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Discarded Gunny Bags-- A Promising Raw Material for Paper-Making

Preliminary experiments show that old discarded gunny bags can be very well used for the manufacture of paper grade pulp. In view of high yield of pulp,gunny bags would be an economical raw material. It is emphasized that this raw material would be very useful for those small scale units which have limited machinery and equipment.

Introduction

Gunny bags become unfit for packing after repeated use. So far, such discarded gunny bags have not been utilized for any useful purpose on a large scale. Though, thin cords and ropes are reported being made on cottage industry scale, but since the strength of these cords and ropes is very low, this sort of industry does not seem to have much scope for expansion. Discarded gunny bags can be easily procured in the same way as waste paper is procured and collected.

Gunny bags are made mainly from jute and jute type fibers. The jute fibers of commerce come from outer portion of the stem of Corchorus Olitorius, Corchorus Capsularis and Hibiscus cannabinus plants[1]. The fiber layers, which are (in number) 13-17 in C. Olitorius and 17-19 in C.Capsularis (popularly known as jute plants), consists of a number of fiber bundles or groups varying greatly in shape and size. Each of these bundles represents a single filaments which is thus seen to be composite in character being made up of a number 4-50 of cells as seen in a cross section. In the plant, these bundles or strends are held in position by the intervenning soft tissues viz, rays, sieves. tubes, phloem parenchyma, etc. During retting (wetting of jute plant in water) these intervenning tissues disintegrate and the fiber bundles become separated.

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The chemical and physical characteristics of the jute fibres beg patronization as a potential raw material for the manufacture of paper-pulp. The fiber characteristics[2,3] are summarized below :

The fiber cells vary from 500 to 600μ in length and from 10 to 13μ in diam. The walls are thick and lignified. The lumen and cell cavity is as wide as the cell wall. Each fiber bundle contains 8 to 20 individual or ultimate fibers, each of which is a single plant cell. Each fiber cell is a polygonal in cross section and has a small, more or less circular lumen. The average measurements of a single cell are :

1.	Cross sectional area (total)	118.0μ
2.	Cross sectional area of cell wall	108.9μ
3.	Cross sectional area of lumen	9.0μ
4.	Total area occupied by lumen	7.5%
5.	Length of fiber	2.4mm
6	Width (filar micrometer)	10.0μ

The cell wall has a fibrillar structure, the fibrils being arranged in slow right handed spirals. When examined by X-Ray spectrographic methods, jute fibers give a typical cellulose diagram. The cellulose chains are more or less parallel to the axis of the fibrils and hence lie at a small angle to the fiber axis. The degree of micellar orientation is about 35%. The jute fibers show a fairly high degree of.

double refraction corresponding with its quasicrystalline nature, due to the more or less parallel arrangement of cellulose chain molecules. The breaking extension of single jute fiber strend is generally below 2%. The density of B.D. jute fibers, as determined in benzene is 1.42. The material as small cut pieces of gunny bags is called "Hessian".

Chemical composition

The main constituents of the fiber are: cellulose, hemicelluloses and lignin The percentage of true cellulose, does not exceed 60% in the O.D. fiber, but the percentage of holocellulose usually exceeds 80%. In addition, the fiber contains fat, nitrogenous and colouring matters, waxes and minerals together with cuticular and corky material. Clean fiber contains little or no tannin or pectin.

Average composition of jute fibers is as under :

True cellulose,	%	56-60
Hemicelluloses,	%	22-26
Lignin,	%	11-12
Nitrogenous matter,	%	1-1.5
Fats and waxes	%	0.8-1.2
Ash,	%	1-1.5
Miscellaneous,	%	1.5-2.5

Since gunny bags are made from Jute type fiber, it was rightly thought that discarded bags may prove to be suitable for paper-making. In conducting trials to find out their suitability for paper-making the following points were kept in mind :

1. Maximum pulp for paper-making should be obtained.
2. Pulping process snould not be very elaborate as is the case with usual raw materials like bamboo and hardwoods, so that the process may also be employed by small units which do not have elaborate pulping equipment.
3. The cost of chemicals used for pulping should be kept to be minimum.

Experiments

Object of having maximum pulp can be attained if discarded bags are pulped without using any cooking chemicals as is the case with mechanical pulp from wood. For this purpose three different samples of discarded gunny bags were selected for trial by their look as superior, medium and inferior grade. They were cut into small pieces by a sharp hand wood chopper (Gandasi) and were separately given one pass through 12" disc laboratory Sprout Waldron refiner at 50 Thou and at 4% consistency without intial cooking. The yield of pulp at this stage was about 95%. This pulp was then beaten in laboratory Valley beater (Valley Iron Works Co. U.S.A.) to a freeness of 35° SR. Test sheets of 60 g/m^2 were made on laboratory sheet-making machine (The British Paper & Board Makers Association, London) and tested for strength properties as per standard method. The results are given in table No. 2 under the columns of uncooked pulp.

The strength properties of sheets made from pulp obtained without initial cooking of the discarded gunny bags, did not seem promising. Therefore, a second portion of the above three samples was separately cooked to see how far the strength properties can be improved by cooking, consistent with the idea of high yield of the pulp. Cooking conditions (shown in table no. 1) were according to the optimum found as for cook no. 4 in table no. 3.

Table No. 1

Cooking conditions	
Sodium Hydroxide on b.d. hessian	3.0 %
Sodium carbonate on b.d. hessian	3.0 %
Hessian to liquor ratio	1 : 4
Temperature raising time	75 mts.
Maximum temperature	130° C
Time at maximum temperature	180 mts.
Relieving time	15 mts.

Cooked hessian samples, like uncooked, were also given one pass through Sprout Waldron Disc refiner and beaten to 35° SR in Laboratory Valley Beater as in previous experiments. The results are given in table no. 2 under columns of cooked pulp.

TABLE NO. 2

Properties of cooked & uncooked hessian

Quality of Hessian	Cooked/ uncooked pulp	Unbleached pulp yield %	Initial freeness after refining °SR	Beating Time (To attain 35°SR freeness) mts.	Physical strength properties at 35° SR: Breaking length m	Burst Factor	Tear Factor
1. Superior	uncooked	95	10°	81	1875	10.8	35
	cooked	78.4	11°	32	5100	39.3	86
2. Medium	uncooked	93	10°	65	1615	10.0	31
	cooked	75.6	11°	28	4580	34.0	84
3. Inferior	uncooked	92	11°	48	1500	9.0	30
	cooked	71.0	13°	19	4210	30.0	80

The above results show that cooked hessian pulp is better than uncooked one as regards to strength properties of paper. Therefore, hessian should be used after cooking only.

In order to obtain a high yield of cooked pulp three sets of cooking were done with the following cooking materials :

1. Mixture of lime and sodium carbonate.
2. Mixture of sodium hydroxide and sodium carbonate.
3. Sodium hydroxide only.

Cooking was done at 130°C, 140°C and 150°C with each set of chemicals, keeping other variables the same for all the cooks. Cooking conditions are given in table no. 3.

Cooked material was given one

TABLE NO. 3
Cooking conditions and properties of pulp and paper

Cook No.	Cooking chemicals on o. d. hessian%: Sodium Hydroxide	Sodium carbonate	Lime as $Ca(OH)_2$	Hessian to liquor ratio	Cooking conditions: Temp. raising time mts.	Maximum °C	Time at max. temp. mts.	Relieving time mts.	Unbleached pulp yield %	Initial freeness after refining °SR	Beating time to attain 35°SR freeness mts.	Physical strength properties at 35°SR: Breaking length m	Burst Factor	Tear Factor
1.	6.0	—	—	1:4	75	130	180	15	75.7	12	35	4240	40.7	68.6
2.	6.0	—	—	1:4	75	140	180	15	72.5	12	32	3840	40.8	67.6
3.	6.0	—	—	1:4	75	150	180	15	70.3	13	30	3755	35.0	71.6
4.	3.0	3.0	—	1:4	75	130	180	15	77.8	12	33	3950	37.0	69.3
5.	3.0	3.0	—	1:4	75	140	180	15	75.2	13	30	4055	37.3	63.5
6.	3.0	3.0	—	1:4	75	150	180	15	72.8	11	34	4445	40.7	67.6
7.	—	5.0	10.0	1:4	75	130	180	15	76.5	12	35	3195	28.4	68.9
8.	—	5.0	10.0	1:4	75	140	180	15	72.8	12	37	3030	30.0	67.5
9.	—	5.0	10.0	1:4	75	150	180	15	71.0	14	29	3590	34.9	72.7

pass through Sprout Waldron Disc Refiner and then beaten to 35° SR in laboratory Valley beater, noting the initial freeness and time taken to attain freeness of 35° SR. Results of strength propeities are given in table no. 3.

From view point of economics and strength properties of hessian paper, the optimum conditions of cooking seem to be as for cook no 4 in table no. 3.

Encourged with the results of cooked hessian pulp, a thorough study of hessian pulping was taken up. Therefore, a few tonnes of old discarded gunny bags were procured for studies. The stock consisted of gunny bags that had been used in packing of all sorts of materials such as wheat, cement, fertilizers and other chemicals. These bags were, therefore, extremely dirty and cleaning of which became a necessary first step This was done on mill scale in the Rag Plant of the factory. The following processing was done ;

Processing of gunny bags

1. Dedusting : Dedusting or removal of dust from the gunny bags was done in dry state in a Dedusting machine. The dust fell down under the machine.
2. Cutting : The cleaned bags were fed to a cutter where they were cut into small pieces. The remaining dust from the deduster got off along with some lose fibers and was blown off the machine and collected elsewhere.
3. Digestion : When cooking was desired, the cut pieces were digested in rotary spherical digesters.
4. Beating : Cooked hessian was beaten in beaters of the factory, with gradually increasing load. Washing of pulp was also done in the beater during beating itself.

The beaten pulp was stored in a stock chest from where it was taken for paper-making in the factory.

From the previous results it may be seen that paper from hessian pulp exhibits quite good strength properties, and thus hessian impresses one as a very good paper-making material. But since hessian cannot be treated as a main pulp because of its limited availability, this material can only be used as a blending material with other main pulps in order to make them cheaper, giving paper with better strength properties. The natural colour of hessian very well matches with the kraft pulp, so it would not create any colour problem if mixed with kraft pulp. In flutting media, the colour of pulp is of minor importance, so it can be used with waste paper pulp for flutting media without any serious problem.

With these ideas in mind, it was thought worthwhile to study whether it could be used as a blend with waste paper, for using as a liner in corrugated board. For this purpose hessian, cooked with NaOH and Na_2CO_3 at 130°C was mixed with waste paper pulp in different proportions. Cooking conditions and test results are given in table no. 4 and shown fig. no. 1.

It was found that by addition of even 20% hessian pulp to waste paper pulp, paper of improved strength properties can be made.

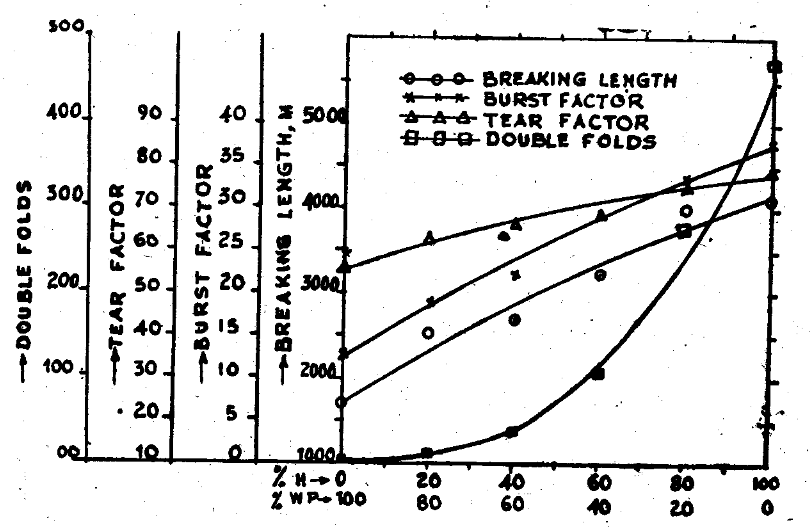

FIG.1 EFFECT ON STRENGTH PROPERTIES OF PAPER BY BLENDING HESSIAN PULP WITH WASTE PAPER PULP

TABLE NO. 4

Strength properties of paper made from the mixture of hessian pulp and waste paper pulp.

Cooking condition :

Hessian : liquor ratio	1:4	Freeness of hessian pulp	35° SR
Concentration of cooking NaOH)	0.75	Freeness of waste paper pulp	38° SR
liquor, % .... Na_2CO_3)	0.75		
Maximnm temperature °C	130		
Temp. raising time, min.	75		
Duration at max. temp. min.	180		
Yield of pulp, %	76		

Sl.No.	FURNISH Hessian pulp %	FURNISH Waste paper pulp %	Breaking length m	Burst Factor	Tear Factor	Double fold	Variations from those of paper made from waste paper pulp, %: Breaking length	Burst Factor	Tear Factor	Double fold
1.	100	nil	4110	38	78	470	+142	+200	+42	+11650
2.	80	20	4000	34.3	75	275	+135	+170	+36	+ 6775
3.	60	40	3230	28.8	68.6	105	+ 90	+127	+25	+ 2525
4.	40	60	2670	22.1	65.6	34	+ 57	+ 74	+19	+ 750
5.	20	80	2515	18.7	62.5	9	+ 48	+ 47	+14	+ 125
6.	nil	100	1700	12.7	55	4	zero	zero	zero	zero

Blending of hessian pulp with mixture of unbleached bamboo & salai wood pulp :

Hessian was cooked under the conditions as per cook no. 4 in table no. 3 and then after refining as usual, was beaten to 35° SR. Mixture of bamboo and salai wood pulp (routine pulp) obtained from the factory was also beaten to 35° SR. Test sheets were made after mixing the two beaten pulps in different proportions. The results are given in table no. 5 and shown in figs. nos. 2, 3, 4 and 5.

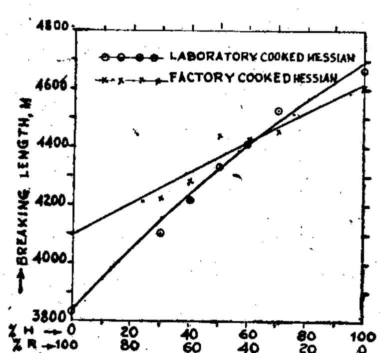

FIG. 2 EFFECT ON BREAKING LENGTH OF PAPER BY BLENDING HESSIAN PULP WITH ROUTINE PULP

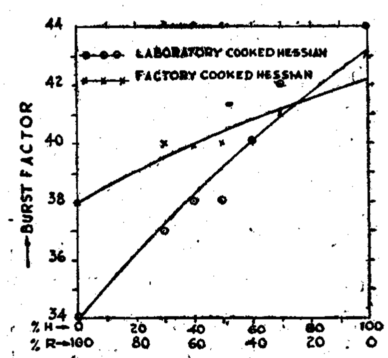

FIG. 3 EFFECT ON BURST FACTOR OF PAPER BY BLENDING HESSIAN PULP WITH ROUTINE PULP

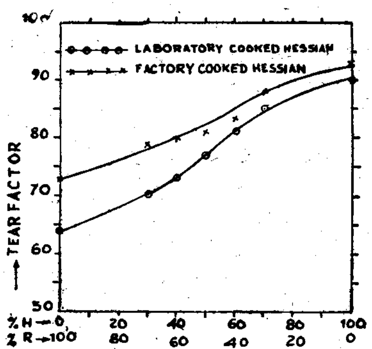

FIG. 4 EFFECT ON TEAR FACTOR OF PAPER BY BLENDING HESSIAN PULP WITH ROUTINE PULP

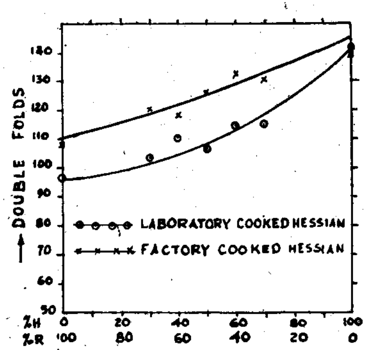

FIG. 5 EFFECT ON FOLDING ENDURANCE OF PAPER BY BLENDING HESSIAN PULP WITH ROUTINE PULP

The results indicate that hessian can be very well used as a blending pulp to get paper of improved strength properties. To confirm the laboratory results in practice factory trials were also made.

Factory trial

Old gunny bags were processed in the Rag Plant of the factory and then cooked in rotary digest-

TABLE NO. 5

Strength properties of paper made from hessian, and of hessian blended with routine pulp.*

Cooking condition :

Hessian : liquor ratio	1:4	Freeness of hessian pulp	35° SR
Cancentration of cooking) NaOH	0.75	Freeness of reutine pulp	36° SR
liquor,% ... ...) Na_2CO_3	0.75		
Maximum temperature °C	130		
Temp. raising time, min.	75		
Duration of max. temp. min.	180		
Yield of pulp, %	76		

Sl.No.	FURNISH Hessian plup %	FURNISH Routine pulp %	Breaking length m	Burst Factor	Tear Factor	Double fold	Variations from those of paper made from routine pulp, % Breaking length	Burst Factor	Tear Factor	Double fold
1.	100	nil	4660	44	90	141	+22	+29	+48	+47
2.	70	30	4520	42	85	115	+18	+23	+39	+20
3.	60	40	4405	41	81	114	+15	+21	+31	+19
4.	50	50	4330	38	77	106	+13	+12	+24	+10
5.	40	60	4215	38	73	110	+10	+12	+17	+15
6.	30	70	4100	37	70	103	+ 7	+ 9	+11	+ 7
7.	nil	100	3830	44	64	96	zero	zero	zero	zero

*Routine pulp : A mixed pulp of bamboo and salai obtained from factory.

ers of 8- m^3 capacity. The cooking conditions were maintained as in the laboratory digestion. Maximum temperature was 130°C. Cooked hessian was then beaten in the factory beaters and half stuff thus prepared was then again beaten in the laboratory to 35° SR. This pulp was blended with factory's bamboo-salai mixed pulp (routine pulp) which had been beaten separately to 35° SR as well in the laboratory. Test sheets were then prepared. The results are given in table no. 6 and shown in fig. nos. 2, 3, 4 and 5.

The results are found to agree closely with those of laboratory experiments and so the conclusion drawn seems correct.

General remarks and conclusions

From economics point of view, hessian is a very good raw material for paper grade pulp, because of the following merits over bamboo or wood.

1. Hessian gives pulp of reasonable strength properties at a high percentage of yield. In the present crisis for raw materials, this high yielding hessian would be a great help to paper industry.

2. Because of higher yield of pulp from hessian than from bamboo or wood, it becomes a cheaper source of pulp.

3. Cooking of hessian is easier and cheaper because of lesser chemical consumption and lower cooking temperature in comparison to sulphate pulping of bamboo or wood.

4. Initial costs, such as that of raw material (Rs. 300/ton) and of processing (dedusting and cutting) of gunny bags are lower than that of bamboo or wood and its chipping with respect to power consumption in huge installations of heavy equipments in chipper house.

5. The processed or unprocessed hessian can be stored in a much smallar space after packing by a bailing machine than chips could be stored.

Table No. 6

Strength properties of paper made from hessian, and hessian blended with routine pulp.*

(Hessian cooked in the factory)

S. No.	Furnish: Hessian pulp %	Furnish: Routine pulp %	Breaking length m	Burst Factor	Tear Factor	Double fold	Variations from those of paper made from routine pulp, %: Breaking length	Burst Factor	Tear Factor	Double fold
1.	100	nil	4600	43	93	139	+15	+12	+27	+28
2.	70	30	4450	41	88	130	+8·5	+ 8	+21	+20
3.	60	40	4420	40	83	132	+8·0	+ 5	+14	+22
4.	50	50	4440	40	81	126	+8·0	+ 5	+11	+ 7
5.	40	60	4280	39	80	118	+4·0	+ 3	+10	+ 9
6.	30	70	4220	40	79	120	+30	+ 5	+ 8	+11
7.	nil	100	4100	38	73	108	zero	zero	zero	zero

*Routine pulp : A mixed pulp of bamboo and salai obtained from factory.

This increases the storage capacity or lesser space would be required for storing hessian than wood and chips. The space factor is of great importance for small scale industries.

6. Hessian would be a boon to the small scale paper industry because it needs a low pressure (2·8 kg/cm² or 40 Psi) digester at lower cooking temperature 130°C as compared to kraft pulping of bamboo, at (7 kg/cm² or 100 Psi) pressure in the digester and higher temperature (165°C). Also since small scale factories generally do not make fine and sophisticated papers, which need pulp of high quality, hessian would be very suitable for them.
7. Old discarded gunny bags can be very well used as a substitute of bamboo pulp for paper making. It can be mixed with bamboo pulp in any desired proportion without hampering the strength properties of paper made, which in some cases may be better, depending upon the quality of gunny bags used.
8. It can also be mixed with waste paper pulp to get improved strength properties than made from only waste paper. A slight variation in results of different sets is due to non-uniformity of quality of the old gunny bags in different trials.

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