Appropriate Technology For Improving Productivity In Small Paper Mills

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ABSTRACT

In the ever present background of Economic and Energy Crisis, the Indian Paper Industry is keen to improve its over all productivity through a linked programme of (a) Energy Conservation (b) Use of alternative raw materials and (C) Adopting appropriate technology.

For the small paper mills which process Rice straw, Bagasse and Waste paper, the concept of using an appropriate technology is af primary importance in order to achieve good overall productivity.

It is a common practice for small paper mills to process blends of Rice straw, waste paper and Imported virgin pulp today, after the Govt's liberalized policy of imports of pulp.

This paper attempts to high-light the key areas where use of Appropriate Technology for processing of such blends can improve the productivity of small Paper Mills.

Rice straw, used by most small paper mills, is to be given a different treatment in pulping since it is a delicate fibre with low alkali requirement. Different pulping processes such as Soda, Carbonate, Alkaline Sulphite etc. are discussed.

Pulping data and strength characteristies of Old and New Rice straw are discussed. Other features such as wet cleaning, and bleaching sequences, CEH, H_1, H_2, are also critically examined for achieving a good quality pulp.

Important physico-chemical characteristics of straw black liquors and alternative processes for recovery of c hemicals are also discussed in the light of their simplicity and lower capital costs.

For stock preparation, a mild brushing action in disc refiners; additives such as retention aids etc are suggested.

On the paper machine, problems of slow drainage and fluff accumalation on press rolls etc are discussed.

Some data on blends of Rice straw, Waste papers and Imported virgin eucalyptus Hardwood pulp are discussed with some final recommendations.

The survival of small paper mills in the present context of energy and economic crisis depends to a large extent on improving their productivity through a linked programme of :

(a) Energy Conservation.

(b) Use of alternate raw material.

(c) Adopting appropriate technology.

Small paper mills have grown at an astonishing pace in the last few years. Over 50 mills started up in 1979 – 81 alone, and more are on the way. The present situation is not healthy for small paper mills on account of the poor capacity utilization (58 % average only), due to shortage of resources and inadequate financial inputs.

"The concept of appropriate technology is viewed as being the technology mix contributing most to economic social and environmental objectives in relation to resource endowment and conditions of application."

This concept calls for changes in the envisaged industrial growth of small paper mills, with a technology base which is different from what is practiced today.

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It is a common practice for small paper mills to use rice straw and other agricultural residues as the principal raw material. Although the processing of rice straw is a well established technology, its effective utilization depends largely upon the type of product mix used for the end product, i.e. paper, board etc. and the relevant changes or modification adopted in processing stages.

This paper describes the various fundamental and technical espects of processing rice straw, and its blends with virgin pulps from Hardwoods, and recycled print outs. (C. P. O.)

Some specific recommendations are also given for obtaining increased productivity in a small paper mill.

CHARACTERISTIC NATURE OF RICE STRAW MORPHOLOGY

Rice straw differs morphologically from the other agricultural residues in many respects. Table No. I illustrates these differences.

TABLE—I

MORPHOLOGICAL COMPARISION OF RICE STRAW WITH OTHER AGRICULTURAL RESIDUE

Raw Material	Stems or culms %	Leaf sheaths %	Leaf blades %	Nodes etc. %	Grains %	Foreign material %	Fines %
Rice straw	32.4	33.1	16.4	11.9	0.7	0.7	4.8
wheat straw	68.5	20.3	5.5	4.2	1.0	0.2	0.3
Barley straw	58.8	31.5	4.9	1.8	1.1	1.9	.....
Rye straw	68.1	19.8	2.9	7.4	1 3	0.5	.....

The straw stem are erect, elastic and hollow seperated at intervals by nodes. The leaf starting nodes, forms a sheath partway up the stem and ends in a leaf blade.

The bast cells from the intervals are the major part of straw pulp. They are comaratively short and slender with pointed ends. Other than the bast fibres in the straw are the epidermal cells, the platelets, the serrated cells and the spirals all being small and non fibrous material.

It is obvious from the figures in Table No. I that rice straw has more leaf blades and sheaths and less culm than other straws.

Since culm contains most of the strong fibres suitable for papermaking while the leaf material contains short and broken fibres it is reasonable to expect rice straw, if cooked whole to give pulp of lower strength characteristics.

FIBRE MORPHOLOGY

Although rice straw has very short fibres compared to other agricultural residues, its fibre length to diameter ratio is higher than most of them (Table No. II).

TABLE—II

A : MORPHOLOGICAL ASPECTS OF RICE STRAW FIBRE

PARTICULARS	DIMENTION
Length, mm	0.92
Diameter, micron	7.5
Lumen width, micron	3.2
Cellwall thinkness, micron	2.2
Tabular fibre, %	92
Ribbon type,	8

B : FIBER LENGTH DISTRIBUTION, %

0 0	0.57	7.5
0.59	0.86	40.2
0 87	1.14	38.3
1 16	1.43	9.3
1.44	1.72	4.7
1.73	2.00	....

CHEMICAL COMPOSITION OF RICE STRAW

Chemical composition of rice straw compared to wheat straw and Bamboo is given in the Table No. III. The main differences are :

1) Rice straw has more percentage of silica (20–24 %).
2) Rice straw contains less lignin (11–15 %).

Presence of silica and appriciable amount of extraneous material such as grain, husk, levels etc. make rice straw not so desirable for making pulp. However in the light of existing trend of demand and availability of fibrous raw material it appears to be the most suitable raw material for small paper mills. Advantages of

using rice straw are its comparatively lower requirement of chemicals for cooking bleaching and lower energy consumption.

Its availability in many cultivated areas is ample and cost is comparatively lower than the conventional raw materials. Being a residue of a biannual crop its supply is assured.

STORAGE OF RICE STRAW

Like other agricultural residues, rice straw is stored in stacks at the mill yard. Since paddy crop is normally raised only for two reasons namely, Kharif and Rabi, storage of straw for at least six months is necessary to protect from the rain. Generally the top layer of the stack is kept sloping on all the four sides covered with a closely knit layer of straw. Care should be taken to stock only air dry straw, as wet straw in the stock can cause combustion due to biological fermentation.

The effect of storage on quality of rice straw was investigated to assess the degree of deterioration that occurs. It was found that after two years of sotrage a noticeable amount of deterioration takes place. The top layers, more exposed to the weather are naturally more affected.

Table No. IV gives a result of these tests. The results of course, vary depending upon the climatic conditions and geographical areas.

TABLE—III

CHEMICAL COMPOSITION OF RICE STRAW AS COMPARED TO OTHER RAW MATERIALS

		Rice straw	Wheat straw	Bamboo
1	Ash, %	16–22	7–8	3–0
2	Lignin, % (ash corrected)	12–14	16–18	26–28
3	Pentosans, %	19–20	26–30	15–16
4	Hotwater solubles, %	13–14	10–15	4–5
5	Alcohol — Benzene solubles, %	5–6	3–4	2–3
6	1 % NaOH solubles, %	43–44	41–45	22–23
7	Hole cellulose, % (ash corrected)	55–57	67–70	60–62
8	Alpha cellulose, %	35–36	39–40	40–42

TABLE—IV

EFFECT OF STORAGE ON THE QUALITY OF RICE STRAW

Storage period (years)	Fresh	1	2	3
Position of sample in stock	——	Inside	Inside	Surface
Ash, %	17.9	18.2	18.5	19.8
Alcohol–Benzene solubility, %	4 3	4.0	13.5	2.8
1 % NaOH solubility, %	49.0	52.7	53.5	55.0
Lignin, %	12.1	12.6	13.1	15.1
Hollocellulose, %	62.5	58.5	56 3	45.2
Alpha cellulose, %	40.6	39.4	37.5	31.4

RAW MATERIAL PREPARATION

Rice straw is subjected to chopping and dedusting in this section. On account of high silica content of rice straw, the cutter knives dull quickly and sharpening of the knives has to be done more frequently.

Capacity utilization of the chopper is very low due to the bulkiness of straw. Straw has to be compacted before feeding into the choppers. This problem can be taken care of to some extent by making ropes of straw by twisting it at the site before feeding to the choppers using the same technique as is used in coir rope manufacture.

The dusted rice straw loses about 3 – 4 % of its original weight. These losses consist of dust separated at the dusting chamber and grain and sand in the air separation system.

WET CLEANING OF RICE STRAW

The seperation of undesirable materials in the dry cleaning stage is far from satisfactory. Higher percentage of husk, silt, spikes are embeded in the straw. So it is desirable to have a wet cleaning which claims the following advantages.

1) Better bulk density and hence better yield per digester.
2) Lower consumption of chemicals in cooking stage.
3) Good quality pulp because of removal of undesirable materials from the system.

However, the active alkali content of the wet straw charges require careful monitoring to avoid variations between different lots.

The morphological nature of rice straw is discussed before. It is apparent that the leaf portion of the straw is a poor papermaking raw material. The removal is accomplished by taking advantage of the tendency of the leaf fraction to desintegrate into fines when exposed to strong rubbing action. Many modern mills outside India have adopted this system with good resu lt. Some new mills in our country are also going in for removal of leaves by this method.

Figure No. I shows a conventional wet cleaning system. The chopped straw is fed in a continuous pulper. Severe vortex action in the pulper serves to disintegrate the leaf fraction of the straw. Back water is added continuously and also extracted from a screen set at the bottom of the pulper. The water extracted contain a good part of the disintegrated leaf fraction.

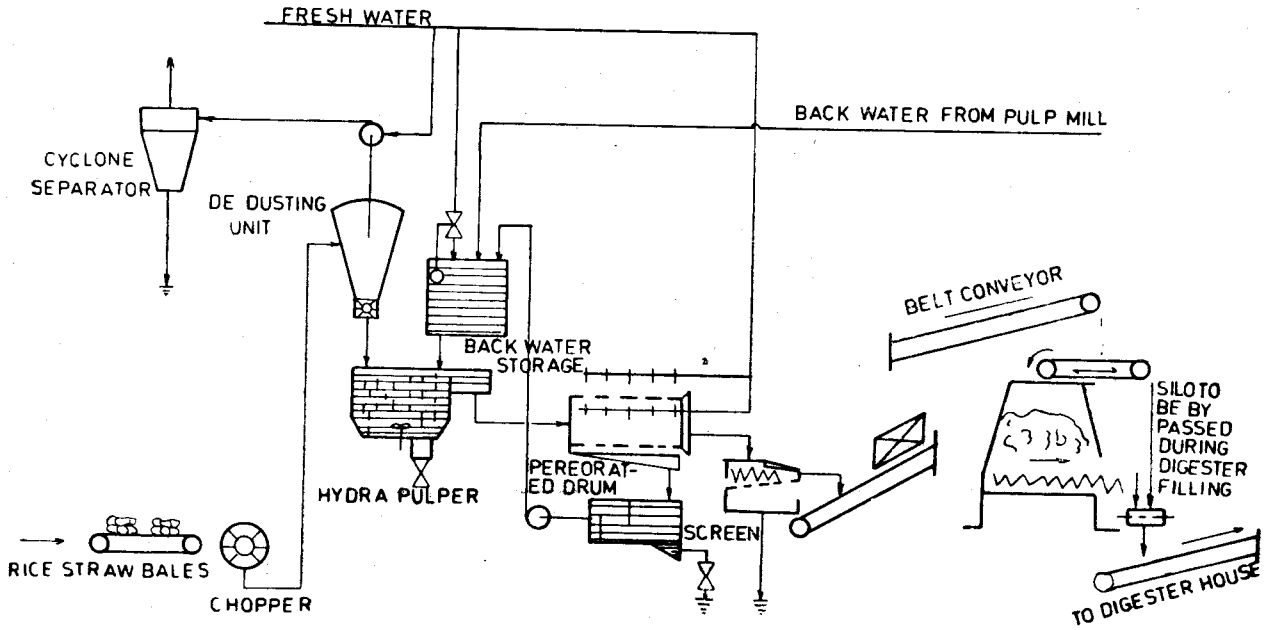
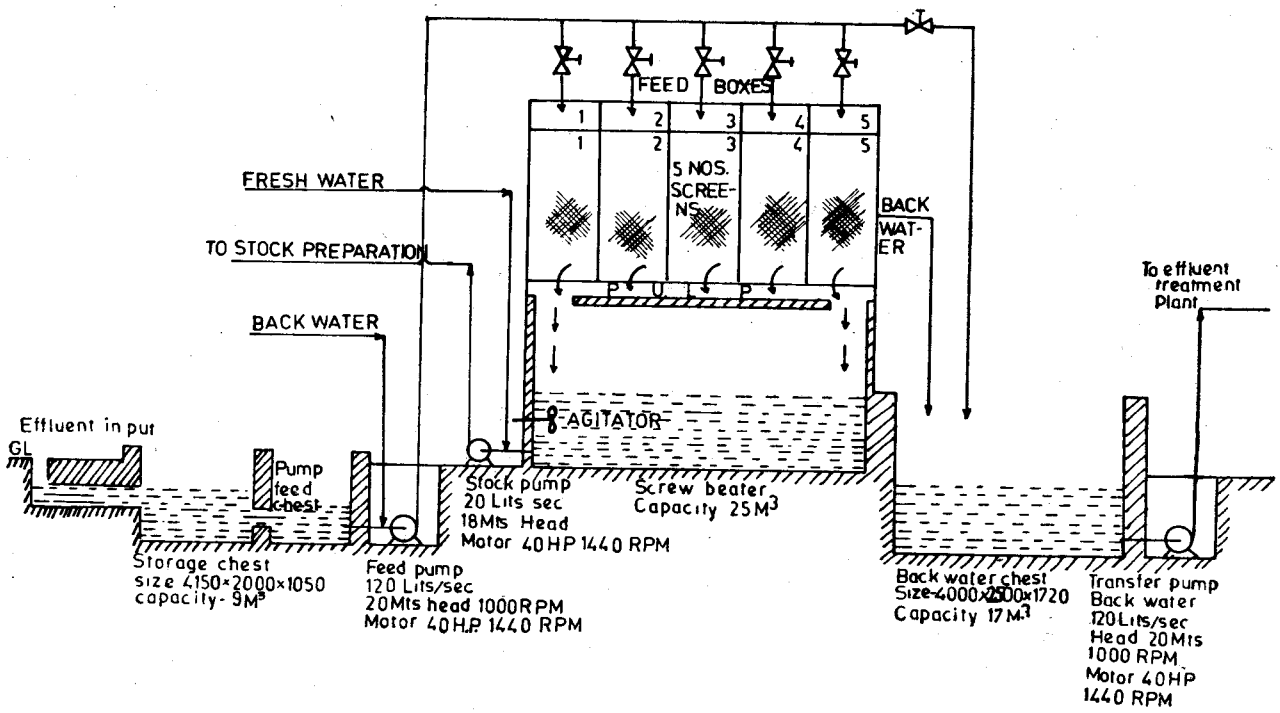


Fig. 1-COMBINED CHOPPING AND WET CLEANING SYSTEM



FIBER RECOVERY SYSTEM

FIG.—II

Buffer storage for wet straw can be done in a false bottomed storage silo with an inverted cone design. Buffer storage is necessary to reduce the charging time into digester

PULPING OF RICE STRAW

Alkaline pulping of rice straw is a well established technology. The influence of sulphidity in straw pulping is less remarkable than in the pulping of woods and Bamboo. In our country most of the mills use batch pulping in rotary digesters using soda process under pressure. Table No. V shows the results of soda pulping process at two bath ratios and also the influence of selectivity of straw (Old and new straw) on the pulp yield and their subsequent strength properties.

TABLE—V

SODA PULPING OF RICE STRAW

Sr. No.	Particulars	Set I	Set II	Set III	Set IV
1	Type of straw	Old	Old	New	New
2	Chemical charge, %	6.5	6 5	6 5	6.5
3	Bath ratio	1:2 75	1:3	1:2.75	1:3
4	Cooking temp., °C	160	160	160	160
5	time to temp., min	90	90	90	90
6	Time at temp., min	60	60	60	60
7	Screened yield, %	46.24	45.52	44.93	43.8
8	Rejects, %	2.9	3.03	4.6	4.8
9	Kappa No.	15.71	15.73	27.40	27.44
10	Residual alkali, gpl	0.62	0.31	0.62	0.31
	Physical strength properties				
11	Bulk	2 45	2.53	2.47	2.55
12	Breaking length, M	3332	2853	2844	3986
13	Tear factor	62.64	65.89	70.20	68.17
14	Burst factor	22.85	17.78	22.97	24.16
15	Double folds	12.0	8.0	13.0	17.0

It is obvious from the table that alkali consumption is better at 1 : 3 bath ratio as shown by the free alkali data after pulping.

Old rice straw has shown higher percentage of screened yield as compared with new rice straw. These datas are irrespective of the bath ratio while all other physical strength properties are comparable between old and new rice straw, the Kappa Nos. are very much higher in case of new rice straw pulp. This indicated that in subsequent bleaching operation the total chlorine demand will rise significantly for new rice straw in order to achieve the required brightness level.

Hence it is recommended that whenever possible a mixture of old and new rice straw may be used for pulping.

MECHANOCHEMICAL PULPING

Mechanochemical pulping is done in Hydrapulpers at atmospheric pressure and at 95°C temperature using caustic soda as a cooking chemical. The advantages of using this process are listed below.

1) Cooking chemical requirement is lower.
2) As the straw and chemicals are subjected to high degree of agitation, cooking cycle is reduced.
3) As the straw is subjected to milder cooking conditions, there is an improvement in the pulp yield due to less degradation.
4) Pulp drains more rapidly because of less generation of fines and it has better strength properties.
5) Inherent silica can be easily removed from the pulp due to lower temperature and rapidity of a cooking cycle.
6) Other contaminants such as nodes, spikes can be easily separated because the treatment causes only swelling of these contaminants to facilitate their subsequent removal by pulp cleaning equipments.

However, in mechanochemical process, following are few disadvantages :

1) High power consumption.
2) Lower opacity of paper

Even though the power consumption per ton of pulp is higher, it is only to an extent of 20%. The advantages of the process, as listed above are quite obvious to offset these disadvantages. Opacity of the paper can be increased by increasing loading materials.

OTHER PROCESS FOR STRAW PULPING

The carbonate process, where a mixture of 40 % NaOH and 60 % Na_2Co_3 is used, also gives pulp of satisfactory strength with 12 % chemical charge.

Sulphite process at a chemical charge of 12% and at 140°C gives a pulp yield as high as 65 %. However the sulphite pulps have lower strength compared to those of the pulps from soda and carbonate process.

In brief, these pulping studies indicate that it is possible to produce satisfactory pulp with milder process conditions because rice straw is much easier to pulp. The open structure and thin walls of the straw presents a large initial surface for chemical attack and minimise the problem of diffusion encountered with all other pulp woods. The pulping reaction is therefore rapid and chemicals required for the pulp productson are lower than with other raw material.

However, the pulp from different pulping processes do not show any remarkable variation in the strength properties.

WASHING AND SCREENING

After cooking the pulp is stored in either blow tank in case of pressure cooking or in stock chests when mechanical pulping is done. The difficulties encountered in the washing of rice straw pulp are mainly due to :

1) Higher slowness of pulp (usually 200—250°CSF) because of high content of fines (fraction passing through 200 mesh is 50 — 60 %).
2) High silica content of black liquor which partly precipitates in the filter screens and suction pipes forming scale, thus reducing the efficiency of washing.

As a remedy for these problems washing filters with larger capacity which are easy to clean, have to be used. The area required for washing straw pulp is

nearly three times more than that required by bamboo pulp. As a result of practical experience about 1 M^2 of surface area of the washer can wash 1.5—2 TPD of straw pulp.

In case of pressure pulping process, it is necessary to process the stock through deflakers before sending it to screening section. This has been found to be an essential step in order to get better separation of undesirable materials like spikes, nodes, husk etc. in the subsequent cleaning section.

BLEACHING OF STRAW PULP

Wherever possible, it is advisable to use a multi-stage bleaching sequence (Chlorination, alkali extraction and hypo stage) for quality papers. In order to obtain good brightness (77±2) with a high Kappa No. pulp, CEH/CH sequence has to be incorporated, since HH sequence is not capable of giving the desired brightness level even with high chlorine dosage.

Table No. VI shows the studies of different Kappa No. pulps bleached with appropriate bleaching sequence under optimum conditions,

These data show that pulps having Kappa No. above 15 should be treated with CEH sequence, to get a better brightness with less chemical comsumption and shrinkage. While for the pulps between 9-15 Kappa Nos., a CH sequence would be advisible. Pulps below Kappa No. 9 can be treated by an HH sequence which gives moderate shrinkage.

TABLE—VI

BLEACHING WITH CEH, CH AND HH SEQUENCES UNDER OPTIMUM CONDITIONS

Particulars	I (Kappa No. 12.0) CEH Sequence	II (Kappa No. 10.4) CH Sequence	III (Kappa No. 7.8 HH Sequence
CHLORINATION			
Cl_2 added, %	4.5	4 0	——
Cl_2 consumed, %	4.18	3 60	——
Final pH	2.2	2.4	——
ALKALI EXTRACTION			
NaOH added, %	1.2	——	——
Final pH	9.4	——	——
HYPO STAGE I			
Cl_2 added, %	1.0	3.0	5 0
Cl_2 consumed %	0.94	2.64	4 74
Final pH	7.3	6 3	6.8
HYPO STAGE II			
Cl_2 added, %	——	——	3.0
Cl_2 consumed, %	——	——	2.17
Final pH	——	——	7.0
Total Cl_5 added, %	5.5	7.0	8.0
Total Cl_2 consumed, %	5.12	6.24	6.91
Brightness, PV	77.1	78.0	76 3
Shrinkage, %	20.0	14.72	12 8
P.C. No.	5.10	6.42	6.9
Vicosity (CED), Cps	6.2	4.7	4.1

STOCK PREPARATION

Straw pulp requires practically no refining, the refiners here should be used for final adjustments in stock freeness prior to blending with long fibre pulps. For refining of straw pulp, disc refiners with disc patterns should be used only to give brushing action on the pulp.

The stock chests should have good circulation, because slime formation is another acute problem faced by straw based mills. Continuous addition of slimicide will control the slimes to a greater extent.

Addition of retention aids are advisible to improve the retention of fibres on the wire.

PAPER MACHINE

As the vergin straw pulp has low strength properties as compared with other pulps it is necessary to blend straw pulp with other stronger pulp. Table No. VII shows the properties of different blends of pulps.

Imported pulps currently available in the market were processed separately in the laboratory and mixed with rice straw pulp in the beater. Results in Table No. VIII show that when a mixture of Canadian and Spanish pulp were taken separately with rice straw pulp in the ratio of 55% straw pulp and 45% Imported pulp, the resultant physical strength properties are lower than of a same mixture of C. P. O. and rice straw pulp.

In order to meet the strength requirement of a C.P.O. straw mixture (45% : 55%) another formulation with 35% Imported pulp, 10% C.P.O. and 55% straw pulp was studied. This formulation give physical strength properties comparable to those of C.P.O. and straw mixture.

Due to the slow drainage characteristic of straw pulp, the wire table has to be necessarily longer by at least 15-20% over that for bamboo or wood pulp. Also that the wire should be so selected to have more retentlon.

Further more, rice straw paper shrink about 7% compared to 4% shrinkage in bamboo paper. Proper care should be taken in designing of wet end of a paper m/c in this respect.

The following are the few considerations suggested on paper m/c.

1) Addition of good binder to minimise the fluff problem.

2) For trouble free operation of web transfer from wire to first press, it is desirable to have suction pickup arrangement for speeds above 200 m/min.

3) High pressure oscillating showers should be employed on the wire to clean it because fine tends to clog it frequently. Efficient felt cleaning system should also be adopted for the same reason.

TABLE—VII

COMPARATIVE STUDY OF DIFFERENT GRADES OF PULPS

Sr. No.	Particulars	Set I	Set II	Set III	Set IV
1	Pulp grade	100% Spanish	100% Canadian	100% C.P.O.	100% Rice straw
2	Initial freeness	490 ml CSF	490 ml CSF	365 ml CSF	240 ml CSF
3	Beating time	75 mins	68 mins	50 mins	21 mins
4	Final freeness	144 ml CSF	151 ml CSF	139 ml CSF	140 ml CSF
	Physical Strength Characteristics				
5	Bulk, ccs/gm	1.86	1.85	1.26	2.41
6	Breaking length, M	5141	4141	9615	2512
7	Burst factor	41	32	67.7	10 8
8	Tear factor	75	75	77	50
9	Double folds	34	21	160	2

Testing Conditions : Temp. / RH ... 23/58

TABLE—VIII

BLENDING SVUDIES OF RICE STRAW PULP WITH IMPORTED WOOD PULPS AND CPO

Sl. No.	Particulars	Set I	Set II
1	Furnish	45% Spanish pulp + 55% Rice straw pulp	45% Canadian pulp + 55% Rice straw pulp
2	Final freeness, ml CSF	154	159
	Physical strength characteristics		
3	Bulk, ccs/gm	2.17	2.11
4	Breaking length, m	4797	4200
5	Burst factor	33.88	29.0
6	Tear factor	60.0	54.3
7	Double folds	22 0	23.0

Sl. No.	Particulars	Set III	Set IV	Set V
1	Percentage addition	45% C.P.O. pulp + 55% Rice straw pulp	45% Imported wood pulp mixture + 55% Rice straw pulp	35% Imported wood pulp mixture + 10% C. P. O. + 55% Rice straw pulp
2	Final freeness of furnish, ml CSF	152	150	154
	Physical strength characteristics			
3	Bulk, ccs/gm	2.17	2.20	2.15
4	Breaking length, M	4430	4157	4390
5	Burst factor	26	25.53	26.2
6	Tear faetor	71	62.92	63.6
7	Double folds	13	11.0	10

Testing conditions : Temp./R.H. ... 23/58

4) Installation of lump breaker roll over the suction couch will help in compacting the paper web thereby minimising the chances of fluff getting released to the press and drier section.

5) The first press felt should be preferably synthetic or partly synthetic with needled construction.

6) The press rolls and drying cylinders should have efficient doctors of oscillating types.

7) Smoothening press in between the press and dryer part will help to some extent to reduce the fluff in the dryer section.

CHEMICAL RECOVERY SYSTEM

Chemical recovery plants for small paper mills are considered uneconomical in view of their large capital investment and operating costs. However, taking into consideration the increasing cost of caustic soda, seasonal imbalance in its availability and the heavy pollution caused by black liquor enforces the small paper mills to examine their options critically if the black liquors have to be advantageously processed later.

PHYSICO—CHEMICAL CHARACTERISTICS OF BLACK LIQUORS

The black liquor from soda pulping of rice straw differs substantially in physico chemical properties from other black liquors Table No. IX illustrates the characteristics of black liquor of rice straw in comparision with other agricultural residues.

TABLE—IX

CHARACTERISTICS OF BLACK LIQUOR FROM AGRICULTURAL RESIDUES

Sr. No.	Raw Material	Sio_2, %	Organics, %	Ca orific value, Kcal/Kg.
1	Rice straw	15–17	58–65	2600–2100
2	Wheat straw	4–8	54–58	2800–3000
3	Bagasse	1.2–3	56–60	3200–3400
4	Bamboo	2–4	52–54	3200–3340

The viscosity of rice straw black liquor is also relatively high and increase sharply above concentration of about 35 % solids. The high silica content in rice straw black liquor has drastic effect on the chemical recovery: Most of the silica in straw dissolves into the spent liquor during the silica in straw dissolves into the spent liquor increases in proportion to the added alkali. Silica has no causticizing effect in the alkali recovery system. The low alkali recovery from rice straw black liquor is not due to chemical reactions but due to physical properties of silica in the rice straw. Following methods for removing silica from black liquor have been adopted and practicised.

1) Carbonation of black liquor and subsepunt precipitation of silica.
2) Treatment of black liquor with lime.
3) Green liquor acidification and precipitation.

CHEMICAL RECOVERY PROCESSES

The chemical compcsition of rice straw black liquor (i. e. higher pentosans and silica content) leads to some processing difficulties during chemical recovery operations.

Following methods are the alternatives for processing black liquor from small paper mills based on straw.

1) Wet air oxidation process and
2) Ferrite process.

WET AIR OXIDATION PROCESS

Wet air oxidation or zimmerman process developed for sludge handling has been adopted by few mills abroad for recovering pulping chemicals. The basic principle of this method is oxidation of organic constituents of black liquor by air under high pressure and temperature to give a green liquor. The weak black liquor is directly converted to green liquor eliminating the conventional evaporation and combustion steps. This method appears to be satisactory for handling the viscous and high silica content black liquor.

FERRITE PROCESS

This process was invented and patented by Toyo Pulp Company of Japan. This process is mainly applicable to non-sulphur black liquor to recover sodium hydroxide. The work on this process was initiated in CPPRI Laboratory. Ferrite process is an auto causticizable process. In this process the spent liquor is burnt with ferric oxide at temperature 850°C. Combustion product when hydrolysed gives sodium hydroxide and ferric oxide. This process is promising and suitable for using in small paper mills due to its simplicity and lower capital investment.

USE OF BLACK LIQUORS IN DETERGENT INDUSTRY

In recent years Lignin Sulphonates are finding increasing use to replace the costly Alkyl Aryl Sulphonates in detergent industries all over.

In India too, one or two firms have successfully used Lignin sulphonates for detergent manufacture.

Since Lignin sulphonates are not readily available as a bye product from the Paper Mills (Black Liquor) an intermediate conversion step for Sodium Lignate to lignin sulphonates is necessary.

This field appears to be very attractive for Small Paper Mills to dispose off their Black Liquor economically, and will be a boon for abating pollution.

EFFLUENT TREATMENT SYSTEM

Amount of fresh water requirement, amount of effluent discharge as well as BOD and COD loads of effluent are dependent on the methods adopted for processing raw materials, end product and capacity of

mill. The effluent from pulp and paper mills is very complex in nature and is hazardous to aquatic animals and also for soil if used without treatment.

The paper mills having no conventional recovery system uses following treatment methods to their effluent before disposal.

a) Lime addition.

b) Acidification.

c) Primary clarification and lagooning.

d) Aeration.

e) Secondary clarification.

The spent liquor after brown stock washing system and effluent from bleaching section requires above treatment methods while the effluent form paper machine requires only primary clarification and aeration. The nutriants like urea and phosphoric acid are also used

CONCLUSIONS

For a better quality pulp wet cleaning of rice straw before cooking is a necessary step as it removes the undesirable material embeded in the straw.

Mechano-chemical straw pulps are superior to pressure cooked pulps both in pulp yield and quality. The pulp yields are at least 5–6% higher. The strength properties of the mechanochemical pulp especially the double folds are many times higher than the other one, However, pressure cooked pulps have less lignin content.

Mildr cooking chemicals and conditions can produce straw pulps of satisfactory quality with lower pollution loads, less chemical losses and with low silica content in spent liquor.

Soda pulpiag of old rice straw pulp has lower Kappa No, and less screen reject than that of new rice straw at the same chemical charge,

Pulps with high Kappa No., above 15 can be conveniently bleached with CEH sequence upto a brightness level of $77 \pm 2°$PV. HH sequence is not recommended for high Kappa No. pulps because of high shrinkage and more chemical consumption.

Blends of straw pulp with other imported pulps shows good strength properties and economic viability.

Straw pulp refining is comparatively easier but care should be taken in stock preparation and approach flow system to avoid colour mottling effect and slime growth. Addition of retention aids is very much desirable to improve retention of the wire.

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