Some Morphological and Anatomical Critera for Selection of Hardwoods for Pulping

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SUMMARY

The importance of morphological properties and anatomical characteristics, in the selection of hardwoods for pulping has been discussed.

Chemical constitution along of the fibrous material, is not the only deciding factor for determining the nature of the pulp that may be made out of it. Much will also depend on the morphological properties and anatomical structure of the raw material and the methods employed, in determining the yield and quality of the pulp.

Whatever the chemical method employed for pulping a fibrous material, the resultant pulp (and hence also the paper made with it) must have some relationship with the morphological properties and anatomical structure of the raw material.

The effects of fiber length and fibre flexibility and also that of the thin-walled and thick-walled fibres in determining the strength properties of the paper have been discussed. The flexibility of the fibre is more important that the length in determining the strength properties of the paper. Sheet formation properties are better with short fibres than with long fibres.

In the selection of pulp wood, the influences of colour, specific gravity, extractives and heart wood have been discussed. In general, other factors remaining similar, wood of light colour, low specific gravity (0.3 to 0.6) with little or no extractive and with light coloured small proportion of heart wood is preferable.

Provided other conditions are suitable, the more the fibre content of a hardwood, the more suitable it is for pulping. While the yield of pulp will depend on the proportion of fibre, the quality of the pulp and the strength of the paper will depend on the shape and size of the fibres and their wall thickness.

The variations in the pulping qualities of different cellulosic materials, especially the hardwoods can be traced in their heterogeneity and differences in the proportion, size and distribution of various types of cells and the cellwall thickness.

The morphological and anatomical studies have their limitation. While the studies are suitable in determining the pulp quality of a wood or a mixture of woods or (more or less) similar characteristics, In a heterogenous mixture the studies will be of little applicability.

INTRODUCTION

The Indian forests are comprised during 1970–71 of about 74.6 million hectare, out of which around 4.2 million hectare or about 5.6% of the forest area was under conifers and around 70.4 million hectare or about 94.4% was under nonconiferous or broad leaved forests. Of the total wood harvested, during the period, around 7.2% constituted of coniferous wood and 92.8% of decidious or hardwoods (loc. cit.). The composition of the hardwood forest areas, during the said period, was Sal (Shorea robusta) 15.6%, Teak (Tectona grandis) 11.9% and other 66.9% (thus accounting for 94.4% of the total forest are) (loc. cit.) It may be presumed that the above proportion is valid even at the present time.

From the foregoing account it will be observed that more than two third of the total hardwood forest area is of non descriptive type and the woods available are in the form of mixed hardwoods, while softwoods occur generally in pure stands. The hardwoods

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in the Indian forests are available, more often that not, in mixtures of several species with widely varying properties(2). The Indian paper industry is presently using mixtures of tropical hardwoods of diverse chemical, morphological and anatomical properties, as may be available from the Indian forests. This is because in natural Indian forests, different species of plants belonging to different botanical families and of different morphological and anatomical characteristics are growing at random. Harvesting of a single selected species from mixed hardwood forests and supplying the same for pulping and papermaking on a commercial scale, is ruled out on the ground of cost and availability. The industry is thus left with no other alternative than to use heterogenous mixtures of hardwoods, the composition of which may also very from time to time. Runkel has observed three different types of hardwood mixtures for pulping(3).In brief they may be of:

1. mixed hardwoods belonging to the same botanical family hence more or less similar morphologicaly and chemicaly. (pulping of such a mixture of hardwoods will offer little difficulty to produce an uniform pulp).

2. mixed hardwoods of heterogenous type of different specific gravity (in this case the rate of diffusion of the cooking liquor will differ, depending on the density of the chips, hence uniformity of pulp is likely to be affected), and,

3. mixed hardwoods in the same proportion as existing in the forests. If the individual hardwood of the mixture be morphologically and anatomiclly similar (more or less), uniform pulp will result. If, however, some of the species of higher specific gravity and/or contain high extractives or have low pore volume, difficulties are likely to occur in pulping. With the establishment of man-made forests in the country, pulp wood is expected to be available to the industry in a more homogenous form. It is now generally recognised that chemical composition alone, of the fibrous material does not determine the nature and quality of chemical pulps, can be produced by various processes. Whatever chemical process may be used for pulping the fibrous material, the resultant pulp (and hence also the paper) must have some relationship with the morphological and anatomical properties of the raw material(4). The relationship between pulping properties and fibre characteristics in softwood was first studied by Pew and Pnechtges(5). and later by Haywood(6). Although technical data on the properties of diffetent hardwood tissues and fibre dimensions have been published(7). A little study on the pulp properties and fibre characteristics of the Indian hardwood appears to have been made. A general anatomical studies on indigenous hardwoods with reference to their suitability for pulp and paper has been made by Ghosh and Rao(8). It is not intended to decry the importance of the chemical characteristics, of the fibrous material inconsonance to the chemical pulps that could be made out of it by any chemical process or by its modifications, but it is to be appreciated that the overall properties of the pulp will not only depend on the chemical composition of the fibrous material and the (chemical) pulping process employed, but also on the morphological properties of the material.

Chemical composition a part, of the suitability of a fibrous material for pulping and papermaking will depend to a large extent on the morphological properties and anatomical characteristics.

INFLUENCE OF FIBRE LENGTH AND FLEXIBILITY

The fibre dimension and flexibility have a profound influence on the properties of paper made with it(9). In general, pulps with longer fibres produce paper with higher tear. However, for hardwood pulps it is not only the fibre length but also the ratio of fibre length to fibre diameter which is of more importance and the higher this ratio, the greater the tear resistance (ibid). Fibre length of more than 0.8 mm have practically no influence on tear resistance (ibid).

Properties like tensile and burst strengths are little influenced by the fibre length and the folding endurance is affected only slighlly by the length of the fibre. In fact, the sheet forming properties are better with short fibres than with long fibres. The flexibility of the fibre, which is the ratio of fibre diameter to lumen diameter, is more important than the length of the fibre. Thin-walled fibres on drying collepse to form flat flexible ribbons, to produce a more dense sheet than what could be obtained by the thick-walled fibres which are stiffer. It is a common knowledge that the denser the paper, the more the burst and tensile strengths and the lower the opacity. The flexibility of the fibre influences the folding endurance and in general the higher the flexibility, the higher the folding endurance.

Beside chemical composition of the fibrous material, the main morphological criteria which should govern the selection of a hardwood or a mixture of more or less similar hardwoods are (1) colour, (2) specific gravity (3) extractives (4) heart wood and (5) the fibres and their distribution.

COLOUR

The colour of the wood varies from white to various shade of light to dark colour (e. g. Gray, Yellow, Brown, Pink, Red, Black, etc). Other factors remaining similar, light coloured woods are preferable than dark coloured woods. A dark coloured wood will tend to produce a dark coloured pulp and will require more chemicals for bleaching, thus enhancing the cost of bleaching and hence also the finished paper.

SPECIFIC GRAVITY

The specific gravity or density of wood is likely to give some indication of the pulping quality, if other factors are similiar. While the average dry wood substance, consisting mainly of alpha

cellulose, hemicelluloses and lignin has a specific gravity of about 1.5, the average dry wood block has a specific gr. of 0.5, indicating thereby that about two-thirds of wood is composed of air cavities. The specific gravity of wood may therefore be considered as an index of cell cavities to cell wall that is of the porosity or capillarity of the wood, on which depends to some extent the penetration of the cooking liquor.

High specific gravity of wood is, in general, associated with high extractives, an undesirable property of the wood intended to be used for pulping and paper making. Other factors remaining favourable, wood suitable for pulping and papermaking should preferably have a specific gravity range of 0.35 to 0.65 and should be of light to medium weight.

HEART WOOD

Since heartwoods are darker in colour due to the deposition of colouring matter and other extractives, it is desirable from the papermakings point of view, that the heartwood should be as light and as little as possible. Extractives and deposits are generally found in heartwood. More often than not, relatively high extractives are associated with high density but also low extractive.

FIBRES AND THEIR DISTRIBUTION

Hardwoods are more heterogenous in their properties and structure. Kollmann has indicated the wide range of variation in the hardwood tissues([10]).

TABLE—I

DIFFERENT TISSUES IN HARDWOODS (PROPORTION BY VOLUME)

	Maximum	Minimum	Average
Libriform Fibres	78	26	49
Vessels	58	5	20
Parenchyma Cells	21	3	13
Raycells	28	6	18

The foregoing Table–I indicates that the proportion of fibres varies ennormously, in hardwoods depending on the species, from 26 to 78% by volume. Provided other conditions are suitable, hardwoods containing more fibre are likely to be more suitable for pulping. While pulp yield will depend on the proportion of shape and size of the fibres and their cell wall thickness.

Little is at present known regarding the effect of variation in the shape of the fibre on the quality of pulp produced. However, due to wide variations in the density of Indian Hardwoods a marked difference in their fibre wall thickness is to be noticed. The thickness of the fibre-wall can be measured by preparing microscope sections and can be used as one of the criteria for evaluation of the pulp quality.

Applicability of morphological study for evaluation of pulp properties of hardwood is possible when the wood used is of a single species or of homogenous to near homogenous mixture. In a heterogeneous mixture of hardwoods, morphological study is not possible to evaluate the pulp quality. Nevertheless, mixed hardwoods are being used by the Indian paper Industry, to produce useable chemical pulps by suitable control of various parameteres of pulping. While pulping of mixed hardwood is a necessity from industrial stand point, it can not be considered ideal from chemical and morphological points of view.

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