(Report) 2184

FEED-SPEED RELATIONSHIPS FOR CUTTING TOOLS

April 1960

No. 2184

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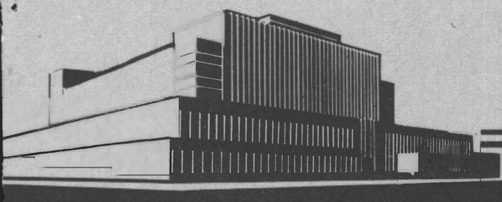

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

FEED-SPEED RELATIONSHIPS FOR CUTTING TOOLS

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In working with machines for cutting wood or metal, it is frequently desirable to analyze the interrelationships between the number of cutting edges of the tool, its speed, and the feed per cutting edge or per minute.

To simplify straightforward single computations and to facilitate the exploration of the effect of changing the speed, feed, or number of cutting edges, the alinement chart presented here was prepared.

This chart is applicable to rotating cutters of few to many cutting edges such as shapers, planers, cylinder or disk chippers, milling cutters, and circular saws for metal or wood. It is also applicable to linear multiple-edge cutting tools, such as band and chain saws. The extensive range of values provided by the scales for the interrelated factors can be extended further by multiplying or dividing the scale values by 10 to accommodate the high rotational speeds of air-driven routers or the very slow feed rates of drills and augers.

The key under axis B shows how the chart can be used to determine the fourth factor when the other three are known. When two factors on opposite sides of the blank axis C are fixed, all possible combinations of the remaining two factors can be obtained by properly pivoting the second interceptor line.

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The interceptor lines are shown in the key. The interceptor line (which can be a straightedge) is passed through the proper values on the A and E axes, and the point of interception with the blank axis C is held by a needle. (For convenience, sealing wax or an eraser from a mechanical pencil can be used to provide a head for the needle.) The straightedge is then pivoted around the needle until it passes through the proper value on axis B (or D), and the unknown value is read from axis D (or B). By pivoting the second interceptor around the needle, all possible pairs of B and D values may be read. The procedure is reversed when B and D are known and either A or E, or all pairs of A and E values are to be determined.

Precautions in using the chart are few. When the "No." scale of axis A is used, the scale of axis E must be read in terms of revolutions per minute. When the "Spacing" scale of axis A is used, the scale of axis E must be read as a scale of band, chain, or rim speed in "Ft. per Min." For end-cutting tools (mills, drills, disk chippers), spacing cannot be used because it varies with radius and is zero at the center, hence, "No." of cutting edges and "R. P. M." must be used.

When cutters cut alternately, as with spring-set saws, the "Bite" value on axis B is the feed per tooth. The feed between successive right-hand teeth or successive left-hand teeth is, however, twice this amount. This may be determined directly by entering the "No." scale of axis A with the number of pairs of left and right teeth, giving the chip dimension in the feed direction (except for any notched rear inner corner removed by the preceding tooth).

Values of bite are always in terms of distance in the feed direction, whether knives are straight or helical, whether the axis of the cutter-head is at right angles to the feed direction or skewed, and whether the feed is vertical (drills, etc.), sloping (chippers), or horizontal (saws, planers, rotary-head barkers).

Feed is assumed to be positive and uniform. When the cutting tool limits the bite per cutting edge, as in gravity-feed disk chippers, a theoretical feed can be computed from the knife setting. Thus, for a 4-knife chipper at 600 revolutions per minute with knives set for a 0.5-inch chip length, the theoretical feed rate will be 100 feet per minute. If the lengths of a sample of chips are measured, their average value may be used to read a corresponding average feed rate from the chart.

Surface quality is largely dependent on the spacing of the successive cuts that produce the surface;power requirements and the forces on the cutting edge are affected by the thickness of the chip removed; chip storage requirements for tools buried in the workpiece such as saws are determined partly by chip thickness; and the rate at which cutting edges are dulled is strongly influenced by the number of cuts required to remove a given volume of material. Numerous combinations of feed speed, tool speed, and number of cutting edges on the tool may be used to obtain a given value for chip thickness. Conversely, various chip thicknesses may be used with a preselected value of a second factor to determine the appropriate combination of the remaining two factors.

A saw operator having a machine with one spindle speed and one feed speed could make a simple analysis of the interrelationship of these four factors to determine the possibility of producing sawdust of a specific size for a certain market. From the feed and spindle speeds, and the bite per tooth set by the sawdust particle size, the required number of saw teeth may be calculated.

More complex situations may arise. Operations may involve a production line moving continuously with perhaps one machine feeding two machines in parallel. Further along, their output may feed a single machine in a third step. Assume the first machine is a straight-line ripsaw making glued-up stock, such as lumber cores or shelving, for gluing in the second stage directly from the saw. The feed speed through the saw must be high enough to keep ahead of the supply rate, yet the bite per tooth must not be so large that it will produce a torn gluing surface nor so small that the saw will dull quickly and produce a gluing surface weakened by the battering of rounded tooth corners. Suitable combinations of spindle speed and number of saw teeth can be selected, with possible modification of bite per tooth, by increases in feed speed above the minimum established by the raw stock supply rate.

After the two-machine gluing-up stage the third stage may involve a planer in which the feed rate must be at least equal to the supply rate. The chip thickness during planing will be unregulated and variable to the extent of the excess thickness removed, but ordinarily chip thickness will be within safe limits. The spacing of the cuts, however, may have a profound effect on the product since the cylindrical cutter head makes a series of cuts that form very shallow, sharp-crested waves. An increase in the spacing of the cuts or knife marks produces an even greater increase in crest height. A small number of cuts or knife marks per inch results in high, widely spaced crests that are readily visible and may even show through a thin veneer surface or paper overlays. A large number of cuts or knife marks per inch results in low-crested, shallow marks that are not readily visible and may be satisfactory for painting without further machining.

The planer stage thus requires the selection of the number of cuts per inch that will produce an acceptable surface. This factor, plus the feed rate already established, will permit the selection of a suitable combination of the number of knives in the cutter head and its speed in revolutions per minute.

It is suggested that the accompanying chart be mounted on a piece of heavy backing material, using dry mounting tissue to avoid wrinkling or distortion of the chart.

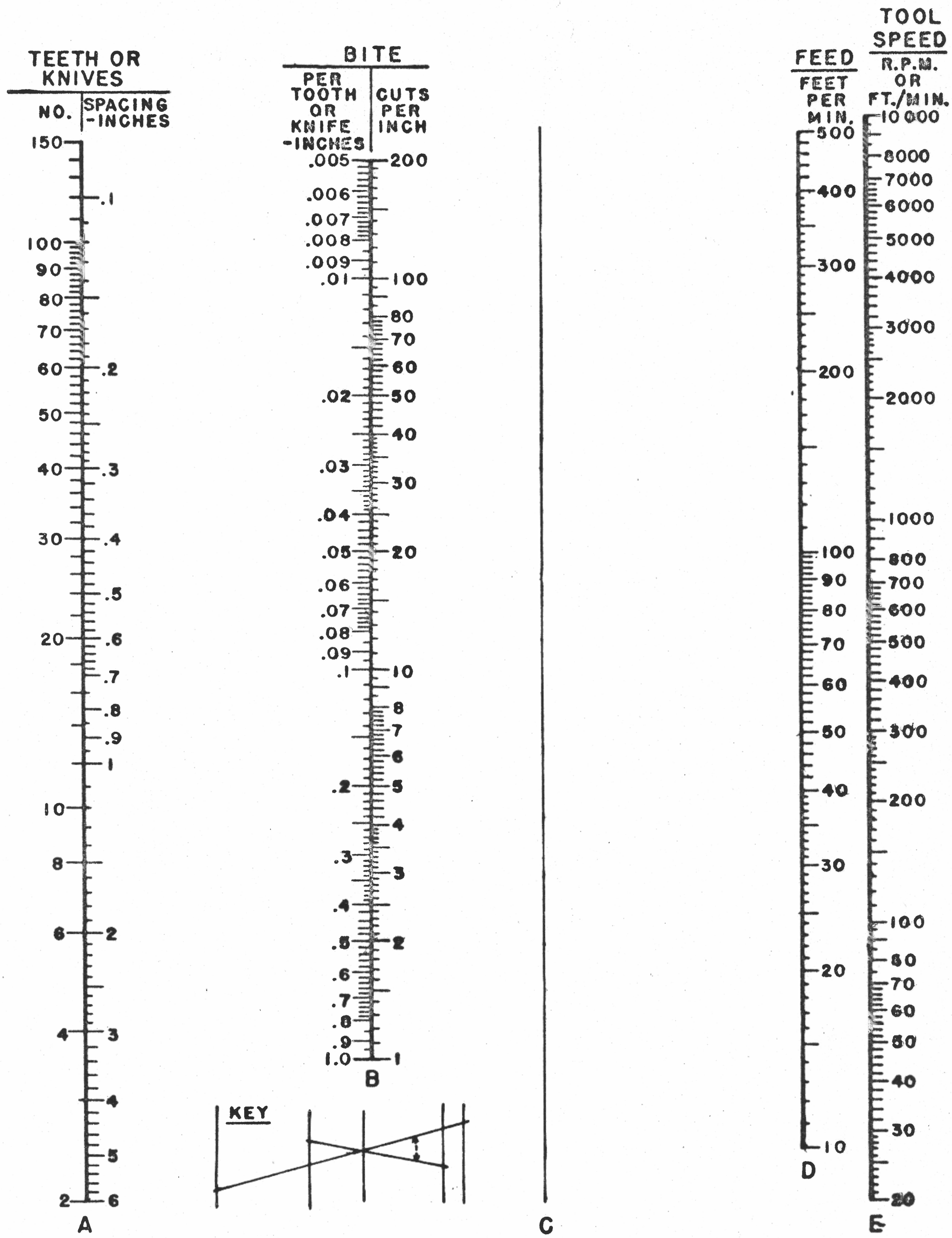

Figure 1.--Chart for computing feed-speed relationships for cutting tools.

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