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PRINTABILITY OF FIBRES AND VESSEL ELEMENTS FROM OAK KRAFT PULP

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THE evaluation of printability is usually done on large printed areas; imperfections on a microscopic scale have been mostly ignored, in spite of their obvious importance. The unevenness of the paper surface often originates from non-uniformity in the morphology of the fibrous material. Thick fibres or particles standing out from the paper surface will produce dark spots, while the very thin, small ones will cause 'valleys' having lighter tones. With the increased use of hardwoods, which may contain 10–50 per cent by volume or 10 per cent by weight vessel elements of 50–500 μm in diameter, whereas the fibres may be only 15 μm, these problems are even more serious.

Procedure

TO DETERMINE the role of vessel elements in the structure of the sheet and its printing properties, vessel elements were separated from fibres by a combination of fractionation and flotation of an oak kraft pulp and used for sheetmaking in unbeaten and beaten (PFI) form.*

Printing was done with a Vandercook No. 4 proof press at various printing pressures. The surface of the printing plate was engraved with straightline grooves at screen rulings of 59 parallel lines per inch. The pattern on the printed sheet consisted of alternate printed regions 0·30 mm wide and unprinted regions 0·15 mm wide.

Evaluation of the print was done by scanning with a microdensitometer and recording the reflectance of the printed and unprinted lines. The results were expressed as a printability factor P (a type of contrast ratio)—

$$P = 100 \log \frac{\text{average reflectance maximum}}{\text{average reflectance minimum}}.$$

* The strength properties of oak and other hardwood fibre and vessel element fractions were reported in *Tappi*, 1965, **48** (5), 264–268

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The degree of whiteness and blackness was also recorded. Some of the results obtained are seen in Fig. 1 and 2, which represent the *P* value and the degree of blackness at 3 and 9 mils printing pressure.

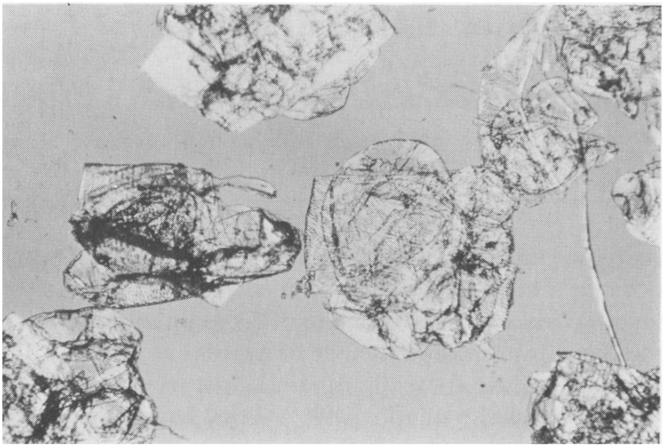

Fig. 1—Photomicrograph of vessel segments from white oak kraft pulp

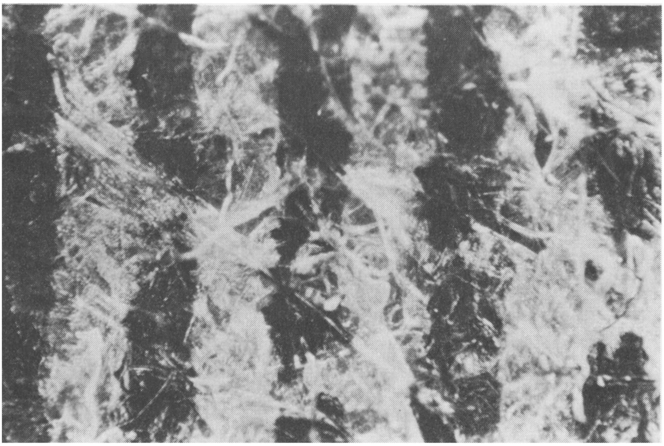

Fig. 2—Print on sheet of white oak kraft pulp (unbeaten)

Printability factor

It is observed that the pulp from which the vessels have been removed (thus consisting mostly of fibres) has a higher *P* value than the 'whole pulp' or the

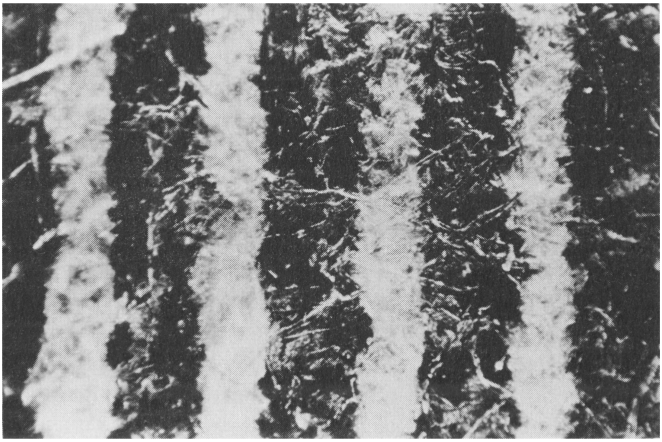

Fig. 3—Print on sheet of white oak kraft pulp (beaten)

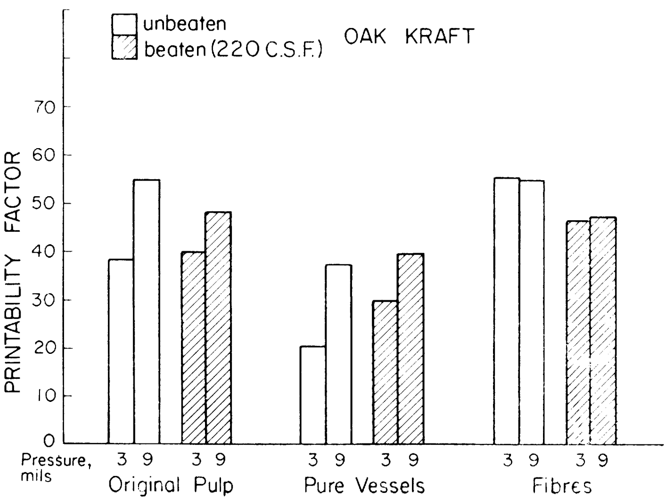

Fig. 4—Printability factor at printing pressures of 3 and 9 mils

pure vessels. Evidently, the thin hardwood fibres conform to each other so well that a uniform and well-contrasted print is obtained even at 3 mils pressure. Increasing the printing pressure to 9 mils does not improve the contrast significantly. Another piece of evidence that the printability is at a maximum is the fact that, with beating, *P* declines.

Vessel elements show an extremely low *P* value for two reasons—(*1*) unevenness of the print and (*2*) poor ink retention. The first stems, of course, from the fact that vessel elements are bulky cells of high coarseness and produce a very rough surface. The second is the nature of the surfaces of the vessel elements themselves. They contain numerous and deep pits, a situation promoting the 'skipping' of ink, whereas the rest of the surface is of a waxy nature, repelling the ink. Therefore, an increase in printing pressure improves the printability of vessels and beating of the cells to low freeness levels has the same effect. Even both of these actions together, however, do not produce a printability compared with that of the pulp fibres.

As could be expected, the whole pulp (which is a mixture of vessel elements and fibres) occupies an intermediate position, though the effects are not strictly additive.

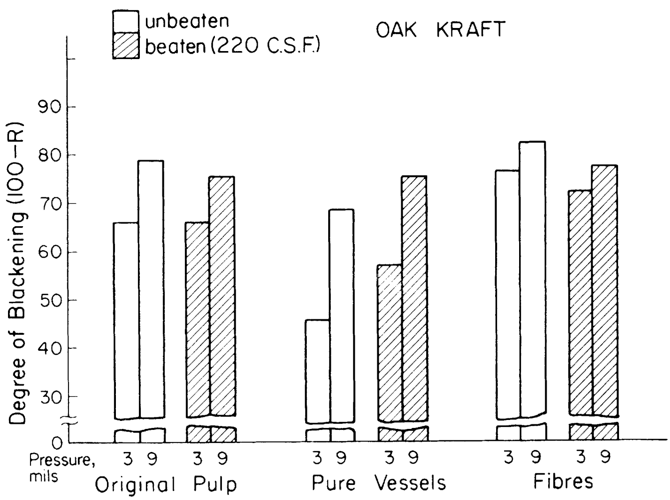

Fig. 5—Degree of blackening at printing pressures of 3 and 9 mils

Whiteness and blackness

As MENTIONED earlier, the printability factor is a measure of the printing contrast and is a ratio. As such, it gives no indication of degree of whiteness and blackness in unprinted and printed areas, respectively. Therefore, it is useful to give values for degree of blackness; these values are shown in Fig. 2.

Again, it is seen that the fibres print well, whereas the unbeaten vessel elements are about half as black as the fibres; only a combination of strong beating and high printing pressures brings up the printing quality of vessel elements to that of the fibres. Once more, the original pulp occupies a position intermediate between vessel elements and fibres.

Transcription of Discussion

Discussion

The Chairman The next contribution is rather unusual. It is the presentation of illustrations by Dr J. Mardon, who has studied the interrelationship between a number of factors that relate to the things we are talking about this morning and to other areas covered by the symposium. He has offered to supply copies of the charts to anyone who approaches him for them.

Dr Mardon is associated with Mr George Williams in describing these results as important. They state that it is not accurate to discuss the sheets produced by two-wire formers as if they were identical. Each two-wire former has its own characteristics. Results obtained during a paper structure investigation carried out over a long period are shown in Fig. L. It should be noted that the results of the Bel Baie former are for the Bel Baie mark 1.

Fig. M relates papermaking technology and those papermaking characteristics important in printing to sheet structure.

Fig. N illustrates uniformity of sheet strength and printing quality as related to furnish, system and papermachine characteristics.

Fig. O illustrates the interrelationship of surface and internal structure characteristics, which together determine the total sheet structure. The vital areas of study of sheet structure are given.

Fig. P–T illustrate typical sheet structural characteristics as described from sheet cross-sections.

Dr J. Marton My one comment is on the basic difficulty in printability assessment of fine papers and boards, namely, that the customer may have minimum requirements in most properties, but they have a preference. Their variety may make it very difficult (if not impossible) to express printability of a paper in one given number. Nonetheless, certain properties might be more generally sought after than others—one group of customers will prefer matt paper, others glossy paper. It seems usual for one common demand to be for high printed gloss. A good understanding of the printed gloss measurements or the development of printed gloss would be quite useful and generally applicable: it necessarily depends *inter alia* on the gloss of the unprinted

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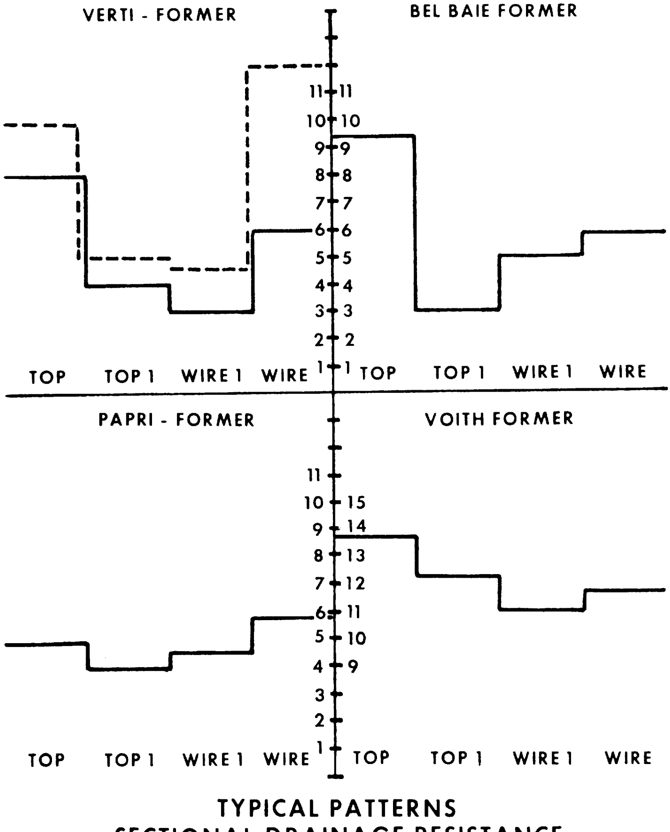

Fig. L—Table and drainage resistance for four types of two-wire former for four successive layers of the sheet

paper, on the smoothness of the surface and on the ink absorbency. Taking a homogeneous group of samples of coated board, our study indicated that, in a homogeneous group in which the variance comes mainly from production, both from changing formulation or conditions, 60–70 per cent of the printed gloss variance was caused by the variance of the unprinted gloss of the board and the rest by variance of surface roughness. This means that, although the level of expected printed gloss cannot be predicted from the unprinted gloss alone, it would be a challenging task—to keep production more uniform—and it would be very useful if one could measure the unprinted gloss of the paper or the smoothness or both, continuously and directly on-line. Our greatest challenge is to maintain consistency of product quality.

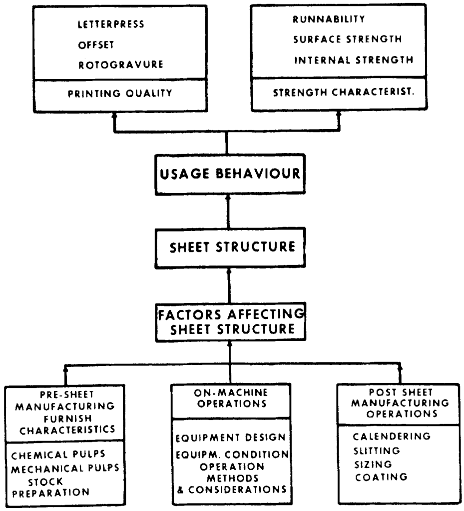

Fig. M—Sheet structure as the focal point in a study of papermaking technology

Mr J. R. Parker Just before this conference, I spoke to Dr Larsson by phone and his comment on my paper was about the term printability. He said, 'It's very misleading, for it conveys the idea of just one number.' Printability is a term that we realise embraces a number of very different properties. It is impossible to express the idea of printability in any one number and paper must quite clearly be tailored to the requirements of certain customers. With newsprint, those running fast presses want one thing and those with old slow presses want another.

Dr H. G. Higgins I should like to refer to your conclusion or thesis that it is not merely the compression of the projecting parts of the paper surface, but also the flexing of the paper that is responsible for the decrease of roughness with pressure. Just before I left Melbourne, Dr Colley completed some Print-Surf experiments on a range of hardwood kraft handsheets beaten to 2 000, 4 000 and 8 000 rev in the PFT mill. We were prepared for the effect of roughness either to decrease or to remain constant (based on our experience with de Yong's profiler). What happened in fact was that the roughness decreased with beating in some cases, but there was a highly significant increase in the Print-Surf measurement with beating in others. I think this to be consistent with your thesis. We have not yet measured the elastic modulus of these papers, but it may be interesting to see how the trends with beating in relation to the roughness changes fit in with your hypothesis. I should mention also that compressibility measurements were taken as the ratio of the Print-Surf readings at 10 kgf/cm² to that at 20 kgf/cm² (soft backing, gloss side of the sheet). The compressibility figures ranged 1·03–1·08.

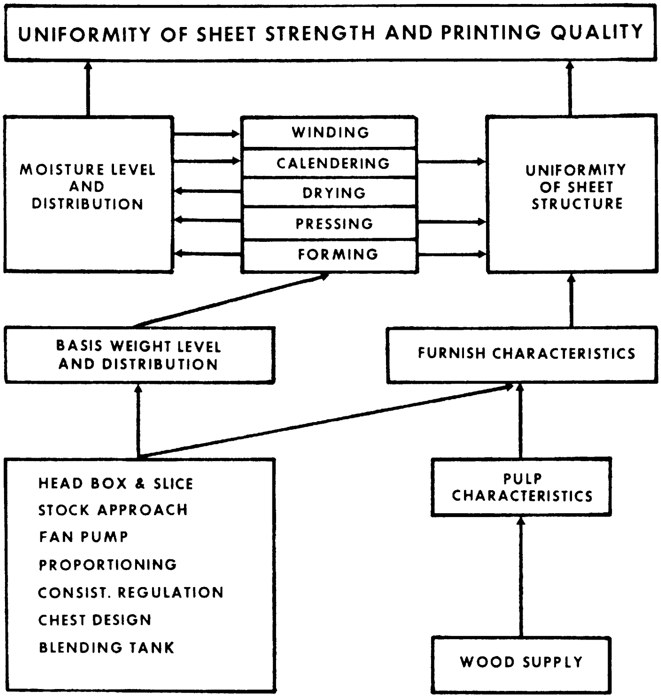

Fig. N—Relationship of papermachine system characteristics to uniformity of sheet strength and printing quality

(*Submitted addendum* The variation of stiffness with beating—an initial increase arising from increase in Young's modulus, followed by a decrease because of reduction in thickness—was discussed by Gallay in his symposium contribution. Different positions of the stiffness maximum, with beating, could help to determine whether there is a rise or fall in Print-Surf roughness.)

Dr S. Karttunen I would like to speak about Joe Marton's comment on print gloss and paper gloss. It is quite natural when trying to explain the variations in print gloss to use the paper gloss as the first argument. It is because paper gloss measures the paper smoothness indirectly in the same manner as print gloss is measured, since paper gloss is normally measured without using any pressure. Most current roughness or smoothness methods use pressure, which is another thing. Pressure comes into the picture at the printing nip, but it has nothing to do with paper or print gloss in its relaxed state after the ink film has been set and dried.

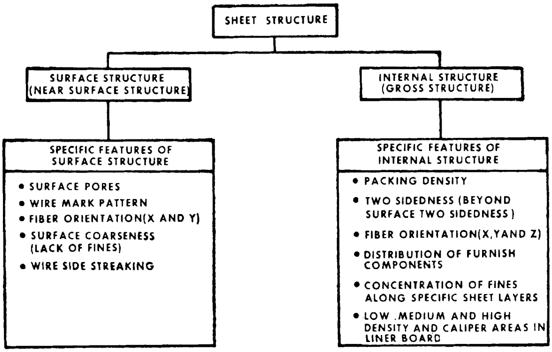

Fig. O—A breakdown of vital study areas when examining sheet structure

Mr J. A. S. Newman The oil penetration test measures the time it takes for an oil drop to penetrate the sheet completely. This time can be very different, depending on which side of the paper is tested; furthermore, it can be altered drastically by the action of the wet presses on the papermachine—for instance, a straight press increases the time that the oil takes to go from the wire side of the sheet to the top side. Thus, this change may occur through a change in the structure of the paper and particularly of the surface of the paper.

Has this change in structure ever been observed physically in any other tests on the porous structure of the sheet or of the surface of the sheet? Secondly, has it ever been considered as a possible reason for differences in printability on the two sides of the sheet?

Prof. D. Wahren Mr Graeme Robertson at STF, Stockholm has performed a long series of experiments that relate to this question. In general, the more wet pressing used and the higher the temperature in drying and the higher the drying wire tension, the more dense the paper and the rougher its surface measured with a Bendtsen surface roughness tester and a Print-Surf tester using various pressures.

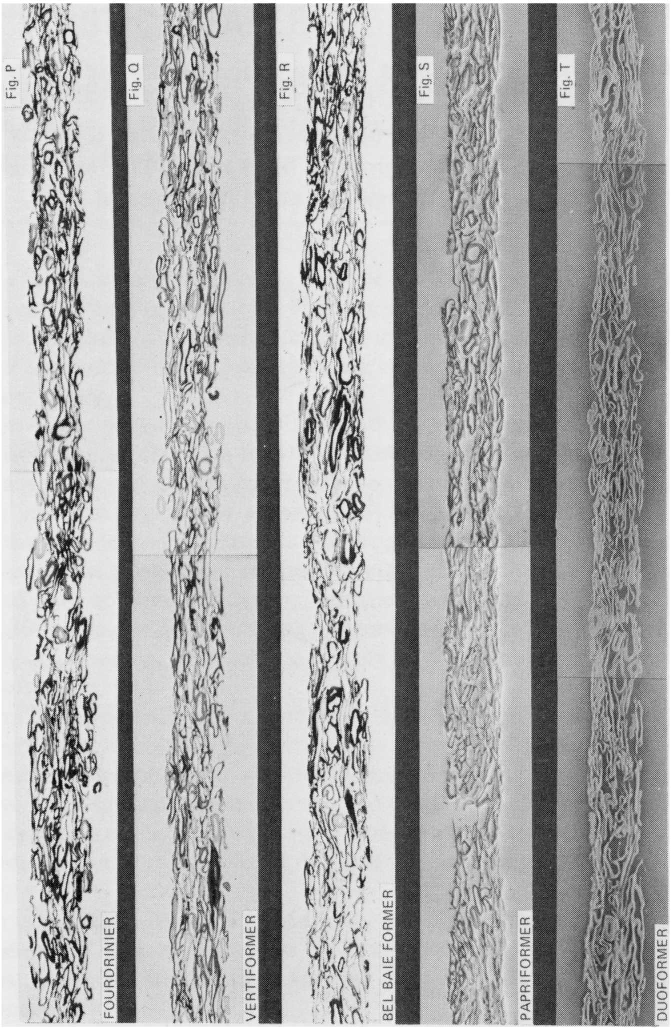
Fig. P
FOURDRINIER
Fig. Q
VERTIFORMER
Fig. R
BEL BAIE FORMER
Fig. S
PAPRIFORMER
Fig. T
DUOFORMER

Fig. P—T

Mr B. Radvan It was suggested that conformability is concerned rather than compressibility of the paper. This takes place over very small distances comparable with the thickness of the paper, so it is not really stiffness as measured by modulus or by any flexural test, but something rather more complicated.

Mr Parker I was talking about flexing over distances of the order of 100 microns. I agree with you, but I do not know what is the appropriate property. There is an empirical test by Paszkiewicz (referred to in my paper) in which the paper is pushed through small holes to find how far it has gone. This looks relevant, but it is of course not at all fundamental.