

Homework #3: Metal Cutting

2.008 Design and Manufacturing II
Spring 2004

Out: February 25th
Due: March 3rd

Problem 1:

(a) Consider the Merchant's Cutting Force diagram in Figure 1 and the chip-workpiece interface during orthogonal cutting in Fig. 2.

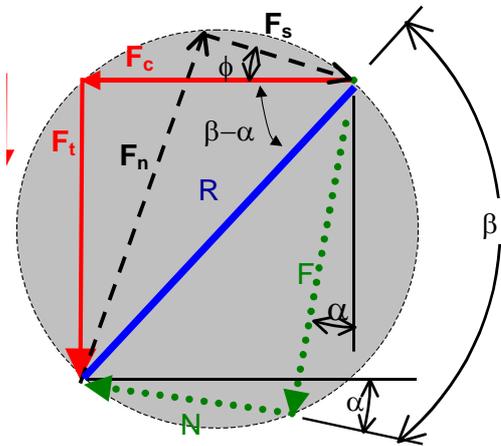


Fig 1. Merchant's diagram

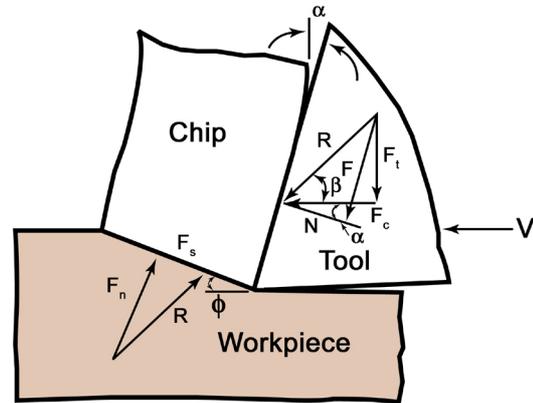


Fig 2. Cutting FBD

Merchant's hypothesis is that the shear plane is located to minimize the cutting force, or where the shear stress is maximum. Derive the Merchant's relationship between shear angle, rake angle, and friction angle as below from the diagram above.

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

(b) Consider the directions of the cutting force and the thrust force. F_c , cutting force, is always positive, since the material is removed. Is the thrust force, F_t , also positive at all times? If not, explain why. Also explain how you can make $F_t = 0$ for a given friction coefficient between the tool and the work piece.

Problem 2:

Your lab group decided to make fancy transparent-look Yo-Yos and designed the body of the Yo-Yo to be injection molded as follows. For a solid look, two identical parts are supposed to be assembled with an insert-molded bolt and nut.

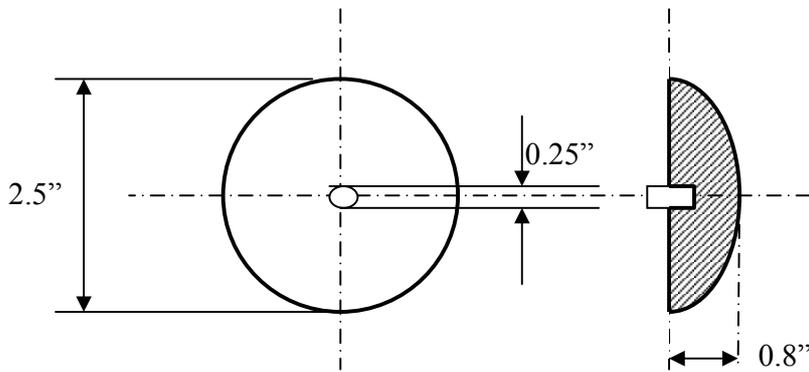
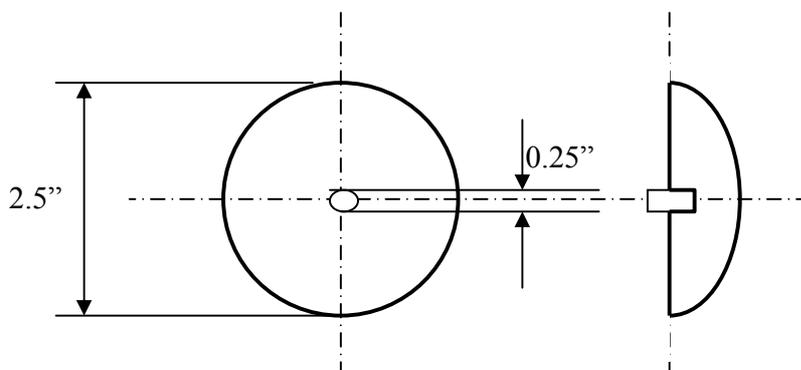


Figure 1. Injection molded YoYo body

- a) After learning about polymer materials and processes, you now know this design is not good for injection molding. Make necessary design changes on the figure below and explain why you chose to make them.



- b) The material provided by Dave and Pat is Polypropylene, which is translucent. Explain in one sentence why Polypropylene (PP) is not transparent. After searching for crystal clear and high impact resistant materials, you find out that polycarbonate (PC) is the right one for your nude Yo-Yo. Why is PC transparent? (1 sentence) Are those materials thermosetts or thermoplastic? How you can prove that?
- c) From the manufacturer of the Polycarbonate resin, you received the modulus-temperature curves shown below. Which is the right M-T curve of Polycarbonate? (A or B?) What is the approximate T_g of PC?

- d) What would be the clamping force required for this part? Choose a proper parting line and assume the injection pressure is 1000 psi with a packing process which requires a packing pressure about twice the injection pressure.
- f) The cycle time of the part (after making necessary design changes in (a)) is still measured as 2 minute. It is composed of mold filling (10%), part cooling (75%), ejecting and mold closing, etc. This cycle time cannot justify the selling price at the market. Therefore you redesigned it with 40% reduction of the thickness of the part. Assume that the thickness is changed uniformly over the whole part. Please estimate the new cycle time.

Modulus-temperature of PC

