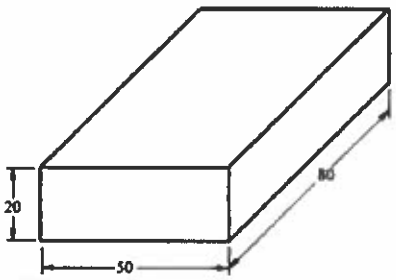
PhD Qualifying Exam
Manufacturing
Fall 2015

Answer all problems. Clearly show all of your work. List all relevant assumptions.

1. Metal Casting

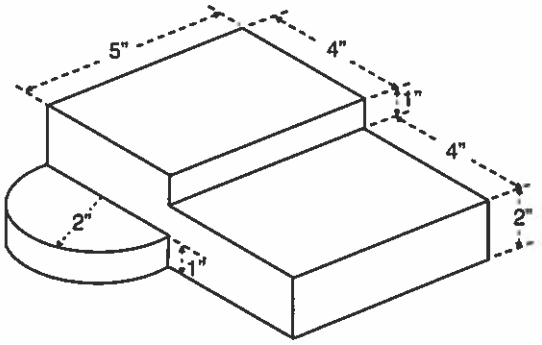
Within one month 1,000 parts, as shown in Figure 1, made of steel must be manufactured, using a casting process. The surface finish of the parts can be on the order of 15 um R_a. You have been tasked with designing a solid pattern, to form the mold.

a) What casting process should most likely be used?
b) What material should the pattern be made of?
c) What are the dimensions of the wooden pattern? Assuming a machining allowance of 2 mm on each side, shrinkage allowance of 2% and a taper allowance of 1 degree.
d) Graphically depict the final pattern with dimensions.
e) If 50,000 parts were need, what changes would you make?



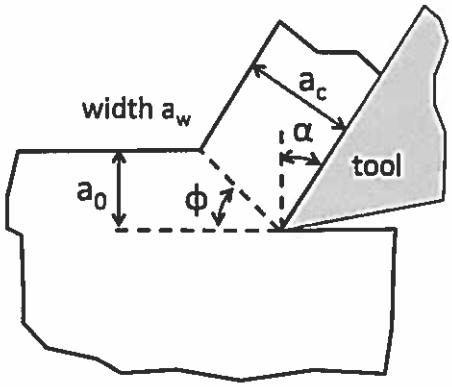
2. Polymer Processing

In considering the use of an injection-molding machine to make a plastic part of the following dimensions, there is a limiting injection pressure level beyond which the machine will leak along the parting line. (a) Draw in the figure below the injection direction with which the limiting pressure presents its lowest possible value? (b) For a machine of 280,000 lb capacity (maximum clamping force, that is) to be used, what is the lowest possible limiting pressure, in psi? (c) If one is allowed to design the injection direction freely, what is the highest possible limiting pressure, in psi?



3. Machining

Inconel 718 is subjected to an orthogonal cutting configuration with an undeformed chip thickness of $a_0 = 0.250$ mm, width $a_w = 2.5$ mm and rake angle $\alpha = 0$ degrees as is shown in the schematic below. Answer the questions provided below and show all work. For parts (a)-(c) assume cutting force $F_c = 1100$ N, tangential force $F_t = 550$ N and deformed chip thickness $a_c = 0.750$ mm.



(a) Determine the mean friction angle β and shear angle ϕ.
(b) Determine the mean shear strength of the work material.
(c) If the cutting speed was $V_0 = 1$ m/s, what would the thermal rise in the shear zone be due to the plastic dissipation in shear (ignore friction) assuming adiabatic conditions? You can assume density ρ=8220 kg/m^3 and conductivity c=450 J/(kg-K).
(d) Assuming chip formation occurs by minimum work (e.g., $dF_c/d\phi = 0$), what is the shear angle ϕ as a function of friction angle β.