Kraft Pulping of Eucalyptus Hybrid with Anthraquinone

CHOWDHARY, L.N.*, SAKSENA, U. L.**, SUBHASH CHANDRA***, SINGH, B.****

SUMMARY

The use of Anthraquinone as additive in pulping, has evoked world wide interest recently. It has been established by various researchers that use of Anthraquinone in alkaline pulping helps in improving the pulp yield and reducing the chemical consumption. Laboratory scale trials were conducted by us on Kraft Pulping of *Eucalyptus hybrid* mainly *E. tereticornis* using Anthraquinone as additive. The objective of the study was to establish the optimum dosage of anthraquinone to achieve reduction in active alkali requirement maintaining same Kappa number and to investigate its effect on strength properties of pulp. Varying quantity of anthraquinone (0.025%- 0.10% on O.D. Weight of chips) was added at different alkali levels. It was observed that for identical pulping conditions, addition of anthraquinone resulted in reducing the Kappa number of pulp by 10-15. It was also observed that anthraquinone is more effective in smaller dosages. The strength properties of resulting pulp, mainly burst factor, double folds and tearing strength also increased significantly with the use of Anthraquinone.

INTRODUCTION

The use of Anthraquinone (AQ) and its derrivatives, in alkaline pulping, has received considerable attention in recent past. It has been established by trials in various parts of the world, that even the small quantities of AQ or its derivative like Sodium Salt of Anthraquinone-2-monosulphonic acid (AMS), considerably increase the rate of delignification in alkaline pulping. [1,2,3]. This development has revived the interest in Soda Pulping and it is believed that Soda-AQ process, has a matching potential with normal kraft process as far as quality of pulp is con cerned. The Soda-AQ process is also expected to offer a satisfactory solution to the kraft odour problem.

*Dy. Works Manager, **Manager, ***Process Engineer, ****Research Chemist, Star Paper Mills Ltd, Saharanpur.

The presence of AQ and its derivatives, in alkaline medium, has been reported to give enhanced pulp yields also. The increase in pulp yield is cannot be attributed entirely to the increased rate of delignification. It is believed that the stabilisation of Carbohydrates must also be taking place in presence of quinones. Ruoho and Sjostrom ([4]) has shown that AQ and specially AMS are highly specific oxidants for polysachharide and groups. They have also shown that stabilisation of carbohydrates is much more pronounced in presence of oxygen, possibly due to fact that oxygen activates the reactions of quinones with cellobiose.

The present work was initiated to evaluate the effect of AQ on pulping of Eucalyptus Hybrid and Pine which are the main raw materials being used at our mills. So far the trials with 100% eucalyptus have been completed and as expected, the results have quite encouraging.

EXPERIMENTAL

For all the pulping experiments, wood chips were collected from chip storage pile of the mills. The chips were screeened and $1'' \pm 0.25''$ size chips were used for the lab trials. The cooking was carried out in the electrically heated laboratory rotary digester with a capacity of 15 litres. White liquor from the mills with a sulphidity of 21 was used for cooks without AQ while in case of cooks using AQ the sulphidity level was brought down to 10% by addition of calculated quantity of sodium hydroxide. Requisite quantity of AQ was added to white liquor before charging. The effect of varying A A level and AQ dosage was studied keeping other pulping conditions constant as given below:

Bath ratio	=	1:3.5
Cooking Temp.	=	170°C
Time to constant temp.	=	90 min.
Time at " "	=	60 min.

For evaluation of pulp, the Kappa numbers were determined as per Tappi Standards. The beating was carried out in laboratory valley beater and hand sheets were prepared and tested as per ISI Standards.

RESULT AND DISCUSSION

PRELIMINARY EXPERIMENTS

Initial experiments were conducted without AQ to assess the effect of different active alkali levels on yield, residual active alkali and total solids present in black liquor. The results are shown in Fig. 1. It can be observed that residual active alkali is minimum at 12% AA level. Theoretically, the consumption of alkali is maximum at this point but this may not represent the right level for mill scale operation where certain amount of RAA is must in black liquor to have smooth operation of chemical recovery plant. From strength properties point of view, it was observed that optimum conditions exist at 16% AA charge.

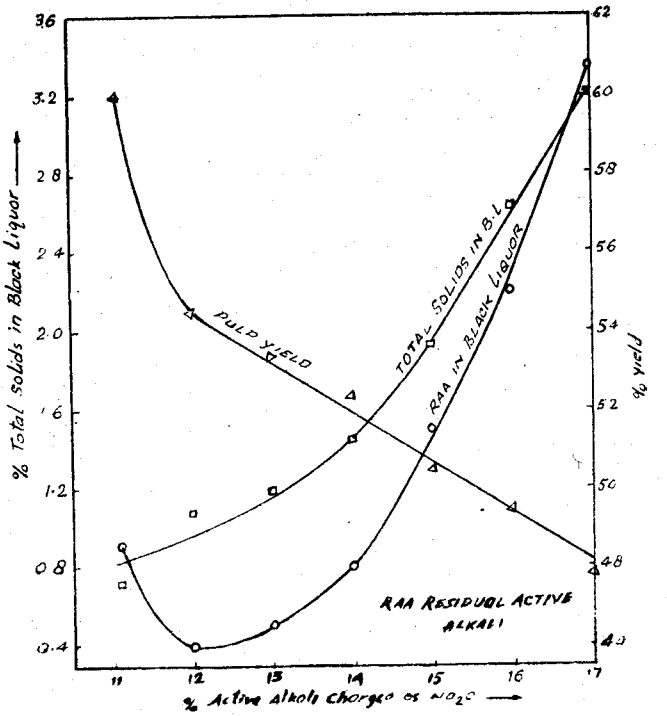

Fig. 1. Effect of % Active Alkali charged on Yield RAA and Total Solids present in Black Liquor for Normal Kraft Cooks.

EFFECT OF ANTHRAQUINONE ON DELIGNIFICATION AND YIELD

The experiment with AQ addition were carried out at lower AA levels viz 11%, 12%, 13% and 14%. The quantity of AQ added was varied from 0.025% to 0.1% on O.D. weight of wood. The results have been included in Table—1 and depicted graphically. Fig. 2 & 3 show the effect of AQ addition on kappa number of pulp. It can be observed that addition of 0.25% of AQ brings down the kappa number by 8–15 units, the drop being more at lower alkali levels. The higher doze of AQ reduces the kappa number further but the reduction is to a lesser extent. Fig. 4 shows the effect of AQ addition on pulp yield. The addition of AQ apparently lowers the yield at all levels of AA though the kappa numbers are also lower. The combined effect of AQ addition on pulp yield and kappa number has been shows in Fig. 5. It will be observed that it is possible to obtain the same kappa number of pulp with higher yield if AQ is added to the system at lower AA charge. This depicts that addition of AQ results in faster delignification resulting in lower kappa number pulps. It is believed that AQ modifies the ligning in high alkaline medium resulting in their faster dissolution and giving easily bleachable pulps. The rejects

TABLE—I

RESULTS OF KRAFT PULPING OF E. TERETICORNIS WITH ANTHRAQUINONE ADDITIVE

Cook	AA charge on OD woods	AQ on OD wood	Sulphidity	Pulp yield	Rejects	Screen yield	Kappa	RAA in spent liquor
No.	% as Na_2O	%	%	%	%	%	No.	gpl as Na_2O
1	15	Nil	21	50.5	2.5	48.0	34.5	4.6
2	16	Nil	21	49.5	0.8	48.7	31.5	6.7
3	17	Nil	21	47.9	0.7	47.2	29.0	9.3
4	11	Nil	10	59.9	22.8	37.1	56.0	2.23
5	11	0.025	10	57.4	6.8	50.6	49.0	1.24
6	11	0.050	10	57.0	6.8	50.2	47.0	0.62
7	11	0.075	10	56.8	6.2	50.6	45.0	0.62
8	12	Nil	10	54.5	5.9	48.6	44.0	1.12
9	12	0.025	10	53.1	2.0	51.1	32.0	1.24
10	12	0.050	10	52.4	1.5	50.9	30.0	0.9
11	12	0.075	10	51.7	1.4	50.3	29.0	1.0
12	13	Nil	10	53.4	5.1	48.3	39.0	1.5
13	13	0.025	10	52.2	2.0	50.2	30.0	1.4
14	13	0.050	10	50.9	1.2	49.7	28.5	1.5
15	13	0.075	10	50.6	1.1	49.5	28.0	1.5
16	14	Nil	10	52.4	4.9	47.5	37.0	2.0
17	14	0.025	10	51.1	1.5	49.6	30.0	2.1
18	14	0.050	10	50.9	1.2	49.7	28.0	2.2
19	14	0.075	10	50.6	0.9	49.7	26.0	2.2
20	14	0.10	10	50.7	0.9	49.8	24.0	2.5

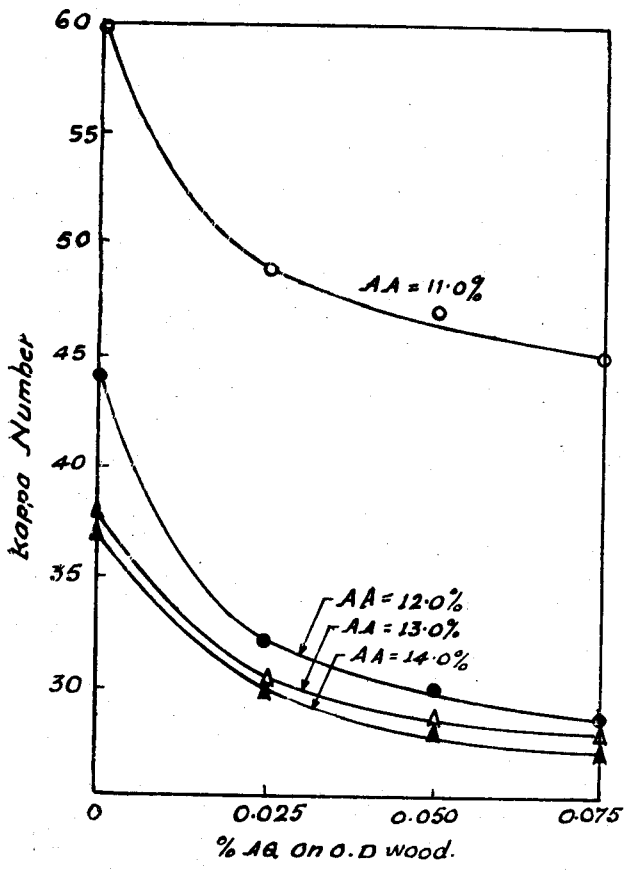

Fig. 2. Effect of AQ on Delignification.

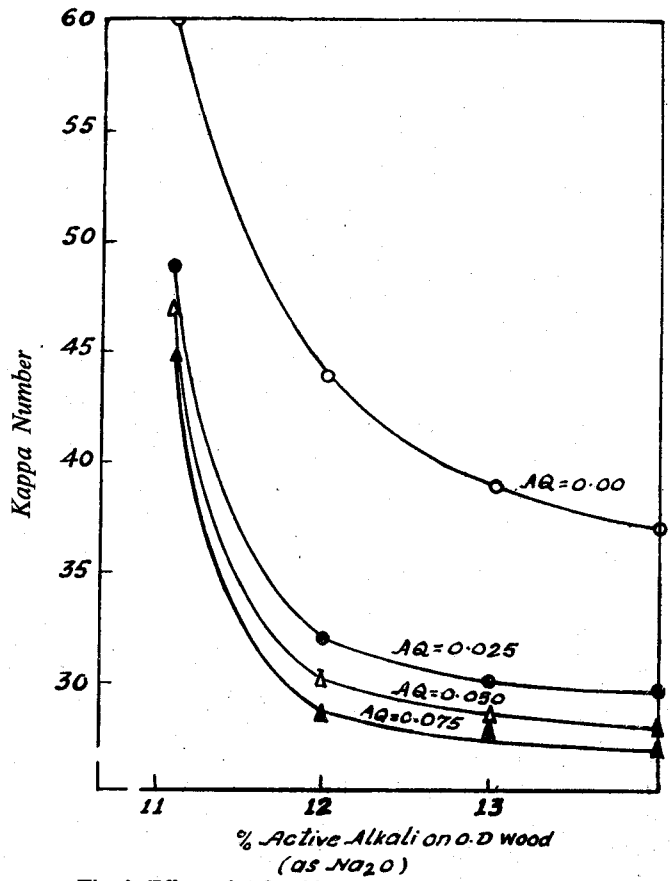

Fig. 3. Effect of AQ addition on Kappa No. at various Alkali Levels.

percentage in pulp was also found to be lower with increasing level of AQ. It will also be observed that effect of AQ is more pronounced at lower AA levels. While comparing the AQ additive pulping with normal kraft pulping, it was observed that kappa number and quantity of rejects obtained by using 16% AA as Na_2O, was similar to that obtained by using only 12% AA as Na_2O alongwith 0.025–0.05% AQ. At the same time, the yield was higher by about 3% in later case which means a substantial savings on raw material and chemicals.

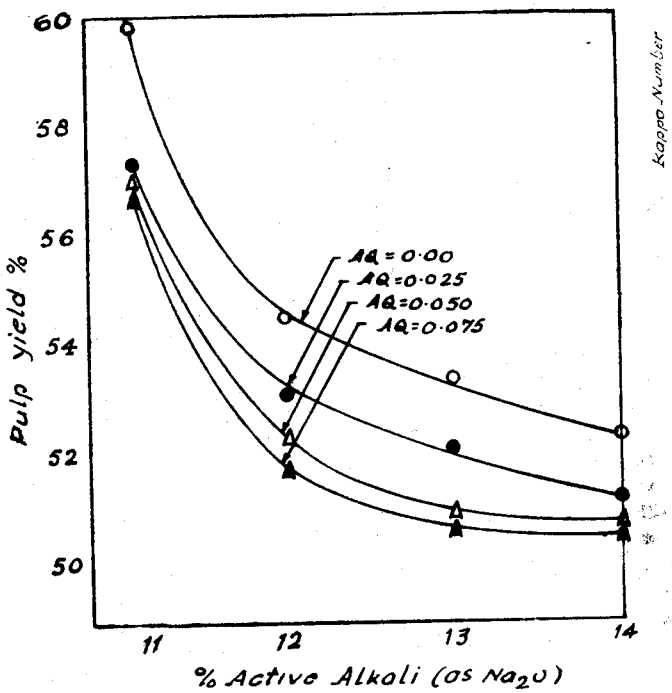

Fig. 4. Effect of AQ Addition on Pulp Yield at various Alkali Levels.

EFFECT OF AQ ON PAPER PROPERTIES

Fig. 6,7,8 & 9 depict the effect of AQ addition on strength properties at different AA level. The burst factor was found to increase by about 25% by addition of AQ as shown in Fig. 6. The tear factor and breaking length were found to increase by about 10–15% after the addition of AQ. It may be noted that effect of AQ addition is more pronounced at 12% AA level, as far as the above mentioned strength properties are concerned. At higher alkali levels, the gain in strength properties is relatively less but even then the strength properties are better with the AQ addition when compared to the strength properties at same AA level without AQ. In case of double folds, the addition of AQ gives surprisingly high values, at all AA levels. Though the double fold values sometimes exhibit erratic behaviour but this fact certainly strengthens the earlier conclusion that strength properties improve with the addition of AQ.

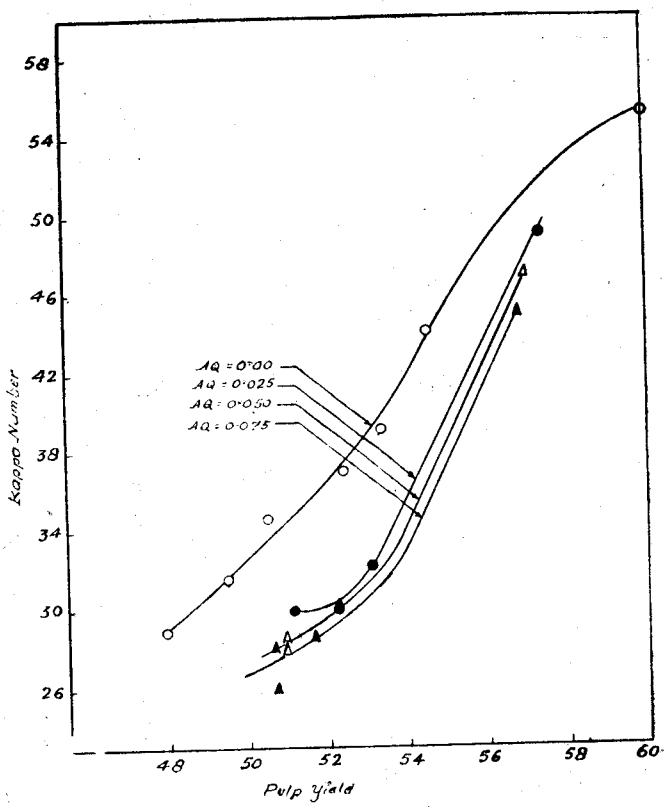

Fig. 5. Relationship between Kappa Number and % Yield at different AQ Dosage.

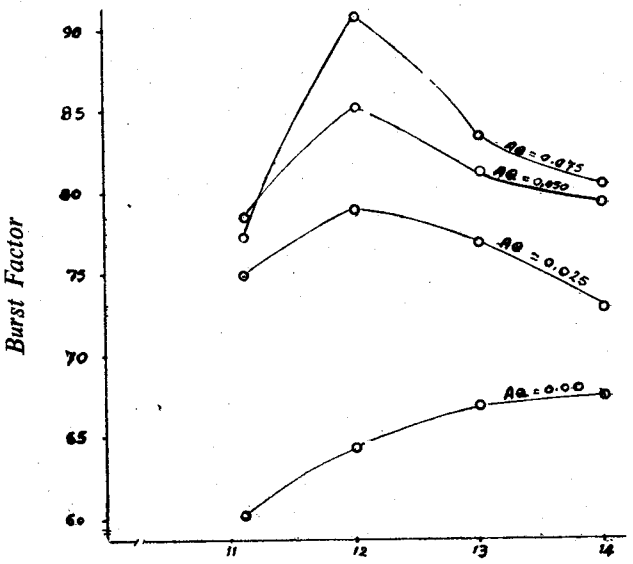

Fig. 6. Effect of AA on Burst Factor at different AQ Level.

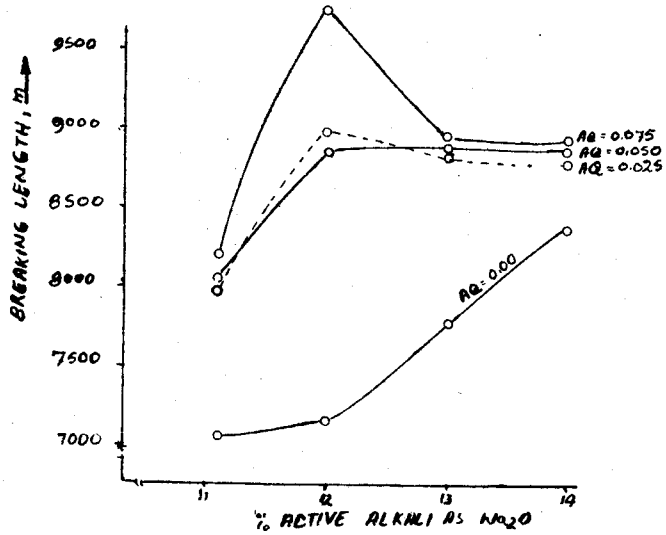

Fig. 7. Effect of AA on Breaking Length at Different AQ Level.

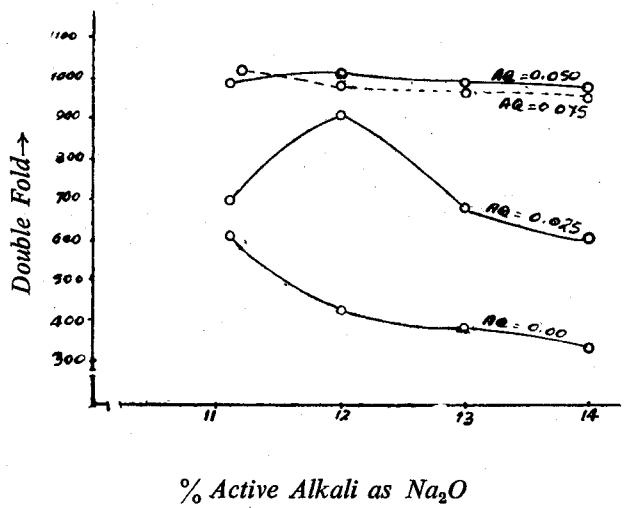

Fig. 9. Effect of AA on Double Folds at AQ Level.

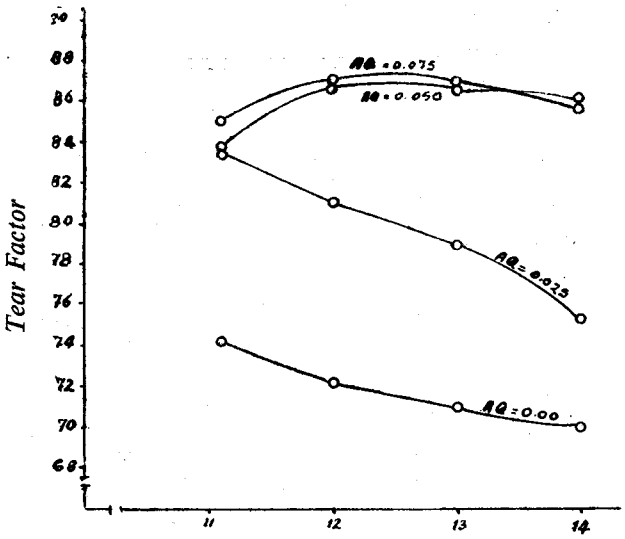

Fig. 8. Effect of AA on Tear Factor at Different AQ Level.

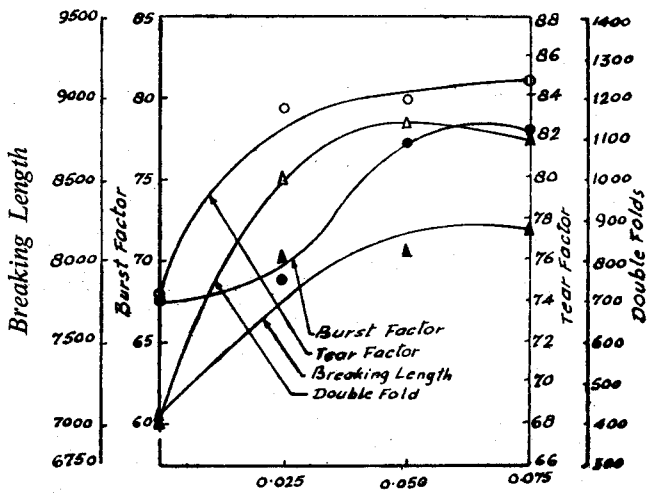

Fig. 10. Effect of Varying AQ Dosage on Strength Properties at 11% AA Charge.

These results have been also shown in a different manner in Fig. 10,11,12 & 13. Here the effect of varying AQ dosage has been shows on different strength properties at one AA level. These figures shows that maximum advantage of AQ addition is obtained a lower dose and the curves flatten out at higher AQ levels.

EFFECT OF AQ ON BEATING CHARACTERISTICS OF PULP

Strength properties of pulp obtained at 11% AA have been plotted as a function of SR in Fig. 14,15,16 & 17 for varying AQ dosage. The curves exhibit the well established trend in different cases. As mentioned earlier, addition of AQ gives better yield of pulp by conservation of polysachharides. The presence of more hemicelluloses is expected to render the pulps easily beatable under normal conditions, but in our case no significant difference was observed in case of normal kraft cook pulps and AQ-kraft pulp.

CONCLUSIONS

1. AQ in alkaline medium is shown to have beneficial effect on delignification and pulp yield when used at lower active alkali levels. Experimental results indicate that AQ promotes delignification and helps in conservation of polysaccharides. The higher levels of alkali is believed to increase the loss of polysaccharides, a characteristics of strongly alkaline pulping.

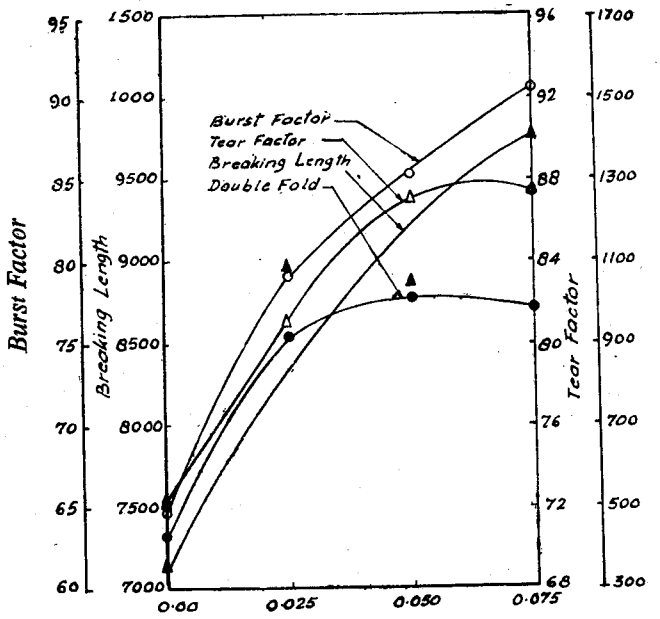

Fig. 11. Effect of Varying AQ Dosage on Strength Properties at 12% AA Charge.

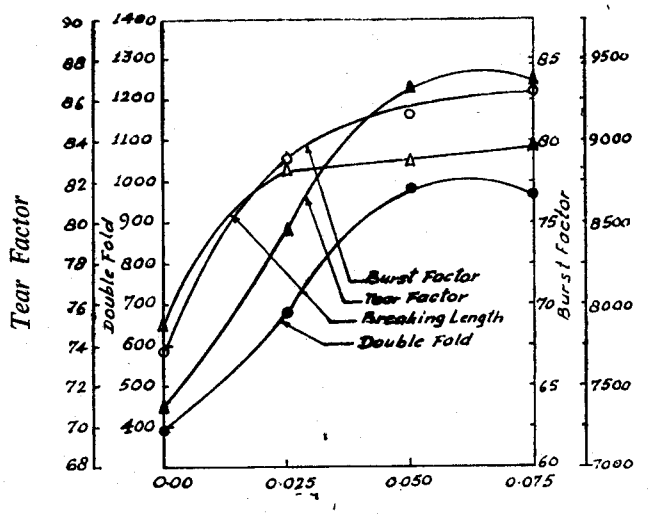

Fig. 12. Effect of Varying AQ Dosage on Strength Properties at 13% AA Charge.

2. Pulping with 12% active alkali as Na_2O alongwith 0.025%–0.050% AQ was found to give the best results with E.tereticornis. At this level, the pulp yield was about 53% at a kappta number of 30–32. This compares favourably with normal kraft pulping at 16% active alkali as Na_2O resulting in yield of 49.5% and 31.5 kappa number. It may also be mentioned that sulphidity in normal kraft cook was 21% as compared to only 10% in case of cooks with AQ additive.

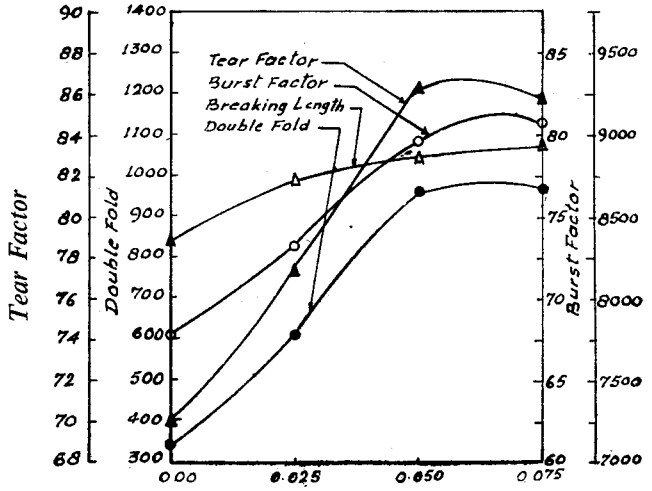

Fig. 13. Effect of Varying AQ Dosage on Strength Properties at 14%AA Charge.

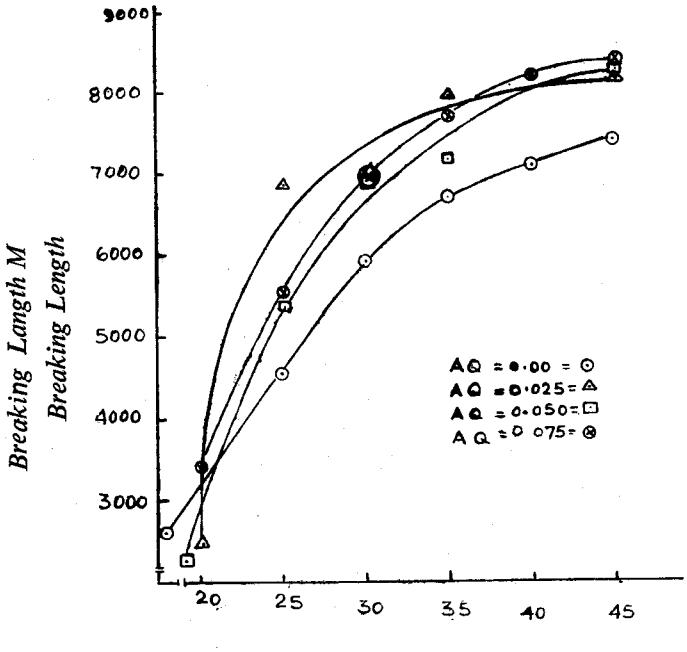

Fig. 14. Effect of °S R on Breaking Length of Different AQ Levels (AA 11%)

3. The physical properties i.e. burst strength, tensile strength, tear and double folds, of high yield anthraquinone pulps from E.tereticornis show substantial improvement. The burst factor increases by about 20–25% tear factor and breaking length by about 10–15% whihly double fold shows much higher improvement.

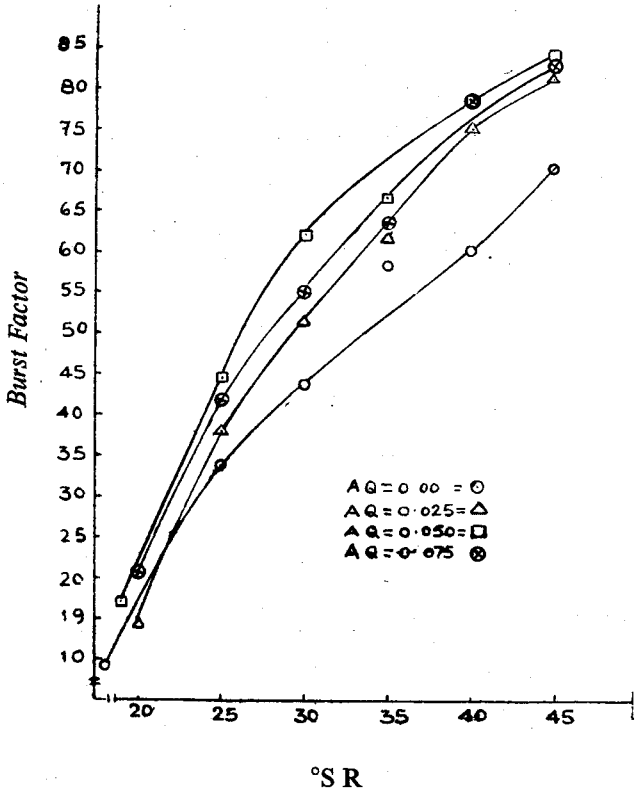

Fig. 15. Effect of °SR on Burst Foctor at Different AQ Levels (AA 11%)

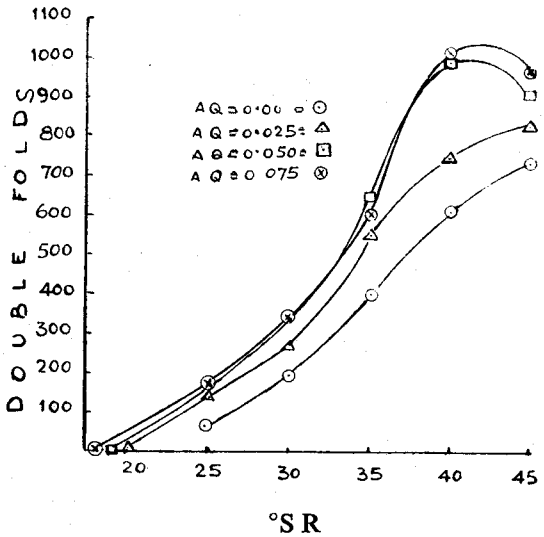

Fig. 16. Effect of °SR on Double Folds at Different AQ Levels (AA 11%)

4. The lower level of sulphidity required with AQ, would cut down the salt cake requirement and reduce the emission of malodourous sulphur compounds to the atmosphere. Lower sulphidity would also help in reducing the corrosion problem. However, effect of AQ on corrosiveness is yet to be as certained.

5. The use of AQ can help small pulp and paper mills which do not have the chemical recovery system. It might be possible for them to cut down the chemical consumption and reduce the pollutant load. Studies have revealed that the toxicity of effluent does

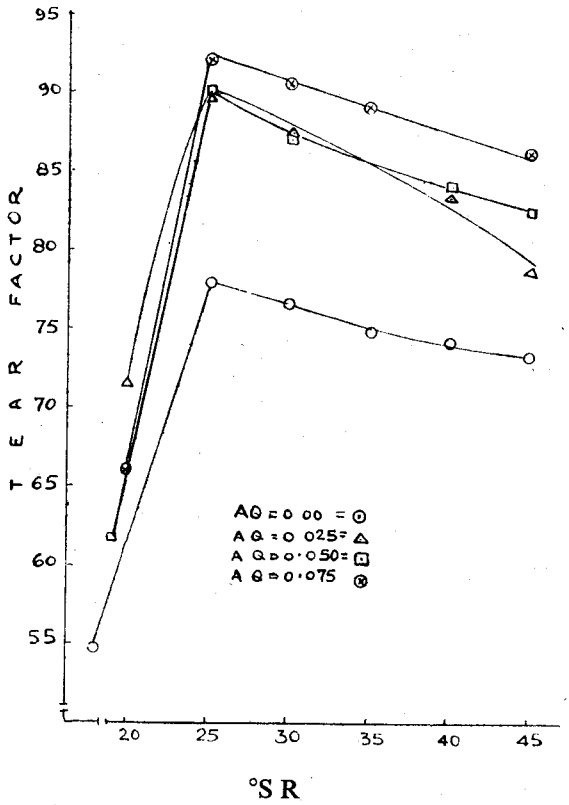

Fig. 17. Effect of °SR on Tear Factor at Different AQ Levels (AA 11%)

not alter noticeably with the use of AQ. It would be desirable to have exhaustive studies on AQ Soda pulping of straws, bagasse and other annual crop fibres.

6. The AQ additive pulping has remarkable advantages on yield and physical properties. The economics of the process appears excellent at present time. The relatively small amount of anthraquinone required for pulping could save the cost of chemical and will also help in better utilization of existing raw material.

TABLE—II

STRENGTH PROPERTIES OF UNBLEACHED PULP FROM KRAFT PULPING OF E. TERETICORNIS WITH ANTHRAQUINONE (AT 40° SR)

Cook No. (ref. Table—1)	Burst factor	Breaking length Metres	Stretch %	Tear factor —	Double folds Nos.
1	63.0	8474	3.5	70.80	340
2	69.8	8282	3.5	69.0	368
3	61.6	8130	3.5	68.0	221
4	60.20	7065	3.0	74.10	615
5	75.10	8026	4.0	83.52	654
6	78.62	8050	4.0	83.86	990
7	77.41	8195	4.5	85.05	1026
8	64.49	7123	3.2	72.19	433
9	79.00	8974	4.1	81.00	914
10	85.21	8866	4.0	86.88	1008
11	90.46	9781	4.5	87.17	982
12	66.90	7889	3.1	70.93	390
13	77.09	8826	4.2	79.57	681
14	81.71	8882	4.2	86.71	992
15	81.50	8950	4.5	86.93	970
16	67.87	8365	3.8	70.10	340
17	73.11	8723	4.0	77.51	614
18	79.52	8865	4.1	86.32	976
19	80.71	8937	4.1	85.71	970
20	82.36	8910	4.0	82.00	1037

ACKNOWLEDGEMENT

The authors are thankful to the management of Star Paper Mills Ltd., Saharanpur for according the necessary permission to present this paper.

REFERENCES

1. Holton, H., 'Pulp & Paper Canada', 78 (10) : 19 (1977)
2. Holton, H., Chapman, F., "Tappi" 60(11) : 121, (1977).
3. Ghosh, K.,Venkatesh, V., Chin, W., and Gratzl, J., 'Tappi' 60(11): 127, (1977).
4. Ruoho, K. and Sjostrom, E., 'Tappi' 61 (7), 87, 1978.
5. Zanella, E.F., Mckelyey, R.D., and Joyce, T.W., 'Tappi' 62 (2), 65, 1979.