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THE BEHAVIOUR OF SINGLE WOODPULP FIBRES UNDER TENSILE STRESS

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Dr Page presented an interesting film with an informative commentary upon it, which without the film is not of value in itself and so cannot usefully be reproduced, but the authors have provided the following synopsis.

A unique apparatus has been built and techniques developed that permit a fresh approach to the study of fibre properties. The apparatus is a stress/strain recorder for testing single fibres under axial tensile load. It is fitted with a high power polarising light microscope so that fibres can be observed during straining. Both the microscopical image and the trace of the stress/strain curve can be recorded on ciné film, in synchronism, so that the visual appearance of the fibre and its state of stress and strain at any time can be displayed. The detailed physical events that coincide with initiation of yield and failure are dramatically revealed.

The presentation consisted of a series of ciné sequences that demonstrate phenomena that relate to the tensile properties of fibres, including—

1. The effect of fibril angle on fibre strength and stretch-to-break.
2. The initiation of rupture by defects.
3. The tensile behaviour of microcompressed fibres.
4. The phenomena that occur when a fibre dries under tensile stress.
5. The tensile behaviour of wet fibres.

Under the chairmanship of Prof. H. W. Giertz

Transcription of Discussion

Discussion

Dr J. Marton I would like to comment on the Z-directional distribution of vessel segments in paper made on Fourdrinier papermachines. Unlike the handsheets of Dr Higgins, the machine-made papers usually are two-sided. It is a well-known problem that the top side of the sheet is more involved in vessel segment picking troubles than the wire side. Vessel segment picking is especially disturbing when making hardwood-based offset paper.

A still widely held belief has been that the vessel elements float on to the *top side* while the sheet is being formed on the wire, just as there is an accumulation of ash in this direction. Byrd & Fahey (*Forest Prod.J.*, 1969) found, however, more vessel elements surprisingly in the *wire side* of the sheet. If I remember correctly, they investigated unfilled hardwood furnishes. Thus, the question remains why the top side releases more vessel segments if their number is, in fact, larger on the opposite side of the sheet.

Most printing papers contain fillers to achieve desired optical properties. We investigated paper rawstock made on Fourdrinier machines with speeds ranging 700–1 500 ft/min; the grammage of the rawstock ranged 35–55 lb/ream. The fibre furnish contained hardwood (2/3) and pine (1/3) bleached fibres. Since the desired level of ash in the sheet was around 10 per cent, the headbox furnish could have contained about 25 per cent pigment and, in addition, about 30 per cent cellulose fines. Thus, an actual furnish contains less than 50 per cent of fibre.

1 mg furnish contains

7 500	hardwood fibres
750	pine fibres
60	vessel fragments
15–20	oak vessel elements
0·23 mg	pigments
0·27 mg	cell fines

Sheets from five different machines were split into two parts on a Beloit splitter, ash was determined in the splits, fibre content and vessel segments were counted on a slide by the usual microscope technique. The felt side splits usually contained 2–3 times as much ash as the wire side parts. The

Under the chairmanship of Prof. V. T. Stannett amount of vessel segments proved to be, however, identical in both top and wire side parts (see Table 1).

In general, 1 mg of the actual headbox furnish (about 0·5 mg fibres) contained around 8 000 hardwood and 800 pine fibres, a good number of disintegrated vessel fragments and around 60 largely untouched potentially harmful, mostly oak vessel segments. Even though the great majority of the vessel elements had been disintegrated during refining, there would be hundreds of thousands of potentially harmful vessel segments on the paper surface contacting the tacky printing forme on a press. Even a few picks are judged as unacceptable, thus the vessel elements must be bonded in the sheet with better than 99 per cent efficiency in order to pass the mill quality control test.

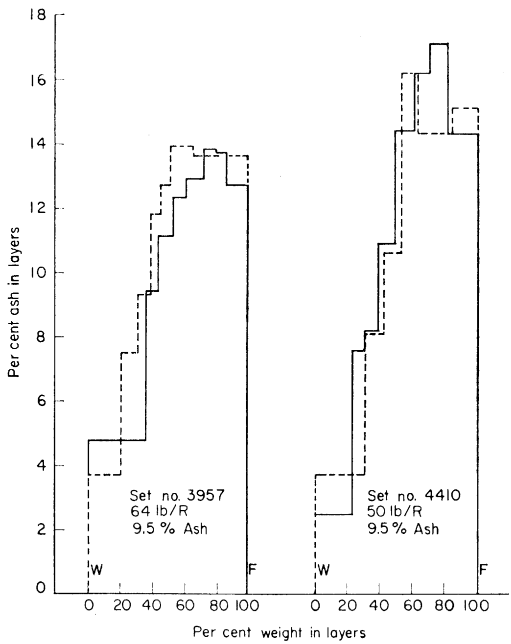

Fig. I

I suggest the following explanation for the lower surface strength and inferior vessel segment pick resistance of the top (felt) side. It has been demonstrated by several authors that ash distribution exhibits a very skewed form (towards the felt side) in machine-made (Fourdrinier) papers. A typical ash distribution curve is presented in Fig. I. A rawstock that has an average 10 per cent ash content may have only 5 per cent ash in the wire side surface layer, but over 15 per cent ash in the felt side layer, directly in contact with the printing plates. The fillers are adsorbed on fibre surfaces, physically preventing fibre-to-fibre contact. The more filler, the more extensive this debonding effect. The reduced interfibre bonding also means weakened bonding between fibre and vessel element. We propose that the increased vessel segment picking potential of the top (felt) side of the sheet is not caused by any increase in the number of vessel segments present in the felt side layer (compared with the wire side), but the surface pick resistance weakens because of the increased ash content on the felt side effecting debonding between fibre and vessel segments in the top side layer. The practical solutions sought must then counteract this effect.

TABLE 1—VESSEL SEGMENTS AND ASH IN THE SPLITS
(Beloit sheet splitter)

Paper-machine No.	*Grammage, l/r*	*Weight ratio W/F at split**	*Total number of vessel elements and fragments per mg oven-dry pulp (S+K)*		*Oak elements and fragments per mg oven-dry pulp (K)*		*Distribution ratio (S+K) W/F*	*Total ash, per cent*	*Ash ratio W/F*
			W	*F*	*W*	*F*			
3	45	1·2:1	51	37	15	12	1·4:1	5·9	0·6:1
5	58	1·1:1	53	52	12	14	1:1	8·3	0·6:1
8	39	0·6:1	60	62	20	18	1:1	9·6	0·3:1
9	32	0·9:1	73	65	21	19	1·1:1	10·2	0·4:1

* Mean values of 10 splits

Dr J. Mardon There is another possible explanation for Dr Marton's findings. In the press, the total pressure is made up of the hydraulic pressure and the compaction pressure of the sheet. The total pressure must remain the same as the sheet passes through the nip. The hydraulic pressure has to change: it is greatest on the bare roll side, least on the side of the sheet in contact with the felt. Therefore, the compaction pressure is greater on the side against the felt than that on the bare roll, so it may be that Dr Marton's sheets come more compacted on one side than on the other, owing to the pressure gradient in the nip.

Dr Marton Differential sheet compaction may have some effect that may be of more significance in unfilled sheets. Our conclusion is based on a quite detailed study of different variables with filled sheets. A most convincing one is the observation that, by increasing the specific surface area of the chosen filler (at constant filler load), we can increase the debonding effect and, correspondingly, the pick number strongly increases. This behaviour can hardly be explained by a compaction hypothesis.

Discussion

Dr J. Grant This is an interesting and new approach to a very old problem, but I am rather surprised that there is any problem with fluffing from eucalyptus furnishes. When I first started using eucalyptus, I suppose about 40 years ago, it was something of a problem, but much has happened in the meantime. For example, it has been known for many years that beating reduces the fluffing tendency; on the other hand, if you overdo it, you lose opacity. You may rectify this by going to the expense of adding titanium dioxide, but you still have the dimensional instability induced by beating, so there are limitations to the use of beating. On the other hand, by striking the right balance between beating, loading, furnish, etc., it is possible to produce papers that give no fluffing trouble whatsoever, even though they contain a high proportion of eucalyptus. If these expedients cannot be used, the machine size press remains; if this fails, quite the best method of removing the offending fines is to put the stuff through a Celleco or similar screen. I am puzzled therefore that the necessity for such an investigation should arise in this day and age.

Dr H. G. Higgins Our interest in this subject is not only for eucalyptus, but for tropical hardwoods as well. We commonly use eucalypts as reference pulps, in addition to our intrinsic interest in them. For young plantation-grown eucalypts, the problem of vessel picking may be of lesser significance than for the overmature eucalypts that are pulped in Australia and now in Japan and that have larger vessels than young wood. Furthermore, the high density eucalypts, which are not yet used for pulping, would be expected to give rise to enhanced picking problems, as indicated in our paper. We are of course aware of the various methods used to overcome vessel picking. Size press application and high consistency beating could also be mentioned.

Dr D. W. Clayton Do the dark streaks due to ellagic acid disappear easily on bleaching or do they pose a problem? I presume that, in any case, they increase the chemical consumption.

Dr H. G. Higgins Yes, the spots in unbleached paper have been correlated with the occurrence of ellagic acid in the wood. These materials tend to be removed by conventional bleaching processes. In pulping, they increase chemical consumption very substantially.