Potential High Yield Processes For Small Paper Mills Based On Agricultural Residues

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INTRODUCTION

In India small paper mills have to play an important role in increasing the production. Out of the proposed additional capacity of 4.5 lac tonnes, 2 lac tonnes will be covered by small paper mills. The economic of small paper mills depend on :

i) Use of locally available raw material

ii) Simple processes of production of pulp which require small quantities of chemical and no chemical recovery is warranted.

Conventional forest raw materials like bamboo, softwood and hardwood require complicated processes of pulping and chemical recovery for the production of industrial and cultural papers and can economically be used in large units. Besides this, these raw materials are in short supply for the present production of 9.7 lac tonnes/year. According to recent reports of Government of India, pulp and paper industry including newsprint will require 2 million tonnes of fibrous raw material by 1985. Surprisingly only 5% of this will be agricultural residues. India being an agricultural country, lot of agricultural residues are available which are at present used as animal fodder or are burnt in fields after harvesting the crops. They can be easily used for the production of some grades of papers like corrugating media, wrapping and printing papers.

In the past few years several experiments have been conducted on agricultural residues by two high yield processes, namely hot caustic soda process and mechano-chemical processes for small paper mill projects in this laboratory on laboratory scale as well as on pilot plant scale.

The hot caustic soda process[1] consists of treating the cellulosic raw material with a solution of caustic soda at boiling temperature under atmospheric pressure for short period varying from 5 min. to 60 min. The raw material so treated is then mechanically treated to separate the fibres.

The mechano-chemical process[2] consists of subjecting the material to simultaneous chemical and mechanical action at atmospheric pressure and at temperature near 100°C. The so treated material is subjected to refining for complete defibration.

PILOT PLANT PRODUCTION OF HOT CAUSTIC SODA PULPS

Experiments on pilot plant scale were undertaken on the production of hot caustic soda pulps from raw materials. like jute sticks, bagasse and from a mixture of sabai grass and rice straw. Sabai grass alone has also been tried.

These raw materials were cut into small lengths in a cheff cutter and screened. Bagasse bales were opened and used. The chemical treatment was given in a vertical digester of 2.8 cu. metres capacity and liquor circulation system was used for uniform temperature. Hot caustic soda solution was added and the required material to liquor ratio was maintained. The liquor was kept circulating throughout the period of treatment. Digester lid was not closed.

After the treatment the liquor was pumped out and treated material was washed with fresh water. The treated material was unloaded in a Banning beater with basalt lava stone roll and bed plate to defibrize the treated material.

The pulps so obtained were washed and screened. The pulps were bleached in a single stage by calcium hypochlorite. The bleached pulp yield was determined. The pulping and bleaching conditions are given in Table–I.

The pulps were then beaten in Wolf beater. The beaten pulps were sized and loaded with China clay. In case of jute sticks and bagasse bleached bamboo sulphate pulp was blended to ensure smooth running on paper machine. In all cases the paper machine ran smoothly. Details of stock preparation and strength properties of paper are given in Table—II.

From the data presented in Table—I and II, the following inferences can be made :

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i) Pulps in high yield can be produced by hot caustic soda process.

ii) Unbleached pulps produced by this process are suitable for the production of wrapping papers, newsprint and cheap quality printing papers.

iii) The brightness of the unbleached pulps can be increased by single stage hypochlorite bleaching to a reasonable brightness suitable for ordinary grade of printing paper. Bleaching of pulps also increases the strength properties of paper.

iv) These experiments cofirm that the process has commercial feasibility and is specially suitable for small paper mills for the reasons :

1. Simplicity of process
2. High yield
3. Lower requirement of cooking chemicals and elimination of pressure vessels.
4. Pulps are readily beatable and have good strength.

PILOT PLANT PRODUCTION OF MECHANO-CHEMICAL PULPS

Pilot plant scale experiments were also carried on the production of mechano-chemical pulps. The raw materials tested were rice straw, wheat straw, bagasse[3], jute stick[3] and mixtures, like, sabai grass and rice straw, and rice straw, kahi and kana grasses.

These raw materials were prepared in a similar manner as in case of hot caustic soda process before use.

The pulping experiments by this process were carried out in a hydrapulper of 2.14 m. diameter and of 5.2 cu. m. capacity. It has a rotor of 107 cm. dia. which runs at a 275 r.p.m. The power input is 60 H.P. The contents of the hydrapulper can be heated with direct steam.

The caustic soda or a mixture of caustic and lime was dissolved in water, sufficient to give a consistency of about 10%. The water was heated

TABLE—I PILOT PLANT TRIALS, PULPING CONDITIONS, ALKALI CONSUMPTION, UNBLEACHED AND BLEACHED PULP YIELD BY HOT CAUSTIC SODA PROCESS

				Cooking conditions					Fiberisation condition			
Raw Material	Expt. No.	Moisture in chips %	Caustic Soda %	Raw material to liquor ratio	Time to boiling temp. mts.	Time at boiling temp. mts.	Boiling temp. °C	Alkali consumption %	Fiberisation time hrs.	Consistency %	Unbleached pulp yield %	Bleached pulp yield %
Jute sticks	1	10.5	15	1 : 10	5	30	94	8.1	3.0	5 0	76.4	69.4
Bagasse	2	8.0	6	1 : 5.5	10	30	94	3.4	4.0	5.0	81.4	75.3
	3	11.0	10	1 : 5.5	10	15	96	5.4	3.5	5.5	73.1	—
	4	10.0	15	1 : 6	5	15	95	8.5	2.0	4.8	58.8	63.0
Sabai grass	5	12.0	10	1 : 6	5	15	94	6.1	0.75	5.0	63.5	56.3
	6	12.0	15	1 : 6	5	30	94	7.2	0.5	5.5	60.8	54.1
Mixture of Sabai grass 45% and Rice Straw 55%	7	12.0	10	1 : 5	5	15	95	7.7	0.5	4.0	60.4	55.1

TABLE—II PILOT PLANT TRIALS : STOCK PREPARATION AND STRENGTH PROPERTIES OF PAPERS MADE FROM HOT CAUSTIC SODA PULPS. (Expt. Nos. in this table corresponds to the Expt. Nos. in Table—I.)

1.	Raw Material	Jute sticks	Bagasse			Sabai grass		Mixture of Sabai grass and Rice Straw
2.	Expt. No.	1	2	3	4	5	6	7
3.	Freeness of unbeaten pure pulp, ml.	370	415	397	300	289	500	240
4.	Freeness of stock before addition of chemicals, ml(CSF)	210	190	115	220	170	250	175
5.	Rosin soap on o.d. pulp, %	3	3	3	3	3	3	3
6.	Alum on o.d. pulp, %	9	9	9	9	9	9	9
7.	China clay on o.d. pulp, %	5	5	5	5	5	5	5
8.	Freeness of stock after the addition of chemicals, ml.(CSF)	155	140	85	180	135	235	150
9.	pH of stock in head box	4	4	4	4	4	4	4
10.	Speed of machine ft/minute	220	110	100	250	225	225	125
11.	Basis weight	64.0	64.8	69.4	65.2	62.4	62.4	56.0
12.	Breaking length, metres							
	(a) Machine direction	3200	3590	2720	5100	4460	3150	4610
	(b) Cross direction	2000	2710	2090	3290	2860	2150	4030
13.	Folding endurance (double folds)							
	(a) Machine direction	18	16	10	80	110	66	67
	(b) Cross direction	11	9	8	42	69	26	57
14.	Tear Factor							
	(a) Machine direction	59.6	43.3	41.7	66.7	56.1	70.8	44.2
	(b) Cross direction	71.8	46.6	49.0	71.3	56.1	83.8	47.5
15.	Burst factor	14.6	15.6	14.7	21.4	15.7	24.1	21.4
16.	Brightness (EEL)	68	66	52	71	67	71	66
17.	Remarks	Bleached printing paper	Bleached printing paper	Unbleached printing paper	Bleached printing paper	Bleached printing paper		Bleached printing paper

to 98°C by means of steam. The raw material (350 kg. o.d. per run) was then added in the hydrapulper. After addition, the temperature was raised to 96°-98°C and the treatment continued for a maximum of 60 min. The treated contents of the hydrapulper can be discharged by a centrifugal pump at a consistency of about 7.0% to a Banning beater fitted with phosphorus bronze tackles on roll and bed plate or with basalt lava roll and bed plate for defibration.

After defibration, the pulps were screened, washed and wet laps were made on paper machine. The wet laps were loaded in beater for beating. In some cases waste paper has been added as long fibred component in furnish for smooth running of paper machine. Paper was made on fourdrinier machine.

In case where printing paper was made from these pulps, single stage hypochlorite treatment was given. Details of pulping, bleaching are given in Table-III and of stock preparation and properties of paper are given in Table-IV.

TABLE—III PILOT PLANT TRIALS : PULPING CONDITIONS, UNBLEACHED AND BLEACHED PULP YIELDS BY MECHANO-CHEMICAL PROCESS.

Raw Material	Rice Straw		Wheat Straw		Bagasse		Jute stick	Mixture of 5% Khai grass 15%Kana grass 80% Rice straw
Expt. No.	1	2	3	4	5	6	7	8
1. Chemical used on o.d. raw material								
(i) NaOH %	10.0	1.0	1.5	1.5	3.0	15.0	15.0	5.0
(ii) CaO %	—	8.0	8.0	6.0	7.0	—	—	14.0
2. Temperature of treatment. °C	96	98	98	98	98	95	95	96
3. Period of treatment min.	20	45	45	60	105	60	60	60
4. Unbleached pulp yield on o.d. raw material %	57.4	55.0	55.0	55.5	71.4	72.6	82.9	61.5
5. Chlorine applied on pulp as hypochlorite %	—	—	—	—	—	6.0	6 0	—
6. Bleached pulp yield %	—	—	—	—	—	64.4	76.6	—

TABLE—IV **PILOT PLANT TRIALS : STOCK PREPARATION AND STRENGTH PROPERTIES OF PAPERS MADE FROM MECHANO–CHEMICAL PULPS** (Expt. Nos. in this table correspond to the Expt. Nos. in Table-III)

Raw Material	Rice Straw		Wheat Straw		Bagasse		Jute sticks	Mixture of 5% Kahi grass 15% Kana grass 80% Rice Straw
1. Experiment No.	1	2	3	4	5	6	7	8
2. Freeness of unbeaten pulp, ml (CSF)	230	220	260	280	230	400	450	285
3. Freeness of beaten pulp, ml (CSF)	190	200	200	220	175	200	250	220
4. Long fiber component added & percentage	Waste paper 40%	Waste paper 40%	Waste paper 20%	Kraft waste paper, 20%	Wheat straw pulp of Expt. No. 3 75%	Bamboo pulp 15%	Bamboo pulp 20%	—
5. Rosin soap added on o.d. pulp, %	2	2	1.5	1.5	1	3	3	1
6. Alum added on o.d. pulp, %	6	8	5	5	5	9	9	3
7. pH of stock on Head box	5.0	4.5	4.5	4.5	4.5	4.5	4.0	5.0
8. Machine speed, metre/minute	25	23	25	25	23	55	30	26
9. Quality of Paper	Corrugating medium	Corrugating medium	Corrugating medium	Corrugating medium	Corrugating medium	Printing paper	Printing paper	Corrugating medium
10. Basis weight, g.s.m.	120	100	130	118	100	72.0	64.4	115
11. Thickness, mm	9.0	9.0	9.0	9.0	8.5	—	—	9.0
12. Breaking length, metres (a) Machine Direction	4480	3630	4000	3630	3900	5380	4270	2850
(b) Cross Direction	2610	2060	2460	2060	2230	3260	3060	2170
13. Tear Factor (a) Machine direction	60	61	61.5	60	50	45.8	36.5	59
(b) Cross direction	63	69	78.3	78	57	50	37.7	61
14. Burst Factor	21 6	15.0	15.2	12.2	15.8	—	—	14.0

From the pilot plant experimental data given above the following inferences can be made :

1. The process is simple and well suited for the agricultural residues and grasses.
2. Elimination of pressure vessels with the consequent reduction in equipment cost and safety devices.
3. Reduction in steam consumption.
4. Shorter pulping time.
5. Higher yields of pulps.
6. The pilot plant experiments conducted on mechanichemical process using indigeneous raw materials confirm the possibilities of commercial exploitation of this process for the production of printing papers, corrugating media, etc.

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