Aluminum Metal Casting with High Speed Die Casting Machine and It's Powder Coating Process: A Case Study

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Abstract

The high pressure die-cast process is used to produce parts from aluminum, magnesium, copper and zinc. Advantages of this process include conformity to the mold, favorable mechanical properties and low cost. Powder coating of aluminum castings can be a challenge, particularly if there are contaminants present within the casting during the pretreatment and coating of the cast parts. This document provides some in-depth research and contains important data for use between the casting provider and powder coat processor to ensure good life anticipation of powder coated hardware for the fenestration industry.

Keywords
Powder Coating Process, Aluminum casting, Pretreatment, High pressure Die Casting Machine

1. Introduction:

Basic Aluminum employs high pressure die casting process using cold chamber machines. The definition of high pressure die casting effectively covers the squeeze or intensification phase of metal injection process where the aluminum pressure is taken above 10,000 psi. Cold chamber die cast machines are ones where the shot sleeve, where metal is poured into prior to injection, is non-heated.

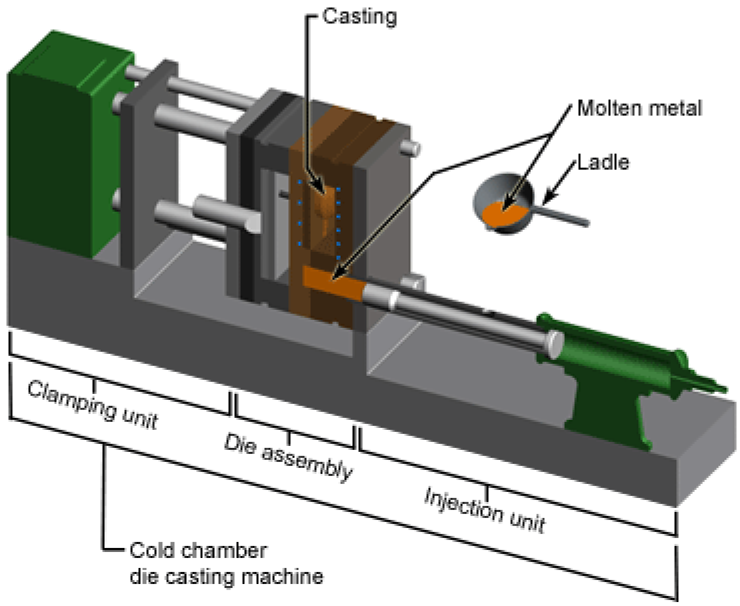

Figure: 1. Cold Chamber Die Casting Machine

2. Process Cycle of Aluminum Die Casting

The process cycle for die casting consists of five main stages, which are explained below. The total cycle time is very short, typically between 2 seconds and 1 minute.

2.1 Clamping

The first step is the preparation and clamping of the two halves of the die. Each die half is first cleaned from the previous injection and then lubricated to facilitate the ejection of the next part. The lubrication time increases with part size, as well as the number of cavities and side-cores. Also, lubrication may not be required after each cycle, but after 2 or 3 cycles, depending upon the material. After lubrication, the two die halves, which are attached inside the die casting machine, are closed and securely clamped together. Sufficient force must be applied to the die to keep it securely closed while the metal is injected. The time required to close and clamp the die is dependent upon the machine - larger machines (those with greater clamping forces) will require more time. This time can be estimated from the dry cycle time of the machine.

2.2 Injection:

The molten metal, which is maintained at a set temperature in the furnace, is next transferred into a chamber where it can be injected into the die. The method of transferring the molten metal is dependent upon the type of die casting machine, whether a hot chamber or cold chamber machine is being used. The difference in this equipment will be detailed in the next section. Once transferred, the molten metal is injected at high pressures into the die. Typical injection pressure ranges from 1,000 to 20,000 psi. This pressure holds the molten metal in the dies during solidification. The amount of metal that is injected into the die is referred to as the shot. The injection time is the time required for the molten metal to fill all of the channels and cavities in the die. This time is very short, typically less than 0.1 seconds, in order to prevent early solidification of any one part of the metal. The proper injection time can be determined by the thermodynamic properties of the material, as well as the wall thickness of the casting. A greater wall thickness will require a longer injection time. In the case where a cold chamber die casting machine is being used, the injection time must also include the time to manually ladle the molten metal into the shot chamber.

2.2 Cooling

The molten metal that is injected into the die will begin to cool and solidify once it enters the die cavity. When the entire cavity is filled and the molten metal solidifies, the final shape of the casting is formed. The die cannot be opened until the cooling time has elapsed and the casting is solidified. The cooling time can be estimated from several thermodynamic properties of the metal, the maximum wall thickness of the casting, and the complexity of the die. A greater wall thickness will require a longer cooling time. The geometric complexity of the die also requires a longer cooling time because the additional resistance to the flow of heat.

2.4 Ejection

After the predetermined cooling time has passed, the die halves can be opened and an ejection mechanism can push the casting out of the die cavity. The time to open the die can be estimated from the dry cycle time of the machine and the ejection time is determined by the size of the casting's envelope and should include time for the casting to fall free of the die. The ejection mechanism must apply some force to eject the part because during cooling the part shrinks and adheres to the die. Once the casting is ejected, the die can be clamped shut for the next injection.

2.5 Trimming

During cooling, the material in the channels of the die will solidify attached to the casting. This excess material, along with any flash that has occurred, must be trimmed from the casting either manually via cutting or sawing, or using a trimming press. The time required to trim the excess material can be estimated from the size of the casting's envelope. The scrap material that results from this trimming is either discarded or can be reused in the die casting process. Recycled material may need to be reconditioned to the proper chemical composition before it.

3.1. Advantages of Using Aluminum Material:

- ✓Low density
- ✓Good corrosion resistance
- ✓High thermal and electrical conductivity
- ✓High dimensional stability
- ✓Relatively easy to cast

3.2. Aluminum Casting Alloy Properties:

There are six property elements that compose the alloys, these include:

1. **Silicon** – Second to iron, this element contains the greatest impurity level in electrolytic commercial aluminum (0.01 to 0.15%).
2. **Copper** – AL material types will normally mix 2 to 10% of copper. This type of element will allow the alloy to react to solution heat treatment and subsequent aging with an increase in strength and hardness and a decrease in elongation.

3. **Magnesium** – maximum solid solubility is 17.4%. The addition of magnesium shows an increase in the strength of aluminum without unduly decreasing the ductility.
4. **Iron** – the most common element found in Aluminum. It has a high solubility in molten aluminum and is easily dissolved at all molten stages of production.
5. **Manganese** – common element in which its concentration ranges from 5ppm – 50ppm. Manganese decreases resistivity while increasing strength in both solid solutions and precipitated inter-metallic states.
6. **Zinc** – alloys containing a blend of Zinc and other elements will provide the best mix of tensile properties.

Table 1 : Chemical Composition of the material types

Grade	*Si*	*Cu*	*Mg*	*Zn*	*Fe*	*Mn*	*Ni*	*Sn*
ALSi12Fe / A413	11.0-13	1.0	0.3	0.5	0.9	0.3	0.5	0.1
A360 / ADC3 / ALSi10Mg	9.0-10.0	0.6	0.4-0.6	0.5	0.9	0.3	0.5	0.1
A514 / ADC 6	1.0	0.4	2.5-4.0	0.1	0.5	0.4	0.4	0.1
A380 / ADC10 / AlSi8Cu3Fe	7.5-9.5	2.0-4.0	0.3	1.0	0.9	0.5	0.5	0.1
A383 / ADC 12	9.6-12.0	1.5-3.5	0.3	1.0	0.9	0.5	0.5	0.1

We are taking as example of ceiling fan making company as an example and also it's chemical pretreatment and Powder coating process.

There are three casting parts in ceiling fan production as below:

- Top Cover
- Bottom Cover
- Rotor

For Ceiling Fan manufacturing ADC-12 is used for top cover, bottom cover and pure Aluminum is used for rotor.

4.Top and Bottom Cover Die casting:

High pressure die casting is a process where metal is melted and forced into steel dies. The metal hardens into the desired shape. Molten metal is injected into a die cavity through a channel by movement of a plunger. After a preset solidification time, the plunger reverses direction, the part is ejected, and the machine is ready for the next cycle.

4.1 Cycle time: It takes 29-33 sec per Operation. Rotor casting process is little bit different form Top and bottom cover casting. For this casting we need to use one kinds of fixture,

4.2 Material: Total core product weight 800-1000 gms and after trimming it will be 400-500 gms. Raw material (ADC-12) temperature should be 650-700c and furnace temperature 800c. For rotor casting, pure aluminum temperature is above 700c and furnace temperature 850c.

4.3 Machining process: After completing the machining by using CNC. After the performing Drill and taping process, then it is ready for chemical Pretreatment.

5. Chemical Pretreatment Process:

Table 2: Chemical Pretreatment Data

SL no	Process	Chemical	Concentration	Material of Tank	Temperature	Dipping time	Bath point age	Remarks
1	Degreasing	Phosclean 1100	5-6%(W/V)	SS204	60-70c	10-15 min	50-60 mls	Water breakage done to ensure proper degreasing
2	Water washing	Running Water		SS204	Ambient	1-2 min		Over Flowing facility
3	De-rusting	Rustokik 178	10%(V/V)	SS316	Ambient	5-15 min	15-20mls	*
4	Water washing	Running Water		SS204	Ambient	1-2 min		
5	Chromating	Alibond 279	2-4%(V/V)	SS316	Ambient	2-5 min	7-9 mls	Chormating coating for excellent corrosion resistance and paint bonding properties
6	Water washing	Running Water		SS204	Ambient	1-2 min		
7	D.M.Water washing	D.M.Water		SS204	Ambient	1-2 min		Replacement of bath daily basis

*Dipping time depends on desmuting

Curing: After completing the chemical pretreatment process, it is taken to Woven (160-170c) for 40-45 minutes. After that it is ready for Powder coating.

6. Powder coating process:

Powder coating is a dry finishing process, using fine particles of paint, which are electro statically charged and sprayed onto a work piece. Once the powder is applied, the part is cured, causing the powder to adhere to the surface.

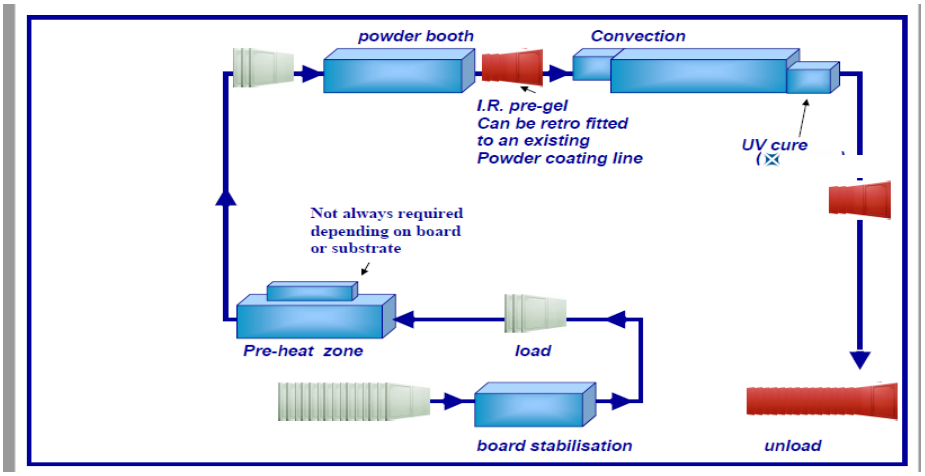

Figure 2: Powder Coating Layout

6.1 Painting Process flow:

- Fine particles are fluidized in a feed hopper
- Powder is vacuumed into the spray gun
- A second burst of air increases the particle velocity
- Particles are then charged by high velocity friction
- Spray gun applies powder to the grounded workpiece
- Coated part is then oven cured at 170-200c temperature for 45-60 minutes

This is the whole process of Casting, Pretreatment and Powder Coating of Aluminum casting. I

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Acknowledgements
I am very grateful to Mr. Cheng Che Cheng (Vice-Present of Crystal Group) and Ms. Ko Chow Mui (TSS Manager) of the company for giving me the opportunity to work with Industrial Engineering Department and for giving me the support in learning about the entity production system.

Biography:

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