Kraft Anthraquinone Pulping of Bamboo+Mixed hard woods (70:30), Bamboo (100·/.) and Mixed Hard Woods (100·/.).

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Laboratory scale kraft pulping studies were carried out at 17% Sulphidity on bamboo+mixed hard woods (70:30), Bamboo (100%), Mixed hard woods (100%) by addition of anthraquinone dosages. It was observed that by adding different anthraquinone dosages (0.05% to 0.25%) the kappa No. of Bamboo+Mixed hard woods (70:30) reduces. The bleach consumption of all the anthraquinone based pulps was lower and physical strength properties were superior to the pulps without anthraquinone additive. It was observed that anthraquinone in small dosage (0.05%) was more effective in improving the yield of bamboo+Mixed Hard woods (70:30) digested at higher Kappa No. than with lower Kappa No. digested Bamboo and Mixed Hard woods.

The increasing scarcity of fibrous raw materials for pulp and paper making has directed the attention of paper technolcgist to search alternative pulping process other than kraft process. Although the kraft process has several well established advantages over other pulping processes, including unmatched product quality, high chemical and energy efficiency, and the ability to pulp almost any wood species but inferior yields coupled with economic and environmental pressures constitute strong incentives for a continuing search for superior processes. Various mechanical processes viz T.M P.,-C.T.M.P; C.M.P. gained world wide importance as regards the high pulp yield but the pulp properties were inferior to chemical pulp. Pulping additives viz anthraquinone and its derivatives have gained world wide[1-10] importance for improving the pulp yield in the Soda and kraft pulping processes without addition to the cost of plant and machinery.

Anthraquinone has a marked catalytic effect on delignification in both Soda and kraft pulping of soft wood and hard woods.[6] Many authors have examined aspects of the additive performance and its mechanism of action [1,3,5,9,11-20]. It has been found that anthraquinone addition enhances the rate of delignification, stablizes Carbohydrate which results in increased pulp yields. Small amount of AQ (0.05–0.1%) on wood is effective in enhancing the rate of delignification and achieving higher yield. The influence of additive was more pronounced in Soda than in kraft pulping of hard woods.

In our mill we are using 65–70% Bamboo and 30–35% mixed hard woods in the mixed cooking of these raw materials using kraft process for producing different grades of papers. It was planned to see the effect of anthraquinone (AQ) addition on Bamboo+mixed hard woods (70:30) on a laboratory scale and compare the findings with Bamboo and mixed hard woods using AQ. Bamboo *(Dendro Calmus Strictus)* and mixed hard woods viz Sal *(Shorea Robusta)* Salai *(Boswellia Serrata)* formed 50% of the total wood species used and remaining hard woods species were Saza *(Terminalia Tomentosa)*, Tendu *(Deospyrus Melanoxylon)*, Harra *(Terminalia Chebu'a)*, Haldu *(Adina Cordifolia)* and Gunja *(Garuja Pinnata)* mixed in equal proportion for carrying out pulping studies.

EXPERIMENTAL :

Screened Bamboo and mixed hard woods chips (–22, +10 m m. size), mixed in 70:30 proportion were taken for mixed cooking. Bamboo+mixed hard wood chips (70:30) were digested with 16–19% chemicals (17% Sulphidity) for four hours (60 minutes hold time at 165 C) and bath ratio was kept at 1:4 to get a pulp of around 40.0 kappa No. The cooking conditions and results are recorded in Table-1 The effect of alkali dosages applied on Bamboo+mixed hard woods (70:30) and the resulting kappa No. of pulp, unbleached yield (%) and rejects percentage is depicted in figure-1 All the unbleached pulps (Experiment No. 1–5) were bleached

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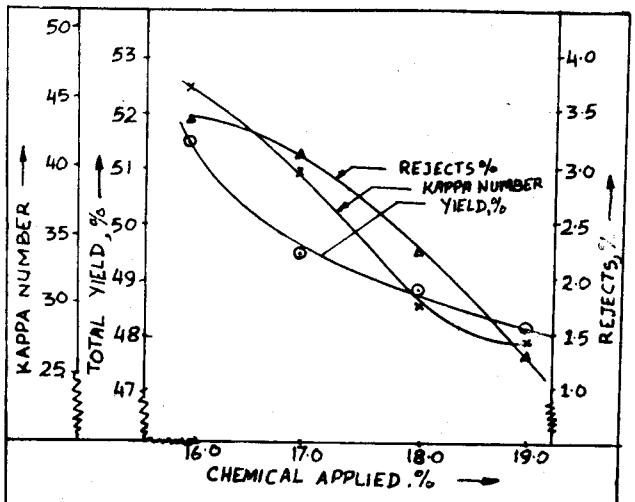


FIG-1 EFFECT OF CHEMICAL APPLIED, % V/S KAPPA NUMBER, YIELD,% AND REJECTS,% OF BAMBOO + MIXED HARDWOODS (70:30)

under C/E/H bleaching Sequence for getting pulp brightness 77–78% P.V. The bleaching conditions and results are given in Table-2. The effect of chlorine consumption versus bleached pulp yield of different pulps (Expt. No. 1–5) is projected in figure-2. These

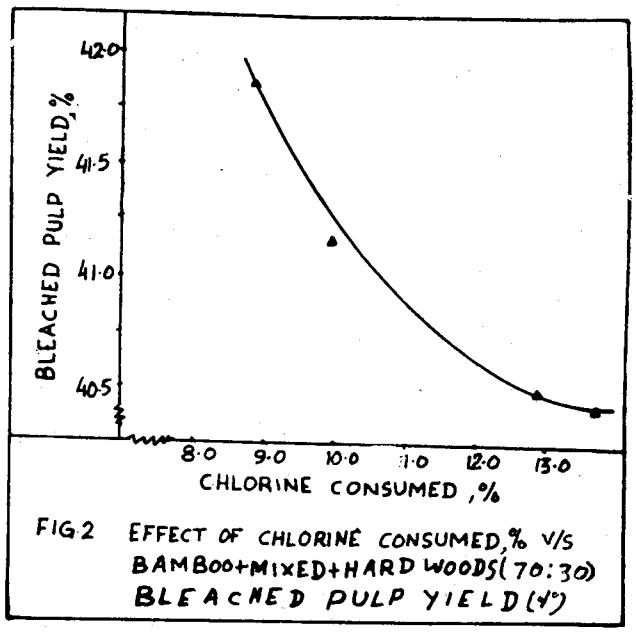


FIG 2 EFFECT OF CHLORINE CONSUMED, % V/S BAMBOO+MIXED+HARD WOODS (70:30) BLEACHED PULP YIELD (%)

bleached pulps of Bamboo + mixed hard woods (70:30) were beaten at 45°SR in a laboratory valley beater and standard sheets were made and tested as per Tappi Standards. The effect of different alkali dosages versus strength properties like Tensile Index, Burst Index and Tear Index is depicted in figure-3.

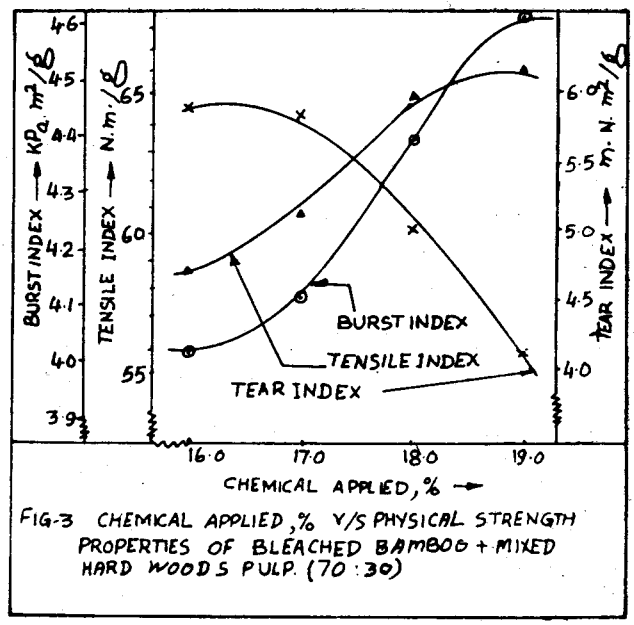


FIG-3 CHEMICAL APPLIED, % V/S PHYSICAL STRENGTH PROPERTIES OF BLEACHED BAMBOO + MIXED HARD WOODS PULP (70:30)

Digestion oonditions and raw material proportion of Table-1. (Expt No. 2) were kept same throughout the six digestions which were carried out with AQ by varying its dosages 0.05%, 0.1%, 0.15%, 0.2% and 0.25%. The effect of AQ dosages on pulp yield and kappa No. is shown in figure-4 and the results are given in Table-3.

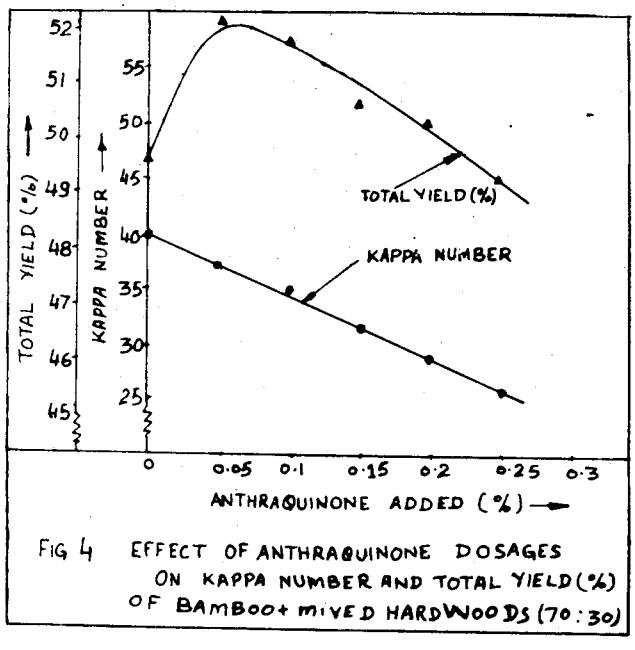


FIG 4 EFFECT OF ANTHRAQUINONE DOSAGES ON KAPPA NUMBER AND TOTAL YIELD (%) OF BAMBOO+ MIXED HARDWOODS (70:30)

Unbleached anthraquinone based pulps were bleached under C/E/H Sequence. The bleaching conditions and results are recorded in Table-4. The effect of anthra-

TABLE—1

Effect of Alkali Concentration on Pulping of Bamboo+Mixed Hard woods (70:30 ratio).

S. No.	Particulars	Expt. No. 1	Expt. No. 2	Expt. No. 3	Expt. No. 4	Expt. No. 5
1.	Active chemical% (applied as Na_2O)	16	17	17	18	19
2.	Sulphidity, % of white liquor	17	17	17	17	17
3.	Bath ratio	1:4	1:4	1:4	1:4	1:4
4.	Hold time for Max. temperature° C (minutes)	90	90	120	90	90
	Total cooking time (mts)	240	240	270	240	240
5.	Total yield, % (on O.D. raw material)	51.3	49.4	48 8	48.8	48.1
6.	Reiects, % (on O.D. raw material)	3 4	3.2	2.2	2.3	1.3
7.	Kappa Number	45.6	40.0	35.1	30.7	26.9
8.	**Weak Black liquor Analysis**					
	a) °TW at 60° C	16.5	17.0	17.5	21.5	19.5
	b) RAA as Na_2O, g.p.l.	15.5	17.8	16.5	21.7	20.2
	c) Total solids, %	18 7	18.6	20.1	23.7	22.1
	d) Inorganic content, %	31.4	33.1	31.8	31 0	39.5
	e) Organic content, %	68.6	66.9	69.2	69.0	60.5

TABLE—2

Bleaching of Bamboo+Mixed Hard woods (70 30) Kraft pulps under C/E/H Sequence.

S. No.	Particulars	Expt. No. 1	Expt. No. 2	Expt. No. 3	Expt. No 4	Expt. No. 5
1.	**CHLORINATION STAGE**					
	(i) Chlorine applied, %	10.5	10.0	9.0	8.0	7.0
	(ii) Chlorine consumed, %	10.0	9.7	8.7	7.7	6.8
	(iii) End pH	2.1	2 15	2.0	2.1	2.0
2.	**ALKALI EXTRACTION STAGE**					
	(i) Caustic added, %	2.5	2.5	2.5	2 5	2.5
	(ii) End pH	10.5	10.9	10.5	10.8	11.0
3.	**HYPOCHLORITE STAGE**					
	(i) Hypochlorite applied, %as Cl_2	4.0	3.5	3.5	2.5	2.0
	(ii) Chlorine consumed, %	3.7	3.2	3.3	2.3	1.8
	(iii) Buffer added, %	0.4	0.4	0.45	0.4	0.5
	(iv) End pH	8.0	7.8	8 1	8.8	8.0
4.	Total chlorine applied,%	14.5	13.5	12.5	10.5	9.0
5.	Total chlorine consumed,%	13.7	12.9	12.0	10.0	8.6
6.	Brightness, %	77.5	77.5	77.0	77.0	78.0
7.	Viscosity (0.5% CED), Cps	5.5	5.9	6.0	6.2	6 5
8.	Post colour No	5.1	4.9	4.7	4.0	4.2
9.	Bleached pulp yield, % (on O.D. raw material)	40.47	40.85	41.0	41.19	41 8

TABLE—3

Effect of AQ Dosages on Bamboo+Mixed Hard woods (70:30) Kraft Pulping.

S. No.	Particulars.	Expt. No.1 (Blank Expt No. 2 of Table 1) AQ 00%	Expt. No.2 AQ 0.05%	Expt. No.3 AQ 0.1%	Expt. No.4 AQ 0.15%	Expt. No.5 AQ 0.2%	Expt No.6 AQ 0.25%
1.	Total yield, % (on O.D. raw material)	49.4	52.2	51.9	50.6	50.3	49.2
2.	Rejects,% (on O.D. raw material)	3.2	1.4	0.9	0.5	0.7	0.7
3.	Kappa Number	40.0	35.4	34.9	32.0	28.5	26.0
4.	Weak black liquor analysis						
	a. TW at 60°C	17.0	18.0	17.0	16 0	15 5	15 5
	b. R A.A, as Na_2O, gpl	17.8	16.5	16 0	15.3	16 5	15.0
	c. Total solids, %	18 6	18 9	19 7	20.2	19.8	21.2
	d. Inorganic contents,%	33.1	34.5	34 6	35.8	35.9	36.5
	e. Organic contents,%	66.9	65.5	65 4	64.2	64.1	63 5

Table–4

Bleaching of Anthraquinone (AQ) Bamboo+Mixed Hard woods (70:30) Kraft pulps under C/E/H Sequence.

S.No.	Particulars	Expt No. 1 (Blank Expt No. 2 of Table 1 AQ 00%	Expt. No.2 AQ 0.05%	Expt. No.3 AQ 0.1%	Expt. No 4 AQ 0.15%	Expt. No. 5 AQ 0.2%	Expt. No. 6 AQ 0.25%
1.	**CHLORINATION STAGE**						
	i) Chlorine applied,%	10.0	9.5	9.0	8.0	7 0	6.5
	ii) Chlorine consumed,%	9.7	9.2	8 3	7.6	6 8	6.3
	iii) End pH	2 15	2.0	2.0	2 1	2.1	2 0
2.	**ALKALI EXTRACTION STAGE**						
	i) Caustic added,%	2.5	2.5	2.5	2.5	2 5	2 5
	ii) End pH	10.9	10.8	10.5	10 6	10.7	10.5
3.	**HYPOCHLORITE STAGE**						
	i) Hypochlorite applied,% as Cl_2	3.5	3 5	3.5	2.5	3.0	2.5
	ii) Chlorine consumed,%	3.2	3.3	3 4	2.4	2.7	2.0
	iii) Buffer added, %	0.4	0.5	0 5	0 5	0.4	0,5
	iv) End pH	7.8	8.0	7 8	8.1	7,9	7 9
4.	Total chlorine applied,%	13,5	13,0	12,5	10,5	10,0	9,0
5.	Total chlorine consumed,%	12,9	12,5	11,7	10,0	9,5	8,3
6.	Brightness,% P.V.	77.5	78.5	77.5	77 5	78.0	77.5
7.	Viscosity (0.5% CED) CPS	5.9	6.5	6.6	6.7	6.6	6.2
8.	Post colour No.	4.9	4.8	4.4	4.5	4.3	4.0
9.	Bleached pulp yield,% (on O.D. raw material)	40.85	42.8	41.9	42.03	41.8	41.07

quinone dosages in the digestion and respective reduction in bleach consumption in the C/E/H bleaching Sequence is shown in figure-5.

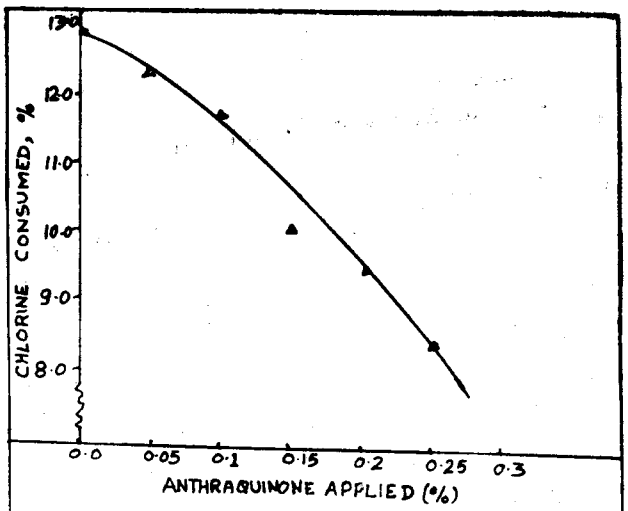
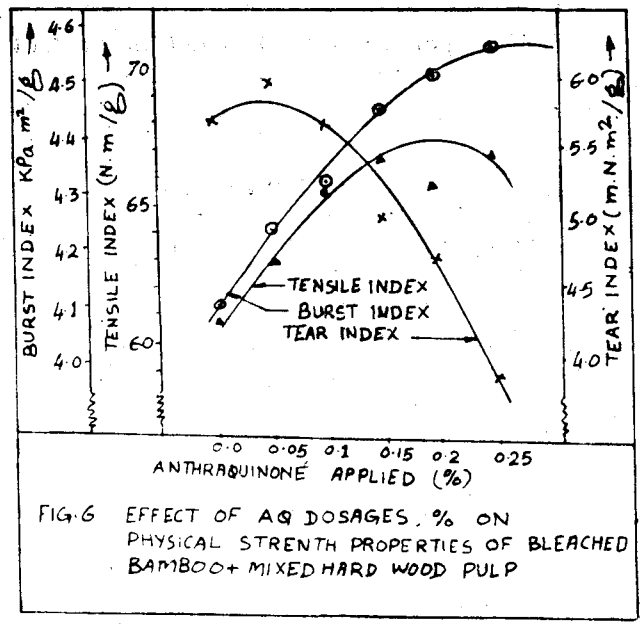


FIG 5. AQ BASED BAMBOO + MIXED HARD WOODS PULPS V/S TOTAL CHLORINE CONSUMPTION

The fibre classification of bleached anthraquinone based bamboo+mixed hard woods (70:30) pulps was carried out in a Bauer Mc nett classifier. The fibre retention on different meshes is tabulated in Table-5. The anthraquinone based bleached pulps were also beaten in a valley beater at 45°SR and the physical strength properties of the sheets like tensile Index, Burst Index and Tear Index versus anthraquinone dosages applied are shown in figure-6.

Blank experiments of Bamboo (100%) and mixed



FIG·6 EFFECT OF AQ DOSAGES, % ON PHYSICAL STRENTH PROPERTIES OF BLEACHED BAMBOO+ MIXED HARD WOOD PULP

hard woods (100%) digestions were carried out with 16% and 18% alkali respectively (17.0% Sulphidity) for a cooking cycle of four hours (90 mnts hold time at 165°C) and bath ratio was kept at 1:4, Anthraquinone (AQ) dosages (0.05%) were also applied in the digestion of Bamboo and mixed hard woods under identical cooking conditions as mentioned above and the results are compared with their blank experiment in Table-6. Bamboo and mixed hard woods pulps (with and without additive AQ) were bleached under C/F/H bleaching Sequence. The bleaching conditions and results are recorded in Table-7. These bleached pulps were beaten in a valley beater at 45°SR and Standard sheets were tested for physical strength properties which have been recorded in Table-8.

Table-5

Fibre Classification of additive based bleached pulps (Bamboo+Mixed hard wood (70:30).

S.No.	Mesh size	+20	−20 +40	−40 +70	−70 +100	−100 +140	−140
1.	Bamboo + M H W. (Blank)	38.64	10.42	24.54	4.62	2 52	19.26
2	Bamboo + M H W. + AQ 0 05%	42.64	12 52	24.36	6 43	5 86	9 19
3.	Bamboo + M.H.W + AQ 0 1%	40 61	12 8	26 84	4.82	3.64	11.29
4.	Bamboo + M.H W. + AQ 0 15%	38.50	8.45	32.21	7 4	4.0	9. 4
5.	Bamboo + M.H W. + AQ 0 2%	38 43	10.18	32 85	1.52	5.93	11.09
6.	Bamboo + M H W. + AQ 0.25%	36 16	5.82	37 07	6 58	1.71	12.66

Table-6

Kraft pulping of Bamboo and Mixed Hard woods with and without anthraquinone addition.

S.No.	Particulars	Bamboo Blank	Bamboo+AQ 0.05%	Mixed Hard woods Blank	Mixed Hard woods + AQ 0 05%
1.	Active alkali, % (applied as Na_2O)	16	16	18	18
2.	Sulphidity, % of white liquor	17	17	17	17
3.	Additive all added, % (on O.D. Raw material)	00	0.05	00	0.05
4.	Bath ratio	1:4	1:4	1:4	1:4
5.	Hold time at maximum temp. °C (mts)	90	90	90	90
6.	Total cooking time (mts)	240	240	240	240
7.	Total yield, % (on O.D. raw material)	47.8	49.7	46 4	48 6
8.	Rejects, % (on O.D. raw material)	2.5	1 5	2 8	1.8
9.	Kappa Number	30.52	25.4	35.2	28.4
10.	Weak black liquor analysis				
	a) °TW at 60°C	21 0	18 5	18 5	17 0
	b) R.A A. as Na_2O gpl	17.1	16.0	17.5	16 5
	c) Total solids, %	20 5	21.7	19.8	19 8
	d) Inorganic contents, %	33.6	34 1	34 4	35,8
	e) Organic contents, %	66.4	65.9	65 6	64 2

Table-7

Bleaching of Bamboo and Mixed Hard woods with and without anthraquinone additive under C/E/H Sequence.

S.No.	Particulars	Bamboo Blank	Bamboo+AQ	Mixed Hard woods Blank	Mixed Hard woods+AQ
1.	**CHLORINATION STAGE :**				
	(i) Chlorine applied, %	7.5	6.0	7.5	6.0
	(ii) Chlorine consumed, %	6.9	5.8	7.0	5.5
	(iii) End pH	2.0	2.0	2.0	2.0
2.	**ALKALI EXTRACTION STAGE**				
	(i) Caustic added, %	2.5	2.5	2.5	2.5
	(ii) End pH	10.8	10.5	10.8	10.6
3.	**HYPOCHLORITE STAGE**				
	(i) Hypochlorite applied% as Cl_2	3.0	2.5	3.5	2.5
	(ii) Chlorine consumed	2.8	2.2	3.0	2.2
	(iii) Buffer added, %	0.5	0.5	0.4	0.5
	(iv) End pH	8.1	8.2	8.1	8.2
4.	Total chlorine applied, %	10.5	8.5	10.5	8.5
5.	Total chlorine consumed, %	9.7	8.0	9.8	7.7
6.	Brightness, % P.V.	77.0	77.5	77.5	77.5
7.	Viscosity (0.5% CED) CpS	6.2	7.6	6.6	7.0
8.	Post colour No.	4.5	4.0	4.6	3.5
9.	Bleached pulp yield, % (on O.D. raw material)	4.5	13.18	39.9	41.78

Table-8

Physical strength properties of Bamboo and Mixed Hard woods bleached pulps with and without AQ Addition.

S.No.	Particulars	Bamboo Blank	Bamboo AQ 0.05%	Mixed Hard woods Blank	Mixed Hard woods + AQ 0.05%
1.	Initial Freeness of pulp, °SR	18	17	18	19
2.	Final freeness of pulp, °SR	45	45	45	45
3.	Tensile index (N.m/g)	63.18	65.14	56.9	63.77
4.	Tear Index (m.N.m²/g)	5.93	6.23	4.46	4.95
5.	Burst index (K.Pa m²/g)	4.94	5.23	3 88	4.99
6.	Folding Endurance	1015	952	540	520

RESULTS AND DISCUSSIONS :

Bambo + mixed hard woods (70:30) chips were digested with 16%, 17%, 18% and 19% alkali (17% Sulphidity) at constant cooking conditions as given in Table-1 which shows that the unbleached pulp yield obtained were 51.3%, 49.4%, 48.8% and 48.1% respectively and rejects percentage 3.4%, 3 2%, 2 3% and 1.3% respectively. The rejects percentage yield and kappa No. of the pulp decreases with increase in alkali dosages as shown in figure-1. R.A.A and total solids of the spent black liquor increased with increase in alkali dosages (Table-1). These unbleached pulps were bleached under C/E/H Sequence using 10.5%, 10.0%, 8.0% and 7.0% chlorine respectively in the first stage and 4.0%, 3 5%, 2.5% and 2.0% hypochlorite in the third stage bleaching to get pulp brightness around 77-78% P.V. The effect of alkali dosages applied versus bleached pulp yield have been shown in figure-2. It was observed that as the chlorine consumption decreases the viscosity of bleached pulp increases (5.5, 5.9, 6.2 and 6.5 Cps, CED (0.5%) respectively). The bleaching conditions and results are recorded in Table-2. These bleached pulps evaluated for physical strength properties, shows that as the total chlorine dosages decreases Tensile Index, Burst Index increased but Tear Index showed a reducing trend as projected in figure-3.

Optimum digestion conditions for cooking Bamboo + mixed hard woods (70:30) were followed (Expt. No 2, table-1) using 17% alkali and different anthraquinone dosages 0.05%, 0.1%, 0 15%, 0.2% and 0 25% were applied. The findings are recorded in Table-3. The addition of anthraquinone dosages resulrs in lowering of Kappa No. (35.4,34.9,32.0, 28.5 and 26.0 respectively) and unbleached pulp yield (52.2%, 51.9%, 50.6%, 50 3%, and 49 2% respectively). The effect of anthraquinone addition on pulp yield and Kappa No. has been shown in figure-4. It is seen that unbleached pulp yield in the blank experiment was 49.4% whereas with 0.05% anthraquinone addition (lowest dosage of additive) the yield has gone upto 52.2%, a net increase of 2 8% in unbleached yield whereas the rejects have come down from 3 2%, to 1.4% with 0 25% anthraquinone (additive dosage on the higher side) the unbleached yield has come down to 49.2% which is in the vicinity of unbleached pulp yield of blank experiment (49.4%). Unbleached Bamboo + mixed hard wood pulp (70:30) was also bleached under C/E/H Sequence for comparison. The findings are recorded in Table-4. It was seen that with increase in anthraquinone dosages in the pulping stage the chlorine consumption decreases appreciably in the bleaching stage as shown in figure-5. The viscosity of the bleach pulp (blank experiment) was lower than the AQ base experiments which shows that AQ based bleached pulps are less degraded as compared to the blank experiment bleached pulp (Table-4). Fibre classification of AQ based bleached pulps and blank experiment was carried out in a Bauer Mc nett classifier. The results reported in Table-5 shows that fibre retention on +20 mesh with 0.5% and 0.1% AQ dosages was higher than the blank experiment which gradually reduces on + 20 mesh with increase in AQ dosages. It may be concluded that anthraquinone addition (in lower dosages) protects the damage of the fibres.

Anthraquinone based pulps were beaten in a valley beater at 45°SR and physical strength properties of the Standard sheets viz Tensile Index, Burst Index and Tear Index have been plotted against AQ dosages applied (figure-6). It was found that Tensile Index, Burst Index increased with AQ dosages but Tear Index

showed a decreasing trend. The physical strength properties of AQ based pulps are superior to the blank experiment of bleached pulp, but the rejects percentage with additive has come down to 0.7%. The higher AQ dosage has reduced Kappa No. by 14 points. When we compare results of digestion (Expt. No. 5 Table-1) using 19% alkali for Bamboo+mixed hard woods (70:30) with that of AQ based experiment (Expt.No. 6, *Table-3*) using 0.25% AQ dosage, it was seen that 2% alkali can be saved with AQ dosage, 1.0% gain in pulp yield and lower rejects percentage for same Kappa No. pulp. Black liquor analysis of AQ based experiments shows that R.A.A. was reduced with increase in anthraquinone dosages whereas total solids showed an upward increasing trend (Table-3).

Unbleached pulps of AQ based experiments 2,3,4, 5 and 6 were bleached under C/E/H Sequence using 9.5%, 9.0%, 8.0% 7.0% and 6.5% chlorine respectively in the first stage and 3.5%, 3.5%, 2.5%, 3.0% and 2.5% hypochlorite respectively in the third stage bleaching for attaining pulp brightness 77—78% P.V.

Bamboo and mixed hard woods were digested for comparison with 16% and 18% alkali respectively under same conditions as followed earlier in Table – 3. It was found that unbleached yield of Bamboo and mixed hard woods were 47.8% and 46.4% respectively whereas after addition of AQ dosage (0.05%) the yield was improved to 47.9% and 48.6% respectively The net increase in yield of bamboo and mixed hard wood was 1.9% and 2.2% respectively with AQ addition The Kappa No. of Bamboo and mixed hard woods were 30.52 and 35.2 respectively whereas after addition of AQ dosages the Kappa No. have come down to 25.4 and 28.4 respectively. The rejects (%) of Bamboo with AQ has come down from 2.5% to 1.5% whereas in mixed hard wood it has come down from 2.8% to 1.8%. R.A.A. of Black liquors with AQ addition has decreas whereased total solids have increased in Bamboo and mixed hard woods (Table-6).

Bamboo and Mixed hard woods unbleached pulps (with and without AQ addition) were bleached under C/E/H Sequence using 7.5% chlorine for Bamboo and mixed hard wood pulps in the blank experiment and 6% chlorine for AQ based pulps. Hypochlorite dosages 3.0% and 3.5% were applied for Bamboo and mixed hard woods pulps respectively in the third stage bleaching of the blank experiment whereas 2.5% hypochlorite was applied for AQ based pulps. It was observed that AQ based bleach pulps have lower chlorine consumption and higher pulp viscosity than their blank experiments. Results are tabulated in Table-7. Bamboo and mixed hard woods bleached pulps were evaluated for physical strength properties It was seen that the physical strength properties of AQ based Bamboo and mixed hard wood bleached pulps were superior to Bamboo and mixed hard woods bleached pulps.

CONCLUSION :

Anthraquinone has beneficial effect on delignification and improvement in pulp yield of Bamboo+ mixed hard woods (70.30) when used in small dosage (0.05% Although improvement in yield and reduction in Kappa No. was noticed with higher anthraquinone dosages but the gain in pulp yield was lower. Pulp obtained with 0.25% AQ and 17% alkali (17% Sulphidity) has same Kappa No. which was obtained by using 19% alkali (17% Sulphidity) thus 2% alkali saving was possible with anthraquinone addition.

The bleach chemical requirement of anthraquinone based Bamboo+mixed hard woods pulps were lower than Blank Bamboo+mixed hard woods pulps. The viscosity and physical strength properties of anthraquinone based bleached pulps were superior to blank Bamboo+mixed hard woods pulps.

The gain in unbleached pulp yield for Bamboo and mixed hard woods with higher alkali dosages as desired for Kappa No. 25-30 with 0.05% AQ dosage was 1.9% and 2.2% respectively. It can also be concluded that pulp yield improvement was significantly higher with 0·05% AQ dosages for higher Kappa No. pulp or Bamboo+mixed hard woods 2.8% yield improvement). The bleach chemical requirement for Bamboo and mixed hard woods AQ pulps were lower and viscosity were higher for same brightness of pulp than the blank Bamboo and mixed hard woods pulps.

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