagasse not only provides better pulp and paper quality, but also improves process efficiency and properties of black liquor thereby the process efficiencies during processing of the black liquor during chemical recovery process, besides other benefits in term of ....chemical and ......environmental problems.

Composition of Bagasse

Bagasse is composed of three principal components:

i) **The rind fibers** including the epidermis, cortex and pericycle.

ii) **The fibro vascular bundles** comprising of the thin walled conducting cells, associated with relatively thin walled rather short fibers with narrow lumen.

iii) **Ground tissue** (parenchyma tissue) or **pith** with fiber bundles distributed irregularly.

The proportion of pith, fiber bundles and epidermis (rind fibers) vary considerably with age of stem and variety of sugar cane. Approximately 50% of the dry weight of the stack consists of high quality fiber bundles concentrated in the hard dense rind. The fiber content of the whole bagasse is around 65% , pith around 30% and water solubles around 5%. The maximum fiber length and diameter of pith are about 0.84 mm and 140 micrometer respectively, whereas average length and diameter of bagasse fiber are about 1.0 mm and 20 micrometer respectively.

The pith is composed mainly of parenchyma cells. Pith cannot be converted in to a satisfactory pulp despite its resemblance to fiber in chemical composition, because of its small dimensions, non- fibrous physical nature and close association with dust.

The drawbacks of pulping bagasse with pith are:

- **Lower yield** and **higher cooking chemical consumption** as pith consumes the chemicals reducing their availability for pulping and bleaching operations thereby necessitating use of high chemical doses.
- **Slower drainage rate** at all dewatering stages. Typically a higher soda loss during brown stock washing operations.
- Requirements of **more bleaching chemicals** and other effects on paper machine.

Of all the agricultural based residues used by the paper industry, the share of bagasse is the maximum. Bagasse is the industrial waste, which originates from the processing of sugar cane for the manufacturing of sugar, gur (jaggery) and khandsari (unrefined sugar). Bagasse is recovered from all these processes, but the gur and khandsari sectors typically use almost the entire quantity of bagasse as captive fuel. Therefore, the possibility of sourcing bagasse from these two sub-sectors is negligible.

The sugar industry produces some surplus bagasse, which is being utilized by the paper industry particularly for the production of newsprint, cream wove and maplitho grades of paper.

India is the world's largest producer of sugar cane with about a present total production of 280-million tonnes/ annum. **Table- 10**shows the distribution of the supply of sugar cane for various uses. Bagasse obtained from the sugar mill is known as the '**'mill wet bagasse'** and is approximately about 1/3rd of the total sugar cane crushed.

TABLE- 10
Distribution of Sugar Cane in Different Sectors

Particular	**Cane Sugar**
Production, million tonnes/ annum	280
Supply to sugar mills, %	50
Seeds, %	12
Unrefined sugar industry, %	30
Household, %	8

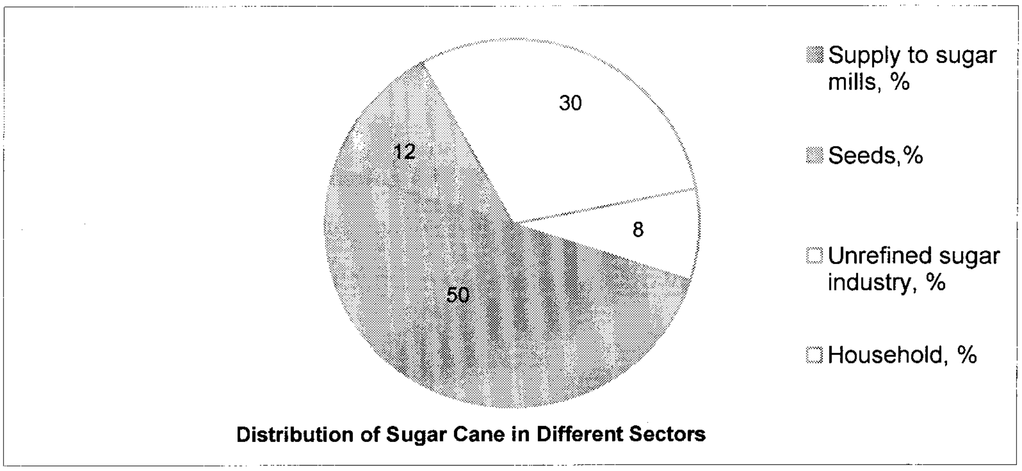


Fig.11

Cultivation of sugar cane and hence the availability of bagasse is concentrated in the states of Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Tamilnadu and Uttar Pradesh.

Among various non-wood plant fiber sources, bagasse occupies a commanding position. Bagasse has proved itself to be the most promising alternative for hardwoods.

TECHNOLOGY STATUS – PRIOR TO THE PRESENT PROJECT

INDIAN SCENARIO

Depithing operations in the Indian pulp and paper industry are being carried out by the conventionally available methods of the dry, wet or a combination of the two methods. In the Indian mills, the average depithing efficiency is only of the order of 50%, thereby generation at best a bagasse having a residual pith of about 15-27%. Even in case of the most efficient depithing operations being practiced in India, the residual pith content in the depithed bagasse has never been less than 15%.

INTERNATIONAL SCENARIO

Research work has been going on for producing efficiently depithed bagasse since the early 1900. Many US patents have been given for various processes. These depithing processes have been 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 away from the remaining 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 after the 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% The previous 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 fiber which is more useful for paper making. There have been other methods also which give mechanical action by different means for the separation of the pith from bagasse. However, the best of the available knowledge, these methods have also not been able to yield a treated bagasse fiber with a residual pith content of less than 15%.

Moreover, the short milling concept that is being proposed in this project has never been investigated for the treatment of bagasse for the purpose of depithing.

PLANNED ACTIVITIES OF THE PROJECT

Activities:
Phase – I

a) Fabrication of the additional equipment required to make the system a continuous operating one i.e., appropriate selection and design of the raw material feeding equipment & disc milling system.

b) Optimization of the process and control parameters for demonstration of the efficient depithing of bagasse on a continuous basis using the pilot facility at CPPRI.

c) The studies on the pulping and paper making from the depithed bagasse and its comparison with the depithed bagasse obtained by the conventional depithing process, to be obtained from a mill.

Preparation of feasibility report and Design details for the development of the depithing equipment required for 200 TPD pulp mill

The following section give out the details of the studies carried out in the project, the results obtained and the salient achievement and conclusions

MATERIALS AND METHODS

PROXIMATE CHEMICAL ANALYSIS OF BAGASSE

Chemical Proximate Analysis:

Proximate chemical analysis of raw material provides information which is useful in preliminary characterization of a raw material to explore its applicability in pulp and paper making. Proximate chemical analysis of fibrous raw material mainly comprise of determination of lignin content, pentosans, alpha cellulose and solubility in cold-water, hot water, 1/10N NaOH, Alcohol –benzene, etc.

The determination of proximate chemical analysis is just a preliminary assessment of the lignocelluloses raw material in terms of its fibrous content (cellulose) and non- fibrous content, lignin and hemicelluloses that undergo chemical reactions during cellulose extraction process of delignification for paper pulp production. Besides these two major examinations, determination of ethers, alcohol benzene solubility gives an idea of resinous matter present. Hot water solubility along with methanol is of use in getting an approximate estimate of poly phenols present.

The raw material mainly wood or non-wood is a complex material that consists mainly of cellulose, lignin, and hemicellulose in proportion that varies from species to species. These components are extremely varied in their nature and embrace much different class of organic compounds including tannins, resins, essential oils, fats, terpenes flavonides, quinones, carbohydrates, glycosides and alcohol.

The analysis of raw material is necessary for technological utilization of different wood elements, in research investigation to the changes which occur in raw material and its constituents as they are subjected to alternation by chemical or physical processes and in the study of biological change, which accompany growth and decay.

Preparation of Sample for Analysis

Dust for chemical analysis of Bagasse was prepared using Wiley Mill (make: Thomas), after passing through 40 mesh and collected in a polythene bag.

Methods of Analysis

The Proximate Chemical analysis of the samples of bagasse was carried out as per the Standard Operating Procedure (SOP) prepared and firmed up based on standard procedure laid down in various standard methds such as TAPPI, SCAN and the published literature

2.0.4 RESULTS: The results of proximate chemical analysis of all the samples of bagasse i.e. whole bagasse and the depithed bagasse collected from the mills as well as the depihted bagasse obtained by a depithing procedure developed and patented by CPPRI as employed in the present study are placed in Table 11,

TABLE- 11

Comparison of Proximate Chemical Analysis of various depithed bagasse Samples

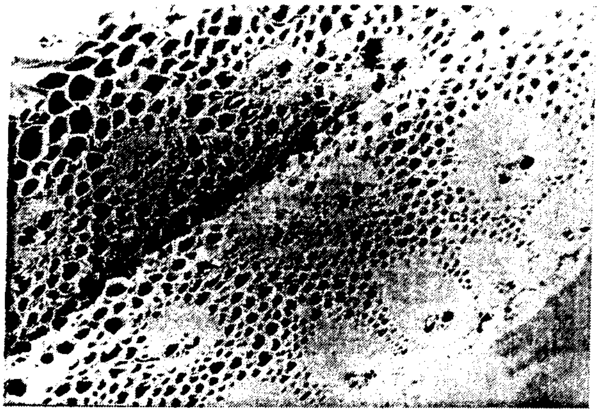
S.No.	Parameters	Unit	Dry/Moist Depithed bagasse	Wet Depithed bagasse	Disk mill depithed bagasse
1	Ash Content	%	2.35	2.10	1.52
2	Cold Water Solubility	%	4.03	2.56	2.98
3	Hot Water Solubility	%	7.78	5.05	6.2
4	1/10 N NaOH Solubility	%	29.89	27.78	25.98
5.	Pentosan	%	26.1	26.3	26.10
7	Holocellulose	%	75.7	78.4	79.45
8	Alpha Cellulose	%	40.8	42.6	43.7
9	Beta Cellulose	%	24.45	24.5	24.8
10	Gamma Cellulose	%	10.42	11.2	11.4
11	Acid Insoluble Lignin	%	18.00	17.93	21.6
12	Acid Soluble Lignin	%	0.92	1.10	1.37

The above results go to indicate that the quality of the bagasse depithed using the disk mill depithing process is better in respect of showing lowest NaOH solubility and relatively higher α- cellulose content.

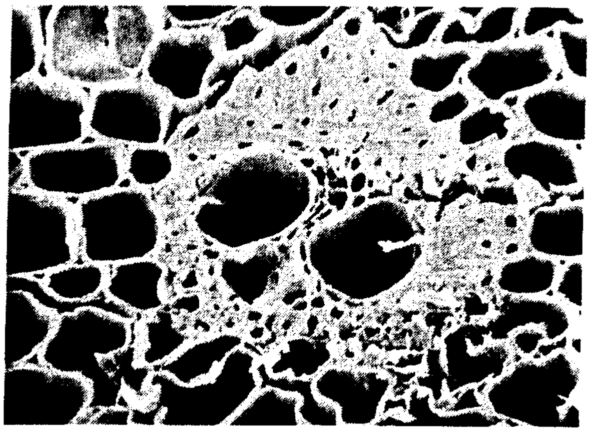
MORPHOLOGICAL CHARACTERISTICS

Various fiber morphological characteristics of bagasse were measured under Reichert projection microscope and Olympus research microscope and the photographs were taken using DC150 digital camera. The same are depicted in the figure 12 on the next page.

Morphology of Bagasse (*Saccharum officinarum*)

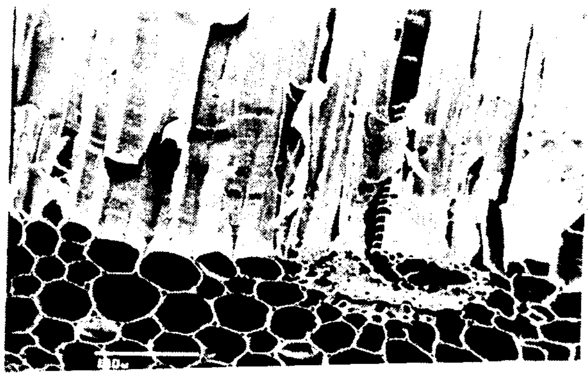


Cross section of bagasse

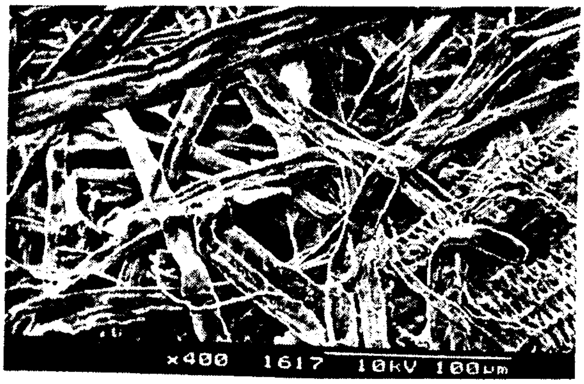


Magnified view of vascular bundle

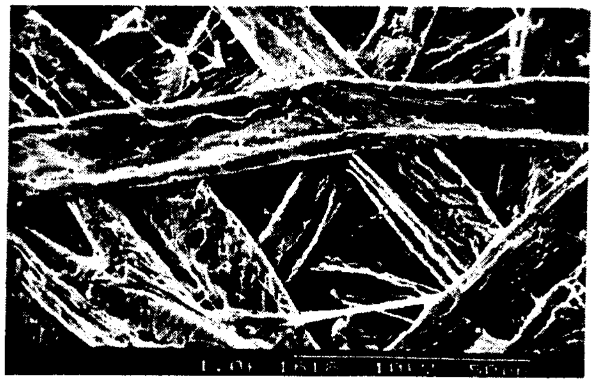
Cross section of fibers



Section showing ground tissue



Surface view of paper

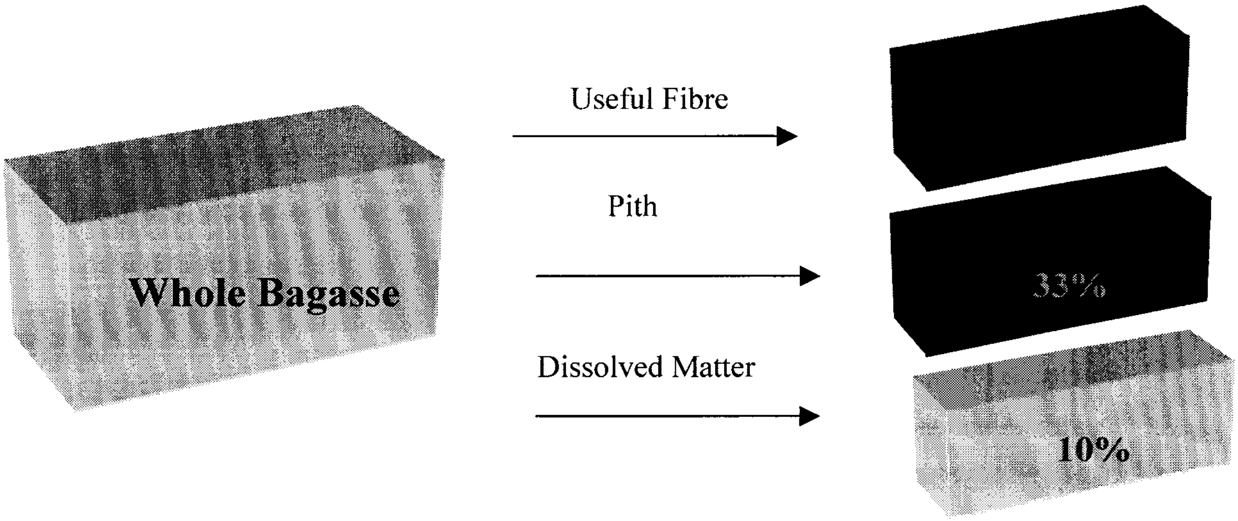


Magnified view of fiber crossings

Fig.12

DEPITHING OF BAGASE

Bagasse, which is a potential raw material for the paper industry has serious problem of pith associated with the cellulosic fibrous material. which is undesirable from the point of view of papermaking.



Constituents of Whole Bagasse

Fig.13

The presence of pith in the bagasse results in lower pulp yield, high kappa number and high chemical consumption during pulping. There has always been interest in the removal of this pith from the fibrous portion of bagasse so that the same can be effectively for high quality pulp production..

BAGASSE PREPARATION:

Pith separation from the fiber is essential to upgrade the quality of the raw material. bagasse. Pith constitutes nearly 30-35% of bagasse, the rest being usefull fiber (60-65%) & solubles (5%). The chemical properties of fiber and pith are more or less similar, but they differ vastly in physical and morphological properties. Pith contains a lot of soft, thin walled, irregularly shaped parenchymatous cells, with higher quantity of inorganic ash and high absorbency. Therefore it is necessary to remove this pith as effectively as possible. Because of this drawback and associated inherent problems of efficient removal of the pith from the fibrous raw materials is useful which otherwise consumes more chemical to produce pulp of similar kappa number

Depithing Operations:

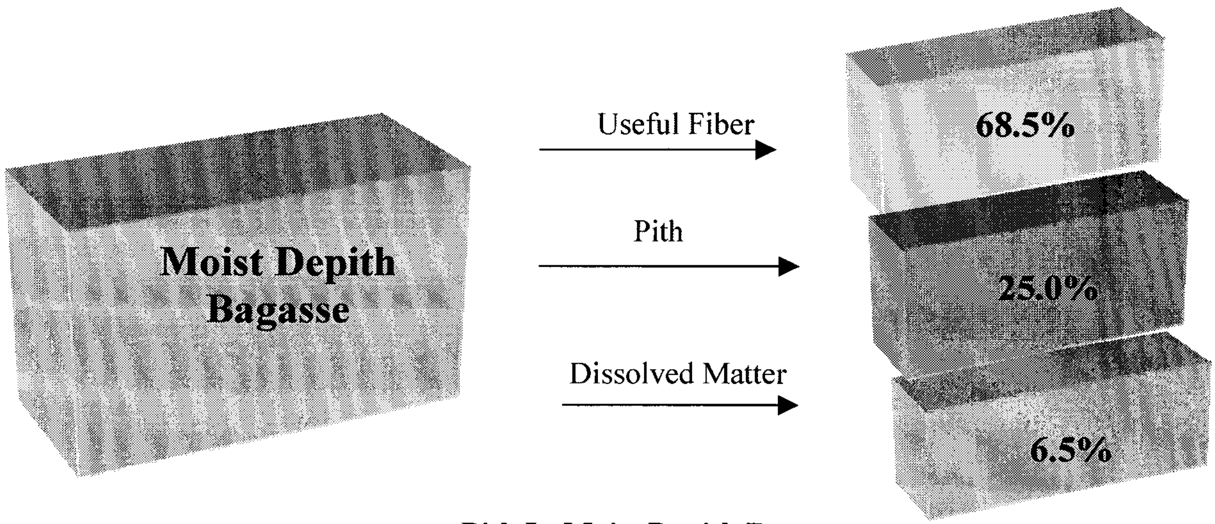
Crude bagasse or partially depithed bagasse can be used for making low-grade corrugating medium, insulating boards and similar varieties. Depithing is an important and necessary step to upgrade bagasse for the production of high-grade pulps. Pith has the same calorific value as that of whole bagasse and its burning in sugar mill boilers (bagasse fired) does not pose problems. Therefore, it is desirable to separate the pith partially, at the sugar mill and returns the same fraction for use in the sugar mill boiler, with the following advantages;

1. Saving in transportation costs of unwanted pith to paper mill.
2. Depithed bagasse requires relatively less storage space at paper mill yard.
3. Partially depithed bagasse forms a compact bale.
4. Disposal of pith at paper mill would be reduced considerably.
5. Depithed bagasse requires fewer chemicals in cooking and bleaching, increase yield and improves the brightness and strength properties of the pulps.

Research work has been going on for producing quality-depithed bagasse since the early 1900. Many US patents have been given for various processes. There are three common methods used for of depithing bagasse. The same are discussed hereunder

1.Dry Depithing Processes: Dry depithing is carried out on stored bagasse having a moisture content of less than 35%. Hammer and shredders, are used in the separation of pith from bagasse. This method has several disadvantages like heavy wear and tear of the process equipment, loss of valuable fiber along with the pith and production of lots of dust etc. The depithing efficiency of the process is also quite low and not more than 40% i.e. the depithed bagasse obtained by this process still contains 20% residual pith as against the original pith content of 30-35% in the original bagasse.

2.Moist Depithing: This type of depithing is generally done at the sugar mill when the wet bagasse has about 50% moisture. Several types of depithers such as Horkel, Rieth, Gunne, Peadcco & others are commercially used for moist depithing. These depithers are designed to break open the fiber bundles and to dislodge the pith by mechanical rubbing and mild disintegrating action. The unit consists of a rotor with sewing or rigid hammers attached to it. The hammers are enclosed fully or partially by perforated screen plates through which the pith fraction is discharged .The bagasse feeding to depithers is along either the horizontal or vertical axis of the unit depending upon the construction. The depithed fiber is discharge at the end of the rotating axis. Up to 50% of the original pith content in bagasse is removed by this method.

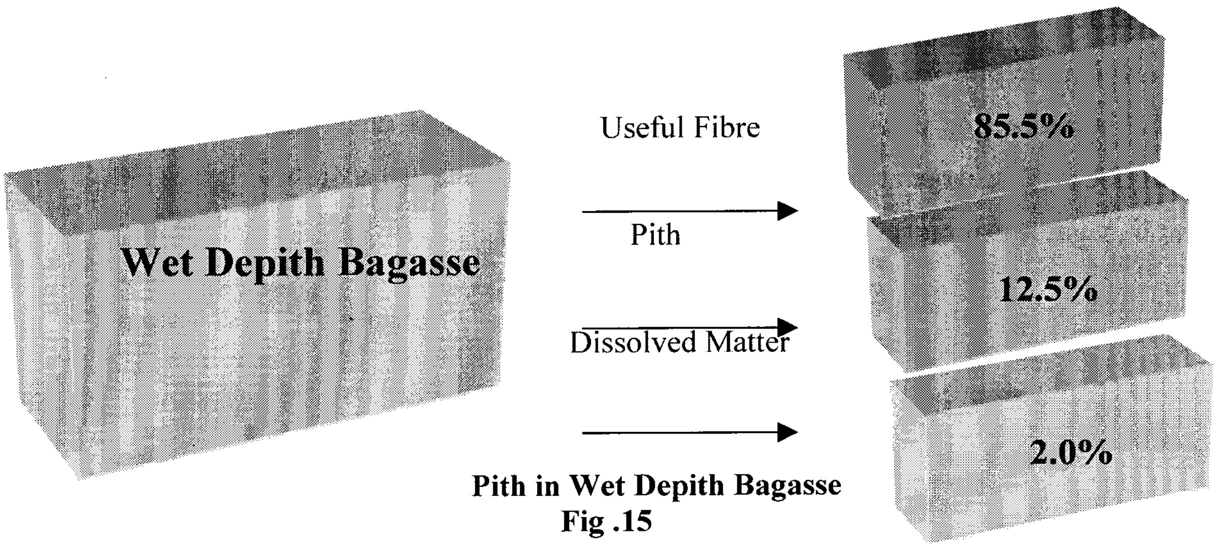


Pith In Moist Depith Bagasse

Fig.14

3 **Wet depithing:** The process is suitable for either baled bagasse or bagasse delivered from bulk storage. This method is more applicable at the pulp mill for the final cleaning and depithing just before bagasse enters the digester. The bagasse is fed to the hydrapulper where it is thoroughly wetted and broken up at a consistency of around 2 to 2.5%, which maintained by continuous recirculation of process water. The slurry is pumped to the depither where defibrating operation is completed. The pith passes through the perforated screen. The depithed bagasse is delivered at about 20% consistency to the pulping unit and the pith is separated and thickened by dewatering press before disposal.

In all the above depithing process residual pith content is not less then 14-15%. Maximum depithing efficiency achieved is around 70%. It is therefore very difficult to produce a bagasse chemical pulp having high alpha cellulose content. from bagasse obtained by emloying the above processes



Pith in Wet Depith Bagasse
Fig .15

DISC MILL DEPITHING-A NOVEL PROCESS DEVELOPED BY CPPRI

In view of the requirement of the project wherein the pulp with high α-cellulose was required, efforts were made to depith bagasse with a more efficient depithing process. A novel process for efficient depithing of bagasse was developed using the existing pilot machine for cleaning of straws. The use of disk mill method for depithing results in a clean raw material having a residual pith content of nearly 5%. The procedure can also work with most bagasse having a higher moisture content of 50%.

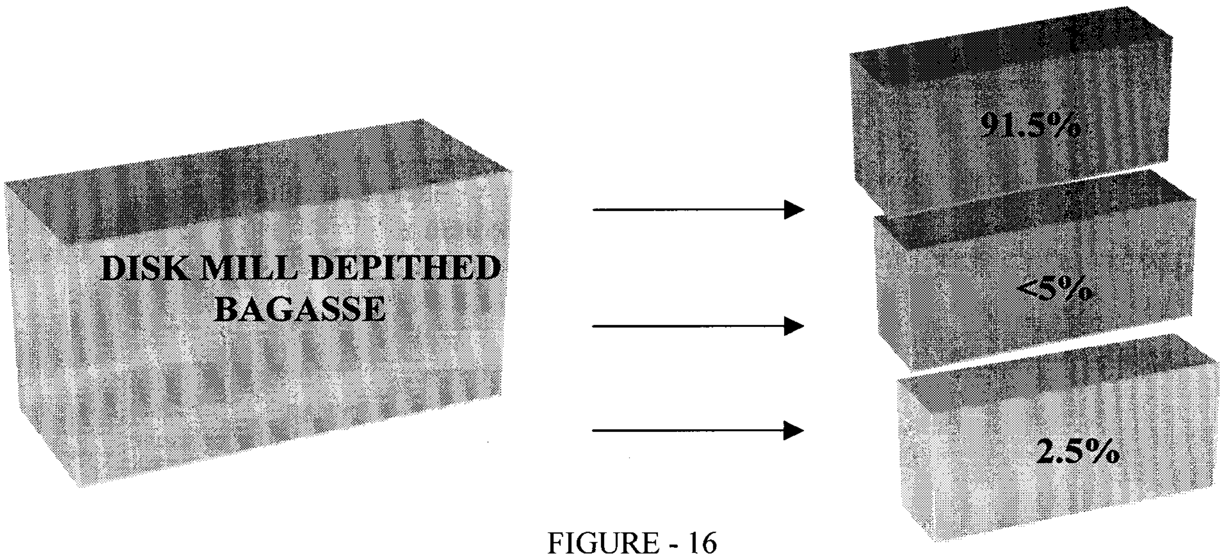


FIGURE - 16

The schematic diagram of the depithing process as mentioned above is given in **figure 17**

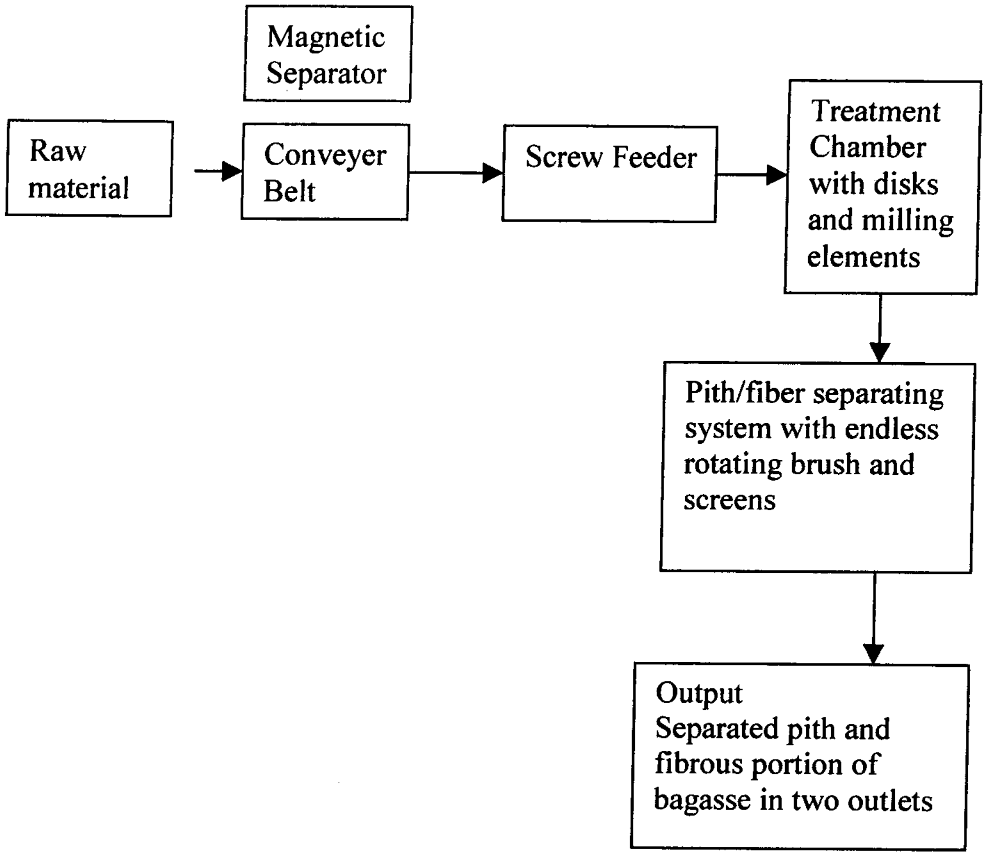
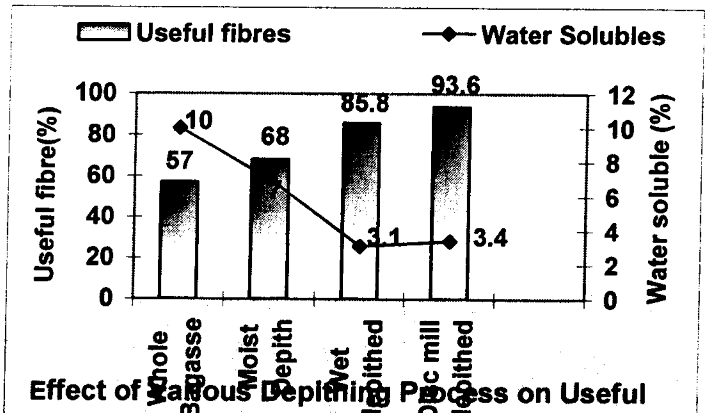


FIGURE – 17

At the outset, the mill wet bagasse obtained from the sugar mill after the crushing operation is put in a yard so that the same can be used as a feed to the belt conveyor. 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 screw conveyor is used to lead the whole bagasse in to the treatment chamber. The treatment chamber consists of a pair of vertically mounted metallic disks to which the bagasse is fed at a constant rate, which can be adjusted as per the need of the raw material, i.e. based on the gap between the disks and the moisture content of the input bagasse. One of these disks is stationary and the other is rotary. The balanced rotating disk is mounted on a shaft with a friction brush assembly. The shaft is mounted in a cast iron housing supported by double ball bearing. There are specially designed milling component fixed along the periphery of both the disks. Each of the milling component is fixed on to the disk using a groove-screw method. The diameter of the disks and the size of the milling component fixed on the disk depends on the size and throughput desired from the equipment/set up. The disks are mounted inside a housing that can be opened as and when required for cleaning and servicing purposes. In any case one milling component is placed at every 15 degrees on the disk. The length and width of the milling component is therefore fixed accordingly, depending on the diameter of the disks. The gap between the rotating and the stationary disk is adjusted by means of a device mounted on the basic housing of the shaft. The said gap is optimized to give maximum performance and is adjusted as per the quality, type and moisture content of the raw material being used for depithing. The whole assembly of the disks and the gap adjustment mechanism are mounted on a welded steel profile frame. The incoming raw material is distributed evenly with the help of special structures protruding over the surface of the rotary disk. The raw material is subject to mechanical action by the milling components on the rotating and fixed disks. During this process, the necessary action is given to the bagasse, so that maximum pith is dislodged with minimum effect on the quality of the fiber. After this process, the treated bagasse comes out of the disks and falls down under the influence of gravity. The extent of grinding is determined by the type and the nature of the feed raw material, its moisture content, the distance between the surfaces of the disks, their angles and also on the patterns of the milling components. Subsequently, the treated raw material is made to fall in to a specially designed apparatus/equipment which separates the pith from the fibrous portion of the bagasse. In this apparatus/equipment, the treated bagasse is made to pass over a series of sieves with the help of an endless rotating brush, which cleans the screens / sieves as it moves the treated material above them, thereby aiding effective separation of the pith and the fiber. The endless brush is propelled by a suitable motor. 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. The positioning of the sieves and the opening per linear inch is optimized to separate out the pith from the fibrous portion of bagasse.

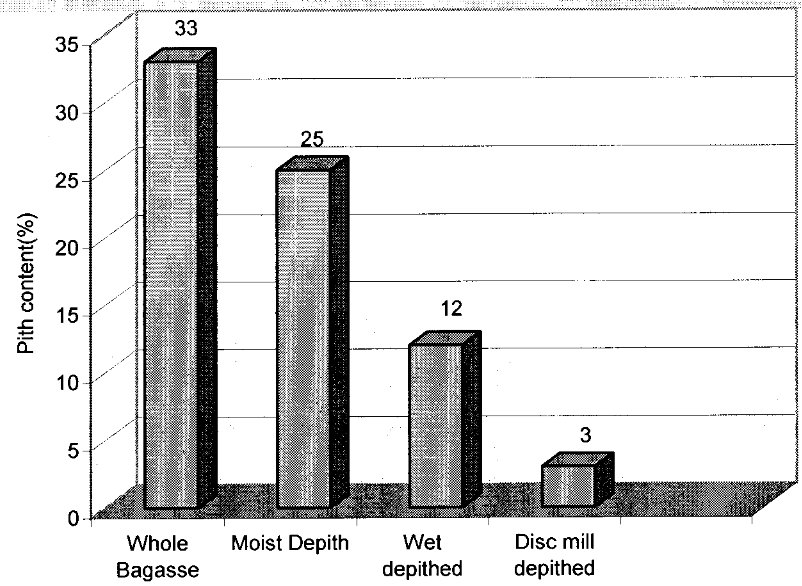
The method described above is a major improvement in the conventional methods for the depithing of bagasse. As of now, methods such as dry depithing, wet depithing, moist depithing, and a combination of these methods are used to separate the pith from the bagasse. At best, these methods are able to give a cleaned raw material, which still has about 12-15% residual pith. In the disc mill depithing method we are able to obtain clean raw material with no more than 7-8% residual pith in any of our trials. The results of the studies and trial runs are summarized as under:

Typical Results of From The Conventional Depithing Of Bagasse



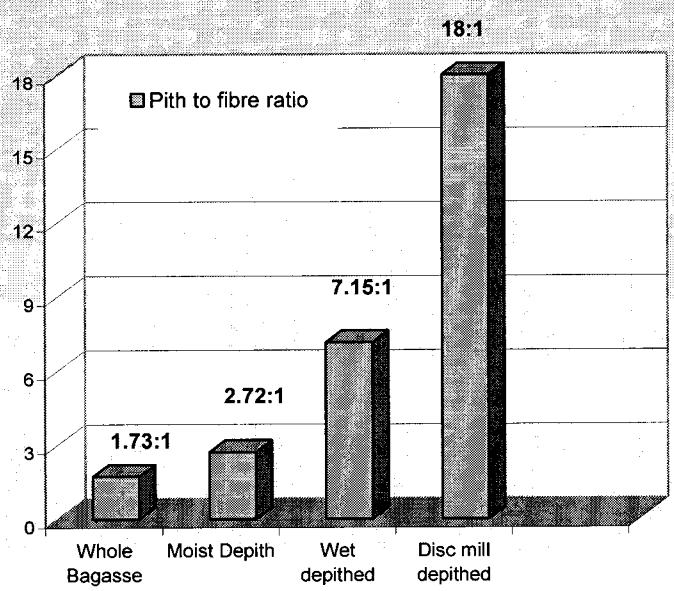
Effect of Various Depithing Process on Useful Fibre content of Bagasse

Fig.18



Residual Pith content In Bagasse After Depithing

Fig.19



Pith to Fibre ratio in Bagasse after Depithing

Fig.20

As clear from the above fig.18,19,20 the proposed method is a substantial improvement over the present available practices.

TRIAL RUNS ON THE DISK MILL DEPITHING

EXPERIMENTS AND OPTIMIZATION STUDIES

It is mentioned herewith that the optimization of the process parameters and other related studies have already been filed under a separate patent entitled " NEW PROCESS FOR EFFICIENT DEPITHING OF BAGASSE. The provisional patent specification has been filed in India on 08/03/2006 vide patenet application No. 0613DEL2006. However, for the sake of brief explaination and continutry, some of the studies carried out and the results and optimization steps followed are being placed hereunder, which are abstracted from the above said

EXPERIMENT – 1

CONTROL SAMPLES

To begin with the depithing trial experiments with the new proposed depithing process, all the three different samples of bagasse viz the whole bagasse sample, depithed bagasse samples obtained from moist depithing operation and a combination of moist and wet depithing operation were analyzed for the parameters of interest.

The water-soluble content and the useful fiber content in the samples under test were determined by following the standard TAPPI procedure T-230cm-99.

To determine the pith content, the test sample of 1% consistency was disintegrated for 30 minutes in British Pulp Disintegrator by using 2500 ml of water. This sample was transferred on a 300-mesh sieve and washed under running water. The substrate retained on the mesh was disintegrated again by following the same procedure as descried above. The pith material passing though the sieve in both cases was collected on a muslin cloth. Both the fibrous portion retained on the mesh as well as the pith collected in the muslin cloth were dried in an oven at 105 ± 1 °C. The fibre and the pith content were calculated on a weight percent basis.

Table gives a comparative study of the analysis of samples of bagasse as obtained by the conventional depithing process with the proposed equipment and methodology. The composite samples of the moist and the combination of moist and wet depithed bagasse were collected from a paper mill and preserved in poly bags for shipment. These samples were analyzed for the characteristics of interest with the least possible lag time using the procedures described earlier. The determinations were carried out in triplicate and the values obtained are presented in the table.

TABLE –
COMPARATIVE RESULTS OF DEPITHING AMONG THE CONVENTION DEPITHING PROCESS AND THE NEW PROPOSED DEPITHING PROCESS

S. No.	Particulars	Moist depithed bagasse			Combination of Moist and Wet depithing			Depithing by the new proposed method		
		Determination			Determination			Determination		
		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 Soluble in useful fiber, %	7	6	8	3.1	2.8	2.6	3.4	3.5	2.8
4	Useful Fiber to pith ratio	2.72:1	2.92:1	3.0:1	7.15:1	6.48:1	7.85:1	17.23:1	19.1:1:	17.69:1

The above table compares the bagasse samples obtained after depithing by the best available present methods with the depithed bagasse using the present method as having 50% initial moisture. As can be seen from the above results, even the lowest values of useful fiber to pith ratio obtained by the present proposed method are substantially higher at around 18:1 as compared with the best value of 8:1 obtained for depithed bagasse by the present art of depithing.

EXPERIMENT - 2

COMPARISON OF THE GAIN IN PROPERTIES BETWEEN THE ELEMENT DESIGN OF THE PRIOR ART AND THE MODIFIED ELEMENTS IN THE PRESENT DESIGN

Disk Spacing	**Prior art Element Design**					**New Element Design**				
	Residual pith (%)	Through output Kg/d	Accept Fiber (%)	Middle fraction (%)	Pith Separated (%)	Residual pith (%)	Through output (Kg/d)	Accept Fiber (%)	Middle fraction (%)	Pith Separated (%)
1mm	5.0	300	60	9	30					
2mm	5.6	600	60	7	30	6	1500	65.4	7.6	27
3mm	8.1	600	60	16	27	6.6	1700	63.5	6.4	27
4mm							------	------	------	------
5mm						6.7	2500	65	5	28
7mm						8.0	4800	65	5	27
9mm						7.0	5000	65		

With the present machine, it was not possible to operate beyond a disk gap of 3 mm as it was designed to treat cereal grains which does not require large throughputs

Further with the design of the machine as per the prior art, frequent jamming of the disk was observed even when the feeding rates were lowered. However, by using the modified design . .

Further, in the prior art, the grinding elements were short in length with sharp edges providing more cutting action than brushing action, as the machine was designed primarily for the treatment of cereal grains. When this machine is used for the treatment of bagasse, due to the cutting action, the middle fractions obtained are mixed with pith and as such are not of the required quality for appropriate end use.

EXPERIMENT – 3 - CHARACTERIZATION AND COMPARISON OF PULP QUALITY OF DEPITHED BAGASSE FROM CONVENTIONAL MEANS AND BY THE EQUIPMENT DESCRIBED IN THE PROJECT

In an effort to compare the performance of the depithed bagasse obtained from conventional methods and by the proposed new method, a lab scale pulping operation was performed under normal conditions employed in pulping operations in order to ascertain the advantage of the efficient depithing by the proposed new methodology as described herein. The pulping experiment done with all the three different bagasse samples containing various proportions of residual pith obtained by conventional depithing processes viz dry/moist depithing process, combination of dry and wet depithing and the new proposed depithing operation as described herein. The bagasse sample obtained by conventional dry/moist depithing, combination of moist and wet depithing and that obtained by the present method used for Experiment – 3 had a residual pith content of 25%, 12% and nearly 5% respectively. The results of this experiment are summarized hereunder. All trials were carried out in triplicates.

EXPERIMENT – 3 A

Pulping conditions

Sulfidity	:	17%
Bath Ratio	:	1:3.5
Temperature	:	160°C
Time	:	60 minutes
Alkali charge	:	17%

S. No.	Parameters	Dry/ Moist depithed bagasse	Combination of moist and Wet Depithed bagasse	Depithed bagasse from the present method as detailed in claims 1-15
DETERMINATION - 1				
1	Unscreened yield, %	51.5	52.2	53.9
2	Screen yield, %	51.4	50.7	52.6
3	Kappa Number	17.4	12.9	9.7
4	α Cellulose, %	70	75.1	76.5
5	Holocellulose	95	96.2	97.1
6	Viscosity, CPS	10.5	11.2	18.3
DETERMINATION - 2				
1	Unscreened yield, %	51.4	51.9	53.5
2	Screen yield, %	51.9	49.6	52.4
3	Kappa Number	17.2	13.1	9.4
4	α Cellulose, %	69.8	75.3	75.9
5	Holocellulose	94.3	96.3	97.6
6	Viscosity, CPS	10.2	11.4	18.6
DETERMINATION - 3				
1	Unscreened yield, %	51.6	52.4	54.1
2	Screen yield, %	51.4	50.4	52.8
3	Kappa Number	17.04	12.9	9.7
4	α Cellulose, %	70	75.1	76.5
5	Holocellulose	95	96.2	97.1
6	Viscosity, CPS		11.2	12

EXPERIMENT – 3B

Alkali Charge = 20%

DETERMINATION - 1				
S. No.	Parameters	Dry/ Moist depithed bagasse	Combination of moist and Wet Depithed bagasse	Depithed bagasse from the present method as detailed in claims 1-15
1	Unscreened yield, %	48.75	49.1	50.2
2	Screen yield, %	47.2	48.4	49.8
3	Kappa Number	11.2	7.5	5.95
4	α- Cellulose, %	78.2	79.7	81.8
5	Holocellulose	97.5	98.8	99.3
6	Viscosity, CPS	12.1	13.5	18.2
DETERMINATION-2				
1	Unscreened yield, %	49.3	49.4	51.4
2	Screen yield, %	47.8	48.6	50.2
3	Kappa Number	10.9	7.8	6.4
4	α- Cellulose, %	78.6	80.1	82.3
5	Holocellulose	97.2	98.7	99.4
6	Viscosity, CPS	12.5	13.4	18.6
DETERMINATION-3				
1	Unscreened yield, %	47.9	48.7	50.8
2	Screen yield, %	46.8	47.5	50.4
3	Kappa Number	111.4	7.4	5.7
4	α- Cellulose, %	78.2	79.5	81.3
5	Holocellulose	97.8	98.4	99.7
6	Viscosity, CPS	11.9	13.5	18.9

From the above results it can be clearly seen that the pulp obtained from the new depithing method as described in the present method , showed higher viscosity values with a better cellulose content as well as higher screen pulp yields. The pulp thus obtained by the improved depithing operations as described in the claim 1-15 in the present method could find better application for value added product.

Direct Benefits Accrued from the new proposed depithing procedure.

As per the pulping and bleaching experiments carried out, with depithed bagasse obtained from the new proposed method of depithing and its comparison with the conventional best available depithing technology (wet depithing process), the benefits accrued for 100 TPD pulp production are placed below while mainting the similar kappa number(7.8) and viscosity levels (19 cps) (table - 3)

TABLE - 3

CHEMICAL SAVINGS BY DISC MILL DEPITHING

Sample details	Experiment	Chemical Charge,%	Kappa Number	Yield, %	Alpha Cellulose (%)	Viscosity
Bagasse obtained by conventional depithing, having pith of around 12%	**Determination-1**	**20**	**7.7**	**47.5**	**78.2**	**19.05**
	Determination-2	**20**	**7.6**	**48.0**	**78.4**	**19.81**
	Determination-3	**20**	**7.8**	**47.2**	**79.0**	**19.46**
Treated bagasse by the proposed depithing process as developed by CPPRI	**Determination-1**	**18**	**7.6**	**50.5**	**78.4**	**19.59**
	Determination-2	**18**	**7.4**	**51.3**	**78.1**	**19.95**
	Determination-3	**18**	**7.8**	**49.9**	**78.6**	**19.86**

Pulp yield

The yield of depithed bagasse obtained from the proposed method is about 2% more than that obtained by conventional method ie net gain of 4 ton pulp for 100 TPD pulp production while maintaining the similar kapp number and viscosity of the pulp at comparable levels (19cps)

Savings in chemicals

The chemical used for cooking of the depihted bagasse from the proposed method is also around 2% lower (ca 18% alkali charge used in place of 20% for the conventionally depithed bagasse ie net savings of 5.6 tons of cooking chemicals (Caustic soda) for 100 TPD pulp production.

IMPROVEMENT IN VISCOSITY PROFILE

In an effort to exhibit the gain in the properties of the viscosity profile of the black liquor obtained from puling the depithed bagasse as per the process developed by CPPRI an experiment was carried out wherein the viscosity profile of the black liquor was determined as a function of the increasing solid content

Sample : **Treated at a gap of 3mm**

Residual Pith content of the sample so obtained : **8%**

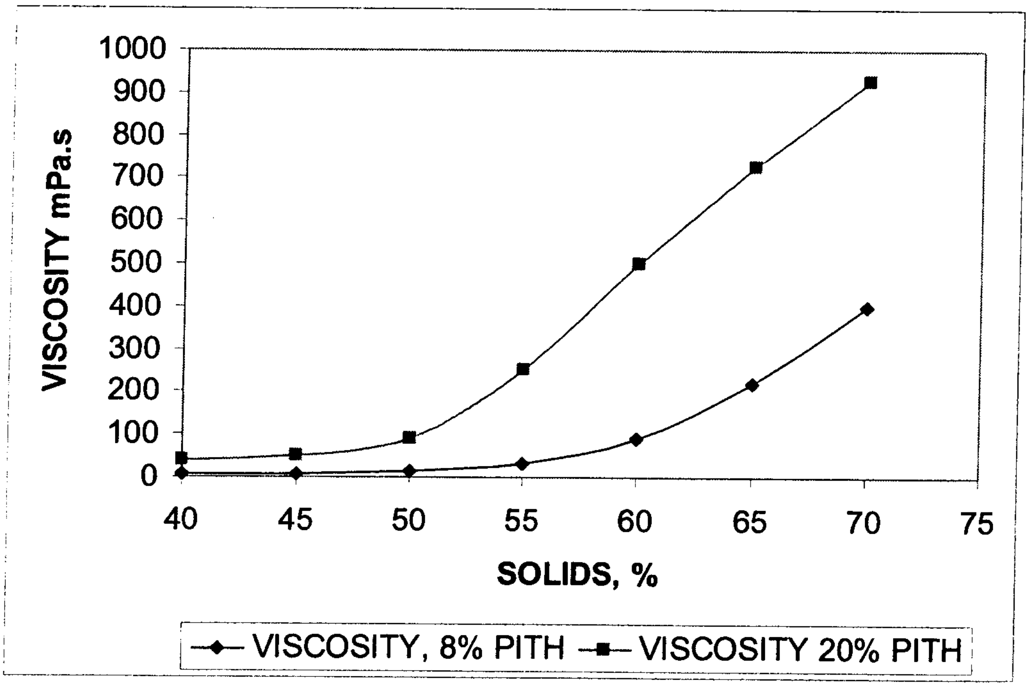
S No.	Solids (%)	Log Viscosity	Viscosity*
1.	40	0.75	5.63
2.	45	0.95	8.91
3.	50	1.20	15.85
4.	55	1.50	31.62
5.	60	1.95	89.13
6.	65	2.34	218.78
7.	70	4.67	400.75

Sample : **Treated at a gap of 7mm**
Residual Pith content of the sample so obtained : 20.18 %
(This would be the nominal pith content of the bagasse depithed by the conventional means)

Sample :
Pith content:- **20%**

S No.	Solids (%)	Log Viscosity	Viscosity*
1.	40	1.6	39.81
2.	45	1.7	50.12
3.	50	1.81	90.57
4.	55	1.9	250.43
5.	60	2.0	500.00
6.	65	2.41	727.58
7.	70	2.88	928.00

* Note:- Viscosity in mPa..s



The above profile of the two samples clearly depicts a marked improvement in the viscosity profile of the bagasse black liquor obtained from depihted bagasses wherein a drastic reduction in the viscosity of the black liquor was noticed which was reduced to around 400 at 70% solids at a temperature of around 95 degree centigrade and making it possible to fire the black liquor at high dry solids that is 70% thereby increasing energy efficiency in the chemical recovery system. It is worth while to mention here that the black liquor resulting from the pulping of depithed bagasses resulting from the conventional depithing processes normally have a viscosity value of around 500 at a black liquor solids of around 60% at 95 Deg C thereby restricting the firing of black liquor at comparatively lower black liquor solids (around 60%) resulting in comparatively lower energy efficiency in the chemical recovery system

COST ECONOMICS OF DISC MILL DEPITHING PROCESS FOR SETTING UP 100 TON PER DAY CELLULOSIC PULP PLANT

Assumptions

Pith in Original Bagasse	-: 30%
Pith in Conventional Depith Bagasse	-: 18%
Pith in Disc Mill Depith Bagasse	**-: 5%**
Accept after disc milling	-: 70%
Pulp Mill Capacity	-: 100 TPD
Pulp Yield from Conventionally Depith Bagasse	- 48%
Pulp Yield from Disc Mill Depithed Bagasse	-: 50%

Raw Material required for 100 Ton Pulp Production

Disc Mill depith Bagasse (yield 50%)	-: 100 TPD
Original Bagasse (accept 70%)	-: (100x200)/70 = 286 TPD

Raw Material to be processed will be 15 ton/hr for 20 working hrs. Three-disc mill of 5 ton/hr capacity each are required.

Drive Motor Capacity (3 nos.)	-: 250 kw

Cost of Plant

Cost of three disc mills (3 x 8lacs)	-: 24 lacs
Cost of three motors (3 x 4lacs)	-: 12 lacs
Cost of Conveyers and other accessories	-: 14 lacs

Total Equipment Cost	**50 lacs**

Cost of Disc Mill Depithing per Ton of Pulp

Equipment cost	-: 50 lacs
Depreciation per year(10%)	-: 5 lacs
Interest per year (10%)	-: 5 lacs

Interest & depreciation per day (330 working days)	-: Rs. 3000
Electricity consumption per day (100 x20 x3)	-: 6000 kwh
Cost of electricity per rate @ Rs. 4.5 per unit	-: Rs. 27000
Maintenance (2% of equipment cost) per day	-: Rs. 300
Manpower cost per day	
(Three shifts two persons per shift)	
Rate 150 per day per person (6 x 150)	-: Rs. 900

Total operating cost for producing 100 TPD bleached bagasse pulp

= Rs. 3000+27000+300+900 =

= **Rs. 31200**

BENEFIT ACCRUED FROM DISC MILL DEPITHING DEVELOPED BY CPPRI

The exercise has been done to calculate the cost accrued by adopting the depithing process for manufacture of high quality chemical bagasse pulp employing elemental chlorine free bleaching sequence.

Total processing Cost per ton of pulp -:Rs. 312

Gain in yield per day (2% on 200 ton raw material processed)-: 4 tons

Extra cost on this 4 ton pulp (per ton of pulp)

Electricity (800x 4.5)	-: Rs. 3600
Water 80 M3 @ Rs. 1.0 per M3	-: Rs. 80
Cost of Bleaching	-: Rs. 500
Cost of lime etc & recovery	-: Rs. 1800
Total	**Rs. 5980**
Say	**Rs. 6000 per ton**
Price of 1.0 ton pulp	-: Rs. 19000
Less extra cost	-; Rs. 6000
Gain per ton of pulp	-: Rs. 13000
Total gain	-: Rs. 13000x4= Rs. 52000 per day

Saving in Cooking Chemicals

a.	**Raw Material Charged without Disc Milling (Yield 48%)**	**:- 208.3 ton**
	Chemicals Charge (20%)	**:- 41.6 ton**
b.	**Raw Material Charged with Disc Milling (Yield 50%)**	**:- 200 ton**
	Chemicals Charge (18%)	**:- 36 ton**

Saving in Chemicals	**= 41.6-36**
	= 5.6 ton
Cost of recovered caustic	**= Rs. 4000 per ton**
Total saving	**= 4000 x 5.6**
	= Rs. 23000 per day

Therefore accrued benefit per day

= Rs. 52000 + 23000 -31200

= **Rs. 44800 for 100 tons of pulp**

= **Rs. 448 per ton pulp**

Note: - *In case of disk clearance of 1.00mm and 3.00mm frequent jamming of the disk and magnetic separation even at lower feeding rate of bagasses was noticed in the existing element design.

**Universal separation in the existing pattern is not adequate to take feeding of bagasse with feed rate1200 – 1500 Kg/ d.

TRIALS CONDUCTED FOR OPTIMIZATION AND FINALIZING OF ENGINEERING PARAMETERS, IN ASSOCIATION WITH THE EXPERTS FROM THE INDUSTRY PARTNER

Experiment - 1

DETERMINING THE MINIMAL OPTIMUM DISK CLEARANCE.

The experiments were carried out using the fresh bagasse received from M/S Bajaj Hindustan Ltd., and the aim of the experimental design was to fix the minimal gap required to be engineering in the up scaled machine, so as to achieve the desired depithing efficiency. To this effect, the disk milling was carried out a a cleqrence of 2, 3, and 4mm and the results are placed hereunder.

Date 01.12.06 Trial 3 Bagasse Pith Content 34.7

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept
30 min	2mm	06.14	24.50	4.6 %
		02.12	08.46	
		01.22	04.87	
		00.84	03.35	
		14.74	58.82	
	Total	25.06		
Capacity (T/D)		1.2		

Date 01.12.06 Trial 3 Bagasse Pith Content 34.7

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept
30 min	2mm	06.14	24.50	4.6 %
		02.12	08.46	
		01.22	04.87	
		00.84	03.35	
		14.74	58.82	
	Total	25.06		
Capacity (T/D)		1.2		

Date 01.12.06 Trial 2 Bagasse Pith Content 34.7

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept
30 min	3mm	4.62	19.61	5.3 %
		2.24	09.51	
		1.24	05.26	
		0.82	03.48	
		14.64	64.14	
	Total	23.56		
Capacity (T/D)		1.13		

Date 01.12.06 Bagasse Pith Content 34.7

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept
30 min	4mm	3.78	12.17	4.32
		3.12	10.05	
		1.66	05.35	
		1.26	04.06	
		21.23	68.37	
	Total	31.05		
Capacity (T/D)		**1.5**		

The trials in experiment 1 were conducted with first consignment of bagasse reached from BHL having a moisture content of 40 %. Three trials with almost constant feeding were conducted at 4mm, 3mm & 2mm opening for 30 minutes each. Residual pith content in each of the case was found to be around 4 – 5 %. Thus the results clearly indicate that an operating parameter with a disk clearance of less than 4mm does not have any significant gain on the depithing efficiency and as such, only results in a lower through out put, whish is not required. Therefore, the operation of the machine was further studies at more than the 4 mm clearing.

EXPERIMENT - 2

The trials were conducted at 7 mm and 9 mm clerance to determine its depithing efficency using the freash bagasse received from BHL. The results are summarized as under.

Date 12.12.06 Trial 4 Bagasse Pith Content 34.7

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept	
15 min	7mm	01.74	12.32		
		01.28	09.07	Free pith	Embedded pith
		00.68	04.82		
		00.54	03.82	7.14	8.92
		09.88	69.97		
	Total	14.12			
Capacity (T/D)		1.35			

The above trial conducted with 7.00 mm disc clearance shows that free pith around 7.00% is remaining in the accept while embedded pith is around 9 %. The results go to indicate that at 7 mm clearance, the separator starts to become overloaded and the pith which is separated from bagasses during the treatment (i.e. 7% pith is already separated from the bagasse due to disk milling process, but has not been separated due to the over loading of the separator. None the less, at this operating condition, the pith that would be carried over in the treated bagasse would be about 9%.

Date 13.12.06 Trial 5 Bagasse Pith Content 34.7

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept	
10 min	9mm	01.1	12.76	Free pith	Emb pith
		00.64	07.42		
		00.40	04.64		
		00.36	04.18		
		06.12	71.00	3.61	6.55
	Total	8.62			
Capacity (T/D)		1.24			

A 9 mm gap, at the outset is a large gap and it was expected that the depithing efficenecy of the trial will be lower.

Further the present pilot machine quickly became over loaded and when beyond its break through capacities and consequently jammed the entire system down line starting with the disk mill ilet section to the universal separtor. Clearly, at the current lelve of operations such a large throughout put

Date 15.12.06 Trial 6 Bagasse Pith Content 34.7

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept	
				Free pith	Emb pith
10 min	7mm	09.40	09.40		
		06.36	06.36		
		03.23	03.23		
		02.54	02.54		
		78.45	78.45	12.38	8.92
	Total	99.98			
Capacity (T/D)		9.6			

The trial was carried out by loading more input bagasse to the disk mill. As evident from the results, a load of about 10 tons/day was treated in the disk which Trial 6 shown that disc can handle up to 10 T/D bagasse but separator is not sufficient to separate free pith from treated bagasse. None the less, with the upgradation of the quality of the separator, the accept material will carry a residual pith content of about 9%.

Date 22.12.06 Trial 7 Bagasse Pith Content 34.7

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept	
				Free pith	Emb pith
	4mm	01.28	12.72		
		01.02	10.14		
		00.56	05.57		
		00.46	04.57		
		06.74	70.00		
	Total	10.06			
Capacity (T/D)					

Note:-Trial 7 was carried out on new element having extended element length with curved impeller. Pith content in accept is yet to be analysed.

Date 05.01.07 Trial 8 Fresh Bagasse

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept	
		0.66	5.07	Free pith	Emb. pith
	Direct to Separator	0.78	05.99		
		00.40	03.07		
		00.32	02.53		
		10.86	83.41		
	Total	13.02			
Capacity (T/D)					

Trial 8 – were conducted with new bagasse having a moisture of 50 %.

In trial 8 bagasse was fed to separator directly and the disc was bypassed, analysed is yet to be carried out.

Date 05.01.07 Trial 9 New Bagasse

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept	
		00.40	13.79		
	Separated accept through disk mill	00.26	08.97		
		00.16	05.52		
		00.12	04.14		
		01.96	67.59		
	Total	02.90			
Capacity (T/D)					

Date 05.01.07 Trial 10 New Bagasse

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept	
	4 mm	00.62	21.31		
		00.28	09.62		
		00.12	04.12		
		00.08	02.75		
		01.91	65.64		
	Total	02.91			
Capacity (T/D)					

Date 09.01.07 Trial 11 New Bagasse

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept	
	Direct to separator	01.04	06.67		
		00.88	05.64		
		00.54	03.46		
		00.40	02.56		
		12.74	81.67		
	Total	15.60			
Capacity (T/D)					

Date 09.01.07 Trial 12 New Bagasse

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept	
	Re separated obtained from previous trial accept.	00.60	05.33		
		00.46	04.09		
		00.28	02.49		
		00.20	01.78		
		09.72	86.32		
	Total	11.26			
Capacity (T/D)					

Date 09.01.07 Trial 13 New Bagasse

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept	
	Direct to separator	00.90	06.59		
		00.86	06.30		
		00.50	03.66		
		00.40	02.93		
		11.00	80.53		
	Total	13.66			
Capacity (T/D)					

Bagasse was directly feed to separator. Accept sample was 80.5 %

Date 09.01.07 Trial 14 New Bagasse

Duration	Disk Clearance	Fraction	Percentage	Residual Pith in accept	
	Re separated obtained from previous trial accept.	00.40	04.11		
		00.32	03.29		
		00.24	02.46		
		00.16	01.64		
		08.62	88.50		
	Total	09.74			
Capacity (T/D)					

Testing : Fiber content of manually screened pith

Trial date : 05.01.07

Samples : direct to separator samples, screened bagasse through disk mill at 4mm

Fraction	Direct separator	Direct separator (Percentage)	Screened bagasse through disk space of 4mm gap	Screened bagasse through disk space of 4mm (Percentage})
1	0.78	5.99 %	0.40	13.79 %
2	0.66	5.07 %	0.26	8.97 %
3	0.40	3.07 %	0.16	5.52 %
4	0.32	2.46 %	0.12	4.14 %
5	10.86	83.41 %	1.96	67.59 %
Total	**13.02**		**2.9**	

<table>
<tr><th>Fraction</th><th>Screened bagasse through 4mm disk space (Kg.)</th><th>Percentage</th><th>Total (Kg.)</th><th>Percentage</th></tr>
<tr><td>1</td><td>0.40</td><td>13.79 %</td><td></td><td></td></tr>
<tr><td>2</td><td>0.26</td><td>8.97 %</td><td rowspan="2">0.42</td><td rowspan="2">14.48 %</td></tr>
<tr><td>3</td><td>0.16</td><td>5.52 %</td></tr>
<tr><td>4</td><td>0.12</td><td>4.14 %</td><td rowspan="2">2.18</td><td rowspan="2">75.17 %</td></tr>
<tr><td>5</td><td>1.96</td><td>67.59 %</td></tr>
<tr><td>Total</td><td>2.9</td><td></td><td></td><td></td></tr>
</table>

Fresh bagasse was first feed to separator and accept was subjected to disk milling followed by separator. The trial shows that nearly 16 % pith is removed by separator only. Results of disk milling are awaited.

UPGRADATION OF BAGASSE THROUGH ADVANCE DEPITHING PROCESS

The test was conducted in following manner

(1). Manually Screened : Whole bagasse was passed through 10 mesh wire sheet manually.

(2). Disk Mill Out Let (4mm) : whole bagasse was passed through disk clearance 4mm.

(3). Separator Out let : the outlet of disk mill was supplied to separator.

S. No.	Samples	Free Pith %	Embedded Pith %
1.	Manual Screened	20.02 %	6.90 %
2.	Disk Mill Out Let	22.22 %	4.58 %
3.	Separator Outlet Accept	1.40%	4.50 %

1) The results were shown that whole bagasse contains nearly 7.00 % embedded pith and 20 % free pith.

2) Disk mill outlet contains 22.2 % free pith and 4.5 % embedded pith. This shows that 2.2 % embedded pith has been removed during disk mill at 4mm clearance.

3) Separator outlet shows that it contains 4.5 % embedded pith which is close to disk mill outlet. This express that separator has no effect on embedded pith.

EXPERIMENT –
STUDY ON PRE TREATMENT OF FRESH BAGASSE PRIOR TO DISK MILLING OPERATIONS

In an effort to reduce the input load on the present pilot machine so as to aim at getting an increased throughout put, the fresh bagasse was initially pretreated by passing it through the separator. The accept fraction of this experiment was subsequently treated in the Disk mill at the clearing of 4 mm. The results are placed hereunder.

Test : Free & Embedded Pith
Samples : Fresh Bagasse, Accept sample direct to separator (40 rpm separator brush speed)

SAMPLES	PITH CONTENT	
	FREE PITH	EMBEDDED PITH
Fresh bagasse	32.71 %	6.00 %
Direct to separator accept at 40 rpm of separator brush speed.	17.86 %	8.00 %

The sample labeled fresh bagasse is the control sample of the untreated fresh bagasse as received from the paper mill. The total bagasse content of the sample is about 38%, out of which the free pith is 32.71% and the embedded pith is about 6%.

As a second step to the experiment, the fresh bagaase as described above was pre treated in the separator prior to being subjected to disk milling .

IMPROVEMENT IN DESIGN OF THE ELEMENTS OF THE PRESENT PILOT PLANT.

After going through the preliminary results obtained during the depithing operations, it was felt that the present design needed to be changed and upgraded so that it is fine tuned for the use with fresh bagasse as obtained after the crushing operations.

DESCRIPTION

The process of this invention presents a new, highly efficient system for the processing of bagasse, a waste leftover from the crushing operation in the sugar industry, so as to obtain a fibrous bagasse portion having a residual pith content of no more than 10%

The schematic diagram of the depithing process as proposed in the new improved design is given in figure 1. The same is also depicted in the schematic diagram – 1. At the outset, the bagasse obtained either directly from the crushing operations in the sugar mill or from a storage yard in the paper/sugar mill is put in to a vibratory hopper A fitted on top of a conveying system, such as a conveyer belt C. If desired, a magnetic separating system may be placed above the conveyor belt to remove any metal contaminants from the bagasse. The function is important if de - bailing operations are used as no metallic impurity should be allowed to enter the system. However, in case the machine is used at the sugar mill site and there is no possibility of metal intrusion, the same can be dispensed with.

The conveyor belt C, driven by the motor B leads the whole bagasse in to a screw conveyer (at D) on top of the disk mill . The material comes off the conveyor belt and falls in to the small screw conveyer, which feeds the bagasse in to the disk mill (E) by gravity. After the treatment, the siftable material obtained is led in to a cyclone F, which separates out the fines and dust obtained during the process. The outlet of the cyclone bottom is fed in to the sifting device G directly. It may be mentioned that in case the operations are being carried out at a sugar mill site, the use of the cyclone may not be done as the treated material can be made to pass in to a silo or a storage heap as such a space is normally available at sugar mill sites.

The treatment chamber of the disk mill consists of a pair of vertically mounted metallic disks to which the bagasse is fed at a constant rate, which can be adjusted as per the need of the raw material, i.e. based on the gap between the disks and the moisture content of the input bagasse. One of these disks is stationary and the other is rotary. The balanced rotating disk is mounted on a shaft with a friction brush assembly. The shaft is mounted in a cast iron housing supported by double ball bearing. The stator and rotor disks are crafted to hold the elements in place by the use of two counter sunk screws per element. The rotor disk (figure edr) is edr11 cm in diameter having a thickness of edr4 cm the provision of holes with suitable diameter for two counter sunk screws to fit the grinding elements. All the other dimensions shown in figure edr have been proportionated to ensure the best fit of the grinding elements on the disks, the proper entry space of the raw material in to the disk, the fitting of the shaft and the insertion of an impeller with curved veins to push the bagasse towards the disk gap for defiberization.

The stator disk (figure eds) is similar to the rotor disk in all respects save the fact that it has a central circular hole of (eds5 cm).

The side view and the front views of the two disks mounted on a shaft using suitable matching base supports in a casing are depicted in figure E. The dimensions of the same are indicated on the figure. The inlet with a diameter of e4 feeds in the material to the disks. The outlet of the disk mill is e7 cm long and e13 cm broad. The other dimensions are proportioned for the machine stability and smooth operation.

There are specially designed milling component fixed along the periphery of both the disks. Each of the milling component is fixed on to the disk using a groove-screw method at two places.

The diameter of the disks and the size of the milling component fixed on the disk are a function of the size and throughput desired from the equipment/set up. The disks are mounted inside a housing that can be opened as and when required for cleaning and servicing purposes. In any case one milling component is placed at every α ° on the disk. (Figure – ede1). The length and width of the milling component is fixed to an optimized scale, depending on the diameter of the disks which may be increased to fabricate a larger machine.

The gap between the rotating and the stationary disk is adjusted by means of a mechanical system. The said gap is optimized to give maximum performance and is varied with respect to the quality, type and moisture content of the raw material being used for depithing. The whole assembly of the disks and the gap adjustment mechanism are mounted on a suitable welded steel profile frame.

The incoming raw material is forced in to the disk gap evenly with the help of a specially designed impelling surface connected with the base of the shaft (figure 3). The diameter of the impeller (figure id) fit on the rotor is (id5 cm) with curved veins put at an angle of b degrees. The length of each of the curved blades on the impeller is (id2 cm). The curvature of the impeller blades subtends a radial angle of (rd1°). The width of each impeller blade is (ib1 cm).

The raw material is subject to mechanical action by the milling components on the rotating and fixed disks. Each of the grinding elements (figure ede) are ede1 cm in width at the top and ede3 cm at the bottom. The elements are ede2 cm having two sunk screw holes at appropriate distances with internal and external diameter of edei and edeo cm respectively. The distance between two successive edges on each element is ede4 cm and the top edge of the same is ede5 cm. The depth of the groves in the elements is ede8 cm . The angle between two successive groves is edeta degrees . There are two sets of grinding elements. One set of elements have the groves parallel to the left edge of the element and the other has groves parallel to the right of the element, at an angle plus or minus edela degrees as the case may be. These are used on the rotor or stator as per need, optimally the elements with the same inclination of the ridges are on the same disk. The stator and rotor disks are crafted to hold the elements in place by the use of two counter sunk screws per element.

During this process, the necessary action is given to the bagasse, so that maximum pith is dislodged with minimum effect on the quality of the fiber i.e. the design of the elements is so optimized so as to impart maximum brushing action and the least cutting action to the bagasse fibers. After this process, the treated bagasse comes out of the disks and falls down under the influence of gravity. The extent of grinding is determined by the type and the nature of the feed raw material, its moisture content, the distance between the surfaces of the disks, the design on the surface of the milling components.

After the milling action, the treated siftable substrate comes out of the system due to the centrifugal force and falls downwards under the influence of gravity. However, this mass has a considerable velocity which needs to be reduced for further processing. Hereinafter there can be two ways of handling the substrate. If the processing is being done in a sugar mill, where the bagasse is relatively wet, the siftable material may be let in to a silo where the material is collected and led in to the sifting device, viz a brush auger separator.

In case the device is to be put up in a small area and if the bagasses is relatively dry, it is desirable to use a suitably designed cyclone after the disk mill, which not only acts as a pressure reducing device but also separates out the very fine dust from the material.

Subsequent to the above, the siftable bagasse is made to fall in to a specially designed apparatus/equipment consisting of a brush auger and sieves which separates the pith from the fibrous portion of the bagasse.
In this apparatus/equipment, (figure G) the treated bagasse is made to pass over a series of sieves with the help of an endless rotating auger brush, which cleans the screens / sieves as it moves the treated material above them, thereby aiding effective separation of the pith and the fiber. The assembly is g1 cm high and g2 cm broad. The outer casing of the auger brush is (g7 cm) in diameter and the diameter of the brush is (g8 cm). There are three outlets to the bottom of the assembly. There is a provision for fitting of screens in the bottom of the assembly as per need. The openings of the screens used have been optimized in diameter and length. from the material inlet to the outlet.

The endless brush is propelled by a suitable motor. 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. The positioning of the sieves and the opening per linear inch is optimized to separate out the pith from the fibrous portion of bagasse.

It may be mentioned that the method described above is a major improvement in the conventional methods for the depithing of bagasse. As of now, conventional methods such as dry/moist depithing and combination of moist and wet depithing are used to separate the pith from the bagasse. At best, these methods are able to give a clean raw material which still has a residual pith content of not less than 12% , and that too by using the best commercial technology available today, i.e. the combination of dry and wet depithing, involving two operations. In this case, the other disadvantage is that the pith obtained as a wet slurry is difficult to be disposed off creating a sever problem of pollution.

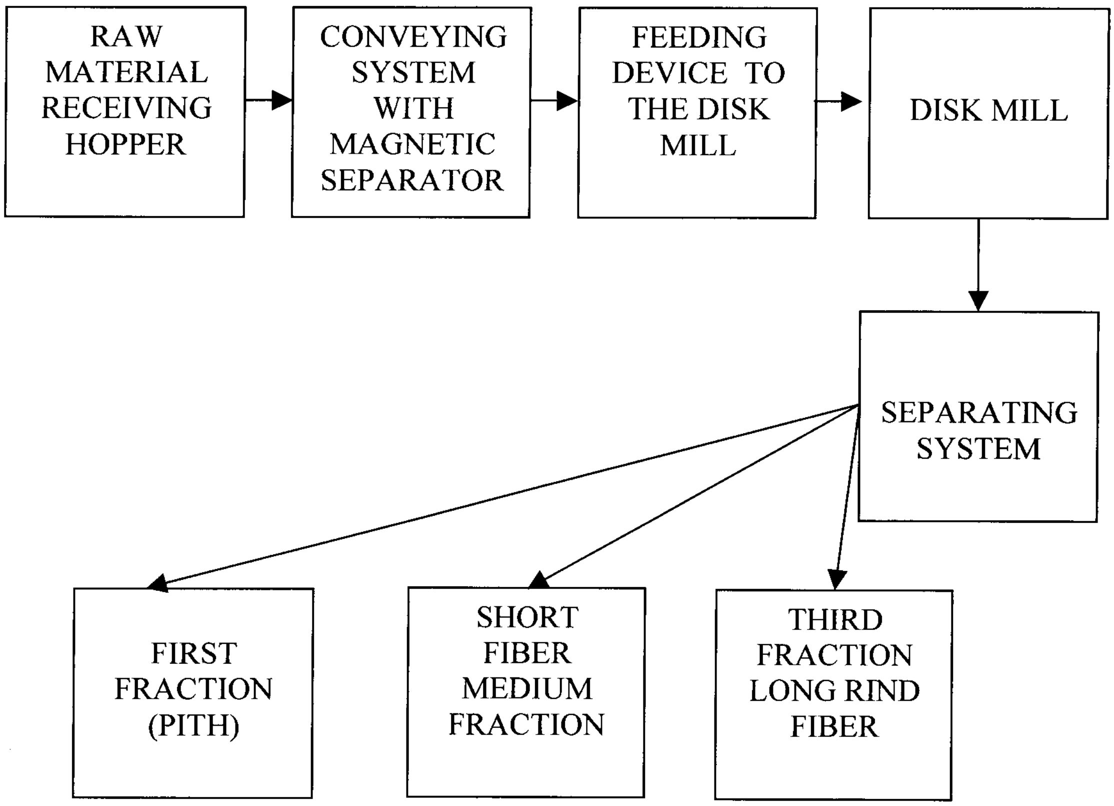
SALIENT DESIGN IMPROVEMENTS IN THE DISK MILL AS COMPARED WITH THE ORIGINAL DESIGN

ORIGINAL DESIGN	NEW IMPROVED DESIGN
The machine is specifically for the method and device for milling grains.	The present device and method is specifically for the treatment of cereal straws, particularly bagasse. The design of the treatment / grinding elements has been optimized for the use in cereal straws, particularly bagasse. The difference in the design of the grinding elements are as follows: 1. The elements are longer in our case by about two times and having two counter sink screws as against one in the prior art to improve the stability of the element. The elements are designed in order to provide the required action on the bagasse, which is different from the requirement of treating the cereal grains in the prior art. (measuring 8.74 cm as against 4.5 cm. The lower length of our elements is smaller at 391 mm as against 500 mm.)

	2. The top width of our elements is twice as compared to the design in the prior art (at 2.0 mm.). The teeth are more flat than the prior art in order to decease the cutting action and increase the brushing action of the elements. 3. The top gap of the teeth in the grinding elements is more by a factor of 1.4 (2.5 mm as against 1.8 mm.) 4. The depth of the grooves is more in our case by a factor of 1.4 (at 1.75 mm as against 1.25 mm.) The factors at 2,3, and 4 are designed to increase the through output and material flow through the system, side by side decreasing the cutting action of the fiber.
The present machine uses an impelling system which consists of parallel impelling leaves.	The improved design carries a specially designed curved impeller to increase the throughput put of the machine. The veins of the curved impeller are placed at 60 degrees with an arc radius of 42 mm

FIGURE – 1

FLOW SHEET OF THE PROPOSED NEW PROCESS OF DEPITHING OF BAGASSE



MEMORANDUM OF UNDERSTANDING WITH M/S BAJA ECO PRODUCTS LTD., A SUBSIDIARY OF BAJAJ HINDUSTAN LTD.

Consequent upon the results being obtained on the pilot depither at CPPRI, retrofitted and optimized in design for optimum depithing on a continuous basis, a need was felt for an industrial partner who would be interested in collaborating with CPPRI to develop a full scale depither that could be used on a commercial scale. To this effect, the institute was approached by M/S Bajaj Eco Products Ltd., (BEPL)a subsidiary of M/S Bajaj Hindustan Ltd., the sugar major of India, who were interested in a technology that could depith the bagasse on a manner more efficiently than the present arts.

As a result of the negotiations, a Memorandum of Understanding was entered in to between the institute and M/S BEPL, wherein the two parties agreed to jointly work towards the development of the commercial scale machine. A copy of the duly signed MoU is attached in annxure –

INTELLECTUAL PROPERTY RIGHT APPLICATION

The institute has filed a patent to protect the rights of the institute for the use of the new technology developed for the efficient depithing of bagasse. The technology has been taken up for the purpose of patenting through the Patent Facilitating Cell of the TIFAC, Department of Science and Technology, Government of India.

The patent has been review by the screening committee and has been allotted the application number dated .

PROJECT TEAM FOR STATISTICS

1. **Principal Investigator : Dr. R. K. Jain**
2. Co- Investigator : Dr. K. Singh
3.