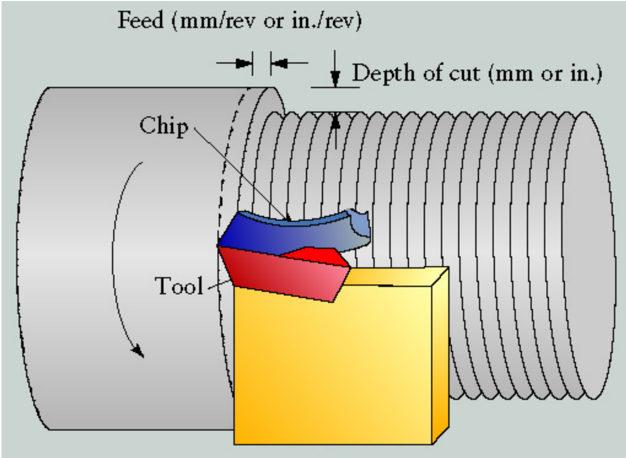
ME 338
Manufacturing Processes II
HW#1

Instructor: Ramesh Singh
Assigned Date: August 5, 2017
Due Date: August 15, 2017

1. Consider the Merchant's Cutting Force diagram and tool-chip interface presented in the lecture notes. Consider the directions of the cutting force and the thrust force. Will the Fc, cutting force, be always positive and why? Is the thrust force, Ft, also positive at all times? If not, explain why. Show from force expressions how you can make Ft = 0 for a given friction coefficient between the tool and the work piece. Please provide physical explanations of your suggestions/recommendations.

2. During an orthogonal machining operation results are obtained as:
   Uncut chip thickness, $t_0 = 0.25$ mm, chip thickness, $t_c = 0.75$ mm, w = 2.5 mm
   $\alpha = 0$ deg, Fc = 950 N, Ft = 475 N.
   a. Determine the coefficient of friction between tool and chip
      i. Determine the ultimate shear stress of work material

3. Mild steel is being orthogonally turned at an average cutting speed of 280 m/min with a rake angle of 10^0. The depth of cut is 2 mm and feed is 0.2 mm/rev. The average value of the coefficient of friction between tool and chip is 0.5 and the shear stress τ_s of the work material is 400 N/mm^2. Determine:
   a) Shear angle
   b) The cutting and thrust forces
   Merchant's equation,
   $2\phi + \beta - \alpha = \pi/2$



4. During deformation of material in machining, the shear strain, γ, is a function shear angle, ϕ, and rake angle, α:
   a) Derive the expression for shear strain in orthogonal machining.
   b) Find the expression for shear angle as a function of α for minimum shear strain condition.
   c) Prove that the expression for chip ratio, r, as a function of α for minimum shear strain condition is:

$$r = \frac{\text{Sin}\left(\frac{\pi}{4} + \frac{\alpha}{2}\right)}{\text{Cos}\left(\frac{\pi}{4} - \frac{\alpha}{2}\right)}$$

   d) What is the expected value of the chip ratio at minimum shear strain and provide the physical explanation for this value.

5. For the orthogonal cutting of a particular work material with zero rake angle, it has been found that the tool-chip contact length is always equal to the chip thickness (t_c) and the mean shear stress (τ_f) at the tool-chip interface is a proportion k of the mean shear stress on the shear plane (τ), i.e., τ_f=k τ . Find the cutting forces in terms of t_0, w, k and ϕ.

6. A 300 mm x 300 mm x 25 mm flat block of alloy steel is machined using orthogonal planing process. The process parameters are as follows: Rake angle (α) = 10 deg; Cutting Velocity (V) = 2m/s; uncut chip thickness (t_0) = 0.25 mm; deformed chip thickness (t_c) = 0.83 mm, and width per pass = 2.5 mm. Tests have shown that F_c = 1670 N and F_t = 1001 N. The length of contact between the tool rake face and chip is 0.75 mm.
   a. If the shear strength of the tool material is 400 MPa. Will the tool fail? (Assume uniform stresses at the tool-chip interface)
   b. Draw the actual stress distribution at tool chip interface (normal and shear stresses)?

7. The top view of as tube being turned orthogonally is shown in the Figure 1. Rake angle is + 10° and the dynamometer shows Fx = 1259 N, Fy = 0 and Fz = 1601 N. The axial feed is 100 mm/min and the rotational speed of the spindle is 1000 rpm. The chip thickness is 0.28 mm. Estimate the shear strength of the workpiece material and list the assumptions underlying the theory you are using.

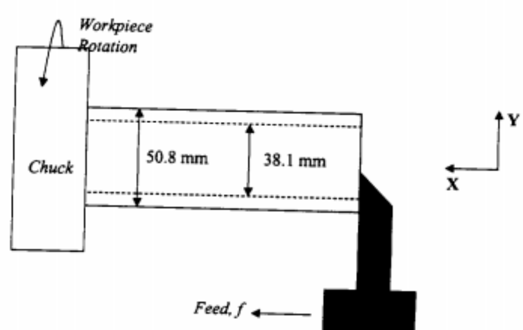
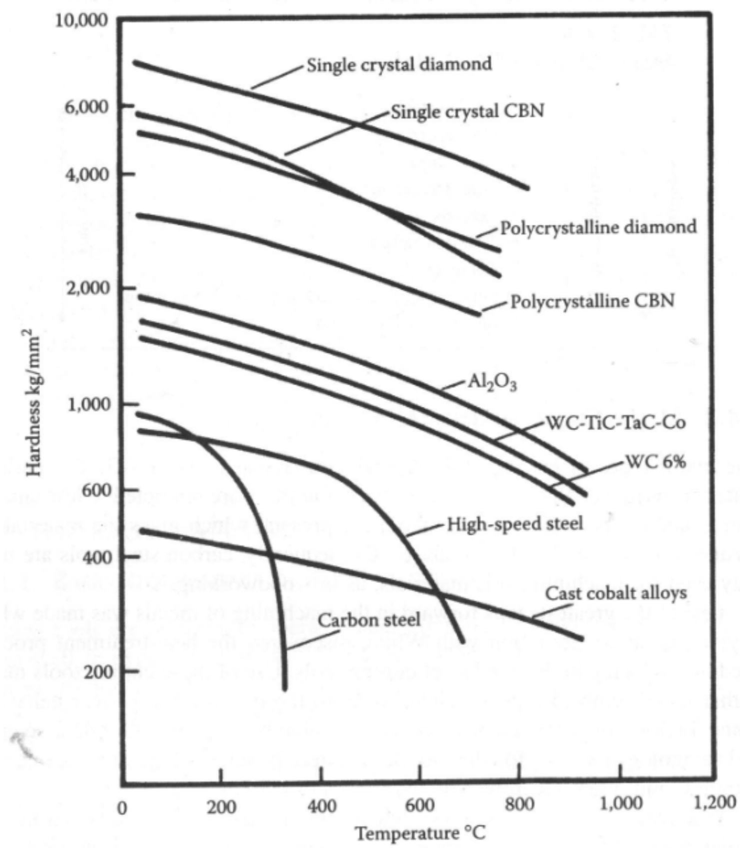


Figure. Top view of cutting process

8. See the chart (hardness vs. temperature) below and use the information to solve the following problem:

A 300 mm x 300 mm x 25 mm flat block of alloy steel is machined using orthogonal planing process. The process parameters are as follows: Rake angle (α) = 10 deg; Cutting Velocity (V) = 2m/s; undeformed chip thickness (t_0) = 0.25 mm; deformed chip thickness (t_c) = 0.83 mm, and width per pass = 2.5 mm. Tests have shown that F_c = 1670 N and F_t = 1001 N.



a) Calculate the shear plane temperature if the ambient temperature is 25degC. The specific heat/volume (ρc) is 3.7 N/(mm^2.^{0}C)
b) Calculate the mean temperature of the chip if 10% of the total heat is conducted to the workpiece and 5% is lost to the atmosphere. Assume the temperature is uniformly distributed in the chip.
c) Choose the right cutting tool based on the constraint that minimum hardness for successful machining is 400 kg/mm^2.

9.

a) Plot the parametric effect of change in coefficient of friction (or friction angle) on cutting and thrust forces for unit width. Assume that μ lies between 0.3 and 1 and the shear stress of the material is 400 MPa and rake angle is 10 deg and uncut chip thickness is 0.1 mm.
b) Now alter the depth of cut 0.1 mm to 0.01 mm and plot the specific cutting energy vs. uncut chip thickness.

Use Merchant's shear angle relationship. Explain the physical significance of your findings. (Use Mathematica, Matlab or excel to plot. No messy hand plots please)

10. Derive the expression of equivalent rake angle in oblique cutting (slide 20 in notes)