Cutting Speed, Feed, and Depth of Cut

Cutting Speed

- Rate at which point on work circumference travels past cutting tool
- Always expressed in feet per minute (ft/min) or meters per minute (m/min)
- Important to use correct speed for material
  - Too high: cutting-tool breaks down rapidly
  - Too low: time lost, low production rates

Lathe Cutting Speeds in Feet and Meters per Minute Using High-Speed Steel Toolbit

	Turning and Boring					
	Rough Cut		Finish Cut		Threading	
Material	**ft/min**	**m/min**	**ft/min**	**m/min**	**ft/min**	**m/min**
Machine steel	90	27	100	30	35	11
Tool steel	70	21	90	27	30	9
Cast iron	60	18	80	24	25	8
Bronze	90	27	100	30	25	8
Aluminum	200	61	300	93	60	18

Cutting Conditions in Turning

The rotational speed in turning is related to the desired cutting speed at the surface of the cylindrical work-piece by the equation

$$N = \frac{v}{\pi D_o} \qquad (22.1)$$

where N = rotational speed, rev/min; v = cutting speed, m/min (ft/min); and D_o = *original* diameter of the part, m (ft). The turning operation reduces the diameter of the work from its original diameter D_o *to a final diameter* D_f *as determined by the depth of cut d:*

$$D_f = D_o - 2d \qquad (22.2)$$

The feed in turning is generally expressed in mm/rev (in/rev). This feed can be converted to a linear travel rate in mm/min (in/min) by the formula

$$f_r = Nf \qquad (22.3)$$

where f_r = feed rate, mm/min (in/min); and f = feed, mm/rev (in/rev).

The time to machine from one end of a cylindrical work-part to the other is given by:

$$T_m = \frac{L}{f_r} \qquad (22.4)$$

Where

T_m *=machining time, min; and L = length of the cylindrical work-part, mm (in).*

Cutting Conditions in Turning

A more direct computation of the machining time is provided by the following equation:

$$T_m = \frac{\pi D_o L}{f v} \qquad (22.5)$$

where D_o =work diameter, mm (in); L=work-part length, mm (in); f=feed, mm/rev (in/rev); and v = cutting speed, mm/min (in/min). As a practical matter, a small distance is usually. added to the work-part length at the beginning and end of the piece to allow for approach and over-travel of the tool.

The volumetric rate of material removal can be most conveniently determined by the following equation:

$$R_{MR} = vfd \qquad (22.6)$$

where R_{MR} *is material removal rate, mm^3/min (in^3/min). In using this equation, the units* for f are expressed simply as mm (in), in effect neglecting the rotational character of turning. Also, care must be exercised to ensure that the units for speed are consistent with those for f and d.

Example

- A cylindrical workpart 200 mm in diameter and 700 mm long is to be turned in an engine lathe. Cutting conditions are as follows: cutting speed is 2.30 m/s, feed is 0.32 mm/rev, and depth of cut is 1.80 mm. Determine (a) cutting time, and (b) metal removal rate.

Solution: (a) $N = v/(\pi D) = (2.30 \text{ m/s})/0.200\pi = 3.66$ rev/s $f_r = Nf = 6.366(.3) = 1.17$ mm/s $T_m = L/f_r = 700/1.17 = 598$ s = **9.96 min**

Alternative calculation using Eq.(5),

$T_m = 200(700)\pi/(2{,}300 \text{ x } 0.32) = 597.6$ sec = 9.96 min

(b) $R_{MR} = vfd = (2.30 \text{ m/s})(10^3)(0.32 \text{ mm})(1.80 \text{ mm}) =$ **1320 mm^3/s**

Calculating Lathe Spindle Speed

- Given in revolutions per minute
- Cutting speed of metal and diameter of work must be known
- Proper spindle speed set by dividing CS (in/min) by circumference of work (in)

$$\text{r/min} = \frac{\text{CS x } 12}{\pi\,\text{D}} = \frac{\text{CS x } 4}{\text{D}}$$

Example:

Calculate r/min required to rough-turn 2 in. diameter piece of machine steel (CS 90):

$$\text{r/min} = \frac{\text{CS x 4}}{\text{D}}$$

$$\text{r/min} = \frac{90 \text{ x } 4}{2} = 180$$

Metric Formula $\quad \text{r/min} = \dfrac{\text{CS x 320}}{\text{D}}$

Lathe Feed

- Distance cutting tool advances along length of work for every revolution of the spindle
- Feed of engine lathe dependent on speed of lead screw for feed rod
  - Speed controlled by change gears in quick-change gearbox

Two Cuts Used to Bring Diameter to Size

- Roughing cut
  - Purpose to remove excess material quickly
  - Coarse feed: surface finish not too important
    - .010- to .015-in. (0.25- to 0.4-mm)
- Finishing cut
  - Used to bring diameter to size
  - Fine feed: Produce good finish
    - .003- to .005-in (0.07- to 0.012-mm)

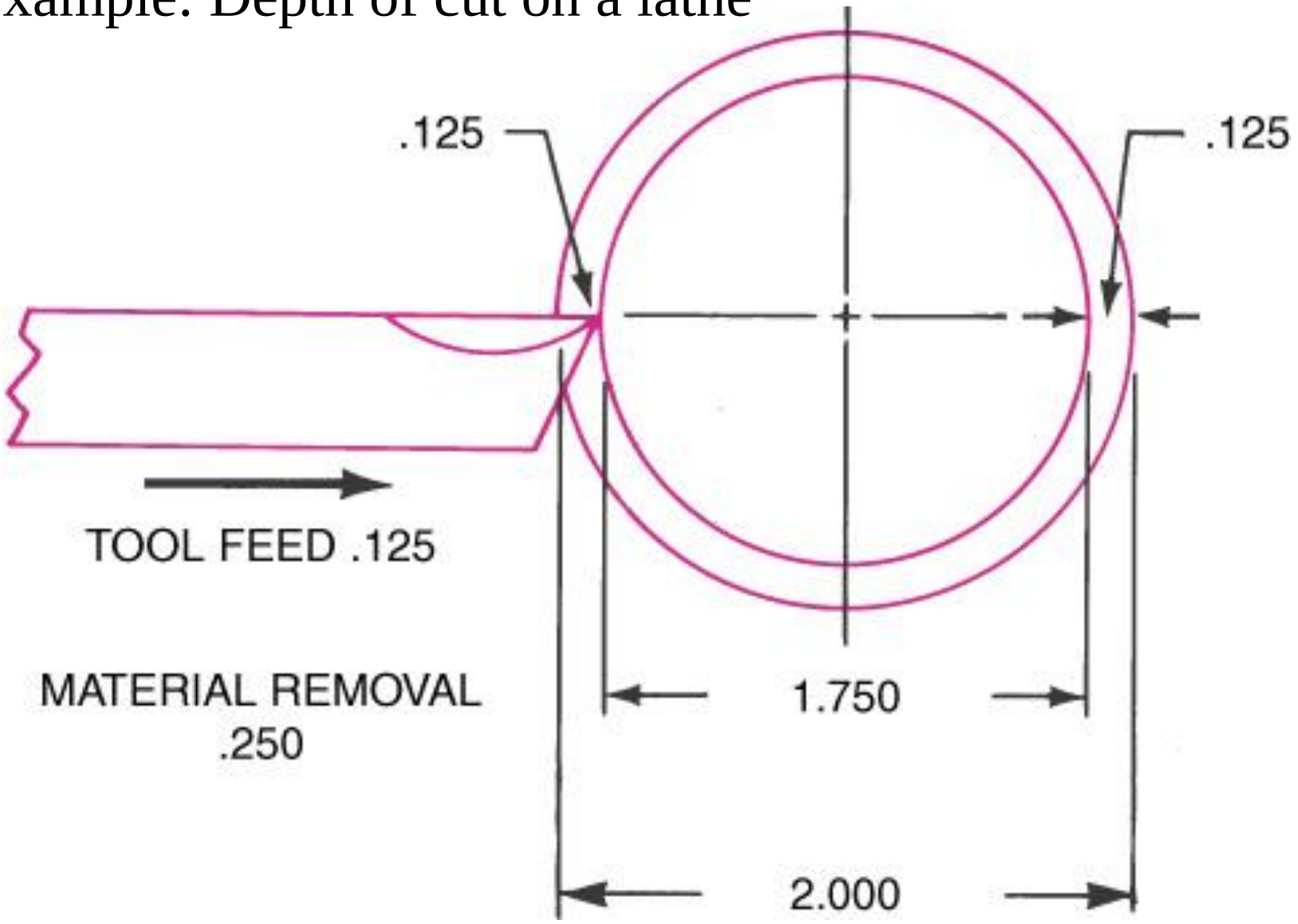
Feeds for Various Materials (using high-speed steel cutting tool)

	Rough Cuts		Finish Cuts	
Material	**in.**	**mm**	**in.**	**mm**
Machine steel	010–.020	0.25–0.5	.003–.010	0.07–0.25
Tool steel	.010–.020	0.25–0.5	.003–.010	0.07–0.25
Cast iron	.015–.025	0.4–0.65	.005–.012	0.13–0.3
Bronze	.015–.025	0.4–0.65	.003–.010	0.07–0.25
Aluminum	.015–.030	0.4–0.75	.005–.010	0.13–0.25

Depth of Cut

- Depth of chip taken by cutting tool and one-half total amount removed from workpiece in one cut
- Only one roughing and one finishing cut
  - Roughing cut should be deep as possible to reduce diameter to within .030 to .040 in. (0.76 to 1 mm) of size required
  - Finishing cut should not be less than .005 in.(0.127 mm)

Example: Depth of cut on a lathe



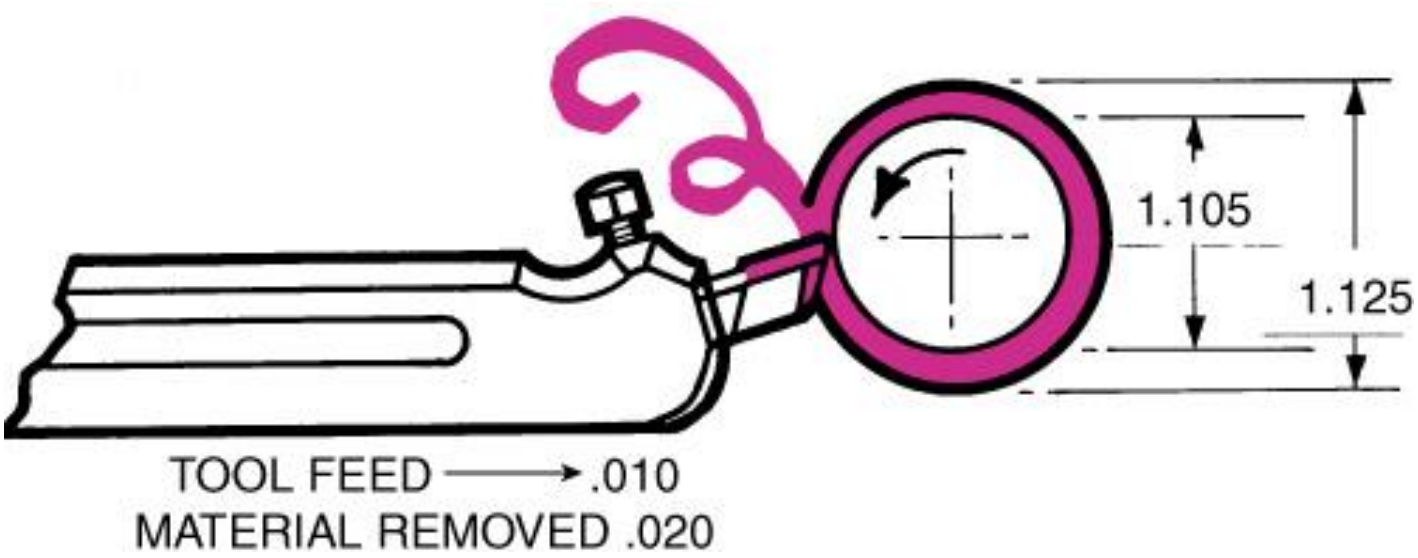
Factors Determining Depth of Rough-Turning Cut

- Condition of machine
- Type and shape of cutting tool used
- Rigidity of workpiece, machine, and cutting tool
- Rate of feed

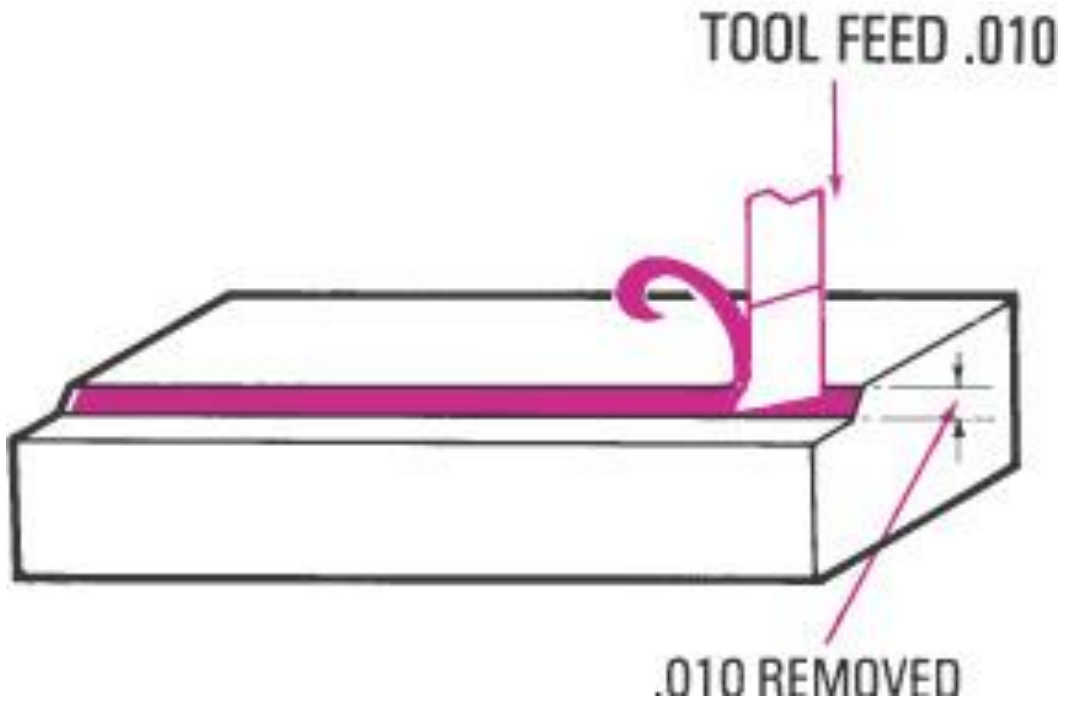
Inch System

- Circumference of crossfeed and compound rest screw collars divided into 100-125 equal divisions
  - Each has value of .001 in.
    - Turn crossfeed screw clockwise 10 graduations, cutting tool moved .010 in. toward work
    - Lathe revolves, so .010 depth of cut taken from entire work circumference reducing diameter .020 in.
- Check machine for its' graduations

On machines where the workpiece revolves, the cutting tool should be set in for only half the amount to be removed from the diameter.



On machines where the workpiece does not revolve, the cutting tool should be set in for the amount of material to be removed.



Hints on Graduated Collar Use

1. Make sure collar is secure before setting a depth of cut
2. All depths of cut must be made by feeding cutting tool toward workpiece
3. If graduated collar turned past desired setting, must be turned backward half-turn and fed into proper setting to remove backlash
4. Never hold graduated collar when setting depth of cut

5. Graduated collar on compound rest can be used for accurately setting depth of cut
   - Shoulder turning
     - Compound rest set at 90º to cross-slide
     - Lock carriage in place
     - Spacing of shoulders to within .001 in. accuracy
   - Facing
     - Compound rest swung to 30º, amount removed from length of work = ½ amount of feed on collar
   - Machining accurate diameters
     - Set compound rest to 84º16' to the cross-slide
     - .001 in movement = .0001-in. infeed movement

The compound rest is set at 84º16' for making fine settings.