Best Paper Award at the 113th METALCASTING CONGRESS
April 7-10, 2009 • Las Vegas, Nevada

Using Gas Injection in High Pressure Die Casting Technology

Thomas Weidler, Experimental Research Coordinator
Aalen University of Applied Sciences
Aalen, Germany

Lothar H. Kallien, Professor
Aalen University of Applied Sciences
Aalen, Germany

Introduction

High pressure die casting is a process which combines short cycle times and high productivity with the production of highly integrated metal parts of complex shape[1], where plastic injection molding is a comparable process for the production of plastic parts, being similar in many aspects to die casting. Gas injection is a special variation of plastic injection molding, allowing the production of hollow structures[2-4]. The advantages of gas injection are free design of thick and thin walls in one part, local feeding pressure, reduced sink marks and distortion, as well as shorter cycle times.

The possible application of gas injection technology in high pressure die casting has been published[5-8]. This paper gives an overview and discusses new results which have been gained at Aalen University of Applied Sciences.

The Gas Injection Process

There are various processes known for gas injection, but only one is described here in detail[2,3]. The cavity is filled with liquid melt. After a partial solidification of the melt, gas is injected into the cavity while a valve is opened. The liquid material is pressed into the cavity that was opened by the valve (Figure 1). After total freezing, the gas pressure is released.

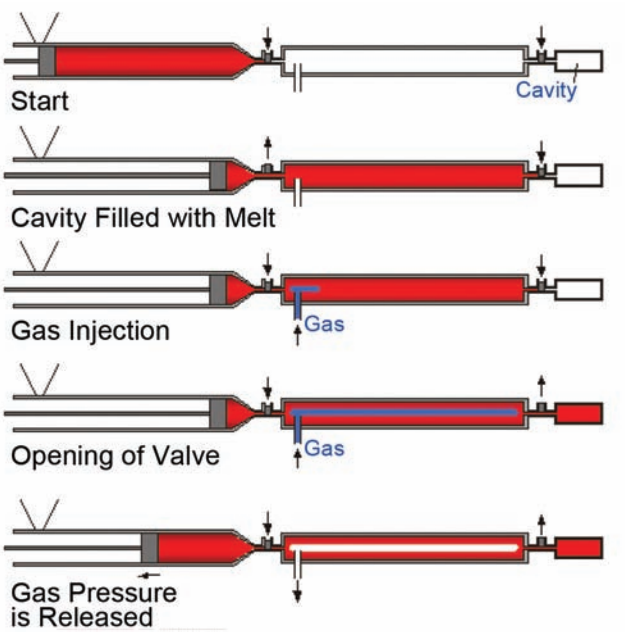

Figure 1 – Gas injection using a side cavity[4].

Motivation for Using Gas Injection in High Pressure Die Casting

A lot of possible applications exist for gas injection in high pressure die castings. Some are depicted in Figures 2-4. Using gas injection for channels in oil filter housings would allow 3-D structures instead of straight lines and optimized fluid flow with less resistance. Many other applications where long cores can be avoided are possible.

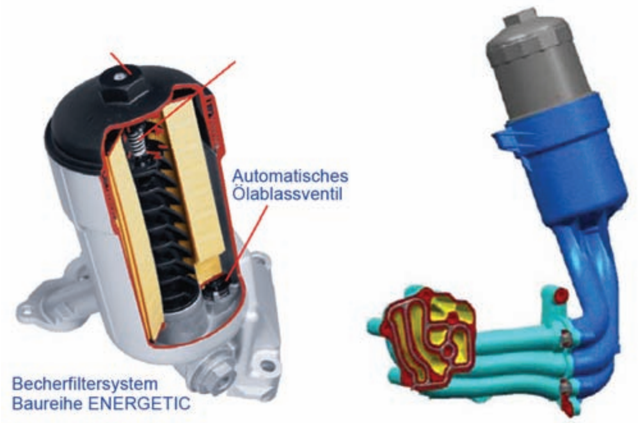

Figure 2 – Optimized channels in oil filter housings.

Figure 3 – Channels in intake manifolds.

Figure 4 – Hollow structures in clutch pedal.

Experimental

With the knowledge of gas injection in plastic parts, experiments have been made at Aalen to apply gas injection on high pressure die castings. As a test geometry, a door handle was used and a die (Figure 5) was built with a side cavity. In the beginning, a standard gas injection apparatus was used[5,6] which was later substituted by its own gas supply. The first gating system was designed to inject the molten metal not in the vicinity of the gas injector. This gating, however, did not show positive results. After a gate change, high pressure die castings from zinc,

Figure 5 – Test die for high pressure die castings with gas injection; 1) Side Cavity; 2) Valve; 3) Gas Injector; 4) Gating 1; 5) Gating 2.

magnesium and aluminum could be produced with hollow structures using gas injection (Figure 7). The simulation of the filling explains the basic differences (Figure 6). Gating 1 ends up with cold melt in the vicinity of the gas injector, resulting in rapid solidification not allowing gas to go through. Gating 2 solved this problem.

The parts that have been made showed a hollow structure, depending on the gas pressure applied. Another very important parameter is the injection delay time after complete die fill. Compared to plastic injection molding, the delay time must be much shorter, as solidification times in metals are more than 10 times quicker.

X-ray analysis indicated a very solid metal structure around the gas bubble. This is a result of the fact that melt solidifies under high pressure, which compensates for shrinkage even in sections far away from the gate (Figure 8). Very important — the parts show a very smooth surface inside, similar to the surface of metal when gas bubbles evolve in castings. This makes it suitable for fluid transport in later applications (Figure 9).

Meanwhile, new test dies were built to analyze the possible length of a hollow gas structure (Figure 10). Test runs have been performed, and it has been proven that the gas injected into the cavity exits at the end of the part, leaving a totally hollow structure. The complete die

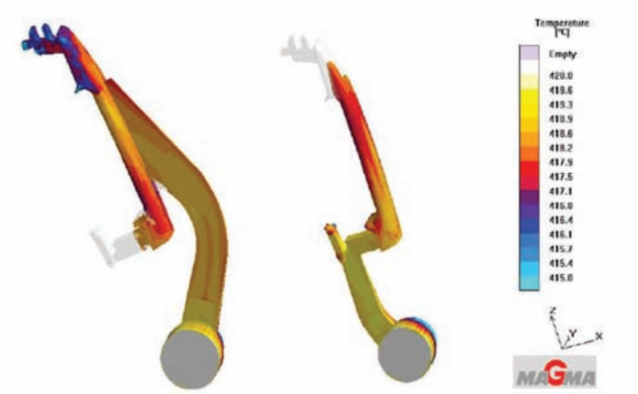

Figure 6 – Simulation of die fill indicating cold metal in the vicinity of the gas injector for Gating 1 (left) and optimized metal temperatures for Gating 2 (right).

Figure 7 – Die casting produced by gas injection[6,7].

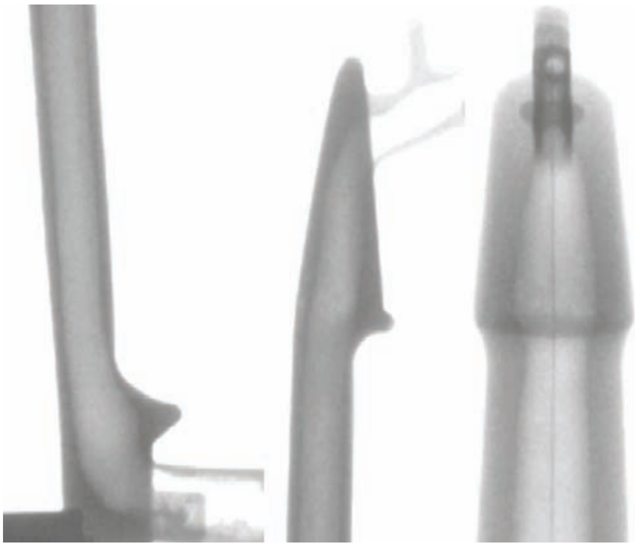

Figure 8 – X-ray of gas injected parts.

Figure 9 – Smooth surface of gas injected parts.

was used on a die casting machine with 200 tons locking force. In addition, a new gas injection unit has been developed, allowing much faster pressure build-up. It is obvious that the internal surface has not yet reached the quality of the first parts shown in Figure 9. However, it is one of the prime goals of the research to optimize the process with respect to this internal surface quality.

Figure 10 – Complete die set up in the die casting machine.

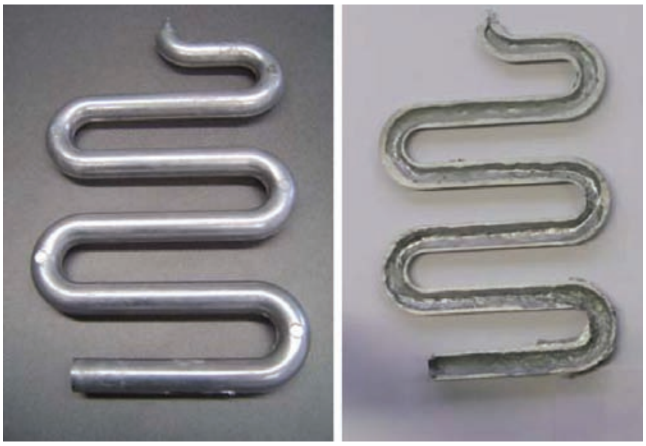

Figure 11 – Two casting geometries produced with gas injection.

Conclusion

The results show that gas injection is applicable for relatively complex geometries. Further research will deal with the optimization of the process with respect to later application in production and the optimization of the internal surface structure that depends on the gas pressure and the alloy.

Acknowledgements

The research project was funded by the "Landesstiftung Baden-Württemberg."

About the Authors

Dr. Lothar Kallien is professor and head of Department of Foundry Technology at the Aalen University of Applied Sciences. Kallien earned a master's degree in foundry engineering and metallurgy in 1984 and a Ph.D. in foundry engineering and metallurgy in 1988, both from the University in Aachen. Prior to his appointment at the Aalen, Kallien was with MAGMA GmbH in Aachen and MAGMA Foundry Technologies in Chicago and Germany. In 1998, MAGMA and Kallien founded a new company, SIGMA Engineering GmbH, and developed the first full 3-D simulation tools for the application in plastic injection molding. Since 2004, Kallien has been a professor at the University in Aalen and head of the foundry laboratory. Meanwhile, he has published more than 100 papers in foundry related journals and holds patents.

Thomas Weidler studied engineering at the Aalen University of Applied Sciences. His main task is the technical and financial coordination of experiments in the research foundry, including two cold chamber and two hot chamber machines, melt-shops for iron, magnesium, aluminum and zinc, permanent mold casting facility, sand laboratory, 3-D computertomography, mechanical testing and others. Together with Kallien, Weidler published several papers in the die casting field.

References

1. Ernst Brunhuber (1971): *Moderne Druckgussfertigung*, Fachverlag Schiele & Schön.
2. W. Michaeli, T. Brinkmann, V. Gessenisch-Henleys (1995): *Kunststoffbauteile werkstoffgerecht konstruieren*, Carl Hanser Verlag.
3. G. Menges, P. Mohren (1991): *Spritzgießwerkzeuge*, Carl Hanser Verlag.
4. Peter Eyerer/Peter Elsner/Marc Knoblauch-Xander/Andreas von Riewel (2003): *Gasinjektionstechnik*, Carl Hanser Verlag.
5. Lothar Kallien (2006): Die Castings with hollows structures using Gas Injection, High Tech Die Casting, AIM Conference, Vicenza 2006.
6. Lothar Kallien (2005): Herstellung von Druckgussteilen mit funktionalen Hohlräumen durch Gasinjektion, Vortrag: Große Gießereitechnische Tagung 2005, Innsbruck, 21. und 22. April 2005, Verein Deutscher Gießereifachleute und Verein Österreichischen Gießereifachleute.
7. L. Kallien, T. Weidler, C. Hermann, U. Stieler: Pressure die casting with functional cavities produced by gas injection, International Foundry Research, 58 (2006), Nr. 4, S. 2-10.
8. L. Kallien, T. Weidler, C. Hermann und U. Stieler: Druckgussteile mit funktionalen Hohlräumen durch Gasinjektion. Giesserei 93 (2006) Nr. 11, S. 20-29.