Vessel picking of printing papers-a problem in need of greater attention

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ABSTRACT

The printing papers come under very important grade and their requirement is maximum. At the same time keeping in view the fast changes taking place in the printing technology, changes in use of various types of fibrous rawmaterial specifically use of hardwoods, etc., force paper technologists to constantly review the manufacturing technology of paper. It has been normally observed that printing papers made from tropical hardwood pulp give 'pick problem' during printing. This pick problem is due to presence of vessel elements in pulp. This paper reviews in detail regarding vessel, its impact on paper quality with particular reference to printing quality and various methods proposed to overcome this problem of picking. It has been suggested that extensive study is required to further improve the techniques to overcome this problem.

The printing papers are very important grade of paper (and the quality of these varieties of papers are required to be made of improved and specific requirement). The fast developments in printing technology, in recent years, made it compulsory for paper technologists to review every aspect of manufacture of this grade of papers.

In recent years use of hardwoods for manufacture of paper has been also increased significantly to meet growing requirement of fibrous raw material. Printing papers made out of tropical hardwoods are known to give pick problems during printing especially on fast off-set printing press. The loosely bound elements of paper surface tend to pick on press owing to the tacky nature of ink employed, leaving a white spot on the surface. It is well established that this phenomena is mainly because of the presence of vessel elements on the surface of paper. This phenomena is of great concern because of increasing demands on paper quality and increasing necessity to utilize tropical hardwoods for papermaking. Though 'pick' problem is so far reported in papers made from hardwood pulp, it cannot totally be ruled out for papers made out of non-wood plants, as non-wood plants also contain vessel elements to a significant extent. However, so far 'pick' problem for non-wood papers has not been reported.

In this paper review has been presented regarding fundamental relations of vessel, picking problem and printability. These measures proposed to reduce picking tendency due to presence of vessel is also reviewed.

Vessel :

Vessel refers to a series of elements called vessel elements, lying end to end to form conducting tubes. In hardwoods and in non-wood plants through these vessels, the plant sap is transported. However, in general usage it is not uncommon that the term vessel is used for vessel element and is also followed here.

The vessels are usually thin walled, enclosing large empty cavities and contain numerous pits of various shapes on the cell wall. Generally, the vessels are broader but shorter than fibers. The typical dimensions of vessels present in various plant species is given in

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table—1. In addition to the variation in dimensions they also exhibit variation in form, ranging from a squat drum shape to elongated tubes, according to species. In fact, this variation in form some times affords an useful means of identification of species from which the pulp is made. The size of the vessel also varies with the growth conditions of tree/plant.

Vessel constitute around 10% by weight in hardwoods and some times more in non-woods. However, volumewise vessels may constitute as high as 50% of the wood. The weight and volumewise contribution of vessel to hardwood is given in table—2.

The cell wall structure of vessel has not been studied as extensively as that of fibres; but preliminary investigations have shown that the structure resembles that of fiber. Like wood fiber wall, the wall of vessel is also built of three layers, the primary wall closely resembles that found in fibers but the secondary wall is greatly disordered due to pitting on both the radial and tangential surface. Large areas of uninterrupted parallel fibril orientation in vessel are therefore absent. The pit in one cell usually has a complementary openings directly in opposite in adjoining cell so that there can be free movement of liquid throughout the wood. However, like the fiber wall of non-woods, the vessel of non-woods may also contain a multilayered structure.

TABLE—1

Vessel dimensions of some non-wood plants[7]

Sl. No.	Name of the non-wood plant	Dimensions Microns Length	Width
1	Sugarcane Bagasse	1000-1350	100-150
2	Rice Straw	650	40
3	Wheat Straw	60-100	60-80
4	Kenaf (Whole)	800-1000	80-100
5	Bamboo	200-300	80-100

TABLE—2

Vessel content and dimensions of some hardwoods[4]

Sl. No.	Species	Vessel dimensions approx. Mean Length mm.	Width mm.	Area Sq.mm.	Vessel to fiber ratio
1	Dillenia schlectri	2.0	0.38	0.81	1:21
2	Myristica globosa	1.06	0.22	0.24	1:200
3	Dimeleodendran amboinicum	0.78	0.25	0.20	1:173
4	Intsia palemvanica	0.51	0.36	0.18	1:187
5	Pometia pinnata	0.46	0.27	0.12	1:267
6	Ficus botryocarpa	0 39	0.22	0.089	1:270
7	Terminalia solomonesis	0.41	0.23	0.093	1:252
8	Eucalyptus regnans	0.39	0.16	0.066	1:327

Presence of vessel vis-a-vis paper printability :

As already mentioned, the presence of vessel cause problems in printing. These can be of two types : (1) picking problem and (2) low printability. While the picking problem was well recognised and explained but the printability of vessel received little attention. It was found in the laboratory experiments that vessels have lesser capability in accepting the ink.

Printability of paper depends among other things on: (i) surface strength of paper, (ii) smoothness and compressability and (iii) absorbency and ink receptivity. Presence of vessel on a paper surface, possibly could affect these three important qualities of paper.

(1) Pick Problem:

Vessels because of their non-confirmable nature, when present on the surface of paper, tend to pick of from the surface. Though, not much efforts have been made to find out the various reasons for picking tendency, however, the studies conducted by J. Colley etal and Junji Ohswa etal have contributed much for under-standing the problem.

J. Oshwa has cited three fundamental factors affecting the vessel picking tendency :

a) Number, size and shape of vessel.

b) Bonding strength of vessel to fiber.

c) Number and bonding strength of fibers which are covering vessel.

These three factors will inevitably be influenced by process parameters viz., nature of wood species, processing of wood, stock refining and nature of web formation on the machine, etc.

a) **Vessel content and dimensions Vs. Picking tendency:**

When hand sheets were made from pulps prepared with increasing vessel content, it was observed that vessel pick no. increased in proportion to the vessel content at a given beating consistency.

In order to evaluate the effect of vessel size on picking tendency, the vessel pick tendency was studied in relation to vessel size distribution. It was found that the larger vessel elements in hand sheets tend to be more easily picked off at printing press than smaller ones.

b) **Fiber to vessel bonding Vs picking tendency :**

The bonding strength of vessel-paper surface (fibers) vs. picking tendency was evaluated, using two layered hand sheets. As one layer, a pulp with no pick problem was used and on the other layer vessels separated from beaten pulp was dispersed and this side was tested for picking tendency.

It was observed that with increasing degree of beating of pulp layer, the pick no. is reduced proportionately. This was explained in terms of increased bonding between fibers and vessels. It was also found that the vessel pick no. varied depending on pulp fiber shape. These observations clearly indicate that easily confirmable fibers, because of their good bonding potential could bind the vessel to surface and thereby reduce the pick tendency.

c) **Number of fibers covering vessel Vs. picking tendency :**

Since, only when the vessels are exposed to printing ink, the pick problem arises, covering such surface could automatically reduce the picking tendency.

It was found that the addition of a very thin fine layer of fibers to two GSM to a paper surface having picking tendency can effectively reduce the picking tendency of that surface. From this it is said that a few fibers covering vessels in the paper surface could highly contribute to prevention of vessel picking.

In addition to these factors, the sheet structure and the distribution of vessel in it can also affect the vessel picking tendency.

2) **Printability of vessels :**

When vessels were separated from fibers and were evaluated for printability separately, it was observed that pure fibers showed a higher 'P' value than whole pulp, which in turn showed a higher 'P' value than vessel elements alone.

The extremely low 'P' value observed for vessel elements is attributed to two reasons: (1) Unevenness of the print and (2) poor ink retention. The first stems from bulky nature of vessel, which does not allow

vessel to confirm to the sheet, and the second factor is due to the very nature of vessel surface. Because of numerous and deep pits, 'skipping of ink' is possible and the rest of the surface is reported as of waxy nature repelling the ink.

It was also found that printability of vessel could be improved by applying higher pressures during printing operation.

Measures to reduce picking tendency :

As mentioned, the vessel picking tendency can be influenced by no. of process parameters; so by affecting modifications of these processes it is possible to reduce the picking tendency of paper.

1) **Wood selection :**

Though all the papers made from tropical hardwood are known to cause pick problem, the picking tendency appears to vary with density of the wood used. Change in wood density inevitably affects the fiber morphology which in turn affects the paper smoothness.

Fibers those collapse easily give smoother surface than the uncollapsed fibers. A study of the surface profiles of papers made from eucalyptus wood ranging in wood density 300-900kg/M³ has shown that at constant pulp yield, surface roughness increases continuously with wood density. This indicates clearly that denser woods cause more pick problems than lighter woods.

However, practically it is not always possible to select wood according to density. This is more true in case of mixed hard woods.

2) **Extent of cooking :**

The extent of cooking can influence the lateral confirmability of fibers, chemical composition of fibers etc , which in turn can influence the surface properties. It was found that kraft cooking conditions of hardwood chips affect the vessel picking tendency considerably.

It was found that with increasing active-alkali charge, the vessel pick no. of paper has gone up. This corelation was made possible because of the observed fact that bleaching has no marked affect on surface properties of paper. The observation that less alkali charge-less vessel pick is attributed to two reasons (1) Higher hemicellulose content of low active alkali charged pulps may help in establishing bonding between vessel to fiber; (2) High fiber strength resulting from high pulp viscosity.

It is imperative from the above results that vessel pick no. should also be considered, when devising the optimum Kappa No. for tropical hardwood chips.

3) **Treatment of pulp :**

Practically it is very difficult to follow the above two methods. It is somewhat easier to treat the pulp to reduce the vessel pick tendency.

a) **Elimination of larger vessels :**

It is well established that size of vessel plays a significant role in vessel picking; by eliminating larger vessels by screening should lead to pick improvement. Among other methods, hydrocyclones could effectively remove the large, square shaped vessels from pulp. However, the efficiency of vessel removal by hydrocyclones was also found to be lower for mixed tropical hardwoods compared to single wood pulp.

It was found that hydrocyclone treatment could effectively reduce the pick no. of treated pulp but could not eliminate the pick tendency entirely.

However, the practical problems with hydro-clone treatment of pulp are: (1) low consistency requirement, (2) additional cost for treatment and (3) loss of useful fiber alongwith rejects. However, depending upon economie feasibility, hydroclone treatment may become a part and parcel of pulp treatment plant. Especially, this type of separation for non-wood pulps can be highly useful, as non-wood pulps containing high amount of non-fibrous material. Separation on non-fibrous fraction of non-wood pulps will be an extremely useful step to upgrade the pulp quality.

b) **High degree of refining :**

As is already mentioned high degree of refining by improving the vessel to fiber bonding and by

TABLE—3

Influence of beating on vessel picking tendency[4]

Sl. No.	Species	PFI beating revs.	Freeness CSF	Drainage Time Sec.	Vessel pick no./ 20 cm² Mean value
1	Dillenia schlectri	2000	534	5.2	31.8
		4000	225	10.4	6.7
		8000	82	46.6	1.2
2	Ficus Microcarpa	2000	428	5.5	78.6
		4000	301	6.4	34.1
		8000	168	10.6	6.2
3	Intsia Palembanica	2000	618	3.9	56 9
		4000	540	4.5	27.1
		8000	322	5.3	7.8
4	Terminalia solomonesis	2000	460	5.0	106.9
		4000	344	5.7	52.4
		8000	179	8.4	19.0
5	Eucalyptus reganans	2000	406	5.3	10.3
		4000	228	8.2	3 2
		8000	64	33.4	3.2

cutting the vessels to smaller fragments can substantially reduce the pick no. of paper. The influence of degree of beating on vessel pick no. can be seen from Table—3. It is highly interesting to note here about the suggestion that high consistency refining could reduce the vessel pick no. of paper. It was found that when hand sheets were prepared from the pulps beaten at high consistency were tested for pick no. at laboratory, showed reduced pick nos. However, when these sheets were tested on printing machine, they showed high picking tendency than the papers made out of pulps beaten at low consistency.

However, high refining means extra energy and slow down of machine speed.

e) Biotechnological approach :

Enzymes can be used to modify/upgrade the pulp. When hardwood pulps were treated with 'celluloses', vessel picking of papers made from these pulps has been found reduced by 85% than those made from untreated pulps.

4) **Sheet Formation :**

As already mentioned covering a surfacc having vessel picking tendency with thin layer of 2 GSM with a pulp having no vessel pick problem could prevent the picking tendency of the surface. For this, to achieve on machine, stratified sheet formation with single hydraulic head box is suggested. With this technique, it is possible to produce printing papers with no vessel pick problems without limitation of wood species, and without any loss in paper quality.

Stratified sheet formation, to prevent vessel pick trouble, may become an attractive alternative to pulp treatment, where additional stage in pulp processing is involved.

5) **Coating :**

Coating the sheet obviously eliminates the vessel pick problem, as in coating, a new surface is developed which is totally free from pick problems.

Surface sizing to prevent vessel picking is also an attractive alternative. However, with increase in surface sizing paper becomes starchy and stiff.

CONCLUSION :

Despite the good amount of understanding gained regarding vessel pick mechanism, to eliminate the pick problem economically on industrial scale a method is yet to be developed. However, from the perusal of the factors that can influence vessel picking tendency of paper from hardwood pulp it can be said that the potential solutions to eliminate the problem are many. Since, vessel pick being influenced by wood species, by pulping conditions, by stock preparation conditions and by mode of web formation, all in total forms papermaking process, by adopting modifications in any one area it is possible to bring down the problem to a considerable extent. However, the pick problem needs further attention of technologist, especially in India where no attempt has been made so far to study the problem.

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