ME 383 Homework #3 Solution

1. Briefly state the functions of the pattern, the core, and the riser in sand casting (9 pts.)
   Pattern: form external shape of the part
   Core: form internal cavities of the part
   Riser: supply additional molten metal to mold cavity during solidification

2. (a) The blank for the spool shown in the figure below is to be sand cast out of A-319, an aluminum casting-alloy. Make a sketch of the wooden pattern for this part, and include all necessary allowances for shrinkage and machining.

   (b) Repeat Problem 11.53, but assume that the aluminum spool is to be cast using expendable-pattern casting. Explain the important differences between the two patterns.
   (a) The sketch for a typical green-sand casting pattern for the spool is shown below. A cross-sectional view is also provided to clearly show the shrinkage and machining allowances, as well as the draft angles. The important elements of this pattern are as follows:
   1. Two-piece pattern
   2. Locating pins
   3. Shrinkage allowance = 5/32 in./ft
   4. Machining allowance = 1/16 in.
   5. Draft = 3°
(b) A sketch for a typical expandable-pattern casting is shown below. A cross-sectional view is also provided to clearly show the differences between green-sand and evaporative casting patterns. The important elements of this pattern are as follows:

1. One-piece pattern, made of polystyrene
2. Shrinkage allowance = 5/32 in./ft
3. Machining allowance = 1/16 in.
4. No draft angles necessary.

![Sketch of a typical expandable-pattern casting](image)

3. The optimum shape of a riser is spherical to ensure that it cools more slowly than the casting it feeds. Spherically-shaped risers, however, are difficult to cast. (a) Sketch the shape of a blind riser that is easy to mold, but also has the smallest possible area-to-volume ratio. (b) Compare the solidification time of the riser in part (a) to that of a riser like a right circular cylinder. Assume that the volume of each riser is the same and that, for each, the height is equal to the diameter.

(a) A sketch of a blind riser that is easy is shown, consisting of a cylindrical and a hemispherical portion. Note that the height of the cylindrical portion is equal to its radius (so that the total height of the riser is equal to its diameter). The volume \( V \) of this riser is

\[
V = \pi r^2 h + \left( \frac{1}{2} \right) \left( 4\pi \frac{r^3}{3} \right) = \left( \frac{5}{3} \right) \pi r^3
\]

Let \( V \) be unity, we have \( r = \left( \frac{3}{5\pi} \right)^{\frac{1}{3}} \).

The surface area \( A \) of this riser is

\[
A = 2\pi rh + \pi r^2 + \left( \frac{1}{2} \right) \left( 4\pi r^2 \right) = 5\pi r^2 = 5.21
\]

Thus, the solidification time \( t \) for the blind riser will be

\[
t = C \left( \frac{V}{A} \right)^2 = C \left( \frac{1}{5.21} \right)^2 = 0.037C
\]

(b) From p.252, we know that the solidification time for a cylinder with a height equal to its diameter is 0.033C. Thus, the blind riser in (a) will cool a little faster.
4. Which casting design in each group is correct? Why? (30 pts)

(1) Uniform part thickness, less shrinkage porosity, less warpage because of ribs, more stiffness because of ribs.

(2) Casting (b) needs only one core, while casting (a) uses two cores.

(3) Uniform section thickness.

(4) Eliminate inclined surface to simplify mold making, uniform section thickness.

(5) Orient flanges so that they can be easily casted, uniform section thickness.
5. (a) For this case, we have
\[ V_a = (1 - 0.09)V_f = 0.91V_f \]
where \( V_a \) and \( V_f \) are actual material volume and final part volume, respectively.

Because the linear shrinkage during firing is 7%, we write
\[ V_d = V_f / (1 - 0.07)^3 = 1.24V_f \]
\[ V_a / V_d = 0.73 \]
where \( V_d \) is the part volume before firing.

Consequently, the porosity of the dried part is \( 1 - 0.73 = 0.27 \) or 27%.

(b) For firing, we can write
\[ (L_d - L) / L_d = 0.07 \]

or
\[ L_d = L / (1 - 0.07) = 20 / (1 - 0.07) = 21.51 \text{mm} \]

For drying, we can write
\[ (L_0 - L_d) / L_d = 0.07 \]
\[ L_0 = 1.07L_d = 23.12 \text{mm} \]

6.
(a) Remove the flange  (b) increase the thickness of thin section  (c) remove the undercut