Paper Components for Corrugated Boxes

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The Corrugated Box Manufacturing Industry is one of the major allies of paper industry. In developing nations like India, more consumer items coming into the market, Packaging Industry has an important part to play in the marketing of such items. Establishment of export-oriented light engineering goods and other special products demand the production of more corrugated boxes with quality standards. In the competitive export market, unless a high standard of packing is ensured, there is every possibility of Indian goods losing export market due to the excessive damage caused to the faculty containers.

The present demand of wrapping and packing paper in our country is estimated around 2.5 lakh tonnes out of total output of 10 lakh tonnes of paper and paper board per annum. For converters, mostly one type of paper is available for their multifarious use under the trade name "KRAFT PAPER".

An attempt is made in this paper to analyse the various paper components ideally suitable for manufacturing corrugated boxes.

Specific paper quality requirement for Corrugated boxes :

Two important paper components are required for making the corrugated boxes. They are Kraft liner and the corrugation/fluting medium. The important quality requirement of kraft liner and corrugated medium can be summarised as follows:

Kraft liner : Burst factor/Tensile Strength (Breaking Length)/Tear Factor

Corrugating medium : High stiffness (ring crush)/Concora medium test to test the fluting quality.

"Kraft" means "strength" in German and naturally the Kraft papers expected to be a stronger paper. In our country, the "Kraft" or "sulphate," sulping process is being followed to pulp bamboo/hardwoods which will yield pulp of maximum strength properties from the cellulosic materials. Advanced technique of kraft pulping, like optimum "sulphidity" in the cooking conditions etc. have improved the pulp characteristics to considerable extent.

After extraction of fibre (pulp) from the cellulosic raw materials, the manufacture of stronger paper depends mainly on the "fibre treatment" in beating or refining of pulp. As per the theory of fibre morphology, the fibre contains center opening called the 'lumen' with its outer surface composed of several layers called primary and secondary walls. During the process of refining primary wall which is very thin usually gets damaged and quickly removed, and the layers of secondary wall are unwound and become highly fibrillated. Under these circumstances there is increase in specific surface of the fibres and degree of swelling. Also the fibres become more flexible, and they develop better molecular contact between fibre surfaces and stronger fibre to fibre bonding. The strength properties of papers and board depend primarily on the hydrogen bonding and other molecular inter-bonding of fibres. When the fibres are subjected to beating/refining in water and converted into sheet of paper the strength characteristics of the paper changes considerably with degree of beating/refining. So a judicious degree of refining is required to attain optimum strength properties from a particular type of cellulosic material.

Much work has been carried out to study the strength development of Bamboo and Hardwoods pulps. Tables No. 1, 2 and 3 give a characteristic development of strength properties with increase in refining as represented by slowness (freeness) of pulp for Bamboo, Hardwoods and 60% Bamboo and 40% Hardwoods blend respectively.

From the data and graphs given in Tables it can be observed that with increase of refining the strength properties in respect to Burst, Tensile and

Table No. 1

BAMBOO

Development of Strength Properties with Refining / Beating

Sl. no.	Slowness °SR	Bulk cc/gm	Burst Factor	Breaking Length Metres	Tear Factor	Double Folds No.
1.	17	2.5	5.0	560	93	—
2.	20	2.33	6.8	1670	100	2
3.	25	2.25	14.2	2500	120	4
4.	30	2.16	25.0	3560	166	16
5.	35	2.0	26.5	4440	136	49
6.	44	2.0	33.3	4670	120	93
7.	52	1.83	38.3	5110	103	120-
8.	57	1.66	36.6	4890	94	106
9.	65	1.66	35.4	4780	89	83
10.	70	1.66	34.3	3000	72	41

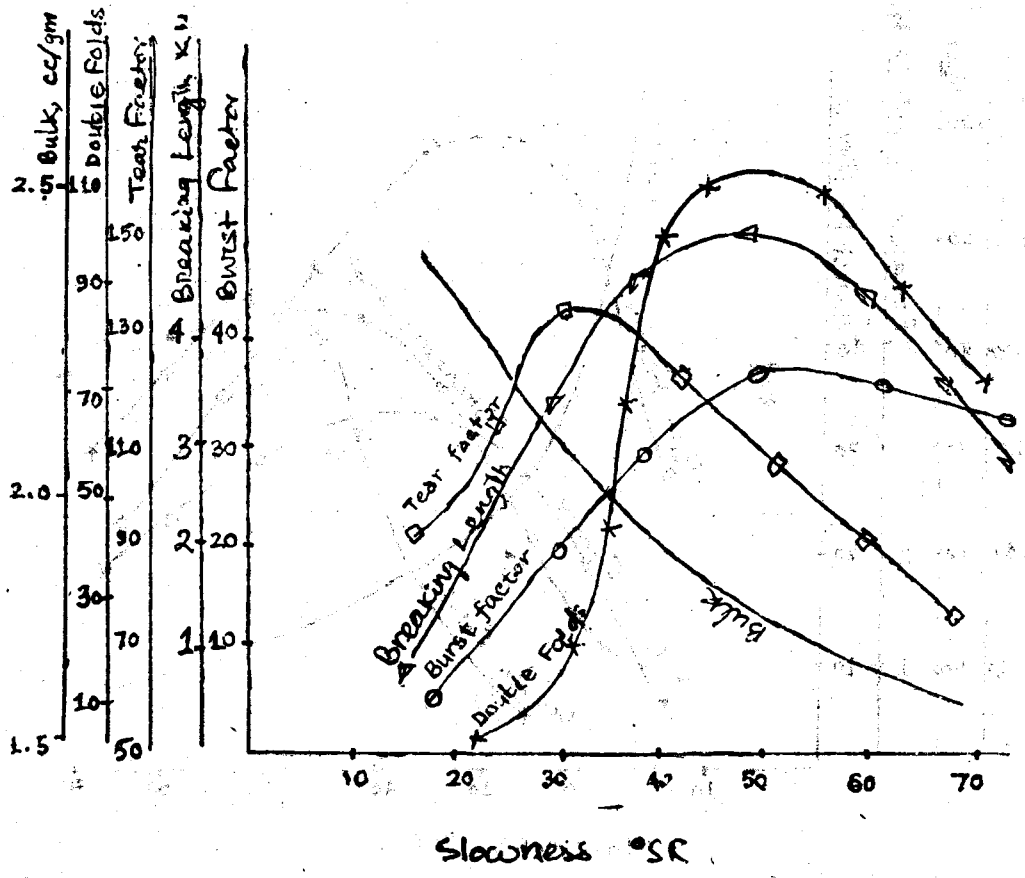


Table No 2.

HARDWOOD.

Development of Strength Properties with Refining/beating.

Sl. No	Slowness °SR	Bulk cc/gm	Burst Factor	Breaking Length Metres	Tear Factor	Double Folds No.
1	14	3.33	5.8	840	66	–
2	22	2.16	21.6	1110	86	2
3	25	2.00	27.5	2280	103	4
4	30	1.83	31.3	2400	106	16
5	40	1.80	33.8	4010	92	48
6	46	1.75	30.3	4500	83	27
7	50	1.66	29.8	4310	81	93
8	56	1.58	29.7	4280	75	84
9	66	1.50	27.0	4160	68	70
10	70	1.50	26.5	4010	60	56

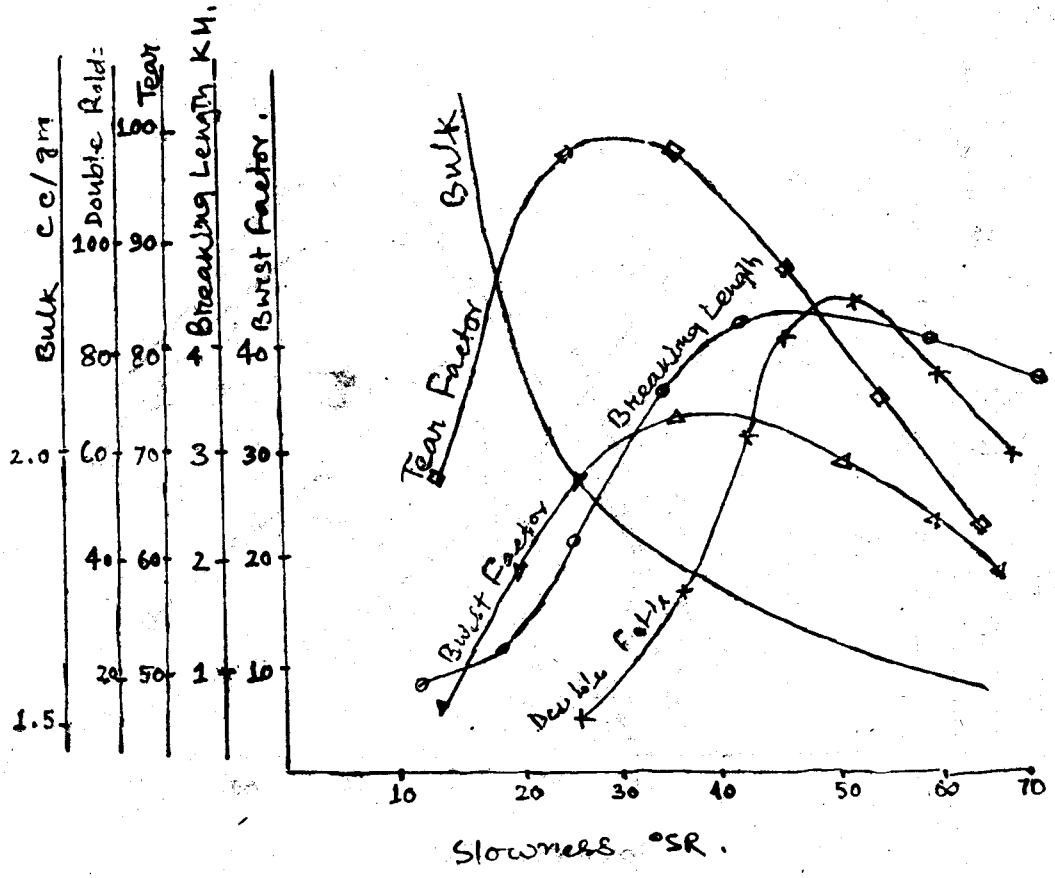
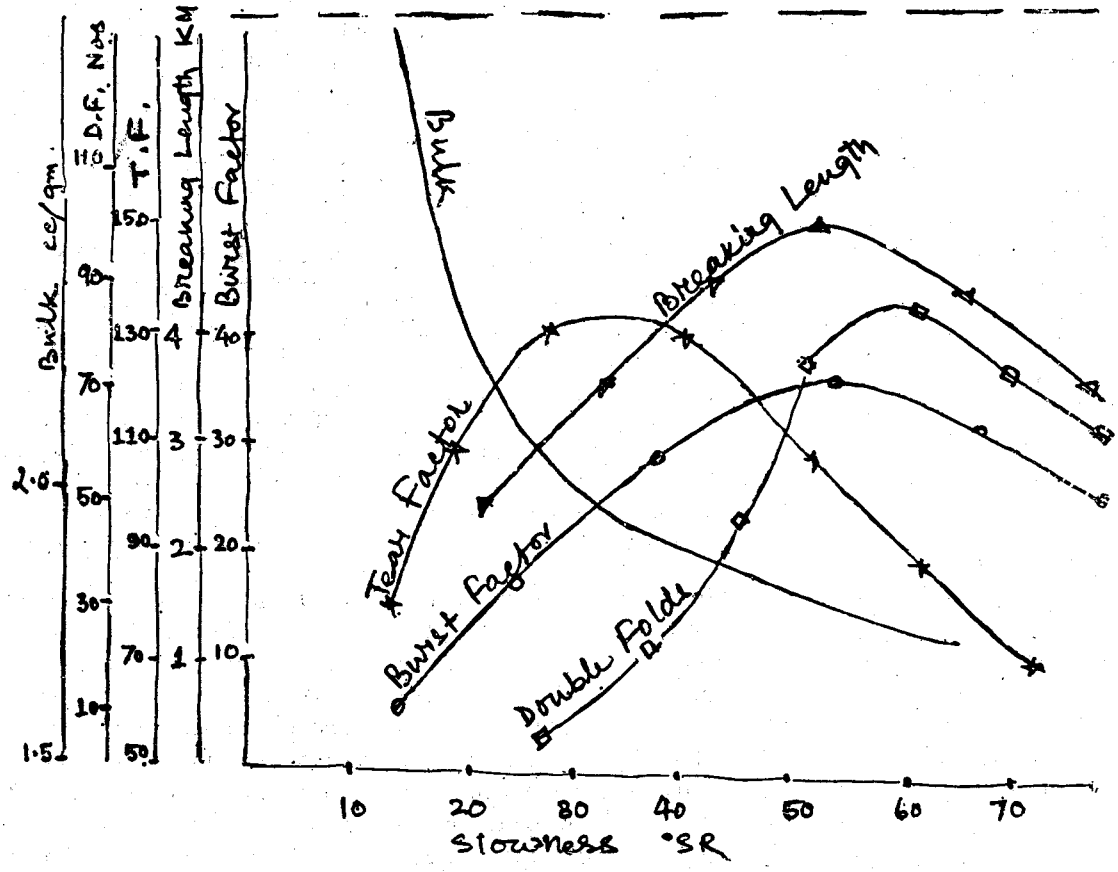


Table No 3.

BAMBOO HARDWOOD BLEND. 60 : 40 %

Development of Strength Properties with Refining / Beating

Q) No	Slowness °SR	Bulk cc/gm	Burst Factor	Breaking Length Metres	Tear Factor	Double Folds No.
1	12	3.0	5.4	—	80	—
2	20	2.3	18.4	2462	120	5
3	25	2.14	21.4	3523	—	8
4	35	2.0	27.0	4143	140	23
5	42	1.92	30.7	4282	138	53
6	48	1.84	33.4	4513	110	80
7	56	1.8	36.8	5320	102	110
8	60	1.8	34.3	4820	92	90
9	65	1.80	32.1	4420	81	82
10	70	1.56	30.3	4080	75	71



Double Folds increase whereas the tearing strength increases at the initial stage and drops down as the refining progresses. However, excessive refining also brings down the overall strength properties as the burst tensile and double folds drops after a certain level of refining. So it is imperative for paper makers to fix an optimum level of 'fibre treatment' to achieve maximum strength properties in the paper.

The individual tests on paper components although establish a fair relation to the finished containers, several attempts in the past did not indicate any exact/ or logical correlation between the tests on paper components and performance of the corrugated containers.

Today much importance is being given to the bursting strength of the kraft paper by the coverting industry. Despite its many disadvantages, it is still widely used because it is an important internal sheet property and also in one test it gives indication of composite strength of paper as well as its toughness which correlates fairly with the end-use. The bursting strength, the tensile strength and the tearing strength are all proportional to the fibre length, but to a different degree :

$$\begin{aligned} \text{The burst} &\propto \sqrt{L} \\ \text{Tensile} &\propto L \\ \text{Tear} &\propto L_{3/2} \end{aligned}$$

The Mullen or bursting strength is predominently dependent on the greatest number of fibres or particles of fibres packed in a given area of a given thickness and held firmly compacted. In other words, the greater the firmly compacted density of the sheet, the higher the bursting strength. Conversely the Elmendorf tear strength is predominently dependent on the brushing out of the fibres to their greatest length so that they will interweave physically during formation.

For all practical purposes, it is accepted that 70% of light weight and 35% of heavy weight kraft papers, the bursting strength is attributable to short fibres and fines, and the rest 30 to 45% attributable to the so-called hydration or wetting of tho fibres. In competitive market where paper mills have extra drying capacity in their Paper Machines, there is a tendency to carry out over-beating/refining of the pulp and maintain marginally higher burst factor in their kraft papers. Such papers show a poor tearing strength and when fluted, the flutes show a cracking tendency and the containers made out of them fail largely in the actual performance test. Papers made from highly refined pulp from more slowly on the wire, shrinks more on drying, more dense and translucent, less opaque and compressible and they show a tendency to curl and cockle.

Other important quality aspects of kraft paper are :

1. Uniform basis weight : For techno-economic reasons, the basis weight of paper should be uniform. The variation in the basis weight will result in variation in final box quality, as the burst and CMT value will vary as per the basis weight. Non-uniform sheet will expose weak spots in the paper giving rise to low bursting at those points resulting in ultimate failure of boxes.

2. Uniform Caliper : Uniform thickness is required to give smooth operation of the corrugating machines.

3. Shade : The shade of the kraft is preferred in Golden-yellow colour and should be uniform to make attractive appearance of boxes and gives printing contrast. Most of the kraft papers are generally dark brown in colour due to the kraft pulp which yields dark coloured pulp. In addition to this, since all the paper mills are forced to use certain amount of hardwoods, the resulting pulp varies in shade from dark to blackish brown, which not only further darkens the shade and causes variation from batch to batch. In order to tone up the shade and maintain uniformity, a mild treatment with 2 or 3% hypochlorite to the unbleached pulp is being followed to maintain a uniform colour of the pulp.

4. Cleanliness : The paper should be free from dirt and excessive shieves to give a clean appearance. However, the cleanliness of paper is mostly dependent upon the pulp which is being used. Any addition of mechanical/semichemical pulps is bound to give some shievy appearance to the paper.

Corrugation/Fluting media, the ring crush or stiffness test and the Concora test are the important qualities. The ring crush test means stiffness in the edgewise direction while the Concora test indicates the quality of flutes. These two tests combinely predicts the flat crush

test of the containers. Low Concora indicates a soft corrugated board while high concora value in the paper will result in the fracturing of flutes and may give operational difficulties. Apart from the above two properties, high moisture content and uniform caliper are important properties required in the corrugating medium.

Optimum results and how to achieve them :

Having discussed above, the quality requirements of the kraft and corrugating medium papers, let us analyse what would be the optimum strength properties Indian Mills can achieve. Manufacturers of kraft papers can be grouped into three categories as per their raw material usage :

1. Mills using certain amount of long fibre coniferous wood or reeds.
2. Mills using bamboo-hardwood mixture.
3. Small mini-Paper Mills using unconventional raw materials like straw, waste paper etc.

When Coniferous (Pine) wood or reeds are used it is possible to achieve a burst factor of 28/30 and the maximum achievable in case of bamboo/hardwoods is around 22/24. The kraft paper from unconventional raw material or from the secondary fibre/waste paper is around 16/18 only.

In recent times, Mills are able to overcome other paper making difficulties and marginally improved the burst factor by using some of the beater-additives available in the country. As stated earlier over-refining of pulp destroys the fibre and is detrimental to many other desireable properties. Beater additives like starch, glue, natural gums and synthetic polymers impart better fibre to fibre bonding. The increased fibre bonding, although the pulp is refined to lesser degree of slowness, results in better strength properties.

There is a misconception among many of us that use of waste gunny for kraft paper production shall improve the strength properties. However, the gunny pulp quality is mostly depending upon the quality of gunny-waste. The gunny-waste available to paper mills is by and large of very poor in quality due to various stages of gunny bag use before they were finally condemned. In certain cases, it is observed that apart from giving specky appearance due to unremovable foreign matters gunny fibres impart brittleness to the paper. Although much has been discussed at various levels and considerable research works have been carried out for the production of corrugating/fluting media, it is unfortunate that the manufacture of C.M. has not been taken up on large commercial scale. It has been proved that good quality currugating media can be manufactured from semi-chemical pulp obtained from mixed hardwoods or Eucalyptus. Some data are given in Table No. 4 from the Research work carried out in the Research Centre of West Coast Paper Mills, Dandeli. From the data it can be observed that by the semi-chemical pulping method, the corrugating media acn be manufactured with high bursting strength, ring crush and concora values, which are important qualities for fluting media. Apart from the use of semi-chemical pulp having high semi-cellulosic content and

TABLE 4

		BAMBOO KRAFT				*EUCALYPTUS SEMI-CHEMICAL (MONO-SULPHITE)*			
1.	Slowness °SR	22	31	42	50	20	30	40	50
2.	Basis Wt. gms/M²	100	105	101	100	102	102	102	102
3.	Bulk, cc/gm	1.97	1.85	1.77	1.72	2.27	2.14	1.97	1.85
4.	Burst factor	31.7	35.2	37.6	40.0	21.5	30.4	38.2	42.2
5.	Breaking Length kilometres	4.92	5.52	5.86	6.08	5.27	6.18	6.57	7.20
6.	Tear factor	104	93	84	83.5	54	56	62	62
7.	CMT, Kgs.	22	23.2	23.4	22.7	17.7	28.2	25	26.6
8.	Scan B. Stiffness	2.05	2.15	1.9	1.8	2.75	2.4	2.2	1.9

good quality corrugating medium can be manufactured by certain specific controlled paper making factors, such as :

1. Improved wet pressing—i.e. high initial pressure at first wet presses.
2. With the installation of fine textured felt design in the wet presses.
3. Improved draw conditions—tight draws at the paper manufacturing stage improves the ring crush test in cross direction.

By a proper combination of raw material, pulping process and mechanical treatment a superior grade of fluting media can be manufactured in our country.

Special grade krafts :

For export of cement; chemicals and other products of late, there is good requirement of strong "SACK Kraft" for making "multi-wall bags". A recent survey has indicated that the present demand of "Sack Kraft" is around 10,000 tonnes per year which is being partially met from the comparatively stronger kraft paper available in the country. The other such special grade of kraft paper used for multi-wall bags, is "Extensible Kraft Paper"—a special grade of paper having high stretch percentage and tensile energy absorption (TEA). With the establishment of export-oriented industries, the requirement of such special grade papers is expected to go up to 25,000 tonnes per annum in 1983-84.

Conclusion :

1. There should be a close co-ordination between Paper Industry—and Corrugated Industry to know each other techno-economically.
2. The specification of kraft paper should be comprehensive and based on what is best achievable from the available raw material resources. Much insistance on burst factor in the kraft papers leads to adoption of different paper making patterns which ultimately leads to the overall poor performance of the containers although kraft paper shows higher bursting strength. The paper mills on their part should try to maintain high overall strength properties in the kraft paper by optimising their pulp and paper making processes and by use of beater additives available in the country.
3. Corrugated industry by and large should regulate the requirement of different paper components in two categories 'Kraft Paper' for their liner and corrugating for fluting instead of using kraft paper for both the purposes.
4. If the demand of the corrugating medium goes up with the adoption of semi-chemical processes, the yield from the raw-materials can be achieved higher at 70% against 45-48% being obtained from the chemical pulping which is used for manufacture of kraft papers. This will further save considerable quantity of raw materials and lead to the use of more hardwoods by the paper mills to conserve bamboo resources. Some thought can be given on feasibility of establishing paper mills to produce corrugating medium on massive scale based on semi-chemical pulping of hardwoods.
5. With increase in demand of special grades of multi-wall papers like "Sack Kraft"/"Extensible Kraft" necessary steps may be taken up to establish one integrated pulp and paper mills based on Coniferous (Pine) wood exclusive for manufacturing high grade krafts. The recent discussions of the Development Council have indicated the possibility of establishing such a paper mill with 70 tonnes per day capacity in Himachal Pradesh or Kashmir based on coniferous wood.

Also, liberal permission may be granted to paper mills to collaborate with the specialised know-how for extensible kraft paper production. It is a matter of interest to note that such extensible kraft paper production is established recently from short-fibred raw materials like Bamboo / Bagasse / Hardwood etc.

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