T E C H N I C A L   U P D A T E

Unique Design Opportunities Presented by Hitchiner's CV Countergravity Casting Process




Molds up to 20" (508mm) diameter can be cast automatically using the CV process by the machine above.

1. Background

Publications by Hitchiner Manufacturing Co., Inc. over the years have reported that the quality of metal castings made by counter gravity mold filling is much better than that made by traditional gravity pouring. Confirmation of this quality improvement has also been independently reported by others [1,2,3]. Hitchiner's original process, CLA, was limited to relatively small parts thinner than one half inch (12.5mm) in wall thickness. The purpose of this monograph is to describe how a new process, called CV (for Check Valve) process enables the designer to utilize counter gravity for economic production of large parts with thicker sections, especially when such castings also have thin sections.

2. The CV process

a. A schematic of how the process works is shown in Figure 1. Since operations a–c are relatively short on the casting machine, and operation d, which can be many minutes, is not on the machine, molds are cast quickly. Gating is designed to fill the mold with the metal feed reservoirs (risers) down, so when the mold is rotated, the risers with hot metal are up, significantly improving gating efficiency. Vacuum counter gravity filling enables use of much lower mold and metal temperatures to fill thin sections, which reduces the heat removal needed to make thick sections solidify directionally and thus metallurgically sound.

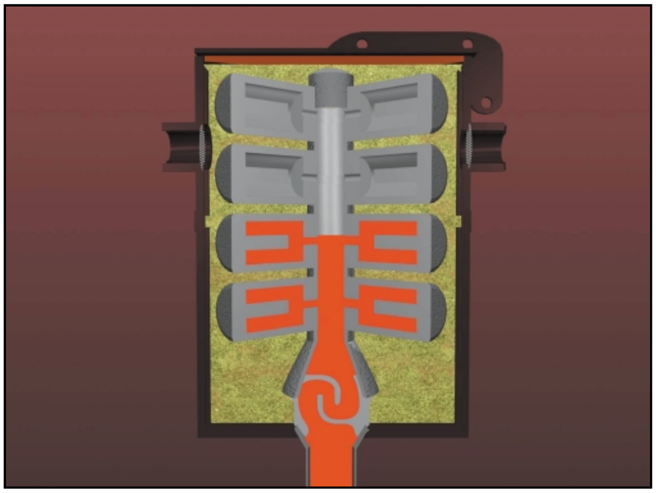
3. Case studies of how to design for the CV process

a. The first study is a complex 347 stainless steel housing (Figure 2). As can be seen from the figure, some walls are very thin which require high metal and mold temperatures for proper filling when metal is ladle poured. This caused the thick center section to cool slowly and solidify as a hot spot, giving an unsound casting in that area. Many gatings were tried with ladle pouring, but it was not possible to fill the thin sections at metal and mold temperatures that would adequately solidify the thick center section. By CV casting the housing as shown in Figure 2 with lower metal and mold temperatures, excellent quality was obtained.

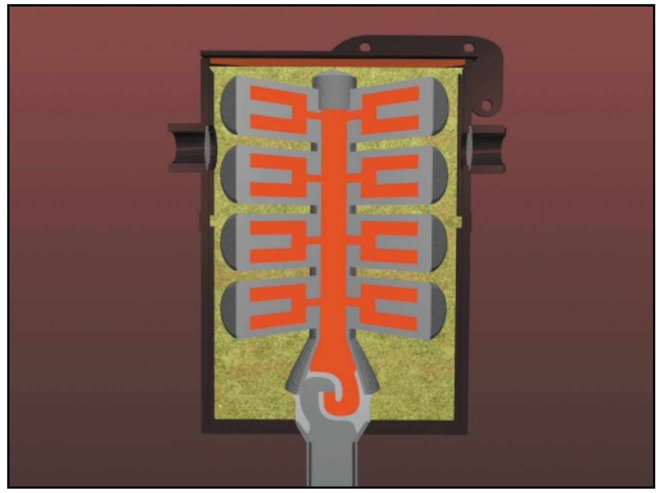
b. A second example is the 17-4PH stainless steel missile fin of Figure 3. In production, eight parts per mold were cast, but for ease of discussion, only one part per mold is shown. When cast by gravity as shown on the left, inertia due to gravity forces the hot metal into the part cavity, reducing temperature gradients. A mid fin ingate is required to prevent shrinkage porosity and meet the soundness requirements of the part. When cast by CV as in Figure 3, right, the cold metal is in the top of the fin as cast and the hottest metal is in the riser. When inverted for solidification, the hot metal is up so gravity can provide much better directional feeding, allowing elimination of the mid fin gate, saving much ceramic, metal, and finishing cost.

c. The final example is the shaft casting, Figure 4. Use of the CV process enabled much lower

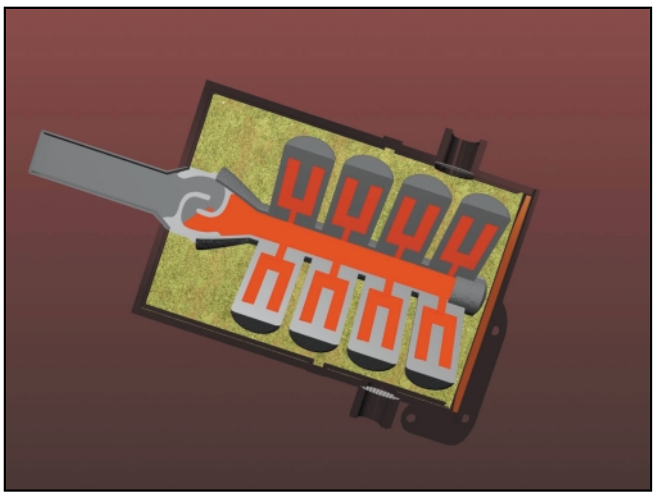
Figure 1



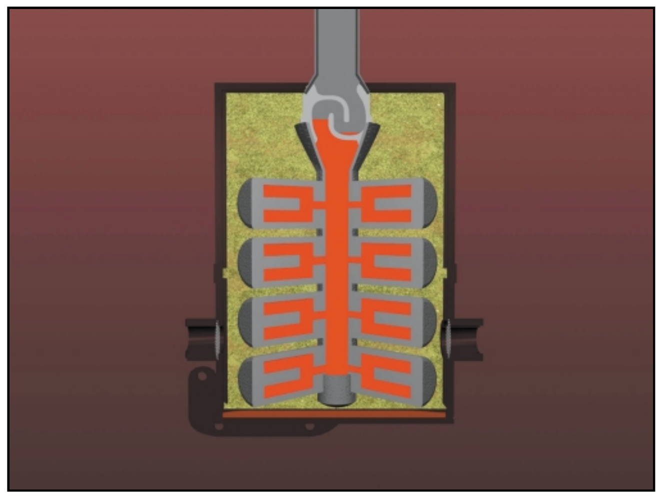
a. A mold is placed in a casting chamber and backed up with dry sand. The mold is filled by applying vacuum to the chamber.



b. After casting, the "S" shaped check valve allows the metal in the bottom part of the passage to flow back into the melt, while that in the top part is retained by atmospheric pressure.



c. The chamber is rotated to prevent metal from flowing out when vacuum is released.



d. The mold is allowed to cool inside the chamber in an inverted position.

mold and metal temperatures for casting without cold shots and laps and eliminated the shrinkage porosity in the heavy section near the core.

4. Advantages of the CV process for the designer

a. Lower cost complex castings with wall thicknesses greater than 1/2" (13mm) due to less gating and better quality than can be obtained with gravity pouring.

b. More design flexibility, since heavier, more complex shapes can be made, even when they have very thin sections as well.

c. Better mechanical properties in thicker castings since they are cast with lower metal and mold temperatures than can be used with gravity pouring.

d. Better dimensional control for large castings due to sand support during mold filling.

REFERENCES

1. Monroe, R.W., Blair, M., "Reoxidation Macroinclusions in Steel Castings," Paper 1, 37th Annual Technical Meeting, Investment Casting Institute, 1989.

2. Metal Casting Technology Center, a national metal casting research institute, Spring 1995 Newsletter, Vol. 10 No. 1.

3. Guy R. Lambert, "Low Pressure Green Sand Process Produces Thin Walled Castings," Modern Castings, August 1999.

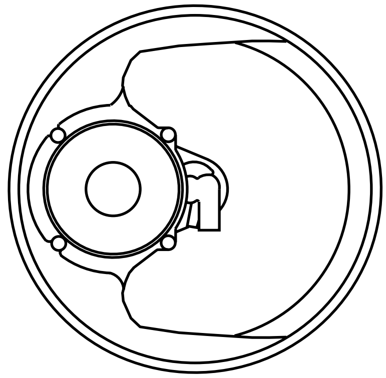
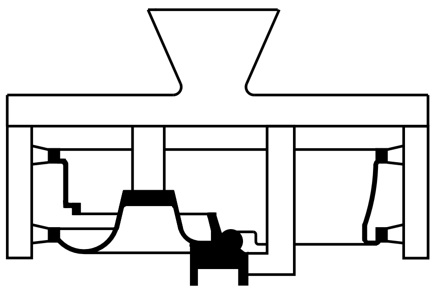


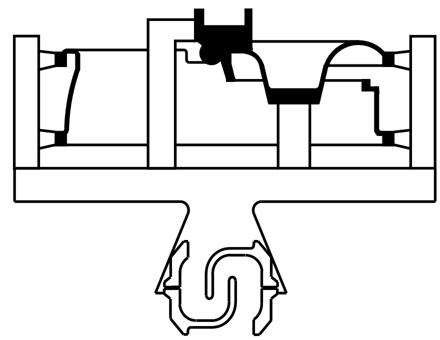
Figure 2

Stainless steel housing in alloy 347 with gravity pour gating. The outer wall, about 12" (305mm) diameter, only averages 0.080" (2mm) thick, while the center section is of complex contour and more than 1.2" (37mm) thick.

Position when cast by gravity pouring. Black shows casting cross section.



Same gating for CV with low mold and cast temperatures made sound castings.



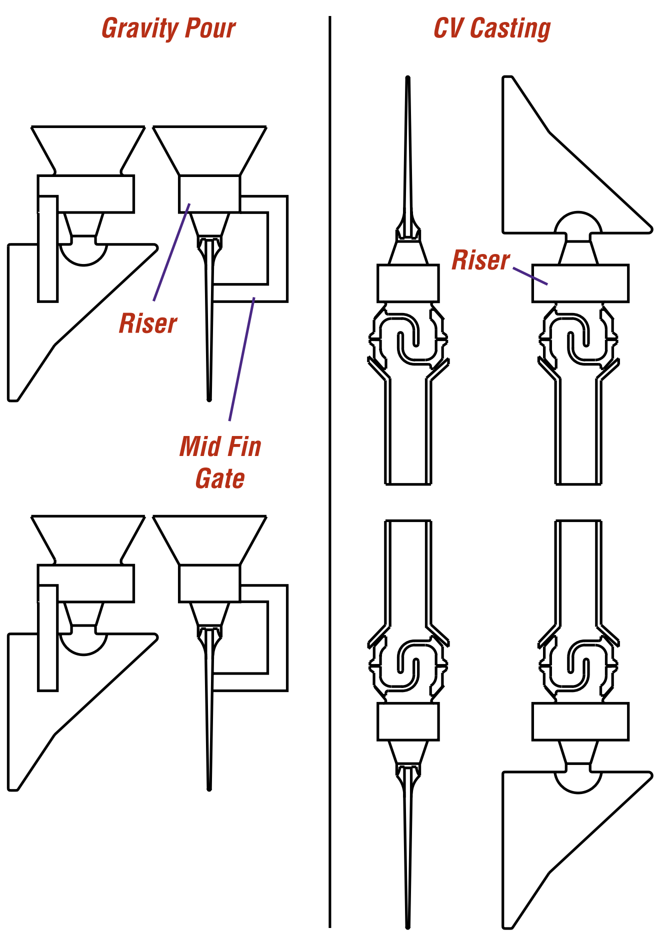


Figure 3

Comparison of the filling of a 17-4PH stainless steel missile fin by gravity pour and CV. Upper row shows filling position, lower row is solidifying position, left for gravity pouring, right for CV casting. Better thermal gradients in CV allow elimination of mid fin gate.

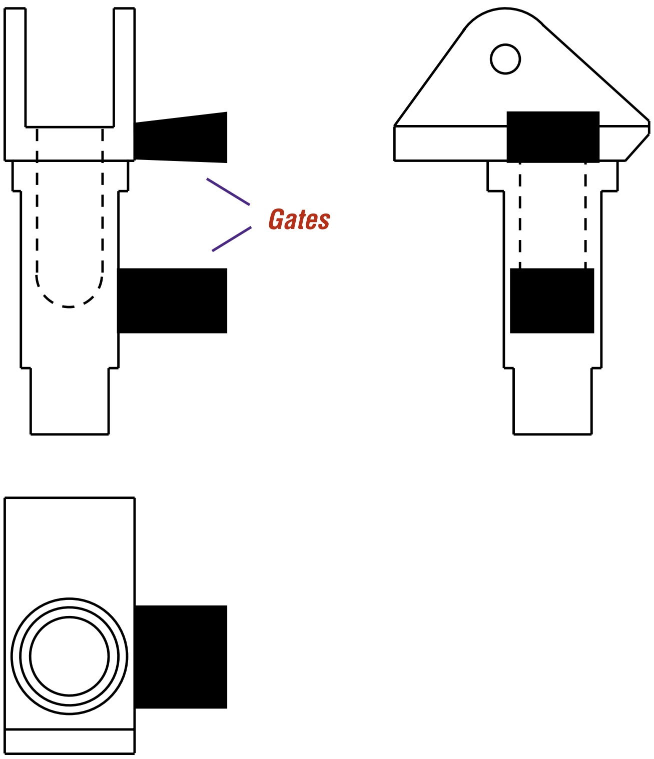


Figure 4

A heavy, hollow shaft (gating shown black) in alloy 15-5PH stainless steel, when gravity pour cast was not sound due to its shape, which gave inadequate core heat capacity so the part would not directionally solidify in a way to make a sound part.

Gating for One Shaft

When many are put in a mold for low cost, ladle pouring requires high mold and metal temperatures to prevent cold shuts and laps. This causes shrinkage porosity due to saturation of the core with heat. Larger gates made the problem worse. Casting by CV enables lower temperatures and the core is not saturated with heat, so a sound casting is formed.

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