# Technology developments in bagasse pulping

Paul M., Peeris R., Praburaj T., Prasad D. Y., Mohan Rao N. R.**

**Abstract**

Bagasse has become the finest proven non-wood raw material for paper making. This requires further technological improvements in the areas of pulping and bleaching. A variety of approaches have been considered including the soda process which was the forerunner of kraft process, the application of suitable additive to enhance the efficiency of the soda process, the introduction of oxygen to extend the delignification and using the oxidative extraction for bagasse kraft pulp for achieving high brightness.

## Introduction

Tamil Nadu newsprint and papers Ltd. is one of the largest manufacturers of paper in India using bagasse as the principal raw material. The plant has been successfully utilizing bagasse which has emerged as the most potential non-wood substitute for wood in countries like India where wood is in a short supply. The mill has installed two major pulping lines using bagasse for production of Newsprint and Writing and printing. The furnish for Newsprint constitutes about 50% of Kraft bagasse pulp and 20% mechanical bagasse pulp, while the writing and printing furnish contains 75% of Kraft bagasse pulp and 25% hardwood pulp. Hence TNPL has been and will continue to be in the forefront in the development of bagasse based paper making technology. With the advent of modern pulping and bleaching methods to produce high quality pulps while complying with environmental regulations, it becomes inevitable that TNPL should also develop pulping methods in the area of bagasse technology. This work presents a series of upgraded pulping methods in the area of bagasse technology. This work presents a series of upgraded pulping methods, which can be applied on bagasse pulping. Many mills are coming up in India and other countries using bagasse where these pulping processes can be effectively put into commercial exploitations.

## EXPERIMENTAL

### Pulping

Pulping experiments were carried out with commercially, stored, and washed bagasse used in the regular process in the plant. These experiments were performed in 18 L capacity, electrically heated programmable tumbling digester, 500 g (o.d.) bagasse was used for each pulping experiments. Cooked pulps were washed over a muslin cloth kept on a 250 mesh screen and washed pulps were thickened in laboratory hydro extractor. The thickened pulps were shredded in an electrically operated high consistency shredder to a uniform consistency. The pulps were screened over a Sommervillie shive analyser fitted with 0 25 mm slot screen. The screened pulps were used for determining the kappa number and brightness. The refining of pulps to a standard freeness level of 300 ml CSF was performed using a PFI mill at 10% consistency. The pulping conditions are shown below.

| | | |
|---|---|---|
| Bath Ratio | | 1 : 4 |
| Steaming Time | min. | 55 |
| Cooking Time | min. | 20 |
| Cooking Temperature | °C | 170 |

**Tamil Nadu Newsprint and Papers Limited, Kagithapuram-639 136. TRICHY Dt, (T. N.)

## Bleaching

All of the unbleached pulps were bleached with CEH sequence. For high brightness experiments hydrogen peroxide was used in the extraction stage. Chlorination was carried out in a plastic container on 200 gm. o.d pulp with a charge equal to the chlorine multiple factor of Kappa number X 0.19. For high brightness experiments and oxygen delignified pulps chlorine charge was optimised. Alkali extraction was performed in polythene bags in a thermostatic water bath. The pulps were manually kneaded for thorough mixing. Hypo stage was also carried out in polythene bags. For alkali extraction, the minimum amount of NaOH required to maintain the final pH above 10 5 was taken as the optimum. The bleaching conditions maintained are given below.

| | | C | E | H |
|---|---|---|---|---|
| Consistency | % | 3 0 | 8.0 | 8.0 |
| Temperature | °C | Amb | 60 | 40 |
| pH | — | 2 0 | > 10 5 | 8.5-9 5 |
| Time | min. | 30 | 60 | 120 |

## Analysis

Unscreened pulp yields were determined with a laboratory oven after drying at 105°C to a constant weight. Kappa number, Viscosity and other physical properties were evaluated according to the TAPPI standards. Optical properties were evaluated with a Elrepho brightness tester.

## Results & Discussions

### 1 Soda pulping of bagasse Vs Kraft pulping

Alkaline pulping processes like kraft process and soda process are commonly used for producing chemical pulp from wood and other noon-wood raw materials. Soda process employs sodium hydroxide for the delignification while the kraft process involves a cooking liquor which contains 10 - 15 g/l of sodium sulphide (as $Na_2S$) corresponding to 18-20% sulphidity. In both soda and kraft liquors the lignin is degraded by the cooking chemical, and it is faster in the case of kraft pulping due to the high redox potential of the kraft liquor (1).

The possibility of applying the concept of soda process for bagasse was studied as early as the bagasse pulping itself was considered for the production of paper pulp. The main disadvantage of kraft process is its inability to meet the strict environmental regulations on sulphur emission. This can be overcome by employing the soda process. Pulping of bagasse with both processes were performed and the results are shown in the Table I. The results reveal that even though the soda process enjoys the advantage of being sulphur free still it lacks other distinct merits of kraft process. The unbleached bagasse pulps obtained by kraft process was much cleaner than the soda pulp, as can be seen from the screen rejects. The extent of delignification was considerably improved in the case of kraft pulp whose kappa number was 10.6 while the kappa number of soda pulp remained at 18 6

TABLE–I

Kraft Pulping of Bagasse in Comparison to Soda Pulping

| Parameters | Unit | Soda Pulping | Kraft Pulping |
|---|---|---|---|
| Chemicals as $Na_2O$ | % | 12 00 | 12.00 |
| Sulphidity | % | 0.00 | 19.80 |
| TAA as $Na_2O$ | g/l | 84 30 | 81.80 |
| Screen Rejects | % | 1 08 | 0.37 |
| Screened Yield | % | 56.39 | 56.79 |
| Kappa Number | | 18.60 | 10 60 |
| Brightness | % ISO | 37.00 | 37 90 |
| Viscosity | Cps | 16.20 | 26.00 |
| **Stength properties at 300 ml CSF** | | | |
| Tensile Index | Nm/g | 75.95 | 84.54 |
| Tear Index | mN m²/g | 5.41 | 5.44 |
| Burst Index | Kpa m²/g | 4.88 | 5.04 |

Kraft pulp's bonding strength is improved when compared with soda pulp, which is due to the enhanced delignification. The soda pulping of bagasse requires more cooking chemicals than kraft process to a similar kappa number (Table II). At a similar kappa number the kraft yield is about 3% higher than the soda yield, even though the unbleached kraft pulp brightness is low. These findings on soda pulping of bagasse indicate that soda pulping alone cannot replace the kraft process. Hence. another option of administering a suitable pulping additive to make the soda process equal to kraft process was pursued.

TABLE-II

Kraft Pulping and Soda Pulping at a similar Kappa Number

| Parameters | Unit | Soda Pulping | Kraft Pulping |
|---|---|---|---|
| Kappa Number | | 18.60 | 20.40 |
| Brightness | % ISO | 37.00 | 30.80 |
| Viscosity | Cps | 16.20 | 27.90 |
| Screen Rejects | % | 1 08 | 0.95 |
| Screened Yield | % | 56 39 | 59.18 |
| Chemicals as $Na_2O$ | % | 12.00 | 10.00 |
| **Strength properties at 300 ml CSF** | | | |
| Tensile Index | Nm/g | 75 95 | 81.30 |
| Tear Index | mN m²/g | 5 41 | 5.17 |
| Burst Index | Kpa m²/g | 4.88 | 5.11 |

## 2 Soda pulping of bagasse aided by Anthraquinone (AQ)

In order to achieve a pulp with similar characteristics of a kraft pulp, two important factors were considered namely, to stabilize the carbohydrate against alkaline peeling and to increase the rate of delignification. A number of quinone derivatives have been developed since 1970 (2) out of which AQ only has received the commercial acceptance. Systematic studies on replacing the sulphur compounds either partially or completely with AQ in the kraft process have been reported (2) The results obtained from Soda-AQ pulping of bagasse are given in Table 3 Addition of 0 1% AQ with the soda pulping improved the pulp quality significanlty in terms of screen rejects and Kappa number. Under the identical pulping conditions Soda-AQ bagasse pulp was similar in all respects to kraft pulp.

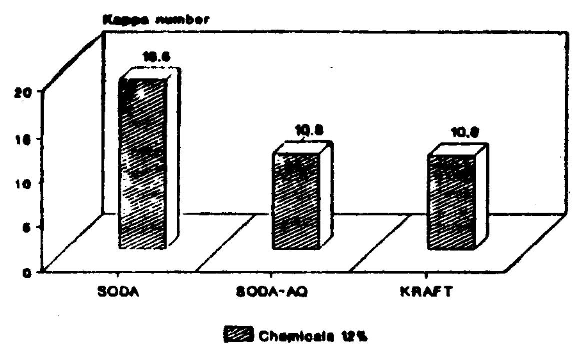
TABLF-III

Effect of Anthraquinone in Soda Pulping

| Parameters | Unit | Soda Pulping | Sooda-AQ Pulping |
|---|---|---|---|
| Chemicals as $Na_2O$ | % | 12.00 | 12.00 |
| Sulphidity | % | 0 00 | 0.00 |
| TAA as $Na_2O$ | g/l | 84.30 | 84.30 |
| Anthraquinone | % | 0.00 | 0.10 |
| Screen Rejects | % | 1.08 | 0.45 |
| Screened Yield | % | 56.39 | 56.71 |
| Kappa Number | | 18.60 | 10.80 |
| Brightness | % ISO | 37.00 | 38.60 |
| Viscosity | Cps | 16.20 | 18.10 |
| **Strength properties at 300 ml CSF** | | | |
| Tensible Index | Nm/g | 75.95 | 82.28 |
| Tear Index | mN m²/g | 5.41 | 5.27 |
| Burst Index | Kpa m²/g | 4.88 | 5.13 |

The use of AQ in soda pulping of bagasse does not make it weaker than the kraft pulp as can be observed from the Table 3. Viscosity of the unbleached Soda-AQ pulp is preserved due to the carbohydrate retention which may be attributed to the oxidation of the reducing end group of the polysaccharides. At a similar Kappa number Soda-AQ requires the same quantity of pulping chemicals as in the case of kraft process. (Fig. 1)

**Fig. 1 Effect of Anthraquinone in Soda pulping.**




### Bleachability of Soda and Soda-AQ Pulps

Under identical bleaching conditions the bleaching response was found to have improved in the case AQ treated soda pulps in comparison to Soda pulps. Mc Donough et al (3) reported that AQ treatment of kraft pulps innibit the lignin condensation during the cook and renders the residual lignin more easily removable by chlorination and caustic extraction. Comparison kraft pulp bleachability to soda AQ reveals (Table 4) that kraft pulps are superior at high as well as low kappa levels, which may be attributed to the enchanced, greater delignification due to the presence of sodium sulphide in the kraft cooking liquor. Thus it can be stated that soda pulping with AQ only can be commercially exploited for the production of bagasse chemical pulp.

TABLE-IV

Bleachability of Soda, Soda-AQ Pulps in Comparison to Kraft Pulp

| Parameter | Unit | Soda Pulp | Soda-AQ Pulp | Kraft Pulp (1) | Kraft Pulp (2) |
|---|---|---|---|---|---|
| Kappa Number | | 18.6 | 10.80 | 20.4 | 10.6 |
| Total Chlorine | | | | | |
| Applied | % | 4.03 | 2.55 | 4.38 | 2 51 |
| Consumed | % | 3.83 | 2.36 | 4.11 | 2.30 |
| Final Brightness | %ISO | 80.40 | 82.60 | 83 00 | 84 80 |

Chlorine charge in Chlorination = Kappa Number x 0.19

Alkali in Extraction as NaOH = 1.0% (for low Kappa Number)
= 1.5% (for high Kappa Number)

## 3 Modifications in bagasse kraft pulping process

### 3(a) High Kappa Number Vs low Kappa Number

Though the kraft process occupies a dominant position over the other pulping process, it still contains several areas for improvements. But these improvements can be made only on the basis of the final product. TNPL produces about 50000 T of newsprint per annum and its furnish consists of 50% kraft chemical bagasse pulp. Newsprint has been graded as a low priced sheet among the paper grades, its main technical requirements being good printability characteristics and other optical properties like opacity. The requirement of very high cleanliness is not desired in the case of newsprint as it is expected from writing and printing grade pulp.

Bagasse unlike wood can be pulped to lower Kappa number very easily with less chemical and with reduced cooking time in a continuous digester, Kraft pulps cleanliness is normally observed to be proportional to the kappa number of the unbleached pulp. The hard shives are undesirable as they are harmful to the appearance of the paper surface. In the current practice in our plant, bagasse is cooked to a very low Kappa number of 10-11, to take care of the cleanliness. This may not be required for newsprint production. The pulping chemicals can be reduced to PRODUCE A PULP OF KAPPA number (20) which is EQUAL TO HARD WOOD PULP.

Hence, our experience has shown that unbleached bagasse pulp with higher kappa number is satisfactory for the newsparint grade A comparison between high kappa pulp (20) and a low kappa pulp (10) has been made in Table (5). There is significant yield gain observed in the case of high kappa pulp as expected. Because of enhanced delignification the low kappa bagasse pulp is brighter and stronger than the high kappa pulp, but even then the strength and other optical properties are satisfactory in the case of high kappa pulp with respect to newsprint production. Since the chlorination has to be optimised on the basis of the unbleached kappa number, it seems that the bleachability is little affected in the case of high kappa pulp when compared to the low kappa pulp (Table 4).

TABLE—V

HIGH KAPPA NUMBER Vs LOW KAPPA NUMBER IN KRAFT PULPING OF BAGASSE

| Parameters | Unit | High Kappa No. | Low Kappa No. |
|---|---|---|---|
| Kappa Number | | 20.40 | 10.60 |
| Brightness | % ISO | 30.80 | 37.90 |
| Viscosity | Cps | 27 90 | 26 00 |
| Screen Rejects | % | 0.95 | 0.37 |
| Screened Yield | % | 59.18 | 56 97 |
| Chemicals as $Na_2O$ | % | 10.00 | 12 00 |
| Strength properties at 300 ml CSF | | | |
| Tensile Index | Nm/g | 81.30 | 84.54 |
| Tear Index | $mNm^2/g$ | 5.17 | 5.44 |
| Burst Index | $Kpa\ m^2/g$ | 5.11 | 5.04 |

### 3(b) Pulping of bagasse with extended second stage delignification with oxygen

Bleaching techniques involving oxygen have been widely known and have become commercially viable. In order to achieve very high brightness of the kraft pulp, the Kappa number of the caustic extracted pulp should be reduced substantially. Hence unbleached kraft pulps are reported to have been delignified with oxygen (4) followed by subsequent conventional bleaching. While oxygen application definitely improves the pulp brightening capability, it need not be confined to only bleaching. Under the scope of oxygen delignification pulping process can also be included. A secondary oxygen delignification as a continuation of wood-soda cook has been reported 5)

As a modification of the established bagasse kraft pulping, an attempt was made to study the effect of extended secondary oxygen delignification. Because soda pulps are already weaker than kraft pulps, kraft process was opted for this study. Kraft pulping was carried out with reduced chemicals (8% as against the regular charge of 12%) to deliver a pulp with very high Kappa number (43) and the delignification was further extended with oxygen at a reduced temperature (120°C).

The Kappa number of the kraft oxygen pulp was 9.8. In order to evaluate the advantages obtained from the modified oxygen pulping, the same bagasse was pulped to the same Kappa number by regular direct-conventional kraft pulping with 13% active alkali charge. The results are shown in Table 6. Fig. 2 shows the screen yield gain obtained by modified kraft-oxygen pulping over the regular direct conventional kraft pulping. The overall chemical requirement to achieve the same Kappa number was considerably reduced due to oxygen introduction (Table 6). The unbleached strength properties of the kraft-oxygen pulp at the original freeness are equally comparable to the direct kraft pulp. Hence at a similar Kappa number, higher yield could be gained using a less chemical with this proposed modified kraft-oxygen pulping.

However, in order to examine the effectiveness of the modified kraft-oxygen pulping, a direct pulping to produce a pulp with same plant kappa number (11.0), was performed. The results ((Table 7) show that the yield gain due to the modified pulping is around 2.0% over the kraft pulping with 12% chemical.

The bleachability of the modified oxygen pulp was found to have improved considerably

TABLE—VI

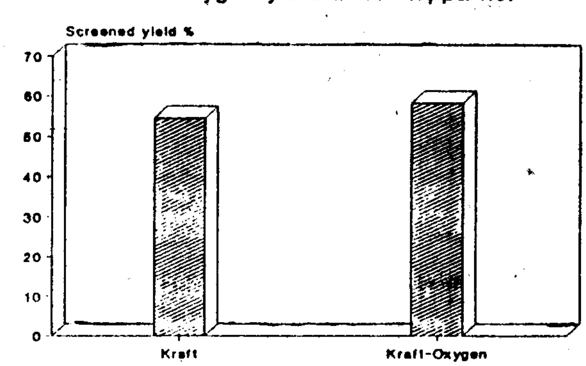
KRAFT PULPING OF BAGASSE IN COMPARISON TO EXTENDED OXYGEN DELIGNIFICATION

| Parameters | Unit | Direct Pulping | Extended Oxygen Pulping |
|---|---|---|---|
| Chemicals as $Na_2O$ | % | 13.00 | 8.00 |
| Bath Ratio | | 1:4 | 1:4 |
| Steaming time | min | 55.C0 | 55.00 |
| Cooking time | min. | 20 00 | 20.00 |
| H-Factor | | 460 00 | 460.00 |
| Chemical in Oxygen delignification as $Na_2O$ | % | Nil | 1 94 |
| Screen Rejects | % | 0 07 | 0 26 |
| Screened Yield | % | 54 53 | 58.16 |
| Kappa Number | | 9.80 | 9.80 |
| Brightness | % ISO | 41 20 | 41.50 |
| Viscosity | Cps | 22 80 | 22 80 |
| Yellowness | % | 26 40 | 37.40 |
| Freeness | ml CSF | 480.00 | 450.00 |
| Tensile Index | Nm/g | 51.76 | 56 37 |
| Tear Index | $mNm^2/g$ | 5.13 | 5 96 |
| Burst Index | Kpa $m^2/g$ | 3.33 | 3.66 |

Conditions during extended delignification with Oxygen

| | | |
|---|---|---|
| Temperature | °C | 120 |
| Time | min | 60 |
| Consistency | % | 10 |
| Oxygen | Kpa | 490 |

Fig. 2 Comparison of Kraft yield and Oxygen yield at 10 Kappa no.



TABLE—VII

KRAFT PULPING OF BAGASSE IN COMARISON TO EXTENDED OXYGEN DELIGNIFICATION

| Parameters | Unit | Direct Pulping | Extended Oxygen Pulping |
|---|---|---|---|
| Chemicals as $Na_2O$ | % | 12.00 | 8.00 |
| Bath Ratio | | 1:4 | 1:4 |
| Steaming time | min. | 55.00 | 55.00 |
| Cooking time | min. | 20.00 | 20 00 |
| H-Factor | | 460.00 | 460 C0 |
| Chemical in Oxygen delignification as $Na_2O$ | % | Nil | 1.94 |
| Screen Rejects | % | 0.10 | 0.26 |
| Screened Yield | % | 56 10 | 58 16 |
| Kappa Number | | 11.00 | 9.80 |
| Brightness | %ISO | 40.70 | 41.50 |
| Viscosity | Cps | 22.90 | 22 80 |
| Yellowness | % | 28.80 | 37.40 |
| Freeness | ml CSF | 470.00 | 450.00 |
| Tensile Index | Nm/g | 55.09 | 56 37 |
| Tear Index | mN $m^2$/g | 5.36 | 5 96 |
| Burst Index | Kpa $m^2$/g | 3.59 | 3 66 |

Conditions during extended delignification with Oxygen

| | | |
|---|---|---|
| Temperature | °C | 120 |
| Time | min | 60 |
| Consistency | % | 10 |
| Oxygen | Kpa | 490 |

(Table 8). It can be observed that, though the initial yellowness is high in the case of oxygen-kraft pulp, surprisingly on bleaching both the direct pulp and the oxygen-karft pulp have nearly the same yellowness.

## 4 Achieving high brightness of Chemical Bagasse Pulp

Bagasse pulps are easily bleached in a CEH sequence with single hypochlorite bleaching Under optimum bleaching conditions the bagasse plups easily brighten to 85% ISO. This Is very much satisfactory for the production of bleached pulp for writing and printing grades of paper. Recent developments in the paper industry in the area of bleaching have always been towards very high brightness (90 +). This high brightness is essential for competing in the market, where there is ever increasing pressure for new product development. Kraft pulp of Kappa number 10.6 was obtained from the pulp mill for conducting bleaching studies to attain 90+ brightness.

TABLE-VIII

BLEACHABILITY OF SECOND STAGE EXTENDED OXYGEN KRAFT PULP IN COMPARISON TO REGULAR PULP

| Parameter | Unit | Regular Pulp | Oxygen Kraft Pulp |
|---|---|---|---|
| **Unbleached Pulp** | | | |
| Kappa Number | | 11.00 | 9.80 |
| Brightness | % ISO | 41 00 | 41.50 |
| Yellowness | % | 28.80 | 37.60 |
| Viscosity | Cps | 22 90 | 22.80 |
| **CEH Bleaching** | | | |
| Total Chlorine Added | % | 2.60 | 2.40 |
| Consumed | % | 2.40 | 2 10 |
| Final Brightness | %ISO | 83.30 | 85.00 |
| Viscosity | Cps | 14.60 | 16.30 |
| **Strength Properties** | | | |
| Freeness | ml CSF | 430 00 | 440.00 |
| Tensile Index | Nm/g | 53.43 | 52.75 |
| Tear Index | mN $m^2$/g | 5.90 | 6 45 |
| Burst Index | Kpa $m^2$/g | 3.60 | 3 30 |
| Scattering Coefficient | $m^2$/kg | 31.00 | 29.80 |
| Yellowness | % | 9.30 | 8 30 |

The experiments were conducted with single stage hypo using CEH sequence. While, maintaining the optimum chlorine and alkali charge as constants, hypo dosage was varied from 0.5-1.5%. The results are shown in the Table 9. The results revealed, eventh-

TABLE—IX

BRIGHTNESS ACHIEVEMENT ON BLEACHING

| BLEACHING SEQUENCE | BRIGHTNESS % ISO | VISCOSITY Cps |
|---|---|---|
| C E $H_{0.5}$ | 85.60 | 17.70 |
| C E $H_{1.0}$ | 88.10 | 13.40 |
| C E $H_{1.5}$ | 88.50 | 10.90 |
| C E $H_{0.5}$ $H_{0.5}$ | 86.60 | 12.90 |
| C E $H_{1.0}$ $H_{0.5}$ | 87.00 | 10.20 |
| Chlorine in Chlorination stage | 1.9% | |
| Alkali in Extraction stage | 1.0% | |

ough the hypo charge was increased to a very high dosage of 1.5%, it was inefficient to bleach the pulp to a brightness of 90+ISO. The maximum brightness obtained was only 88 5% ISO. There was only a very narrow improvement of 0.4 points with 1.5% hypo when compared to 1.0% hypo charge.

Bleaching the kraft bagasse pulp with double stage hypo bleaching (CEHH) with the split addition also could not enhance the brightness to 90+ (Table 9.). The increased hypo charge resulted in the considerable reduction in pulp viscosity. Therefore, it was concluded that further increased charge fo hypo were not desirable.

In order to attain very high brightness, and at the same time to retain the acceptable strength, the conventional bleaching method has to be modified. Paper industry has been observing in the past few years, that more and more mills have started including other bleaching chemicals based on oxygen like oxygen, ozone, hydrogen peroxide (6). It is reported that adding a chlorine dioxide at the final stage in the CEH sequence would produce a bleached bagasse pulp upto 90+ brightness with better strength properties (7). Another technique called oxygen-alkali extraction has been reported to have improved the pulp bleachability substantially (8). It is very advantageous to have two bleaching agents coupled in the same stage as it does not require additional sequences. Hydrogen peroxide reinforced alkali extraction has also been found to be effective in improving the pulp bleaching (9). With respect to kraft bagasse bleaching peroxide reinforced oxidative extraction experiments were carried out to reach very high brightness.

Hydrogen peroxide addition in the 'E' stage was optimised with respect to the final brightness gain proportional to the peroxide charged (Table 10). Even-

TABLE—X

EFFECT OF OXIDATIVE EXTRACTION IN FINAL BRIGHTNESS

n* bleached Pulp

| | | |
|---|---|---|
| Brightness | % ISO | 43.8 |
| Kappa Number | | 10.6 |
| Viscosity | Cps | 27.2 |

| Parameters | Unit | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Peroxide Charge | % | 0.00 | 0.50 | 0.80 | 1.00 |
| Alkali charge | % | 1.00 | 1.20 | 1.20 | 1.20 |
| CE Kappa Number | | 1.70 | 0.90 | 0.70 | 0.60 |
| CE Brightness | % ISO | 57.40 | 73.50 | 74.50 | 76.50 |
| CE Viscocity | Cps | 26 00 | 17.80 | 13 10 | 11.80 |
| Hypo chlorite as $Cl_2$ | % | 0.50 | 0.50 | 0.50 | 0.50 |
| Final Brightness | % ISO | 84.90 | 87.30 | 87.50 | 88.10 |
| Bleached Viscosity | Cps | 18.50 | 13.50 | 10.70 | 10.50 |

though, there is significant improvement in the CE brightness its impact is not felt in the final bleached brightness. Beyond 0.5% peroxide charge there is no appreciable improvement. With this optimum peroxide charge (0.5%) the bagasse pulp was bleached with single stage hypo CE (P)H (Table 11) and double stage

TABLE—XI

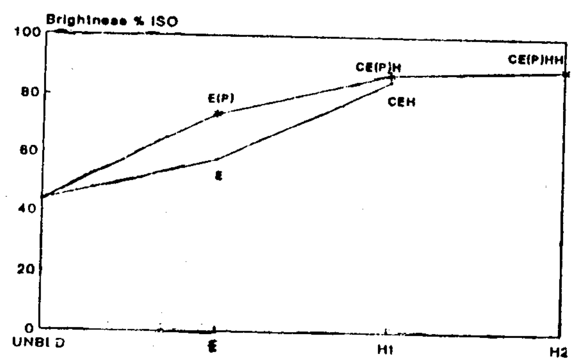
LARGE SCALE BLEACHING FOR MAXIMUM BRIGHTNESS ACHIEVEMENT

| Parameter | | Unit | C E H | C E (P) H | C E (P) H H |
|---|---|---|---|---|---|
| **Chlorination** | | | | | |
| Chlorine as $Cl_2$ | Applied | % | 1.90 | 1.64 | 1.64 |
| | Consumed | % | 1.80 | 1.55 | 1.56 |
| **Extraction** | | | | | |
| Alkali as NaOH | Applied | % | 1.00 | 1.20 | 1.20 |
| | Consumed | % | 0.65 | 0.83 | 0.81 |
| Peroxide as $H_2O_2$ | | % | Nil | 0.50 | 0.50 |
| **Hypo I Stage** | | | | | |
| Hypo as $Cl_2$ | Applied | % | 0.50 | 1.00 | 1.00 |
| | Consumed | % | 0.44 | 0.76 | 0.71 |

| | | | | | |
|---|---|---|---|---|---|
| **Hypo II Stage** | | | | | |
| Hypo as $Cl_2$ | Applied | % | — | — | 0.50 |
| | Consumed | % | | | 0.71 |
| Total Chlorine as $Cl_2$ | Applied | % | 2.40 | 2.64 | 3.14 |
| | Consumed | % | 2.24 | 2.31 | 2 54 |
| **Bleaching Losses** | | % | 2.76 | 3.51 | 3.94 |
| **Bleached Pulp** | | | | | |
| Brightness | | % ISO | 84.90 | 88.80 | 89.40 |
| Viscosity | | Cps | 18.50 | 10.40 | 9.20 |

hypo CE (P)HH. The maximum brightness (89.4% ISO) was obtained with $C_{1.6}\,E_{1.2}$-$(P_{0.5})$-$H_{1.0}$-$H_{0.5}$ sequence. The brightness enhancement is shown in Fig. 3.

Fig. 3 Effect of Hydrogen peroxide in the final brightness.




These bleaching sequences do not affect the bonding properties but tearing strength is slightly reduced. The strength properties are tabulated in Table 12. Hence, application of hydrogen peroxide in the existing extraction stage could yield a final pulp of high brightness without major modification. Still higher final brightness gain can be envisaged with the effective application of other species like oxygen, ozone and chlorine dioxide. Besides improving the pulp bleachability, peroxide also reduces the 'E' stage effluent colour considerably.

## Summary

From the foregoing series of experiments we conclude that,

1 Soda pulping of bagasse with the organic additive AQ can produce a pulp with the similar characteristics of kraft bagasse pulp.

TABLE—XII

STRENGTH PROPERTIES OF HIGH BRIGHTNESS PULPS COMPUTED AT 300 ml CSF

| DESCRIPTION | Unit | Unbleached | C E (P) H | C E (P) H H |
|---|---|---|---|---|
| Tensile index | Nm/g | 78.10 | 72.00 | 68.50 |
| Burst Index | Kpa $m^2/g$ | 5.10 | 4.70 | 4.40 |
| Tear Index | mN $m^2/g$ | 6.20 | 5.55 | 5.45 |

2 For Newsprint paper grade, where the appearance is not critical parameter, high kappa kraft pulping is recommended.

3 Interrupting the kraft bagasse pulping at a very high Kappa number, then extending the delignification with oxygen produce pulp with increased yield, and with very good bleachability.

4 It can be stated that it is very easy to bleach the kraft bagasse pulp to 85% ISO but high brightness like 90+ can be obtained only by other bleaching methods like CE(P)H.

**Acknowledgement**

The authors are grateful to the management of TNPL for granting permission for publishing this paper and sincere acknowledgements are due to Mrs. R.S. Tamilarasi for her timely technical assistance.

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