Cleaning of straw by straw treatment plant

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ABSTRACT

Due to shortage of wood & bamboo and also due to ecological reasons, the main raw materials for paper making in India will be non-conventional raw materials particularly agriculture residue like straw, bagasse etc. These raw materials, however, have some shortcomings inherent to them. One of the shortcomings is the presence of large amount of non-fibrous material, like pith in bagasse and high silica content in straws, particularly rice straw Also, straws have lot of other portions not suitable for paper making like leaves, nodes, grains etc. So, these raw materials must be given some treatment to remove undesirable materials prior to pulping to reduce the chemical consumption, during pulping to make them more suitable for making paper both ordinary and also high quality and also to improve black liquor characteristics from recovery point of view. In addition, this cleaned straw can be used for making Particle Board. Bagasse is already being depithed to get rid of pith but there is no treatment for straw to remove silica, dust, wax on epidermal layer, nodes, grains, leaves and husk etc.

In this context, an attempt has been done to clean the agroresidue raw material by dry cleaning treatment in a suitable plant called 'straw treatment plant/Disk mill unit' which can clean straw by separating undesirable materials and can also depith bagasse. The results of the various trials performed with rice straw for the purpose of removing silica and other undesirable material have been presented

Introduction

The present estimated total demand of paper and board including newsprint is about 25 lac tonnes and will increase to about 41 lac tonnes by 2000 A.D. Table-1 indicates the gap in paper production for which extra raw material is needed, considering no extra growth of forest based raw material. So in future there will be more dependence on non-conventional raw materials like straw, bagasse etc. But there are certain drawbacks with these raw materials in

TABLE No. 1

The Amount of Raw Material that Need to be Mobilised in Future[1]

(Lakh tonnes)

Year	Raw material Available			Demand for paper, paper boards & Newsprint	Paper that can be produced	Gap in production for which extra raw material is needed
	Bamboo	Wood	Total			
1987	19 0	13.1	32.1	21.05	12.11	8.94
1990	19.0	13.1	32.1	24.45	12.11	12 34
1995	19.0	13.1	32 1	31.61	12.11	19.50
2000	19.0	13·1	32.1	41.12	12.11	29.01

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addition to short fibers. Bagasse contain about 30% pith which must be efficiently removed to make it more suitable for paper making. Similarly straw contain lot of silica & undesirable portion like leaves, grains, husk etc. which create problems in the process of paper making and chemical recovery. If this silica & other undesirable materials can be separated in the raw material preparation, it will be much better from pulp and paper making point of view and will also improve the black liquor characteristics from chemical recovery point of view. The Straw Treatment Plant is a set of equipments which can clean straw efficiently and can also depith bagasse by mechanical treatment. This milling system converts non-homogeneous raw material into fractions that are chemically or physically homogeneous to improve the quality of these raw material.

Various trials to upgrade raw material for paper making were performed with rice straw for cleaning purpose and satisfactory results had been obained in removing silica and other undesirable material like leaves, nodes and husk etc.

Description of the Straw Treatment Plant :

The disk mill plant had been supplied by M/s. United Milling System A/S, Copenhagen, Denmark. They have designed it to separate straw into its two fractions viz internode fraction which can be used for cellulose or particle board industry and mill fraction consisting leaves, nodes, and chaff etc. which can be use for feeding purpose.

The various components of the Disc Mill Plant which is shown in Fig. 1 are :

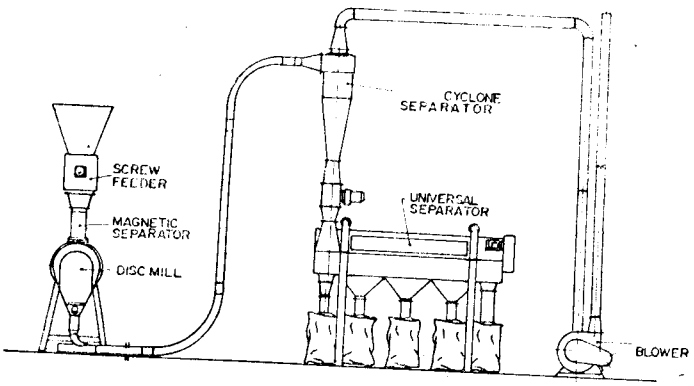


FIG.1, STRAW TREATMENT PLANT

1. Screw Feeder
2. Magnetic Separator
3. Disc Mill
4. Fan and cyclone separator
5. Universal separator

Screw Feeder :

It is installed at top of Disc mill to provide constant volumetric feed rate to disc mill. Its speed can be regulated.

Magnetic Separator

This is fixed at the inlet of disc mill. It consists of permanent magnet to remove iron pieces which otherwise will damage the disc surface.

Disc Mill

This is a high quality grinding machine consisting of a pair of vertically mounted grinding and dehulling discs, one stationary and one rotating. The grinding discs are exchangeable and made of steel and the grinding surface is mounted with exchangeable grinding elements made in wolfram carbide. Each disc has 24 grinding elements, each fastened in a groove in only the outer periphery of the discs. The inside and outside diameter of circular grinding surface are approximately 384 mm & 482 mm respectively & diameter of disc is 510mm. The balanced rotating disc is mounted on the shaft with a friction bush assembly. The shaft is mounted in a cast iron housing on double spherical ball bearings. The grinding house is made of cast iron. The motor is with pulleys and V-belt drive and the motor sledge is enclosed by sandwich constructed steel plates.

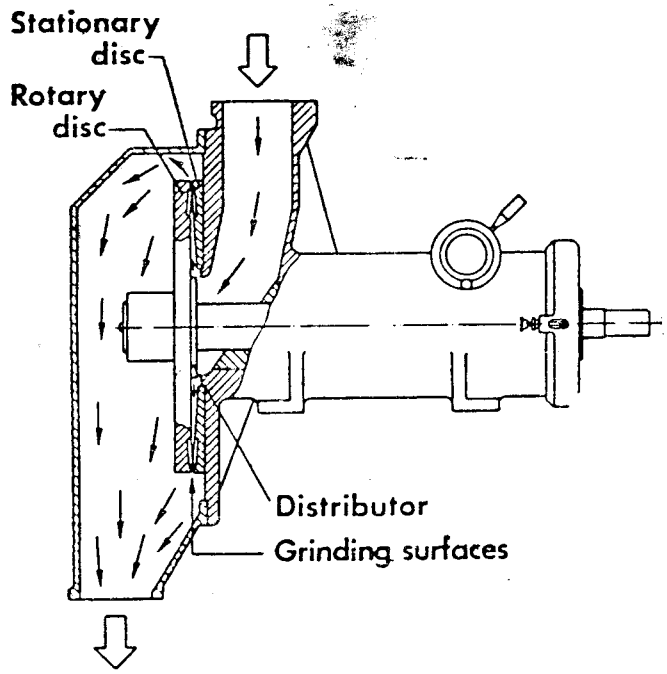
The grinding gap is adjustable by means of a dial hand wheel mounted on the basic house. All are mounted on a rigid welded steel profile frame.

Working Principle

The grinding takes place between the grinding surface of a rotary and a stationary disc. The process involved is as described below and illustrated in Fig. 2. The raw material enters the machine through the top positioned inlet and falls/slides directly into the centre of the milling chamber. In here the raw-material stream is met by a distributor mounted in the

center of the rotating disc. This distributor evenly feeds the material out between the whole periphery of the inner most part of the circular grinding surface of the two discs Well caught between the grinding surfaces the raw material is gradually grinded while passing through the grinding areas by the centrifugal force created by the rotating disc. Finally being thrown out from the grinding area the grinded material falls down by gravity,

FIGURE-2



The grade of grinding is dependent on the distance (adjustable) between the grinding surfaces of the stationary disc, their angles and also on pattern of grinding elements; the narrower the distance, the finer the fractions and vice versa.

Blower and cyclone separator :

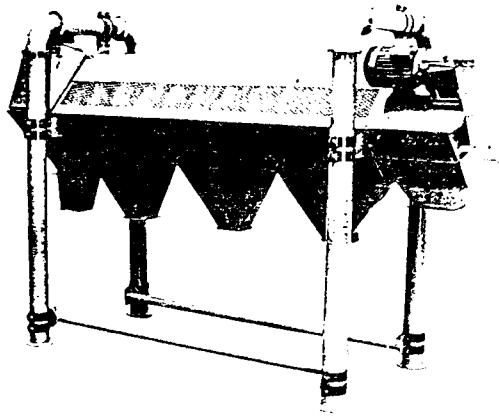
It consists of high pressure centrifugal fan for pneumatic conveying of the grinded material. The grinded material is sucked through the high efficiency cyclone. Cyclone is used for elimination of fine grained particles & dust. The fine grained particles & dust are removed from top via fan and required material passes from bottom outlet through rotary valve to universal separator.

Universal separator :

The universal separator is an advanced U–shaped trough with inlet and out let and supplied with a brush auger. It is used for the purpose of cleaning and separating different fractions (Fig 3.)

FIGURE-3

Universal Separator



for cleaning and separating purposes

The material to be separated is led past the screen area by the brush auger. On the way through the screen, materials with the same structure as the hole size are separated. The remaining material leaves the separator through the outlet at the end of the screen. The screen area consists of 1 to 4 screens where the hole size gets bigger, the nearer you come to the outlet. Now it is fixed with 1.0 mm screen above first and second outlet and 1.6 mm screen above third and fourth outlet.

The separator is supplied with an independent outlet for each screened size. The separated material can be bagged off directly or taken via a cell sluice for further conveyance. Otherwise it can be taken to a place for storage by means of the suction blower.

This separator is having following advantages.

- Can separate materials having nearly the same specific gravity.
- The screens are easy to replace as per the nature of materials and cleaning rates.
- Many adjustment and combination alternatives.
- Can separate up to 4 gradings at a time.

Precautions :

1. The raw material must not contain moisture above 15% otherwise efficiency of milling will be decreased due to jamming.
2. Raw material should be free from hard foreign particles otherwise they will damage the disk surface.
3. There must be no material between disks while starting the plant otherwise the friction thus added to the discs may be so high that the motor will be overloaded.

Advantages of Pretreating straw :

Straw from various sources is a non–homogeneous raw material. It consists of three major botanical components (Fig 4).

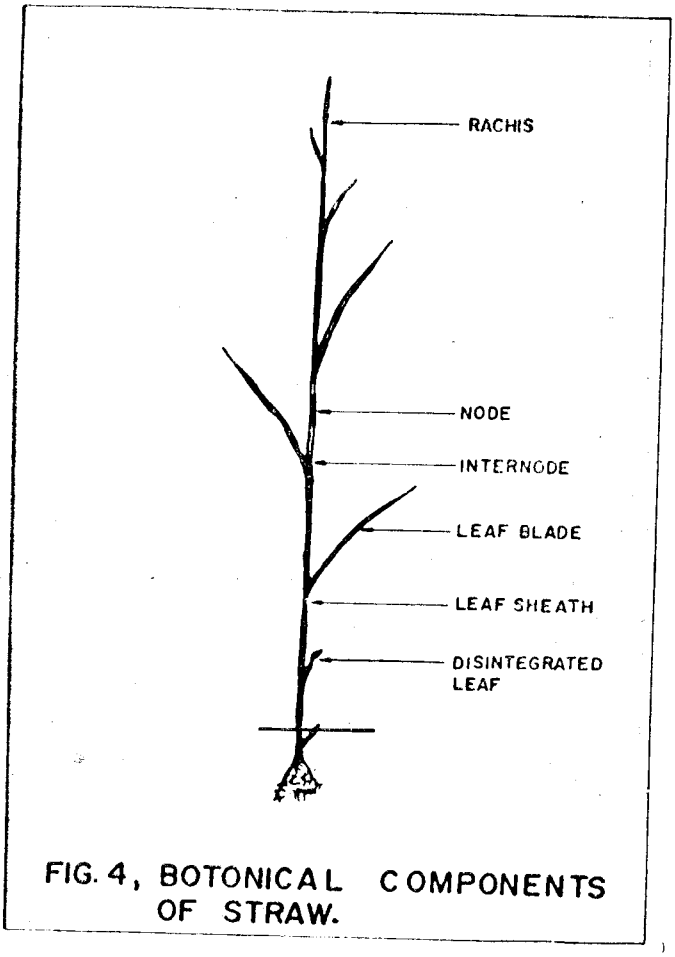


FIG. 4, BOTONICAL COMPONENTS OF STRAW.

1. Nodes.
2. Leaves
3. Internodes and

also have wax on epidermal, rachis or pod at top consisting grain & also husk. The percentage of these components for particular rice straw of Indian variety are given in Table 2. The percentage silica and ash in these fractions is also given.

These components of straw have different physical strength properties. The leaves are very fragile, the inter nodes on the other hand are very tough and strong. It is well known that the botanical components also differ in chemical composition. The internode has a high c ntent of cellulose while the leaves and nodes have a higher content of ash, protein and silica.

Thus, the internode fraction is the fraction of high quality as raw material for cellulose industry since it has a higher content of cellulose, relatively higher average fiber length, a lower content of ash and very important, a low content of silica as compared to other components of straw. The content of silica in straw is much higher than that in wood and so straw fractions obtained after pretreatment in disc mill with a low silica content would clearly be of high value from point of view of black liquor recovery and subsequent paper making process.

Secondly, the non-fibrous portion obtained after pretreatment has a higher mineral content (silica), coarser fiber, contain more protein, and has a high digestibility for animal feed.

Thus from technical point of view the value of straw as raw material for the industry can be increased by separating it into its botanical components and this job is done by straw treatment plant or disk mill by mechanical separation of straw material into accept for paper making and in this way major fraction 60–70% will be low in silica and nonfibrous material and thus will be suitable for paper making process including black liquor recovery and meal fraction can be converted to :

— Fuel

— Fodder

So, the main advantage which will be achieved by cleaning straw by Disk Mill can be summarised as :

1. Less chemical consumption due to removal of non fibrous material.

TABLE No. 2

Average Botanical Components (% W/W) of Rice Straw and Ash & Silica Content in Components :

Component	% of Component in Straw (w/w)	% Ash in Component	% Silica in Component
Pod/Rachies	5.00	13.45	8.87
Leaf+Leaf Sheath	45.00	15.84	11.10
Interndes	40.00	12.97	4.80
Nodes	9.00	15.47	11.16

2. Less solid waste generation during pulp and paper making process.
3. Improvement in paper properties.
4. Improvement in properties of black liquor.

Disadvantage

The main disadvantage of the straw treatment plant is that raw material must not contain moisture more than 15% and no foreign particles must be present.

Results and Discussion :

Dried and chopped raw material was treated in a Disc Mill with different disk clearances between the discs The milled mass was sieved first using 2 mm screen in separator into five fractions. The percentage yield as shown in Table 3 was very low (assuming 3rd, 4th and 5th fractions as accept) and so, no ash and silica determination was made for this lot. Of course, considering the internode fraction which consist only 40 percent, this is all right but practically it is very

TABLE No. 3

DISK MILL TRIAL NO. 1.

Disc Mill clearance	:	1.0 mm
Disk Mill angle		
Rotary	:	2.5^0
Stationary	:	2.5^0
% Ash in unprocessed straw	:	—
% Silica in unprocessed straw	:	—
Any other remarks	:	Chopped by conventional chopper to about 1" length

Fraction	% Fraction (wt %) on whole material processed.	% Ash in Fraction (o. d. material basis)	% Silica in Fraction (o. d. material basis)
No. 1 (Reject - 2mm screen)	30.00	—	—
No. 2 - 2 mm screen	16.00	—	—
No 3 - 2 mm screen	6.00	—	—
No. 4 - 2 mm screen	3.00	—	—
No. 5 Accept	46.00	—	—

TABLE NO. 4
DISK MILL TRIAL NO. 2

Disc Mill clearance	:	0.65 mm
Disk Mill angle		
Rotary	:	4.0^0
Stationary	:	4.0^0
% Ash in unprocessed straw	:	14.84
% Silica in unprocessed straw	:	08.49
Any other remarks	:	Chopped by grinding machine with 30 mm screen

Fraction	% Fraction (wt %) on whole material processed.	% Ash in Fraction (o. d. material basis)	% Silica in Fraction (o. d. material basis)
No. 1 (Reject -1.0 mm screen)	24.00	16.59	14. 02
No. 2 -1.0 mm screen	09.00	15.15	12.31
No. 3 -1.6 mm screen	10.00	14.62	07.08
No. 4 -1.6 mm screen	03.00	14.32	07.01
No. 5 Accept	54.00	13.30	05.48

TABLE NO. 5
DISK MILL TRIAL NO. 3

Disc Mill clearance	:	0.5 mm
Disk Mill angle		
Rotary	:	2.5^0
Stationary	:	2.5^0
% Ash in unprocessed straw	:	15.49
% Silica in unprocessed straw	:	08.11
Any other remarks	.	Chopped by conventional chopper to about 1" length

Fraction	% Fraction (wt %) on whole material processed.	% Ash in Fraction (o.d. material basis)	% silica in Fraction (o d. material basis)
No. 1 (Reject —1.0 mm screen)	13.40	18.05	15.00
No. 2 —1.0 mm screen	02.80	15.14	12.33
No. 3 —1.6 mm screen	04.90	15·05	10.60
No. 4 —1.6 mm screen	02.60	14.98	07.66
No. 5 Accept	76.30	14.28	06.12

low & at this low yield no mill will be interested. Then, sieve was changed to 1 mm screen over 1st and 2nd outlet and to 1.6 mm screen over 3rd and 4th outlet. Three trials were conducted under these conditions of screen but with variation in disc clearance and angle. The percentage of different fractions and ash and silica percentage on o.d. material basis in given in the tables 4, 5 and 6 for different disk clearances.

TABLE NO. 6

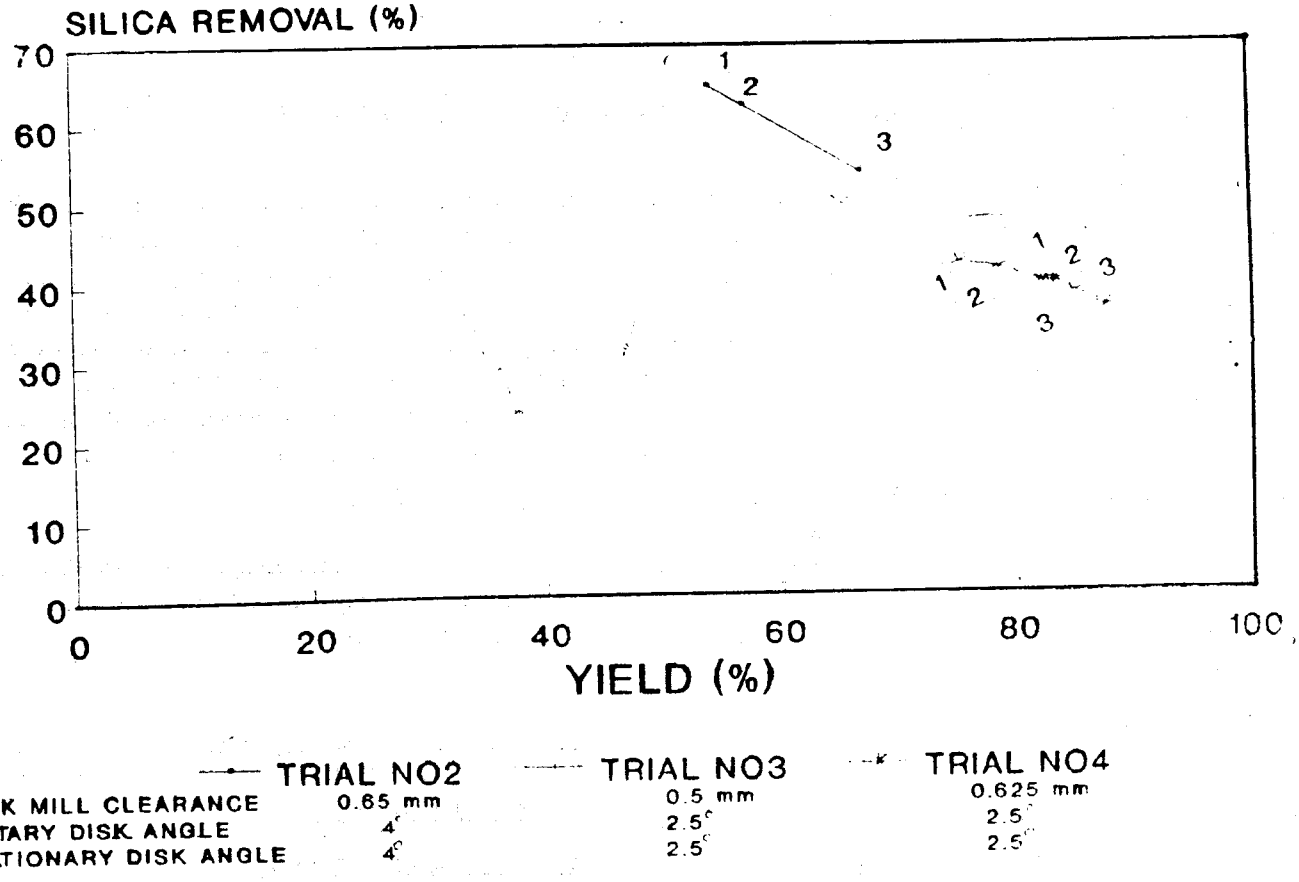
DISK MILL TRIAL NO. 4.

Disc Mill clearance : 0.625 mm
Disk Mill angle
Rotary : 2.5°
Stationary : 2.5°
% Ash in unprocessed straw : 16.00
% Silica in unprocessed straw : 08.21
Any other remarks : Chopped by conventional chopper to about 1" length

Fraction	% Fraction (wt %) on whole material processed.	%Ash in Fraction (o.d. material basis)	% silica in Fraction (o. d. material basis)
No. 1 (Reject -1.0 mm screen)	12.00	18.05	15.03
No. 2 -1.0 mm screen	02.00	16.36	13.21
No. 3 -1.6 mm screen	03.50	16 00	12.29
No. 4 -1.6 mm screen	00 5	14 09	08.00
No. 5 Accept	82.00	14.80	06.18

FIGURE A: SILICA REMOVAL V/S YIELD (WITH DIFFERENT TRIALS)

POINT 1 => 5TH FRACTION ONLY AS ACCEPT
POINT 2 => (4+5)TH FRACTION AS ACCEPT
POINT 3 => (3+4+5)TH FRACTION AS ACCEPT



	TRIAL NO2	TRIAL NO3	TRIAL NO4
DISK MILL CLEARANCE	0.65 mm	0.5 mm	0.625 mm
ROTARY DISK ANGLE	4°	2.5°	2.5°
STATIONARY DISK ANGLE	4°	2.5°	2.5°

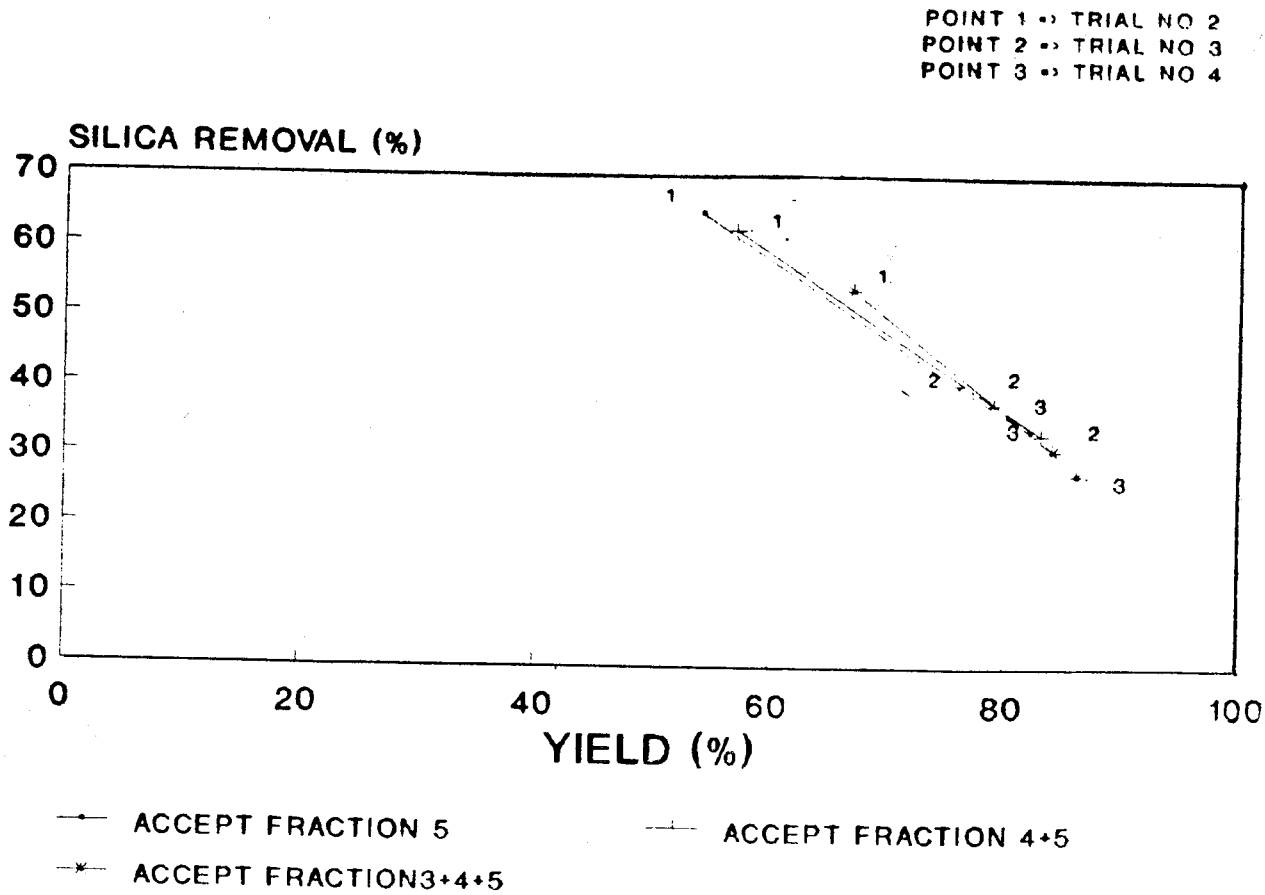


FIGURE B: SILICA REMOVAL V/S YIELD (WITH DIFFERENT ACCEPT FRACTION)

The yield in 2nd trial is lower but % ash and %silica removal is higher than next two trials. From 2nd to 4th trial yield increases but silica & ash percentage removal decreases (see graph of figure A and B). In the 2nd trial straw was cut by grinding mill which generates more dust and fine material so in the next two trials it was cut by conventional chopper.

Thus the results of trials conducted till now shows that there is about 30—50% reduction in total silica content and by observation, it was observed that the desired fraction was free from leaves, grain husk and nodes etc. depending upon treatment. If we desire raw material totally free from leaves, grains etc. then yield will be low and ash and silica removal will be high.

Conclusion

Disk mill is a suitable plant which can be used for both straw cleaning and bagasse dry depithing. This will not only make straw more suitable for paper making considering consumption of chemicals during pulping, quality of paper and properties of black liquor due to removal of undesirable components and silica but provides meal fraction which can be further used as fuel, fodder etc. Various trials performed with rice straw gives satisfactory results about the silica and undesirable material, leaves etc. removal.

Acknowledgements

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