HOW GROWTH OF WHITE PINE AFFECTS ITS PROPERTIES FOR MATCHES

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The matchstick that breaks when struck is a source of irritation and possible danger to the user. Manufacturers of domestic or kitchen matches have long recognized this and have given considerable attention to proper selection and grading of wood. Research findings at the U. S. Forest Products Laboratory on growth and intrinsic characteristics of wood can help bolster inspection procedures by providing means of eliminating wood that is inherently weak because of conditions under which it grew.

The effects of such conditions are readily detected in western white pine, a softwood species widely used for matchsticks because of its straight grain, ease of working, and good texture. Examinations of samples of western white pine submitted by a manufacturer recently showed how improvement can be made in selection and grading match blocks by applying research findings to inspection.

The grading of match blocks is based primarily on ordinary visual examinations. In order to accomplish such grading satisfactorily, it is necessary to understand what the visible characteristics of the wood indicate and their practical limitations with respect to desired properties of the wood. Certain conditions of growth of trees are reflected by the visible characteristics of the wood; for example, vigorous growth is shown by relatively wider annual rings than slow growth, and abnormal structure of the wood can be detected by its peculiar color and appearance.

Characteristics of Wood Affecting Its Strength

For many common uses of wood, its density, or specific gravity, is a practical index of strength properties; that is increased specific gravity is associated with general increase in strength properties. Under certain growth conditions, wood of a species may be considerably below average in

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specific gravity, and hence weaker. White pine wood having exceptionally low specific gravity and poor strength properties is not suitable for matchsticks because it tends to break suddenly and abruptly when the match is struck.

Variations in Density

Many old-growth stands of western white pine that supplied highly satisfactory material for matches grew under different conditions than some second-growth timber that is now used. As a result, the annual rings of match-block samples from second-growth trees were appreciably wider than the typically narrow rings of old-growth trees. Figure 1 shows cross sections of match blocks, at the top, a section having 10 to 15 rings per inch, and in contrast, at the bottom, a section having only 4 or 5 rings per inch. The samples with the exceptionally wide annual rings had appreciably lower specific gravity than those with narrower rings for which the specific gravity was reasonably close to or even above the general average for western white pine.

The annual rings of white pine include proportionately larger amounts of springwood fibers having thin walls and wide cavities than of summerwood fibers having relatively thicker walls and narrower cavities. Figure 2 shows the general characteristics of springwood and summerwood fibers greatly enlarged. The variations in the relative thicknesses of fiber walls contribute to the variations in specific gravity. In addition to the differences in structure between springwood and summerwood fibers, the match blocks with wide annual rings tended to have proportionately more springwood than the blocks with narrower rings, since the summerwood parts of the rings normally tend to be nearly constant in width as is shown in the top and bottom pieces in figure 1.

Some matches made from blocks with exceptionally wide annual rings consist entirely of springwood, since the sticks are narrower than the springwood parts of the rings. On the other hand, most of the matchsticks made from blocks with relatively narrow annual rings include both springwood and summerwood. Matchsticks that include both springwood and summerwood have greater strength than those made entirely of springwood.

Variations in Fiber Structure

An abnormal type of wood known as compression wood sometimes is present in match blocks. The summerwood fibers of compression wood differ greatly from the summerwood fibers of normal wood; in the first place, they are more numerous in proportion to springwood fibers than is the case in normal annual rings. Secondly, the internal structure of compression-wood fibers is different from that of normal wood. Because of the proportionately greater amounts of summerwood-type fibers, white pine blocks with compression wood are as dense, or frequently denser, than those with normal wood. The internal arrangements at large angles of the strands making up the fiber walls are associated with poorer strength properties as compared to small
angles and with abrupt, or brittle, fractures instead of the typical splintering fractures. The fiber walls of compression wood are made up mostly of strands arranged at larger angles to the length of the fibers (fig. 3), while in normal summerwood those strands usually are at much smaller angles.

Not only are the fiber walls of springwood relatively thin, but they are made up of strands arranged at larger angles than those in normal summerwood. Thus, the relatively thin walls and the angles of the strands in springwood fibers together contribute to poor strength and abrupt fractures when the wood breaks, as in matches made up entirely of springwood.

**Selection of Suitable Wood for Matches**

Inspection of white pine lumber and grading of match blocks are common practices in order to eliminate such defects as knots and local deviations in the grain before the matchsticks are made. The additional inspection to detect other characteristics that result in poor matches imposes no serious problems, but requires only that those characteristics are recognized by their appearance in the wood.

**Width of Annual Rings**

The selection of wood for match blocks should begin with the lumber. For example, lumber with less than about eight annual rings per inch, which tends to produce numerous weak and brittle matches, frequently can be recognized in the planks from which the blocks are cut. In general, planks which have only three to five rings per inch should be diverted to other uses at the source.

It is not always practical, however, to exclude all planks with relatively wide annual rings even by careful selection. Many stands of white pine timber include some trees or parts of trees that grew rapidly and produced wood having the wide annual rings while other trees in the same stands produced wood having uniformly narrower rings; hence are more desirable for matches. Because of such variations in growth, some of the sorting of wood must remain until the final grading of the blocks, which can then be sorted out for wide annual rings without excessive rejection of suitable pieces.

**Compression Wood**

There are large variations in the characteristics of compression wood, from the borderline forms that merge with normal wood through a range of intermediate forms to the extreme forms of the abnormal wood. Compression wood is a response to certain conditions of growth on the lower side of leaning trees that causes differences in the minute anatomy of summerwood-like fibers. Thus, variations in the form of compression
wood result from growth conditions of the trees in much the same manner as variations in the width of annual rings, even though the essential causes are different. Only some of the intermediate, and all of the extreme, forms of compression wood differ seriously in strength and brittleness from normal wood. Thereby, the detection of compression wood is simplified.

The forms of compression wood that need to be excluded from match blocks have yellow to light tan colors in contrast to the white to cream color of normal white pine. In addition, the annual rings of compression wood include appreciably larger proportions of summerwood to springwood than those of normal wood, as is shown in figure 1 by the center block (compression wood) in comparison with the top and bottom blocks (normal wood). Because of its greater proportions of summerwood, the harder and denser appearance of compression wood also aids in its detection.

The practical grading of match blocks for compression wood depends mainly on familiarizing workers with the readily visible characteristics of intermediate and extreme forms of compression wood. The borderline forms, detectable only by microscopical or other complicated examinations that are not practical for the grading of match blocks, differ only slightly in strength and brittleness from normal wood. Samples that show typical compression wood and normal wood are of considerable help in developing such grading that will exclude the serious forms of compression wood without rejection of suitable material.
Figure 1.--Cross sections of white pine match blocks showing: Top, wood suitable for matches (10 to 15 annual rings per inch); center and bottom, wood not suitable for matches, respectively, because of compression wood and of exceptionally wide rings (4 to 5 per inch).
Figure 2. -- Photomicrograph of cross section of white pine showing differences in fiber diameters in summerwood and springwood parts of the annual rings. Highly magnified.
Figure 3. --Photomicrograph of longitudinal section of compression wood, showing typical fibers with spirally oriented checks in the cell wall. Highly magnified.

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