**A Complete HandBook For Metal Die Casting**

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# Introduction

Die casting is an important manufacturing technology used in many industries. Companies can make nearly all parts using different casting processes. In this eBook, we shall explain everything you need to know about die casting, metal alloys, die casting techniques and its applications. It is designed to give a comprehensive overview and details about all you need to know about die casting.

# Chapter 1: Die casting definition

This section is designed to introduce the reader to the basic concepts of die casting. This first chapter covers a comprehensive definition about die casting, the necessary videos to watch and die casting examples. By the end of this chapter, you should be able to understand the following key factors:

1. Differentiate die casting from other metal casting processes
2. Understand the history of die casting
3. Features of die casting materials

## What is die casting?

To begin with, we need to understand what metal casting is. According to [The Engineer’s Handbook](http://www.engineershandbook.com/MfgMethods/casting.htm), this is a manufacturing process where solid metals are melted and heated to a desired temperature after which, it is poured into a cavity or mold with proper shape. The melting and heating process may require different furnace heating temperatures. Moreover, different chemical substances may be added to modify the chemical composition of the metal. It is this mold that contain the desired shape and size.

The process may be a single step of a series of steps depending on the complexity of the metal substance. The final product can have virtually any size depending on what the designer desires. The cast parts may range from fraction of inches to over 35 feet. It will depend on the design of the mold or the end product.

Apart from these, it is also crucial to highlight the major metal casting processes that have been used in this industry. These include:

1. Sand casting
2. Investment casting
3. Lost Wax casting
4. Permanent mold casting
5. Centrifugal casting

***What makes die casting a distinct and more importantly intriguing?***

All the other process I have listed above are collectively referred to as “foundry processes” except die casting.

Let’s zero in to what die casting is.

The [Engineering.com](http://www.engineering.com/Library/ArticlesPage/tabid/85/ArticleID/143/Stamping.aspx) defines die casting as *a manufacturing process that produces metal parts of virtually all designs by forcing molten metal under high pressure into a die cavity.* The underlying factor here is *exerting high pressure through a die.* It is a key factor that distinguishes this metal fabrication process from the other metal casting procedures listed above.

For instance, if we look at a processes such as lost wax casting, investment casting and sand casting procedures; the underlying factor in this case is the fact that, the process depends on *gravity* to fill the mold. The [Cambridge Dictionary](http://dictionary.cambridge.org/dictionary/english/gravity) defines *gravity* as a natural force that attracts objects towards one another, more so that force, which makes things fall on the ground.

This further reveal more properties of die casting in relation to other metal casting processes. Here are the key points to note here:

1. The metal die casting process has a short cycle time
2. The metal flow is faster in die casting due to existence of external force
3. The molds in die casting are not as thick as those used in the sand casting or investment casting processes

The metal die casting process, is used to produce various shapes from a number of non-ferrous metals such as brass ([an alloy](http://dictionary.cambridge.org/dictionary/english/alloy)), zinc, aluminum, magnesium and copper among other metals. It is one of those manufacturing processes with the ability to produce high detailed and accurate parts. It is also preferred for mass production of components as opposed to other manufacturing processes. Take for instance, the faucet parts, door knobs, decorative parts, etc. Virtually everything we come across in our daily lives are manufactured from metal die casting.

To understand the evolution of die casting, it will of great value if we explore its origin. That is:

## The history of die casting

The history of this manufacturing technique could be traced back to the 1880s. It was during this time that a [patent was awarded to Sturges in 1894](https://www.google.com/patents/US546498). This was after the invention of a manually operated machine that was used for the casting printing type. 20 years later, the technology was mainly used for [tin](http://dictionary.cambridge.org/dictionary/english/tin) and [lead](http://education.jlab.org/itselemental/ele082.html). This was before the technique was used for other metals such as [aluminum](http://dictionary.cambridge.org/dictionary/english/aluminum?q=ALUMINUM) and [zinc](https://en.wikipedia.org/wiki/Zinc) in the 1920s.

Since then, there are a number of technological advancements that have been witnessed in the industry. This include a number of [metallurgical](http://dictionary.cambridge.org/dictionary/english/metallurgy?q=metallurgical) control measures that have improved the manufacturing and processing criteria. The technological advancements focus on the following key aspects:

1. Increasing the die casting capacity, thus higher production/short production runs
2. Sophisticated die construction processes
3. An advanced casting capability with a number of metals such as steels and brass being included in the process

The evolution took place so fast that by 2005, in North America alone, the total number of sales for die cast products was about $8 billion. Apparently, this number has doubled with most manufacturers focusing on various alloys. This is due to the high demand in the office equipment, sporting, toys, machinery, automotive and many other applications of dis cast parts and components. A number die casting factories that have focused on various niches in the industry. For example, there are:

1. The captive die casting companies; these are companies that produce components for their own use. A good example is the [GM metal casting plant in Bedford](http://media.gm.com/media/us/en/gm/home.html). According to the [Inside Indiana Business](http://www.insideindianabusiness.com/story/30696260/bedford-bags-127m-gm-investment), the company has invested more than $127 million in its Bedford Casting Operations.
2. The custom die casting companies mainly focus on producing the die cast parts for their company. This is mainly for the original equipment manufacturer (OEM). One such company is the Chinese Company, Gatonbrass. It has focused on brass lamp, electrical, furniture, plumbing and home accents, among other parts.

So, what should we learn from this section?

You should be able to distinguish die casting from other metal casting processes and a key point to note is, the process requires some induced pressure. It is an old manufacturing technique that dates back to 1880s and has evolved over time. Lastly, it has been adopted in a number of industrial setups with companies such as GM and Gatonbrass. This clearly shows how important the entire process is.

To get insights on die casting, and the practical aspect of the process, we need to focus on the actual procedure. This will be explained through the videos in the next section of this chapter.

## The Die Casting Videos

These die casting videos will try to give an insight on the basic factors about this manufacturing process. Generally, this a practical process that neither die casting technicians nor professionals must not depend on the theoretical part of it. The understanding should be based on both the theoretical aspects, watching videos and implementing the knowledge one gets. Below are 5 die casting videos you should have a look at:

<https://www.youtube.com/watch?v=Pj_mjjUQad8>

This video explains the most basic form of die casting. The key parts that are involved, how various parts move until we obtain the final product – die cast part. Even thou there are different machines in the industry, the principle of operation is still the same. <https://www.youtube.com/watch?v=W6VgCaRozq8>

This is an animated version of the high pressure die casting process. The process begins by pouring the melted metal that is pushed by the piston. The piston starts at a low pressure followed by a high pressure.

<https://www.youtube.com/watch?v=azS9OjHVDnA>

This video is essential for people who want to adopt low pressure die casting manufacturing technique. Comparing this video and the previous one, it will be quite clear that the mechanisms and amount of pressure involved is quite different.

<https://www.youtube.com/watch?v=h2A7oUMeLmM>

This is a vital video for companies that would wish to invest in the die casting manufacturing process. They’ll be able to understand the choice of machines and the reason as to why they need either go for a horizontally or a vertically [hydraulic operated](http://www.machinerylubrication.com/Read/277/hydraulic-systems-fluid) machines. Alternatively, if they should opt for the cold or hot chamber machines.

<https://www.youtube.com/watch?v=JLfV_u8HRcY>

This video illustrates how cold chamber die casting process takes place. It aims at guiding the viewers on how the entire process takes place. It is mainly used for the copper, aluminum and zinc alloys. The die cast brass parts are some of the most common parts that can be manufactured through this mechanism.

In short, these are but, a few resources that can be vital when it comes to learning every aspect in the die casting process. In fact, the other elements of the die casting process that are explained in the next chapters can have their video version for a proper understanding of the entire process. They can supplement the information contained in this eBook.

In the next, section, we shall discuss various die casting examples. These are tangible items or structures that we use or see in our daily lives.

## The Die Casting Examples

Die casting is one kind of technology that we have lived to embrace in our day-to-day activities. This is a popular manufacturing process that is used to produce a number of metal parts both for industrial and domestic applications.

For this particular section, we’ll categorize these parts based on where they are used i.e. their industrial or domestic applications. The most common die casting examples include the following:

### The brass parts

These are common examples of die cast parts that we meet in our daily lives. They are available in different configurations. These lamp parts include brass fixture body parts, necks and breaks amongst others.



*Examples of brass lamp parts*

With these designs, you can easily make your own custom lighting fixtures. Be it a custom floor or table lamp. It doesn’t matter whether you need antique lighting fixture or one that can meet the unique requirements of your house.

Other brass pars may include:

1. The brass electrical components such as the socket termination parts and coaxial cables.
2. Mechanical parts such as those that are used in the plumbing industry. These may include pipe joints, washers, nuts, flanges and T-joints just to mention a few.
3. The house accents such as brass candle holders, vases, canisters, decorative pillows, etc.
4. The furniture hardware such as door knobs, locks and handles.
5. The brass precision components such as clips, connectors and taps among other sections.

### The zinc cast parts

Zinc is also a popular metal that is used in this industry. Normally, the manufacturers have to choose between the ZA and ZAMAK alloy. The choice of any alloy will depend on the desired physical properties of the end product. That is, parts cast using the ZA alloys have superior strength due to high mounts of aluminum. The Zamak alloys offer better castability.



The zinc cast components

The cast parts may include window hardware, electrical components, bathroom fixtures and office equipment, just to mention a few.

### The steel cast parts

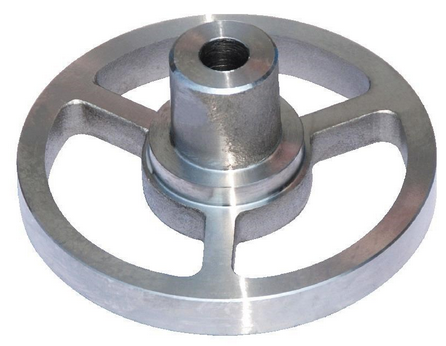
Like the other metals mentioned above, the steel cast parts also form an integral role of our lives. This involves casting different types of steels such as stainless steel. Some of the most common components that are manufactured via this technique include valves, hydroelectric turbine wheels, tooling equipment and pumps among other parts in food, electrical and power industries. All these parts must be manufactured as per the international standards and regulations.



*The steel cast components*

### The iron cast parts

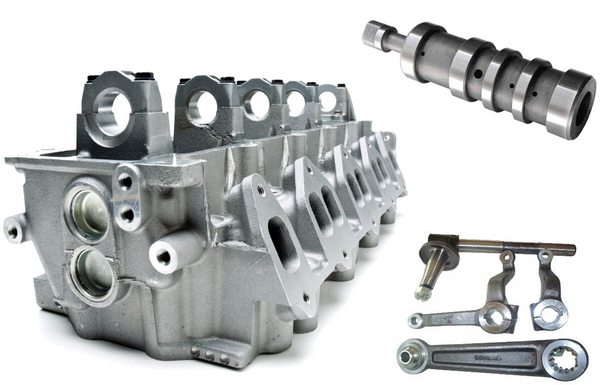
This involves casting a number of iron carbon alloys. These metals have a carbon content that is more than 2%. Again, the iron casting company should be able to choose that specific metal that can meet the requirements of the end users. This involves determining the carbon content, iron and silicon content. Below are images of the iron cast parts:



*Examples of iron cast components*

### The aluminum cast parts

Both aluminum and aluminum alloys are commonly used to cast different machine components. These alloys contain different elements such as copper, manganese, magnesium, silicon and zinc, just to mention few. These elements exist in different proportions thus, different procedures can be used to cast the aluminum parts. These parts are used in different industries such as aerospace, electronics, plumbing and chemical industries.



*Examples of aluminum cast components*

In summary, there are very many types of components and structured that can be manufactured through die casting. It is upon the end user to choose that kind of metal he/she desired for a given application. However, some may require additional secondary operations. After this section, you should be able to list the various components or industries that depend on brass die cast components.

# Chapter 2: Die Casting Materials

Not all metals or alloys can be die cast. This is due to the varying chemical and physical properties. As we all know, die casting involves heating the metal until it melts and forcing it under pressure into re-usable molds. First, we need to understand two aspects here:

1. Heating a metal to a desirable melting temperature; therefore, the metal should be able to maintain its desirable characteristics within that temperature range, otherwise, the whole process will be futile.

2. Exerting pressure, the metal must be able to maintain the same properties when subjected to these high pressures.

In this chapter, we shall discuss the various materials that can be manipulated through this manufacturing technique. This will act as a guide to enable the readers choose the right material for a specific application. Moreover, they should be able to adopt the right die casting technique based on the chemical and physical properties of the metals or alloys.

Ideally the main die casting alloys that are commonly used in industries include zinc, magnesium, tin, lead, aluminum and copper. However, for the purpose of this eBook, we shall focus on the following key materials: zinc, aluminum, brass and steel.

### The Die Casting Material Selection Criteria

This should be based on research and not a trial and error or unapproved theories. It is through a proper understanding of each metal or metal alloy that one will be able to choose the right material and die casting technique.

As matter of fact, these alloys and metals have different mechanical and physical properties. This explains the reason why they react differently when subjected to certain manufacturing processes. It is advisable to work closely with experts to establish the right material for any given application. This may involve a simple comparison process that may be simplified as:

1. It is vital to consider all the vital mechanical properties of those materials. This is what we shall also expound on every material. The vital mechanical properties include elongation, tensile strength, hardness, impact strength and yield strength. These will be based on actual tests.

2. The physical properties of the metal alloy; it is important to understand the behavior of the metal when subjected to extreme environmental conditions. These may include high temperature or extreme stress and heat.

3. It is vital to examine and understand the composition of the alloys. This should be based on the basic composition of individual element and their uses.

In short, these three aspects will help you to narrow down to that specific alloy or metal that can meet the desired application requirements. This should be a perfect comparison that aims at getting the best material for die casting. Having noted, all these, let’s explore the available options. Below are the most common materials that you can die cast:

## Zinc Die Casting

Zinc is one of the most popular metals that is used to make a number of products. Like other metals, casting zinc requires that one understands its basic alloys. The available [zinc alloys](https://en.wikipedia.org/wiki/Zinc) can be categorized as:

1. The [ZA alloys](http://www.eazall.com/Gravity-Casting-Alloys); these alloys are mainly used to cast components that require superior strength. This strength is due to the fact that they contain higher amount of aluminum.
2. The [Zamak alloys](https://en.wikipedia.org/wiki/Zamak); these alloys contain about 4% aluminum. Like the ZA alloys, they are known to have provide good castability and strength.

For decades, these alloys have been used in major metal casting applications. Like other die casting technologies, this process involves forcing the molten zinc under high pressure into a mold cavity.

The zinc cast parts are used in a wide range of applications that impact our daily lives. It is worth noting that zinc casting contribute a lot to the global economy. This ranges from creating employment to the finished products that we use in our daily lives. We use these products both for functional and decorative applications.

### The advantages of zinc die casting

Ideally, these are the basic facts that make zinc the best choice for a number of manufacturing processes. Opting for zinc alloys should be designed for individuals who wish to achieve the following key aspects:

*Process flexibility*

This is a critical aspect in the metal alloy processing industry. The zinc alloys can be die cast to any shape of choice. This is actually the main reason why it is used for both high quantity and quality production processes.

*Precisions and tolerance*

This eliminates any additional machining operations that would otherwise increase the production costs. This is due to the fact that zinc alloys can be die cast to closer tolerances that other metal alloys. Basically, this implies that the final product will be exact component that is desired.

*Strength and ductility*

A number of plumbing or machinery component are die cast. Zinc alloys can withstand very extreme pressure – as high as 60,000 psi. Due to its ductility, the end products are suitable for riveting, bending and crimping operations. Again, it is also worth noting that the zinc alloy is tougher than most metal alloys.

*Excellent thermal properties*

These die cast parts possess desirable electrical conductivity. This is the main reason why they are used for electrical components such as heat skinks or any other application that requires an electromagnetic shielding.

Apart from the properties listed above, it is worth mentioning that other properties of die cast zinc parts also possess the following key features: excellent rigidity, anti-sparking, good bearing properties, easy finishing, thin wall castability, long tool life, recyclable and ease to machine.

### Applications of zinc die casting

As mentioned above, the die casting process produces structures with a number of superior chemical and physical properties. This is actually one of the main reasons why the process is popular across very many industries. Generally, the zinc cast parts are mainly used in the following key applications:

1. To manufacture complex metal parts; this is due to the fact that it is easier to manufacturer items that are accurate with very tight tolerances. Moreover, this is also attributed to the fact that the zinc can be manipulated to a wide range of shapes.
2. These alloys are also used to manufacture parts that should be wear resistance with the ability to maintain high structural integrity. This is essential in the electrical and automotive industry.
3. The fact that zinc alloys can be used to manufacture very thin parts makes it a perfect choice for a number of consumer products, especially the consumer electronics.

In summary, as we wind up this section, there are a few things you need to note and these include:

1. You should be able to choose the right zinc alloy for any die casting process
2. Understand the basic properties that make zinc alloy a perfect choice for a given application.

## Aluminum die casting

Since [aluminum](http://education.jlab.org/itselemental/ele013.html) was discovered over 200 years ago, it has remained to be one of the most abundant metal. It used for a wide range of engineering applications and it can be manipulated to any shape depending on the requirements at hand.

Apparently, die casting aluminum has proved to be environmentally and sustainable. This is from the fact that about 95% of the metal can be recycled. This reduces the amount of waste in the environment. In fact, it is a non-ferrous metal that is commonly die cast in the world today.

Again, die casting aluminum is generally cost effective. This is basically due to the intrinsic physical and chemical properties of aluminum. This is the main reason why it has been adopted globally.

To decide whether to use aluminum alloys for a particular application, you need to understand the basic physical and chemical properties. This forms and integral part when it comes to decision making.

### Characteristics of aluminum alloys

This is a versatile metal with a wide range of desirable physical and chemical properties. This is actually the reason why the aluminum die cast parts are used in a number of domestic and industrial applications. Some of these properties include:

*Superior corrosion resistance*; this explains the reason why these die cast parts are used in chemical and petroleum industries. This metal cannot be attacked by most organic and inorganic compounds. This is due to the fact that it reacts with atmospheric air to form a thin oxide layer that is inert. In some instances, the die cast parts can be processed using the electrolytic oxidation process.

*Lightweight*; it has an average density of 2.70 g/cm3. The aluminum alloys are some of the lightest alloys available. This implies that the die cast components can be used in applications where the overall weight of the product should be reduced as much as possible. They are commonly used in the aerospace industry.

*Superior thermal and electrical properties*; this is due to its position in the periodic table. Aluminum has an oxidation no. +3. It as free electrons that can conduct electricity and thermal energy. This is actually the main reason why they form a perfect alternative for copper. Its electrical conductivity can be estimated to about 36 m/Ohm mm².

*High operating temperature*; this is the main reason why the die cast aluminum parts can be used in a number of electrical applications. These include heat sinks, electrical connectors, thermometer covers, etc. This is also the main reason why the die cast parts are used as utensils. On average, the aluminum alloys have a melting point of about 660 °C.

*Strength and hardness*; generally, the aluminum alloys are stiff with superior strength to weight ratio. This explains the reason why they can be used as rails.

*Environmentally friendly*; these metals are fully recyclable thus, reducing the scrap metal in the environment.

*RFI and EMI shielding properties*; this is the main reason why they are used in electrical components where these radiations may reduce or interfere with the systems performance.

In addition to these, the aluminum alloys also possess superior surface finish. Blending all the above properties together, the designers are always sure of a die cast aluminum part with superior performance. This is the main reason why these die cast parts are used in the following industries:

### Applications of aluminum alloys

Since we have highlighted a number of applications when discussing the characteristics of these metals, we shall list the various industries and specific components that are manufactured from these alloys. However, you should note that this list may not be exhaustive. These industries include:

1. They are used in the automotive and aerospace industry. This is because their lightweight contribute significantly in fuel efficiency.
2. They are used in electrical, thermal and electronics industries. This is due to superior electrical and thermal properties and good shielding properties. The die cast aluminum can be used as electrical connectors in the high temperature applications.
3. The die cast parts are used in networking in both computers and communication industries. This is because they can dissipate heat and act as the radio frequency filter. Again, they provide a good RFI/EMI shielding making a perfect choice for a number of handheld devices.

In short, it is virtually impossible to live without the die cast aluminum parts. Again, we need to note that there are different types of alloys optimized for different applications. This makes it crucial to discuss the aluminum alloys as essential die casting materials. This will also help when it comes to deciding on the kind of materials one should opt for.

### Types of aluminum alloys for die casting applications

In this eBook, we shall focus on 7 different types of aluminum alloys that are die cast in most industrial setup. These alloys include the following:

*The K-alloy*; this aluminum allow is known to possess the following key properties: resistance to corrosion, improved cooling and zero post die casting operations.

*Alloy 413*; superior die casting properties and it possess good fluidity and guarantee better pressure tightness.

*Alloy 383*; it possesses the following key properties: dimension stability, ease of casting and good mechanical properties. It has superior corrosion resistance too.

*Alloy B390*; it is known for its superior wear resistance and high hardness. They are mainly used to die cast the internal combustion engine pistons.

*The A360*; it is mainly used to cast aluminum parts where pressure tightness and fluidity is a priority. It maintains corrosion resistance and strength even at elevated temperature.

*Alloy A413*; its properties are similar to that of the alloy A360. This alloy is mainly used to die cast hydraulic cylinder components.

*Alloy A380*; it has good thermal and mechanical properties. Its performance properties is similar to most alloys listed above.

In summary, by the end of this section, you need to understand the basic properties of all the possible aluminum die casting alloys. This is important when you need a specific aluminum alloy for a given application.

## Brass die casting

[Brass](http://www.azom.com/article.aspx?ArticleID=4387), is an alloy of mainly copper and zinc. By varying the amount of copper and zinc in the final product (brass), we are able to obtain different types of brass alloys. Choosing a given type of alloy will depend on the primary objectives one intends to realize. In most cases, the standard brass may have about 67% of copper and 33% of zinc.

Normally, these metals may not provide the desired performance properties of brass, thus, other metal elements can be added. This basically aims at incorporating the desired features. For instance, lead can be added to the alloy (about 2%) to improve the [machinability property](http://www.businessdictionary.com/definition/machinability.html) of brass. This implies that, without lead, then it will be difficult to die cast brass.

In this section, we shall focus on the main properties that we need to consider when we want to choose brass alloy for any given applications. This implies that, we shall discuss the characteristics/properties, applications and types of brass alloys. With this information, we should be make the right decision as far as choosing the right metal is concerned.

### Characteristics of die cast brass

The die cast brass possess the following key characteristics or properties:

*Easy to machine/die cast*; this is an important property of brass. Metals that are cumbersome to die cast will result in high production cost. It is important to note that brass is not inherently easy to machine. Adding about 2% of lead enhances the machinability properties. Lead is a perfect choice for this application since it has a low melting point than both copper and zinc.

In some instances, silicon can be used instead of lead. However, brass alloys with silicon must not be mixed with the ones having lead.

*Corrosion resistance*; brass alloys can be modified to offer high level of corrosion resistance. A good example is the [dezincification resistant (DZR) brass](http://www.diehl.com/fileadmin/diehl-metall/dlc/Diehl_Metall_Messing/Aqcuarin_en_einzeln.pdf). It will remain effective and reliable even in harsh environmental conditions. They can resist aggressive environmental conditions.

This is the main reason why the die cast brass parts are used in plumbing systems with high temperature or high concentration of chloride. Die casting these parts require careful manufacturing process. This is crucial when it comes to balancing the desired metal elements.

*Low melting temperature*; this makes die casting brass a cost effective process. The melting point of brass is about 900 °C. This implies that less energy will be required to melt and subsequently process it to obtain the desired shapes.

Bright or gold like appearance; this makes it a perfect choice for most decorative applications. The brass parts that have been die cast are used to make door knobs, window locks, flowers vases, bearings, etc. The brass cast parts are extensively used in a number of electrical, musical instruments and plumbing applications. Its color, which tend to resemble that of gold makes the brass die cast components resistant to tarnishing.

Low co-efficient of friction; brass is generally soft thus, it can be used to make die cast parts that do not require friction. These include bearings and fittings.

Relatively strong; a given quantity of aluminum can be added to improve its strength. The die cast brass parts with a thin layer of transparent aluminum are self-healing. *[Tin](http://www.rsc.org/periodic-table/element/50/tin)* also serves the same purpose. A reason why it is a perfect choice for the brass parts used in water applications such as the naval brasses.

Environmentally friendly; nearly 90% of brass cast parts can be recycled. This makes it a sustainable metal as it reduces the amount of scrap metal. This is due to the fact that brass is a *[non-ferromagnetic](http://dictionary.reference.com/browse/ferromagnetic)* metal. This makes the separation process easy – by using a magnet.

In summary, from these properties, you can easily examine the situation at hand and decide whether to adopt brass die cast parts of not. So, what are the main applications of brass die cast components?

### Applications of brass die cast parts

Based on the above properties, we can summarize the key applications of brass die casting as:

1. Parts that should be resistant to corrosion e.g. marine/salty water applications
2. Resistance to adverse temperature e.g. pipes carrying hot water or gas
3. Superior electrical conductivity e.g. socket terminals and electrical parts
4. Withstand high pressure (about 300psi) e.g. pressure pipes
5. Decorative components e.g. lamp parts and furniture hardware
6. Abrasion resistance or low co-efficient of friction.

In short, brass is a versatile alloy that can be used for nearly all applications. It is upon the end user to examine the requirements of the application at hand. Another demanding process is to determine the right brass alloy. That is, one that meets the required application of a given die casted part. Let’s explore the various brass alloy types:

### Types of brass alloy used in die casting

There are very many types of brass alloys. This is based on the basic constituents of the alloy alongside the primary elements (copper and zinc). The variation in their constituents make the alloys suitable for different applications. This basically calls for critical analysis and evaluation of every aspect before deciding on a specific alloy to go for. Some of the most common brass alloys include:

1. Admiralty brass; it is mainly used in applications where dezincification is a problem. It is made of zinc, copper and tin.
2. Aich's alloy; it is mainly used in marine applications. This is due to its high corrosion resistance. The main constituents include copper, zinc, tin and iron
3. Alpha brass; they are mainly used in pressing applications. They have less than 35% zinc.
4. Duplex brass; it has α and β' phase and it contains between 35 to 45% of zinc.
5. Aluminium brass; they’re mainly used to cast brass parts that should be resistant to corrosion. They contain aluminum.
6. Arsenical brass; the die cast parts from this brass alloy are mainly used in boiler fireboxes.
7. Beta brass; they can be die cast easily. They contain between 45 and 50% zinc.
8. Cartridge brass; they are mainly used to make ammunition cases and the have 30% zinc.
9. Rivet brass; it contains 37% zinc.
10. DZR brass; contain arsenic and very resistant to most weather conditions.
11. Red brass; it contains 85% copper with the other three elements (tin, zinc and lead) available in same proportion (5% each).
12. Rich low brass; it is mainly used to cast jewelry. It contains 15% zinc.
13. White brass; contains more 50% zinc and it’s also brittle.
14. Yellow brass; contains 33% zinc.

As you can see, there are very many alloys of brass that you can die cast. This actually makes it difficult to choose the right alloy for a specific application. This is why you need to get an expert in the die casting materials. It is quite evident that all these variations are as a result of varying the main constituents of these metal elements.

In summary, by the end of this section, you should be able to evaluate all the available types of brass alloy. This should be based on the desired performance requirements. This is actually the 3rd material that we have discussed. Note that the properties/characteristics of the material is a determinant factor here. You need to understand it to make the right decision. The last material in this category is the:

## Steel die casting

Like other metals, steel is also a common metal that can be die cast. This is due to its versatility and functionality. It is also important to evaluate the various characteristics/properties, applications and types of steel available. This is will form the foundation of any steel die casting process.

Steel itself is an alloy of carbon and iron. This implies that, the steel die cast parts have both properties of iron and carbon. Again, it is also worth noting that this alloy may contain other elements that enhance its performance.

It is important to note that there is clear difference between steel and either cast or wrought iron. This is mainly based on the amount of carbon content in these materials. In most cases, the percentage of carbon in steel may be between 0.2% and 2.14%. Steel may also contain other elements such as vanadium, chromium, tungsten and chromium, just to mention a few. All these alloying elements are mainly used to alter the mechanical properties of steel.

### Characteristics/properties of die cast steel

We need to note that the physical and chemical properties of steel depend on the percentage of the constituent elements. Again, the properties of steel are slightly different from that of iron and carbon. What are some of the desirable properties of steel?

*High strength*; steel is stronger than most metals that are used in engineering applications. This strength is determined by the carbon content in the alloy. A die cast steel part with higher carbon content will be both harder and stronger.

*Resistance to corrosion*; the stainless steel is corrosion resistant thus, making it a perfect choice for a number of industrial applications. This include mining and chemical processing industries. That is, it doesn’t corrode easily when it is subjected to any adverse environmental conditions.

*Lightweight*; it has a relatively lightweight than a number of building materials. However, the die cast aluminum parts are lighter than die cast steel parts.

*Dimensional stability*; the steel cast parts do not change with time even when subjected to extreme environmental conditions. That is, even when subjected to high or low temperature, it will in the long run retain its original dimensions.

*Thermal and electrical conductivity*; steel has free electrons thus, it conducts both heat and electricity. This is the main reason why steel parts can be used in boilers and other electrical components/sections.

*Recyclability*; steel can be recycled effectively. This reduces the amount of scrap metal in the environment. Again, it cuts the production costs making the die cast parts cheaper.

It is quite clear that steel is a versatile material that can be used for a wide range of applications. This is the same scenario when we discussed zinc, brass and zinc. For example, steel can be used to make the following components:

1. The scientific or medical equipment; these include scalpel, needles, instrument covers, etc.
2. Parts of various infrastructure such as bridges, railway lines, roads, stadiums, buildings, etc. These may include bolts, connectors, etc.
3. Automotive parts and components. Basically, all industries depend on steel.

In short, there are very many applications of steel die cast parts/components. Again, this will also depend on the type of steel in question. May be we should look at the types of steel:

### Types of steel used in die casting

There are very many types of steel that can be die cast. [The American Iron & Steel Institute](http://www.steel.org/) has classified all the available steel based on their chemical composition as:

*The alloy steels*; these steels contain the alloying elements in varying proportions. These alloying elements include: nickel, copper, aluminum, chromium, copper and titanium. These elements impart different properties on the alloy such as strength, corrosion resistance, strength and ability to be die cast.

*The tool steels*; they are mainly known for their high strength. They contain vanadium, cobalt, tungsten and molybdenum in different quantities.

*The carbon steel*; the die casting companies can choose from the low carbon (less than 0.3% carbon), medium (0.3 to 0.6% carbon) and high carbon steel (more than 0.6% carbon). Basically, this classification is based on the carbon content in the alloy.

*The stainless steel*; they contain between 10% and 20%. This makes it corrosion resistant. There are 3 types of stainless steel:

1. Austenitic stainless steel; contain about 18% chromium, 0.8% carbon and 8% nickel. It is one of the most common and it is mainly used to die cast plumbing systems, kitchen equipment, etc.
2. Ferritic stainless steel; contain between 12 and 17% chromium and less than 0.1% carbon. The die cast stainless steel can be strengthened by cold working.
3. Martensitic stainless steel; it contains about 1.2% carbon and between 11 and 17% carbon. The die cast parts can be treated by heat and are magnetic. Good examples are surgical and dental equipment.

Again, it is also quite clear that by varying the different constituents of steel, we can achieve different properties. It is also worth noting that the choice of a given type of steel will be based on the physical properties of the type is stainless steel.

In summary, in this die casting material section, you need to take note of the following:

1. You should be able to distinguish between zinc, brass, aluminum and steel cast parts.
2. Differentiate the metals based on their unique properties
3. List all the types of alloys for each metals
4. Be able to choose the right metal whenever you’re planning to die cast any metal.

# Chapter 3: Types Of Die Casting

In this section, we shall discuss the various types of die casting technologies used in industries. We shall focus on three main types of technologies: pressure die casting, gravity die casting and vacuum die casting. We shall discuss the important procedures involved in these techniques, benefits and disadvantages of every process. This is an important section that will guide you whenever you want to opt for a specific process to die cast a given types of metal

By the end of this chapter, you should be able to:

1. Distinguish each type of die casting technology
2. Explain how each technology works
3. List the advantages and disadvantages of each technology

## Pressure die casting

The pressure die casting is suitable for [high volume run](http://smallbusiness.chron.com/definition-high-volume-manufacturing-processes-36143.html) parts. This manufacturing technique can produce parts with thinner wall thickness without compromising their quality. It uses different types of die casting machines that may range between 80 ton and 1100 ton. This depends on the ultimate pressure one wishes to achieve. Of course, it will also depend on the type of metal die casting technique.

***Why is it called pressure die casting?***

This name basically refers to the nature of the process itself. This process does not depend on the force of gravity to distribute the molten metal within the mold. Instead, an external pressure must be exerted (air pressure). This force distributes the molten metal within the mold. This implies that, this process is faster and it can be used to manufacture high quality parts. This process can be categorized as:

1. High pressure die casting
2. Low pressure die casting

The above classification depends upon the amount of pressure used in the process. Again, it is worth noting that high pressure die casting has a wide range of applications. That is, almost 50% of light alloys are manufactured via this technique. On the other hand, the application of low pressure applications constitute about 30%. In the recent past, companies have begun incorporating the low pressure die casting process.

#### Advantages of pressure die casting

There are several reasons why manufactures prefer it to other die casting techniques. These include:

1. It can produce parts with superior mechanical properties. That is, the parts have a good finish and tight dimensional tolerance/accuracy. This makes it a perfect choice for producing intricate machine parts. Again, it is the main reason for its popularity.
2. It is suitable for large scale production of parts. This is because the pressure increases rate of flow of molten metal. However, it may not be suitable for short run production. This is due to high setup costs of the system.
3. The final product is in its “purest form”. That is, the final product is free from oxidation effects with no gas trapped within the metals.
4. The pressure casting is relatively economical compared to other casting techniques. This is for large scale part production. In fact, thousands of parts can be produced before considering a replacement of the machine components.
5. It is easier to control the dimensions of the final product depending on the amount of pressure.
6. It is a perfect choice for casting metals with thin walls and lightweight.

#### Disadvantages of pressure die casting

This metal part manufacturing process is associated with the following main disadvantages:

1. The entire process is only suitable for large scale metal part production.
2. The initial set up costs is relatively high. This is due to the technology involved.
3. The process is mainly suitable for high-fluidity metal parts.

In short, this is an overall overview of pressure die casting. So, we need to discuss the various types of metal die casting technology.

### High pressure die casting technology

The high pressure die casting is one of the most competitive metal processing technologies used in the manufacturing industries today. At times, it may be referred to as the pressure die casting. In this metal die casting process, the molten metal is injected in a metal die under high pressure. Normally, the process takes place under high speed and pressure. In most cases, the die casting temperature is always around 700°C during the casting process.

This technology has been adopted by a number of manufacturing companies. This is due to the superior and thin walled die cast parts.

#### Advantages of high pressure die casting process

This manufacturing technique guarantees the following desirable properties:

1. It is suitable high volume production of parts.
2. It is possible to achieve parts with very tight tolerances.
3. The die cast parts have superior finish i.e. they have a smooth surface with fine grain finish.
4. It guarantee high metal part production rate.
5. The process is also suitable for parts with very small thickness i.e. about 1 to 2.5 mm
6. This is a precise manufacturing process, thus, little or no additional machining may be required.
7. Very light parts may be manufactured through this process.
8. It can be used to manufacture complex parts.
9. It guarantees flexible and rapid delivery

#### Disadvantages of pressure die casting

It is also important to note that, this metal part manufacturing technique may not be suitable for all manufacturing processes due to the following reasons:

1. The tooling costs is higher than the gravity die casting processes.
2. It may not be economical for small scale part production process.
3. This process requires complex machinery.
4. The size of casting is limited by the machine size.

Again, it also worth noting that this process may be prone to porosity problems. This is the main reason why the evacuation chamber technique may be used to reduce its effects.

### Factors to consider in pressure die casting

This is a fundamental aspect that will guarantee the success of the entire process. That is, the choice of a recommended pressure, heating temperature and weight are key issues to consider. This choice of a suitable metal is also an integral aspect. Not forgetting the efficiency of the pressure die casting machine. For instance, an efficient machine will guarantee high production rates – about 200 castings per hour. This will depend on the complexity of the part and the capacity of the die casting machine.

This makes sustainability and suitability some of the fundamental aspects to consider. In most cases, this die casting process is mainly used to cast zinc and aluminum.

These are a number of factors that makes them suitable for this process and these include their availability and the fact that they can be recycled. The two metals can be recycled without losing their essential priorities. Let’s examine the requirements for each case:

*Die casting zinc*; the molted zinc is injected at 425°C. Normally, the specific pressure is maintained at about 500 bar. This requires a high grade mold and high speed.

*Die casting aluminum*; the molten aluminum is maintained at 670°C. This requires a high grade mold and the process should take place at a high speed with the temperature maintained at 1000 bar.

In summary, by considering all the aspects mentioned above, you can decide whether this process is suitable for a given application or not.

### Low pressure die casting

This is yet, another die casting technique that is popular in very many industries. The surface finish of this process can be compared to that of the gravity die casting technology. Thou, they are not actually the same. In this process, the molten metal is injected in the mold under low pressure. Generally, the die cast parts produced by the low pressure die casting are better than the gravity die casting. Again, it is important to note that they are not as good as those produced by the high pressure die casting.

The technique is mainly used to die cast the low melting point alloys such as those of magnesium and aluminum. In most cases, the pressure required to sustain the process may range between 2 and 15 psi. This pressure causes the molten metal in the furnace to rise up a tube and enter a die cavity. The air pressure is only released after the molten metal changes into solid.

#### Advantages of low pressure die casting

This process has the following key benefits:

1. It is suitable for small production quantities.
2. It has a fairly high metal part production rate
3. Guarantees high yields – about 90%
4. The casting can be heat treated
5. The production costs is slightly lower than the high pressure die casting.
6. Improved surface finish thus, reduced finishing operation. The surfaces produced through high pressure die casting are better.
7. An improved linear tolerance than gravity casting.
8. It’s possible to obtain parts with thin walls.

#### Disadvantages of low pressure die casting

This manufacturing technique has the following main disadvantages:

1. The tooling costs is slightly higher than other casting technologies such as gravity casting.
2. It requires complex machinery that may be very expensive.

In summary, the high pressure and low pressure die casting technologies share a lot manufacturing process. The mainly difference comes in the amount of pressure required. Of course, this is the only integral factor that may make the tools used to vary slightly.

It is important that you understand the main features you’d wish the final product to possess. This could be a superior surface finish or one with a tight tolerance. From this you can decide to go for a low or high pressure die casting process.

## The Gravity die casting

The gravity die casting is one of those processes that is popularly used for both medium and high volume production process. Under normal circumstances, this process uses permanent mould, thus, it is easier to achieve a near net shape product.

This die casting capability varies from one manufacturer to the other. That is, there are those companies that use the automated systems whereas other use the manual systems. Again, the weight of the final product that can be cast depend on the type of machine.

The gravity die casting technique has been adopted by most companies due to the fact that it reduces the production cost. The tooling that is used in here, is cheaper that those used in the high pressure die casting. A company that has all the above manufacturing techniques can always examine the project at hand and subsequently choose a technique that suits their customers.

***What does the process involve?***

Unlike the high pressure die casting where the molten metal moves into the die due to high pressure, this die casting technique depends on gravity. NOTE: There’s no any other force that is applied to facilitate the flow of molten metal. This metal parts manufacturing process is suitable for non-ferrous alloys. That is, copper, aluminum and zinc alloys. It is a manufacturing process that is mainly used to produce heavier metals sections. However, the parts are thinner as compared to those produced by sand casting.

This process involves four major processes:

1. The mould should be heated, sprayed with a lubricant and then closed. The lubricant helps to control the temperature of the mould.
2. The molten metal is poured in the mould and allowed to cool.
3. The die is opened to remove the metal cast components. This can be done with the help of ejector pins.
4. The die is prepared for the next casting process.

The gravity die casting can be used to manufacture components with complex shapes. Examples of products that can be manufactured using this technique include diesel engine parts, air conditioning systems, cylinder parts and valve flow systems, just to mention a few.

#### Advantages of gravity die casting

The main advantages of this manufacturing technique include the following:

1. Better dimensional accuracy.
2. Thinner wall can be cast thou, they can be smaller than those of the pressure casting process.
3. It reduces a number of secondary operations.
4. It imparts desirable mechanical properties on the metal parts e.g. high tensile strength.
5. The final parts have smoother surface than those made from sand casting.
6. A faster production can be realized.
7. It’s possible to produce undercuts with the help of undercuts.

#### Disadvantages of gravity die casting

The process has the following key disadvantages:

1. It has high initial cost.
2. Very complex shapes cannot be produced using this technique.
3. The minimum wall thickness that can be die cast ranges between 3 and 5 mm.

In summary, it is important to note that, this process differs from the two die casting process mentioned above in the following key aspects:

1. The quality of the parts produced.
2. Depending on force of gravity as opposed to induced force.
3. The size of parts that can be cast.

Therefore, it is important to consider the above three aspects before opting for the gravity die casting as the main manufacturing process. The aspect of production cost is also an important factor to consider.

## The Vacuum die casting

The vacuum die casting technology has been adopted by companies that manufacture large parts. Normally, these are parts that tend to have porosity problems. This is due to the air entrapped within the casted component. Over the years, the vacuum die casting has proved to be the best way to eliminate the porosity problem.

***How does the vacuum die casting work?***

In most cases, the die is manufactured from steel in an airtight bell housing. It has two receivers – outlet top and sprue through which the molten metal enters the die and the vacuum. The molten metal flows into the die due to pressure difference. The molten metal flows up the sprue to the die where the metal solidifies. This cycle keeps on repeating itself. In the vacuum die casting, the desired pressure differential is controlled by varying the vacuum. This is between the molten metal and cavity. The process requires a tight control system that can be achieved during the design process.

The vacuum die casting has been adopted in a number of manufacturing companies. The automotive industries depend on this technique to produce various engine parts.

#### The advantages of vacuum die casting

The main benefits of this manufacturing technique include the following:

1. The die cast parts have good welding properties.
2. The parts possess high mechanical strength.
3. They are associated with low production scatter.
4. It is superior when it comes to reducing gas porosity.
5. The die produces accurate parts that may not require secondary operations.

#### The disadvantages of vacuum die casting

This metal casting technique has the following main disadvantages:

1. The initial setup cost is relatively high.
2. It is cumbersome to setup a vacuum die casting process.
3. Some parts may requires secondary operations. They may not be as precise as those produced by pressure die casting.

***How to make vacuum die casting successful***

To get the desired shapes, it is important to observe the following key aspects:

1. For high performance, the vacuum component must be of high quality. Both the shot assembly and die must be sealed tightly. This will guarantee efficiency and reliability.
2. To attain high reproducibility and precision, it is important to control both the pressure and velocity profiles.
3. The following components should be controlled: die spraying, plunger lubrication, molten metal fees and die temperate control.

NOTE: Achieving an optimized vacuum casting process can be a challenging process. It’s only a high vacuum that can fulfill the requirements of the above specification. Therefore, each process should be optimized.

Generally, this process can be used to manufacture pressure tight components. The parts are used in the automotive, aerospace, gas manufacturing and food processing industries among other industries. Some of the most common parts manufactured via this technique include oil pumps, engine cradles, brake components, transmission transfer cases, manifolds and oil filter mountings, amongst others.

In summary, this is a unique manufacturing process that plays a significant role in the manufacturing process. In this chapter, we should be able to note the following key points:

1. List and explain the different types of die casting technologies. That is, pressure die casting, gravity die casting and the vacuum casting.
2. Explain the different advantage and disadvantages of each manufacturing process.
3. Select the best die casting technique for a particular project.
4. Explain the principles of operation for each manufacturing technique

# Chapter 4: Die Casting Machine

Choosing the right die casting machine is an important process. Since these machines were invented, they have undergone a number of innovations. All these aim at improving:

1. The process flexibility; the machine allow for different metal die casting procedures. That is, whether it is lean, compact or extended die casting process.
2. A high degree of reproducibility and precision; the modern die casting machines allow for a precisely controlled and dynamic casting process. This guarantees consistency in the parts produced.
3. Energy saving; this ensures total cost advantage. This is achieve through a good control of the machine.
4. One-stop die casting solution; this allows for easy handling thus, an improved performance of the machine.

All these machines vary in both design, specification and performance. Take for instance, those casting machines manufactured by [L.K. Machinery, Inc.](http://www.lkadvantage.com/diecasting.html) and [The Toshiba DC-J Series](http://www.toshiba-machine.co.jp/en/product/diecast/lineup/dcj.html). Each machine has unique specifications that make them suitable for a specific task. Below is an example of a die casting machine manufactured by The Toshiba Machine Japan.

### Considerations when buying die casting machines

There is one simple rule, the machine should be able to perform the desired task. That is in terms of maximum productivity and efficiency. The critical parts to consider in a machine include the following:

*The ton capacity*; they come in different capabilities that may range from 80, 120 to 250 tons. This will depend on the task the machine should perform.

*The machine base*; this is the section where the entire machine structure rests. It should have a strong structural base to support the machine.

*The die locking mechanism*; most machines use the [hydraulic systems](https://en.wikipedia.org/wiki/Hydraulic_drive_system). It should be adjustable with the ability to hold all types of dies.

*The heat exchanger system*; it is mainly used to cool the system. This prevents over heating of the mould.

*Injection and ejection system*; the injection system operates based on a hydraulic system. They are designed to be powered by high pressure accumulator.

*The hydraulic system*; it is responsible for all the movements of various components. It consist of the following key parts, relief valve, accumulator, vane pump, unloading valve and vane pump. These may vary depending on the design of the die casting machine.

*The electrical systems*; these essential parts of the hydraulic machines. The electrical parts may consist of relays, contactors, switchgears, motors, etc.

It is important that you evaluate every section of the machine at the time of purchase. It should be one that meets the performance criteria of your client’s needs.

Now that we have an idea of why we need these machines and the basic sections that make up the machine, we may discuss the various types of metal die casting machines for different applications.

## The pressure die casting machines

The pressure die casting is a common process across very many industries. There are a number of companies that manufacture the pressure die casting machines. They come in different configurations depending on the metal to be die cast. For instance, there are the fully automated and semi-automated machines. There are two main types of pressure die casting machines and they include:

1. [The hot chamber pressure die casting machines](http://thelibraryofmanufacturing.com/hot_chamber_diecasting.html); these machines are also available in different configurations and designs. They have different locking forces depending on the design of the machine. These machines are designed for high productivity and accuracy. The machines are mainly used to die cast magnesium, zinc and lead alloys. These are basically metal alloys with low melting point. To ensure high level of accuracy, the modern machines are equipped with a complete control system. That is, a [closed-loop control system](http://www.electronics-tutorials.ws/systems/closed-loop-system.html). They are designed to reduce production costs by being energy efficient.
2. [The cold chamber die casting machines](https://en.wikipedia.org/wiki/Die_casting); they come in different capacities that may vary from: 80, 180, 280 to 400 tons. These machines have been designed for metal alloys with high melting point such as aluminum, brass and copper. They are designed to guarantee high level of accuracy and repeatability. This makes them suitable for high scale production.

There are both the vertical and horizontal machines available. It depends on the manufacturing requirements. The horizontal hot chamber and cold chamber die casting machines are some of the most common machines that used in this industry.

In short, the choice of a cold or a hot chamber die casting machine will depend on the type of metal you’d wish to die cast. That is, whether it is an alloy with high or low melting point.

## The gravity die casting machine

The [gravity die casting machines](https://www.youtube.com/watch?v=_A6KG010u3o) are also used in the metal die casting industry. They are available in different configurations, depending on the type of metal to die cast. The modern die casting machines feature advanced technology that aim to increase production and quality of the final die cast components. They include manual, automate and the PLC controlled systems. The available gravity casting machines can be used to cast a wide range of metal such as copper, aluminum, zinc, iron and copper alloys.

Broadly, the available machines can be classified as vertical, inclined or horizontal. Most of these machines have hydraulic systems that can be used to adjust the degree of tilt. That is, the title angle can vary between 0 and 90 degrees. The tilt may be adjusted depending die casting process. The end users can choose from the following options:

*The tiltable machines*; these machines are mainly used to achieve better finishes. They can be adjusted depending on the type of metal. They are mainly used to die cast copper, zinc and aluminum alloys. With this machine, it is possible to achieve better dimensional accuracy and most of them are basically high capacity machines.

*The hydraulic die casting machines*; these machines are mainly used to die cast copper and aluminum alloys. They come in both the tilt and non-tilt configurations.

*The non-tiltable machines*; these machines are mainly used to die cast non-ferrous metal such as aluminum, zinc and copper. They have both the digital and hand operated functionalities.

In summary, these are the most common types of die casting machines available in the market. It is import to consider functionality, convenience and quality of the final product before opting to purchase one. As a general rule, you need to acquire these machines from an authorized dear.

## Die casting mold

The [die casting mold](http://www.custompartnet.com/wu/die-casting) is an important tool in the metal casting industries. The mold have channels, which the molten metal flows to form the desired shape and design. The design of the mold will depend on the desired shape of the final product.

In the metal die casting, the mold design is a fundamental aspect of the entire manufacturing process. This is from the fact that, all attributes and shape of the die will affect the final product. Normally, the manner in which the molten metal flows will depend on the die casting technique. That is, for high pressure die casting, the molten metal will flow due to high external pressure. For gravity die casting, the flow will be due to the force of gravity.

{An image of a die casting mold}

### What determines a quality die casting mold?

This will be determined by a number of mold design factors. They must meet the desired design specifications. The key [die casting mold parts](http://www.thomasnet.com/articles/custom-manufacturing-fabricating/die-casting-molds) to consider include:

*The die draft*; this refers to the extent a mold core is tapered. This reduces chances of shrinkage and makes it easy to remove the cast part. Factors that determine the type of draft include: type of metal alloy, wall thickness and the shape of the die.

*The parting line*; this is the line that connect various sections of the mold. It should not deform due to any work strain to avoid any non-uniformity molding.

*The fillets*; these are smooth surfaces that form concave junctions. They are inserted on the sharp corners of the mold. Basically, they create round edges making it easy to remove the die cast part. NOTE: They are not placed on the parting lines.

*The bosses*; they are used as mounting points during the mold design. To fill the deep bosses, ribbing and filleting may be necessary. It helps to achieve a uniform thickness of the mold.

*The ribs*; these structures are used to improve the strength of the material, reduce stress cracking, and improve fill capabilities.

*The holes and windows*; makes it easier to eject the die cast part since it creates substantial drafts. The unwanted casting can be eliminated with the help of this structure.

*The symbols*; these could include brand names, logos or instructions. They can be included during the mold design. It is worth noting that their use can only increase production costs. This depends on the complexity of the design/symbol.

In summary, designing the die casting mold can be a challenging process. It requires both the metal casting company and consumer to work very closely together. This should be from the design conceptualization, [product prototyping](https://en.wikipedia.org/wiki/Prototype) to the actual design process.

By the end of this chapter, you need to have an understanding of the various machines used in the metal die casting. This is essential for the manufacturing companies in this industry. It’s only by choosing the required die casting machine that you can realize a good end product.

# Chapter 5: Die Casting Process

To maximize on profitability, reliability and performance of the metal die cast parts, it is important to adopt the best manufacturing process. The manufacturing process will depend on several factors that we have listed in the previous chapters. The main aspects include:

1. The type of alloy; high or low melting point alloy.
2. The desired finish. This can be very fine or one that may require secondary finishing operations.
3. Size of the die cast part and application.

We have already discussed some critical aspects of the die casting processes. These include:

1. Where each process may be used and reasons why.
2. The choice of die casting machine for each process.
3. The basic application of each process.
4. The advantages and disadvantages of each process.

In this chapter, we shall focus on the step-by-step process involved in each case. The main metal die casting process that we shall focus on include:

## Pressure die casting process

In pressure die casting, the molten metal is subjected to high compression rates and specific pressure. In other words, the process takes place at both high pressure and speed. It is used to cast non-ferrous alloys. Depending on the type of alloy, the casting process may done in the following chambers:

1. [The cold die casting chamber](https://www.youtube.com/watch?v=te_sSfxjJKw)
2. [The hot die casting chamber](https://www.dynacast.com/hot-chamber-die-casting)

The quality of the die cast part may depend on a number of engineering actors such: ventilation systems, design of the die, evacuation process, pressure and temperature stability among other aspects.

{An image of the process}

Generally the high pressure die casting process is used for high productivity manufacturing process. That is, where high precision, surface clarity and dimensions stability is required. Good examples are parts with very thin thickness. It is one of those processes that has been adopted for high volume run parts. The machines also vary in tonnage depending on the specified criteria. That is, they may vary between 80 and 1100 tons. Others have high capacity.

## Gravity die casting process

This metal die casting technique depends on the force of gravity. That is, the molten metal is allowed to flow without an external force or pressure. The nature of the final product will depend on the design of the gravity die casting machine.

The gravity die casting technique is mainly used to cast light alloys. Before the process begins, the mold must be heated and sprayed with a lubricant. The molten metal is poured in the die and allowed to flow with the help of gravitational force. The metal alloy then cool and the die cast part removed. Normally, the coating is used due to the following key reasons:

1. Prevent premature solidification. The molten metal flows at a low rate since it depends on force of gravity. There are gravity die casting machines that are titled to facilitate flow.
2. It prevents the molten metal from adhering of the wall of the mold.

Generally, these are some of the simplest techniques used to process metals. The principle of operation is almost the same except for the manufacturing procedure involved. The choice of a particular manufacturing process should be based on those listed on the previous chapters.

# Chapter 6: Die casting applications

Metal die casting has become popular in very many industries across the globe. These include automotive, recreational, medical, alternative energy, electrical and transportation, just to mention a few. This is due to its flexibility and reliability. It’s possible to attain different surface finishing requirements. These include complex shapes, near-net shape, very tight tolerances and high strength.

### Applications of brass die casting

The brass die cast parts are used in application that require extreme operational characteristics. The high pressure die casting produces parts that are:

1. Have relatively high strength.
2. Corrosion resistance.
3. Heat resistance.
4. Reasonable electrical conductivity.
5. Pressure tight (up to 300 psi).
6. Easy to polish.

Ideally, this materials can be used in very many industries such as: aerospace, automotive, chemical processing, alternative and decorative industry, just to mention a few.

{The brass application images}

### Applications of aluminum die casting

This is a common alloy used to die cast products. However, it is prone to cracking shrinking and cracking at elevated temperature. It can be alloyed with silicon or copper. This improves its hardness and fluidity. It is dimensionally stable making it a perfect choice for complex and thin walled shapes. Due to its low melting point, it is a perfect choice for hot chamber die casting.

{The aluminum applications}

### Applications of zinc die casting

These alloys are easy to die cast. They can be mixed with other metal alloys to improve the chemical and physical properties. Zinc has a low melting point, this makes it suitable for hot chamber die casting. It used to die cast parts that should be sturdy, but with high precision. Some of these factors have been discussed in the previous chapters too. These die cast parts are used in the manufacturing and processing industries. Some of these parts include:

{Insert image of gears}

### Applications of steel die casting

The steel die casting is popular in very many industrial applications. That is, automotive, manufacturing, production, energy production alternative energy, etc. Furthermore, they are used to make the metal die casting tools. This is due to the superior physical and chemical properties. The stainless steel is used to die cast medical equipment and instruments parts. It doesn’t rust thus, the components can guarantee optima performance.

{Insert image for steel die casting application}

### Applications of copper alloys

Copper alloys are mainly used to die cast mechanical parts. Such alloys are known to be durable and high resistance alloys. A reason why they are used in electrical and plumbing applications.

The copper die cast parts used in applications that should have:

1. Superior resistance to corrosion.
2. High electrical and thermal conductivity.
3. Superior bearing-surface qualities.
4. High elongation and high tensile strength.
5. Low to medium hardness.

This makes copper to be a versatile alloy in the metal die casting alloys. The parts are used in electrical, chemical manufacturing and petroleum industries, just to mention a few.

{Insert images of copper die cast parts}

In summary, the choice of a specific metal will depend on the desired application. This calls for one to understand the intrinsic chemical and physical properties. Most of these have been discussed in the previous chapters. In general, the die casting has very many application in industrial and domestic applications. It is important that one chooses the right metal and manufacturing technique.

# Chapter 7: The Advantages Of Die Casting

From the previous chapters, it is quite clear that die casting is a versatile process used in industries. It is possible to produce complex and dimensionally accurate parts. This depends on:

1. The right die casting technique.
2. The metal alloy to use.

By integrating the two, you’ll get a die cast component that will be suitable for any application. The advantages of die casting outweigh its disadvantages. A reason why it has been adopted in the industry. Let’s have a look at the main advantages of this process:

***Economical manufacturing process***; the process offer one of the best total cost advantages. It requires that one adopts a desired die casting process. This could be high pressure, vacuum or gravity die casting. Each process is designed to provide cost benefits. This depends on the manufacturing process. For example:

1. The high pressure die casting is used for very thin and accurate parts.
2. The gravity die casting can be used for parts that may require additional secondary operations.

There are a number of metal die casting designed for different manufacturing requirements. This may include long or short run production services. However, this will only be possible by hiring a reliable and a trustworthy company. That is, one that can choose a process depending on the process requirement.

The parts are generally durable. This implies that they have a long cost term benefits. The die cast parts have a long service life. This makes them a perfect choice for nearly all applications.

***Rapid or high speed production process***; with die casting, as long the right metal alloy and manufacturing process has been chosen; the final product can be realized within a short period of time. This is the main reason why it is highly recommended for high volume production.

The tooling process is simple as one mold/die can be used to produce different parts of the same specification. Again, depending on the desired surface finish, an appropriate technique can be chosen. Thus, the finishing operations can be minimal if not eliminated completely. Ideally, thousands of parts can be produced without necessarily using an additional tooling. It doesn’t matter whether they are complex shapes or those with higher tolerances. This reduces the lead time significantly.

***High precision, accuracy and dimensional stability***; this is a crucial part in the manufacturing industry. It’s only through die casting that you can get an accurate and precise part. The parts are dimensionally stable and it is easy to maintain tight tolerances. They are also heat resistant due to the manufacturing process that involves heating the metal. As long as the tooling is designed to the required specifications, the final product will definitely meet the desired design requirements. This will also depend on the desired manufactured process. Be it gravity or pressure die casting. The metal die casting technique is used for parts that require tight dimensional tolerance.

***The strength and weight***; when compared to other metal manufacturing processes such as injection molding, die casting produces stronger parts. This does not compromise both weight and dimensions. With pressure die casting, it is possible to obtain parts with walls, lightweight and stronger. This ensures that the part maintains its quality and desired features. Most die cast parts are compact and they may not require other joining processes. Such parts are stronger.

Since different metal die casting techniques can be adopted for specific alloys, the required strength and weight can be realized easily.

***Different finishing techniques***; this makes the process versatile and compatible with a number of manufacturing process. It doesn’t matter whether one requires a textured and smooth surface. It all requires one to choose the best manufacturing technique. That is, high pressure die casting for very fine finish or gravity casting for surfaces that require minimal secondary operations. Again, unlike other manufacturing processes, these finishing operations are cheap. This is because they require minimal surface preparation.

***Simple assembly process***; the metal die casting has a simple assembly process that is not as complicated as in other metal manufacturing processes. The process provide integral fastening elements that may include studs and bosses.

This doesn’t imply that this process 100% perfect. Some procedures may be expensive for short run production processes. This requires that the company of choice should be able to adopt the right manufacturing process. It is only through this that one can benefit from the advantages listed above. The company should prove beyond any reasonable doubt that manufacturing a given part will be economical when the die casting process is adopted. Otherwise, it will be wise to consider other manufacturing processes.

As we had mentioned earlier, the metal die casting may have some disadvantages. This is actually the main reason why the process can’t be adopted for all manufacturing processes. In the next chapter, we shall look at some of these drawbacks.

# Chapter 8: Die Casting Defects

Under normal circumstances, the metal part manufacturers use different processing techniques to get the desired designs. That is, one process may be perfect for short run products thou, it may be very expensive for long run production process. This calls for a critical evaluation of every process before it is adopted for a specific task.

As a matter of fact, each metal die casting process has its unique advantages and disadvantages that we’ve discussed in the previous chapters. Below is a summary of the disadvantages of die casting process:

*High initial cost*; setting up the metal die casting plant can be an expensive process. This is the main reason why it is highly recommended for the metal die casting companies to conduct a comprehensive feasibility study. It is through this that they can tell whether the process is feasible or not. The cost of the dies, machines and other equipment is somehow high.

*Limited to high production*; this process is only economical for large production. The small scale production makes the process very expensive. This explains the reason why most companies avoid small quantity production.

*The process is limited to fluidity metals*; this refers to those metal alloys that can flow. It will be nearly impossible to force a metal that can’t flow through the die. Therefore, it is important to evaluate all factors that can affect the fluidity of the metals. The company should have a lab to test each metal to ensure that they meet the desired die casting criteria.

*Limitation of the type of metals to die cast*; not all metal alloys can be die cast. In most cases, the process is suitable for non-ferrous alloys.

Apart from this, it is also worth noting that the process may not be suitable for heavy casting. This is the main reason why companies opt for the sand casting processes. Thus, you need to be sure of the exact specifications of the metal to die cast. Again, you need to take special considerations when removing the cast part from the die. This is to avoid porosity problems.

From the above, it is quite evident that the advantages of die casting process are actually more than the disadvantages. This further confirms the reason why it has been adopted for a number of manufacturing processes. You need to have effective measures that will eliminate any circumstance that may compromise the quality of the final die cast component.

# Chapter 9: Die Casting Association

Like other professions, the die casting association is an umbrella of people and companies in the die casting industry or business. These associations not only oversee the how these companies go about their businesses, but also set rules and guidelines that they should follow. The associations also provide avenues for acquiring new information and news. These may include research work or news articles. Examples of die casting associations include:

## [The North America Die Casting Association (NADCA)](http://www.diecasting.org/)

It was founded in 1889 after the Society of Die Casting Engineers (SDCE) and American Die Casting Institute (ADCI) merged. The ADCI was founded in 1928, while SDCE was founded in 1957.

NADCA focuses on promoting awareness and growth in the die casting industry. It reaches out to its members through magazines and newsletters. This die casting association focuses on development & research, marketing, education, design assistance, government affairs and chapters relations among other factors that affect this industry.

## [The Canadian Die Casters Association](http://www.diecasters.ca/english/index.php)

This a die casting association whose membership are companies and die casters in Canada. It communicates important information to its members. It also represents the interest of its members to both the government and other stakeholders. This association plays the following key roles:

1. Avail all material that aim to promote the industry ventures.
2. Collect and distribute important information of interest to its members.
3. Promote industry standards.

Provide a forum for exchange of information.

## [The Die Casting Society](http://www.dcsoc.org.uk/)

This society was formed in 1967. It was to represent the views of all die casting companies. It promotes technology and a forum for debate and discussion. In addition to this, it also provides valuable information that aim to educate its members.

It is important to note that there are very many die casting association across the globe. In fact, almost every country has their own die casting association. Here is a list of other [die casting associations](http://www.castool.com/content/die-casting-associations).

# Summary

Metal die casting is an important manufacturing process that is used in very many industries.

This is due to the numerous benefits listed in this eBook.

Ideally, this eBook has been designed to provide a complete guide to any die casting application.

That is, understanding what metal casting is, types of casting processes, machines used and the processes involved.

It also expounds on the various properties of various alloys. Thus, making decision should not be based on one parameter.

It is important that one blends all these elements to realize efficiency and maximize on production.