Aluminium die casters pin hope on economic growth, auto demand

-Metalworld Research Team

India has emerged as a significant player in the global automotive supply chain where aluminium die casting plays dynamic role. The automotive industry accounts for 7% of India's GDP. With continued development in the infrastructure and entry of newer FDIs, auto component industry will be further boosted. This will have a positive impact on the die-casting industry as an estimated 60% of the die castings produced in India are used in the auto Industry. Added to this, educated labour at competitive costs and economies of operations is another advantage, Indian die casting industry is enjoying. This should help the industry grow and become the world's largest aluminium die casting base in coming years, said Prasan Firodia, President, Aluminium Casters' Association of India.

Introduction

Die casting is a metal casting process that is characterized by forcing molten metal under high pressure into a mold cavity. The mold cavity is created using two hardened tool steel dies which have been machined into shape and work similarly to an injection mould during the process. Most die castings are made from non-ferrous metals, specifically zinc, copper, aluminium, magnesium, lead, pewter and tin based alloys. Depending on the type of metal being cast, a hot- or cold-chamber machine is used.

The casting equipment and the metal dies represent large capital costs and this tends to limit the process to high volume production. Manufacture of parts using die casting is relatively simple, involving only four main steps, which keeps the incremental cost per item low. It is especially suited for a large quantity of small to medium-sized castings, which is why die casting produces more castings than any other casting process. Die castings are characterized by a very good surface finish (by casting standards) and dimensional consistency. Two variants are pore-free die casting, which is used to eliminate gas porosity defects; and direct injection die casting, which is used with zinc castings to reduce scrap and increase yield.

"India is the third largest producer of aluminium castings in the world with a total production of over 900,000 tonnes annually. India has a reserve base of 1,400,000 thousand tonnes of bauxite which is the world's main source of aluminium. Considering the immense reserve that our country holds, this industry is poised to grow phenomenally and will become world's largest manufacturing base for aluminium die casting," said RAR Prasad, Secretary, Aluminium Casters' Association of India.

Die casting equipment was invented in 1838 for the purpose of producing movable type for the printing industry. The first die casting-related patent was granted in 1849 for a small hand operated machine for the purpose of mechanized printing type production. In 1885, Otto Mergenthaler invented the linotype machine, an automated type casting device which became the prominent type of equipment in the publishing industry. The Soss die-casting machine, manufactured in Brooklyn, NY was the first machine to be sold in the open market in North America. Other applications grew rapidly, with die casting facilitating the growth of consumer goods and appliances by making affordable the production of intricate parts in high volumes. In 1966, General Motors released the Acurad process.

Advantages of aluminium die casting

- Being light weight and anti corrosive material, aluminium die casting is a preferred metal for use in auto industry. Its high dimensional stability for complex shapes and thin walls; good corrosion resistance; good mechanical properties; high thermal and electrical conductivity; retains strength at high temperatures are some of the additional strengths aluminium offers. Thus, major advantages of aluminium die casting are listed as follows:
- Excellent dimensional accuracy (dependent on casting material, but typically 0.1 mm for the first 2.5 cm (0.005 inch for the first inch) and 0.02 mm for each additional centimeter (0.002 inch for each additional inch)
- Smooth cast surfaces (Ra 1–2.5

micrometres or 0.04–0.10 thou rms)

- Thinner walls can be cast as compared to sand and permanent mold casting (approximately 0.75 mm or 0.030 in)
- Inserts can be cast-in (such as threaded inserts, heating elements, and high strength bearing surfaces)
- Reduces or eliminates secondary machining operations
- Rapid production rates
- Casting tensile strength as high as 415 megapascals (60 ksi)

Disadvantages

The main disadvantage to die casting is the very high capital cost. Both the casting equipment required, and the dies and related components are very costly, as compared to most other casting processes. Therefore, to make die casting an economic process, a large production volume is needed. Other disadvantages are that the process is limited to high-fluidity metals, and casting weights must be between 30 grams (1 oz) and 10 kg (20 lb). In the standard die casting process the final casting will have a small amount of porosity. This prevents any heat treating or welding, because the heat causes the gas in the pores to expand, which causes micro-cracks inside the part and exfoliation of the surface. Thus a related disadvantage of die casting is that it is only for parts in which softness is acceptable. Parts needing hardening (through hardening or case hardening) and tempering are not cast in dies.

The global auto Industry is moving towards improving fuel efficiency by reducing the weight of vehicle. Replacement of heavier parts made from cast iron and steel by lighter aluminium parts is the future. These aluminium parts are now further being redesigned to achieve lower weights.

Type of die casting

Hot-chamber die casting, also known as gooseneck machines, relies upon a pool of molten metal to feed the die. At the beginning of the cycle the piston of the machine is retracted, which allows the molten metal to fill the "gooseneck". The pneumatic or hydraulic powered piston then forces this metal out of the gooseneck into the die. The advantages of this system include fast cycle times (approximately 15 cycles a minute) and the convenience of melting the metal in the casting machine. The disadvantages of this system are that it is limited to use with low- melting point metals and that aluminium cannot be used because it picks up some of the iron while in the molten pool. Therefore, hot-chamber machines are primarily used with zinc, tin, and lead based alloys.

Cold chamber die casting: These are used when the casting alloy cannot be used in hot-chamber machines; these include aluminium, zinc alloys with a large composition of aluminium, magnesium and copper. The process for these machines starts with melting the metal in a separate furnace. Then a precise amount of molten metal is transported to the cold-chamber machine where it is fed into an unheated shot chamber (or injection cylinder). This shot is then driven into the die by a hydraulic or mechanical piston. The biggest disadvantage of this system is the slower cycle time due to the need to transfer the molten metal from the furnace to the cold-chamber machine.

The following are the four steps in traditional die casting, also known as high-pressure die casting, these are also the basis for any of the die casting variations: die preparation, filling, ejection and shakeout. The dies are prepared by spraying the mold cavity with lubricant. The lubricant both helps control the temperature of the die and it also assists in the removal of the casting. The dies are then closed and molten metal is injected into the dies under high pressure; between 10 and 175 megapascals (1,500 and 25,400 psi). Once the mold cavity is filled, the pressure is maintained until the casting solidifies. The dies are then opened and the shot (shots are different from castings because there can be multiple cavities in a die, yielding multiple castings per shot) is ejected by the ejector pins. Finally, the shakeout involves separating the scrap, which includes the gate, runners, sprues and flash, from the shot. This is often done using a special trim die in a power press or hydraulic press. Other methods of shaking out include sawing and grinding. A less labor-intensive method is to tumble shots if gates are thin and easily broken; separation of gates from finished parts must follow. This scrap is recycled by remelting it. The yield is approximately 67%.

The high-pressure injection leads to a quick fill of the die, which is required so the entire cavity fills before any part of the casting solidifies. In this way, discontinuities are avoided, even if the shape requires difficult-to-fill thin sections. This creates the problem of air entrapment, because when the mold is filled quickly there is little time for the air to escape. This problem is minimized by including vents along the parting lines, however, even in a highly refined process there will still be some porosity in the center of the casting. Most die casters perform other secondary operations to produce features not readily castable, such as tapping a hole, polishing, plating, buffing, or painting.

Dies used in casting

Two dies are used in die casting; one is called the "cover die half" and the other the "ejector die half". Where they meet is called the parting line. The cover die contains the sprue (for hot-chamber machines) or shot hole (for cold-chamber machines), which allows the molten metal to flow into the dies; this feature matches up with the injector nozzle on the hot-chamber machines or the shot chamber in the cold-chamber machines. The ejector die contains the ejector pins and usually the runner, which is the path from the sprue or shot hole to the mold cavity. The cover die is secured to the stationary, or front, platen of the casting machine, while the ejector die is attached to the movable platen. The mold cavity is cut into two cavity inserts, which are separate pieces that can be replaced relatively easily and bolt into the die halves.

The dies are designed so that the finished casting will slide off the cover half of the die and stay in the ejector half as the dies are opened. The ejector pins are driven by an ejector pin plate, which accurately drives all of the pins at the same time and with the same force, so that the casting is not damaged. The ejector pin plate also retracts the pins after ejecting the casting to prepare for the next shot. There must be enough ejector pins to keep the overall force on each pin low, because the casting is still hot and can be damaged by excessive force. The pins still leave a mark, so they must be located in places where these marks will not hamper the casting's purpose.

Other die components include cores and slides. Cores are components that usually produce holes or opening, but they can be used to create other details as well. There are three types of cores: fixed, movable, and loose. Fixed cores are ones that are oriented parallel to the pull direction of the dies (i.e. the direction the dies open), therefore they are fixed, or permanently attached to the die. Movable cores are ones that are oriented in any other way than parallel to the pull direction. These cores must be removed from the die cavity after the shot solidifies, but before the dies open, using a separate mechanism. Slides are similar to movable cores, except they are used to form undercut surfaces. The use of movable cores and slides greatly increases the cost of the dies. Loose cores, also called pick-outs, are used to cast intricate features, such as threaded holes. These loose cores are inserted into the die by hand before each cycle and then ejected with the part at the end of the cycle. The core then must be removed by hand. Loose cores are the most expensive type of core, because of the extra labor and increased cycle time. Other features in the dies include water-cooling passages and vents along the parting lines. These vents are usually wide and thin (approximately 0.13 mm or 0.005 in) so that when the molten metal starts filling them the metal quickly solidifies and minimizes scrap. No risers are used because the high pressure ensures a continuous feed of metal from the gate.

The most important material properties for the dies are thermal shock resistance and softening at elevated temperature; other important properties include hardenability, machinability, heat checking resistance, weldability, availability (especially for larger dies), and cost. The longevity of a die is directly dependent on the temperature of the molten metal and the cycle time. The dies used in die casting are usually made out of hardened tool steels, because cast iron cannot withstand the high pressures involved, therefore the dies are very expensive, resulting in high start-up costs. Metals that are cast at higher temperatures require dies made from higher alloy steels.