Studies on Alkoxygen and Alkoxygen–Anthraquinone Delignification of Cannabis sativa

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ABSTRACT

The proposed study was undertaken to assess the suitability of Cannabis sativa by alkoxygen delignification process and to know the effect of anthraquinone (AQ on pulp and paper characteristics The comparatively loose and more open structure and low specific gravity of cannabis sativa chips makes it possible to diffuse dissolve oxygen easier to accomplish alkoxygen and alkoxygen–anthraquinone delignification of C. sativa The effects of cooking variables like oxygen pressure (0,5,8,10 and 12 kg/cm²), alkali charge (14,16 and 18%), cooking time (60,90,120 and 150 minutes), cooking temperature (150, 155, 160 and 165 °C) and AQ dose (0.0, 0.05, 0.1% and 0.2% on o.d. wood basis), on pulp yield, Kappa number, screening rejects, were evaluated The alkali-oxygen-AQ delignification of C sativa led to a significant increase in screened pulp yield, faster rate of delignification alongwith substantial drop in kappa number.

The results of these studies revealed that the following process conditions could be considered as optimum values for alkoxygen and alkoxygen-AQ pulping of C. sativa (alkali dose —16%, as Na_2O; temperature—160°C, time at temperature—120 mts oxygen pressure-10 kg/cm² and AQ dose 0 1%) These pulps beat fast and the optimum degree of beating was found to be around (42± °SR) in order to preserve tear and opacity. The unbleached pulps showed good response for bleaching by CEH and/or CEHH bleaching sequence to attain a brightness level around 76% (Elrepho). Both unbleached and bleached pulps showed good level of strength properties to be used for making various grades of paper. The total solid content of C sativa spent liquor was high, thereby increasing the calorific value. The silica content was found to be very low.

The alkoxygen–AQ pulping gave positive and very promising results for the possibilities of improving the existing soda pulping method to one that is fully commensurate with kraft process, with comparatively low pollution load It can also be concluded that AQ has a favourable influence not only on increasing pulp yield with improved strength properties but also reduce the pollution load to preserve the natural ecosystem of the environment

Introduction :

It is well known that oxygen in an alkaline medium can be used as a delignifying agent in pulp bleaching both as a substitute for chlorine as well as a true delignifying agent for chemical pulping. Although it is accepted that molecular oxygen is a specific oxidising agent for lignin, a first immediate draw-back to its use is the low solubility in cooking liquors. This causes a serious problems of mass transfer in a heterogeneous chemical process such as wood pulping Even applying very high dose of oxygen,

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useful mass transfer of the delignifying agent (molecular oxygen) into the fiber walls, where the reaction should take place is difficult to obtain in one stage pulping (1). Most efforts have been made in the development of two stage alkali-oxygen delignification of wood to give pulps comparable to kraft in yield and quality (2-4). These generally involve a first, more or less mild cooking stage followed by mechanical defibration. The coarse pulp thus obtained is very suitable for subsequent alkaline treatment in the presence of oxygen due to its higher exposed surface (5-9); but unfortunately the two stage pulping process is rather cumbersome and likely to be high in capital construction costs. Afterwards instead of wood chips, thermomechanical fibers have been used for alkali-oxygen pulping (5-9) to develop one stage oxygen pulping, but some strength deficiences have taken place, originating from mechanical damage caused in the pressurised refining, which itself is an operation high in energy consumption (10).

Environmental control laws on industrial emission, particularly the emission of sulphur compounds together with the need of more effective utilisation of raw materials have contributed to the intensive work done in recent years for the development of cooking methods which will give similar pulp qualities and preferable higher yields than the kraft process, without the addition of sulphur compounds. One such method might be the old soda process, if only the yield and pulp quality could be improved. Many different additives have been used to improve the yield and quality of soda pulp. Among the additives anthraquinone (AQ) was found to produce quite encouraging results. It appears that AQ is still the most cost effective sulphur free accelerator for alkaline pulping, albeit of limited applications. The soda-AQ process does offer a direct advantage of eliminating air pollution associated with kraft process.

Unlike that of wood, in C. sativa the problems of mass transfer of delignifying agent (Molecular oxygen) should be much important, since the plant structure should permit much easier diffusion and penetration of the delignifying agent into the reactive zones of fiber wall. The loose and open structure and low lignin content of C. sativa makes it suitable to perform soda-oxygen and soda-oxygen-AQ pulping.

Experimental Methodology :

Raw Material And its Preparation :

The stalks of C. sativa were collected from nearby regions of Saharanpur and were chopped by hand and screened. The chips those passing through 30 mm screen but retained on a 20 mm screen were collected. The accepted chips were air dried under atmospheric conditions.

The selected air dry material was disintegrated in the laboratory WEVERK disintegrator. The portion of wood meal passing through 40 mesh sieve but retained on 80 mesh sieve was utilized for proximate chemical analysis. The proximate chemical analysis was carried out as per TAPPI standard procedures. The chemical composition of C. sativa is reported in Table-I.

Pulping Studies :

The screened C. sativa chips were cooked in electrically heated rotary digester of 0 02 M^3 capacity having 4 bombs of one liter capacity, furnishing sufficient pulp for evaluation as well as for conducting bleaching experiments. To determine the optimum pulping condition during the course of pulping, a number of experiments were conducted at different conditions by varying the different process variables such as alkali charge (14, 16 and 18%, as Na_2O), oxygen pressure (0, 5, 8, 10 and 12 kg/cm²), temperature (150. 155, 160 and 165° C) and AQ doses (0 0, 0 05, 0.1 and 0 2% on o.d wood basis). During the course of pulping the liquor to wood ratio of 3.5:1 was used with following time schedule for heating the digester.

Time from room temperature to 105°C =45 minutes
Time from 105°C to maximum temperature=45 minutes

During cooking the digester pressure was reduced by gas relief until the temperature reached to 105°C. The charge was then blown from the digester and the chips were defibred through a Bauer refiner with a plate

TABLE—1

Proximate Chemical Analysis of C. sativa and C. sativa bast fibres.

Sl. No.	Particulars		C. Sativa	C. Sativa bast fibres
1	Cold water Solubles,	%	3.94	3.94
2	Hot water solubles,	%	7.46	8.06
3	Alcohal–Benzene solubles	%	3.50	—
	(1:2 V/V)	%	3.50	12.00
4	1% Sod. hydroxide solubles,	%	24.00	29.00
5	Lignin,	%	18.25	7.30
6	Pentosan,	%	16.40	6 30
7	Hemicellulose,	%	24.40	—
8	Holocellulose,	%	73.80	—
9	Alpha Cellulose,	%	49.40	58.80
10	Beta Cellulose,	%	10.60	—
11	Gamma Cellulose,	%	13.50	—
12	Ash,	%	1.30	5.30
13	Silica,	%	0.25	
14	Acetyl content,	%	3.12	
15	Methoxyl content,	%	3.56	

TABLE—2

Effect of Oxygen Pressure and alkali charge on pulp yield of C. sativa.

Fixed cooking parameters :

Time from room temp to 105°C	=	45 minutes
Time from 105°C to 160°C	=	45 ,,
Time at 160°C	=	120 ,,
Liquor to wood ratio	=	3.5:1

Alkali dose, as Na_2O	Oxygen pressure, (Kg/cm^2)	Pulp Yield, (%)	Screening rejects, (%)	Screened Yield, (%)	Kappa No.,	Spent liquor pH
	0	51 90	1.95	49.95	54	8.8
14	5	54·40	1.40	53.00	51	8 5
	8	55.20	1.20	54.00	48	8.0
	10	55 63	1.13	54.50	46	7.9
	12	52.07	1.07	51.00	38	7.8
	0	50.00	1.50	48.50	43	10.5
16	5	52.00	1.00	51.00	40	9.1
	8	53.37	0.87	51.50	35	9.2
	10	52.65	0.80	51.85	32	9.3
	12	49.70	0.70	49 00	28	9.3
	0	45.18	0.68	44.50	38	10 6
18	5	48.88	0.33	48.55	35	9.3
	8	49.76	0.26	49.50	31	9.4
	10	49.87	0.17	49.70	29	9.6
	12	47.13	0.13	47.00	27	9.6

clearance of 0.15 mm, followed by second pass at 0 07 mm plate clearance. The pulp was screened through a laboratory vibratory flat WEVERK screen with 0.15 mm slits and the screened pulp was washed, pressed and crumbled. The yield, rejects and Kappa number were determined. The spent liquor was analysed for total solids, inorganics, organics, silica, BOD and COD. All the results of pulping as well as spent liquor analysis are reported in Table 2 to 9.

Bleaching Studies :

The C. sativa pulp showed good response towards bleaching and were bleached with conventional CEHH bleaching sequence to get pulp of higher brightness. The bleaching conditions alongwith results are given in Table 6.

Pulp Evaluation :

The unbleached and bleached pulps were beaten in PFI mill with a beating pressure of 1.8 kg/cm to different freeness levels and hand sheets of 60 gm/cm^2 were prepared on standard British sheet forming machine. These handsheets were evaluated as per BIS method for their different physical strength properties at a temperature of 27±2°C and at a relative humidity level of 65±2%. The pulp evaluation results are recorded in Table-5, 7 and 8.

Fibre Classification Studies :

The fibre classification studies of C. sativa pulps were made with the help of Bauer-McNett fibre classifier using screens with mesh number 28, 60, 80 and 150. The results of fibre classification studies are reported in Table-10.

Results And Discussions :

The results of proximate chemical analysis showed that the plants of C sativa have moderate quantities of solubles thereby creating lesser pitch troubles with improved homogenities in the paper sheet. These plants have low lignin and comparatively higher total carbohydrate fraction (in comparison to woody materials), thereby require less amount of cooking chemicals with shorter cooking cycles.

The effect of following variables on pulp yield and degree of delignification were studied in order to get their optimum level.

- Oxygen pressure.
- Alkali charge.
- Cooking Temperature.
- Cooking Time.
- Anthraquinone (AQ) dose.

Table-2 showed the results of alkali delignification of C sativa at different alkali charges viz 14, 16 and 18% (as Na_2O). with and without oxygen, under pressure viz. 0, 5, 8, 10 and 12 kg/cm^2 at fixed cooking parameters. viz temperature 160°C, time to temperature 90 minutes, time at temperature 120 minutes and bath ratio 1:3:5. Figure 1.01 showed that under otherwise cooking conditions, oxygen has a considerable effect on cooking parameters.

Pulping of C. sativa chips with soda-oxygen resulted in an increase in pulp yield from 5.9% over that obtained from soda pulps prepared under the same pulping conditions. Increasing oxygen pressure from 0 to 10 kg/cm^2 increased the pulp yield attaining the maximum value and a further increase in oxygen pressure beyond 10 kg/cm^2 resulted in a slight decrease in pulp yield The maximum carbohydrate yield was obtained at a oxygen pressure of 10 kg/cm^2.

Table–2 indicated the results of alkali oxygen delignification of C sativa at different doses of alkali with varying oxygen pressures. As far as the effect of delignification is concerned it can be observed that an increase in caustic soda charge from 14 to 18% (as Na_2O) has a very positive effect on delignification, the Kappa number dropped from 49 to 19 depending upon oxygen pressure. Alkali charge also has an important influence on pulp yield. An increase in alkali charge resulted in substantial yield loss The increased delignification alone dose not seem completely responsible for these losses. The screened pulp yield obtained at an alkali charge of 16% (as Na_2O) and oxygen pressure of 10 kg/cm^2 (Fig 1.01) seems to be

TABLE—3

Effect of temp. during alkali oxygen delignification of C. sativa.

Fixed cooking parameters :

Active alkali	=	16% (as Na_2O)
Oxygen pressure	=	10 Kg/cm²
Liquor to wood ratio	=	3 5:1

Sl No.	Temp, °C	Pulp Yield, %	Screening rejects,(%)	Screened Yield,(%)	Kappa No.,	Spent Liquor pH
1	150	53 69	2 10	51 59	40	9 8
2	155	53 50	1 20	52 50	35	9 5
3	160	52 65	0 80	51 85	32	9.3
4	165	48 35	0.35	48.00	29	9 0

TABLE—4

Effect of time during alkali oxygen delignification of C. sativa.

Fixed cooking parameters :

Maximum temperature	=	160°C
Oxygen pressure	=	10 Kg/cm²
Liquor to wood ratio	=	3 5:1

Sl. No	Time at max. temp, (min.)	Pulp Yield, (%)	Screening Reject,(%)	Screened Yield,(%)	Kappa No,	Spent liquor pH
1	60	57.44	8 44	49 00	46	9 1
2	90	53 50	2.20	51 30	38	9 2
3	120	52 65	0 80	51 85	32	9 3
4	150	48 75	0.40	48 35	30	9.0

TABLE—5

Comparison of soda, soda-oxygen and soda-oxygen-AQ delignification of C. sativa at 16% active alkali dose, 160°C temperature and 2 hours time at temperature.

Sl. No.	Oxygen pressure, Kg/cm²	AQ dose, %	Pulp yield, %	Rejects, %	Screened yield, %	Kappa No.,	Spent liquor pH	Burst index, K.pa.m²/g	Tensile index, Nm/g	Tear index, m Nm²/g	Folding endurance No.
1	0	0.0	50 00	1.50	48 50	43	10 5	5.05*	73 74*	4 81*	212*
2	5	0 0	52 00	1 00	51.00	40	9.1	5 80	74 80	5 90	225
3	5	0.1	53 20	0.90	52 30	35	8.9	5.85	75.00	6 0	228
4	8	0.1	53 30	0 50	52 80	34	8.9	6.20	74.50	6 2	230
5	10	0 05	53.50	0 30	53 20	33	8.8	6.40	76 40	6.4	235
6	10	0 1	53 70	0 20	53.50	30	8.8	6.50	76 50	6 6	240
7	10	0.2	53.50	0.10	53.40	28	8.8	6.60	76.60	6.7	242

*Time at temp. 165°C = 3 hours

Freeness =45°SR.

most acceptable value based on Kappa number. The screening rejects and Kappa number both are having indirect proportional relationship with alkali doses and/or oxygen pressure i.e. screening rejects and Kappa number both decreased continuously as a result of an increase in either alkali dose or oxygen pressure.

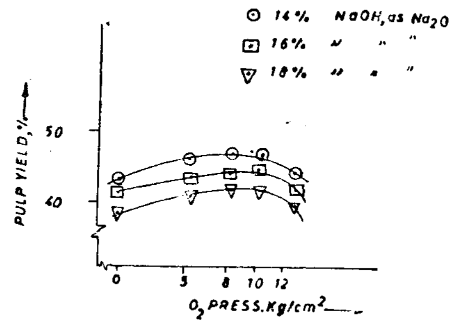

FIG. – 1.01 : EFFECT OF OXYGEN PRESSURE ON PULP YIELD AT DIFFERENT ALKALI DOSE.

Table–3 (and figure 1.02) represented the results of alkali-oxygen cooks carried out at four different temperature viz 150, 155, 160 and 165°C, keeping all other variables constant. These results clearly indicated that an increase in cooking temperature notably improve delignification. As the temperature increased from 150 to 165°C, the Kappa number dropped from 39 to 27. The pulp yield and screening rejects both are having indirect proportional relationship with temperature i. e. as the temperature increased both the pulp yield and screening rejects showed a continuously decreasing trend (Fig. 1. 02). The optimum results were obtained at a temperature of 160°C.

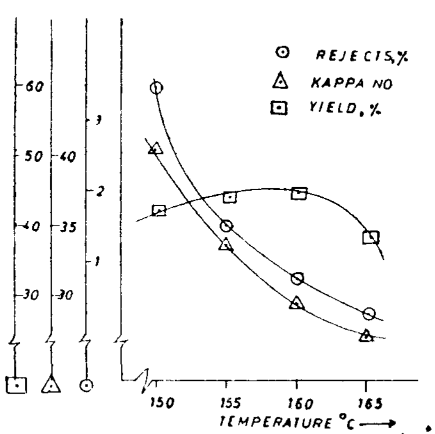

FIG. – 1.02 : EFFECT OF TEMP. ON PULP YIELD KAPPA NO AND REJECTS

Table–4 (and figure 1.03) showed the results of the alkali-oxygen cooks aimed at evaluating the effect of cooking time. The cooks were made for 60, 90, 120 and 150 minutes, keeping all other parameters constant. These results indicated that rejects and Kappa number both are having indirect proportional relationship with time i.e. as the cooking time increased, both the rejects and Kappa number decreased continuously (fig 1.03). As regards to delignification, it is having a directly proportional relationship with time i.e. as the time of cook increased, the amount of lignin removal also increased. The screened pulp yield obtained with a cooking time of 120 minutes seems to be most acceptable value based on Kappa number.

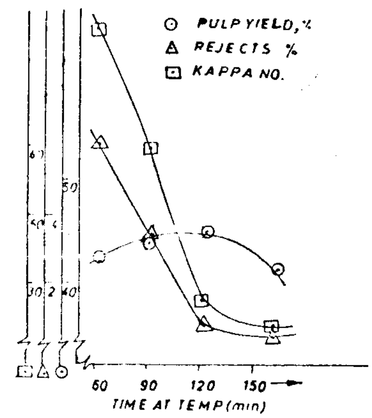

FIG. – 1.03: EFFECT OF TIME ON PULP YIELD KAPPA NO AND REJECTS

As C sativa had proved to be very much suitable for alkali-oxygen delignification, it was deemed interesting to evaluate the effect of AQ on pulp yield, rejects, Kappa number and other properties. Different doses of AQ viz. 0.0, 0.05, 0.1 and 0.2% (on o.d. wood basis) were applied to the cooks made at optimum cooking parameters (i.e. at an alkali charge of 16% (as Na_2O), temperature 160°C, time to temperature 90 minutes, time at temperature 120 minutes and bath ratio 1:3.5). The results of addition of different doses of AQ during alkali-oxygen delignification are tabulated in Table–5.

These results indicated that, on increasing AQ doses, the screened pulp yield increased up to a certain level and beyond that it decreased, while the Kappa number and rejects both showed a continuously decreasing trend. Considering all parameters, an AQ dose of 0.1%

TABLE—6

Bleaching Conditions and Results of Alkali-Oxygen and Alkali–Oxygen–AQ pulps of C. sativa.

Sl. No.	Particulars		Alkali Oxygen Pulp	Alkali–Oxygen–AQ–Pulp
1	Unbleached Kappa No.		32.00	30.00
2	Chlorination Stage (C)			
	Amount of Cl_2 added on pulp	(%)	6.0	5.60
	Amount of Cl_2 consumed on pulp	(%)	5.96	5.55
	Amount of Cl_2 consumed on Cl_2 basis	(%)	99.3	99.10
	Final pH		1.98	2·10
3	Alkali extraction stage	(E)		
	NaOH added on pulp	(%)	3.01	283
	Initial pH		11.62	11.63
	Final pH		10.31	10.28
4	Hypochlorite Stage (H_1)			
	Hypo added as available Cl_2 on pulp	(%)	1.20	1.13
	Hypo consumed as availaale Cl_2 on pulp	(%)	1.19	1.12
	Hypo consumed on Cl_2 basis	(%)	99.16	99.11
	Final pH		8.17	8.12
5	Hypochlorite stage (H_2)			
	Hypo added as available Cl_2 on Pulp	(%)	0.80	0.75
	Hypo consumed as available Cl_2 on pulp	(%)	0.78	0.73
	Hypo consumed on Cl_2 basis	(%)	97.50	97.33
	Final pH		8.12	8-13
6	Total Cl_2 added on pulp	(%	8.00	8.50
7	Total Cl_2 consumed on pulp	(%)	7.93	7.40
8	Bleaching losses	(%)	9.85	9.90
9	Bleached pulp yield	(%)	52.73	53 60
10	Pulp brightness (Elrepho)		78	77

Bleaching conditions :

	C	E	H_1	H_2
Consistency (%)	4	9	10	10
Temperature (°C)	25±2	55±2	45±2	45±2
Time (Minutes)	40	60	60	120

TABLE—7

Strength Properties of alkali–oxygen and alkali–oxygen–AQ unbleached pulp of C. sativa.

AQ dose, (%)	Beating time, (minutes)	Freeness, (°SR)	Drainage time, (seconds)	Tensile index, (Nm/g)	Burst index (K.pa.m²/g)	Tear index, (m N m²/g)	Folding endurance (No)
	0	20	5	36.17	1.45	4.83	8
0.0	8	25	10	51.75	2.96	6 30	95
	25	40	16	72.00	5.95	5.80	200
	35	50	22	74 90	6.50	5.45	225
	0	22	5	40.12	1.84	5.74	8
0 1	8	25	10	52 00	3.36	6 60	120
	25	40	16	69.15	5.80	5 90	225
	35	50	22	76 50	6 70	5 61	240

TABLE—8

Strength properties of alkali–oxygen and alkali–oxygen–AQ bleached pulp of C sativa at optimum condition.

AQ dose (%)	Beating time, (Minutes)	Freeness, (°SR)	Drainage time, (seconds)	Tensile index, (Nm/g)	Tensile index, (K.pa m²/g)	Tear index (MN²m²/g	Folding endurance. No.	Brightness (Elrepho) (%)
	0	21	5	36.20	1.52	4 90	8	78
0.0	10	29	12	49.20	2 90	6 10	90	74
	25	40	22	71.30	5 85	5.75	190	73
	35	50	38	74 21	6 21	5 41	226	72
	0	23	6	38 12	1.79	5.12	10	77
0.I	6	25	10	50.50	3.26	5 02	90	74
	25	40	21	71.98	5.48	5.92	200	72
	35	50	38	75 28	6.30	5 55	230	71

TABLE—9

Alkali–Oxygen–AQ Spent Liquor characteristics of C. sativa at optimum condition.

Sl. No.	Particulars	Percentage
1	Black Liquor Solid, (%)	23.10
2	Residual active alkali, (gpl)	3.45
3	Inorganics, as NaOH (%)	28.00
4	Organics, (%)	72 00
5	Silica, (%)	3 40
6	pH of liquor at 30°C	9 30
7	BOD (5 days at 20°C) (mg/ml.)	19045
8	COD (mg/ml)	69200

TABLE—10

Bauer–McNett Fibre classification of alkali–oxygen and alkali–oxygen–AQ (unbleached) pulp of C sativa at optimum condition.

Sl. No.	Meshsize	Alkali–oxygen pulp, %	Alkali–oxygen–AQ pulp, %
1	+ 20	23	23 5
2	— 20 + 60	52.4	51 6
3	— 60 + 80	10 6	11.8
4	— 80 + 150	6.5	6 0
5	— 150	7·5	6 90

(on o.d. wood basis) was found to be optimum to get highest pulp yield with comparatively lower rejects and Kappa number.

The unbleached pulp brightness was found to be around 32% (Elrepho). The unbleached pulps were bleached using CEHH bleaching sequence for obtaining high degree of brightness. The results of bleaching studies (Table VI) indicated that the pulp of C. sativa showed excellent bleaching response. During chlorination stage, 60–70% chlorine of the total chlorine demand was used. The alkali requirement was about 1.53% in the extraction stage. About 20% and 15% chlorine of total chlorine demand in the form of calcium hypochlorite were applied in hypochlorite (H_1) and (H_2) stages which resulted a pulp with brightness level of 78% (Elrepho).

The results of unbleached and bleached pulps (tables 7 and 8) indicated that initial freeness level and drainage rate was found to be quite higher. The freeness of unbeaten unbleached and bleached pulps were found to be around 20° SR. The plots of pulp freeness (unbleached and bleached versus burst, tensile, tear and folding endurance have shown in figure 1 04 and 1.05 respectively. These plots indicated that burst index, tensile index and folding endurance are is directly proportional with the freeness of pulps i e. all these strength properties showed an improving trend as a result of an increase in freeness level upto a certain level (i e. around a freeness level of 42 ± 2°SR) and beyond that they showed a little decreasing trend, while the tear index for the unbleached and bleached pulps both first showed a little enhancement (up to freeness level of about 27 ± 3°SR) and then showed a continuous decline trend. On the basis of these results, it can be concluded that both unbleached and bleached pulps showed good strength characteristics. The optimum freeness level for these pulps may be considered around 40°SR. The physical properties of alkali-oxygen–AQ pulps showed over all improvement over alkali-oxygen pulps at same Kappa number.

The results of spent liquors analysis obtained from alkali–oxygen–AQ pulping under the optimum conditions (Table-9) indicated that the total solid contents were towards little higher side. The biochemical oxygen demand and chemical oxygen demand of spent liquor are slightly lower than the other non–wood fibres pulps. The silica content in the spent liquors were found to be very low. The lower silica and higher total solid contents are advantageous factor towards energy conservation in the chemical recovery system.

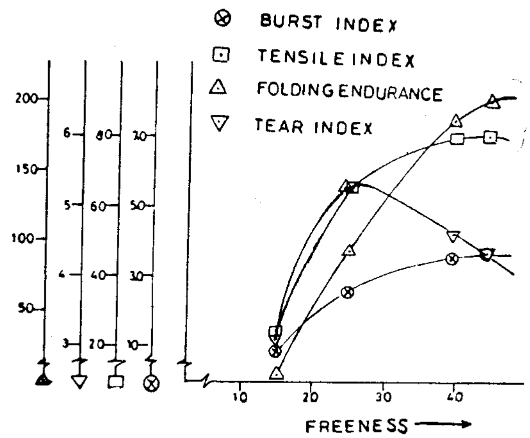

FIG.-1.04: PLOTS OF STRENGTH PROPERTIES Vs FREENESS OF ALKALI-OXYGEN-AQ UNBLEACHED PULPS AT OPTIMUM CONDITION.

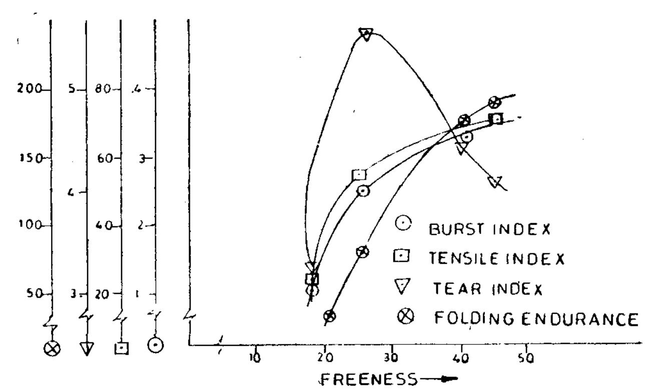

FIG. – 1.05: PLOTS OF STRENGTH PROPERTIES Vs FREENESS OF ALKALI-OXYGEN-AQ. BLEACHED PULPS AT OPTIMUM CONDITION.

Conclusion :

The proposed study have ascertained that the soda-oxygen-AQ delignification of C. sativa is comparatively a better process The lignin of these plants are much more senstive to the action of oxygen and resulted a pulp with higher degree of delignification. The delignification is easier than wood chips due to more open structure of C. sativa chips. There is no diffusion problem of dissolved oxygen into these non-wood plants because of its more loose structure and low specific gravity. Addition of AQ led to a significant increase in screened yield and rate of delignification compared to a soda, soda-oxygen pulping due to stabilisation of carbohydrates towards end-wise degradation. Addition of AQ may be economically beneficial due to substantial decrease in Kappa number, increase in pulp yield and strength properties, and shorter cooking time. As regards the cooking variables it was found that :

— The alkali charge is important for both delignification and yield. Better results were obtained at an alkali charge of 16% (as Na_2O).

— An increase in cooking temperature bring about faster delignification At optimum value of cooking, the temperature was observed at 160°C.

— The cooking time of 120 minutes was found to be optimum for getting better delignification effects.

— The AQ (0 1%) may be economically beneficial due to substantial decrease in Kappa number, increase in pulp yield and strength properties and shorter cooking time.

Based on our experimental results it can be concluded that optimum set of parameters for alkali-oxygen-AQ delignification of C. sativa may be consider as follows :

Alkali dose	=	16% as (Na_2O)
Oxygen pressure	=	10 kg/cm²
Temperature	=	160°C
Time at maximum temp.	=	120 minutes
Bath ratio	=	1 : 3 5
AQ dose	=	0.1%

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