Effective utilisation of cooking chemicals in small paper mills

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SUMMARY

There are about 100 small paper mills in India based on non-conventional raw materials manufacturing around 3 to 4 lakh tonnes of paper and board per annum. A good number of them use rice straw as the basic raw material, since it has got many advantages over conventional raw materials and is well suited for small paper mills.

Since recovery of chemicals for a rice straw based mill is technically and economically not feasible at the present juncture, it is necessary to exercise strict control on the use of cooking chemicals, which is mainly Caustic Soda in our country, so as to bring down the cost of production. This paper discusses a few measures that can be taken to have an effective use of cooking chemicals in the rice straw based paper mills. Measures like use of cut straw, installation of Pre-impregnator, making hard cooks with hot stock refining, wet cleaning of straw, use of old straw, use of anthraquinone, etc., are discussed. It is concluded that care should be taken while planning the straw based mills to select the proper process and to include the necessary equipments to keep the cooking chemical consumption to the minimum. The existing mills can also take care to reduce the chemical consumption by adopting some of the measures mentioned in this paper.

In India, there are about 100 small paper mills based on non-conventional raw materials like straws, rags, gunny, cotton linters, waste paper etc., manufacturing around 3 to 4 lakh tonnes of paper and board per annum. A considerable number of these units make use of cereal straws as the principal raw material contributing to a furnish ranging from 30% to 60%. Pulp from cereal straws has been found to be most economical for small paper mills due to various factors such as its perennial availability in predominantly cultivated areas, lower consumption of chemicals for cooking, ease in bleaching, ease in refining, etc. Along with long fibred pulp straw pulp can make a reasonably good Writing and Printing paper.

But inspite of all these advantages, straw based mills are facing problem due to ever increasing cost of cooking chemicals and inability of the small mills to have chemical recovery plants. The cost of Caustic Soda which is the chief chemical used in India for rice straw pulping has shot up by nearly 30% for the last one year. At present the contribution from the cooking chemical cost towards cost of production for a small paper mill based on rice straw is of the order of about *10 to 15%* which is quite considerable and it is necessary and need of the hour to exercise restraint in the use of chemicals, in pulping.

The purpose of this paper is to present a few measures necessary to be taken at planning stage of new mills as well as in the existing mills to bring down cooking chemical consumption. An attempt is made here to cover only rice straw based mills based on our experience at Delta Paper Mills.

It may be pointed out here that a 1% reduction in consumption of chemicals based on B.D. raw material would bring in a saving of around Rs. 8 lakhs per annum for a 30 TPD Mills using 60% straw in their furnish. This is quite considerable for a small mill and goes to say that every effort should be made to save the chemicals in order to make the working of the mill viable.

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While speaking about effective use of cooking chemicals, it is quite logical to think of recovery of spent chemicals. When we talk of small mills, it means that the entrepreneurs setting up small mills are also small with limited financial resources. The very purpose of small paper mills is to bring down the capital investment per annual tonne of installed capacity to a lower level, so that it becomes attractive to small entrepreneurs. If chemical recovery is included in the paper plant, there will be a hike up in the capital by atleast 25 to 30% which the entrepreneur will not be able to bear.

Secondly, for rice straw, recovery of chemicals is not technically feasible by the conventional system. Though there is an effort to commercialise chemical recovery plants for rice straw based units by a West German firm, its capital cost at present is fantastically high. Moreover, its technical feasibility is not fully established.

Under the circumstances, it will not serve any purpose to think of recovery system for small paper mills till a technically and commercially feasible solution is found. Hence in the opinion of the authors, our attempts should be to concentrate on what best can be done to reduce the consumption of chemicals rather than trying to recover it.

A study of the proximate analysis of rice straw given in Table 1 indicates that the lignin content in rice straw is much lower than that found in conventional raw materials, thereby indicating that the rice straw can be easily pulped at less severe cooking conditions. Also the 1% NaOH solubility (43.37%) of rice straw compared to 20% for bamboo and hardwoods indicates that mild cooking conditions should be used for rice straw.

TABLE NO. 1—PROXIMATE ANALYSIS OF STRAW

Sl. No.	Particulars	Unit	Result
1.	Moisture	%	5.59
2	Cold water solubility	%	9.69
3.	Hot water solubility	%	11.22
4.	Alcohol Benezene solubility	%	6.32
5.	1% NaOH solubility	%	43.37
6.	Pentasans	%	19.25
7.	Holocellulose	%	66.87
8.	Lignin	%	11.20
9.	Ash	%	13.73

Note—1. All the figures are on O.D. basis
2. Holocellulose and lignin percentages are ash corrected.

PULPING PROCESS FOR RICE STRAW

Before discussing ways and means of more effective utilisation of cooking chemicals it is necessary to discuss briefly the different cooking processes commercially practical for straw with special reference to Indian conditions.

The chemicals used for pulping in India are Caustic Soda in most of the cases and sodium sulphite in a few cases. The cooking processess used are given below :

1. BATCH PULPING :

Spherical or tumbling digesters are normally used for cooking straw with Caustic Soda at temperatures ranging from 160 to 170°C. The Caustic Soda used in case of rice straw is between 8 and 9% on B.D. weight. The steaming and cooking time normally are between 2½ hours. The pulps obtained are used for writing and printing paper manufacture or in some cases Wrapping papers.

The capital investment in case of globe digesters is comparatively low. But the disadvantage in this pulping is that the pulp obtained is not uniform since the liquor penetration is not uniform throughout the length and breadth of the digester. As a result, the operating crew will have a tendency to charge more chemicals or increase the cooking time, which ultimately results in a weaker pulp.

The tumbling digesters are not common in India, because of a higher capital cost required.

2. CONTINUOUS PULPING OF STRAW

Of the different designs of digesters available the Pandia continuous system is most popular and most suitable for agricultural residues. The main advantage of this system are[1].

—Maximum uniformity of pulp quality due to a thorough and continuous mixing of chemicals and steam with fibrous raw materials.

—Uniform steam and power requirements which reduce peak load demands in the steam and power plant.

—Low steam requirements because of low liquor solids ratio and continuous recovery of heat from blow tank.

—Uniform liquor demand.

—Potentially higher yields of equivalent pulp quality.

—Small space requirements.

—Lower labour cost because of greater productivity per man hour labour.

But inspite of these advantages, Pandia system has not become popular in India excepting in one or two mills. The main reason for this is the high capital cost involved, which is two to three times the cost of the conventional globe digesters for the same capacity. Moreover, most of the small mills based on agricultural residues are in the range of 15 to 30 TPD and for this operation, continuous system will not be economically viable.

3. MECHANO CHEMICAL PULPING

Though this process was known for a long time, being developed at the Northern Regional Research Laboratory, Peoria, Illinois, U.S.A[2], this process was little known in India. But recently a few small paper mills have adopted this system which has given encouraging results. In due course, it may be anticipated, this process may become quite common in our country.

In this process, cooking of straw is carried out in a Hydrapulper at 95°C in the presence of Caustic Soda. The cooking reaction generally takes place at the inter face between the fibrous material and the liquid containing the active chemical. It is necessary that in any cooking process, the reaction products are removed as they are formed and at the same time, the active chemicals must come in contact with the fibrous material more and more. In this process, this movement is caused by rotating vanes of the impeller of the Hydra pulper. In addition, the impact action of the vanes on liquid soaked plant tissue hastens the diffusion by repetitive compaction and pressure release. This is essentially a recurring expulsion and absorbtion of the pulping liquor from the plant material. The reaction of lignin removal continues throughout the processing as long as active chemicals are present. It has been found that this process is most promising for Indian conditions especially for rice straw. The advantages are :

— Lower chemical requirement
— Lower steam requirement
— Higher yields
— Pulp of better strength properties
— Ash content in the pulp obtained will be much lower than that obtained through pressure cooking.

DISCUSSION ON THE COOKING PROCESS FROM THE POINT OF EFFECTIVE UTILISATION OF COOKING CHEMICALS

Though the pressure cooking process in globe digesters is most commonly being practised for straw pulping in India, this is not the best process. It produces a weaker pulp and lower yield and generates more fines in the system. However, there could be more effective utilisation of cooking chemicals in globe digesters by following means :

1. Many straw based mills suffer from inadequate chopping capacity and as a result, they are forced to use whole straw. It is necessary to provide adequate straw chopping capacity to supply cut straw to match with the pulping capacity. It is unfortunate that many mills do not seem to give adequate provision to augment their straw chopping capacity From our experience at 'Delta', we have found that by using chopped straw the Caustic consumption could be brought down by nearly 1.0 to 1.5% on B.D. straw charged. Also because of better packing the production per digester can be increased by nearly 15%.

2. A Preimpregnator or a mixer conveyor for straw before the Digestor can not only help in better penetration of liquor into the straw but also help in improving the packing in the digester. Unfortunately, many Indian mills using straw do not have this system. It is necessary to incorporate this simple device at the planning stage itself.

3. Making hard cooks and using hot stock refiner or Hydrapulper treatment :

   This is found to be an effective means of reducing the chemical requirement. We at 'Delta' have carried out this trial with encouraging results. The cooking was carried out at lower chemical charging and lower temperature, and the resulting pulp was treated in the Hydrapulper. The pulp obtained was found to be stronger with less fines generation and easily bleachable. The yield was also higher.

4. **Wet cleaning of straw :**

   Straw contains nearly 10% of water solubles. Also the chaffy portion in rice straw is of the order of 20%. Both the things would consume a considerable portion of the cooking chemicals without contributing to fibre value. These can be removed by wet cleaning of the straw and thereby chemical requirement can be brought down considerably. Unfortunately for want of good and reliable equipments for wet cleaning, this is not being practised in most of the mills in India excepting one or two.

   This step can also remove the external silica from the straw thereby reducing the wear and tear on the agitators and pumps.

5. We have also found that old straw and new straw will behave differently in the digester, the

old straw requiring less chemicals for the same degree of cooking than the new straw. In our mill, we have found that straw stored for about 3-4 months consumes nearly 2.00 to 2.5% less Caustic Soda compared to the fresh straw to get the same Permanganate number. This has been further confirmed in the lab-scale experiments.

6. **Use of Anthraquinone in cooking :**

As a result of research work carried out all over the world, it has now been established that Anthraquinone or its derivatives in alkaline pulping increase the yield and also brings down the Permanganate number of the unbleached pulp which means that the cooking chemical dosage can be brought down.

Research work carried out at one of the Indian Mills, on rice straw pulping with Anthraquinone has given encouraging results. Their observations are as follows[3]

(a) Addition of Anthraquinone increases the yield to a significant extent.

(b) There is a reduction in Permanganate number with the addition of Anthraquinone, and analysis of the unbleached pulp obtained has shown that there is a reduction in lignin content and an increase in the alpha-cellulose content.

(c) Anthraquinone is effective as a catalyst in promoting delignification even at temperatures as low as 140°C, provided enough alkali is present at the end of the cook.

It is evident from these results that by using Anthraquinone along with Caustic Soda, the Caustic Soda can be more effectively used.

CONCLUSIONS

Having discussed the various measures that are possible for a more effective utilisation of cooking chemicals, we would like to conclude that care should be taken while planning straw based mills to select the proper process and to include necessary equipments to keep the cooking chemical consumption to the minimum. However, the existing mills also can take care to reduce the chemical consumption by adopting some of the measures mentioned above. The savings obtained by reducing the cooking chemical consumption will be quite substantial. Time is not still ripe to consider recovery of chemicals for rice straw based mills, since there is no commercially and technically feasible chemical recovery system established so far. Till a solution is found to this problem, it is necessary to exercise control on more effective use of cooking chemicals used for rice straw.

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