Simple Riser Design

Dr. Robert Tuttle
Saginaw Valley State University
University Center, MI
Email: rtuttle@svsu.edu

The function of a riser is to supply additional molten metal to a casting to ensure a shrinkage porosity free casting. Shrinkage porosity occurs because of the increase in density from the liquid to solid state of metals. To be effective, a riser must solidify after the casting and contain sufficient metal to feed the casting or portion of a casting. Casting solidification time can be predicted using Chvorinov’s Rule.

\[
t_{TS} = C \left( \frac{V}{A_{surf}} \right)^2
\]

(1)

Where \( t_{TS} \) is the total solidification time of the part or riser, \( C \) is a mold constant, \( V \) is the volume of metal, and \( A_{surf} \) is the total surface area of the part or riser.

Chvorinov’s Rule provides guidance on why risers are typically cylindrical. The longest solidification time for a given volume is the one where the shape of the part has the minimum surface area. From a practical standpoint, the cylinder has the least surface area for its volume and is easiest to make.

Since the riser should solidify after the casting, we want its solidification time to be longer than the casting. If we want the riser to take 20% longer than the riser, then we can write the following expression:

\[
\left[ C \left( \frac{V}{A_{surf}} \right)^2 \right]_{\text{riser}} = 1.2 \left[ C \left( \frac{V}{A_{surf}} \right)^2 \right]_{\text{casting}}
\]

(2)

The term \( \frac{V}{A_{surf}} \) occurs so frequently it is given a special name. It is called the casting modulus. By using the variable \( M \) to represent the casting modulus and simplifying, the above equation can be reduced to.

\[
M_{\text{riser}} = 1.2 \ M_{\text{casting}}
\]

(3)

This expression is used for the simplest method for designing a riser. It is called the modulus method. While modern computer methods make it easier to optimize the riser, an initial guess of the correct geometry is needed. The modulus method provides the best method for obtaining that initial guess.
With modern CAD packages it is easy to obtain the volume and surface area of the part. Many packages will calculate these values for you. If you do not have access to a modern CAD package then the casting geometry is broken up into a series of cubes, cylinders, and other prismatic entities and their volumes and surface areas are added together.

The modulus for a cylindrical riser is given by the following equation.

\[ M_{\text{riser}} = \frac{D H}{4H + 2D} \]  

Where D is the riser diameter, and H is the riser height. Determining the final riser dimensions will require an assumption about the relationship between the riser height and diameter. Typically riser height is twice the diameter (H=2D).

To ensure a riser can feed a casting or casting section, its maximum feeding volume should be checked against the casting or section volume. Equation 5 provides this check for a riser without an insulating sleeve.

\[ V_{\text{max}} = V_{\text{riser}} \left( \frac{14 - S}{S} \right) \]  

Where \( V_{\text{max}} \) is the maximum casting volume that can be fed, \( V_{\text{riser}} \) is the volume of the riser, and S is the specific shrinkage of the alloy in percent. The specific shrinkage for a specific alloy is listed in Table 1.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Contraction (Volume %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure aluminum</td>
<td>6.6</td>
</tr>
<tr>
<td>Aluminum-Silicon alloys</td>
<td>3.8</td>
</tr>
<tr>
<td>Aluminum-Copper alloys</td>
<td>6.3</td>
</tr>
<tr>
<td>Grey Cast Iron</td>
<td>0-1.8</td>
</tr>
<tr>
<td>White Iron</td>
<td>4-5.5</td>
</tr>
<tr>
<td>Plain low carbon steel</td>
<td>3.0</td>
</tr>
<tr>
<td>Copper</td>
<td>4.5</td>
</tr>
<tr>
<td>Tin Bronze</td>
<td>5.5</td>
</tr>
<tr>
<td>Aluminum Bronze</td>
<td>4</td>
</tr>
<tr>
<td>Magnesium</td>
<td>4.2</td>
</tr>
<tr>
<td>Zinc</td>
<td>6.5</td>
</tr>
</tbody>
</table>
The location of a riser is very important for its performance. Riser should always be located at in-gates or in hot spots within the casting. Hot spots are portions of a part that are thicker than the surrounding geometry and therefore cool faster than the rest of the casting.

**Example Calculations**

A single shifter lever part will be placed in a mold. Determine the required riser for the shifter lever if it has a volume of 0.955 in³ and a surface area of 6.905 in².

**Solution:**

It is best to produce this part with a single in-gate at the large boss on the part. To create directional solidification and prevent shrinkage, the riser should directly feed the cylindrical feature by being placed at the in-gate.

\[ M_{\text{riser}} = 1.2M_{\text{casting}} = 1.2(0.955/6.905) = 0.1660 \]

\[
M_{\text{riser}} = \frac{\pi D^2 H}{4} \cdot \frac{2\pi D^2 + \pi DH}{4H + 2D} = \frac{DH}{4H + 2D}
\]

\[
0.1660 = \frac{DH}{4H + 2D}
\]

Assuming \( H/D = 1 \) or \( H = D \),

\[
0.1660 = \frac{DD}{4D + 2D}
\]

\[
D = 0.996 \text{ in}
\]

\[
H = 0.996 \text{ in}
\]
Confirm the riser is large enough,

\[ V_{\text{max}} = V_{\text{riser}} \left( \frac{14 - S}{S} \right) = (0.775) \left( \frac{14 - 3.8}{3.8} \right) = 2.08 \text{ in}^3 \]

Therefore, the riser is big enough.

The final rigging system is pictured below without a downsprue.

References