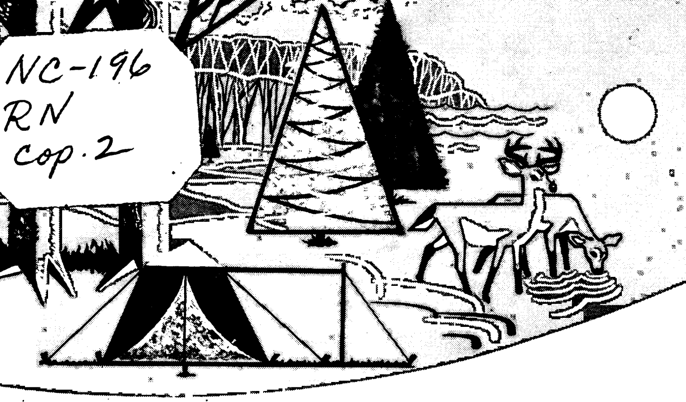

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KNIFE PLANING ACROSS THE GRAIN CAN BE APPLIED TO HARDWOODS

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ABSTRACT.--Shows that knife planing across the grain can be applied to most domestic hardwood species to produce a satisfactory finish knife-planed surface and flakes for particleboard.

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INTRODUCTION

Hardwoods have many variations of sloped grain associated with growth characteristics which do not appreciably affect surface quality when planing cross-grain. The severest depth of defect occurs when planing against approximately 10 to 15 degrees slope of grain (fig. 1e and f). However, when cutting across the grain, a cleavage failure does not advance along the grain ahead of the knife edge. Hence, chipped grain does not occur when knife planing hardwoods across the grain.

Initial development of knife planing technology (Stewart 1970a, 1970b, Stewart and Lehmann 1973) across the grain has been limited either to individual species or to a limited range of machining conditions. Knife planing conditions across the grain have since been systematically applied to hardwoods representing a wide range of physical and mechanical properties and the advantages described previously (Stewart 1970a, 1970b, 1974, Stewart and Lehmann 1973, 1974) appear to apply to the knife planing across the grain of all hardwoods.

METHODS

Seventy-two knife planing combinations across the grain were investigated with a straight 8-inch-long knife on the top front 6-inch-diameter head of a molding machine. The machine parameters were rake angle (10, 15, 20, 25, 30, 35, 40, and 45 degrees); depth of cut (1/32, 1/16, and 1/8 inch); and feed rate (5, 10, and 20 knife marks per inch). The head turned at 4,200 rpm.

The six species machined were basswood, aspen, yellow-poplar, cherry, red oak, and hickory. Panels 3 feet wide were manufactured by edge gluing cuttings from flat sawn stock conditioned at 8 percent equilibrium moisture content (EMC). Consequently, the stock had randomly sloped grain. The panels of each species were cross-cut into specimens 6 inches by 3 feet and reconditioned at 8 percent EMC. Control specimens were machined along the grain on a cabinet planer at 30 knife marks per inch, 25-degree rake angle, and three depths of cut (1/32, 1/16, and 1/8 inch) to compare with conditions generally prescribed for production finish knife planing.

The most severe machining defects were then traced; their peak-to-valley depths determined. Power was recorded using a recording watt hour meter.

RESULTS AND DISCUSSION

Knife planing across the grain produced a shallower maximum depth of defect than did planing along the grain. It also produced a high-quality particle in contrast to the spiral planer shavings typically produced when planing along the grain.

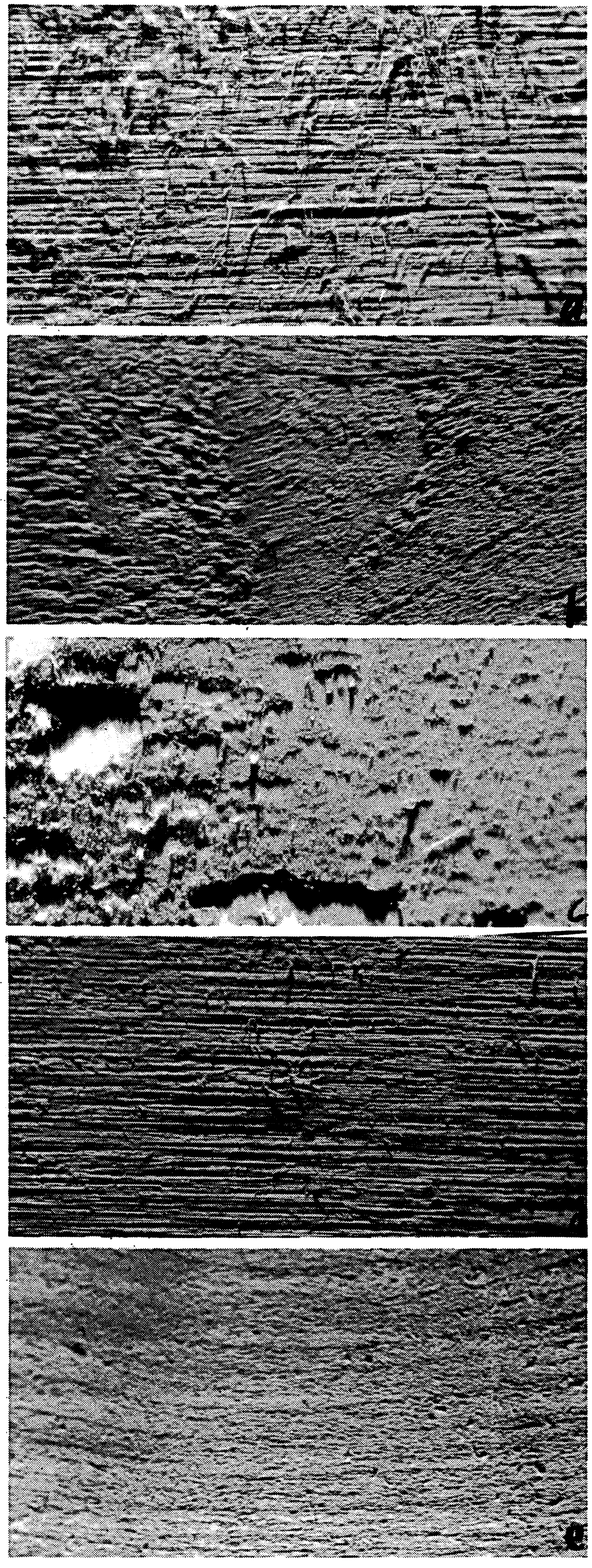
Generally, the results showed that:

1. Surface quality generally improved as the specific gravity of the hardwoods being tested increased.
2. Surface quality improves more on lower density species as rake angle increases than it does on higher-density species.
3. A satisfactory finish knife-planed surface can be machined across the grain at machine settings of 10 knife marks per inch or more.
4. At feed rates that result in up to five knife marks per inch, depth of defect appears unaffected by depths of cut up to 1/8 inch.
5. Depths of defect were less than 1/64 inch at all depths of cut and knife marks per inch combinations using rake angles equal to or more than 30 degrees.
6. Generally, surface quality increased as rake angle increased; i.e., depth of defect decreased.
7. The maximum depth of defect was 1/16 inch or greater when planing against slopes of grain of approximately 10 degrees.
8. The maximum depth of defect increased substantially for all hardwoods when planing at 2.5 knife marks per inch; hence, the study was not conducted beyond feed rates that cut at less than five knife marks per inch.
9. Surface quality (texture) was relatively uniform for a prescribed machining combination.
10. Slightly less power is required than when planing along the grain.

Surface and flake quality improved slightly as the rake angle was increased to 35 degrees and remained approximately the same at rake angles to 45 degrees. Planing across the grain with higher rake angles reduces "fuzzy" grain on lower density species such as aspen and requires less power. Low rake-angle knives generally dull faster than high rake angle knives; thus, down time for sharpening could be reduced. However, high rake-angle knives (greater than 45 degrees) may also dull quickly because their angles are not sharp.

When machined at fast feed rates and/or low rake angles, however, lower density hardwoods (basswood, aspen; to some extent, yellow-poplar) had a coarser overall surface than a conventionally knife-planed surface. This coarse texture probably can be attributed to their lower strength properties (tensile and crushing strength perpendicular to the grain) because the higher cutting forces associated with fast feed rates or low rake angles tend to crush and tear fibers rather than sever them cleanly. Thus, higher rake angles and moderate feed rates improve surface quality more for lower density species when planing across the grain.

The surface quality of panels knife-planed across the grain of lower density species is comparable to the surface quality of surfaces abrasive planed with a 36 grit. The surface quality of higher density species, which includes most valuable hardwood species, exceeds the surface quality of surfaces abrasive planed with a 36 grit. The depth of the wood failures from knife planing across the grain are approximately equal or shallower in depth to the scratches made with a 36 grit (fig. 1). The machining conditions were (A) abrasive planing--36 grit, 1/16-inch depth of cut; (B) cross-grain knife planing--1/16-inch depth of cut, 10 knife marks per inch, and 35 degrees rake angle; (C) conventional knife planing--1/16-inch depth of cut, 20 knife marks per inch, and 25 degrees rake angle; (D) abrasive planing--36 grit, 1/16-inch depth of cut; (E) knife planing across the grain - 1/16-inch depth of cut, 10 knife marks per inch, and 35 degrees rake angle; (F) conventional knife planing--1/16-inch depth of cut, 20 knife marks per inch, and 25 degrees rake angle.



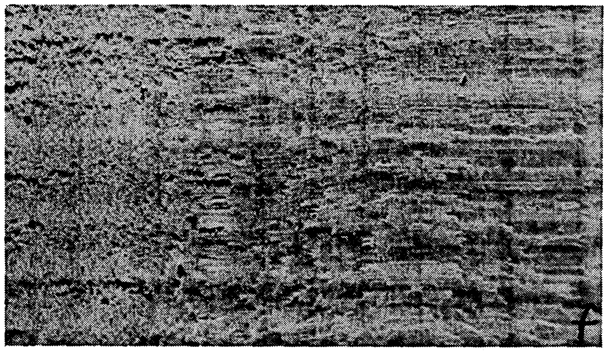


Figure 1.--*Compares abrasive planed, knife-planed across the grain, and conventional knife-planed surfaces of a low density species (aspen at left) and moderate to high density species (black cherry at right). The machining conditions were (a) abrasive planing--36 grit, 1/16-inch depth of cut; (b) knife planing across the grain--1/16-inch depth of cut, 10 knife marks per inch, and 35 degrees rake angle; (c) conventional knife planing--1/16-inch depth of cut, 20 knife marks per inch, and 25 degrees rake angle; (d) abrasive planing--36 grit, 1/16-inch depth of cut; (e) knife planing across the grain--1/16-inch depth of cut, 10 knife marks per inch, and 35 degrees rake angle; (f) conventional knife planing--1/16-inch depth of cut, 20 knife marks per inch, and 25 degrees rake angle.*

In the past, the objective of most machining processes has been to manufacture a satisfactory surface while removing a minimum of stock. However, optimum instead of a minimum quantity of flakes could be manufactured while knife planing if the demand for particles increases sufficiently. For example, core stock or solid wood furniture panels are generally manufactured using 4/4 lumber from which thickness tolerances are sometimes difficult to obtain in dry stock that is warped or cupped. These could be planed across the grain using thicker stock because the excess could be sold as a high-quality secondary product. Thus, the net waste and waste disposal and rejects could be reduced and the trees would be more fully utilized. Subsequent processing and waste also could be substantially reduced because surfaces knife-planed across the grain have shallower defects than surfaces planed parallel to the grain.

Surface quality decreases somewhat more abruptly as knives dull when planing across the grain. However, proper machine maintenance, adjustment, and knife sharpening will produce satisfactory surfaces. Moreover, cross-grain knife planing can be applied to hardwoods and the combined residue from many woodworking plants could support or significantly contribute to the raw material of a particleboard plant.

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