# Salient Features of Die Casting Technology

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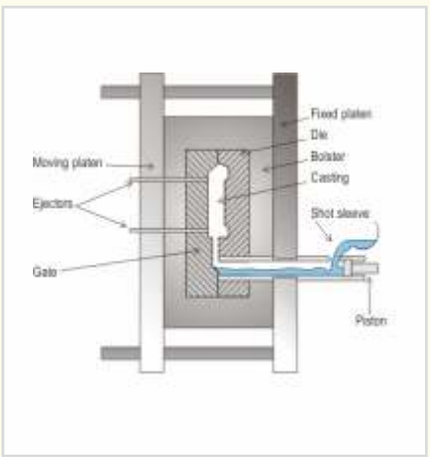
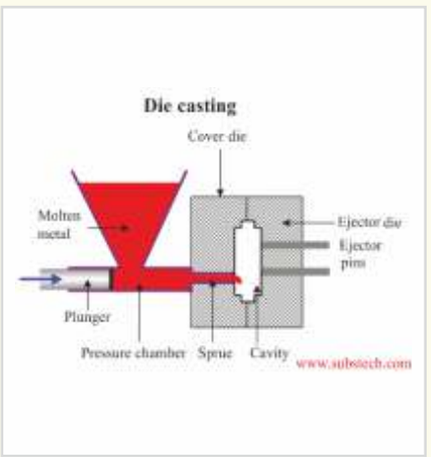
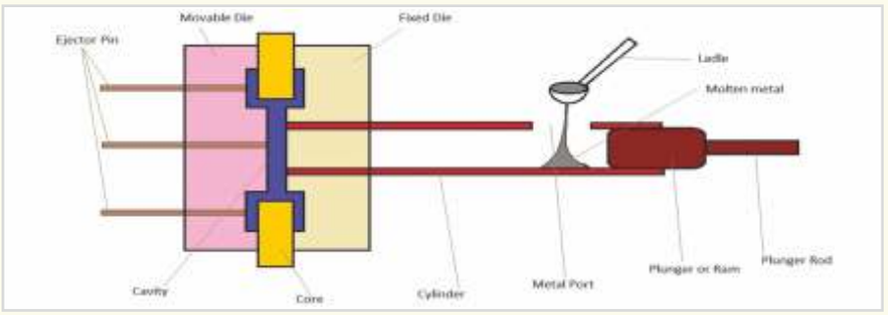
Die casting is an efficient method of creating a broad range of shapes. Die castings are one of the most mass produced components today. Die casting offers high accuracy in its products with a good quality surface finish which is suitable for many products without the need for extra polishing or machining. It is a process, in which the molten metal is injected into the mold cavity at an increased pressure up to 30,000 psi (200 MPa). The reusable steel mold used in the die casting process is called a die. Die casting is a highly productive method of casting parts with low dimensions tolerance and high surface quality. The following parts are manufactured by die casting method: automotive connecting rods, pistons, cylinder beds, electronic enclosures, toys, and plumbing fittings. The molten metal injection is carried out by a machine called die casting machine. There are two principal die casting methods: hot chamber method and cold chamber method.

### Cold chamber die casting

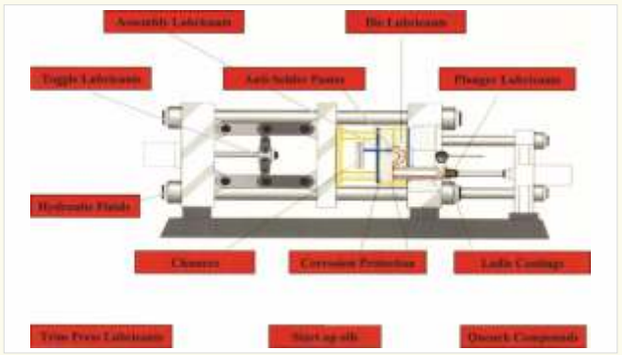
In the cold chamber die casting machines hydraulically operated plunger forces a molten metal to flow in the cold cylinder (chamber). A principal scheme of the cold chamber die casting machine is shown below in the figure.



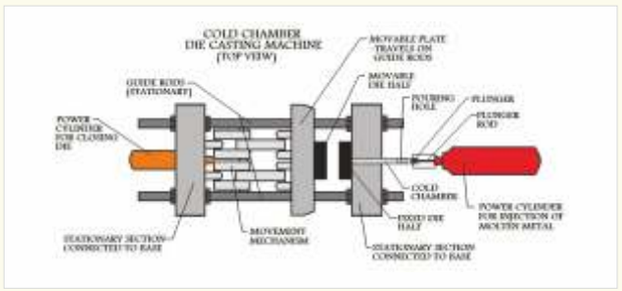



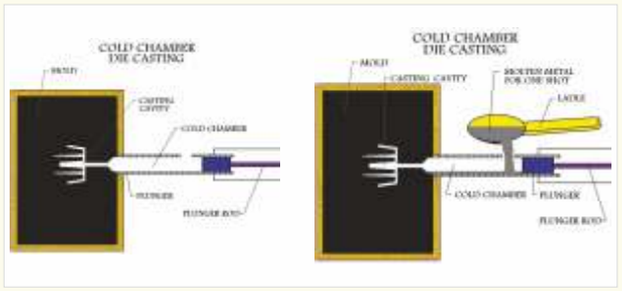
A high-pressure die casting machine has many moving parts that require lubrication and some of these are shown in the diagram below.

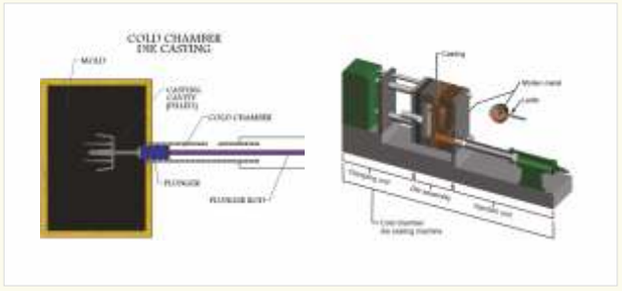


In a die casting system, unique process aid requirements arise because of the thermal stresses experienced as a result of the exposure to molten metal. These include: Die lubricants that are applied to the die to enable production of good castings. Plunger lubricants that perform at the interface of the plunger tip and shot sleeve. Ancillary products that facilitate the smooth operation of the die casting machine and related processes.

All materials must function under the unusually harsh conditions of extreme pressure and molten metal exposure. Since many of the processing aid ingredients decompose rapidly on exposure to molten alloys, it is actually the partially pyrolyzed lubricant that must be functional. The function of a die lubricant is to facilitate production of high quality castings productively while minimizing the environmental impact in the work place and in the effluent stream.



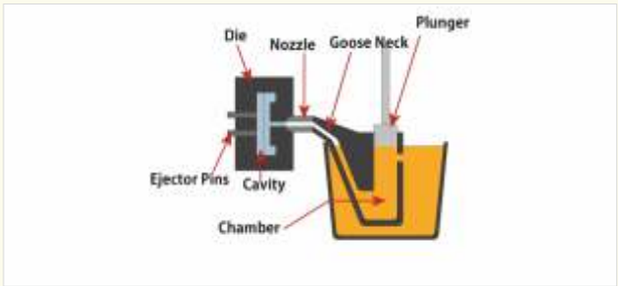




### Cold chamber process:

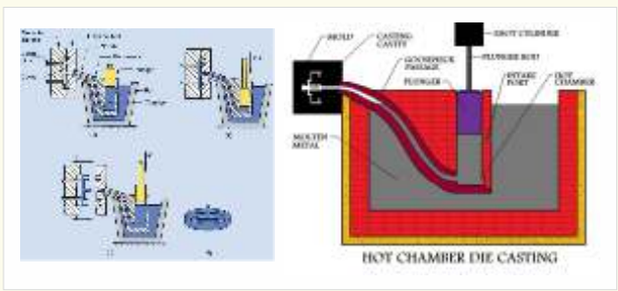
When the pressure chamber is filled with a molten metal the plunger starts travelling forward and builds up a pressure forcing the metal to flow through the sprue to the die cavity. After the metal has solidified the plunger returns to its initial position allowing a new portion of the molten metal to fill the pressure chamber. The die then opens and the ejector pins removes the casting from the die. The casting cycle now may be repeated. Cold chamber method is mainly used for casting aluminium alloys, magnesium alloys, copper alloys and zinc alloys (including zinc-aluminum alloys).

### Hot chamber die casting

In the hot chamber die casting machines the pressure chamber (cylinder) and the plunger are submerged in the molten metal in the pot (crucible). Hot chamber machines have short casting cycle (about 1 sec.). They are capable to cast thin wall casting with good filling the cavity under precise temperature control of the molten metal. Hot chamber process may be used for casting low melting metals, which are chemically inert to the material of the plunger and other parts of the casting machine: zinc alloys (except zinc alloys containing more than 10% of aluminum), tin alloys and magnesium alloys. Maintenance of hot chamber machines is more expensive as compared to the cold chamber process. Hot chamber die casting machine is shown in the picture.




**"Hot Chamber" Die Casting Process**




The plunger goes up allowing the melt to fill the cylinder space. The die is closed at this stage. The plunger goes down forcing the melt to flow through the gooseneck into the die cavity. After the die has been filled with the melt, the plunger is held under a pressure until the solidification is completed. The die opens. The casting stays in the die part equipped with ejectors. The plunger goes up and the melt residuals return through the gooseneck back to the pot. The ejectors push the casting out of the die.

**Design aspects of die casting**

Since the metallic mold of a die casting expands when it is filled with a molten metal and then both the casting and the mold shrinks during cooling the shrinkage allowances taken in the die mold design are smaller than those in the sand casting.

- Parts of 0.05 lb (20 g) to 75 lb (34 kg) may be cast.
- The section thickness of permanent mold casting may vary in the range 0.02" - 0.5" (0.5-12 mm).

• The dimensional tolerances are 0.01-0.03" (0.25-0.75 mm) depending on the casting section thickness.

• Allowances of 0.004-0.01" (0.1-0.25 mm) are taken for the dimensions crossing the parting line of the mold.

• The draft angle is commonly about 1%.

• Lower (as compared to other casting methods) radii of the part corners may be achieved by die casting process.

• Changes of the section thickness should be as gradual as possible.

• The parting line should not cross critical dimensions.

• Water-cooled dies may be used for obtaining faster Solidification at a desired direction.

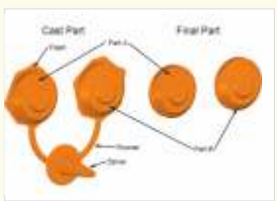
• The dies are fabricated from Tool and die steels. The die life is determined the ability of the material to withstand wear caused by the molten alloys and Fatigue caused by multiple heating and expansion. The cores are made of refractory ceramic materials. Sand based cores are not applicable due to their insufficient strength under pressure applied in die casting.

**Advantages of die casting:**

- High productivity.
- Good dimensional accuracy.
- Good surface finish: 2-100 µinch (0.5-2.5 µm) $R_a$.
- Thin wall parts may be cast.
- Very economical process at high volume production.
- Fine Grain structure and good mechanical properties are achieved.
- Intricate shapes may be cast.
- Small size parts may be produced.

**Disadvantages of die casting:**

Not applicable for high melting point metals and alloys (example: steels)



- Large parts cannot be cast.
- High die cost.
- Too long lead time.
- Some gases may be entrapped in form of porosity.

**Die cast part is shown below in the figure**

**Sample specifications for several different hot chamber and cold chamber die casting machines are given below.**

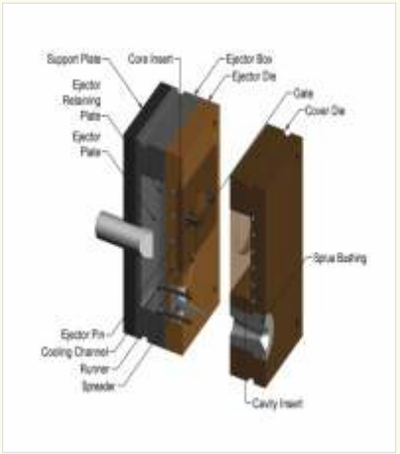
| Type | Clamp force (ton) | Max. shot volume (oz.) | Clamp stroke (in.) | Min. mold thickness (in.) |
|---|---|---|---|---|
| **Hot chamber** | 100 | 74 | 11.8 | 5.9 |
| **Hot chamber** | 200 | 116 | 15.8 | 9.8 |
| **Hot chamber** | 400 | 254 | 21.7 | 11.8 |
| **Cold chamber** | 100 | 35 | 11.8 | 5.9 |
| **Cold chamber** | 400 | 166 | 21.7 | 11.8 |
| **Cold chamber** | 800 | 395 | 30.0 | 15.8 |
| **Cold chamber** | 1600 | 1058 | 39.4 | 19.7 |
| **Cold chamber** | 2000 | 1517 | 51.2 | 25.6 |

**High pressure die casting: Present Requirements and Future Perspectives**

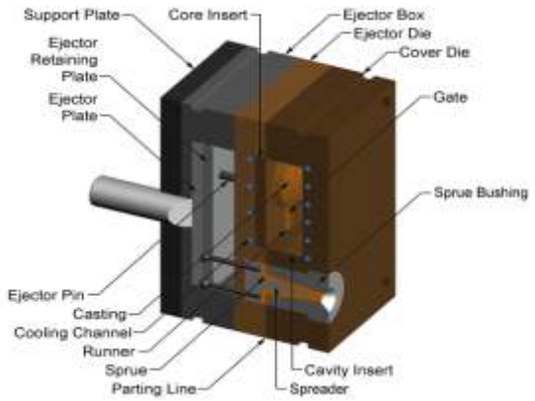
The transportation industry, and in particular the automotive industry, is imposed to seek light materials in the development of robust parts. The global production of aluminium and magnesium alloys has therefore increased, and the consumption of aluminium concurrently exceeds the existing production capacity of primary metal. It is therefore necessary to exploit, or invent, economically sustainable processes that can give light weight products with integrated functions that fulfil the requirements for recycling and fuel consumption regulations. High pressure die casting (HPDC) is a method well suited for those demands. HPDC is a fully automatic, large volume, high productivity process for the production of complex, thin walled near net shape castings, with part weights ranging from a few grams to more than 15kg. It has traditionally been utilised in the production of housings etc, but this has changed. Presently, feasible products are automotive front end structures and instrument panels in magnesium alloys and B-pillars in aluminium alloys. However, for HPDC to be competitive for extended automotive applications and attractive for new market segments, the crash worthiness and fatigue properties must be improved and a scientific comprehension of the process and metal behavior is required.

**The Cold Chamber HPDC Process**

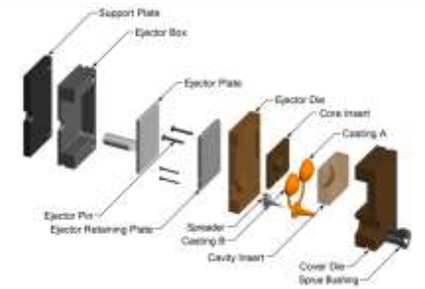
The four principal metals, with different alloy compositions, that are commonly hot- or cold chamber die cast are aluminium, zinc, magnesium and copper-base alloys. The injection system in the hot chamber machines is immersed into the melt and the pressure is therefore limited. The system also degrades quickly if exposed to aluminium. In the cold chamber process, the metal reservoir is separated from the injection system. The metal is filled into a steel shot sleeve. A production cycle in HPDC consists of: 1) metering of metal into the shot sleeve; 2) plunger movement; 3) rapid die filling. The steel die, typically 200-300 degree centigrade, dissipates the latent heat, and during solidification the casting is 4) pressurized hydraulically by the plunger to feed the solidification shrinkage. Locking forces up to 4000 tons are commercially available to withstand the large pressures. Eventually, 5) the die is opened and 6) the casting is ejected. The hydraulic energy is provided by a computerized system that permits control of metal position, velocity and plunger acceleration to optimize the flow and the pressure during filling and solidification. The die cavity may be evacuated to reduce air entrapment during die filling, and high integrity die castings can therefore be produced by utilizing vacuum systems.Die assembly is shown below in the figure.



Die assembly – Open (Hot chamber)




Die assembly – Closed (Hot chamber)



Die assembly - Exploded view (Hot chamber)

Some of the die cast parts are shown below.

| Possible Defects in die cast products | |
|---|---|
| **Defect** | |
| Flash | • Injection pressure too high<br>• Clamp force too low |
| Unfilled sections | • Insufficient shot volume<br>• Slow injection<br>• Low pouring temperature |
| Bubbles | • Injection temperature too high<br>• Non-uniform cooling rate |
| Hot tearing | • Non-uniform cooling rate |
| | • Cooling time too short<br>• Ejection force too high |

## Conclusions

Cold chamber high pressure die casting, (HPDC), is an important commercial process for the production of complex near net shape aluminium and magnesium alloy castings. In the modern casting processes, the turbulence while filling the die cavity is almost eliminated. Air and gas blowholes are very much minimised. Microstructure is excellent. Casting wall thickness has come down to around 0.5 mm, which cannot be obtained in conventional HPDC. Local shrinkages are squeezed out. Castings are heat-treatable and weldable.

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