Studies on Development of Kraft Paper Form Wheat Straw, Sugarcane Bagasse, Gunny Bags and Imported ONP, OCC and NDLKCC Waste Paper

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Kraft paper is a highly specialized paper of high mechanical strength and exclusively used for the manufacture of packaging and wrapping paper. The strength properties like, tensile strength i.e. both wet and dry, tearing strength and bursting strength are the most important. This paper requires long fiber furnish to impart high mechanical strength. In Asian continent, where soft-wood fibers are in short supply; the long fibers were obtained from gunny bags, imported ONP (Old News Paper), OCC (Old Corrugated Containers) and NDLKCC (New Double Lined Kraft Corrugated Cuttings) are the cheapest source of long fibers. The blending of waste papers pulp with agro-based residues in an appropriate blending ratio may add to the mechanical strength of the kraft paper of desired specification. The present study aims at developing of kraft papers of grade-I and grade-II from agro-based residues and waste papers and has been compared with the values of BIS.

Keywords: Wheat straw,bagasse,NDLKCC,ONP, OCC,soda pulping,stock preparation,kraft paper,mechanical strength

INTRODUCTION

Kraft paper is highly specialized paper used for the purpose of packaging and wrapping. The strength properties are the most important. With the exception of the need to be able to resist compression loads, particularly the same measurement are required for kraft paper as for liner boards. The kraft paper for packaging purposes is exposed to great stress. The function of the packaging is to protect goods during transport and storage and in many cases it must also provide a surface for the presentation of printed information about the contents. Many different types of loading occur involving e.g. compression forces and bending moments. The bending may be both static and dynamic, and in addition it often occurs under varying climate conditions, which means that paper for packaging purposes is an extremely qualified product. Paper for packaging is therefore optimized in the first place to obtain high functional strength. The packaging must however act both to protect and advertise the goods and the later need often makes very high demands on the printability of the material. Some function-related strength properties are however specific to this type of paper like, tear strength, tensile strength and bursting strength[1]. Tear resistance characterizes the toughness of packaging papers where the ability to absorb shocks is essential[2]. Tensile strength is indicative of the strength derived from factors such as fiber strength, and bonding and it is important for those paper grades where they are subjected to a simple and direct tensile stress. Bursting strength is used as a measure of resistance to rupture[3].

Indian pulp and paper industries are facing many problems, like dearth of good quality of wood fibers, increasing pressure to control environmental pollution and ecological conservation, which has compelled the pulp and paper industry to think seriously for their survival. The inadequate supply of low-cost fiber has also compelled the Indian pulp and paper industry to spend heavily on imported long wood fiber each year. If India cannot overcome its lack of domestic wood fiber as well as revamp and improve its end products to match imports, then the Indian pulp and paper industry will stagnant and decline. The shortfall of domestic wood fiber can also be solved up to a certain extent by using some of the potentially available non-woody fibrous plants, i.e., both agro-based residues and other non-conventional raw materials. Another source for long fibers is the recycling of imported

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waste paper[4]. It not only provides long fibers to impart mechanical strength but helps to conserve environment.

Present study aims at development of kraft paper of grade-I and II respectively from agro-based residues like, wheat straw and bagasse and waste papers like, ONP, OCC and NDLKCC.

EXPERIMENTAL METHODOLOGY

Pulping of Wood Chips and NDLKCC - Wheat straw, bagasse and gunny bags were digested separately with 8.0 per cent active alkali, (as such), liquor to wood ratio 5:1, max cooking temp 160°C, time to max temp 90 min and time at max cooking time 60 min in electrically heated WEVERK rotary digester of capacity 0.02 m^3. ONP, OCC and NDLKCC were soaked in warm water and digested at 4 per cent alkali dose as such at max cooking temperature 165°C, time to max temp 60 min, time at temp 90 min, bath ratio 1:5 and max digester pressure 6.5 kg/cm^2 in WEVERK rotary digester. The results are reported in Table 1 and 2.

Beating, and stock preparation - The pulps were beaten separately in WEVERK make laboratory beater to a beating level of 40°SR. Various wet end additives like, Ivax (fortified rosin) 10 kg/t, alum (ferric) 65 kg/t of pulp, sulphuric acid 5 kg/t of pulp, 12 kg/t of melamine formaldehyde, gum 3 kg/t of pulp and cartaflex (defoamer) 0.5 kg/t of pulp were added in to the pulp of selected blends.

Blending and sheet making Wheat straw and bagasse pulps were blended with gunny bags, ONP, OCC and NDLKCC pulps in different ratios as shown in tables 3-7. Laboratory hand-sheets of 60 g/m^2 were prepared on British sheet forming machine. These hand-sheets were air dried, conditioned and tested as per BIS specifications and compared with the values specified in BIS 1397-1997: Kraft paper. The results are reported in Table 1-10.

RESULT AND DISCUSSIONS

Table 1 reveals the cooking conditions and results of wheat straw, bagasse and gunny bags. Wheat straw, bagasse and gunny bags are cooked at active alkali dose of 8.0 per cent (as such), liquor to wood ratio 5:1, max cooking temp 160°C, max cooking time 60 min and produce screened pulp yield pulp of 56.6, 57.2 and 70.3 per cent at kappa number of 42, 50 and 70 respectively. All the three pulps were beaten to 40 °SR and evaluated for mechanical strength properties like tear, tensile and burst indexes. The mechanical strength of wheat straw and bagasse is very poor. Therefore, it is necessary to blend these pulps with gunny bags in suitable blend ratio in order to develop kraft paper.

Table 2 reveals the cooking conditions and results of NDLKCC, ONP and OCC. It is known that NDLIC pulp is principally used for manufacturing of fluting for corrugated medium. High elastic modulus is the most important property for the development of fluting medium. High stress/strain ratio can be achieved by using softwood furnish. In India, softwood fibers are scarcely available. Therefore, NDLKCC furnish can be considered a good source of long fibers. The long fibred pulp is blended with wheat straw and bagasse pulps to improve mechanical strength to manufacture kraft paper. Since the kappa number of NDLKCC is very high, i.e., about 75, therefore, it is necessary to bring down kappa number. Wet strength resins and rosin size is added in to the pulp furnish to improve cross-linking and hydrophobic character in fluting medium paper. These chemicals interfere to processing of NDLKCC, hence, it is essential to remove these chemicals prior to pulping. Treatment with HCl at pH 3.5 was employed to remove resinous materials before pulping. An alkali dose of 4 per cent produces screened pulp yield 64.4 at kappa number of 26.0. Alkali further removes resinous materials and also brings down kappa number of the pulp. The screened pulp yield of ONP and OCC are 82.3 and 66.8 per cent respectively at an alkali dose of 4 per cent, liquor to wood ratio 5:1, and max cooking temp 165 for 90 min. The mechanical strength properties of NDLKCC are better than the mechanical strength properties of ONP and OCC. Looking at mechanical strength properties of NDLKCC, ONP and OCC, the pulp of NDLKCC can be used for the development of kraft paper of grade I and ONP and OCC can be used to develop kraft paper of grade - II.

Table 3 and 4 reveal the blending results of wheat straw with gunny bag and bagasse with gunny bags in different ratios at beaten at 40°SR after beating. Pulp blends having wheat straw and gunny bag in the ratio of 70:30 and bagasse and gunny bags in the ratio of 70:30 are found to impart mechanical strength suitable for the development of kraft paper of grade-II.

Table 5 reveals the blending results of wheat straw and new double line kraft corrugated cuttings (NDLKCC) pulps in different ratios at 40°SR. The 100 per cent NDLKCC pulp is found suitable to develop kraft paper of grade-I. When wheat straw and bagasse pulps are blended with NDLKCC pulp in various ratios, the mechanical strength deteriorates and are not suitable for the development of kraft paper of grade-I. On the other hand, pulp blend having wheat straw and NDLKCC in the ratio of 70:30 is found suitable for kraft paper of grade-II. Bagasse pulp when blended with NDLKCC pulp, none of the blend was found suitable for the development of kraft paper of grade-II (Table 6).

Table 7 and 8 reveal the blending results of wheat straw and imported ONP and wheat straw and Imported OCC in various blend ratios. None of the blend was found suitable to develop kraft paper of grade-I and II.

Table 9 shows the comparison of laboratory made hand sheet of NDLKCC with BIS specification. Various wet end additives were added in to the beaten pulp to improve various structural properties of paper. A dose of 10 kg/t of Ivax (fortified rosin) were added to

Table 1 Cooking conditions and results of wheat straw, bagasse and gunny bags

Sl no	Parameters	Wheat straw	Bagasse	Gunny bags
1	Unbleached pulp yield, %	61.0	64.2	81.2
2	Total solids of black liquor, %	8.5	9.0	7.3
3	Screened pulp yield, %	56.6	57.2	70.3
4	pH of black liquor	10.2	10.3	10.2
5	Residual active alkali, g/l	1.2	1.1	0.3
6	Kappa number	42	50	70
7	Tear index, mNm^2/g	3.96	3.80	11.11
8	Burst index, $kPam^2/g$	1.9	2.0	5.2
9	Tensile index, Nm/g	9.96	27.55	55.56
Conditions: NaOH = 8.0 % (as such) on o. d. raw materials basis, liquor to wood ratio =5:1, max cooking temp= 160 °C, max cooking time =60 min and beating level = 400SR				

Table 2 Cooking conditions and results of NDLKCC , ONP and OCC

Particulars	NDLKCC	ONP	OCC
Active alkali, per cent (as Na2O)	4	4	4
Liquor to waste paper ratio	5:1	5:1	5:1
Maximum temp, °C	165	165	165
Time to temp, min	60	60	60
Time at temp, min	90	90	90
Pulp yield, per cent	64.4	82.3	66.8
Kappa no.	26.0		32.2
Tear index, mNm^2/g	12.2	9.66	8.39
Burst index, $kPam^2/g$	5.88	2.62	2.97
Tensile, Nm/g	57.75	49.06	38.39

Table 3 Blending results of wheat straw with gunny bag in different ratios at 40 0SR

Sl no	Particulars	Wheat straw : Gunny bags				
		95:05	90:10	85:15	80:20	70:30
1	Tear index, mNm^2/g	4.27	5.2	5.8	6.6	7.4
2	Burst index, $kPam^2/g$	2.29	2.40	2.53	2.95	3.47
3	Tensile index, Nm/g	39.32	40.58	43.37	45.88	46.35

Table 4 Blending results of bagasse with gunny bag in different ratios at 40 0SR

Sl no	Particulars	Bagasse: Gunny bags				
		95:05	90:10	85:15	80:20	70:30
1	Tear index, mNm^2/g	4.29	5.32	5.87	6.45	7.35
2	Burst index, $kPam^2/g$	2.09	2.32	2.53	3.12	3.33
3	Tensile index, Nm/g	33.81	34.94	35.60	37.86	40.02

develop water repellency property in kraft paper. 65 kg/t of alum (ferric) and 5 kg/t sulphuric acid are added to maintain a pH of pulp stock at 4.5 necessary for internal sizing and to entrap fines and wet end bonding additives. 3 kg/t of gum are added to improve bond strength of paper. 12 kg/t of melamine formaldehyde is added to develop cross linking for wet strength. Foam spots and blemishes affect toughness of paper adversely; therefore, 0.5 kg/t of cartaflex (defoamer) is added to eradicate these paper defects. The test results of laboratory hand sheets having 100 per cent of NDLKCC is comparable with BIS specification of kraft paper of grade-I.

Table 10 shows the comparison of laboratory hand sheets prepared from wheat straw, baggase, NDLKCC, ONP and OCC in various blend ratios with BIS specification (BIS-1397:1997) of kraft paper grade-II. Pulp blends having wheat straw and gunny bags in 70:30, bagasse and gunny bags in 70:30 and wheat straw and gunny bags in 70:30 ratios are found suitable to develop kraft paper of grade-II. Pulp blends of bagasse and NDLKCC, wheat straw and imported ONP and wheat straw and imported OCC are not found suitable for the development of kraft paper of grade-II.

Table 5 Blending results of wheat straw with new double line kraft corrugated cuttings(NDLKCC) pulps in different ratios at 40 °SR

Sl no	Particulars	Wheat straw: NDLKCC					
		0:100	95:05	90:10	85:15	80:20	70:30
1	Tear index, mNm^2/g	12.2	4.27	5.39	5.73	6.84	7.55
2	Burst index, $kPam^2/g$	5.88	2.39	2.61	2.72	2.96	3.18
3	Tensile index, Nm/g	57.75	42.59	44.96	45.30	47.80	49.59

Table 6 Blending results of bagasse with new double line kraft corrugated cuttings(NDLKCC) pulps in different ratios at 40 °SR

Sl no	Particulars	Bagasse: NDLKCC				
		95:05	90:10	85:15	80:20	70:30
1	Tear index, mNm^2/g	3.44	4.02	4.58	5.16	6.76
2	Burst index, $kPam^2/g$	2.05	2.22	2.36	2.49	2.70
3	Tensile index, Nm/g	30.82	32.07	33.11	35.08	40.10

Table 7 Blending results of wheat straw with imported ONP pulps in different ratios

Particulars	Wheat straw: Imported ONP					
	90:10	80:20	70:30	90:10	80:20	70:30
0SR of imported OCC	41	41	41	65	65	65
0SR of wheat straw	35	35	35	35	35	35
Basis weight, g/m^2	61.4	61.5	61.3	61.7	61.2	61.5
Tear index, mNm^2/g	5.74	5.97	6.31	5.36	5.30	5.24
Burst index, $kPam^2/g$	2.70	2.73	2.79	24.4	2.51	2.64
Tensile index, Nm/g	33.62	38.86	38.86	33.30	38.51	41.33

Table 8 Blending results of wheat straw with imported OCC pulps in different ratios

Particulars	Wheat straw: Imported OCC					
	90:10	80:20	70:30	90:10	80:20	70:30
0SR of imported NCC	41	41	41	65	65	65
0SR of wheat straw	35	35	35	35	35	35
Tear index, mNm^2/g	5.24	5.35	5.99	4.58	4.61	4.74
Burst index, $kPam^2/g$	2.35	2.43	2.48	2.60	2.99	3.06
Tensile index, Nm/g	35.72	37.36	38.95	34.06	35.48	41.05

CONCLUSIONS

Kraft paper requires high mechanical strength properties. The indigenous raw materials have poor quality of fibers. The only cheapest source of long cellulosic fibers is the imported waste papers. The major obstacle for the use of imported waste paper is the resinous materials and wet end bonding additives, which interferes the separation of cellulosic fibrous raw materials during slashing. The waste papers like, NDLKCC, imported ONP and OCC are treated with HCl at pH 3.5 to remove resinous matters and wet end bonding additives prior to pulping. Wheat straw, bagasse, NDLKCC, imported ONP and OCC are cooked by soda pulping process to get non-bleachable grade pulp. All the pulps were beaten separately at 40°SR and various wet end additives are added into the pulp blend to serve manifolds purposes. 10 kg/t of Ivax (fortified rosin) for water repellency, 65 kg/t of alum (ferric) and 5 kg/t of sulphuric acid are added to the mix to maintain a pH 4.5 suitable for internal sizing and to entrap fines and non-fibrous additives. 12 kg/t of melamine formaldehyde is added to develop cross linking and 3 kg/t gum for the development of internal bond strength. 0.5 kg/t of cartaflex (defoamer) are added in to the pulp to improve the toughness of kraft paper. Laboratory hand sheets having 100 per cent of NDLKCC is found suitable for kraft paper of grade-I. Pulp blends having wheat straw and gunny bags in 70:30, bagasse and gunny bags in 70:30 and wheat straw and gunny bags in 70:30 ratios are found suitable to develop kraft paper of grade-II. Pulp blends of bagasse and NDLKCC, wheat straw and imported ONP and wheat straw and imported OCC are not found suitable for the development of kraft paper of grade-II.

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Table 9 Comparison of results of laboratory made hand sheets with BIS specifications of kraft paper grade-I

Particulars	BIS-1397:1997	Laboratory made hand sheet of NDLKCC
°SR	--	41
$Cobb_{60}$, g/m²	--	22.4
Tear factor	120	124.5
Burst factor	30	73.5
Breaking length, m		
MD	7000	--
CD	4000	--
Avg	5500	5893

Conversion factor: Tear index/0.0980665 = Tear factor,

Burst index/0.0980665 = Burst factor,

Tensile index/ 0.00980665 = Breaking length

Table 10 Comparison of results of laboratory made hand sheets with BIS specifications of kraft paper grade-II

Particulars	BIS-1397:1997	Set-I	Set-II	Set-III	Set-IV	Set-V	Set-VI
Blending ratio	--	70:30	70:30	70:30	70:30	70:30	70:30
0SR	--	40	40	40	40	41	41
Cobb60, g/m2	--	22.4	23.2	21.4	22.3	20.4	21.6
Tear factor	75	75.51	75.0	77.04	68.99	64.39	61.12
Burst factor	20	35.41	33.97	32.45	27.55	28.47	25.31
Breaking length, m							
MD	4500	--	--	--	--	--	--
CD	2500	--	--	--	--	--	--
Avg	3500	4730	4084	5060	4092	3965	4100

Conversion factor: Tear index/ 0.0980665 = Tear factor,

Burst index/0.0980665 = Burst factor,

Tensile index/ 0.00980665 = Breaking length

Set-I = Wheat straw: Gunny bags,

Set-II = Bagasse: Gunny bags,

Set-III = Wheat straw: NDLKCC,

Set-IV = Bagasse: NDLKCC,

Set-V = Wheat straw: ONP,

Set-VI = Wheat straw: OCC

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