Experience with State-of-the-Art Oxygen-ECF Bleaching of Bagasse Fibreline

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ABSTRACT

This paper highlights the experiences of Tamil Nadu Newsprint and Papers Limited and reviews the subsequent laboratory trials conducted on Oxygen bleaching followed by ECF bleaching. The start-up and commissioning experiences of the Oxygen-ECF fibre line for chemical bagasse pulp, at M/s Quena Newsprint Paper Company, Egypt, is also discussed to give an idea about the results obtained on a real time plant trial. A comparison of existing technology at TNPL has also been made. The constraints and realities have also been discussed.

INTRODUCTION

There has been considerable advancement in pulp and paper making technologies right from fibre preparation to paper finishing. The systems developed are not only energy efficient but also environmentally friendly and also guarantee improved pulp quality. Investing in advanced technologies always pays back. However, switching over to the newer technologies from the older ones warrants sufficient justification with regard to the need for change and return on investment. Bagasse, in addition to being eco-friendly by way of forest conservation, has been very much favourable towards reduced pollutant generation owing to its low kappa number pulp. In addition, Oxygen delignification as a further step yields a bagasse pulp of ultra low kappa number. This in turn results in exceptionally low pollutant generation with respect to colour, COD, TDS and AOX after short bleaching to 90% ISO. Oxygen prebleaching of bagasse chemical pulp gives us the easy approach to meet the stringent pollution standards to be met in the year to come. Our earlier studies (1) on these lines showed Oxygen delignification to be most attractive route to meet high quality pulp standars and the reduced pollution. Peroxide reinforcement in Oxygen delignification results in a still better pulp due to improved selectivity of peroxide. The only aspect withholding the plant scale implementation of Oxygen delignification is its capital cost.TNPL was associated with M/s Quena Newsprint Paper Company, QNPC, Egypt, in the start-up and commissioning of its 400 TPD bagasse based pulp and paper plant. The mill produces both Newsprint and Printing and Writing grades of paper on twin wire machine supplied by M/s Voith, Germany, at an operating speed of 1000m/min at 6.18m deckle width. The machine has been designed with the latest papermaking technological advancements such as Module jet dilution head box, Shoe press, online speed sizer and Soft nip calendar. The 250 TPD chemical bagasse pulping line incorporates a Pandia continuous digester, three stage brown stock washing with screen room in between, followed by Oxygen delignification. The bleaching sequence adopted is D-E(O)-D after Oxygen delignification to a target brightness of 88% ISO. The fibre line has been supplied by M/s Beloit corporation, (now taken over by M/s Lenzing Techniq, Austria). The entire mill operates through DCS, with advanced instrumentation controls. Our experience with chemical pulping and bleaching at QNPC, Egypt with reference to Oxygen delignification of bagasse pulp followed by ECF bleaching has been shared with reference to our earlier research publications and compared with the pulping and conventional CEH bleaching presently followed at TNPL.

RESULTS AND DISCUSSION

Oxygen delignification

Our earlier studies on laboratory scale Oxygen delignification of bagasse kraft pulp showed promising results with regard to improved pulp quality.

substantial reduction in pollutant generation, in comparison to the conventional CEH bleaching sequence (1). The preliminary Oxygen delignification step proved to be quite encouraging for any subsequent bleaching steps such as CEH, D-E(O)-D, single stage Hypo or Chlorine dioxide or TCF bleaching such as Peroxide bleaching. In all the cases the reduction in bleach chemical requirement was proportional to kappa reduction obtained. In addition, reduction in chlorinated organic matter showed significant reduction, making oxygen more attractive (1). The oxygen stage, as literature says (2), became an attractive economic alternative considering the reduction in pollution from subsequent bleaching. The results of our earlier laboratory studies are presented in Table 1.

Still, there are some schools of thought, whether Oxygen delignification is really needed or economical for bagasse pulp, which is easily pulpable to low kappa number of 9-10. Though there is absolutely no doubts regarding the pollutants generated, reaching incredibly low levels, the high capital investment, required for the Oxygen delignification, warrants sufficient justification. The Oxygen prebleaching reduces the subsequent bleach chemical demand and the savings should be substantial to show return on investment. The kappa number reduction, even when 50%, amounts only to 4-5 units drop in case of bagasse pulp. So the recurring cost for bleaching with and without Oxygen stage does not have a significant cost implication. However it has to be kept in mind that environmental benefits cannot be quantified and investment for environmental improvement should not be evaluated for return on investment. The replacement of Chlorine and hypochlorite in bleaching with other environmentally benign chemicals such as Chlorine dioxide, Oxygen and Peroxide is stressed due to the toxic chlorinated organic compound generated. Due to the pulp qulaity factors that suffer at high brightness levels, while bleaching with chlorine and hypochlorite, usage of Oxygen and chlorine dioxide have already gained popularity, as high brightness pulp is the requirement of the day.

Bleaching at QUENA Newsprint Paper Company

The mill started during November 2000, has incorporated O-D-E(O)-D bleaching sequence for bagasse kraft pulp. An effort has been made to compare the performance of the said sequence in comparison to the conventional CE_pH bleaching sequence presently followed at TNPL, Kagithapuram. Since the environmental benefits of Oxygen and ECF are already proven, our discussions have been restricted only to the bleaching aspects and pulp quality aspects. The evaluation has been made to justify the relevance of each stage in the bleaching sequence at QNPC in comparison to the conventional sequence at TNPL. However factors such as bagasse quality, mode of storage, extent of deterioration, climatic conditions do have an impact on the process, which of course need to be dealt with separately.

To briefly describe the process adopted for chemical pulping of bagasse, wet bulk stored bagasse, is reclaimed and it goes through a wet cleaning system to remove pith and debris and fed to a Pandia digester with a plug screw of 26 inches. Kraft pulping is followed and a kappa number of 10 is achieved. The

Table 1. Oxygen delignification of bagasse pulp - laboratory studies

	Unbld.	After O2	After OP	OCEH	OH	OD	O(P)-H	O(P)-P	O(P)-D	CEH
Kappa number	8.9	3.1	2.6							
Brightness % ISO	49.5	66.6	73.4	87.9	84.7	87.8	84.7	82.8	87.4	85.6
Viscosity	27.7	22.6	20.8	13.8	14.9	20.4	20.6	17.8	20.3	13.7
Freeness ml CSF	480	510	500	410	400	500	435	420	485	380
Bulk cc/g	1.53	1.48	1.46	1.4	1.47	1.43	1.45	1.41	1.37	1.4
Breaking length m	6340	5565	6500	5980	6390	5640	6430	6550	6565	6430
Tear factor	60.7	67.6	64.2	61.7	59.7	69.8	63	62.3	65.6	55.7
Burst factor	37.4	34.6	40.9	36.1	38.8	33.6	42.5	41.3	39.5	38.4
Pollutant reduction with respect to CEH sequence %										
Colour				94.0	100.0	98.5	100.0	100.0	98.7	
TDS				51.8	50.3	83.9	50.8	76.4	80.3	
COD				60.4	70.7	86.3	78.1	58.5	83.1	
AOX				81.0	53.5	92.4	72.9	100.0	92.6	

Table 2. Properties across pulping and bleaching

	TNPL	QNPC
Bleaching sequence	CE_pH	ODE_0D
Digester Feed Bagasse		
Moisture (%)	85.0	81.2
Useful fibre (%)	65.2	70.5
Pith (%)	26.6	22.0
Water solubles (%)	8.2	7.5
Fibre to pith ratio	2.47:1	3.20:1
White liquor		
TTA as Na_2O (gpl)	83.1	80.9
Sulphidity (%)	19.0	8.1
Kappa number		
Brown stock	10.7	10.0
O_2 stage	--	7.4
Extraction stage	2.3	1.8
Akali losses		
Brown stock washer (kg/t Na_2SO_4	12.2	60-80
O_2 washer (kg/t Na_2SO_5	--	10.5
Pulp brightness (% ISO)		
Unbleached	49.0	44.0
After Oxygen	--	52.0
After Chlorination/Dioxide	57.0	66.0
After extraction	66.0	73.0
Final bleached pulp	86.6	86.0
Weak black liquor		
Total solids (%)	9.2	6.9
TTA as Na_2O (gpl)	17.3	14.9
RAA as Na_2O (gpl)	5.95	5.30
Bleached pulp properties		
Freeness (ml CSF)	560	450
Bulk (cc/g)	1.41	1.49
Breaking length (m)	6470	6190
Tear factor	46.0	61.5
Burst factor	42.9	43.6
Scattering coefficient m^2/kg	27.7	32.9
Fibre classification		
+ 30 %	4.8	28.3
+ 50 %	25.8	19.4
+ 100 %	30.3	19.8
+ 200 %	12.5	15.1
- 200 %	26.6	17.4

active alkali charge is 11% as Na_2O and the sulphidity levels maintained is about 8-10%. The cooking time can be varied between 8 to 20 minutes. One of the advantages observed in the Pandia digester in comparison to TNPL Sunds defibrator continuous digester is the reverse inching facility for plug screw, to remove plug, screw jamming. The same is being incorporated in TNPL as well. The pulp blown to blow tank using cold blow technique undergoes three-stage counter current washing in drum washers with screening in between second and third washer. The filtrate from the Oxygen stage is used as spray in the third stock washer. Two primary pressure screens and one secondary screens have been provided and the secondary rejects are handled by a vibrating screen via sand cyclone. No centricleaners have been provided.

The pulp from the third washer directly goes to Oxygen reactor, an upflow tower of 22m height at 5-6 kg/cm² pressure. Medium consistency O_2 delignification is followed, with a retention time of 1 hour at 100°C. The Oxygen, pulp and alkali are mixed through a high shear mixer before entering the reactor. The pulp from Oxygen blow tank undergoes two stage washing before storage. The third stage washer filtrate is used as spray water. The pulp from storage tower, before entering the ECF bleaching undergoes the third stage washing with hot water. Three stage MC D-E(O)-D bleaching is followed. ClO_2 generated using $NaClO_3$, Methanol, Sulphuric acid is sbsorbed in cold water at 8°C and ClO_2, of 8-10 gpl obtained is used in bleaching. The pulp, ClO_2 steam and acid are mixed in a high shear mixer followed by an upflow tube and a down flow tower. Online brightness measurement and residual chlorine measurement controls the ClO_2 dosage to the pulp. In addition there is also a pH controller to control the acid flow. The D0 stage at 60°C for 1 hour is subsequently washed and extracted using alkali and Oxygen E(O), at $2 kg/cm^2 O_2$ pressure in upflow tube followed by a down flow tower of 1 hour retention at 75°C. The E(O) pulp after washing, has a brightness of 70-75% ISO and is bleached to 85-88% ISO with a Dioxide stage at 80°C for 4 hours. Here again there are pH, Brightness, Residual chlorine controllers at the inlet. The final washed pulp is treated with Na_2SO_3 to remove residual ClO_2 if any, present after washing. All bleach washers are connected to a scrubbing unit. The brown loop is closed from Oxygen washer 3. The bleach plant is also closed and only D0 stage effluent and partially E(O) stage effluent are drained. Other effluents are recycled.

Some of the unusual hiccups observed in the process could be attributed to excessive foaming in

Table 3. Pulp properties across the bleaching stages

Quena newsprint: O-D-E(O)-D				
Unbleached	After O2	Final D		
Kappa number 9.8	7.2			
Freeness ml CSF	450	490	430	
Bulk cc/g	1.58	1.60	1.50	
Breaking length m	6680	6320	6800	
Tear factor	57.4	60.7	59.4	
Burst factor	41.1	40.3	44.0	
Brightness % ISO	44.4	50.8	85.1	
Opacity (ptg) %	94.1	91.3	78.2	
Sc. coefficient m_2/kg	32.3	34.5	34.5	
Yellowness %	32.3	29.9	3.8	
TNPL C-E(P)-H				
	Unbleached	After C	After E(P)	Final Hypo
Kappa number	9.8		2.3	
Freeness ml CSF	510	500	480	480
Bulk cc/g	1.54	1.5	1.41	1.39
Breaking length m	6620	6480	6920	6750
Tear factor	56.1	55.1	53.6	47.1
Burst factor	38.6	41.2	44.1	42.2
Brightness % ISO	49.1	57.1	65.8	86.7
Opacity (ptg) %	90.8	89.0	82.4	74.7
Sc. coefficient m_2/kg	29.6	31.8	28.1	29.3
Yellowness %	33.1	25.0	19.5	4.2

screen room as screening has been provided in between brown stock washing. Also excessive foaming was observed in Oxygen stage washers also. This was because of nonavailability of foam breakers in filtrate chests of Oxygen washers and vent open to atmosphere. The problem was found to be severe during low ambient temperature. (as low as 4°C). Operationally not much difficulties or abnormalities could be observed with regard to the chemical bagasse pulp and the system could be stabilised very soon.

Comparative evaluation of QNPC and TNPL processes

The pulping and bleaching data average have been presented in Table-2. The data presented correspond to a continuous running period of 6 months during the commissioning and stabilisation. Comparative data with regard to TNPL also refers to the same period. The bagasse quality as decided by the fibre to pith ratio is better in QNPC, with fibre to pith ratio at 3.2:1 whlie the average fibre to pith ratio of TNPL bagasse is in the range of 2.5:1. This is one of the reasons for lower active alkali consumption of 11% Na_2O in QNPC as against 12.5% Na_2O in TNPL. The digester feed bagasse moisture is also lower as the wet cleaning system provides better dewatering of free water from washed bagasse. This anables better consistency after plug screw. The main advantage obtained here is not the better consistency but prevention of the acidic filtrate entering the digesting process along with bagasse which consumes chemicals (3). The white liquor sulphidity levels are low (8%) as the sulphidity levels in QNPC are maintained only with the Sodium Sulphate obtained as byproduct in the Chlorine dioxide generator, and no additional Sodium Sulphate is added. In TNPL however 20% sulphidity is maintained as the same liquor is used for pulping of hardwood also.

The kappa number of pulp obtained is in the order of 10 both the mills, in spite of lower chemical charge and lower sulphidity at QNPC. The shive content of pulp at QNPC, before screening is in the order of 5-9% while after screening the shive content was as low as 0.5%. This was the case when 0.15 mm slotted screen was used in secondary screen. Whenever the reject quantity was higher, the 0.15mm slot screen could not handle the rejects and this necessitated change of screen with 1.6mm perforations. This ultimately resulted in shive content in screened pulp to about 1.2%. Under these conditions, increasing the unbleached kappa number to 14, as per design, could not be implemented as the rejects quantity could not be handled even as the kappa no. reached to 11.5

The brown stock washing performance could not be compared with that of TNPL as Oxygen stage filtrate was used as spray in Brown stock washer 3 in QNPC. The carried over alkali levels in washer 3 pulp, was in the order of 60-80 kg/t as against 12-15 kg/t as Na_2SO_4 in TNPL. The high amount of carry over chemicals increased the Oxygen consumtion in O_2 delignification. It is to be pointed out that for effective Oxygen delignification, the washing losses should be minimum (< 10 kg/t) which is normally achieved by a twin roll press. This was not the case in QNPC. The high carryover can primarily be attributed to the high alkalinity of oxygen stage filtrate and foaming problems encountered in Oxygen stage washing. There were occasional problems with spray water temperature in Oxygen washer 3, which also created washing problems creating problems in the entire brown stock washing and Oxygen washing street. Also the washing efficiency of drum washers is limited, compared to the advanced washing technologies such as belt washers, twin roll washers and presses. This poor washing did definitely have a bearing on the subsequent Oxygen delignification stage. The average kappa number obtained after the Oxygen stage at QNPC was 7.4, which amounted to a decrease of 26% only as against the desired level of 50%. The reasons for the poor response in the Oxygen delignification are:

The sulphidity levels maintained are more close to soda pulping. The sulphidity levels are very low. The role of sulphidity in kraft pulping is two fold. On one hand it promotes and accelerates the clevage of ether linkages in phenolic units aiding the fragmentation of the lignin macromolecules to soluble entities (4). On the other hand it reduces the extent of undèsirable condensation reaction, which results in lignin that are difficult to remove in subsequent Oxygen delignification.

The alkali carryover into the Oxygen stage is very high of the order of 60-80 kg/t as Na_2SO_4. Carryover of black liquor from cooking stage affects both alkali and Oxygen consumption, because of the competing reactions between the pulp lignin and dissolved material in the liquor (5). This lowers the delignification rate. Carryover that is counter currently circulated from the post oxygen washer to Oxygen stage consumes less Oxygen than black liquor carried over from cooking. Also, already oxidised dissolved materials lowers the pH in the Oxygen stage which increases the need for alkali in the reactor. This can lower the delignification rate though it has almost no effect on pulp viscosity (5). In order to obtain maximum benefits from an Oxygen delignification process, and to avoid excessive degradation,adequate upstream washing is required (6). In addition to its effect on selectivity and delignification rate, the carryover to the Oxygen stage also affects the final bleaching. Problems encountered in washing due to low drainage characteristics of bagasse pulp, as discussed earlier, include foam carryover and hot water temperature fluctuations.This has been the main reason for the low kappa reduction across Oxygen delignification.

The properties of pulp at different stages, across bleaching, in QNPC has been provided in Table 3. A comparison of properties across bleaching in TNPL has also been included. The results indicate no significant drop in properties across Oxygen delignification. The strength properties of Oxygen bleached and conventionally bleached pulps are equivalent if the degree of delgnification in the Oxygen stage does not exceed about 50% (2).

ECF bleaching vs conventional C-E(P)-H

The results in Table 2 compares the properties of ECF bleached bagasse pulp with conventional chlorine bleached pulp. The ECF bleached pulp, as envisaged, shows better tear (61.5 as against 51.0) with conventional CE_pH, higher bulk and lower bonding properties. The scattering coefficient is also better. However, comparing the properties of the pulps in Table 3, it may be seen that the unbleached pulp properties are similar and in bleached pulp, the tear factor is significantly higher in case of ECF bleaching. It is quite evident that hypochlorite bleaching severely damages the pulp resulting in lower tear factor. So also the bulk also shows improvement with ECF and the corresponding scattering coefficient. No change in tensile or burst is observed. Brightness levels of 89-90% ISO could be obtained on a continuous basis at QNPC with ECF bleaching without drop in properties which is not possible in TNPL with CE_pH bleaching.

From the results it is very clear that ECF bleaching, as envisaged, results in a better bleached pulp properties, without degradation during bleaching. Also in the ECF the probability of strength loss is only in E(O) stage while in CE_pH, the strength drop can occur at any or all the stages, when conditions are not properly maintained. The brightness stability is better with ECF.

The fibre classification pattern shown in Table 1 shows a significant difference in the +30 fraction and the -200 fines fraction in QNPC pulp, which can be referred back to the original bagasse structure. A significant aspect to be considered with respect to bleaching controls in QNPC is that all bleach chemicals, steam etc are rate based controls. This ensured optimum chemical dosage without wastage ensuring uniform final quality at any desired rate. The controls for pH, temperature, residual chlorine, brightness, pressure linked through DCS and stage wise rate controls helped in fast stabilisation of the plant. Problems in bleaching were encountered only during the poor performance of Oxygen stage or poor washing of final Oxygen washer, when the E(O) kappa number exceeded 2.5. One problem observed with the ECF bleaching was the low pH of pulp obtained at final D stage. This necessitated addition of Na_2SO_3 and NaOH for neutralisation. The low pH of pulp posed problems for alum dosage in paper machine for sizing, as the pulp pH was already on the lower side. So from the figures provided in tables, it is quite evident that ECF surely results in better pulp for the same unbleached pulp. The pollution aspects need no discussion as it is a proven fact that Oxygen and ECF results in considerable pollutant reduction.

CONCLUSION

State of the art Oxygen ECF bleaching of chemical bagasse at QNPC shows better pulp properties, especially tearing strength and bursting strength, compared to conventional CE_pH bleaching at TNPL. The Oxygen delignification at QNPC does not ensure 50% delignification, reasons attributed being poor washing efficiency resulting in high black liquor carry over. This affects the selectivity as well as delignification rate. The low sulphidity is also one of the reasons which results in more condensed lignin. The effect of low sulphidity can be overcome by addition of anthraquinone. Improving Oxygen delignification will help QNPC a long way in reducing ClO_2 demand for bleaching, which at present is on the higher side.

The changeover to Oxygen delignification followed by ECF or only ECF from conventional bleaching needs thorough evaluation with regard to pulp properties vis a vis running cost. Oxygen definitely reduces the running cost. But the initial investment for Oxygen stage makes it less attractive with respect to bagasse pulp bleaching, when environmental aspects are not considered.

The low initial kappa number of unbleached pulp of bagasse, even with conventional CE_pH bleaching does not pose any environment related problems, such as AOX generation exceeding the stipulated levels. However, ECF bleaching is definitely warranted for significantly improved pulp properties, which have a bearing on the paper properties with regard to strength and permanency. With the thrust for high bright paper products, consistent high bright pulp without strength drop can be achieved only through ECF and conventional CE_pH surely produces a degraded pulp at high brightness levels. It is quite obvious that improved bleached pulp obtained through ECF route will definitely improve the machine runnability, though the increase may not be proportionate to the strength improvement. The experience at QNPC are in line with our earlier research publications on ECF and Oxygen delignification of bagasse pulp with regard to pulp properties.

ACKNOWLEDGEMENT

The authors thank the Management of TNPL for granting permission to publish the experiences at QNPC, Egypt in IPPTA Journal.

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