Parting Shots

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Percentage of Cold Chamber Fill, Myth or Method? (Is this the primary process parameter?)

What is "Percent of fill of (the) cold chamber"? It is the percent of molten metal in the cold chamber compared to the total volume of the cold chamber. Another way of saying it would be the percentage of metal compared to the percentage of air in the cold chamber. (For example 50% full (of metal) = 50% air remaining. *See Figure 1.*)

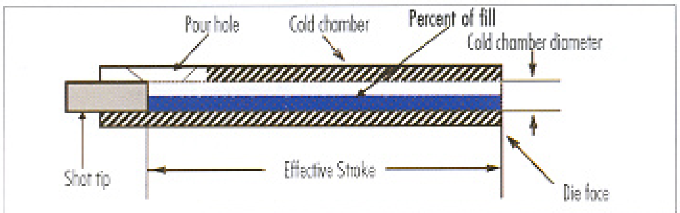

Figure 1.

Knowing the percentage of fill is important because it is used to calculate the optimum slow shot velocity. This can have a quality impact on the die casting.

Ask any die caster and you'll get an opinion about "Percentage of cold chamber fill or percent of fill" as it's referred to in the industry. Some will point to the work begun by Dr's Garber[1] and Lindsey regarding the formation of waves in the cold chamber during the first (slow shot) phase of the shot (injection) cycle. The table generated by Garber's research provided "Critical Slow Shot Velocities" for various cold chamber diameters from 50% to 90% full. Later work extended the range to 40% to 90% full. Engineers might even show you calculations to demonstrate they know the percentage of fill of their jobs. Some will even point with a sense of accomplishment to the fact that all their jobs are running at greater than 50% to 60% full. The idea is by having designed their process with higher percentages of fill they will be entrapping the least possible amount of air and as a result their castings will have the lowest possible porosity. However, there are often operational and quality problems when this parameter is given higher priority than cavity fill time, or cavity, or hydraulic intensifier pressure. This article will discuss the effects on fill time and resulting quality problems.

I regard their velocity tables as correct, however I believe the conclusions the industry has drawn from the tables are often incorrect.

In order to accomplish the high percentage of fill, a smaller diameter and/or shorter cold chamber must be used. As smaller diameter cold chambers are used, it is necessary for the fast shot to travel faster to accomplish a desirable fill time. This is often counter productive. *(See example in Table 1.)*

As shown in the table above, as the percentage of fill is reduced the fast shot velocity required to accomplish the target fill time of 50 milliseconds is reduced also. Depending on the vintage of the machine, it

Percent fill:	50%	30%
Casting vol. cu.in./(cc):	25, (409.7)	25, (409.7)
Target fill time Milliseconds:	50	50
Cold chamber diameter, inches (mm):	2.00, (50.8)	2.60, (66.04)
Fast shot velocity to accomplish fill time:	170 IPS(4.32 M/S)	100 IPS(2.54 M/S)

Table 1.

may be impossible to accomplish the 170 IPS (4.32 M/S) fast shot velocity necessary at 50% fill. Machines that have a maximum fast shot capability of 90 (2.28) to 110 IPS (2.79 M/S) are not uncommon. Therefore, it is often imperative that a larger cold chamber be used in order to accomplish the target fill time. At 30% fill most machines could accomplish the 100 IPS fast shot velocity required to perform the same work.

Other problems associated with using too small cold chamber diameters can include excessive cavity pressure from the impact spike and/or uncontrolled intensifier pressure. The impact spike is often the cause of uncontrolled flash in slides and on die faces. When the accumulator is mounted remote from the shot cylinder as is the case on older machines, this problem is exaggerated. Impact spike pressures can be as much as 3 to 4 times system or intensified pressure.

A couple of case studies might help illustrate the point.

Example 1:

A 2 cavity V-8 valve cover for a big three automotive customer had previously operated in a 1,600 ton die casting machine. Valve covers must be pressure tight so all castings were pressure tested. Valve covers that failed pressure test were impregnated as a salvage operation. After impregnation, they were again pressure tested and castings that failed a second time were scrapped.

When the tool was transferred to a new supplier the following process changes were completed. The primary process changes were using a larger cold chamber in a smaller machine. Previous logic would have dictated using the same size machine and process including the same size cold chamber with a high percentage of fill. The net results of the changes were a significant decrease in scrap and elimination of the impregnation process. This yielded a lower cost process and increased profit for the die caster. *(See Table 2.)*

Example 2:

An automotive generator component was cast in a 4 cavity die. Castings were produced in 600 to 650 ton machines. Both machines were capable of achieving the required fast shot velocity. However, the cavity pressures developed with the 2.5 inch diameter cold chamber generated more cavity pressure than the machine was capable of holding. Excess flash resulted and castings were defective due to the resulting loss of pressure. Castings produced with the larger cold chamber could be produced at a lower percentage of the machines capability and also devel-

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Machine lock-up tonnage:	1,600	1,000
Scrap rate:	35%	Less than 5%
Percent requiring impregnation:	100%	None, see above
Scrapped after impregnation:	35%	None, see above
Percent fill	76%	27%
Casting vol. cu.in./(cc):	42, (688 CC)	42, (688 CC)
Target fill time milliseconds:	33	33
Cold chamber diameter,inches (mm):	3.00, (76.2)	5.00, (127)
Fast shot velocityTo accomplish fill time:	365 IPS (9.27 M/S) (Not possible)	131 IPS (3.33 M/S)

Table 2.

oped sufficient cavity pressure. The measurement of success or failure was the ability to assemble without breaking. Castings produced using the larger cold chamber had a significantly higher success rate in assembly.

Additional problems due to the 35% scrap rate included the equivalent of one entire lost shift per day. This forced the die caster to run Saturday and Sunday to make up for the lost shifts. *(See Table 3.)*

Conclusion

The primary consideration when selecting a cold chamber diameter should first be the ability to fill the casting in the required fill time. Consideration of the fast shot capability of the machine must be part of the equation. The percentage of fill is at least of secondary importance and possibly of lower priority when compared with the ability to accomplish fill time. Once the percentage of fill is determined, use the

Machine sizes:	650	600
Scrap rate at assembly:	35%	Less than 0.1%
Percent fill	60%	35%
Casting vol. cu.in./(cc):	3.9, (63.9 CC)	3.9, (63.9 CC)
Target fill time milliseconds:	33	33
Cold chamber diameter, inches (mm):	2.5, (63.5	3.25, (82.55)
Fast shot velocity to accomplish fill time:	123 IPS(3.12 M/S)	73 IPS(1.85 M/S)
Cavity pressure, PSI/Bar:	10,890 PSI,(750 Bars)	6,400 PSI,(441 Bars)
Shifts required to produce required quantity:	21	15

Table 3.

available tables to calculate the appropriate *slow shot velocity*. If your machine is older than 10 or 15 years, you will often find that the machine is incapable of reaching the calculated *critical slow shot velocity*. If this is the case, consider modifying the machine to increase the slow shot capability of the machine. Meanwhile, set the slow shot at the highest possible rate and concentrate on optimizing the fast shot velocity and slow to fast shot transition point.

Future work for you the die caster: What is your culture regarding percent of fill? Everybody has one. If necessary create a matrix of your jobs to see if a pattern emerges. Odds are you will find you have an established trend. Your results will be some indication of whether it is helping you meet your quality targets.

Contact Bob McClintic for additional training and assistance evaluating your machine capabilities.

References: 1. Garber, L.W., "Theoretical Analysis and Experimental Observation of Air Entrapment during Cold Chamber Filling", *Die Casting Engineer*, The Society of Die Casting Engineers, May/June, 1982

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