Upgradation of Agro-Residue Pulping And Bleaching in Shiva Paper Mills Limited

Chatterjee, A.K. & Srinivasan, G.K.

ABSTRACT:– *The paper highlights how the laboratory scale research trials on Soda-Anthraquinone pulping using different furnish mix and subsequent bleaching with the use of Hydrogen Peroxide in C-E-H stages paved the way for large scale plant trials to produce high brightness pulp with less reversion. From the studies on Soda-Anthraquinone pulping of bagasse and sarkanda (Saccharum Munja) mix using A.Q. doses viz. 0.05, 0.10, 0.15 & 0.20 percent on B.D. raw material and subsequent bleaching by C-E-H sequence, following points emerge:*

2.0-5.0 percent yield increase in bleached pulp at reasonably higher brightness ceiling limit of 80-82% ISO.

Advancing the cooking time of A.Q. cooks has added advantage over reducing caustic percentage so as to achieve the same level of P.No. in respect of higher bleachable yield, mariginally lower bleach chemical saving, at the same achieving higher stable brightness of pulp and increasing long fractions (R-30 and R-50 of Bauer-McNette classifier).

A.Q. saturated black liquor in place of water being used as diluent in cooking to maintain bath ratio has the beneficial effect on bleach yield, final brightness, better stability with less reversion.

Further studies on Hydrogen peroxide reinforced alkali extraction in a C-EP-H bleaching process using 0.6, 0.8 & 1.0% Hydrogen peroxide (50% w/w) had thrown light on gradual improvement in CE-P. No., CE- brightness with

Shiva Paper Mills Ltd.
15th Kms. Bareilly Road,
Jain Nagar, Dhamora
RAMPUR-244 901 (U.P.)

subsequent improvement in final brightness, post colour number and copper number.

Low P.No. Soda-AQ pulps resulted in higher brightness ceiling limit of 85-86% ISO with reasonably high stability and yield.

Plant trials of Soda-A.Q. pulping and subsequent bleaching by C-EP-H as is practised now, clearly supported the findings and highlighted:

The effect of 0.05% A.Q. addition on increase in long fiber fractions (R-30 & R-50 fractions).

Bagasse-fresh sarkanda bleached pulp giving 10% point increase in R-30 + R-50 fiber fractions with the resultant effect on runnability.

Saving in bleach liquor usage to the tune of 2.5-3.0% point achieving 3 ISO units higher brightness levels.

Lower post colour number and copper number of the pulps indicating brightness stability on ageing.

With all concerted efforts in pulping & bleaching area, the runnability and the machine productivity had shown good improvement.

INTRODUCTION:

The ever increasing demand for paper and paper products, due to growing population and steadily increasing level of literacy and civilisation has created severe problem of scarcity of forest based raw materials throughout the world.

This is much more predominant in developing countries like India, due to ruthless deforestation for fuel and timber and also due to lack of planned development in afforestation. It is quite but natural that non-wood fibrous raw materials such as bagasse, cereal straws, Jute fibers as well as secondary fibres have become the major alternative source for papermaking.

For the projected demand of 3.2 million tons of paper and paper boards by 2000-01 A.D., about 60.9 percent, will be from small scale sector of which agro waste based segment contribute to 35.6 percent (1). It is pertinant to point out that agro based industries should rise to occassion in registering over all productivity in terms of bleached yield, raw material utility, upgradation of quality and production to face the present scenario of global competition and economic liberalisation.

Sufficient expertise and technological upgradation has been developed in the field of pulping & bleaching, processing and converting agro residue wastes into various grades of pulp and paper.

PRESENT SCENARIO

To cope up with the present competition there is no option left for the mills but to change

the concept of working environment according to the dictates of marketing & marketability of the existing range to product line. With the steady errossion of marketable base for cream wove and writing paper grades, due to stiff competition from the identical set ups, we had to explore all avenues for diversifying the products line to value added paper qualities such as Super Printing, S.S. Maplitho, Xerox grades, Cover Papers & Calender Paper etc.- a departure from the Conventional grades to value added Quality Paper. Such quality products can be standardised to market requirement, only when there is a quantum change in the existing pulping & bleaching systems for a better output in terms of yield, improved quality of pulp in brightness, stability and other physical properties.

With the earlier system of pulping and bleaching prior to our modification, major constraints had arisen mainly in brightness and brightness stability due to reversion or poor shelf life of cream wove/ writing papers made there from leading to serious customer's complaints, besides opacity and Bulk related problems.

In a planned and systematic operation, we have steadily moved forward in the direction of value added products for which higher, brightness/ whiteness and printability requirements are the prequisites.

Improvement in the depithing & dusting systems for bagasse/ straws, introduction of Soda-Anthraquinone pulping in place of Soda pulping, modifying the bleaching system to tune from the earlier C-E-H sequence of operation to C-E/P-H and subsequently to C-E/P-H-H sequences are some of the quantum changes brought about in the mill. Quality complaints on shade reversion and yellowing tendency on ageing from the customers are not there.

The advisory role of experts from M/s National Peroxide Ltd., Bombay, was of immense help in changing the mode of split dosing of peroxide and Sodium Silicate addition as a stabiliser.

This paper highlights how the laboratory scale research trials on Soda-AQ pulping using on different furnish mix and subsequent bleaching with the use of H_2O_2 in C-E-H sequence pave the way for large scale plant trials. The paper also highlights how the ticklish problem of achieving higher stable brightness of bleached pulp was tackled in pulp mill/ bleach plant for developing value added paper grades.

EXPERIMENTAL

With the sole objective of improving the overall pulping & bleaching processes, main emphasis was laid on Soda-Anthraquinone pulping of different furnish mix to upgrade the pulping quality with regard to soft cook, yield and reduction in chlorine consumption. In this direction, as a first step, several laboratory pulping and bleaching studies on bagasse + Straw and bagasse + sarkanda were conducted and after arriving at a conclusive evidence, short and long term plant trials were initiated to derive maximum benefit.

LABORATORY PULPING TRIALS

Soda-Anthraquinone pulping studies in the laboratory was conducted in our 15 liter capacity, electrically heated rotary digester.

Anthraquinone (AQ), of 98% purity supplied by M/s Indian Dye Stuff Limited, is mainly used for laboratory and plant scale trials. Physical & Chemical properties of Anthraquinone are presented in Table No. III.A.

VARIABLES USED IN LABORATORY STUDIES

Furnish mix	:	Bagasse + Sarkanda (80% + 20%) Bagasse + Rice Straw (80% + 20%)
Anthraquinone:		0, 0.05, 0.10, 0.15 & 0.20% on B.D. Raw Material.
Diluent	:	Water and AQ treated black liquor as diluent to maintain bath ratio.

In all the experiments, depithed bagasse, screened Wheat Straw in depither and 5-6 mm size Paddy Straw and Sarkanda were used.

Data pertaining to pulping conditions, kappa number, screened pulp yield, H-factor and Bauer-Macnette fiber fractions for different furnish mix, are presented in Table No. I. The results pertain to bleaching of the Soda-Anthraquinone cooks are pre-

Table No.I

Laboratory Studies on Soda-Anthraquinone Pulping of Depithed Bagasse

S. No.	Parameters	Soda-Anthraquinone Cooks 1A	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C
1.	Active Alkali as NaOH, % (on B.D. Basis)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
2.	Anthra Quinone (on B.D. Basis)	--	0.05	0.05	0.05	0.10	0.10	0.10	0.15	0.15	0.15	0.20	0.20	0.20
3.	Bath Ratio	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4
4.	Max. Cooking Temperature, °C	160	160	160	160	160	160	160	160	160	160	160	160	160
5.	Time to Raise to Max. Temperature, Hours.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6.	Time at Max. Temperature, Hrs.	3.0	3.0	3.0	2.5	3.0	3.0	2.5	3.0	3.0	2.25	3.0	3.0	2.25
7.	Screened Pulp, %	44.55	45.76	46.20	47.10	47.70	48.25	48.70	48.20	49.00	49.70	47.50	48.70	49.50
8.	Screened Reject, %	3.66	1.75	1.50	2.00	0.60	0.37	0.72	0.35	0.25	0.60	0.75	0.87	1.10
9.	Total Yield, %	48.16	47.51	47.70	49.10	48.30	48.62	49.40	48.52	49.25	50.30	48.25	49.57	50.50
10.	R.A.A. at 70°C in WBL, g/l	0.64	1.02	1.40	2.20	1.24	1.46	2.32	1.40	1.56	2.36	1.60	1.90	2.50
11.	Permanganate Number (40 Ml)	16.50	15.20	14.05	16.00	14.20	14.60	16.20	13.50	13.00	15.80	13.00	12.40	15.50
12.	H-Factor	1080	910	820	940	810	780	900	760	720	880	840	800	920
13.	FIBER QUALITY													
13.1	Freeness, °SR	28	18	16	14	16	14	12	14	12	11	13	12	10
13.2	BAUER-MCNETT FIBER FRACTION													
13.2.1	RETAINED ON, %													
1.	R-30 Mesh	15.94	20.53	22.32	25.94	22.84	23.98	24.30	23.40	25.60	30.00	23.88	24.12	27.66
2.	R-50 Mesh	12.26	21.67	20.28	22.26	22.18	23.22	21.06	20.42	21.38	18.04	22.16	23.80	17.67
3.	R-100 Mesh	30.24	20.10	20.57	20.24	21.16	23.10	24.18	22.74	v24.16	23.10	23.46	c20.22	22.40
4.	R-200 Mesh	25.22	29.58	26.12	20.22	25.76	21.46	20.86	24.70	21.86	20.60	21.38	20.16	20.40
5.	Fines Passing Through 200 Mesh	16.34	8.12	10.71	11.34	8.06	8.24	9.59	8.74	7.00	8.26	9.12	11.70	9.23

LEGEND: All (A) Cooks : Water used as Diluent
(B) Cooks : A.Q. Black Liquor used as Diluent
(C) Cooks : A.Q. Black Liquor used as Diluent and Cooking Time Advanced.

sented in Table No. II.

Hydrogen Peroxide in the Alkali Extraction Stage of C-E-H Bleaching VIS - A - VIS only C-E-H Sequence

Chloro lignins formed in chlorination stage are dissolved and extracted in alkali extraction stage (E-stage). The retention period in E-stage is considered a 'dead period' as the color is darkened without imparting brightness.

By introducing Hydrogen Peroxide in alkali-extraction stage, the so called dead period can be utilised to improve the brightness of the pulp instead of darkening. Washed pulp after E-P stage is easily bleachable further with Calcium Hypo Chlorite either in a single or in two stages.

Usage of Peroxide (H_2O_2) at the E-Stage of C-E-H and C-E-H-H:

Substantially enhances the brightness to produce semibleached pulp.

enhances the color/ brightness stability of pulp.

Reduces to a large extent, the color and BOD & COD load of the effluent.

Table No.II

Laboratory Bleaching of Soda-Anthraquinone Cooks of Bagasse-Sarkanda

S. No.	Parameters	Bleaching of Soda-Anthraquinone Cooks by C-EP-H Sequence												
		1A	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C
1.	P.No. before bleaching	16.50	15.20	14.00	16.00	14.20	14.60	16.20	13.50	13.00	15.80	13.00	12.40	15.50
2.	CHLORINATION													
a.	Cl_2 as gas, %	7.0	6.5	6.0	7.0	6.0	6.0	7.0	6.0	6.0	6.5	5.5	5.5	6.5
b.	Final pH	2.4	2.3	2.1	2.3	2.08	2.0	2.2	1.9	1.9	2.2	1.8	1.9	2.2
c.	Retention time, Minute	35	35	35	35	35	35	35	35	35	35	35	35	35
3.	HYDROGEN PEROXIDE REINFORCED ALKALI EXTRACTION													
a.	NaOH added, %	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
b.	H_2O_2 added, % (50 Vol)	--	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
c.	Sodium Silicate, % (41^oBe, SiO_2 : 29% Na_2O : 8.9%)	--	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
d.	Final pH	10.2	9.8	10.2	10.1	10.3	10.3	9.9	10.4	10.3	10.3	10.2	10.3	9.9
e.	Retention time, Minute	90	90	90	90	90	90	90	90	90	90	90	90	90
f.	Brightness, %	39	45	46	44	47	47	45	48	49	47	50	52	49
4.	HYPO CHLORITE STAGE													
a.	Hypo as Av. Cl_2, %	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.0	4.5	5.0	4.5	4.5	5.0
b.	Caustic Buffer, %	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
c.	Final pH	7.8	7.9	8.0	8.0	8.1	8.2	8.0	8.4	8.4	8.2	8.5	8.6	8.3
d.	Retention time, Minutes	90	90	90	90	90	90	90	90	90	90	90	90	90
e.	Free Chlorine, % on Pulp	0.4	0.8	1.08	0.6	0.48	0.66	0.32	0.40	0.30	0.38	0.32	0.64	0.60
f.	Brightness, % ISO	73	78	80	80	80	82	80	82	84	82	83	84	82
g.	0.5% CED, Viscosity, Cps	9.2	10.0	10.6	11.4	10.8	11.38	12.65	11.82	12.40	13.20	12.36	12.90	14.50
h.	Post Color, No.	2.10	1.24	1.04	1.46	1.05	0.80	1.28	0.88	0.76	0.94	0.69	0.60	0.78
i.	Copper Number	1.04	0.84	0.75	0.85	0.82	0.71	0.88	0.618	0.52	0.70	0.46	0.36	0.52
j.	Bleached Pulp Yield, %	39.0	39.8	40.5	41.0	40.7	41.3	42.4	41.4	42.3	43.0	42.0	42.8	44.0
5.	BAUER-MCNETT FIBER FRACTIONS													
a.	R-30 Mesh	13.86	14.26	14.82	15.44	15.20	16.45	17.19	18.06	18.50	19.16	18.46	18.02	19.36
b.	R-50 Mesh	15.75	16.25	16.76	16.35	16.80	17.18	17.08	17.48	17.66	18.08	19.12	18.88	19.14
c.	% fines through 200 Mesh	20.85	17.98	17.24	19.34	17.16	16.96	15.12	14.68	15.02	14.28	13.75	14.12	12.80

Agro waste pulps with comparitively less lignin relative to wood pulp can be easily bleached to 3-4 ISO units using 0.5% (100% basis) of H_2O_2 in C-EP-H stages.

It is widely acknowledged that the use of chlorine and Hypochlorite leads to chloroform and organically bound chlorine compounds (AOX). (5-10).

In Hypochlorite stages, between 44% and 94% of chloroform and intermediates are produced (H) (7). It is to be noted that the gain in chloroform in a function of Hypochlorite application rate and C-EK (C-E Kappa No.) number of pulp entering Hypo stage. Hence, lower the C-E K number, lower the demand of Hypochlorite and lesser will be the generation of toxic chemicals.

Table No.IIIA

1.0 SYNONYM	9.10 ANTHRACENE DIONE OR 9.10 DIOXO ANTHRACENE
2.0 TRADE NAME	ANTHRA QUINONE
3.0 MOLECULAR WEIGHT	208.20
4.0 MOLECULAR FORMULA	$C_{14}H_8O_2$
5.0 STRUCTURAL FORMULA	
6.0 ACIDITY	NEUTRAL TO CONGO RED
7.0 MELTING POINT	284-286°C
8.0 MOISTURE CONTENT	0.5% MAX.
9.0 ASH CONTENT	0.5% MAX.
10.0 PURITY	98% AND ABOVE
11.0 INSOLUBLES	LESS, THAN 1%
12.0 FORM SUPPLIED	DRY CREAM YELLOW POWDER
13.0 VENDOR'S NAME	M/S INDIAN DYESTUFF INDUSTRIES LIMITED, KALYAN, BOMBAY.

Table No.IIIB

Specification and Physical Properties of Hydrogen Peroxide

Hydrogen Peroxide was supplied by M/s Nationl Peroxide Limited, Kalyan, Bombay, as 50% w/w conforming to IS : 2080-1980.

Hydrogen Peroxide is a clear, colourless, slightly viscous liquid miscible with water in any proportion.

Its molecular weight is 34.02 and has the chemical formula H_2O_2.

SPECIFICATIONS:		
1.	Acidity as H_2SO_4, g/100 ml.	: 0.015 to 0.030
2.	Residue on evaporation, g/100 ml.	: 0.2 max.
3.	Iron (as Fe), g/100 ml.	: 0.0001 max.
4.	Copper (as Cu), g/100 ml.	: 0.00001
5.	Lead (as Pb), ppm	: 10
6.	Arsenic (as As), ppm	: 2
PHYSICAL PROPERTIES:		
1.	H_2O_2, % wt. g/100 ml.	: 50
2.	H_2O_2, % Vol. g/100 ml.	: 59.8
3.	Volume of gaseous O_2 given off per litre of solution at 25°C, l/l	: 197
4.	Active Oxygen content, g/Kg.	: 235.2
5.	Freezing point, °C	: - 52.2
6.	Boiling Point at 760 mm Hg, °C	: 113.9
7.	Density at 25°C	: 1.191

(Ref.: BROCHURE FROM NPL "Hydrogen Peroxide- Properties & Application.")

Introduction of H_2O_2 in E-stage of C-E-H multistage bleaching sequence undoubtedly reduces C-E-K number with the consequent less hypo demand. (11-15)

Available literatures also confirm the utility value of H_2O_2 in small amounts in improving the efficiency of bleaching in case of various fibrous raw materials like bamboo, mixed hardwoods and bagasse. (16,17)

Laboratory Experiments on Hydrogen Peroxide Reinforced Alkali Extraction of Bagasse-Sarkanda Pulp

Unbleached decker washed pulps of Soda and Soda-AQ chemical process pulps at different P.No. levels (High 16.4, medium 14.8 and low : 12.0) were collected on the same day, when the Anthraquinone plant trial was commenced with near uniform furnish mix of 80% bagasse to 20% sarkanda.

Bleaching of Pulp : (EXPERIMENTAL)

The unbleached pulp samples of high, medium and low P.No. levels were bleached by standard C-E-H and C-EP-H sequences. Variables used in EXTRACTION-PEROXIDE STAGE:

- H_2O_2 DOSING: 0.6%, 0.8% & 1.0% in alkali extraction stage of C-E-H sequence.

TEMPERATURE USED:60 $\pm$ 2°C for one set of three different dosing and 63 + 2°C - to study the effect of temperature on brightness of CE-pulp, CE-P. No., alkali consumption, shrinkage loss and hypo consumption, brightness, stability characteristics of pulp in subsequent hypo stage.

Common Parameters Used in C-E-H & C-EP-H Bleaching

Parameters	Bleaching Stages			
	C-Stage	E-Stage	EP-Stage	Hypo Stage
Consistency, %	3.0	9.0	9.0	9.0
pH	2.0-2.3	10.5-11.0	11.0-11.5	7.8-8.5
Retention time, Minutes.	40	60	60 &90	90
Temperature, °C	Ambient	60±2	60±2-63+2	38+2
Caustic, %	--	3.0	2.0	--
Sodium Silicate, %	--	--	0.8	--
Caustic Buffer, %	--	--	--	0.8

The results pertaining to chemical consumption, P.No. & Shrinkage at every stage, brightness, 0.5% C.E.D. Viscosity Post color number and copper number of bleached pulps and BauerMcnett fiber fractions of bleached pulps, are presented in Table Nos. IV, V & VI and their annexures and graphically represented in Figure Nos. 2, 3, 4 & 5.

Pulp Mill Trials on Anthra Quinone Usage in Soda-A.Q. Pulping of Bagasse-Sarkanda and Bagasse-Rice Straw Raw Material Furnish:

For conducting preliminary and subsequent plant trials, Anthra Quinone of 98% purity was used as per the standard specification presented in Table No. III.B.

Preliminary plant trial of Anthra Quinone (A.Q.) in Soda pulping of bagasse-rice straw raw materials, was commenced in the 3rd and last week of October, 93. In the trial, as many as 163 cooks involving separate Soda-AQ cooking of bagasse and rice straw were made batchwise in available 8 globe type digesters of 45 M^3 - standard design.

Table No.IV

Laboratory Studies On C-EP-H Bleaching of Bagasse-Sarkanda (85 : 15) Pulp

S. No.	Parameters	C-EP-H Sequential Bleaching DATA							
		1A	2A	3A	4A	1B	2B	3B	4B
1.0	UNBLEACHED SCREENED PULP								
1.1	P.No. (40 Ml)	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4
1.2	Brightness, % ISO	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
2.0	CHLORINATION STAGE								
2.1	Cl_2 as gas, %	7.0							
2.2	Initial pH/ End pH	2.2/2.0	2.2/2.0	2.2/2.0	2.2/2.0	2.2/2.0	2.2/2.0	2.2/2.0	2.2/2.0
2.3	Cl_2 Consumed, %	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85
2.4	Shrinkage, %	4.85	4.85	4.85	4.85	4.85	4.85	4.85	4.85
2.5	Brightness, % ISO	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
2.6	P.No. (40 Ml)	8.60	8.60	8.60	8.60	8.60	8.60	8.60	8.60
3.0	EXTRACTION PEROXIDE STAGE								
3.1	NaOH, %	3.0	2.0	2.0	2.0	3.0	2.0	2.0	2.0
3.2	Sodium Silicate, %	--	0.8	0.8	0.8	0.8	0.8	0.8	0.8
3.3	H_2O_2 (50 Vols), % on Pulp	--	0.6	0.8	1.0	--	0.6	0.8	1.0
3.4	Initial pH/ End pH	11.4/9.90	11.2/10.2	11.0/10.0	11.1/10.3	11.5/10.10	11.2/10.2	11.0/10.0	10.8/10.2
3.5	Temperature, %	60±2	60±2	60±2	60±2	64+2	63+2	64+1	63+2
3.6	Retention time, Minutes	60	60	90	90	60	60	90	90
3.7	Brightness, % ISO	38	40	44	46	36	42	46	50
3.8	P.No. (25 Ml)	6.0	5.5	5.2	5.0	5.6	5.2	4.8	4.6
3.9	Shrinkage, %	4.44	4.14	3.80	3.40	4.56	3.92	3.60	3.50
4.0	HYPO CHLORITE STAGE								
4.1	Hypo as Av. Cl_2,	5.0	4.5	4.5	4.5	5.0	4.5	4.5	4.5
4.2	Initial pH/ End pH	9.0/7.8	8.90/8.01	8.75/8.12	8.80/8.08	8.8/7.6	8.7/7.85	8.7/8.10	8.8/8.20
4.3	Hypo Consumed, %	4.90	4.15	3.80	3.62	4.56	4.0	3.6	3.2
4.4	Shrinkage, %	4.08	3.28	2.74	2.56	3.92	3.08	2.62	2.36
4.5	Brightness, % ISO	72	74	76	79	73	77	79	81
4.6	0.5% C.E.D. Voscosity, Cps	7.8	8.12	9.2	9.86	7.6	9.4	10.16	11.24
4.7	Post Color Nol	2.16	1.66	1.34	1.08	2.40	1.45	1.12	0.90
4.8	Copper Number M.Eq./100g	1.2	0.98	0.84	0.78	1.31	0.84	0.73	0.66
4.9	BAUER-MCNETT FIBER FRACTIONS								
4.9.1	% Fraction retained on								
	- 30 Mesh	12.86	14.60	14.86	15.04	11.63	13.45	15.21	15.71
	- 50 Mesh	15.50	16.80	16.92	17.08	15.50	16.10	16.28	17.10
	- 100 Mesh	31.50	30.50	31.92	31.09	30.62	31.31	30.13	31.02
	- 200 Mesh	20.75	20.95	21.40	21.08	21.05	21.75	21.68	21.04
	- Fines Pass through 200 Mesh	19.39	17.15	15.30	15.71	21.20	17.39	16.70	15.13

The details pertain to Soda-AQ cooking parameters, average P.No. (40 Ml) of the cooks of the day and bleached pulp characteristics with specific reference to improvement in long fiber fractions, drop in °SR, and strength characteristics of 60 g/m² pulp hand sheets - made from A.Q. pulps, as per TAPPI standard methods, are as presented in table No. V AB and annexure.

Based on the encouraging results of cooks, lesser rejects generated from the Johnson-type vibratory screens and visible improvement in machine runnability, continuous AQ addition in Soda chemical pulping at regular dosings of 0.05% for bagasse/ sarkanda and 0.03 % for rice straw cooks, commenced since middle of November, 93 till date.

Table No.V

Laboratory Studies On C-EP-H Bleaching of Bagasse: Sarkanda (85% : 15%) Pulp

S. No.	Particulars	C-EP-H Sequential Bleaching							
		1A	2A	3A	4A	1B	2B	3B	4B
1.0	UNBLEACHED SCREENED PULP								
1.1	P.No. (40 Ml)	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8
1.2	Brightness, % ISO	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
2.0	CHLORINATION STAGE								
2.1	Cl_2 as gas, %	6.5							
2.2	Initial pH/ Final pH	2.14/1.92	2.14/1.92	2.14/1.92	2.14/1.92	2.14/1.92	2.14/1.92	2.14/1.92	2.14/1.92
2.3	Cl_2 Consumed, %	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
2.4	Shrinkage, %	4.42	4.42	4.42	4.42	4.42	4.42	4.42	4.42
2.5	Brightness, % ISO	42	42	42	42	42	42	42	42
2.6	P.No. (40 Ml)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
3.0	EXTRACTION PEROXIDE STAGE								
3.1	NaOH, %	3.0	2.0	2.0	2.0	3.0	2.0	2.0	2.0
3.2	Sodium Silicate, %	--	0.8	0.8	0.8	0.8	0.8	0.8	0.8
3.3	H_2O_2 (50 Vols), % on Pulp	--	0.6	0.8	1.0	--	0.6	0.8	1.0
3.4	Initial pH/ End pH	9.2/7.8	8.9/7.7	8.7/8.0	8.8/8.1	8.9/7.6	8.7/7.8	8.7/7.9	8.6/8.0
3.5	Temperature, °C	60±2	60±2	60±2	60±2	63+2	63+2	64+2	64+2
3.6	Retention time, Minutes	60	60	90	90	60	60	90	90
3.7	Brightness, % ISO	38	40	44	46	36	42	46	50
3.8	P.No. (25 Ml)	6.0	5.5	5.2	5.0	5.6	5.2	4.8	4.6
3.9	Shrinkage, %	4.44	4.14	3.80	3.40	4.56	3.92	3.60	3.50
4.0	HYPO CHLORITE STAGE								
4.1	Hypo as Av. Cl_2 %	5.0	4.5	4.5	4.5	5.0	4.5	4.5	4.5
4.2	Initial pH/ End pH	9.6/7.8	9.2/7.9	9.0/8.0	8.8/8.1	9.5/8.0	9.3/8.12	9.1/8.20	9.0/8.30
4.3	Hypo Chlorite Consumed, %	4.72	4.02	3.80	3.62	4.22	3.48	3.24	3.02
4.4	Shrinkage, %	3.48	2.89	2.52	2.35	3.06	2.67	2.44	2.22
4.5	Brightness, % ISO	76	78	80	82	77	79	81	83
4.6	0.5% C.E.D. Voscosity, Cps	9.08	10.20	10.80	11.20	8.40	10.60	11.40	12.24
4.7	Post Color No.	2.13	1.35	1.05	0.84	2.27	1.26	0.96	0.80
4.8	Copper Number m.eq./100g	0.96	0.75	0.645	0.57	1.10	0.69	0.54	0.48
4.9	BAUER-MCNETT FIBER FRACTIONS								
4.9.1	% Fractions retained on								
	- 30 Mesh	15.78	16.01	16.78	17.06	12.55	14.31	14.88	16.64
	- 50 Mesh	18.32	18.86	19.02	19.01	17.90	18.11	18.45	17.20
	- 100 Mesh	36.36	35.41	35.91	36.08	33.88	34.01	34.45	34.70
	- 200 Mesh	16.13	17.32	17.91	17.96	18.55	18.29	18.50	18.67
	- Fines Pass through 200 Mesh	13.41	12.40	10.39	8.99	17.12	15.29	13.72	12.79

Lid-to-lid Cycle of operations for both bagasse/ sarkanda and rice straw cooks are followed as given in the following lines:

S. NO.	PARAMETER	DEPITHED BAGASSE/ 2-3" CUT SARKANDA	RICE STRAW
1.0	Caustic charge, %	12.0-12.5	7.0
2.0	Mode of charging	Double loading	Double loading
3.0	Average B.D. raw material loading, M.T.	6.0	5.0
4.0	Bath ratio	1 : 4	1 : 4
5.0	CHARGING		
5.1	First loading	1-35	1-30
5.2	Lid closing & rotation	0.40	0.30
5.3	Second loading	0.35	0.25
6.0	Steaming to temp., 160°C	1-30	1-00
7.0	Cooking at 160°C	3-30	3-00
8.0	Blowing	0.15	0-15
9.0	Lid-Lid cycle, h-mt.,	8-15	6-30

Mode of Dosing

Anthraquinone was well dispersed in acqueous solution of 1% concentration and constantly dosed by pumping (5 H.P. TULU Type pump/ 10 m Head) and regulated the flow by needle valves throughout the raw material charging in the raw material caustic lye solution mixer. The caustic solution (80 g/l) and Anthraquinone dispersion were mixed intimately with the raw material mix and fed into the digester by means of single/double paddle type mixer. The blown cooks were subjected to screening for rejects, washing in two stage brown stock washers and subsequently screened cleaned and decker washed prior to its entry into 3 stages C-E-H bleach plant for onward processing. Data pertaining to

Table No. V - AB

Preliminary Soda-Anthraquinone Pulping Trial in Digester House

Date	Chemicals Charged in Digester on B.D. Raw Material		P.No. (40 Ml) of Soda-A.Q. Cooks (Range)			Hypo Washer Bleached Pulp Characteristics Bauer- Mcnett Fiber Fractions							Strength Properties of 60 GSM Hand Sheets (28°SR)		
Raw Material Furnish Mix in Pulp	Active Alkali As NaOH %	A.Q., %	Bagasse	Rice Straw	Time of Sampling	Brightness % ISO	°SR	R-30 %	R-50 %	R-100 %	R-200 %	P-200 %	B.L. (M)	B.I. Kp_aM^2/g	D.F. Nos.	Strength Index
20.10.93 Bagasse: Rice Straw 75:25	Bagasse: 12.25% Rice Straw 7.0%	Nil	15.2-16.5	14.0-15.0	Composite of Hourly sample.	73 to 75	35	7.60	14.85	31.85	19.86	25.84	2750	1.57	10	900
21.10.93 Bagasse: Rice Straw 75:25	Bagasse: 12.25% Rice Straw 7.0%	0.03	14.0-15.0	13.0-14.0	4.00AM	73	34	7.79	15.02	30.62	21.05	25.52	2900	1.57	12	924
					10AM	74	34	8.52	15.50	31.50	20.75	23.73	3000	1.58	12	917
					2.30PM	74	29	9.45	16.10	34.31	16.56	23.58	3200	1.58	16	995
					6.00PM	74	29	10.62	17.82	33.09	17.92	20.55	3400	1.66	18	1015
					10PM	74	28	11.21	16.28	30.13	22.68	19.70	3600	1.76	20	1037
22.10.93 Bagasse: Rice Straw 75:25	Bagasse: 12.0-12.5% Rice Straw 7.0%	0.05	13.5-14.5	13.0-14.0	10AM	74	27	11.71	17.10	31.92	21.24	18.04	3800	1.76	18	1087
					2PM	75	27	12.04	17.85	31.68	20.08	18.38	3900	1.86	20	1089
23.10.93 Bagasse: Rice Straw 75:25	Bagasse: 12.0-12.25% Rice Straw 6.5-7.0%	0.05	12.8-14.5	12.6-14.0	4.45PM	75	26	12.56	17.90	33.88	18.55	17.11	4050	1.96	22	1133
					10PM	76	26	12.99	17.01	32.60	19.69	17.78	4250	2.05	26	1190
25.10.93 Bagasse: Rice Straw 75:25	Bagasse: 12.25% Rice Straw 7.0%	0.05	13.2-14.6	12.0-13.5	Composite of 4 Hourly Samples.	75	25	12.13	17.06	32.73	20.55	17.53	4100	2.15	26	1200
27.10.93 Bagasse: Rice Straw 90:10	Bagasse: 12.25% Rice Straw 7.0%	0.10	12.5-13.8	12.0-14.0	6.00AM	74	22	14.31	19.11	34.01	17.29	15.28	4200	2.15	24	1176
					1.30AM	75	22	14.18	19.89	34.11	17.62	14.20	4300	2.15	27	1197
01.11.93 Only Bagasse:	Bagasse: 12.25%	0.10	13.0-14.0	12.0 13.0	Composite of 4 Hourly Samples.	74	22	14.09	20.17	34.82	17.10	13.82	4400	1.96	28	1160
02.11.93 Only Bagasse:	Bagasse: 12.25%	0.10	13.0-13.5	13.0-14.0	-do-	75	21	14.64	17.20	34.67	16.42	17.07	4400	2.06	20	1139
03.11.93 Bagasse: Rice Straw 75:25	Bagasse: 12.25% Rice Straw 7.0%	0.03 6AM-6PM Later Suspended	14.0-15.2	13.0-14.5	-do-	75	26	10.81	17.62	34.47	17.76	19.31	3600	1.86	20	1006
04.11.93 Bagasse: Rice Straw 80:20	Bagasse: 12.25% Rice Straw 7.0%	No AQ.	14.0-15.5	14.0-16.0	-do-	75	28	8.76	14.36	32.58	20.58	23.92	3200	1.57	12	910
05.11.93 Bagasse: Rice Straw 75:25	Bagasse: 12.25% Rice Straw 7.0%	No AQ.	15.0-6.4	13.0-15.2	-do-	73 To 74	29	8.12	13.92	32.72	20.91	24.23	3080	1.47	10	855

Table No. V - C

Batch wise Soda-Anthraquinone Pulping in Plant

Date	Chemicals Charged in Digester on B.D. Raw Material		P.No. (40 Ml) of Soda-A.Q. Cooks		Hypo Washer Bleached Pulp Characteristics Bauer- Mcnett Fiber Fractions								Strength Properties of 60 GSM Hand Sheets (28°SR)		
Raw Material	Active Alkali As NaOH %	A.Q., %	Bagasse	Sarkanda	Time of Sampling	°SR	R-30 %	R-50 %	R-100 %	R-200 %	P-200 %	B.L. (M)	B.I. Kp_aM^2/g	D.F. Nos.	Strength Index
24.12.93 Bagasse: Sarkanda 85:15	Bagasse: 12.5-13.0% Sarkanda 10.0-12.0%	0.05	13.0-14.2	13.5-15.0	Composite of 4 Hourly Sampling	24	19.80	21.30	31.17	13.93	13.88	4600	1.960	16	1075
26.12.93 Bagasse: Sarkanda 85:15	Bagasse: 12.5% Sarkanda 11.0-12.0%	0.05	13.0-14.0	13.5-14.5	-do-	25	19.58	18.96	34.28	14.44	12.74	4480	1.960	18	1076
27.12.93 Bagasse: Sarkanda 80:20	Bagasse: 12.5% Sarkanda 11.5%	0.05	13.0-14.5	14.0-15.0	-do-	24	21.01	19.11	33.78	13.38	12.72	4800	2.15	24	1190
28.12.93 Bagasse: Sarkanda 80:20	Bagasse: 12.5% Sarkanda 11.5%	0.05	13.5-15.0	13.0-15.0	-do-	25	20.95	19.98	35.58	13.83	9.66	4850	2.15	24	1190
23.01.94 Bagasse: Sarkanda 85.15	Bagasse: 12.5% Sarkanda 11.5%	0.05	12.5-14.6	13.0-15.2	-do-	25	18.01	17.36	36.98	17.66	9.99	4780	2.25	30	1217

Table No.VI

Laboratory Studies On C-EP-H Bleaching of Bagasse-Sarkanda (85 : 15) Pulp

S. No.	Parameters	C-EP-H Sequential Bleaching							
		1A	2A	3A	4A	1B	2B	3B	4B
1.0	UNBLEACHED SCREENED PULP (SODA - AQ PULP)								
1.1	P.No. (40 Ml)	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2
1.2	Brightness, % ISO	39.0	39.0	39.0	39.0	39.0	39.0	39.0	39.0
2.0	CHLORINATION STAGE								
2.1	Cl_2 as gas, %	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
2.2	Initial pH/ End pH	2.08/1.80	2.08/1.80	2.08/1.80	2.08/1.80	2.08/1.80	2.08/1.80	2.08/1.80	2.08/1.80
2.3	Cl_2 Consumed, %	5.36	5.36	5.36	5.36	5.36	5.36	5.36	5.36
2.4	Shrinkage, %	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68
2.5	Brightness, % ISO	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
2.6	P.No. (40 Ml)	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60
3.0	EXTRACTION PEROXIDE STAGE								
3.1	NaOH, %	3.0	2.0	2.0	2.0	3.0	2.0	2.0	2.0
3.2	Sodium Silicate, %	--	0.8	0.8	0.8	0.8	0.8	0.8	0.8
3.3	H_2O_2 (50 Vols), % on Pulp	--	0.6	0.8	1.0	--	0.6	0.8	1.0
3.4	Initial pH/ End pH	11.5/10.0	11.3/10.4	11.2/10.6	11.15/10.6	11.6/9.8	11.5/10.3	11.4/10.4	11.2/10.5
3.5	Temperature, °C	58+2	60±2	60±2	60±2	63+2	64+2	63+2	65-2
3.6	Retention time, Minute	60	60	90	90	60	60	90	90
3.7	Brightness, % ISO	43	45	48	52	42	47	50	54
3.8	P.No. (25 Ml)	5.5	5.0	4.6	4.2	5.2	4.8	4.4	3.8
3.9	Shrinkage, %	3.90	3.40	3.12	2.90	4.12	3.30	2.86	2.65
4.0	HYPO CHLORITE STAGE								
4.1	Hypo as Av. Cl_2 %	4.5	4.0	4.0	4.0	4.5	4.0	4.0	4.0
4.2	Initial pH/ End pH	9.2/7.9	9.0/8.1	9.2/8.0	9.0/8.2	9.4/7.7	9.1/8.0	9.2/8.2	9.0/8.2
4.3	Hypo Consumed, %	4.25	3.72	3.31	2.90	4.06	3.54	3.01	2.65
4.4	Shrinkage, %	2.96	2.58	2.25	2.08	3.10	2.46	2.12	1.95
4.5	Brightness, % ISO	78	81	83	85	80	82	84	86
4.6	0.5% C.E.D. Voscosity, Cps	10.46	11.40	11.86	12.32	9.68	12.35	13.18	13.78
4.7	Post Color No.	1.76	0.81	0.69	0.60	1.92	0.61	0.45	0.30
4.8	Copper Number Meg./100G	0.75	0.54	0.435v	0.39	0.90	0.45	0.30	0.26
4.9	BAUER-MCNETT FIBER FRACTIONS								
4.9.1	% Fraction retained on								
	- 30 Mesh	18.01	18.46	18.92	19.41	16.95	18.25	18.40	19.26
	- 50 Mesh	17.26	17.78	16.68	17.66	16.68	17.42	17.66	18.18
	- 100 Mesh	36.08	35.95	35.12	v36.76	35.76	35.88	36.06	36.46
	- 200 Mesh	17.26	17.42	18.06	17.12	17.26	17.80	17.40	17.90
	- Fines Pass through 200 Mesh	11.39	10.39	10.22	9.25	13.35	10.65	10.40	8.20

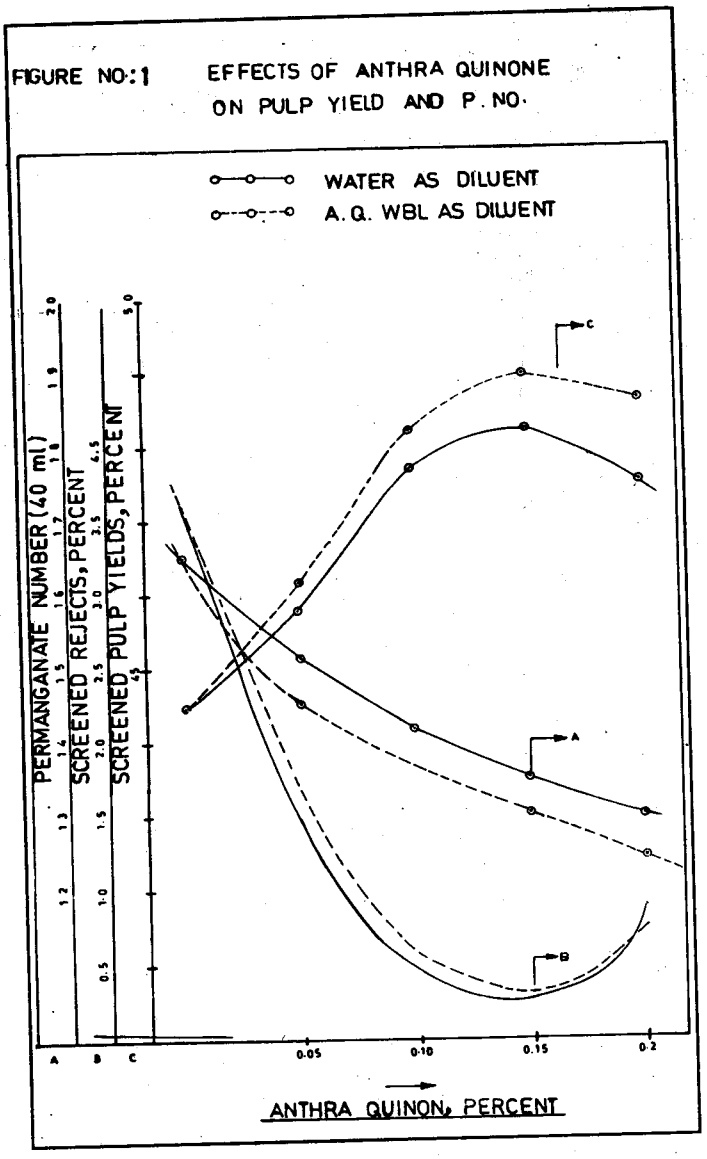
furnish, chemical charge, Average P.No. of cooks and resultant bleached pulp characteristics are presented in Table No. V AB & VC.

Bleach Plant Trials on Hydrogen Peroxide Re-Inforced Alkali Extraction of Bagasse-Sarkanda Chemical Pulps

Based on laboratory studies and encouraging results of preliminary bleach plant trials, continuous Hydrogen Peroxide re-inforced alkali extraction of the Soda-Anthraquinone chemical pulp, was commenced in the C-E-H multi stage processing of bleach plant, since middle of November, 93 for the production of High brightness offset printing.

Hydrogen peroxide solution of 50% w/w strength, as supplied by M/s National Peroxide

FIGURE NO:1 EFFECTS OF ANTHRA QUINONE ON PULP YIELD AND P. NO.



Limited, Bombay is characterised by standard specification and physical properties as given in Table No. III B.

Mode of Dosing

Hydrogen Peroxide solution in the existing form as received basis (50% w/w) is continuously regulated as dilute solution of 37-40 g/l as H_2O_2 from Sintex type drum of 200 litre volume, through nozzle type outlet. The dilute H_2O_2 solution addition as per the requirement is carried out as split dosing at two points in the bleaching stages - 80% of the total requirement of 8.0-9.0 Kg. per ton of pulp processed at the chlorine washer repulper outlet and leading to alkali tower and balance of 20% after Hypo Chlorite stage at the washer repulper.

Addition of Hydrogen Peroxide in Extraction Stage of C-E-H Bleaching

Hydrogen Peroxide solution of 37-40 g/l is regulated through nozzles as per requirement. The chlorine washer pulp mat falling at full length to screw conveyor of the repulper is made intimately alkaline with dilute caustic solution of 40 g/l being added through nozzle type arrangement, covering the pulp fully from the other end before finally reinforced with H_2O_2 at the outlet. H_2O_2 treated alkaline pulp is then steam mixed in the Heater screw type mixer prior to its retaining in the alkali extraction downward flow tower. The temperature at the alkali tower is maintained between 60-63°C but not above for practical reasons. pH of the stock at the tower is kept at 10.8-11.5 at the heater mixer. Frequent monitoring of important control parameters such as H_2O_2 and Caustic dosing rate, temperature at the heater mixer, pH, Consistency and tower levels, are conducted for effective control.

Schematic diagram of the three stage C-E-H bleach plant as a whole indicating specific points of H_2O_2 dosing basically carried out for achieving higher brightness of pulp, is as per the enclosed Figure No.6.

The main parameters practised in the modified C-EP-H sequential bleaching process, as required for the production of Copier/Super Print/Offset Printing grades, as also for medium brightness Cream wove grades, are presented in Table No. VII & VIII. The main characteristics of paper grades made there from, is also presented in Table No. IX.

DISCUSSION OF RESULTS:

It has been established from laboratory and plant scale trials that 0.05% Anthraquinone addition on B.D. raw material, drastically influenced the pulping results. Even though higher dosing rate at 0.1% upto 0.15% resulted in further improvements in yield and pulp properties as indicated by higher long fiber fractions and pulp hand sheet properties as well as easy bleaching tendency, the addition of A.Q. beyond 0.05% was not attempted purely on economic considerations.

From the results presented in Table Nos. I & II, following inferences can be made.

FIG. NO·2- EFFECT OF H_2O_2 ADDITION IN E-P STAGE ON FINAL BRIGHTNESS OF BLEACHED PULP TEMPERATURE IN E–P STAGE 60 ± 2 °C

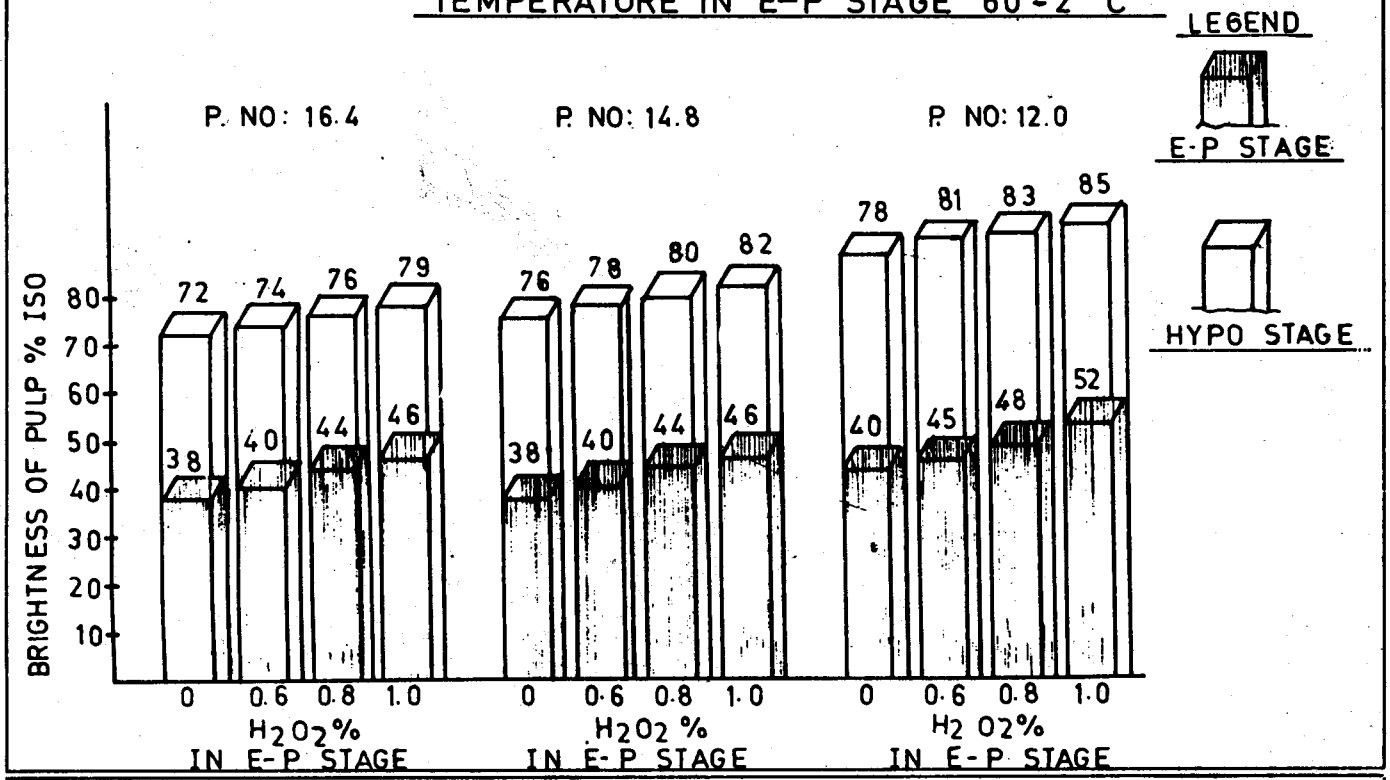
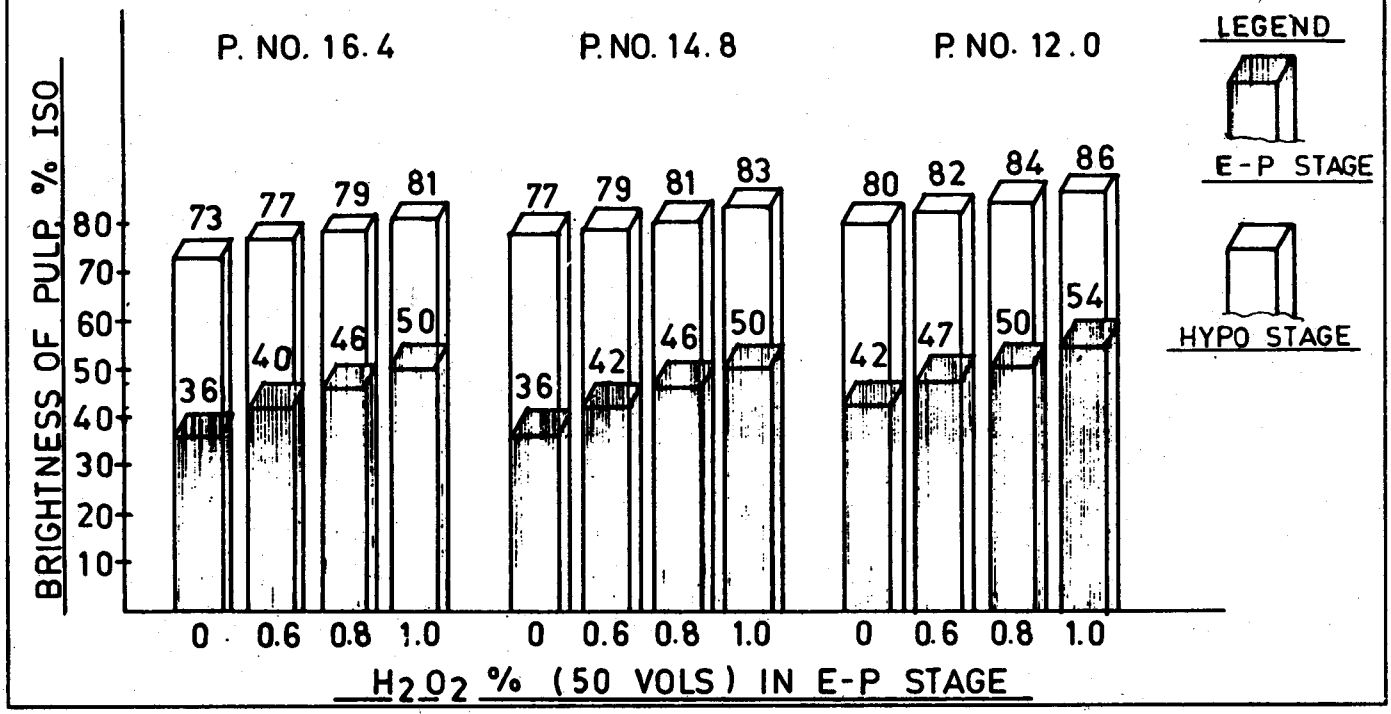
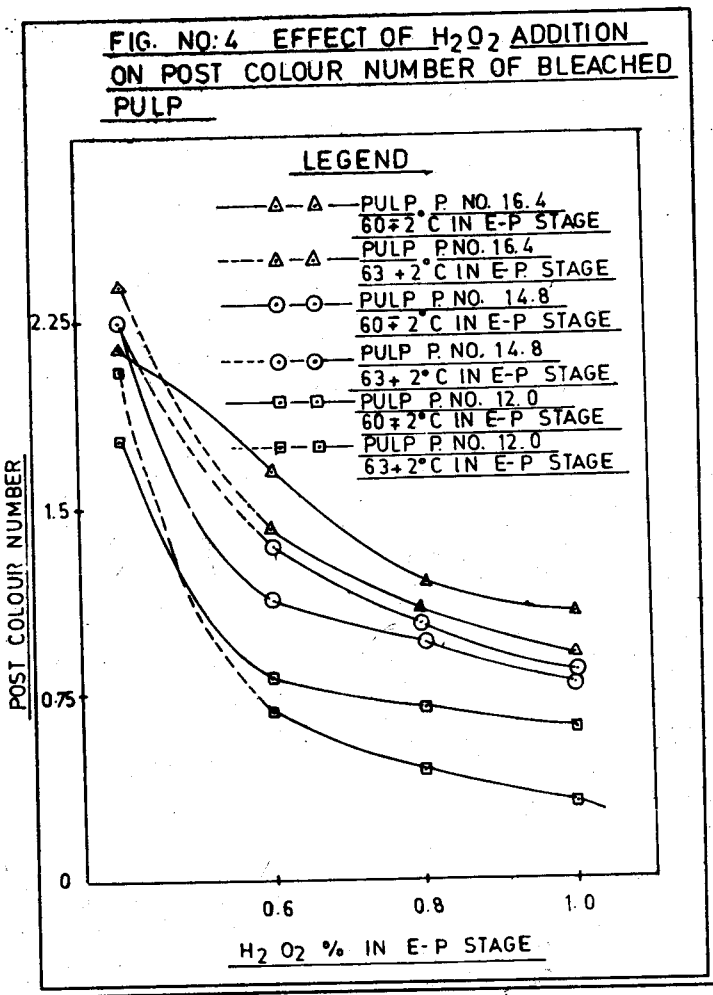
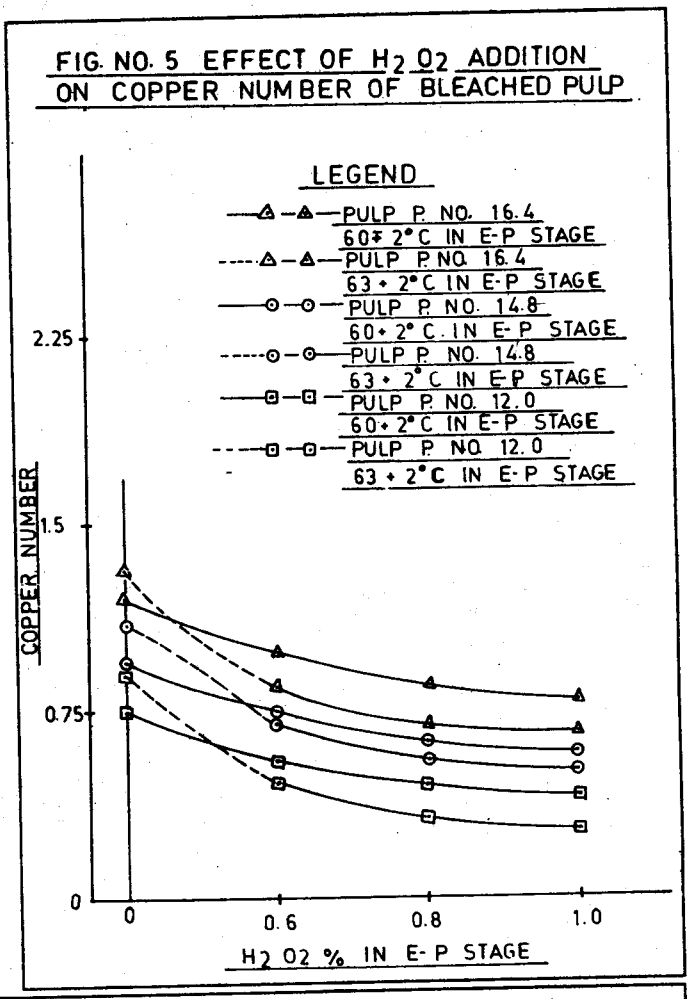
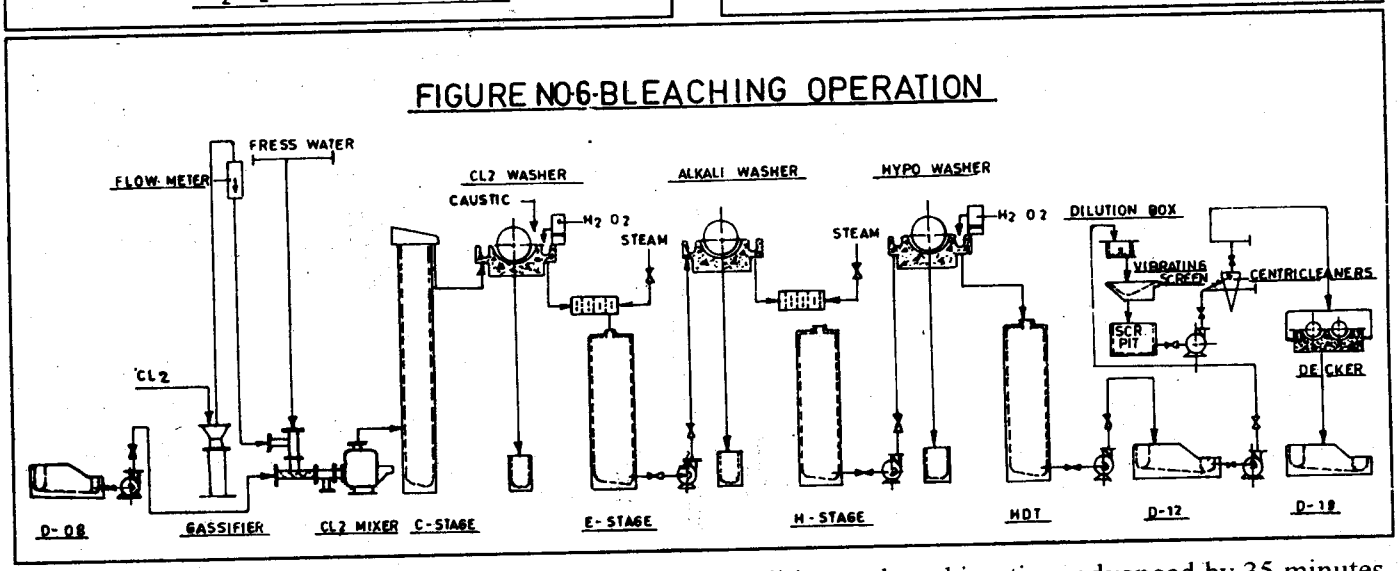


FIGURE NO. 3 EFFECT OF H_2O_2 ADDITION IN E-P STAGE ON FINAL BRIGHTNESS OF PULP TEMPERATURE IN E-P STAGE 63 ± 2°C









PULP YIELD: Improvement in pulp yield by 2.0 to 5.0% in the case of Soda-AQ cooks especially when A.Q. cook black liquor was used as diluent, at the same time cooking time at maximum temperature was advanced by 30-40 minutes. Highest screened pulp yield was obtained with 0.2% A.Q. addition and cooking time advanced by 35 minutes.

H-Factor:

H-factor of Soda-A.Q. cook with 0.05 percent A.Q. addition showed declining trend from 1080 of soda cook down to 910 and 820 respectively for

Table No.VII

Plant Trial of Hydrogen-Peroxide Re-Inforced Alkali Extraction of Bagasse - Sarkanda Mix Pulp For Super Print Grades

1.	Quality of paper for which high brightness of pulp is required.	:	SUPER PRINT and HIGH BRITE OFFSET PRINTING - 80 GSM
2.	CE-permanganate number of pulp	:	4.8 - 5.0
3.	Point of addition of Hydrogen Peroxide diluted solution	:	1. Chlorine washer repulper. 2. Hypo washer repulper.
4.	Mode of addition	:	Split dosing - 80% in C-washer and 20% in H-washer.
5.	Quantity/rate of dosing	:	1. 3.2-3.4 Kg. per ton of pulp processed in E-Stage. 2. 0.8-1.0 Kg. per ton of pulp processed in H.D. tower.

6. General Bleaching Parameters Followed in Hydrogen Peroxide Reinforced Alkali Extraction.

Parameters	C-Tower	E.P.-Tower	Hypo Tower	H.D.-Tower
Consistency, %	2.75-2.90	8.5-9.0	9.0	7.0-7.5
Temperature, °C	Ambient	60+3	40±2	36±2
Retention time, Minutes	30-35	60-90	90	60
pH of Pulp	2.0-2.2	10.8-11.4	7.8-8.3	7.2-7.6

7. Stage Wise Quality of Pulp:

Parameters	Unbleached Decker	C-Washer	EP-Washer	H-Washer	Bleached Decker
PH	8.0-8.4	2.6-2.8	9.60-10.2	7.6-8.0	7.0-7.4
Residual Chemical, g/l	Traces	0.031 as Cl_2	Traces	0.0071 as av. Cl_2	Traces
Brightness, % ISO	32-36	42-45	46-50	79-81	78-80
Viscosity, Cps	22-24	16-18	14-16	11-12.5	10.5-12.0
P.No. (25 Ml)	14.0	8.0-7.8	4.8-5.0	--	--
COD, Kg/Ton	--	--	70-75	--	--

Table No.VIII

Plant Trial of Hydrogen-Peroxide Re-Inforced Alkali Extraction Stage of C-EP-H Bleaching

1.0	Bleached pulp required for Cream Wove	
2.0	Point of addition	Only at Chlorine washer repulper.
3.0	Quantity/ rate of dosing	1.0 - 1.2 Kg. of H_2O_2 (100 Vols.) per ton of pulp processed.
4.0	Fiberous furnish in Bleached Pulp	Bagasse : Rice Straw (70 : 30)
5.0	General Parameters maintained in bleaching stage:	

Parameters	ChlorineTower	Alkali Tower (EP Stage)	Hypo Tower	HD Tower
Consistency, %	2.6-2.9	8.5-9.0	8.5-9.0	6.8-7.0
Temperature, °C	Ambient	60+3	40±2	36±2
Retention time, Minutes	30-35	60-75	90	60
pH of Pulp stock in towers	2.2-2.4	10.8-11.2	7.8-8.0	7.4-7.6

6. Stage Wise Quality of Pulp:

Parameters	Unbleached Decker	Cl_2 Washer	EP-Washer	HypoWasher	Bleached Decker Washer
PH	8.0-8.4	2.8-3.2	10.0-10.5	7.6-7.8	6.9-7.1
Residual Chemical,	Traces	0.012 Spl. as Chlorine	Traces	0.0071 g/l as av. Cl_2	Traces
Brightness,	33-37	40-44	42-46	75-76	72-74
P.No. (40 Ml)	12-14	8.5-8.2	5.4-5.0	--	--
Viscosity, Cps	19-18	14-15	12-13	9-10	8.5-9.2
COD, Kg/Ton	--	--	120	--	--

Table No.IX

Quality of Paper

S. No.	Particulars	Unit	Offset Printing 80 GSM	Super Printing 64 GSM	Creamwove 56 GSM
1.	Thickness	Micron	95 - 100	78 - 80	74 - 76
2.	Bulk	C.C./Grm.	1.23 - 1.25	1.23 - 1.25	1.33 - 1.35
3.	Burst Index	Kpa, M^2/g	2.0 - 2.3	2.05 - 2.20	1.90 - 2.00
4.	Tensile Index	Nm/g			
	M.D.		44 - 48	47	42 - 44
	C.D.		28 - 31	29	24.0 - 25.4
5.	Breaking Length Meter				
	M.D.		4500 - 4900	4800	4300 - 4500
	C.D.		2900 - 3200	3000	2400 - 2600
6.	Tear Factor	$mN.m^2/g$			
	M.D.		4.50	4.31	4.11 - 4.20
	C.D.		5.26	5.29	5.09
7.	DOUBLE FOLDS	Nos.	15/ 10	14/ 10	12/ 06
8.	Gurley Smoothness,	Sec/ 50 Ml	60 - 70	60 - 70	25 - 30
9.	Ash	%	15 - 16	14	12
10.	Cobb-60	g/m^2	17/ 16	18/ 20	22/ 24
11.	Brightness	%, ISO	75 - 77	74 - 75	68 - 70
12.	Opacity	%	89 - 90	86 - 88	86
13.	Dennisson Wax pick	No.	16A	16A	10A

A.Q. cooks in which water and A.Q. black liquor were used as diluents to maintain bath ratio. However, H-factor showed a rise from 820 to 940 for 0.05% A.Q. cook using A.Q. black liquor as diluent and the cooking time at maximum temperature, was advanced by 30 minutes. Similar trends were observed for all A.Q. cooks using 0.1 & 0.15 percents A.Q. in order. However, with 0.2 percent A.Q. addition, the H-factors for 5A, 5B, and 5C cooks showed an increase after achieving the lowest values for the corresponding cooks with 0.15 percent A.Q. addition. Hence, it may be inferred in general, that to achieve the same P.No. as Soda-cooks is 16.00, reduction of cooking time pays divident in terms of higher yield with less rejects, long fiber fractions especially in R-30 and R-50 fractions, higher bleached pulp yields than other Soda-A.Q. sets (viz B&C sets).

Permanganate Number

Drop in P.No. with increase in A.Q. percentage additions predominantly seen for all Soda-A.Q. cooks in which A.Q. black liquor was used as diluent.

Lowest P.No. was observed with Soda-A.Q. cooks using 0.2 percent A.Q. and when A.Q. black liquor was used as diluent. This was reflected in lower bleach consumption by 1 percent than other cooks and higher bleached pulp yield of 43 percent, above 4% more than the normal soda bleached pulp.

Long Fiber Fractions (Bauer-Mcnett)

Increase in long fiber fractions (R-30 & R-50) was found in the unbleached and subsequent pulps after bleaching. Among the sets of cooks, Soda-AQ cooks using A.Q. black liquor as diluent and lesser cooking time by 30-40 minutes at 160°C resulted in highest ever increase in R-30 and R-50 fractions. Hence, it may be inferred that it is more beneficial to reduce the cooking time (H-Factor control) rather than saving caustic charge by few percent. The pulp after bleaching by C-EP-H sequence maintains the same trend in retaining R-30 & R-50 fractions of the furnish mix, bagasse-fresh sarkanda (80 : 20) resulted in as high as 6.5% in R-30 fraction and 4.5% in R-50 fractions in the case of cook with 0.2% A.Q. in which the cooking time reduction to the tune of 35 minutes was effected. (5C of Tables I & II).

From the results presented in Table No. II, following points emerge.

For the same level of additions of Caustic, Sodium silicate and Hydrogen peroxide (0.8% on 50% w/w basis), the brightness of CE-pulp showed

steady improvement with A.Q. dosage in the original unbleached Soda-AQ pulp. Highest brightness of 52% ISO was achievable with Soda-AQ pulp obtained with 0.2% A.Q. addition & using black liquor as diluent. Brightness of bleached pulp after C-EP-H bleaching of Soda-AQ pulps showed similar trend as was observed with CE-pulp.

Chlorine Consumption

Maximum saving of 3.2 percent of chlorine on bleached pulp basis was observed with 0.2% A.Q. treated cooks using AQ black liquor was the diluent.

Viscosity of Pulp

0.5% C.E.D. viscosity of bleached pulp showed increasing trend with % A.Q. addition in pulp. Higher level of viscosity was observed for all A.Q. cooks in which cooking time was reduced by 30-40 minutes. The increase in viscosity over other cooks might be attributed to the increase in fiber quality in terms of increase in long fiber fractions.

Brightness Stability

Post colour number and copper number of bleached pulps showed diminishing trend with A.Q. addition in original Soda-A.Q. pulping. These two factors indicating brightness/colour stability of bleached pulp found to be the lowest due to combined effect of 0.2% A.Q. addition and A.Q. black liquor usage in the digester. (Post colour number and copper number of 0.60 and 0.36 respectively were achieved for the bleached A.Q. cooks under coloumn 5C of Table No. II.)

From the results presented in Table Nos. IV, V & VI and Figure Nos. 2, 3, 4 & 5 following points emerge.

High P.No. Pulps, when bleached by C-EP-H, under the parameters specified, the CE-P. No., CE-brightness and CE-pulp shrinkage loss varied between the higher and the lower limits.

In general, P.No., brightness and shrinkage after CE-P stage, showed the same trend with increasing dosages of Hydrogen-Peroxides in EP-stage.

With high P.No. Pulp (Viz. 16.4), CE-P. No. decreased from 6.0 as in the case of C-E-H bleaching, to a P.No. of 5.0 gradually, with stepwise H_2O_2 dosage. In the case of low P.No. pulp (Viz. 12.2), CE-P. No. has gone down further low to 4.2 with 1.0 percent H_2O_2 (50 volumes) dosage. With medium P. No. pulp (Viz. 14.8), CE-P. No. values were intermediate in levels between these of high and low P. No. pulps.

By increasing the EP stage temperature by 3-5^0 from 60^{0}C, the effectiveness of alkali extraction of chlorolignin was enhanced, having bearing on bleach consumption and brightness of pulp in the subsequent stage.

With high P. No. pulp, the CE-P. No. for 1.0% H_2O_2 (50 volumes) at 65^{0}C in EP stage resulted in the lowest P.No. value of 3.8. The shrinkage loss was found to be 0.25% point lower than the corresponding pulp re-inforced with H_2O_2 at 60^{0}C. Shrinkage loss after CE-stages showed diminishing trend with H_2O_2 dosage, irrespective of the P. No. Further, increase in reaction temperature from 60^{0}C to 65^{0}C undoubtedly stabilized carbohydrates with subsequent bleaching of residual lignin in hypo stages. The stabilizing of cellulose, in particular, is reflected in the improvement in 0.5% C.E.D. Viscosity of the bleached pulp.

Graphical representation of CE and CEp stages and their corresponding C-E-H and C-EP-H pulps on brightness clearly showed that the brightness was increasing in stepwise manner with 0.6 to 1.0% H_2O_2 addition in both the temperature ranges. Higher the temperature in EP stage (around 65^{0}C), better the quality of final pulp after bleaching. Hence, it can be inferred that softer the unbleached pulp, higher the level of improvement in brightness with reasonably lower consumption of bleach liquor. Gradual improvement in brightness of bleached pulps from 74% ISP to 79% ISO was achieved in the case of high P.No. pulp (viz. 16.4) corresponding brightness ceiling limits achieved for the low P.No. pulp (viz. 12.2) with increasing dosage of H_2O_2 in EP stage, were 81, 83 and 85% ISO respectively. (Fig. No.3). When the temperature of EP stage was maintained at 65^{0}C as against 60^{0}C, an increase of 2-3^0 ISO rise in brightness value was observed in all the corresponding cases. Highest brightness ceiling limit of 86% ISO could be achieved with low P.No. pulp when re-inforced with 1% H_2O_2 (50 volumes) at

65°C in EP stage and subsequently bleached with lower hypochlorite requirement.

The curves in figure No. 4 represents the gradual but steady drop in the post colour number of bleached pulp, with stepwise increase in H_2O_2 dosage in EP stage. Post colour number of the final bleached pulp resulting from 1% H_2O_2 addition at a temperature of amound 65°C in the EP stage, was lowest (0.30 PC. No. for 1.0% at 65°C versus 1.92 value for no H_2O_2 addition). The lowest value is indicative of the much improved stability and irreversibility of brightness. From Figure No. 5, similar trend was observed for copper number of pulp indicating the oxidative effect on cellulose, resulting in the formation of the least reducing group. Considerable drop in yellowness with consequent increase in brightness and stability characteristics as shown by lower copper number and post colour number, could be traced to the formation of C_2 and C_3 carbonyl groups in cellulose, which further oxidizes to -COOH groups.

Increasing trend of 0.5% C.E.D. viscosity of pulp with H_2O_2 addition and lowering trend of post colour number and copper number are clear indication of good brightness stability of the pulps. In a nut shell, it is evident from all the results that softer the initial pulp, maximum are the benefits achieved as described.

The increase in long fiber fractions of all A.Q. pulps, especially from A.Q. pulps of P.No. 14.8 and P. No. 12.2, was mariginal over what had been achieved without H_2O_2 addition (All 1A cooks of P.No. 14.8 and P.No. 12.2).

The results presented in Table Nos. VAB pertains to the preliminary plant trials on Anthra quinone usage (0.05% on B.D. raw material) in Soda Cooks of bagasse-rise straw furnish mix and their subsequent bleaching by C-E-H bleaching to brightness level of 74-75% ISO.

Following inferences can be made:

use of 0.05% Anthraquinone for a near uniform furnish mix of bagasse-rice straw resulted in uniformity of cooking with a drop in P.No. (40 ml) of unbleached pulps by 1.2-2.0 units.

Bauer-McNett fiber fractions mostly retained on 30 and 50 standard sieves showed gradual improvement to as high 14.64% and 20.17% respectively from the control base value of 7.8-8.12% and 14.0% for the two fractions. Suspension of A.Q. addition on 3.11.93 had reverted back to the base value of fractions observed for the near uniform furnish of 80% bagasse and 20% rice straw.

The increase in long fiber fractions of bleached A.Q. pulps is corroborated by the gradual drop in freeness (°SR) values. The hand sheet properties of the mill A.Q. bleach pulps beaten mildly to 28°SR freeness showed gradual increase in Burst Index from 1.57 to 2.15 with matching increase in double folds and overall Strength Index.

$\{S.I. = (B.F. \times T.F. \times \text{Log } D.F.)^{1/3} \times 100)$

Results presented in Table Nos. VC refer to the unbleached and bleached pulp characteristics of Soda - Anthraquinone pulping and subsequent continuous bleaching in the mill with fresh bagasse (depithed) and fresh Sarkanda.

Similar trends were observed with bagasse-sarkanda furnish mix in the average P.No., ranges and the increase in long fiber fractions. R-30 & R-50 fractions of day to day composite bleached pulps found to be 20.95% and 20.0% respectively in comparison with bagasse-rice straw A.Q. pulps, as the control base values for the fractions were as high as 13.6% and 15.2% respectively without A.Q. treatment.

The runnability of the machine during later trial runs for a 15 day period and was very much improved and the machine and finish productions registered an increase of 25-20%. Results in Table Nos. VII, VIII & IX pertain to the plant trials of Hydrogen Peroxide (50% w/w) in the alkali extraction stage of the C-E-H bleaching process in the production of pulps for value added paper grades such as copier/ Offset printing, Super printing and normal grade, Creamwove.

Split dosing of Hydrogen Peroxide (50% w/w) followed in the ratio 80 : 20 in the chlorine washer repulper and hypo washer repulper at the dosing rate of 0.4-0.44% on 100% basis. The brightness of 79-81% ISO with reasonably lower Post Colour number and Copper number was achieved.

For Creamwove grades requiring lower brightness levels, Hydrogen Peroxide dosage was limited to 0.12-0.14% (on 100% basis). The comparison of paper properties as in Table No. VIII clearly indicate the quality upgradation from the normal grades.

BENEFITS & COST ECONOMICS

Despite high cost implications on the two main chemicals viz. A.Q. and H_2O_2 (50% w/w) in pulping & bleaching section, overall benefits in terms of increase in quality of value added products, increase in production & cost economics in pulping chemicals are the highlights. Improvement in finished production. Saving in chlorine in the hypo stage of bleaching by 32-40 Kg. per ton of paper. Approximate saving in pulping & bleaching chemicals.

CONCLUSIONS

1. Anthraquinone charges of 0.06-0.075 percent on B.D. bagasse/sarkanda and 0.05% on B.D. rice straw are well within the economic ranges, considering improved benefits over the present level of 0.05% for bagasse and 0.03% in the case of rice straw raw material.

2. Aqueous dispersion of Anthraquinone is stable over periods of many month and hence, the addition of A.Q. dispersions in water to the raw material charging at regulated rate alone is the best working methodology for achieving optimum benefits. Any attempt to add the quantity of A.Q. in the white, liquor tank and charge the liquor wholly to digester will not actually give fruitful results. The high salt concentration of white liquor or caustic lye mixture will cause destabilizing action on A.Q. dispersion.

3. For batch cooking, the benefits expected to acrue will be related to the cooking time reduction rather than reducing the applied caustic charge.

4. If caustic charge (effective active alkali) is decreased to achieve the same kappa number or P.No. of pulp, in Soda-A.Q. pulping, then A.Q. charged must be increased correspondingly and the yield advantage over the Soda cooks becomes greater.

5. Cost reduction computation and economic advantage anticipated on Anthraquinone usage should be viewed in the light of three basic determining factors such as overall raw material cost, the A.Q. costs per ton of pulp and the value of the resultant extra production. In this context, computation of exact B.D. raw material loading precisely is to be strictly adhered to rather than assumptions.

6. The serious plugging of lines and pumps as experienced in A.Q. handling is entirely on account of settling down of A.Q. slurry at the bottom of the tank. This can be minimised if the slurry of A.Q. is kept at constant circulation or agitation at the time of pumping.

7. To minimise costing on account of Anthraquinone usage, partial substitution of alkaline sulfite 15-20 percent with Soda-AQ pulping in place of equivalent caustic may be considered.

8. **Hydrogen Peroxide re-inforced alkali extraction in the C-E-H sequential bleaching:**

   For all practical purposes, and achieving brightness ceiling limit of 82% ISO, Hydrogen Peroxide dosing should be standardised at 4.0-4.5 Kg/ton of pulp processed on 100% basis (8.0-9.0 Kg. ptp on 50% w/w basis). Dilution of Hydrogen Peroxide 50% w/w as such with ground water containing high amount of minerals (Calcium, Magnesium, Iron salts) ultimately destabilizes peroxide resulting in peroxy compound of the metallic impurity. Hence, Hydrogen Peroxide should be dosed directly as 50% w/w such or also preferrably diluted with waste condensate waters to minimise the effect. Hydrogen Peroxide addition to the alkaline pulp will have to be stabilised with Sodium Silicate solution neutral grade of 41.6°Be' density, containing 29% SiO_2 and 8.9% Na_2O. The addition of silicate to caustic or separately acts in addition to its buffering and stabilising action on H_2O_2, as a protective coating on the surface of metals.

9. To achieve best results with Hydrogen Peroxide, the feed pulp to multi stages bleach plant must be kept as soft as possible, preferrably P.No. below 12.0. C-EP-H bleaching of the

soft pulp, using H_2O_2 in E-stage stabilized with Sodium Silicate - Caustic system will be the right step in achieving higher brightness of bleached pulps for Copier/Super prints.

ACKNOWLEDGEMENTS

The authors are extremely grateful to Shri Pramod Jain, Managing Director and Shri D. Kumar, Exective Director of Shiva Paper Mills Limited for allowing them to publish this paper.

LITERATURE CITED

1. Perspective plan till 2000 A.D. of paper industry based on Agro Residues. - By INDIAN AGRO PAPER MILLS ASSOCIATION, NEW DELHI.
2. Blain, T.J., Tappi 76 (3) : 138-139 (1993)
3. IPPTA 24 (2) : 37, June (1987)
4. Blain, T.J., Tappi 76 (3) : 138-139 (1993)
5. Earl Paul, F., Reeve Douglas, W., Tappi 73 (1) : 179 (1990)
6. Hise, R.G. and Hintz, H.L., Tappi 73 (1) : 185 (1990)
7. Dallons Victor, J., et.al., Tappi 73 (6) : 91 (1990)
8. Hrut flord Bjorn F., & Negri Alberto R., Tappi 73 (6) : 219 (1990)
9. Reeve Doughlas, W., Tappi 74 (2) : 123 (1991)
10. Moriss Gregory, D.L., Chemical week, 40 : May, 8, 1991
11. Mc Ewen, R.L., Sheldon, F.R., & Nelson, D.H., Tappi 34 (5) : 192 (1951)
12. Delatre, M.G., Papageorges, G., Lecture delivered at 6th Annual Convention of Technical Brasilian Association of Cellulose and Paper, Sao Paulo, Brazil, 19-23.
13. Carmichail, D.L., and Althouse, E.B.,
14. Springer Edward, I., Tappi 73 (1) : 175 (1990)
15. Partha Sarathy, V.R. et.al., Tappi 73 (7) : 177 (1990)
16. Venkoba Rao, G., et.al. IPPTA, Vol. 25 (1) : 20 (1988)
17. Tendulkar, S.R., and Shinde, J.K., IPPTA, Vol. 2 (1) : 1 (1990)