MIT 2.810 Manufacturing Processes and Systems

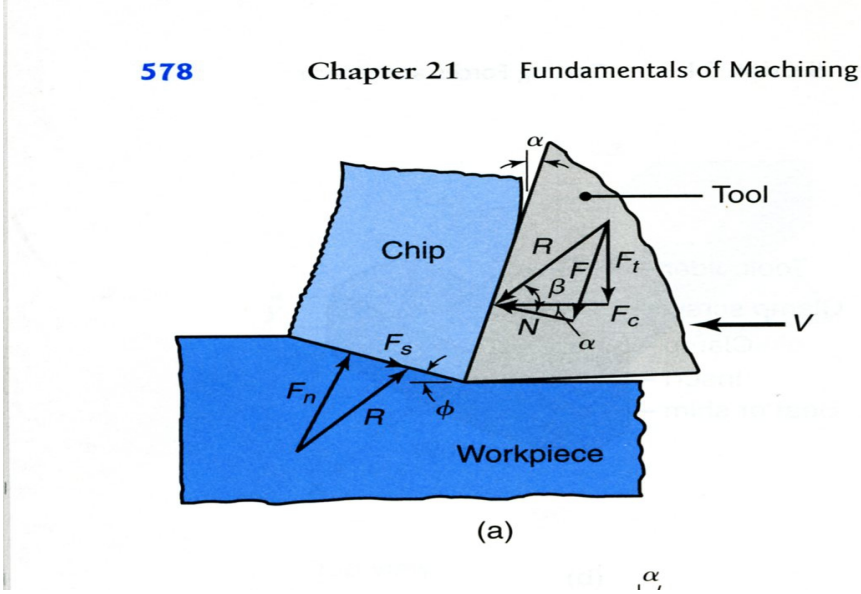
Fall 2013

Homework 2a – Machining

September 27, 2013

Problem 1

a.) Consider the case of orthogonal cutting shown below. We are interested in the force F_s acting at angle over area A_s. The width of cut is w and the depth of cut is t_o. Please verify the expression for shear stress (= F_s/A_s) as given below the figure.



$$\tau = \frac{F_c \sin\phi \cos\phi - F_t \sin^2\phi}{t_0 w}$$

b.) Using the above expression and assuming that the shear angle adjusts to minimize the cutting force, derive the following expression:

$$\phi = 45^{o} + \frac{\alpha}{2} - \frac{\beta}{2}$$

c.) Cutting forces were measured during the machining of a steel bar and found to be F_c = 520 N and F_t = 189 N. The rake angle on the tool is 10º. Based on this information, calculate the coefficient of friction at the tool-chip interface. Also calculate the shear angle.

Problem 2

a.) An 8 in. long 304 stainless steel rod of diameter 0.5 in. is being machined on a lathe to a final diameter of 0.48 in. A collet grips the rod so that a 6 in. length can be turned. The spindle speed is 400 RPM and the tool travel rate is 8 in/min. Please calculate the depth of cut d, the feed f, the MRR and the cutting time.
b.) Also calculate the power and the cutting force (the component tangent to the circumference of the rod.)
c.) We are also interested in possible deflections caused by the cutting forces acting on the rod. Estimate the elastic twist angle when the tool engages at the very tip of the cantilevered workpiece. Assume the shear modulus G is 10.8 X 10^6 psi.
d.) Will these forces cause elastic bending of the workpiece? Of the tool?

Problem 3

A median strength steel alloy bar 4 in. in diameter is being turned on a lathe at a depth of cut, d = 0.050 in. The lathe is equipped with a 10-hp electric motor and has a mechanical efficiency of 80%. The spindle speed is 400 rpm. Estimate the maximum feed that can be used before the lathe begins to stall.

Problem 4

Two tools are being considered for turning a steel rod. The first is a high-speed steel tool and the second is a coated carbide tool. The Taylor Tool Life properties for machining steel are given in table 1.

Properties	High-Speed Steel	Coated Carbide
n	0.125	0.25
C (ft/min)	200	2200
Cutting Speed, V (ft/min)	100	1200

Table 1: Properties for the high-speed steel and coated carbide tools for machining steel

a.) Compare the tool life for these two materials.

b.) Assuming a depth of cut of 0.1 in. and a feed of 0.01 in. for each of the tools, calculate the MRR for each tool.

c.) Now consider the costs associated with using the two different tool materials. Assume that the HSS tool cost $30 each, and the carbide tool cost $150 each, and it takes 5 minutes to change a tool. If you have an operation, as described above, that requires removing 300 in3 of material and the machine and operator costs are $60/hr which tool results in a lower cost? How about if the machine and operator cost $120/hr.