PULP BLENDS OF BEATEN AND UNBEATEN FIBRE: EFFECTS ON PAPER PROPERTIES, AND POSSIBLE COMMERCIAL IMPLICATIONS

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ABSTRACT

The effects on paper strength and optical properties of blending unbeaten and beaten radiata pine kraft pulps have been examined. Various proportions and combinations of unbeaten, lightly beaten, or heavily beaten pulps were blended with a series of pulps which had been beaten to different levels.

The addition of from 10 to 30 percent of unbeaten corewood or slabwood fibre caused handsheet tensile strengths and extensibilities to be substantially increased when compared at the same sheet densities. Tear/tensile strength relations were unchanged by the addition of unbeaten fibre, although an apparent drop in tearing strength occurred for given sheet densities. The effects of adding lightly or heavily beaten fibre to blends of unbeaten and beaten fibre were to decrease strength improvements brought about by the presence of unbeaten fibres.

Some possible commercial implications of the study are discussed and include the suggestion that papers could be produced with conventional strengths but with lower-than-normal basis weights or higher-than-normal opacities. It is envisaged that the addition of unbeaten fibre to beaten pulps could lead to the production of more usable paper from less wood, and possibly with the use of less energy.

INTRODUCTION

Studies with laboratory beating systems have indicated that pulps which consist of fibres with a wide range of flexibilities produce papers with higher-than-normal tensile strengths (Kibblewhite, 1972; 1974). The possibility that small proportions of unbeaten fibre can form a strengthening network within a matrix of beaten fibre is examined in the present study. The effects of blending different proportions of unbeaten fibre, lightly beaten fibre, and heavily beaten fibre with beaten pulps are studied.

The production of papers with high tensile strengths at low sheet densities could give increased opacities and/or decreased basis weights and energy consumptions. The manufacture of products with lower-than-normal basis weights would allow more paper to be produced from less wood, which in turn would lower overall chemical and energy usage.

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EXPERIMENTAL

The experimental studies were carried out over a period of time, and utilised several radiata pine kraft pulp samples. The study of unbeaten and beaten fibre blends used corewood and slabwood pulps described in earlier publications (Kibblewhite, 1973; 1974). The kraft pulp used in the unbeaten, lightly beaten and heavily beaten blends were prepared from a different slabwood sample (Kibblewhite and Brookes, 1977).

Blends were prepared by mixing proportions of fibre slurries of known consistency. Pulps were prepared by standard procedures and were beaten in a PFI mill at 10 percent stock concentration with an applied load of 1.8 kg/cm. Throughout the text the term "primary pulp series" refers to corewood or slabwood processed in the PFI mill for 2000, 4000, 8000 or 16 000 revolutions. Various proportions of unbeaten, lightly beaten (1000 and/or 3000 revolutions) and heavily beaten (24 000 revolutions) fibre were blended with the primary pulp series.

RESULTS

For ease of reading many of the graphs presented show highly correlated linear regressions only. Individual datum points, regression analyses data, analyses of variance, and tests of significance of differences between regression slopes and intercepts have been presented in an unpublished report available from the Forest Research Institute (Kibblewhite, 1976). Numerical subscripts associated with data points shown in certain figures indicate blends corresponding to pulps beaten to different extents. Subscripts 1 to 4 correspond to pulps beaten for 2000, 4000, 8000 and 16 000 revolutions respectively (Figs. 1-4, 9).

Blends of Unbeaten Pulps of the Primary Series

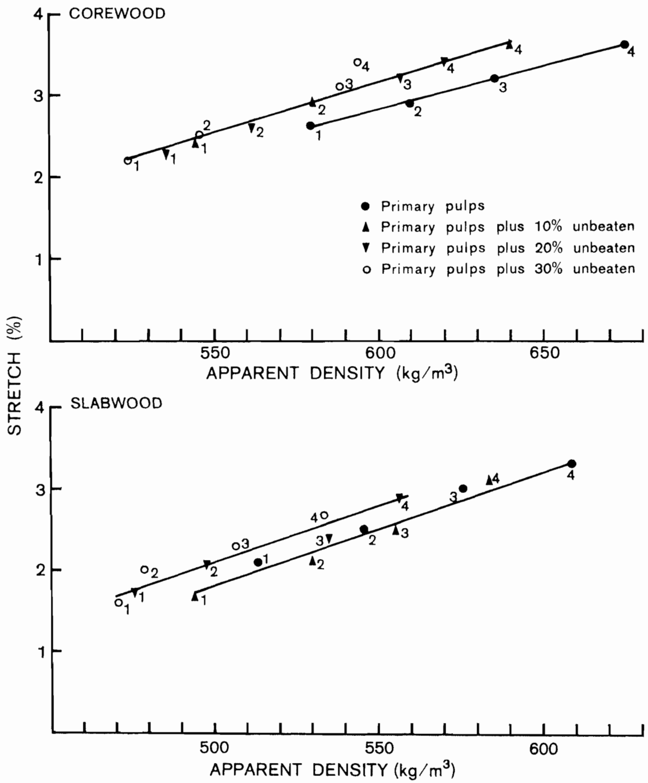
For the same sheet densities, tensile strengths and stretch were increased, and tearing strength was decreased slightly, by the addition of unbeaten fibre to the primary pulp series (Figs. 1-3). Strengths of the corewood pulp were modified by the addition of up to 10 percent of unbeaten fibre, whereas the corresponding slabwood pulp required up to 20 percent of unbeaten fibre before strength properties were altered. The addition of 10 percent of unbeaten slabwood fibre caused tensile strength to decrease proportionately with sheet density (Fig. 1). This behaviour was expected, but it was surprising that disproportionate changes in tensile strength were obtained with the addition of 20 percent of unbeaten slabwood fibre and 10 percent of unbeaten corewood fibre. Further increases in the proportions of unbeaten fibre caused handsheet densities to decrease but not regression slopes and positions (Figs. 1-4).

Effective improvements in tensile strength brought about by the addition of various proportions of unbeaten fibre to beaten pulps are shown in Fig. 5. The results termed "expected" are based on the extrapolation of blend tensile values to the tensile-density regression of the primary pulp series (Fig. 1; corewood).

Trends for tearing strength varied for slabwood and corewood pulps as well as for the unblended and blended pulps (Fig. 3). Corewood sheet densities were higher, and tearing strengths were lower than those of the slabwood pulps. For given sheet densities, the tearing strengths of blended pulps were, in general, lower than those of unblended material (Fig. 3) (Kibblewhite, 1976). Tear/tensile relations on the other hand were in general similar for the unblended and blended pulps (Fig. 4). Thus, the improved

FIG. 1 (right)—Tensile strength and sheet density.

FIG. 2 (below)—Stretch and sheet density.



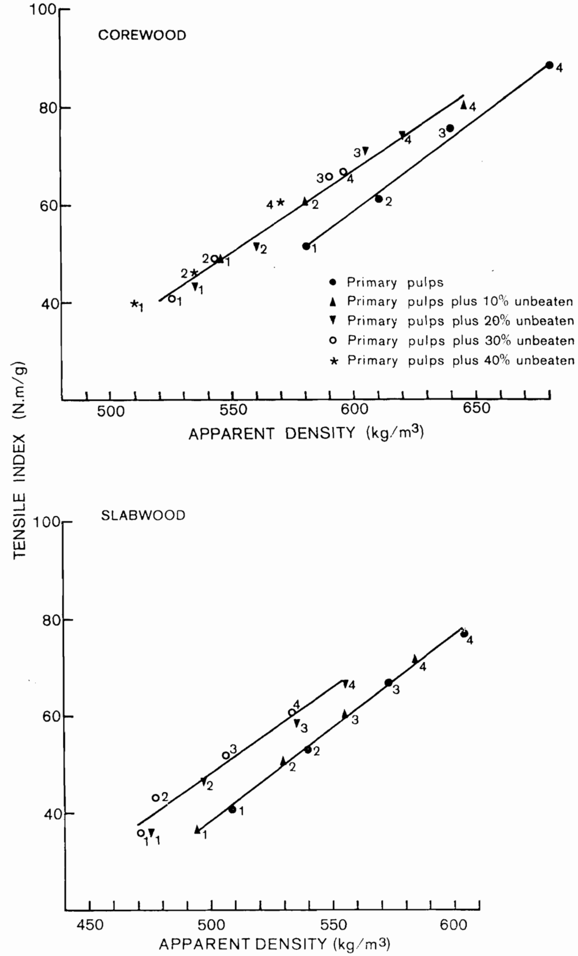
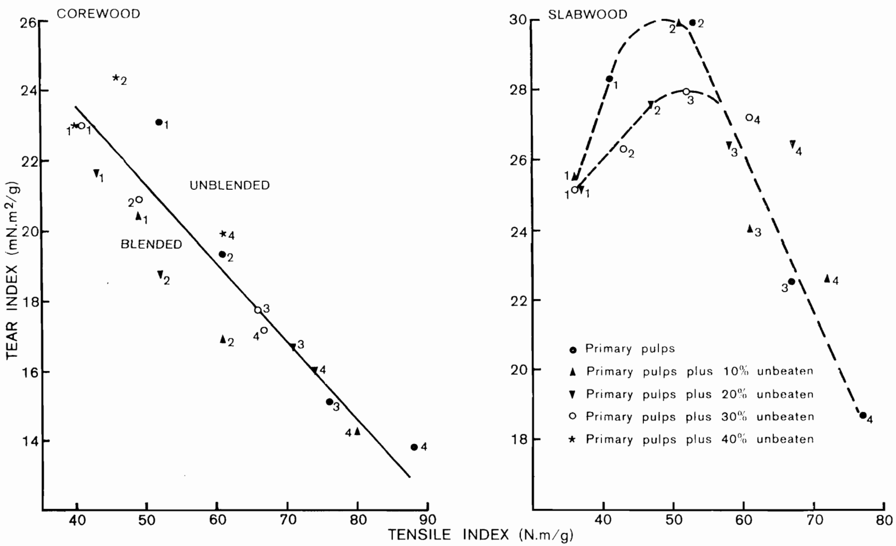
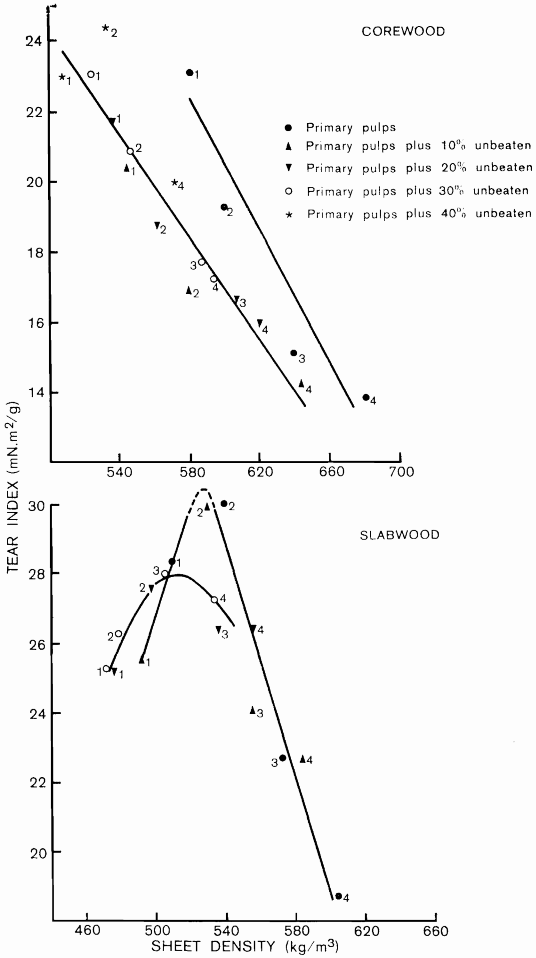


FIG. 3 (right)—Effects of unbeaten fibres — Tear strength and sheet density.

FIG. 4 (below)—Effects of unbeaten fibre — Tear and tensile strength.





tensile strengths developed by the addition of unbeaten fibre were not related to a corresponding decrease in tear strength.

Blends of Unbeaten and Beaten Fibre with Pulps of the Primary Series

The tensile strengths of blends of unbeaten, heavily beaten, and primary pulps were different from those of the primary pulps alone, and consistent with trends shown in the preceding section (Fig. 6 and 1). For the same sheet densities, tensile strengths and stretch were increased by the addition of unbeaten fibre to pulps of the primary series. Tensile, stretch, and tearing properties of blends of unbeaten, heavily beaten, and primary pulps progressively reverted to those of the primary pulps as the proportions of heavily beaten fibre in the furnish were increased (Figs. 6-8). Similar trends were obtained for blends of unbeaten and lightly beaten fibre with pulps of the primary series (Kibblewhite, 1976).

For given sheet densities, tearing strength was decreased by the addition of 20 percent of unbeaten fibre to the furnish (Fig. 8). The converse was true when tear index was considered at the same tensile strengths. Tearing strengths were greatest for the pulp blend which contained 20 percent of unbeaten fibre (Fig. 9). This contrasted with the general trends shown in Fig. 4 and confirmed that the addition of various proportions of unbeaten fibre increased tensile strengths without modifying tear/tensile relationships.

DISCUSSION

Blends of Unbeaten and Beaten Fibre

Adding unbeaten fibre to beaten pulps in proportions of 10 to 30%, depending on fibre density, increased tensile strengths and stretch (Figs. 1, 2, 6, 7). For sheet densities of 580 kg/m^3, tensile index and stretch were increased respectively by up to 10 N.m/g and 0.3%. These increases corresponded with apparent, but variable, decreases in tearing strength (Figs. 3, 8). However, addition of unbeaten fibre did not affect tensile/tear relations which suggested that the apparent decrease in tear strength with sheet density was unimportant (Figs. 4, 9).

Effects of blending small proportions of lightly and/or heavily beaten pulps with beaten stock were intermediate to those obtained with the addition of unbeaten fibre (Figs. 6-8) (Kibblewhite, 1976). The effects were dependent on degrees of beating; the less beaten the added stock, the greater the improvement in tensile properties.

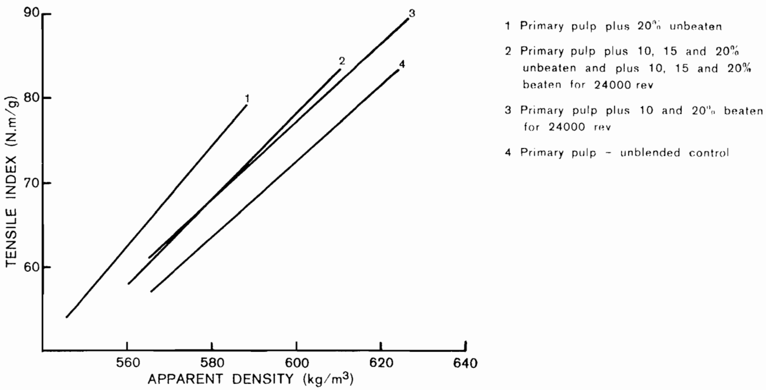
Mechanism of Tensile Improvement

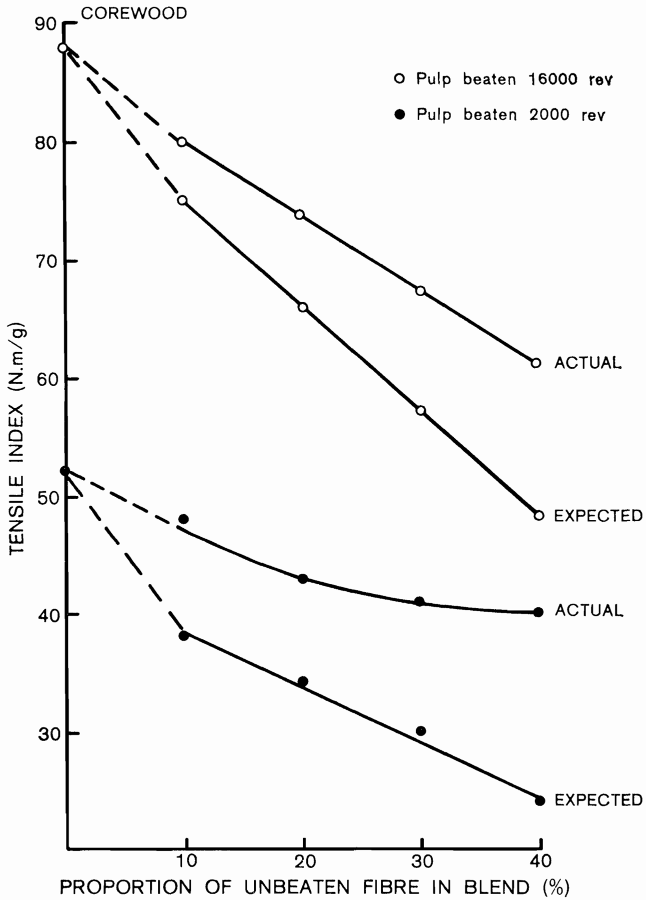
The selective improvement in tensile strength brought about by the addition of unbeaten fibre to beaten stock confirmed the results of previous studies with laboratory beating systems (Kibblewhite, 1974). Pulps refined in a Valley beater contained fibres with widely different flexibilities and produced papers with higher-than-normal tensile strengths. In contrast to the present study, however, Valley beating had little effect on handsheet stretch properties (Kibblewhite, 1974).

Results of the present study supported the hypothesis that tensile strength was improved by the presence of small proportions of unbeaten or "stiff" fibres which form a reinforcing network within a matrix of more flexible fibres (Kibblewhite, 1974). Present indications suggest that the wide distribution of fibre flexibilities obtained by Valley beating may not be necessary to bring about an increase in tensile strength provided sufficient "unbeaten" or "stiff" fibres are available to form the reinforcing

FIG. 5 (right) — Effects of various proportions of unbeaten fibre on tensile strength.

FIG. 6 (below) — Primary pulp series blended with unbeaten and heavily beaten fibre — Tensile strength and sheet density.





matrix. It should be noted, however, that for the same sheet density Valley beating improved tensile strengths by up to 15 N.m/g compared with the 10 N.m/g obtained by the addition of suitable proportions of unbeaten fibre (Kibblewhite, 1974) (Fig. 1).

Possible Commercial Implications

1. That papers with conventional strengths could be produced with lower-than-normal basis weights by the addition of unbeaten fibre to beaten stock. This would result in more usable paper from less wood. It is uncertain whether all products manufactured in this way would show savings in refining-energy, although this is a possibility.
2. That papers with conventional strengths but improved opacity and higher light-scattering coefficients could be produced by blending unbeaten fibre with beaten stock.
3. That refining-tackle and/or refiners could be designed to process fibres in a random fashion. Such treatments would cause pulps to contain a range of unbeaten to heavily

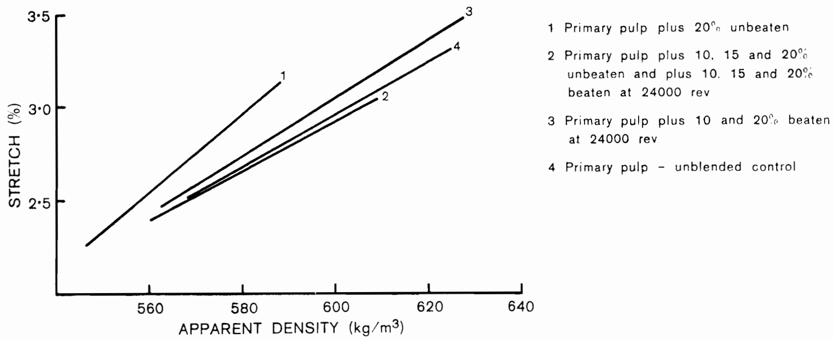


FIG. 7—Primary pulp series blended with unbeaten and heavily beaten fibre—Stretch and sheet density.

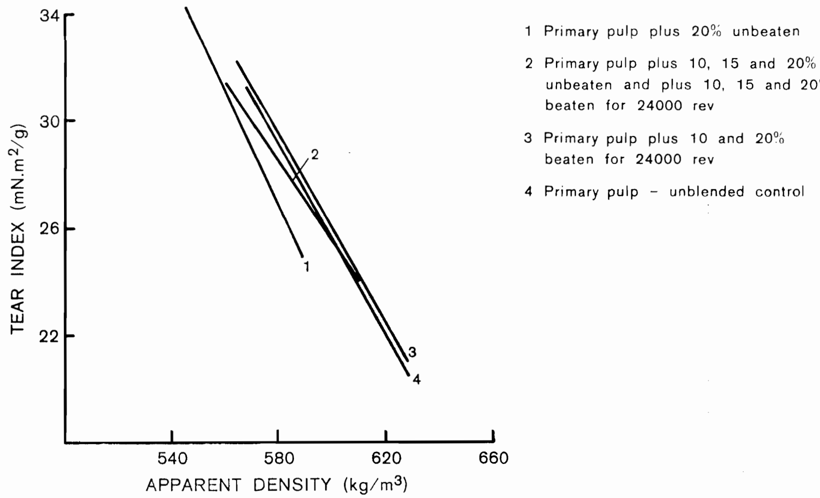


FIG. 8—Primary pulp series blended with unbeaten and heavily beaten fibre— — tear strength and sheet density.

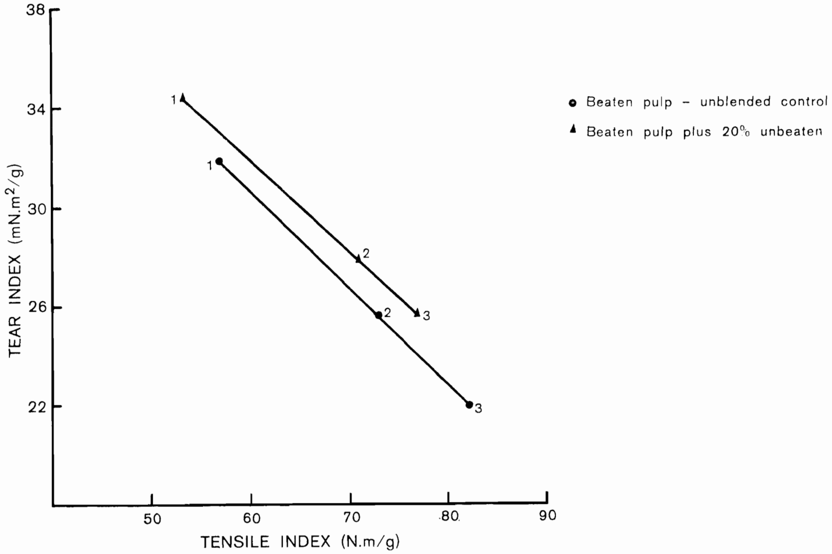


FIG. 9—Primary pulp series blended with unbeaten and heavily beaten fibre — Tear and tensile strength.

beaten fibres, and selectively improve tensile strengths without modifying tensile/tear strength relationships.

CONCLUSIONS

The addition of 10 to 30 percent of unbeaten kraft fibre to beaten stock brought about selective improvements in handsheet tensile strengths without modifying tensile/tear relationships. The addition of small proportions of lightly beaten or heavily beaten fibre to blends of unbeaten and beaten pulps progressively decreased the effectiveness of the unbeaten fibre, depending on the degree of beating of the added pulp.

Some possible implications of blending unbeaten and beaten fibre could be the production of papers with conventional strengths, but with lower-than-normal basis weights or higher-than-normal opacities. This would allow more usable paper to be produced from less wood.

ACKNOWLEDGMENT

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