Towards Higher Yield of Pulp from Bamboo

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Introduction

In tropical countries like India, bamboo is an important raw material for papermaking. Since its growth cycle is only of 4 years duration, bamboo gives a very potential source of paper making fibre. The fast dwindling bamboo forests on one hand, and growing paper demand on the other, pose a serious problem to the Indian paper industry to find out ways and means to increase pulp yield as well as to grow bamboo plantations on sustained basis. Planned afforestation of bamboo for use of paper industry is as necessary at present as it is essential to increase the yield of pulp from bamboo to meet the expanding demand of paper in India.

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Process Of Pulp Extraction From Bamboo

In a brief article like this, it is not possible to go in details of the chemistry of pulping and extraction of pulp from bamboo for paper making. At present, alkaline method of cooking is the common process adopted for pulping of bamboo both in India and abroad. In this process, the lignin portion of plant is dissolved out to as much extent as possible by heat treatment of bamboo chips in a solution of caustic alkali. Since the conventional heat treatment or "cooking" is carried out at temperature above 100°C, particularly in the range of 150° to 170°C, most of the hemicellulosic portion and part of the cellulosic portion of bamboo chips get dissolved out and removed, which if retained could be useful in paper making. So far, no method has been suggested by which this useful part of bamboo could be retained in pulp. If it could be made possible, the pulp yield from bamboo would substantially increase, since the C & B cellulose and pentosans together make more than 60 per cent of the constituents of bamboo plant. To investigate the nature of alkali action at different temperatures on bamboo, these authors have carried a number of experiments to find out how alkali behaves in softening the fibre from the body of bamboo chips and if it is posible to produce bleachable grade pulp under milder conditions of cooking. Although some success has been possible in this respect, but still further research is essential to establish economically and technically feasible methods of cooking. This present work, briefly describes some glaring observations made by us, which will be covered later in a series of articles to follow in detail.

Action Of Alkali On Bamboo Chips Of Different Sizes

After a number of experiments carried by us, it has been found that alkaline liquor penetrates from all sides of chips of a whole bamboo piece at all temperatures. At room temperature, this penetration action is very slow and directly depends on concentration of alkaline liquor and/or time of contact. Presence of sulphidity in akaline liquor enhances its reactivity considerably. It has also been observed that such penetration is more from surface or skin side than from ends or longitudinal direction. This holds good at all temperatures. With the increase of temperature, the penetration of alkali from outer surface and inner hollow surface of bamboo stem increases, dissolving out lignin, waxes and easily solube hemicellulosic portion. The intensity of this reaction is evident from the intensity of cracking of the outer surface or skin of bamboo piece kept under soak-

ing. As the alkaline liquor penetrates into the body of bamboo stem, fibre bundles get loosened and softened. They can be easily peeled out by mild rubbing with hand or separated into form of pulp by mild crushing action. It was found that at 25 lbs. psi. (equivalent steam temperature of 130°C), bamboo stems of 1½" to 2" diameter and of convenient length (6" or so) could be fully soaked with 5 to 10 per cent Na_2O in 2 to 3 hrs. and those stems could be easily crushed by mild crushing action into coarse pulp with an average yield of 85 per cent. This coarse pulp on further alkali treatment with 5 per cent Na_2O (of sulphidity 16 to 17 per cent) at 95 to 98 lbs. psi. for 2 to 2½ hours would yield 52 to 59 per cent of unbleached pulp (on original weight of bamboo taken) of permanganate number range of 28 to 32.

With bamboo chips of different sizes, similar observations were made. With smaller size chips below ¼", generally what we can get as screen dust, it could be possible to prepare a mechano-chemical type of pulp with yield as high as 85 per cent when such bamboo dust (screened and washed over a 20 mesh sieve to remove siliceous matter) was soaked with 2 per cent NaOH in a dilution ratio of 1:6 at 80°-85°C for 24 hours. Soaking could be enhanced by increasing the temperature, which of course affected yield. Such a semi-chemical pulp was found to be soft enough to get refined to 20°-30°SR in lab. Valley beater and could be used in mill board making.

With chips of sizes higher than ¼", i.e. upto 1", 1½", 2", 3", 5" and even slivers upto 24" the nature of akali penetration was found to be the same as described. In one trial cook of long bamboo silvers (upto 24" length as obtained from Chipper House screen rejects) was treated with sulphate black liquor (10°Tw at 86°C, free residual alkali 12.4 gpl. Na_2O) in a dilution ratio of 1:6 at 25 lbs. psi. pressure (130°C) for one hour and the resulting softened stuff was crushtd into coarse pulp. This coarse pulp was given an alkali extration treatment with 12 per cent Na_2O (sulphidity 16 per cent) in dilution ratio of 1:3.5 for a total time of 22 hours (90 minutes taken in raising the pressure to 98 lbs. psi. and 30 minutes at maximum pressure). This gave a clean light brown pulp of permanganate no. 20.2 (yield 46.2 per cent of original chips b.d. weight), chlorine in bleaching to 76° GE which consumed 13.2 percent and bleached yield of 38.5 per cent. A combination of impregnation and subsequent alkali extraction method, as mentioned above was tried on a mixture of bamboo chips having following sizes:

composition:

Upto	¼"	=	3 per cent
¼"	— 2"	=	45 per cent
2"	— 5"	=	40 per cent
5"		=	12 per cent

Above chips mixture was pretreated with black liquor (residual alkali 13.2 gpl Na_2O) in dilution ratio of 1:4 at 25 lbs. psi. (130°C) for 2 hours. (90 minutes taken to raise pressure to 25 lbs and 30 minutes at 25 lbs.). The softened chips were subsequently hand pounded to coarse pulp and treated at 98-100 Ibs. psi. (169°-170°C) for 2 hours (90 minutes to raise to max. presure and 30 minutes at max. pressure) with 8 per cent and 10 per cent Na_2O T.A.A. separately (of average sulphidity 14-15 per cent). Brown pulp of P. No. 29.7 (yield 58 per cent) and P. No. 28 (yield 54.5 per cent) respectively was obtained. Both these pulp on bleaching by CEHH system consumed 16.6 per cent and 17.6 per cent chlorine respectively to a brighteness of 75°GE and bleached yield of 46.9 and 48.8 per cent respectively (on original b.d. weight of chips taken).

Above observations have given very encouraging results, which are yet to be further investigated to find out possibility of higher yield of both bleached and unbleached grades of pulps.

Action Of Alkali Extraction Of Conventionally Cooked Bamboo Pulp

In another set of experiments, it was studied to find the effect of mild alkali extraction of hard-cooked brown bamboo pulp by conventional sulphate process. The idea was to find out if a mild alkali extraction of pulp of P. No. above 21-22 would produce a softer pulp of P. No. below 16 and also help in reducing the ash content of pulp, without much reducing down the shrinkage in yield. In these trials, it was found that the caustic liquor containing 15-17 per cent sulphidity had much better activity than caustic soda alone. When the latter in concentrations of 3.1 per cent Na_2O to 4.65 per cent Na_2O was taken on b.d. weight of pulp, in dilution ratio of 1:12.5 and also 1:5, it would bring down the P. No. of a hard cooked pulp from 39 to 34 and 29 respectively in half an hour reaction. The white liquor containing a sulphidity of 20 per cent and 4.65 per cent Na_2O T.A.A. brought down the P. No. of same pulp from 39 to 14 under similar conditions of reaction. Yield shrinkage was only 15 per cent of the original b.d. weight of pulp taken. Taking a 60 per cent average yield of P. No. 39 pulp, the ultimate yield of pulp of P. No. 14 came to 51 per cent of the original chip weight. Such high yield of a soft pulp of P. No. 14 was noteworthy.

Only caustic soda extraction with 1.55 per cent Na_2O of a pulp of P. No. 21.5 and initial ash content 3.5 per cent at temperatures of 130°C (25 psi.). 147°C (50 psi) and 169°-170°C (100 psi) for 15 minutes and 30 minutes duration only, helped in bringing down the P. No. to 18 and ash to 1.9 per cent with a shrinkage of about 15 per cent in yield. An uncreened brown pulp of P. No. 21.5 and ash content of 3.5 per cent on treatment with only 1.55 per cent NaOH for 15 minutes at a pressure of 50 psi. could be converted into a clean pulp of P. No. 18.2 and ash content of 1.9 per cent. This pulp could be bleached by CEHH system to 80-82° brightness with 10.4 per cent total chlorine with an yield shrinkage of 12 per cent, giving a final yield of 31.7 per cent on chips. Although caustic soda extraction at 70-75°C. for different durations could not bring down P. No. as low as when pressure treatment was given, but still a fall of 1 to 2 units in P. No. and proportionally a fall in ash was observed. Observations from a number of such extraction tests under different concentrations of alkali and temperature ranges, established one fact that it is possible to check against heavy shrinkages in yield if bamboo pulp is cooked in two stages, first to a high P. No. and subsequently to treat the same with alkali under milder conditions. Such a system helps in giving much softer pulps which have equally much lower bleach demand and yield fairly high brightness by conventional CEHH system.

Although two stage cooking system may be difficult to adopt and may be apprehended to be uneconomical, as it appears from its face value; if a combined process of hot crushing of pulp while in cooking is adopted, it

may be commercially feasible and at the same time economical to get bleachable grades of pulp under milder conditions of cooking. This would naturally help in improving the yield.

Effect Of System Of Cooking On Pulp Yield

It has been observed that the mode of temperature treatment, the duration of temperature treatment in different stages and the concentration of effective alkali either alone or together considerably influence pulp yield in general. In case of bamboo also, this holds good, but the conditions which give best yield with wood do not yield similar results with bamboo. The two processes of sulphate cooking, one conventionally known as Impregnation method, wherein pre-digestion and lignin digestion are carried out by a 4-stage temperature treatment, and the other 2-stage temperature treatment method, wherein temperature of cooking is gradually increased to max. pressure and then maintained for desired time at the pressure, do not give the same yield, although alkali concentration, effective alkali, dilution ratio and temperature of cooking may be same. These authors have experienced that upto an effective alkali concentration of 14 per cent Na_2O, the Two Stage Temperature Treatment Method of cooking gives higher yield than the Impregnation Method. Since this subject covers a separate set of findings published earlier, details of data need not be discussed in this paper.

Effect Of Bleaching System On Pulp Yield

System of bleaching and conditions maintained during bleaching play a very important role on pulp yield, besides the end properties of bleached pulp. It has been found that in CEHH bleaching system using 30 per cent Cl demand in clorination stage and the balance as Hypo require nearly 25 per cent more time to attain same brightness and at the same time yield was reduced to 43 per cent as against 44.7 per cent Cl demand was met with chlorination and the balance with hypo while other conditions of bleaching were maintained same. If a pulp is bleached to low brightness of 72°-73° GE by a milder CEH system and subsequently bleached to 80°-82° GE by either Hydrogen peroxide or chlorine dioxide, a substantial advantage in yield is obtained than when the same pulp would have been bleached to — 80-82°GE brightness by CEHH system alone. Economy of a combined system of bleaching with CEH and H_2O_2 or ClO_2 would certainly be feasible in view of gain in yield as well as strength properties of bleached pulp. Stronger pulp directly affects paper production and higher filler retention.

Conclusions

From above observations, it can be concluded that for the production of uniform quality of pulp, the chip size is not as important as it is normally understood. If a combined cooking method is adopted, in which the impregnations of bamboo under milder alkali treatment and subsequently the alkali extraction action of defibred pulp at higher temperature and alkali concentration conditions are carried out, it is possible to have not only a higher yield, but also an improved quality of pulp from bamboo. In chipping operation, nearly 3 to 10 per cent of bamboo is lost as dust and oversized chips. All this loss could be avoided if whole bamboo could be crushed in a dilute alkali medium (or a dilute black liquor from last brown stock washer), so that soaking bundles and softening of fibre bundles in bamboo would go side by side. In wet crushing, the bamboo would not only get crushed, but also broken into pieces and at the same time the adhering siliceous matter would get washed. The soaked and crushed bamboo pieces, without any further chipping operation, can be impregnated and got crushed to yield coarse pulp. This pulp could then be given an alkali extraction reaction at a second stage in a continuous system of cooking, to yield desired quality of pulp. Elimination of chipping operation would itself help in increasing the alkali action in cooking operation.

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DISCUSSION

D. Ganapathi

Have you tried the effect of surface active agents on the rate of penetration of alkali?

N. D. Mishra

Yes. We have tried 'Lissapol D' of M/s. ICI, but we did not get satisfactory results.

D. Ganapathi

Is the improvement in alkali penetration observed at higher sulphidity a result of reduced surface tension?

N. D. Mishra

The improvement observed is due to higher total alkali content.

D. Ganapathi

It is suggested that the effect of specific surface active agents that will work at higher temperature and in the presence of liquor concentration of alkali, be tried for improvement in rate of penetration of alkali.

J. G. Patil

Instead of trying to devise a crushing mechanism which can be located inside the digester, is it not feasible to wash the bamboo first followed by crushing, another wash with dilute black liquor and then chipping? I beileve this will control the chip size, reduce dust considerably and raise the yield of pulp.

N. D. Mishra

Yes. It is a good suggestion.

Tek Singh

General comments.

The author has dwelt on chip size, their impregnation and possibility of disintegration of impregnated chips inside the digester during the cooking process to get better yield (and quality) of bleached pulp.

The idea behind this approach is a good one and should be given a serious thought. Any attempt to make the size of the chips uniform before cooking should result in higher yield and better quality of bleached pulp by the cooking and bleaching techniques being followed by our mills. This object could be achieved by two stage cooking with a disc refining in between. First stage cooking should aim mainly at impregnation of chips with the cooking chemicals i.e. it should be carried but at comparatively low temperature for about 2-3 hours. The semicooked chips should then be discharged, along with the chemicals, and disc refined. The disc refined chips should be cooked under optimum conditions to get the required quality unbleached pulp. This approach will mean additional equipment in the form of digesters, disc refiners, pumps, chests etc.