Ranking of papers by in-plane Tear strength and elmendorf tear strength

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SUMMARY

Ranking studies have bean carried out using Elmendorf tear test and MBR in-plane tear test for offset grade papers manufactured from chemical pulps and for newsprint grade papers. The rank correlation coefficient between two tests for offset grade is significant but for newsprint grade it is quite low. This suggests that Elmendorf tear test is not as relevant to newsprint web runnability as in-plane tear test. For offset papers in-plane tear test does not show any superiority over Elmendorf tear test.

Tearing strength is an empirical property and plays significant role in evaluating paper which is subjected to tearing strains during conversion operations and on printing. There are two tests for evaluating the tearing strength of a sheet. One is the normal Elmendorf tear test, in which test set of pieces are clamped in vertical positition between parallel jaws, one stationary and one movable, fitted to a pendulum. An initial cut is made in a set of test pieces which are then torn through a given distance when pendulum is released. The work done in tearing the test pieces is measured as a loss in potential energy of the pendulum. Characteristic of this test is that tear is continued by antriparallel forces at a large angle to the plane of the sheet. This causes severe twisting and delamination at rupture line of sheet. This phenomenon does not simulate the web break on the printing press. The relevance of the Elmendorf tear test to the performance of paper on printing press has come under criticism for the last few years[1,2]. Another test, namely, in-plane tear test, has been suggested. In in-plane tear test, the specimen is clamped in such a way that high stress is concentrated at its edge, such skew tension is similar to web tension on printing press which may be due to improper press adjustment or faulty reel build. In this test, started tear is continued by forces applied in the plane of sheet. The two modes of sheet tearing--Elmendorf and in-plane are illustrated in fig. 1.

The object of the present investigation was to study the superiority of in-plane tear test over Elmendorf tear test in grading various paper qualities for their web runnability on printing press.

TWO MODES OF TEARING TESTS

ELMENDORF

IN PLANE TEAR
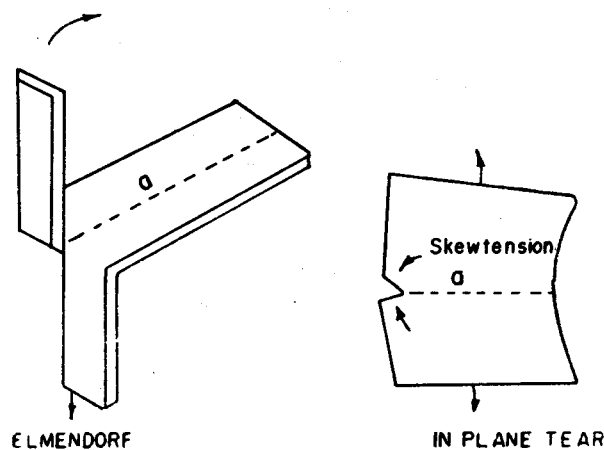
a — Line of tear propagation

Fig. 1

EXPERIMENTAL

Material Used : The following papers were studied in the evaluation :

a. **Offset Grade :** Commercial, indigenous and imported samples were used. Indigenous cream wove quality was also evaluated. These papers were having only chemical pulps as their furnish components.

b. Commercial newsprint : Commercial, indigenous and improted, newsprint sample were used The paper samples were procured from difhierent Indian and foreign paper mills.

Tests : The samples were conditioned at $27\pm1°C$ $65\pm2\%$ RH before testing. The Elmendorf tearing strength was tested according to standard method ISO 1974, using Elmendorf tear tester (model No. 0.9, type 4--3) manufactured by M/s. Lorentzen and Wettre, Sweden. Specimen of 62.0 mm length and 50 mm width were taken with longer side parallel to the direction in which the determination of tearing resistance was desired. As Elmendorf tearing strength is affected by the number of sheets torn together due to interaction of sheets among themselves [2], four test pieces were torn together. However, to get reading within pendulum range, diffierent pendulums were employed. An initial cut of 19.0 mm was provided using the pivoted knife of tear tester and tearing force in mill. Newtons required to tear the remaining 43.0 mm length was noted from the pendulum scale. Five replicat-ions were carried out in each direction.

Tear index was calculated as under :

$$\text{Tear index (mN.m}^\circ\text{/g)} = \frac{R \times f}{w}$$

where

R is the reading in milli Newtons

f is the pendulum factor

w is the grammage.

In plane tearing strength was tested using MBR in-plane tear tester Fig. 3 (model No. 09P, type 1-2) manufactured by M/s. Lorentzen and Wettre, Sweden. Specimen of 80 mm width 92 mm length were cut, the shorter side being the direction in which tear value estimation is desired. An initial cut of 10.0 mm was provided and the tearing force in Newton required to tear the remaining 70 mm width was recorded from the pendulum scale. Five replications were carried out in each direction of sheet.

The tear index was calculated using fellowing relationship :

$$\text{in-plane tear index} = \frac{R \times 1000}{w}$$

$(mN.^2/g)$

Where

R is the tearing force in Newton

w is the grammage (g/m^2)

RESULTS AND DISCUSSIONS

The Elmendorf and in-plane tear strength values cbtained for offset quality papers and newsprint samples are recorded in Table 1 and 2 respectively. For ranking evaluation two values were considered separately, one the average of machine direction and cross direction values and second cross direction value only, the latter should correspond more directly with mode of breakdown of a web on printing press, as the stress of rupture occurs in the cross direction of web on printing press. The relationship between average values of MD & CD Elmendorf tear index and in-plane tear index for offset grade and newsprint grade is shown in Fig. 2.

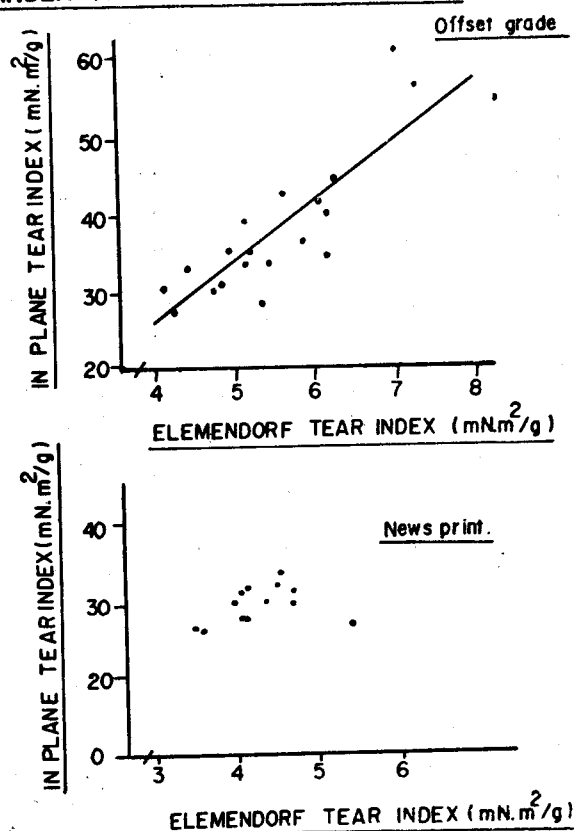**RELATIONSHIP BETWEEN ELMENDORF TEAR INDEX AND IN PLANE TEAR INDEX**

Fig. 2

The Spearman's rank correlation co-efficient web evaluated for both cases. The values are recorded in Table 3. The correlation coefficient for printing grade papers which are having chemical pulps as their furnish is 0.78 for CD and 0.82 for average of

TABLE—1 PLANE TEARING STRENGTH & ELMEDORF TEARING STRENGTH OF PAPER SAMPLES

Sl. No.	Quality	g/m²	Elmendorf (mN.m²/g) MD/CD	tear index Avg.	In-plane tear strength (N) MD/CD	Avg.	CD	In-plane tear index (mN.m²/g) Avg.
1.	Glopaque offset-Australian	70.0	6.60/7.45	7.05	2.5/3.0	2.75	42.9	39.3
2.	Show offset Australian	86.9	7.85/8.70	8.30	4.5/5.0	4.75	57.5	54.7
3.	Offset-American	75.9	6.05/6.25	6.15	2.3/3.0	2.65	39.5	34.9
4.	Offset-American	72.5	4.95/5.30	5.15	2.5/2.6	2.55	35 9	35.2
5.	Offset-Japanese	54.5	5.90/6.20	6.05	2.0/2.5	2.25	45.9	41.3
6.	,, ,,	75.5	5.75/6.70	6.25	3.2/3.5	3 35	46.4	44.4
7.	,, ,,	66.3	6.65/7.95	7.30	3.5/4.0	3.75	60.3	56.6
8.	MF ptg.-Australian	70.1	4.95/5.85	5.40	2.2/2.5	2.35	35.7	33.5
9.	Maplitho-indigenous	72.5	4.95/5.25	5 10	2.4/2.5	2.45	34.5	33 8
10.	,, ,,	76.0	4.10/4.55	4.35	2.5/2.6	2.55	34.2	33.6
11.	,, ,,	64.5	4.65/4.75	4.70	1.7/2.2	1.95	34.1	30.2
12.	,, ,,	76.9	6.00/6.30	6.15	3.0/3.1	3.05	40.3	40.0
13.	,, ,,	67.7	4.65/4.95	4.80	2.0/2.2	2.10	32.5	31.0
14.	,, ,,	62.3	3.85/4.20	4.05	1.7/2.1	1.90	33.7	30.5
15.	Cream-wove indigenous	58.6	4.80/5.00	4.90	1.7/2.4	2.05	41.0	35.0
16.	,, ,,	60.3	5.10/5.50	5 30	1.5/1.9	1.70	31.5	28.2
17.	,, ,,	59.2	3.70/4.65	4.20	1.4/1.9	1.65	32.1	27.9
18.	,, ,,	63.0	5.10/6.60	5.85	2.2/2.4	2.30	38.1	36 5
19.	,, ,,	61.2	4.90/5.25	5.10	2.3/2.5	2.40	40.8	39.2
20.	,, ,,	57.7	5.20/6.00	5.60	2.3/2.6	2.45	45.1	42.5

TABLE—2 IN-PLANE TEARING STRENGTH AND ELMENDORF TEARING STRENGTH OF NEWSPRINT SAMPLES

| Sl. No.	Sample	g/m²	Elmendorf tear index (mN.m²/g) MD/CD	Avg.	In-plane tear strength (N) MD/CD	Avg.	In-plane tear index mN.m²/g CD	Avg.
1.	Australian	51.7	3.50/5.80	4.65	1.2/2.1	1.65	40.6	31.9
2.	Philippines	52.7	3.80/4.20	4.00	1.4/1.5	1.45	28.5	27.5
3.	Japanese	57.5	3.60/5.00	4.30	1.3/2.1	1.70	36.5	29.6
4.	Japanese	58.5	3.40/4.70	4.05	1.2/2.0	1.60	34.0	27.3
5.	Imported	54.4	2.95/4.05	3.50	1.2/1.6	1.40	29.5	25.8
6.	Imported	51.5	3.60/5.30	4.45	1.4/1.9	1.65	36.8	32.0
7.	Imported	52.8	2.90/3.95	3.45	1.1/1.6	1.35	30.3	25.6
8.	Imported	51.3	3.80/5.45	4.65	1.2/1.8	1.50	35.0	29.2
9.	Imported	54.0	3.35/4.45	3.90	1.4/1.8	1.60	33.3	29.7
10.	Imported	53.3	3.90/4.15	4.00	1.5/1.8	1.65	34.0	31.0
11.	Imported	54.2	3.60/4.45	4.05	1.5/1.9	1.70	35.0	31.4
12.	Imported	53.3	3.75/5.25	4.50	1.5/2.1	1.80	39.5	33.8
13.	Indigenous	60.6	5.10/5.65	5.40	1.6/1.6	1.60	27.1	26.5
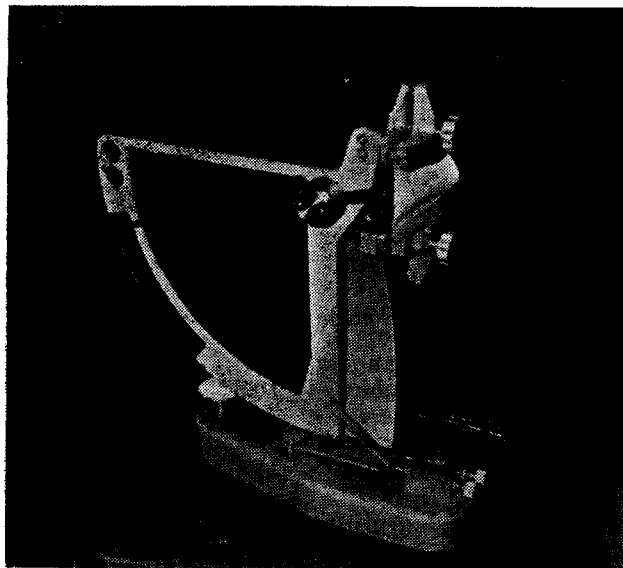
Fig. 3. In Plane Tear Tester

TABLE—3

SPEARMAN'S RANK CORRELATION COEFFI-
CIENT BETWEEN IN PLANE TEARING
STRENGTH AND ELMENDORF TEARING
STRENGTH

Quality	CD	Average of MD and CD
Printing	0.78	0.82
Newsprint	0.50	0.46

MD and CD. The correlation is quite significant, which means similar ranking is obtained by in-plane as well as Elmendorf tear test. For such quality in-plane tear test does not provide special superiority over internal tear test. For newsprint grade papers which are having mainly high pulps in their furnish, the correlation coefficient is only 0.50 in CD & 0.46 when average of MD & CD is considered. This indicates that in-plane tear test gives different ranking of newsprint grade than Elmendorf tear test. As in-plane tear test simulates the conditions of web tension experienced on printing press, this test should be considered relevant for assessing the runnability performance for web printing operations for newsprint.

CONCLUSIONS

From this study it is clear that the web runnability erformance of newsprint grade papers can be assessed petter by in-plane Elmendrof tear test gives different ranking than in-plane tear for such grades. For other papers which are manufactured from only chemical pulps similar ranking is obtained by both Elmendorf and in-plane tear tests.

ACKNOWLEDGEMENT

REFERENCES

1. Van der Akker, J.A., Wink, W.A. and Van Eperen, R.H., *Tappi, 1967*, 50 (9), 466.

2. Lyne, M.B. Jackson, M. and Ranger, A.E. *Tappi, 1972*, 55 (6), 924.