

# THE BASICS OF HORIZONTAL GATING SYSTEM DESIGN



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## ARTICLE TAKEAWAYS:

- Gating components are sized using Bernoulli's Theorem and the Law of Continuity
- Properly sized gating systems help to fill the mold smoothly
- Gating system design can be automated using casting simulation tools

## Basic Theory of Gating Design

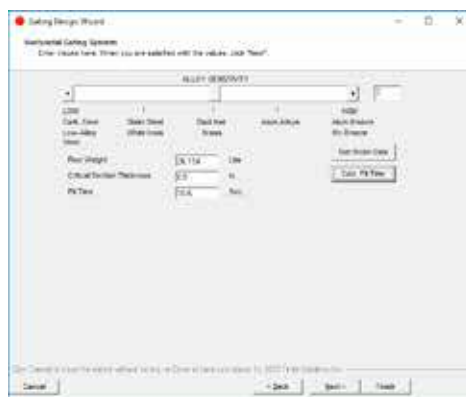
Gating design is actually very simple. One starts by estimating the Fill Time required for a casting. This may be based on experience, or on a calculation involving the weight poured, the alloy type and the critical section thickness.

Knowing the Fill Time, weight and density of the casting, you can calculate the volumetric flow rate using the formula:

$$\text{Flow rate} = \frac{\text{Volume}}{\text{Fill Time}}$$

Next, we consider how far the metal will fall when poured, which gives a metal velocity. Knowing the velocity and the volumetric flow rate, the cross-sectional area of flow required can be calculated. The flow area is adjusted for friction loss, and finally this area is apportioned so there is the desired rate of flow at all gates into the casting. It is also necessary to establish the "choke" point, which controls flow through the gating system.

The example shown following was created using the Gating Design Wizard, a part of the SOLIDCast simulation software. Much of the data input needed for a gating system calculation can be extracted from simulation models. For detailed descriptions of complete design of gating components and systems, see the AFS Handbook on Basic Principles of Gating.



**Figure 1.** Alloy Selection and Optimal Fill Time (OFT) Calculation.

Gating Design starts with calculation of an Optimal Fill Time (OFT). To calculate an OFT, the following is required:

### Alloy Sensitivity

This is specified with the slider bar at the top of the screen (Figure 1). This is the tendency of metals to form oxides during pouring. Alloys of low sensitivity may be poured more quickly. Alloys which are more sensitive should be poured more slowly to avoid turbulence which may form and entrain oxides as inclusions in the finished casting.

### Pour Weight

This is the weight of casting(s) plus rigging. The wizard will extract the weight from the simulation files. If the model does not include risering, you may need to increase the displayed weight. The exact value of the weight is not highly critical, since the OFT formula uses the cube root of the weight to estimate fill time.

### Critical Section Thickness

The thinnest section of the casting, which is most likely to misrun.

You may also select a fill time rather than use the OFT calculation.

Once fill time and weight have been established, we can begin figuring flow requirements. First, a mass flow rate is calculated. Then, using the metal density, this is converted to a volume flow rate.

The next requirement is the height that the metal will drop. This is the effective height of the sprue. The velocity of the metal after falling through this height can be calculated from the following:

$$V = \sqrt{2gH}$$

Where

**V** = velocity

**g** = acceleration of gravity

**H** = height through which the liquid has fallen

This formula is based on Bernoulli's Theorem, which describes the energy in a system.

Given the velocity and volumetric flow rate, the area of flow of the liquid metal can be calculated from the following:

$$\text{Flow Area} = \frac{\text{Volumetric Flow Rate}}{\text{Velocity}}$$

Flow areas are adjusted for frictional losses. A square tapered sprue has an efficiency of around 74%; this means that an area calculated above must be increased by a factor of (1/0.74) or 1.351 to account for the energy losses. Flow through runner systems also loses energy through friction with the channel walls. This is compensated for by increasing the area of the downstream runner segments.

Another entry is the gating ratio, which is the ratio of the area of flow at three different points: the sprue; the runner; and the gates. This is usually expressed as whole numbers, giving the ratio of the area of each of these points as S:R:G. If the gating ratio is 1:4:4 then the area of the runners will be 4 times that of the area at the base of the sprue, and the area of the gates will be equal to that of the runners.

The "choke" is the location in the gating system with the minimum cross-sectional area. In a 1:4:4 system, the choke is at the bottom of the sprue. In a 4:8:3 system, the choke is at the gates.

**Figure 2** illustrates the entry of data about the pattern layout:

The Sprue Type establishes the efficiency factor to be applied to the area calculation for the sprue.

The next calculation is the Effective Sprue Height (ESH). This is based on pattern dimensions by selecting the type of gating system, then entering appropriate dimensions. Note that, if the metal is poured directly into the sprue and not into a pouring basin, then the height of the ladle above the top of the mold should be added to the ESH, since this height will establish the metal velocity after falling to the bottom of the sprue.

The Gating Ratio is entered next, a set of three numbers as described above.

The Number of runners leading away from the base of the sprue and the Total number of gates fed from this sprue are entered. At this point, algebra takes over to perform the gating calculations and design the individual components.

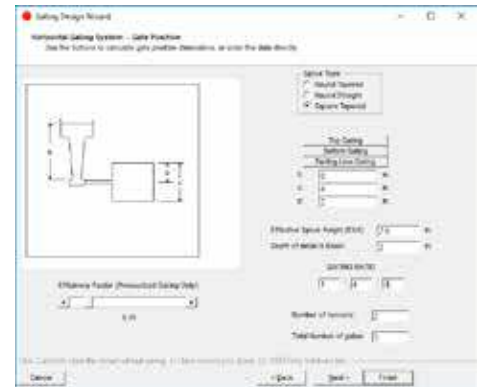
**Figure 3** shows a typical calculation of Sprue Data, including the choke area and areas at the bottom and top of the sprue.

Also shown are the Total Runner Area, Number of Runners and the Friction Loss Factor. A typical Friction Loss Factor is 5%.

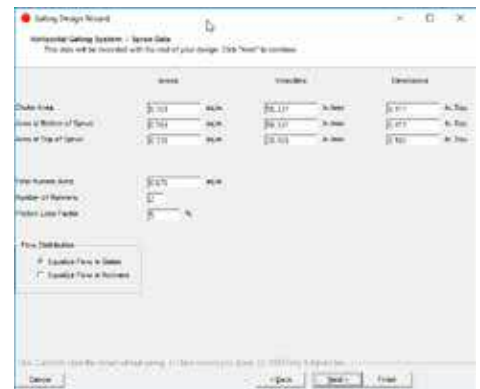
For runners which feed multiple gates, it is common practice to "step down" the runner, after each gate to equalize the flow. The amount each section is reduced is equal to the area of the preceding gate.

A typical Runner and Gate Design are shown in **Figure 4**:

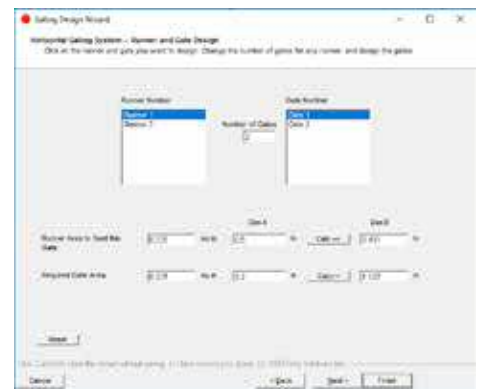
Note that the runner cross-section is reduced for each subsequent gate along a runner, and also that the area of both the runner and the gate have been increased by the friction loss factor to compensate for the energy loss associated with friction. You can keep selecting subsequent gates along the runner until all of



**Figure 2.** Selection of Sprue Type, Pattern Layout and Gating Ratio.



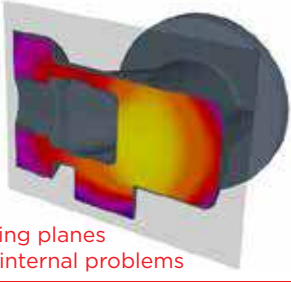
**Figure 3.** Sprue Data.



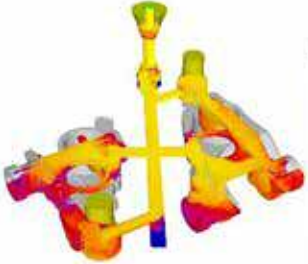
**Figure 4.** Runner and Gate Size Data.

the gates and all sections of this runner have been designed. Once this runner is finished, you can select the next runner to design and perform the same operations to design all gates and runner sections for this runner. This process continues until all runners and all gates have been defined.

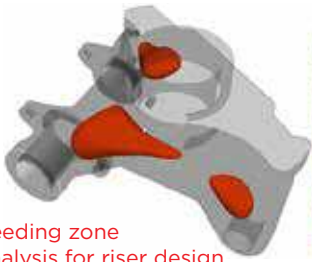
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