Environment Friendly Pulping Of Jute

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ABSTRACT

Jute is an annually renewable lignocellulosic fibre. During the processing of this fibre in jute mills, a large amount of fibre wastes are produced. These waste jute fibres together with old gunny bag fibres and low quality jute fibre can be used as an alternative raw material for small scale pulp and paper mills, which are dependent on scarce raw materials like hosiery cutting and cotton rag.

In order to find an environment friendly pulping process which gives pulp having strength as high as kraft pulp and can be bleached easily, permitting the application of TCF sequences, pulping of jute fibre was carried out by ASAM process (Alkaline sulphite anthraquinone methanol cooking) and compared with alkaline sulphite and kraft pulping of jute fibre. The pulps obtained were bleached with hydrogen peroxide and standard handsheets were made and strength and optical properties were evaluated. The sheets were then subjected to accelerated ageing tests for four days and post color factors were determined to evaluate the colour reversion. It was observed that compared to kraft pulp ASAM pulp of jute fibre gave pulp of higher yield, better strength and better optical properties.

Introduction

India has about 450 handmade paper units scattered all over India which are mainly based on cotton rags & hosiery cuttings producing nearly 50,000 tonnes of handmade paper& board having a turnover of Rs 250 crores (1,2). Whereas the total quantity of paper produced is quiet significant with a total production of nearly 70 lakh tonnes per annum. The per capita consumption of paper and paper board has increased from 4.5 Kg in the year 2010 to 8.0 Kg in the recent past(2). This has created a big gap between the projected demand and the present production of handmade paper which can be reduced by introducing alternative ligno-cellulosic raw material like jute.

Jute is an annual plant which grows to the tune of about 1.5 million tons and this leaves a jute stick yield of about 3 million tons (3). Jute can be used as an alternative raw material if we can produce speciality paper from jute. The pulp and paper industry is under constant pressure to reduce and modify environmental emission to air and water. In order to keep up with the increasing demand for pulp and paper and to meet increasing stringent environment regulations, the industry is looking towards technological improvements in the conventional pulping methods.

The aim of the present work is to study the effect of different methods of pulping and compare the strength properties of the different papers produced from them. Three different processes used are kraft, alkaline sulphite and ASAM pulping these were followed by conventional peroxide bleaching to get bleached paper. The paper samples were then subjected to ageing following the method developed by Preservation Research & Testing Division, Library of Congress, USA. The samples were evaluated for their optical and physical properties before and after ageing. The optical properties included whiteness index, brightness index, post color number etc. whereas, the physical properties included tensile index, fold number, burst index, kappa number and pH value of the paper samples.

Also since the small scale paper and pulp units try to avoid high pressure digester, the three pulping processes were carried out at 120^0 C also.

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Materials And Methods:

Raw material

Jute fibre of low quality was cut into 2-4 cm pieces and used for pulping.

Alkaline sulphite pulp of jute (ASP)

Jute pulp was prepared by alkaline sulphite pulping process in a rotary digester at 13% Na_2SO_3 and 3 % NaOH, using 1: 10 liquor ratio, at 160^0 and 120 for 2 hour, yield was 75-78 %.

Kraft Pulp of Jute (KP)

The jute samples were digested in a rotary digester at 20 % NaOH (and 25 % Na_2S as sulphidity) at 1: 10 liquor ratio, at 160^0 and 120^0 for 2 hour after rise of temperature.

ASAM pulping of Jute(ASAM)

The jute samples were digested in a rotary digester at (12.9%) Na_2SO_3, 3% NaOH, (0.01%) AQ at 1:10 material to liquor ratio having 15 % MeOH, at Temp 160^0 and 120^0 for 2 hrs.

Bleaching of jute pulp

A portion of the unbleached pulp was bleached in a covered vessel using H_2O_2 (20 ml/l) at 1:20 material to liquor ratio, trisodium phosphate (5 g/l), NaOH (1g/l), sodium silicate ((10g/l) and on-ionic detergent (2g/l) for 1.5 h at 85-90^0 C. The pH was maintained at around 10. The bleached pulp was washed in normal water and neutralized with dilute acetic acid (2 g/l) and was given a final wash with water for further processing.

Standard hand sheets

Standard hand sheets of 60 GSM were made from all the three types of pulp i.e., bleached, unbleached after beating them in a Valley Beater to about 40^0SR freeness, using UEC hand sheet former.

Accelerated Ageing

All the paper samples i.e., two bleached paper samples and the two dyed paper samples were sealed in air tight containers and subjected to accelerated ageing in an oven at 100^0 C following the method adopted by at Preservation Research & Testing Division, Library of Congress, Washington DC, USA (4) .

Evaluation of Physical Properties

Tensile Index was determined by Tappi Test Method T 404 om-87, Bursting Index was determined by Tappi Test Method T 403 om-85 and Folding endurance of paper (Schopper type) was determined by Tappi Test Method T 423 0m-89, Tearing Strength by Tappi Test Method T 414 om-88 (5). The instruments used were Tensile Strength Tester Veb Thuringer Industriewerk, Raunstein (Germany), Double Fold Tester,UEC,Saharanpur, Bursting Strength Tester by UEC,Saharanpur and Tearing Strength Teater by UEC,Saharanpur.

Evaluation of Optical Properties

Optical properties of the paper samples before and after subjecting them to accelerated ageing were evaluated for Whiteness Index E 313(D65/10) and Post color number in HunterLab Lab Scan XE Brightness tester.

Post color Number = 100x ($K/S_{\text{After Ageing}}$ $K/S_{\text{BeforeAgeing}}$)

K= Co-efficient of absorption,

S= Co-efficient of scattering

Results And Discussion:

The kraft process is the dominant wood pulping process (6) throughout the world. It is the most economic pulping process, gives the best strength properties. The draw backs are the obnoxious odour associated with even the most advanced mills, to be economical production capacity of 1000 tons per day or more is required, thus huge capital investment is required. The possibility of kraft smelt explosion prevents Tomlinson type recovery furnace as a result of safety factor. Residual lignin in kraft unbleached pulp is resistant to non-chlorine bleaching agents to achieve requisite whiteness. Use of chlorine, chlorine dioxide and chlorine containing chemicals cause environmental pollution. For this reason there is renewed interest in recent years to find alternatives to the kraft system that will yield pulp with kraft like strength properties, but without environmental drawbacks.

In the ASAM process carbohydrate dissolution rate is lower than that of lignin. This is due to lower alkalinity and the presence of methanol and anthraquinone which protects the carbohydrate. The dissolution of xylan does not exceed 30%, whereas, upto 80% of glucomannan is dissolved in ASAM cook of pine. The protection of the carbohydrate in the ASAM liquor results in a very high pulp viscosities (6).

Reactions with lignin using ^{14}C labelled methanol showed that about 99 % of the charged methanol can be recovered, only 1 % remains in the pulp. It can be assumed that in commercialscale operation, the ASAM process will be self-sufficient in regard to methanol (6).

The solubility of anthraquinone in presence of alkali is limited. This is the reason that during the heating phase of a cook, only a certain percentage of the charged anthraquinone can be analyzed. But when the cook reached its maximum temperature, all anthraquinone gets dissolved and then starts to decompose. At the end of the cook 20 % of the initial charge can be analyzed (6).

The high selectivity of the ASAM process results in approximately 10 % higher yield in soft wood pulp compared to kraft process. In hardwood pulping this yield advantage is less evident (6). The selectivity of the process allows delignification to a very low kappa numbers without degradation of the pulp (6).

The strength properties of ASAM pulps are superior to those of any kraft pulp. This is corroborated by the ASAM pulp made from jute vide Table 1 & 2. The high tensile strengths, which are based on the good bonding ability of the fibres, are mainly the result of the high hemicellulose content of these pulps. The ASAM process yields the highest hemicelluloses content in the outer cell wall layers, which are the primary (P) and outer secondary wall (S_1). The high tear strength of ASAM pulps is probably due to the smother pulping conditions, leaving the carbohydrates at a high degree of polymerization (6).

The high hemicelluloses content of ASAM pulps improves beatability. The strength development starts very quickly, meaning that beating can be stopped at low degrees, which saves energy and improves porosity and draining of the paper sheet (6).

Black liquor evaporation and methanol recovery:

As discussed ASAM process does not require additional methanol. Methanol can be recovered directly from the digester and /or from the black liquor.

The ASAM black liquor is easy to concentrate to high dry-solid content. The viscosity of ASAM black liquor is lower than that of kraft black liquor, because of low molecular weight of lignosulphonates and their high degree of sulphonation.

Bleaching of ASAM pulps:

The excellent bleachability of ASAM pulps is another advantage of the

Table 1
COMPARATIVE STUDY OF DIFFERENT PULPING METHODS FOLLOWED BY CONVENTIONAL PEROXIDE BLEACHING

Sl. No.	Pulp	Yield % (after digestion)	Fold No.	Tensile Index Nm/g	Burst Index KPa.m^2/g	Tear Index mN.m^2/g	Brightness 457nm	Post color No. 4 days
1.	Kraft-CPP	57.2	33	40.24	2.50	12.0	59.73	56
2.	ASP-CPP	63.6	71	46.86	2.76	14.0	65.65	29
3.	ASAM-CPP	63.0	43	41.42	2.66	14.0	63.22	34

Kraft-Kraft process, ASP-Alkaline sulphite process, ASAM- Alkaline sulphite anthraquinone methanol process, CPP- Conventional peroxide process

Table 2
COMPARATIVE STUDY OF DIFFERENT PULPING METHODS

Sample	Yield (%)	Folding	Tensile index Nm/g	Burst index KPam^2/g	Tear index mNm^2/g
Kraft 120	72.4	138	50.13	2.92	13.33
ASP 120	73.3	150	63.10	3.87	12.63
ASAM 120	80.23	350	80.65	5.33	17.67

Na_2S = Kraft process, ASP=Alkaline Sulphite pulping process
ASAM= Alkaline sulphite anthraquinone methanol process

ASAM process. Although in the present work peroxide bleaching was carried out. It has been observed that TCF bleaching of ASAM process is competitive to ECF bleaching, from an economical as well as technological point of view. The final brightness as well as the strength properties of the beached pulps are excellent.

A comparative study of pulping of jute by different pulping processes viz., alkaline, kraft, alkaline sulphite and ASAM process was carried out which were followed by bleaching by conventional peroxide process. Standard hand sheets were made and evaluation of the strength properties and optical properties were carried out before and after accelerated ageing for four days. As small scale industries of capacity 100-300 Kg per day generally try to avoid high pressure digesters, pulping was carried out at 120^0 C also.

It was observed from Table 1 that bleached ASAM paper from jute gave better yield, and strength properties viz. fold number, tensile index, burst index and tear index, similarly optical properties of the bleached ASAM paper from jute showed better brightness index and post colour number. The bleached alkaline sulphite paper showed the best result among the three samples. Table 2 reveals that when the pulping was carried out at a lower temperature of 120^0C the best results were obtained in the case of the ASAM paper from jute compared to the kraft and alkaline sulphite paper.

Conclusion:

- Paper made by ASAM process at 120^0 C gives paper of better yield and strength properties compared to kraft and alkaline sulphite process paper from jute
- Bleached ASAM paper is better than bleached kraft paper from jute
- Bleached Alkaline sulphite paper from jute is better than bleached ASAM paper from jute.
- The ASAM process is environment friendly as no obnoxious smell is emitted after cooking.
- The process saves energy as it improves beating due to high hemicelluloses in the pulp.
- The excellent bleachability is another advantage.
- ASAM black liquor is easy to concentrate to a high dry-solid content lignosulphonates which is of high demand as surface active agent.

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