What is Die Casting?

Die Cast is a term many will be familiar with, having heard it used to refer to a particular part; sometimes as a recommendation, or sometimes inferring a cheaper alternative, but always as a 'catch all' for a production process that encompasses a whole range of technologies from cheap and cheerful to the highest technology. Here is a quick overview of what can be termed as **Die Casting.**

Die / permanent mold casting has become the dominant casting process for non-ferrous alloys of aluminum, magnesium and zinc and with the growth of aluminum as a major structural component in automotive design it is set to maintain that position in the future. This is an overview of the various ways and processes in which permanent metal molds are used today.

Typical metals used in die-casting are lower melting point alloys of Aluminum, Magnesium and Zinc. Lead and pewter are also cast in this way and the original process was developed for creating movable type around 150 years ago for the fledgling printing industry. Copper and it's alloys of Brass and Bronze can also be cast in this way and even some cast irons have been cast in permanent molds with suitable mold coatings as the melting / casting temperatures approach that of the mold steels used.

Many of us will probably have used the process to make lead shot, fishing weights, or toy soldiers (showing my age now) in lead which can be melted over a candle. Likewise we see diecasting that can be produced in a vast range of sizes and with high levels of surface finish and accuracy, in our everyday life in almost everything. It is this versatility to produce fine detail, accurate dimensions and fine finishes that has driven the growth and the development of the high pressure machines that can produce these castings in high volumes (40 – more than 100/hr) has ensured its continued popularity.

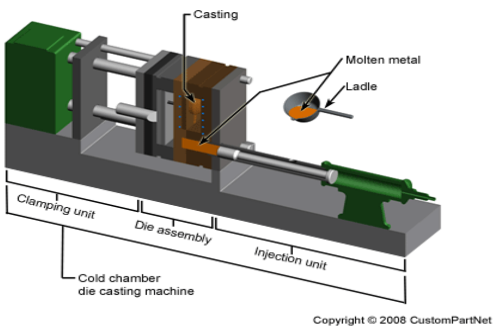
When we talk about diecasting it is normally the automated process using high pressure machines forcing metal into a closed die but there are several different processes that use permanent dies and even within the high pressure diecasting industry there are now different processes in use depending on the product, alloy and industry. The majority of technological developments in the last 20 years have been I the HPDC processes with bigger machines and computer controls.

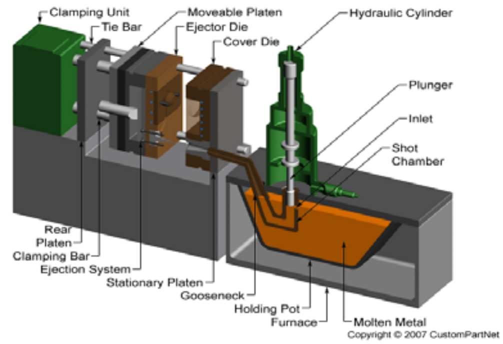
Types of Die Casting Processes

The three principal (most popular) variations on the diecasting process are

- **High Pressure Die Casting (HPDC)**
- **Low Pressure Die Casting (LPDC)**
- **Gravity or Permanent Mold Die Casting**

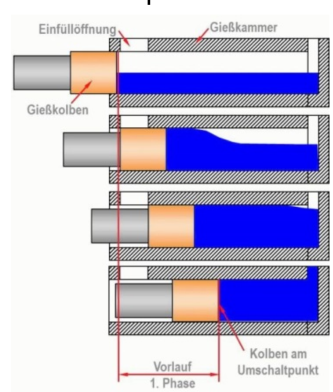
High Pressure Die Casting (HPDC) – is now the most common form of non-ferrous casting production, where the molten metal is forced into the cavity under very high pressures and this process utilises two different means of introducing the metal. A hot chamber machine will have the holding furnace installed as an integral part of the diecasting machine and the metal "pump" is immersed in the metal and forces metal directly into the cavity. Bigger and more sophisticated castings and alloys use a 'Cold Chamber" process where the metal is held in a separate furnace and transferred into a shot sleeve on the machine linked to the die and is then forced directly into the cavity by a ram.



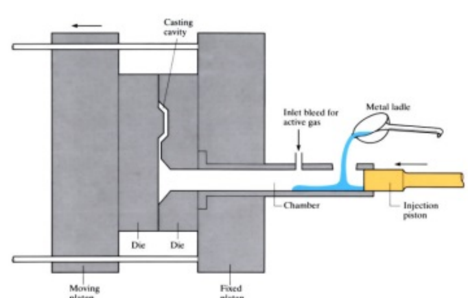


All of these processes have variations which make them uniquely suited to specific types of castings or alloys. The development of novel processes and controls has expanded the scope of HPDC in recent years to the extent where safety critical structural castings can be produced and heat treated.

An historical problem with conventional diecastings was the turbulences of the injection process which caused air and gasses to become entrapped in the solid metal. Attempts to heat treat these casting resulted in expansion of the gasses to create blistering and eruptions on the surface and a reduction in mechanical properties instead of an improvement. New processes, new alloys and improved controls on die casting machines have now eliminated these issues and thin walled structural parts for vehicle bodies and structures are now normal production.



The development of bigger diecasting machines and the evolution of **Shot control** has expanded the scope and size of parts that can be produced. Shot control now means that instead of the ram simply moving at a steady speed to push the metal into the cavity the movement profile can be controlled to move the metal gently at first to avoid air entrapment and then intensifying towards the end of the stroke to ensure complete filling and improvements in metal density. When this feature is combined with vacuum assistance in the die then the casting quality is improved dramatically and along with newly developed alloys can be heat treated to a T6 level for optimum properties.



Cold chamber Machines allow for the metal to be dispensed into the shot sleeve (plunger cylinder) from an outside source. The transfer can be simply with a hand ladle, an automated ladle arm or robot or via a pump or pressurised holding furnace to achieve an accurate and repeatable mass of metal.

Over the last 20 years or so the size of die casting machines has increased dramatically to accommodate both heavier and larger castings. The capacity of a machine is defined as the locking force that can be applied to the die platens and this has now reached over 5,000 tons force. This allows for larger, thin walled parts such as complete door frames to be cast as a single piece.

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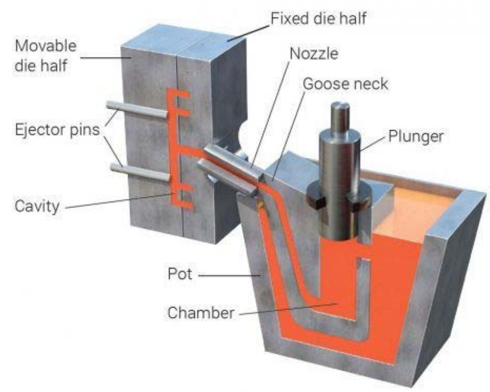
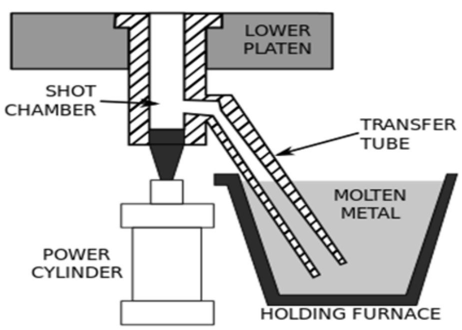
Hot Chamber Machines on the other hand have the holding furnace as an integral part of the diecasting machine and metal is transferred via a pump that is permanently immersed in the metal. A plunger is adjusted to push a defined amount of metal into the die for each cycle.

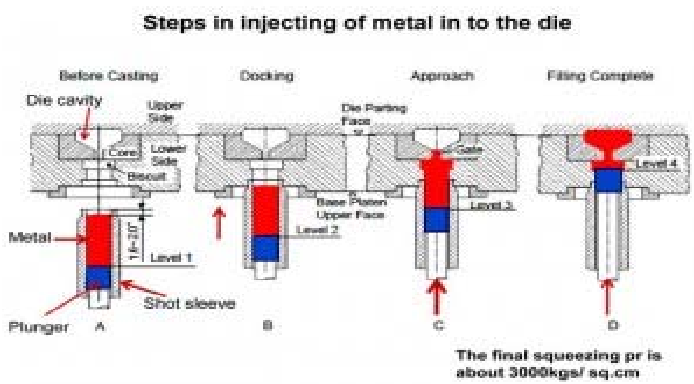


Because of the limitations of the furnace and immersed pump this process is confined to smaller die casting machines and parts and also because of aluminum's aggressive affinity for ferrous metals is more often used for zinc and magnesium casting.

Vertical High Pressure Machines use a similar technology to conventional horizontal machines but the shot sleeve is vertical and is filled completely in a vertical orientation before injection allowing a less turbulent flow of metal into the die.



Siphon Tube Die Casting Process

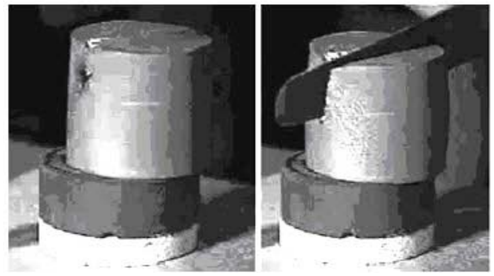


Vertical machines can also use a vacuum and **Siphon tube** system to fill the shot sleeve where the metal is 'sucked' from the holding furnace by a vacuum in the die cavity.
Like the low pressure process it has the advantage of creating a smooth metal flow into the die whilst the vacuum, strong enough to suck the metal, has the added advantage of a partial degassing effect and better quality castings.

There are also other variations of High Pressure Die Casting that generally have well defined niche markets

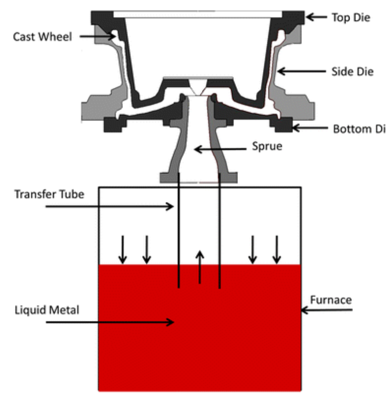
Semi-solid casting, also known as **Thixotropic** or **Rheocasting** uses a similar machine but instead of molten metal a billet of semi-solid metal is inserted into the shot sleeve before injection into the die.

The process uses a property of aluminum alloys to be solidified in a way that retains approx. 40-60% liquid, is stable enough to be handled, but can be cut with a knife. The advantage of this



process is in creating a casting with similar properties to a forging and that can be heat treated and polished. The downside has been the overall cost compared to conventional castings.

Metal powder injection uses fine metal powders with a binder material instead of molten metal and this poured into the shot sleeve in measured amounts and then introduced into the die and compacted by the plunger. The part is then sintered to remove the binder and consolidate the part. Used for small and intricate parts where very specific alloy mixes can be created without having to melt and alloy.
The process is also used for some magnesium parts overcoming the dangers associated with processing molten magnesium.



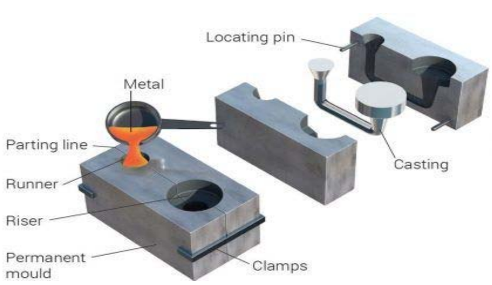
Low Pressure Die Casting (LP casting) is used almost exclusively for Aluminum road wheels as well as other high integrity and safety critical parts where heat treatment is also a pre-requisite to achieve mechanical properties; in this process where the molten metal is forced into the die cavity by pressure in the holding furnace below the die which raises the molten metal into the die where it is held until the narrow inlet area solidifies and the pressure is released. The smooth flow characteristics provide a high quality casting that can be heat treated.

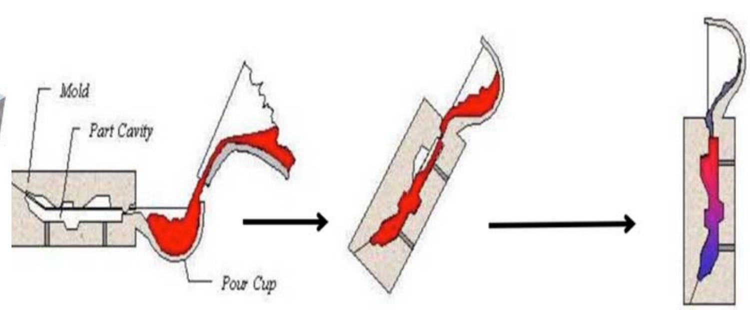
Gravity (Permanent Mold) Die Casting is maybe the simplest of the die casting processes and can vary from a simple mold for lead shot or fishing we– where the molten metal is poured directly into either static or tilting molds and flows by gravity into the cavity.

Static moulds are filled directly by hand or auto ladle into a split metal die. After solidification the die is opened and the casting, with runner system, are removed.

Tilting dies are mounted on a tilting mechanism and the metal is poured into a tundish attached to the die. After filling, the die is tilted to allow the metal to run from the tundish into the die cavity. This enables large castings to be made as the tundish can be filled fully before tilting. Casting of 100 to 300 lbs are not uncommon, the limit is normally the size of the die block.

An advantage of this process is the ability to use sand cores to create hollow internal shapes in

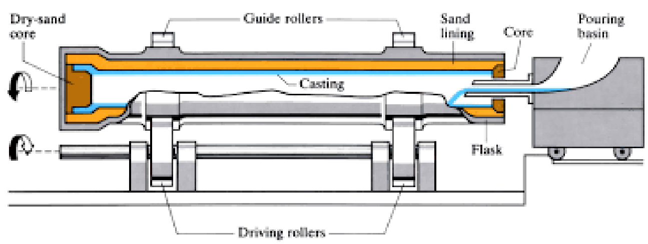




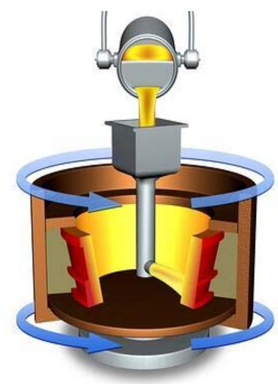
castings. In Gravity and Low pressure Die Casting the metal flow is gentle enough that sand cores can be used without breaking up and producing hard inclusions in the casting. I HPDC the speed and turbulence of the metal entering the die is violent enough to break conventional sand cores. There are some foundries using salt cores which are much harder and these must be dissolved from the casting and can also create corrosion problems if not done correctly.

Other Casting Processes Which Use Permanent Molds Or Dies

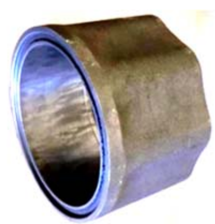
Centrifugal casting, used primarily in the casting of pipes and tubes in a variety of ferrous and non-ferrous alloys.
Molten metal is poured into a spinning tubular mold where centrifugal forces force it into an even 'coating' on the wall of the mold which is then cooled to create the pipe.
The process is predominantly for Ductile Iron water distribution piping as well as engineering pipe and tube stock.



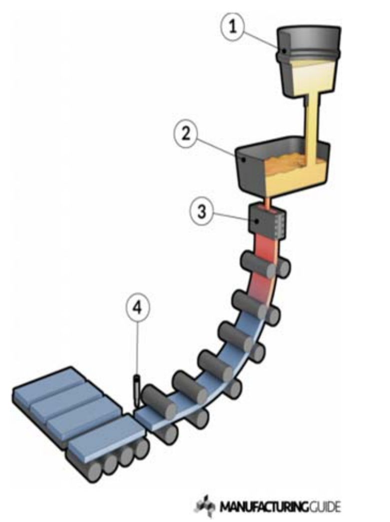
There are 2 basic processes in use industrially either horizontally spun molds or vertically spun molds.
The horizontal process is used for longer – up to 6 m (20 ft) long pipes with molten metal being introduced simply at one end and allowed to flow or progressively along the mold length (DeLavaud process) to provide a more accurate wall thickness in the finished pipe.

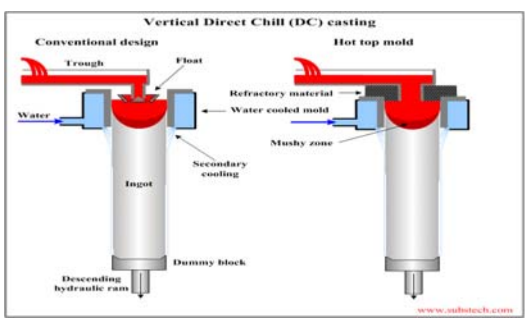


The vertical process is used for smaller cylindrical parts such as brake drums and other parts where a more dense, defect free metal structure is required. The process is confined to simpler geometries where no or simple cores can be used. Brake drums and discs would be typical parts in grey cast iron



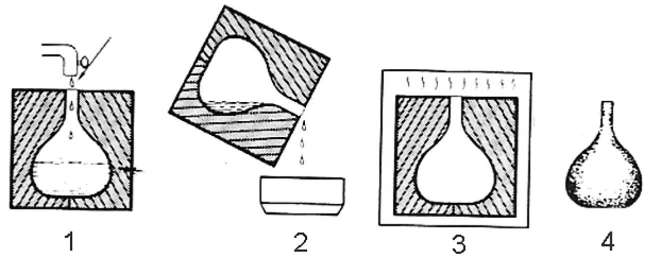
Continuous Casting is a process used to continuously cast various alloys into billets, (DC Casting) Direct Chill Casting, for further processing such as for extrusion or to provide a continuous supply of form to be cut off and processed.
The molten metal is poured into a tundish which provides a continuous and controlled flow of metal into a water cooled die



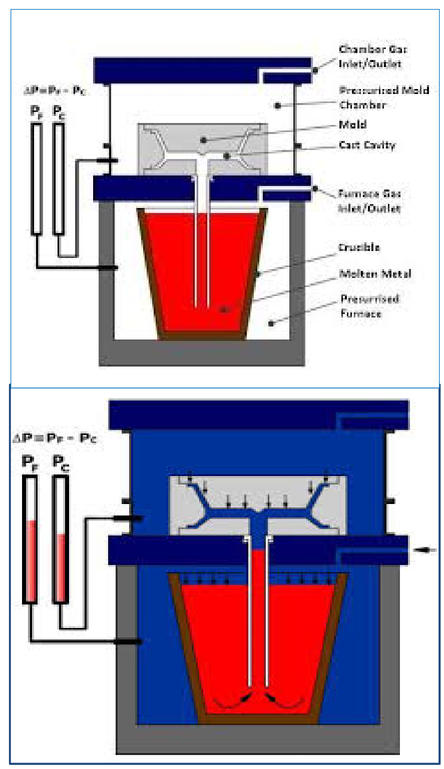


which moves up and down the as the metal solidifies and keeps the solid metal moving downwards making more room for new metal being poured.

Slush Casting is not such a common process and is used where a hollow part is required with simple geometry and a hollow shape without the use of cores. Molten metal is poured into a mold and given enough time for a solid skin to form before any excess metal poured out of the mold. The result is a hollow casting. Used traditionally in the art world for hollow sculptures, decorative pieces, etc., and can be used with most alloys but more often with pewter and precious metals.



Counter Pressure Casting (CPC) uses two separate pressure chambers creating pressure in the holding furnace above the metal surface whilst equalising this with a vacuum above the furnace and in the mold cavity. The result is to draw the molten metal into the mold cavity with the minimum of disturbance and turbulence thus ensuring a sound casting. The metal is encouraged to solidify with water or air cooling, at the in-gate area, before pressures are released.



What is Die Casting?

<u>Terminology</u> *<u>– some common terms used in the foundry industry</u>*

Die or Mold: *is the main component of die casting and the terms can vary depending on location and industry.*

Clamping force; *is the force exerted between the two halves of the die (the platens) which resist the hydrostatic force from the metal entering the cavity at high pressure*

Platen: *is the main carrying plate on the die casting machine to which one half of the die is attached.*

Ram: *is the piston or plunger that is used to force the metal into the die.*

Tundish: *is a simple bowl arrangement that allows for metal to be accumulated before or during a casting process.*

Cores: *are used to create internal cavities in castings. They can be re-useable mechanical components of the die or more often in LP and Gravity they will be expendable pieces made from a resin bonded sand.*

Holding furnace: *used to hold the metal at the chosen casting temperature during casting operations. This is refilled periodically to maintain consistent production*

Shot sleeve: *connected to one half of the die and allows metal to be introduced and held prior to being injected into the die.*

Gooseneck: *named for its similarity to a gooses neck, this is the 'pump' unit that sits in the metal and supplies metal in a hot chamber machine.*

<u>Die casting Defects</u> *<u>– some terms that refer to common defects on die castings</u>*

Mis-Runs*: where the metal has failed to completely fill the die cavity*

Porosity: *internal voids created by gas entrapment or evolution during the solidifying process.*

Blow holes: *produced as a result of moisture or contamination on the die or core surface when metal is introduced and caused by the rapid expansion of moisture*

Inclusions: *foreign matter that has become entrapped in the casting such as core sand, oxide particles, etc.*

Hot tears: *when the casting strength is insufficient to withstand cooling contraction during solidification*

Cold shuts*: created when the metal entering the die is too cold and solidifys prematurely in some positions while metal is still entering the die.*

Die soldering: *aluminum has an aggressive appetite for iron and certain alloys will attack the steel dies even in the short time for die casting injection creating adhesion of the casting.*

Heat checking: *is a form of thermal fatigue cracking where temperature cycling at the die surface creates fine cracks which encourage sticking and degrade the surface finish of the casting.*

Shrinkage: found in castings with heavy sections with poor connections to the main feed path of metal. The contraction to the solid state can create shrinkage depressions at the surface or internal voids.

Laminations: where cold dies allow rapid solidification of a thin skin before final solidification of the main mass.

What is Die Casting?

Typical Die Castings are everyday parts that go together as part of an assembly, household items, auto parts, electrical boxes, power tool components, small engines etc. Most are invisible because they are painted, plated, powder coted and/or part of a larger assembly. But here a few of the more recognisable and impressive parts made as diecastings.

Slush cast heads

Powder metal parts