

Studies on The Surface Strength of Paper

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ABSTRACT

This paper deals with different variables influencing the surface strength of paper. The effect of these variables, such as basis weight, degree of beating, additives fillers and various cellulosic raw materials, has been studied with the help of Dennison wax pick test. It has been found that the inclusion of bagasse pulp, reduction of hardwood fibres in the furnish, higher degree of refining, addition of native starch, lower ash content etc. are some of the parameters for achieving better surface strength of paper.

INTRODUCTION :

Surface strength is the property of paper which enables its surface to accept the transfer of ink smoothly and withstand the forces involved in splitting an ink film between the sheet to be printed and the inked plate or blanket¹. Generally a paper which is sent for printing is expected to have sufficient surface strength to give satisfactory results in a printing press.

One of the usual methods for ascertaining the surface strength of paper is the Dennison wax pick test. This test is used for evaluating the pick resistance of the sheet. Whether the picking occurs in coated papers — where bonding of coating to fibre is involved or uncoated papers — where internal fibre bonding strength of paper web is involved, in general the picking on a printing press is related to bonding strength². Of the various tests available, the wax pick test is used as a simple and convenient test to measure this pick resistance and internal bonding.

The size of the sheet made on the British sheetmaking machine prevented the use of other tests such as IGT printability test.

PLAN OF WORK :

There are various ways by which the internal bonding strength and in turn the pick resistance can be improved. Hence the plan of this study was based on various factors that affect the bonding strength. The effects of following variables were studied in order to

investigate their influence on the surface strength of paper :

- a) basis weight,
- b) degree of beating,
- c) chemical additives,
- d) fillers, and
- e) Type of cellulosic raw material.

EXPERIMENTAL :

- 1) **Effect of basis weight** :— Bleached pulp from plant was brought and beaten in the Laboratory Valley beater to 30° SR. Standard handsheets of different basis weights were then prepared on the British sheetmaking machine. The variation in basis weight was from 60 gsm to 200 gsm. The wax pick test was carried out on the smooth surface of the sheets. The results of wax pick number (no pick value) are as shown in Table No. I.

Table No. I : Effect of basis weight on surface strength (Bleached pulp 'A' from plant beaten to 30° SR)

Basis weight, gsm	60	80	100	150	200
Wax Pick No.	7	7	7	7	7
(No. Pick)					

- 2) **Effect of beating** :— Bleached pulp from plant was beaten in the laboratory Valley beater to three slo-

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wness levels, 20, 30 and 40°SR. Standard handsheets of 100 gsm were prepared of the British sheetmaking machine and wax pick number on smooth side of the sheet was found. The results are as shown in Table No. II. Plant pulps collected on two different days (B and C) were tested in this part of the study.

Table No. II : Effect of beating on surface strength

Slow ness, °SR	Bleached plant pulp 'B'		Bleached plant pulp 'C'	
	Beating time, min.	Wax pick No. (No Pick)	Beating time min.	Wax Pick No. (No. Pick)
20	0	3	0	3
30	13	10	12	8
40	18	13	17	12

- 3) **Effect of additives** :— Bleached plant pulp was beaten to 30°SR, centrifuged to remove excess water and was then used for the study of effect of chemical additives and fillers on surface strength of paper.

Native starch, PVA and Guar Gum (GG) were the additives used to study their effect on surface strength of paper. Their solution was prepared by cooking at about 80°C. for 30 minutes and diluting to 1% concentration. Different doses of these chemicals were separately added and handsheets of 100 gsm were prepared on the British sheetmaking machine and smooth side of the sheet was tested for wax pick to see their effect on surface strength. The results are as shown in Table No. III.

The variation in the dose of each additive was selected according to the price. The additive cost reduces in the order : PVA—GG—Native Starch. The dosage of PVA was therefore kept low while native starch dosage was the highest, GG being in between.

Table No. III : Effect of additives on surface strength (Bleached plant pulp 'C' beaten to 30°SR)

	Blank		Native Starch			GG			PVA		
	No		1.0	1.5	2.0	0.3	0.4	0.5	0.1	0.2	0.3
%on pulp additive	No										
Wax pick No.	8	12	12	12	10	11	11	9	9	9	
(No pick)											

- 4) **Effect of fillers** :— Talcum powder was chosen as filler. The filler content on pulp was varied from 5–30% on pulp. Handsheets of 100 gsm were prepared and wax pick number was found out as before. In order to study the effect of fillers and additives in combination, native starch was chosen as an additive as it gave better improvement in surface strength along with talcum powder. The filler content was varied again from 5–30% on pulp with 1% native starch on pulp in each case. In all cases, standard handsheets of 100 gsm were prepared and their wax pick numbers were found. The results are shown in Table No. IV.

Table No. IV : Effect of filler on surface strength (Bleached plant pulp 'A' beaten to 30°SR)

Filler Additive Filler.% on pulp	Talcum Powder				Talcum Powder Native Starch			
	5	10	20	30	5	10	20	30
Additive, % on pulp	1.0	1.0	1.0	1.0
Ash in paper %	3.9	7.5	12.2	16.6	4.1	7.7	12.3	17.7
Wax Pick No. (No pick)	7	6	6	6	7	6	6	6

Note :— Bleached pulps 'A', 'B' and 'C' are bleached pulps collected from plant on various days.

- 5) **Effect of cellulosic raw material** :— Bleached pulps of Bamboo, Eucalyptus and bagasse & imported bleached softwood pulp were chosen as different raw materials. Unbleached pulps of bamboo and eucalyptus 30 kappa number and bagasse of 16 kappa number were prepared in the laboratory rotary digester by kraft pulping. These pulps were screened and bleached to about 78% brightness (Elrepho) using CEHH sequence (for bamboo and eucalyptus pulps) and CEH sequence (for bagasse pulp) during bleaching.

These pulps and also imported bleached softwood pulp were separately beaten to 20, 30 and 40°SR slowness level. Handsheets of 100 gsm were prepared on British sheetmaking machine and their surface strength, i.e. wax pick number, was found.

The results are shown below :

Table No. V : Surface strength of sheets of bleached pulps from various raw materials (Handsheets 100- \pm 2 gsm)

Bleached pulp from	Slowness, °SR	Beating time, Min	Wax pick No (No. pick)
Bamboo	20	10	7
	30	22	12
	40	29	16
Eucalyptus	20	4	3
	30	20	7
	40	28	11
Imported soft-wood pulp	20	20	12
	30	45	14
	40	59	16
Bagasse	20	0	13
	30	4	16
	40	7	16

RESULTS & DISCUSSION :

From Table No. I, it can be seen that over a wide range of basis weight, i.e. 60—200 gsm, there is absolutely no difference in wax pick number. Thus change in basis weight has not affected the surface strength of paper within the range of basis weights studied.

From Table No. II, it can be observed that, as the beating proceeds there is a marked improvement in the wax pick number. Two different types of pulps have shown the same indication. This indication is also found in Table No. V where the effect of various raw materials is discussed. Thus higher the degree of beating, higher is the wax pick number and better is the surface strength.

From Table No. III, of the various additives studied, native starch has shown better improvement in wax pick number than either GG or PVA. After 1% addition of native starch there was no further increase in wax pick number with higher doses. Maximum wax pick number was 12 in case of 1 % native starch, 11 in case of 0.4% GG and 9 in case of 0.1% PVA as against 8 in case when no additives were added.

From Table No. IV, filler addition has reduced wax pick number by one unit (7 in case of blank and

6 when fillers are used). Increase of filler addition (5—30% on pulp) had no effect on wax pick number. Thus, although other strength properties reduce with increase in filler addition, the surface strength is not affected beyond a certain limit.

The effect of addition of filler together with 1% addition of native starch was that 5% filler with 1% additive had no adverse effect on wax pick number (7 for blank as well as for sheets with 5% filler and 1% additive together). At higher filler content, however, the wax pick number dropped from 7 to 6 & remained constant between 10—30% filler addition.

From Table No. V, it may be observed for all raw materials that, as the beating proceeds, wax pick number increases indicating better surface strength after beating. Bagasse, a short fibred raw material, has shown very good surface strength followed by imported bleached softwood pulp, bamboo and eucalyptus respectively, e.g. at 30°SR, wax pick number for bagasse, imported bleached softwood, bamboo and eucalyptus bleached pulps was 16, 14, 12 and 7 respectively. Bleached eucalyptus pulp gives the lowest wax pick values.

CONCLUSIONS :

From the above study, the following conclusions can be drawn :

- Change in basis weight of paper has no effect on surface strength of paper.
- As beating proceeds, the surface strength is improved, i.e. higher the beating, higher is the surface strength of paper.
- Native starch to the extent of 1% on pulp is sufficient to give maximum surface strength improvement. Higher doses of native starch have no further effect on surface strength. Native starch has been found superior to guar gum and PVA for surface strength improvement. It is also the cheapest of the three.
- Addition of fillers slightly reduces the surface strength of paper but there is no further reduction over a wide range of filler addition. Addition of 1% native starch with filler helps to maintain the surface strength in the initial stages (5% filler on

pulp) but has no effect in later stage (10—30% filler on pulp). The effect of filler on surface strength reduction is not as serious as for strength properties.

As the sheetmaking is carried out on the British sheetmaking machine, the above conclusions are for one pass retention values.

- e) **Effect of raw material :—** Bleached bagasse pulp produces sheets giving higher wax pick values as compared to those of bleached imported softwood pulp and bleached bamboo pulp at 20 and 30°SR. However, at 40°SR, sheets of all the three raw materials give the same wax pick value, viz. 16. It has also been observed that sheets of bleached eucalyptus pulp give poor wax pick values. Also sheets of mill bleached pulp (at 30°SR) give wax pick values of 10 and 8. These lower values of wax pick may be due to the presence of eucalyptus and other hardwoods in the furnish.

In short, inclusion of bagasse pulp, reduction of hardwoods like eucalyptus in the furnish, higher refining, addition of native starch, lower ash content, etc. are the conditions to get higher wax

pick values. Reduction of hardwood pulp in the furnish will depend on the availability and price of other raw materials. However, in coming years, hardwoods are expected to be replaced gradually by bagasse, mesta, etc. Also reduction of fillers, i.e. ash content, to increase wax pick, would depend on the economics of the process and paper properties desired. The degree of refining should be maintained as high as possible consistent with good drainage, machine runnability and paper properties.

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