Studies on Dyeing of Jute Pulp to Make Coloured Paper

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Abstract

The agro-wastes of Jute viz. Jute caddis, jute feshwa, jute root cuttings etc. are good sources of cellulose to make different grades of paper and paper board. Sometimes, it is necessary to dye the jute pulp to make the paper more attractive to the users. In general, the paper industry uses three types of soluble dyes viz. basic, acid and direct which are added to the pulp slurry with uniform mixing followed by the size and alum addition in the beater. Now-a-days the use of natural dyes instead of the synthetic ones has been emphasized due to environmental reasons. Attempts have, therefore, been made to select and apply suitable synthetic/ natural dyes for imparting colour to jute pulp to make paper by handmade process. The correlation of the different optical properties viz. whiteness, yellowness and brightness indices of bleached and dyed pulp with the cooking chemicals has been studied to optimize the alkali concentration of the pulping of jute wastes.

INTRODUCTION

Due to the shortage of conventional paper making raw materials in our country such as wood and bamboo, agro-wastes of jute viz. Jute caddies, Jute feshwa, Jute root cuttings etc. have been utilized as alternative raw-material to make different grades of paper and paper board. Sometimes, it is necessary to dye the jute pulp in different colours to make the paper more attractive to the users.

In industry, paper is generally dyed to impart colour, but even undyed paper appears coloured e.g. corrugated boxes and unbleached kraft wrapping are generally not dyed; the typical brown colour is the natural shade of the unbleached kraft. Paper board made from old newspapers has a characteristic gray appearance. On the other hand, most white papers appear colourless but are readily tinted with dyes or coloured pigments to maintain a specific shade of white. Today, an increasing amount of paper e.g. fine paper; tissue paper etc. is dyed to impart a desired shade. Dyeing of the paper is thus an integral part of the manufacturing operation in these paper mills.

The materials used to colour paper fall into two classes; soluble dyes and pigments. In general, the paper industry limits to the use of three types of soluble dyes viz basic, acid and direct. The dye colours the individual pulp fibres which make up the finished sheet of paper. Three principal methods are used; the most important of these is stock dyeing or beater dyeing. Other methods include surface colouring with dyes at the size press and by coating. The procedure used for dyeing paper is generally governed by the type of paper being made and the end use requirements of the sheet. Frequently, a compromise involving pulps, fillers, sizing, shade requirements, brightness, fastness and cost must be made to produce the desired results. At first, dyes are added to the pulp slurry with uniform mixing followed by the size and alum addition in the beater.

In this paper, attempts have been made to select and apply suitable synthetic/natural dyes for imparting colour to jute pulp and to standardize the process technology to make different coloured papers in an economic way by handmade process. Chemi-mechanical pulp from jute waste were prepared treating the raw material with different alkali concentrations, bleaching of the pulp in different stages using sodium hypochlorite solution, beating and dyeing of the bleached pulps with synthetic/natural dyes to make paper sheets followed by evaluating the optical properties viz. whiteness, yellowness and brightness indices etc. of the dyed pulp that indirectly optimize the alkali concentration of pulping of jute wastes.

EXPERIMENTAL

Material and Methods

Materials

Fibre sample : During processing of jute in the jute mills there are wastages of short unspinable

fibres at different stages that are called jute caddies. This was used for pulping trials.

Chemicals

Pulping chemicals : Caustic soda solution of different concentrations. Bleaching chemicals, Sodium hypochlorite solution. Dyeing chemicals: Chlorantine Fast Tarquish Blue GLL conc., a direct dye as well as a natural dye extracted from the bark of garan tree, Botanical name-Ceriops tagal (perr.) Roxb. Mordanting chemical : Aluminium sulphate.

Methods

Pulping of jute waste was done by boiling the raw material with caustic soda solutions of different concentrations (viz. 0.0%, 2.5%, 50%,10.0% and 25%) at atmospheric pressure in an open digester. Beating of the pulps were done by using a P.F.I. Mill (Model no. 337, designed by Norwegian Pulp and Paper Research Institute) at 3000 rpm. Residual lignin content of respective pulps were determined by TAPPI Standard methods. Bleaching of the pulp was conducted by treating with sodium hypochlorite solution under suitable conditions in single or double stages. Dyeing of the bleached pulps were done by using a direct dye as well as a natural dye extracted from the bark of gram tree and the process includes pretreatment of pulp with a mordant, extraction of natural dye from bark of garan tree followed by dyeing of mordanted pulp with extracted dye. Extraction of dye from bark of Garan is very simple. Bark is first cut into small pieces. Then grinding of the bark is done in a grinding machine, where setting is done in such a way that it produces fine powder. The powder is soaked in soft water and then boiled for four hours. The dye constituents present in the bark is transferred to the aqueous solution during boiling operation. Thereafter dye solutions were filtered twice and preserved separately for application on to jute pulp. Different optical properties of the dyed pulp viz. whiteness, yellowness, brightness indices etc. were evaluated by using a computer colour matching system-Spectrascan-5100 (R).

RESULTS AND DISCUSSION

Production of coloured handmade paper from jute, needs dyeing of the pulp before making paper sheets. Jute fibre was treated with alkali of different concentrations (0%, 2.5%, 5%, 10% and 15%) for pulping. The yield and residual lignin content of the pulp were evaluated and tabulated in Table-1. It is found from the Table-1, that the yield decreases with increase in chemical concentration. As more and more lignin is removed with increase in cooking chemical concentration, the residual lignin in the pulp decreases.

Beating of the pulp was done by a PFI mill at 3000 rpm. Paper sheets were made from a portion of the pulp. Another portion was bleached by sodium hypochlorite solutions by single stage and two stage methods with intermediate alkali treatment. Paper sheets were made from all the bleached pulps. The papers thus produced were evaluated for whiteness index, yellowness index and brightness index by using computer-aided colour matching system. The results have been tabulated in Table-2 It is clear from the table that the whiteness index and brightness index decrease steadily with increase in the concentration of alkali during cooking while yellowness index increases. Bleaching of alkali cooked pulp shows that initially there is a tendency of decrease in whiteness index and brightness index with increase in cooking chemical concentration but with further increase in concentration of alkali whiteness index and brightness index increases after bleaching. The whiteness index and brightness index reach maximum in case of 15% caustic concentration during cooking. It is obvious that whiteness index and brightness index is on higher side after second bleach compared to first bleached samples.

Bleached pulp produced by either of the method were dyed by two different dyestuff like one synthetic and one natural. The paper sheets were produced from the dyed pulps. All the paper

Table 1. Treatment of jute wastes

Chemicals on o.d. jute waste (%)	Yield (%)	Lignin (%)
0.0 (i.e. only water boiled)	74.70	13.61
2.5	71.92	13.01
5.0	65.98	12.70
10.0	63.59	11.68
15.0	61.95	10.70

sheets were tested in the computer aided colour matching system. The results have been tabulated in Tables 3 and 4.

Table 3 shows the effect of cooking chemical on dye uptake with chlorantine Fast Tarquish Blue GLL conc., a direct dye. It is clear from the table that K/S value increases with increase in cooking chemical concentration during pulping. In most of the cases it is found that dye uptake is more in case of double bleached samples compared to that of the dye uptake in case of their corresponding single bleached pulp.

All the pulps have been dyed with natural dye extracted from the bark of gran tree. The process of dyeing includes pretreatment of pulp with mordant (mainly Aluminium Sulphate treatment), then extraction of natural dye from bark of garan tree followed by dyeing of mordanted pulp with extracted dye. The pulp is dyed and then beaten in PFI Mill at 3000 rpm and paper is made by handmade process. The shade imparted to the dyed handsheet is brown in colour with λmax of 430 nm. The same trend is found in case of natural colour dyed pulp also as is evident from table 4. In most of the dyed sample, it is seen that dye uptake is more in case of single bleached pulp than their corresponding double bleached pulp. Pulp produced by 15% cooking chemicals and subsequently bleached showed highest dye uptake and double bleached sample produced maximum dye uptake as K/S value is maximum in this case.

CONCLUSION

Yield of the pulp as well as residual lignin decreases with increase in cooking chemical concentration. Whiteness index and brightness index of the pulp decrease with increase in cooking chemical concentration. Bleaching of the corresponding pulp shows that initially there is a fall in whiteness index and brightness index of the pulp with increase in alkali concentration during pulping but further increase in cooking chemical concentration has a positive effect on bleaching as the pulp cooked with 15% chemical produces very high whiteness index and brightness index after bleaching. Pulp can be dyed with synthetic colour with bright shades if the cooking of the pulp is done with 10% or more chemical and further bleached with sodium hypochlorite. Brown coloured handmade paper can be produced

Table 2. Effect of cooking on the optical properties of bleached jute pulp

Sample	Whiteness Index (Hunter)	Yellowness Index (Astmda925)	Brightness Index (Tappi45)
0% Alkali	57.69	36.93	28.27
0% Alkali + 1st bleach	63.51	43.76	32.65
0% Alkali + 2nd bleach	65.73	34.51	37.08
2.5% Alkali	51.13	37.61	22.34
2.5% Alkali + Ist bleach	63.01	41.34	34.42
2.5% Alkali + 2nd bleach	67.82	43.53	37.10
5% Alkali	49.43	48.18	19.95
5% Alkali + 1st bleach	59.54	45.50	29.10
5% Alkali + 2nd bleach	66.01	45.45	34.91
10% Alkali	50.20	44.74	20.33
10% Alkali + 1st bleach	56.78	44.10	25.88
10% Alkali + 2nd bleach	64.57	43.85	33.51
15% Alkali	46.12	48.20	16.91
15% Alkali + 1st bleach	64.62	44.23	33.49
15% Alkali + 2nd bleach	70.56	41.38	40.04

Table 3. Effect of cooking chemical concentration on dyeing behaviour of jute pulp with direct dye

Sample	λmax	K/S value	RFL	% Strength
0% Alkali + 1st bleach & dyed paper	680	2.14	16.35	100.00
0% Alkali + 2nd bleach & dyed paper	680	2.48	14.68	115.40
2.5% Alkali + Ist bleach & dyed paper	680	2.33	15.37	72.40
2.5% Alkali + 2nd bleach & dyed paper	680	3.22	12.02	100.00
5% Alkali + 1st bleach & dyed paper	680	3.09	12.42	144.24
5% Alkali + 2nd bleach & dyed paper	680	2.82	13.31	131.83
10% Alkali + 1st bleach & dyed paper	680	3.36	11.62	156.99
10% Alkali + 2nd bleach & dyed paper	680	3.78	10.59	176.44
15% Alkali + 1st bleach & dyed paper	680	4.04	10.02	188.82
15% Alkali + 2nd bleach & dyed paper	680	4.03	10.05	188.09

if well cooked and bleached pulp is dyed with natural dyes extracted from bark of garan tree. The process of bleaching and dyeing of the pulp is very simple and can be adopted by handmade paper industries for the production of coloured and decorative papers from jute.

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Table 4. Effect of cooking chemical concentration on dyeing behaviour of jute pulp with natural dyestuff

Sample	λmax	K/S value	RFL	% Strength
0% Raw	430	1.80	18.48	100.00
0% + 1st bleach	430	2.15	16.29	119.65
0% + 2nd bleach	430	1.72	19.03	95.82
2.5% Raw	430	2.60	14.17	100.00
2.5% + 1st bleach	430	2.45	14.83	94.05
2.5% + 2nd bleach	430	2.32	15.43	89.14
5% Raw	430	2.86	13.19	100.00
5% + 1st bleach	430	2.17	16.18	76.05
5% + 2nd bleach	430	1.79	18.53	62.71
10% Raw	430	2.60	14.17	100.00
10% + 1st bleach	430	2.26	15.71	87.04
10% + 2nd bleach	430	1.97	17.37	75.62
15% Raw	430	1.99	17.24	100.00
15% + 1st bleach	430	2.42	14.93	121.97
15% + 2nd bleach	430	3.21	12.03	161.82