MOLD VENTING: A Return to the Basics

The role of proper venting should not be discounted in the total recipe for quality castings. Here’s how to avoid costly gas problems.

**Vent** (vent) a means of escape or passage from a restricted area; an opening which allows the escape of vapor, heat, gas or liquid. *(Webster’s Dictionary)*

To the foundry engineer, a vent is a small channel in molds for letting steam, air or mold gas escape as metal fills the mold. When done properly, venting will reduce gas-related defects, improve surface finishing, allow shorter pouring times and result in fewer misruns.

The need to vent cores and molds has been recognized for many years as a means to avoid the adverse effects of entrapped or evolved gases. Sources of these gases include heated air in the mold, steam generation from water in the binders, and products of combustion from binders and coatings.

However, all too often, venting is forgotten until problems develop. Ideally, it should be considered as the third leg of the casting quality “stool”—along with proper feeding and gating practices. If the gating system is the “plumbing system for molten metal,” then the venting system is the “plumbing system that allows entrapped air and mold-generated gases to escape.” In fact, the venting process is as important to making good castings as the proper design of the gating/rising system.

**Air Expansion and Gas Evolution**

Air in the mold cavity can expand to many times its volume as the molten metal enters the mold. Likewise, the pressures generated from expanding air can be surprising. Assuming an ideal gas, 1 cubic cm (1cc) of air at 77F (25C) expands to 62cc at the same pressure when heated to 2822F (1550C). For the same volume, the increased pressure generated when air at the standard pressure of 10 N/cm² (14.7 psi) is heated from 77F (25C) to 2822F (1550C) is 628 N/cm² (911 psi).

Moisture in green sand can also be a problem if venting is inadequate. For every 1 lb of green sand at 3% moisture, there are 13.6 grams of water. Heated to 2822F (1550C), that 13.6 grams (about 0.5 oz) of moisture provide 0.5 cu ft of steam.

Gas evolution from binders must also be taken into consideration. Table 1 lists an approximate guide for gas evolution for each 1% binder in various types of cores.

By knowing the volume of bonded sand from the mold and core that will burn out and the gas evolution per unit volume, the amount of mold gases generated can be estimated. This can be another guide as to the amount of venting necessary. Without adequate venting, these gases can become entrapped and result in casting defects such as blowholes or scabbing (Fig. 1). There may also be a reaction between the mold gases and molten metal forming undesirable products in the casting. Gas pressure can become high enough locally that it will not allow the molten metal to completely fill the mold cavity, causing misruns or cold shuts. Furthermore, excessive gas pressure can roughen as-cast surfaces.

**Table 1. Gas Evolution at 1% Binder for Various Coremaking Methods**

<table>
<thead>
<tr>
<th>Method</th>
<th>Gas Evolution (cc/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coreless</td>
<td>3.9</td>
</tr>
<tr>
<td>25% Resin binder</td>
<td>3.4</td>
</tr>
<tr>
<td>50% Resin binder</td>
<td>5.8</td>
</tr>
<tr>
<td>75% Resin binder</td>
<td>9.5</td>
</tr>
</tbody>
</table>

Source: BCIRA Bardsheet 16-3

**Fig. 1. Riddled with blowholes due to lack of permeability in the sand, this iron casting wasn’t sufficiently vented.**

**Permeability vs Casting Shape**

- **(a.):** Smooth as-cast surface
- **(b.):** Contoured casting shape
- **(c.):** Roughen as-cast surfaces
- **(d.):** Contoured casting shape with rough as-cast surfaces

**Fig. 2. Permeability is affected by casting shape. Shown here is how contoured shapes pose a more difficult problem for evacuating gases.**

**VSM** (Vacuum Square Moulds)

Vacuum Square Moulds (VSM) are another method of eliminating gas entrapment. The process involves sealing a mold at atmospheric pressure and then evacuating it to a vacuum of about 20 microns. Once the mold is evacuated, the vacuum chamber is then backfilled with a stream of dry, preconditioned air or inert gas. This process helps to remove any entrapped gases and allows for better casting quality.
loosen sand grains, cause mold and core coatings to buckle, and increase pouring times.

**Permeability**

Sand permeability also affects the amount of venting needed to ensure a good casting is produced. Natural openings in the molding sand, as well as through man-made openings (vents), allow air and gases to escape. The measure of how fast gases will diffuse through molding sand is called permeability.

Mold permeability has been defined as the volume of air in cu cm at 1 cm water gauge pressure that will pass through the test piece in 1 min when the test piece is 1 cm long and 1 sq cm in cross sectional area. In an equation form, it is:

\[
\frac{(\text{Volume of Air}) \times (\text{Height of Specimen})}{(\text{Area}) \times (\text{Time}) \times (\text{Pressure})}
\]

Permeability can be measured with commercially available equipment and is usually specified as a permeability number. The larger that number is, the higher its permeability. Permeability can be influenced by the size of the voids between the sand grains.

Regardless of whether the molding sand is classified as "coarse" or "fine," the amount of intergranular voids is the same. But as sand coarseness increases, voids are fewer and larger than when compared to finer sand with many smaller voids. Higher permeabilities are usually associated with coarser sand. The distance the gases must travel also can influence mold permeability.

Mold and core coatings will usually reduce permeability through the mold. Core must be taken to keep openings from blocking vents. Coating can also be helpful in directing the gas to move toward the vents in core prints.

Casting shape also affects mold permeability. Castings with deep pockets or sharp concave contours will result in a mold that has difficulty in evacuating gases (Fig. 2). Additionally, the compaction comes into high-density mold will reduce permeability. Areas of the mold closest to the squeeze will see lower permeabilities than other areas because the sand is more closely compacted in that area as compared to other parts of the mold. While there is no single optimum value of permeability, following two guidelines (BCIRA, June 1973):

- There is risk when the permeability is less than 20 in green sand molds because the margin for error is high if the water content varies.
- If permeabilities over 120 are used in synthetic sands, the surface finish of the castings may not be acceptable.

**Venting Practice**

There are many different types of vents. Small diameter rods or stems (Fig. 3) can be added to the pattern in strategic locations to produce a vent as the mold is made. Parting line vents (Fig. 4) can be either made with strips on the pattern or scratched in the mold before the mold is closed. Remember that a parting line vent ceases to allow air to escape as the molten metal rises above the parting line (Fig. 5). Additionally, parting line vents, if too large, can cause runs and gas blowholes. If cores are hallowed out in areas, not only to affect breakdown but also to help channel the gases toward vents. Commercially available textile, wax or rope vents (Fig. 6) are also available to create channels in molds or cores. Sometimes when an extremely large vent is needed, pouring gates or pipes have been used. Proper gating design should also include a vent at the end of flowoffs to allow air to escape from the gating system (Fig. 7). Weep holes in the sides of flasks also serve as vents. If it is impossible to vent through the sidewalls of flasks, adding small hollow strips to the flask sidewall can create a channel in the sand for venting. Bottom boards should also be vented to allow gases to escape from the bottom of the drag. If bottom boards can't be used, the floor under the mold should be grooved or the molds should be placed on a bed of dry sand. Both techniques will allow for venting.

Venting is most successful, however, when included on the pattern equipment. The proper locations are already laid out...
and the foundry can be assured that venting is occurring, rather than relying on people to perform the operation on the molding line. Mold cycle time is not taken up with drilling vents. Also, adding vents by hand can disturb the mold and increase the possibility of loose sand grains falling into the mold cavity. On the downside, care must be taken to prevent small thin vent rods from damage during molding and pattern handling. Also, vents can cause more work in the cleaning room, since they must be removed if filled with metal.

**Venting Blind Risers**

When using blind feeders, venting becomes more important as the depth of sand increases over the riser or as the pouring rate increases. Failure to properly vent feeders can result in unfilled risers and loss of atmospheric puncture during solidification.

If possible, it is better to vent through the sand (by placing a small post on top of the riser) rather than venting through the sleeve. This is because problems can occur if the vent is too large and the top of the cope becomes disturbed (Fig. 8). This small rod of metal will solidify before the feeder and therefore won't allow the feeder to follow the casting during solidification. The feeder can then become "upset"—especially in skin forming alloys, causing a late stage shrink at the feeder contact.

**General Rules**

There is no set answer as to how much venting is necessary, since every mold can be different. However, there are rules of thumb to follow for proper venting:

- the total vent area should be at least equal to the choke area;
- venting should be added until there is no change in pouring time;
- watch the flames coming from vents. If they are "pressure jets," add more venting until they become "lazy" gas flames;
- if in doubt, vent some more.

This article was adapted from a panel presentation given at the 1997 AFS Casting Congress. For a free copy of this article circle No. 341 on the Reader Action Card.