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MATERIAL LOSSES DURING DEFIBRATION AND BEATING OF HIGH-YIELD PULPS

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1—*Introduction*

ONE of the problems arising in the utilisation of high-yield pulps in paper-making is their tendency to produce various kinds of dissolved matter during mechanical treatment. One result of this is that the amount of paper producible from a given amount of wood is less than that which is calculated from the pulping yield. Moreover, the hazard element of the effluent from the environment aspect is increased.

The literature contains little discussion of this problem, although Sjöström *et al.* have observed the dissolution of xylan from birch pulps of both normal and high-yield. [1, 2]

Within the framework of a project concerning the optimisation of the defibration and beating of high-yield pulps a study has been made of the material losses that occur during these process stages. The results of this study are presented in the following.

2—*Experimental*

IN this study, which was carried out on a laboratory scale, the following types of pulp were prepared:

Magnesium-bisulphite pulp from spruce, yield approx. 50–80 per cent
Magnesium-bisulphite pulp from pine, yield approx. 70–80 per cent
Sulphate pulp from pine, yield approx. 48–60 per cent
NSSC pulp from birch, yield approx. 77–87 per cent.

Subsequent to cooking, the wood chips were carefully washed and defibrated, in one or a number of stages, in an 8-in. Bauer disc refiner at a consistency of approx. 20 per cent. The whole of the quantity of water used during the defibration process was collected, measured, and sampled for further tests. The defibrated pulps were beaten in a laboratory scale conical refiner, at two different specific edge loads of 1·0 and 3·0 Ws/m, respectively.[3, 4] The pulp consistency during refining was 3 per

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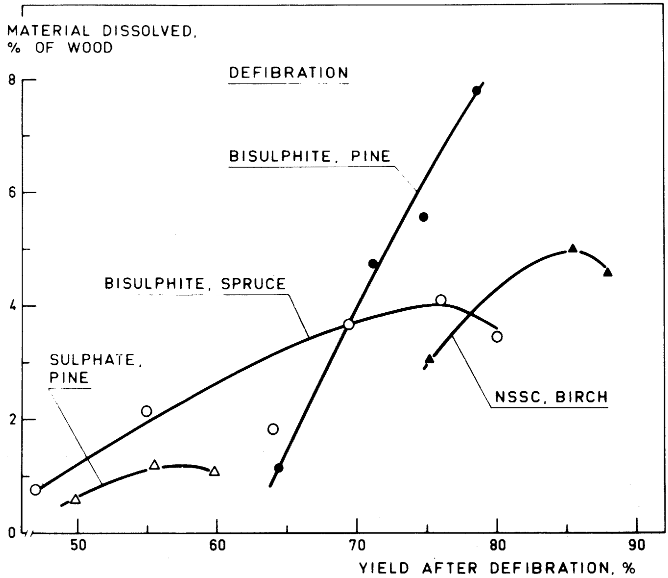

Fig. 1—Material dissolved during defibration of high-yield pulps

cent. A pulp sample was taken at the end of the beating. The water was drained from this through a 100-mesh screen, and retained for further tests.

The water samples thus obtained were analysed for solids content and in some cases for carbohydrate composition and lignin content.

3—*Results*

3.1—*Material losses during defibration*

FIG. 1 illustrates the amount of dissolved material as a function of the pulp yield, measured *after defibration.* It is seen from the curves that considerable material losses occurred during the defibration stage and that the losses increase with increasing pulp yield. One interesting feature is that the material losses seem to be more markedly dependent upon the yield than upon the type of wood, or upon the pulping process applied. For the pine sulphate, spruce bisulphite, and birch NSSC pulps, the defibration losses, related to the amount of wood are:

Approx. 2 per cent at a yield of 60 per cent.
Approx. 3–4 per cent at a yield of 70 per cent
Approx. 4–5 per cent at a yield of 80 per cent.

For the pine bisulphite pulp the losses were substantially higher than for the

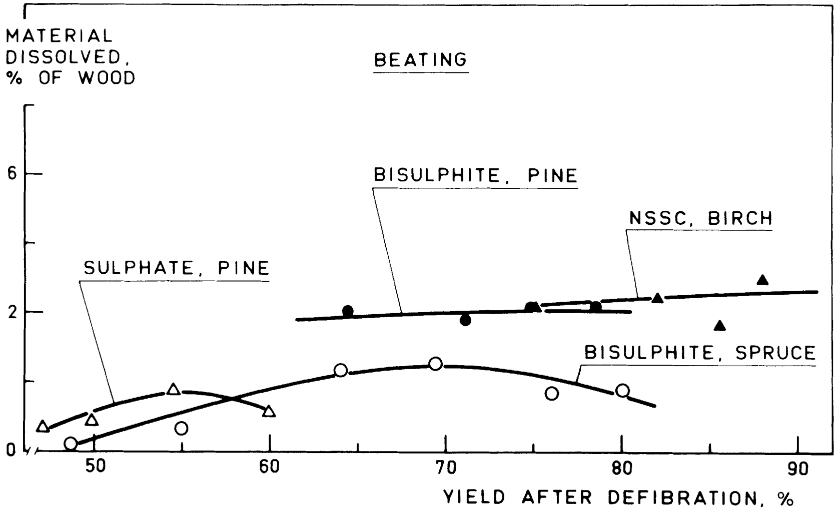

Fig. 2—Material dissolved during beating of high-yield pulps

others. The curves indicate that the material losses may even amount to some 8 per cent if the yield subsequent to defibration is 80 per cent.

Another interesting feature is that during defibration the material losses appear to reach a maximum at a certain yield level which varies from one type of pulp to another. For the pine sulphate pulp, this yield level seems to be at approximately 55 per cent; for the spruce bisulphite pulp it is about 70–75 per cent; for the NSSC pulp about 85 per cent; and for the pine bisulphite pulp above 80 per cent. The results thus indicate that the maximum losses, as a result of mechanical treatment of the chips, occur at a certain stage of delignification, that is to say, at a certain stage of softening of the wood material.

In one case, studies were made of the material losses after a number of consecutive defibrations of a spruce bisulphite pulp at a yield level of approximately 70 per cent. The results indicated that the main part of the losses occur during the two first passages of the pulp through the refiner. The losses are very small at later stages.

3.2—*Material losses during beating*

The material losses during beating are much lower than those that occur during defibration. Fig. 2 indicates that they are of the order of 1–2 per cent on the amount of wood. They rise with increasing pulp yield, but at a rate much lower than in the case of defibration. For the pine sulphate and spruce

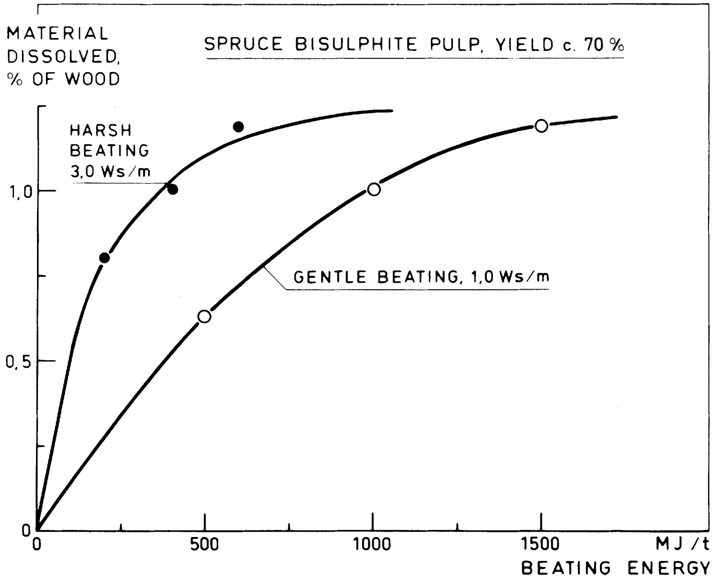

Fig. 3—Influence of the type of beating on material dissolved during beating

bisulphite pulps, clear maxima are observed in the material losses at certain yield levels. These yield levels correspond to those at which the material losses reached a maximum during defibration.

The quantity of material losses measured indicates that about three fourths of the total losses occur during defibration, and no more than about one fourth during beating. From a practical viewpoint, this means that it becomes necessary to arrange a pulp washing stage between the defibration and beating stages, if we wish to prevent a major part of the dissolved material from getting to the paper-machine and hence into the mill environment.

One general aim of this study was to determine the influence of the way of beating on the properties of high-yield pulps. In the case of a spruce bisulphite pulp, measurements of material losses were made on samples taken at different points of beating; in this case, the results presented in Fig. 3 were obtained. In other cases, with waters being sampled solely at the beating end-point, the material losses at 70 per cent yield amounted to approx. 1·1–1·3 per cent (Fig. 2). The conclusion may be drawn that the type (intensity) of beating influences the amount of material suspended for as long as it is a matter of small and medium amounts of beating. With a further increase in the extent of beating, the quantity of material losses approaches a level characteristic of the type and the yield of pulp in question.

Combining these results with those obtained for the defibration of pulps, it may be deduced that the fibres of a high-yield pulp always carry a given, although limited amount of material, which is removable by the application of a particular type of mechanical treatment. For instance, when a pulp is subjected to high-consistency defibration, a certain type and amount of material will be dissolved. When the pulp then goes through a low consistency beating stage, another, although limited, amount of substance is available for the dissolving action of the process.

3.3—*Composition of the material losses*

In a few cases, the material dissolved in the defibration and beating waters was analysed for the ratio between lignin and hemicelluloses, and the composition of the hemicelluloses. The results shown in Table 1 were obtained.

It is seen from these figures that in every case the amount of lignin dissolved was greater than the amount of hemicelluloses. Mannose seems to be the component most easily dissolved during defibration of high-yield softwood bisulphite pulps. In the case of pine sulphate, the type of hemicellulose most easily removed during defibration seems to be the xylose.

Comparing the figures for the beating values with the corresponding values for defibration waters, it is seen that for the two bisulphite pulps, the relative amount of xylose clearly increased during the beating whereas the amount of mannose correspondingly decreased. In the case of pine sulphite pulp, galactose and glucose seem to be the components dissolved during beating.

The composition experiments indicate that the composition of material dissolved is dependent not only on the wood material and the pulping method

TABLE 1—COMPOSITION OF MATERIAL DISSOLVED DURING DEFIBRATION AND BEATING OF DIFFERENT HIGH-YIELD PULPS

	Spruce bisulphite		*Pine bisulphite*		*Pine sulphate*	
	Defibration	*Beating*	*Defibration*	*Beating*	*Defibration*	*Beating*
Lignin (%)	55	60	65	70	>50	>50
Hemicelluloses (%)	45	40	35	30	<50	<50
Composition of hemicelluloses:						
arabinose	3	1	4	1	17	8
xylose	18	51	17	48	53	34
mannose	46	24	44	22	3	4
galactose	12	5	18	5	14	48
glucose	21	18	17	23	13	50
Pulp yield after defibration (%)	68		78		50	

used, but also on the amount of mechanical treatment to which the pulp is subjected. Normally the quantity of lignin suspended is larger than that of hemicelluloses. For softwood bisulphite pulps, mannose is the hemicellulose component most easily dissolved during defibration, whereas the hemicellulose dissolved during beating consists mainly of xylose.

4—Conclusions

THE results presented above permit of the following conclusions to be drawn:

1. During the mechanical treatment of high yield pulps, rather substantial material losses may occur. Some three fourths of the total losses occur during defibration, and approximately one fourth during beating.
2. The material losses are greatly dependent on the pulp yield. For each type of pulp there seems to be a certain pulp yield at which the losses reach, and pass through, a maximum.
3. In many cases, the magnitude of material losses apparently depends more on the yield level than on the species of wood, or the pulping method applied. Nevertheless, for the pulps studied, it was found that pine bisulphite pulp suffered the highest material losses during defibration and beating.
4. For each high-yield pulp, there seems to be a certain, limited amount of material which can be dissolved by the application of a certain type of mechanical treatment. With low and medium amounts of beating, harsh beating will result in higher material losses than a gentle beating. With extended beating the type of beating does not affect the material losses.
5. The material losses themselves are so great in extent that they certainly need to be taken into account when high-yield pulping processes are used.
6. As most of the material losses occur during the defibration stage itself, a large proportion of environmental problems can be dealt with by careful washing of the pulp between defibration and beating.

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Transcription of Discussion

Discussion

Mr B. Cornéer It is obvious that especially for the high yield pulps there is a loss in material during mechanical treatment. Have you been thinking of the question of optimisation between further pulping and lesser defibration energy, especially for these high yield pulps? When you pulp you have a different composition of the dissolved material than when you defibrate. Do you have any comments on this optimisation between pulping and defibration with respect to paper properties, total energy demand, and maybe also to the load on the environmental system?

Levlin We have so far concentrated on the physical properties of high-yield pulp, the strength properties, etc., in relation to defibration and beating. So we haven't taken into consideration optimising the pulping from an environmental point of view. No doubt there is scope for optimisation but I think it is too complicated a problem to discuss here.

Prof. H. W. Giertz When you passed your pulp through a hundred mesh screen did you examine the through-fraction under the microscope to see if it contained fines as well as dissolved material?

Levlin All the measurements that I have reported in my paper are based on the total amount of material which passed through the screen. However, we also measured the amount of solid particles that had passed through the screen and they were normally in the range of 5 to 10 per cent of the total amount found after evaporation of the water.

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