Bagasse Bleaching-Parameters Optimization Pay

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ABSTRACT: *Process parameters optimization is the tool which provides the optimum utilization of the resources subjected to most desirable outputs. The paper highlights the necessity of optimization of parameters connected with the widely accepted multistage bleaching sequence CEH (Chlorination - Extraction - Hypochlorite) for bagasse pulp in the developing countries like India. The parameteric effects on colour reversion, degradation of pulp and its quality provide guidelines for optimal utilisation of resources.*

About Rs. 31 Lakh can be saved on chemicals through the bleaching parameters optimization in a 60 T P D mill. Further, reduced chemical requirement & maximum chemical utilisation in successive stages will result in lesser water pollution from bleaching section.

Normally, Total chlorine requirement is estimated by multiplying kappa number to a factor 0.23, however, it should be derived for particular specie of raw materials. In the present study, this factor is determined to be 0.195.

INTRODUCTION

The main objectives in a bleaching operation are minimum colour reversion, minimum residual chemical, optimum brightness, yield and strength of paper with of course low cost of bleaching process. These objectives are closely interrelated with each other and depend on four crucial input parameters viz. amount of bleach chemicals, pH, time and temperature of reaction mixture. Therefore, these control variables are optimized with respect to commonly used operating conditions for widely used bleaching sequence CEH and further, the validity of optimization is evaluated through economic analysis.

EXPERIMENTAL PROCEDURE

The bagasse collected from a nearby sugar mill was dry depithed manually followed by wet depithing in hydrapulper. Dried bagasse retained on 30 mesh was used for pulping. The proximate analysis of bagasse as given in Table-1, was evaluated as per TAPPI procedures.

Table-1.

Proximate Analysis of Depithed Bagasse

Sl.No.		Ingradients	Value (%)
1.		Ash	1.9
2.		Silica	0.6
3.		Solubilities in	
	a.	Hot water	16.8
	b.	1% NaOH	45.3
	c.	Alcohol-Benzene	10.2
4.		Pentosan content	24.6
5.		Holo-Cellulose	62.4
6.		Lignin	20.2

(On Oven dry basis)

Pulping

Bagasse was digested chemically with 12% NaOH, employing 1:5 solid to liquid ratio at the maximum

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cooking temperature of 433 K (160°C). The reaction time to and at maximum temperature were 100 and 90 minutes respectively. Cooking under these conditions yielded 50% unbleached screened washed pulp with an average kappa number value of 51 and pulp brightness of 20.7% ISO.

During experimentations, kappa number of the pulp was found to be relatively high for all the three sets of cooking which may be due to the fact that the raw material, bagasse used for chemical pulping was not fresh and was lying under ambient conditions for a substantial period of time (more than four months). The adverse effects of bagasse storage on the quality of pulp are well known.

Studies carried out by Reddy et al. [IPPTA, Vol.3 (3) 1991, pp. 32-40] on storage of bagasse indicate that, the stored bagasse undergoes discoloration and deterioration, but the darkening is not uniform throughout the pile. The surface layers are found to be affected the most, followed by middle and bottom innermost layers. Top layers bagasse (even in 15 days sunlight exposure) may result a pulp of very high kappa number (as high as 85) and very low brightness (as low as 15%), whereas, fresh bagasse gives a kappa number and brightness of the order of 14-18 and 40% respectively, under similar pulping conditions. Low brightness (20.7%) of the pulp and proximate analysis of the raw maetrial used in the present study further support the fact that, the bagasse was not fresh and had undergone discoloration and deterioration.

However, it may argued that the layers in the bagasse pile may be mixed up prior to pulping to get uniform kappa number pulp. Yes, it is possible to arrange the experiments according to your convenience at the laboratory scale but in real life situation, where bagasse pile is of the order of 10-12 m or even more, such mixing may not be practically / economically feasible at all. Under such circumtances, there bound to be a gradient in the quality of pulp and hence, kappa number along the depth of the pile. The only possible solution to the problem is to avoid direct exposure of sunlight or do not store it for longer durations.

But looking into the seasonal availability of bagasse and its essential storage, it becomes even more important to evaluate and optimise pulping and bleaching conditions for best possible outputs.

Bleaching

Based on the pulp Kappa number, the multistage bleaching experiments were planned by varying one of the parameters in a particular stage at a time, keeping the others unchanged. Conventionally, as a rule of thumb, total Chlorine requirement in CEH bleaching of pulps is estimated by multiplying kappa number by a factor of 0.23, which needs careful evaluation and verification otherwise may lead in loss of chemicals and enhance pollution load in the liquid stream. Therefore, experiments were planned to optimise the following parameters in the bleaching of bagasse soda pulp.

- chlorine application and reaction time at C stage
- alkali application and reaction temperature at E stage
- hypochlorite application, reaction temperature and time H stage

The operational conditions of CEH bleaching sequence are indicated in Table-2. During chlorination stage, due to non availability of gaseous Cl_2, hypochlorite bleach liquor was used under highly acidic (pH 2) conditions to facilitate elemental Cl_2.

Table-2.

Applied Conditions in CEH Bleaching

Stage	Cy. %	Temp. K	Time min.	Chemical %	pH
C	4	299	60	6.0	2
E	10	338	60	4.0	11
H	8	311-313	180	6.0	9

The experiments were carried out in bleach bottles, kept in thermostatically controlled bath where required parametric conditions were maintained. The liquors were titrated Iodometrically to determine residual chlorine. Parameters mentioned above were altered one by one. Hand sheets were made on British Sheet Former and the brightness was evaluated on ELREPHO BRIGHTNESS TESTER. Post Colour Number (PCN) was also determined as per TAPPI standards.

RESULTS

Based on experimental observations, graphical methods are employed to examine the effect of different parameters on bleaching to seek the optimum values. The optimized bleaching parameters fulfilling the bleaching objectives are presented in Table-3.

Table-3.

Optimized Conditions of CEH Bleaching

Stage	Cy. %	Temp. K	Time min.	Chemical %	pH
C	4	299	52	6.6	2
E	10	336	60	3.4	11
H	8	311	140	3.3	9

Economic Analysis

Since, bleached pulp yield is found to be unaffected in the process of optimization, the parameters considered in economic analysis are the chemical application at each stage of bleaching and the reaction time at C & H stages, whereas, the reaction temperature is found to be the same of operating conditions. Therefore, the formulation of economic analysis is restricted to saving in chemical requirement only. Further, reduction in total time requirement for bleaching operation means an increase in production with same capacity reactors. The size of the reactors can be reduced in a plant at commissioning stage or in an existing plant more bleached pulp can be produced. Staepwise calculations are presented in Table 4. Difference between the operating and optimized conditions of CEH bleaching are shown graphically through Figs 1 & 2.

Table-4.

Economic Analysis

BASIS: One MT unbleached pulp

Bleached pulp yield with optimized conditions,%	=	61.3
Total Cl_2 applied in conventional operation,%	=	12.0
Total Cl_2 consumed with optimized conditions, %	=	9.9
Net saving in Cl_2, %	=	2.1
Total Cl_2 saved, kg/ton	=	21.0
Saving in Chlorine, Rs./ ton unbld. pulp (@ Rs. 2000 per ton)	=	42.0
NaOH consumed in conventional operation,%	=	4.0
NaOH consumed with optimized conditions,%	=	3.4
Net saving in NaOH,%	=	0.6
Total NaOH saved, kg/ton	=	6.0
Saving in NaOH, Rs./ton unbleached pulp (@ Rs. 9000 per ton)	=	54.0
Net saving in chemicals, Rs./ton unbld. pulp	=	96.0
Net total saving, Rs./ton of bleached pulp	=	156.5
Total time required, min	=	300
Total time required with optimized conditions, min	=	252
Total time saved, min	=	48
Increase in production, %	=	16
Annual installed capacity, TPY	=	20000
Net saving in bleaching chemicals per annum (Lakh Rs.)	**=**	**31.3**

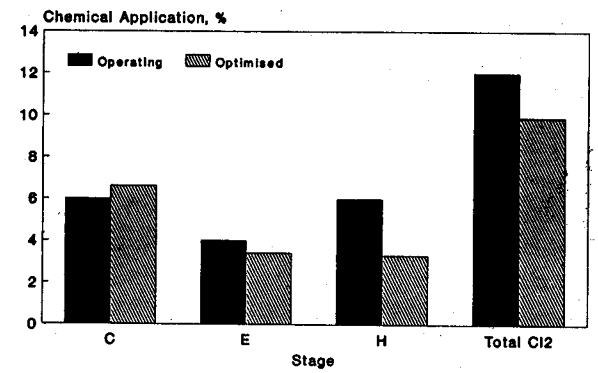

Fig 1 Chemical Requirement in CEH Bleaching Operation

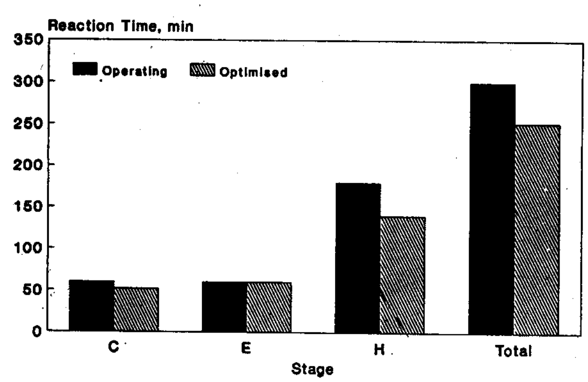

Fig 2 Reaction Time Requirement in CEH Bleaching Operation

CONCLUSIONS

Based on the detailed experimental studies on the bleaching of bagasse pulp and on economical analysis, the following conclusions are drawn:

In CEH bleaching of bagasse pulp, The most likelyhood optimum chemical applications are; 6.6% as available Cl_2, 3.4% alkali and 3.3% as available chlorine in C E H stages respectively. Time factors for C & H stages are 52 minutes and 140 minutes, while, temperatures for E & H stages are 336-338 K and 311 K respectively. The above stipulated conditions are found to predict the best bleaching objectives with improved economy.

Approximately, 17.5% Cl_2, 15% NaOH and 16% time can be saved if optimized conditions are adopted, leading to saving of about Rs. 156 per ton of bleached pulp. For a 60 TPD bagasse based plant nearly Rs. 31 lakh can be saved annually. Saving in chemicals will not only reduce the cost of bleaching operation but also pollution loads from this section will be reduced significantly. In addition, about 16% more bleached pulp can be produced with the existing units.

Present study suggests that the conventional method of quick estimation of chemical requirements should be based on the extensive experimental observations for different raw materials. Total Cl_2 requirement for bleaching of bagasse pulp can be obtained by multiplying Kappa number by a factor of 0.195 instead of 0.23. About 67% of the total available Cl_2 should be used at C stage, while rest 33% at H stage.

The above data will be extremely useful for practising engineers to produce bagasse based pulp and paper conforming to the desired qualities. Further, it is suggested that before employing any bleaching raw materials and for different composition of pulps having different kappa numbers, to ensure minimum chemical residual, optimum bleached pulp yield & brightness, minimum colour reversion and lower cost of bleaching operation.

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NOTATIONS

The following notations are used in the paper:

- C - Chlorination
- E - Extraction
- H - Hypochlorite
- Cy. - Consistency, %
- Temp. - Temperature, K
- TPD - Tons per day