CLA for Bronze, Aluminum & Metal Matrix Casting

Nonturbulent method eliminates inclusions, holes caused by bubbles

Figures 1 and 2 illustrate quite nicely the dramatic, well established ability of the countergravity low-pressure air melt casting process (CLA) to fill molds without turbulence (Technical Update 2D5). Figure 1 shows how pouring a liquid into a container generates bubbles of entrained air. This holds true even in water, which has a low surface tension compared to the oxidized surfaces of molten aluminum and most bronzes bubbles. Figure 2 shows that water (and metal) can be vacuumed up into a container with no bubble formation.

The bubbles formed when metals are poured collapse and the surface oxides of the collapsed bubbles flatten into nonmetallic inclusions. These inclusions take on different shapes depending on the alloy. If the oxides are low in density or have some attached gas, the inclusions can be on upper surfaces. If the oxide has a net density near that of the metal itself, the inclusions can be inside the alloy. Often the bubbles do not collapse entirely, which can leave rounded holes in the castings.

Thus, the ability of countergravity casting to prevent bubble formation in the first place is of great importance in producing castings from molten metals that have high surface tension oxide films or are highly viscous. (Metal matrix aluminum has the highest molten viscosity of all metals currently cast.)

Since the CLA process is limited to parts less than about 0.5 inch (13mm) in thickness, Hitchiner developed a second countergravity process, the check valve process (Technical Update 3D1), to make larger and thicker parts with the same low-turbulence mold-filling capability. Some examples from production parts illustrate the great power of the CLA and CV processes to make high-quality parts that would be difficult to

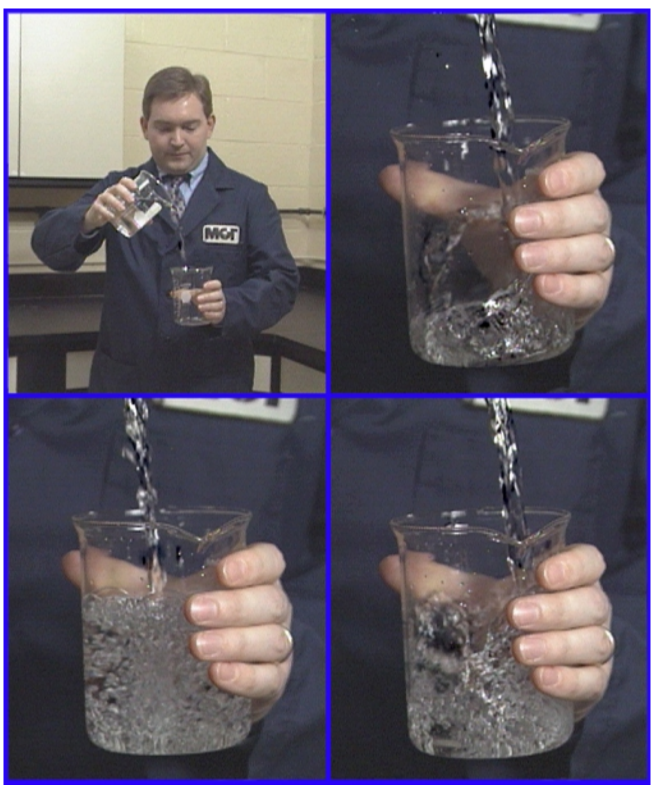

Figure 1. Water poured into a beaker (clockwise from top left) generates dozens of bubbles. When casting metals by gravity pouring, such bubbles collapse, leaving oxide defects in the casting.

Figure 2. Water vacuumed upward into a container is bubble-free (clockwise from top left) . When metal is cast this way, the resulting casting typically contains only about 15% of the oxides found in poured castings.

Figure 3. Callaway Gold, aluminum-bronze golf iron heads cast in high volume by Hitchiner's CV process.

make—in many cases impossible—without them.

Figure 3 shows the Callaway Gold golf iron, which was cast in aluminum-bronze. The high aluminum content of this alloy combined with the requirement of no after-polish visual indications made gravity pouring impossible. Hitchiner used the CV process to cast them, successfully making more than 400,000. The controlled vacuum rise rate had to be optimized to avoid turbulence and while filling out the fine lettering on the irons. To do this, the foundry used Hitchiner's computerized vacuum rise rate control mechanism. This mechanism permits five stages of vacuum / time rates in the course of filling a mold. Once the proper vacuum / time relationship is established, it can be monitored and recorded to assure absolutely reproducible mold-filling conditions and resultant quality.

The CLA and CV processes are key to meeting most classes of the SAE AMS A 21180 specification without the use of metal heat sinks in molds (Hitchiner Technical Update 3D5). For aluminum castings in general, it is possible to use these processes to fill out thin sections at lower metal and mold temperatures. This assures better dendritic arm spacing and soundness, making Hitchiner's parts better than industry average for commercial parts as well.

Metal matrix aluminum parts represent the ultimate challenge in producing defect-free parts as investment castings. These alloys contain from 10 to 40% fine silicon carbide (or alumina) particles. Viscosity increases directly with the amount of particulate—the 40% composition has the viscosity of thick catsup, making it impossible to use gravity pouring in most cases.

Using the CLA and CV processes, however, Hitchiner has developed the ability to make almost any part shape with excellent soundness (See Technical Update 3D6). Doing this requires mold-filling rates that are far slower than those used for aluminum bronze. Because of changes in total cross section area, the rate of aluminum rise for one 26-by-26 inch (660-by-660mm) part was only 0.3 inch (7.7mm) per second at certain levels. If it had been faster, the metal would geyser and entrap air.

For most aluminum alloys, such rates would cause nonfill. Fortunately, the large number of fine (5μm or so in diameter) particles in the alloy prevents segregation and growth of large dendrites. Thus, higher mold temperatures can be used without harming the mechanical properties of the resultant casting. High metal-casting temperatures cannot be used, as the aluminum will react exothermically, destroying the particles.

Figure 4 shows a complex metal matrix aluminum casting successfully made in production using countergravity processes. These parts illustrate the great capabilities of Hitchiner's countergravity casting processes to make high-quality investment castings in the most difficult copper and aluminum alloys needed by industry. These processes also inherently make better-quality and lower-cost parts for simple commercial applications as well.

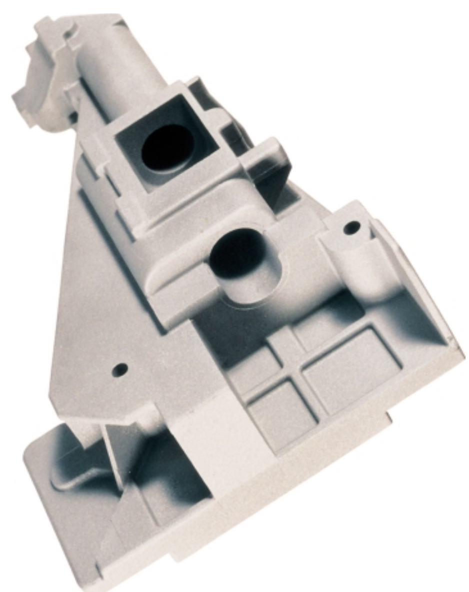

Figure 4. 30 to 40% silicon carbide metal matrix aluminum alloy part made for an application requiring high heat transfer and high stiffness with lightweight.