LOW PRESSURE DIE CASTING - AN ADVANCED PROCESS IN DIE CASTING INDUSTRY

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1. INTRODUCTION

The casting of metals has been practiced for more than 6,000 years, using first copper and bronze, then iron, and now alloys of zinc and other metals. Die castings are among the highest volume, mass-produced items manufactured by the metalworking industry, and they can be found in thousands of consumers, commercial and industrial products. The die casting industry in India has been constantly searching for improved methods of production, to produce casting with reasonably good mechanical properties, less porosity and metal filling related problems. In this scenario, a number of techniques have been developed in die casting technology, out of which a process called "Low Pressure Die Casting (LPDC)", has proved itself for its outstanding product and process characteristics along with very high casting yield.

Low Pressure Die Casting (LPDC) involves forcing the molten metal into a cavity of permanent mould against the force of gravity using a very moderate air pressure (5-20 psi) applied above a pool of molten metal held in a hermetically sealed vessel. After the introduction of this process, LPDC is one of the widely used methods in die casting industry, obviously due to many advantages offered by this process over other permanent mould process such as Gravity Die Casting (GDC) and High Pressure Die Casting (HPDC) [1-3].

Almost all the alloys which can be gravity die cast can be cast by LPDC. Some metals which are cast by the high pressure die casting process, nowadays are also cast by this process very economically. Especially this process is very suitable for the casting of aluminum alloys, as aluminum and its alloys are the most used materials for automotive, and this process has more significance in Indian automobile industry.

2. HISTORICAL DEVELOPMENT [1]

The earliest examples of die casting by pressure injection - as opposed to casting by gravity pressure - occurred in the mid-1800s. A patent was awarded to Sturgis in 1849 for the first manually operated machine for casting printing type. The process was limited to printer's type for the next 20 years, but development of other shapes began to increase toward the end of the century. By 1892, commercial applications included parts for phonographs and cash registers, and mass production of many types of parts began in the early 1900s.

Actually, low pressure die casing process has been developed from to the drawback encountered in high pressure die casting and gravity die casting. Though this process today used in industry widely, initially this process was being used in very few countries in very few metals.

Historically [4,5], this process was

invented by E.H.Lake of England in the years of about 1910 and it was being used then only for Babbit metals and then its use extend to copper alloys. This process was being first time used for alluminium alloys by French in early of 1920. Even though this process was already invented, but it was being little used before 2nd world war. After the 2nd world war a resuscitate interest in the process began. At that time this process was extensively used to produce the finned air-cooled cylinder for aircraft in England. Mr.E.C.Lewic, an engineer of Alumasc limited [6,7], a British firm first updated this process and this process was first commercially implemented by Alumasc limited in the period of 1946. During the same period, the process was being developed in countries like Austria, Japan, Germany and United States to operate their own versions of the equipment necessary for producing castings of automotive (motor cars industries as the prime) and electrical (rotors and others high volume comprehensively machined components) industries. However, it is true to say still, that the U.K. remains the "Home" of the modern LPDC machines and its machines are in production in every industrially developed country of the world [6]. Karl Schimdt of Germany, in 1955 [8], had put valuable efforts in modifying the process, especially to use this process in automobile sector. General Electric Departments (U.S.A.) [8], General Motor Company (U.S.A), Griffin Wheel Co.(U.S.A.) [9] Lebanon Steel Foundries (U.S.A.) [2,9] and Stewart and Lloyds (U.K.) [9] are the main firms, who developed this process for different materials and applications. In last thirty years, this process has undergone different modifications, with the principle being same. The Cosworth process [10,11] (uses electromagnetic pressure instead of air pressure) was conceived by Prof. Cambell in 1978, to produce aluminum castings. Another remarkable and more recent development is the application of this process to produce composite castings (Lost Crucible Process) [12]. "Counter Pressure Die Casting"(FM Process) [12,13] was then introduced, which combines the advantages of both LPDC and Squeeze Casting. Vacuum pressure die-casting is another version, (Hitchiner's CLA Chandley Lamb Air) Process [14] of this technique. Fully automated control system - LPDC machines are available now a days, geared to the requirements of today. With the emergence of software technology in1990's, many simulation techniques related to this process have been developed to produce sound castings.

3. THE FUTURE OF DIE CASTING [16,21]

Refinements continue in both the alloys used in die casting and the process itself, expanding die casting applications into almost every known market. Once limited to simple lead type, today's die casters can produce castings in a variety of sizes, shapes and wall thicknesses that are strong, durable and dimensionally precise. Low pressure die casting almost solve the problems associated with the gravity die casting and high pressure die casting. Uses of low pressure die casting in automobile sector rapidly increasing.

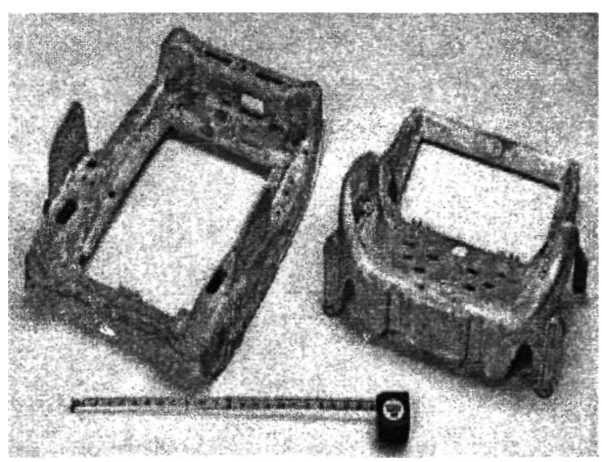

Fig.1. A magnesium seat pan shows how complex, lightweight low pressure die cast components can improve production by replacing multiple pieces.

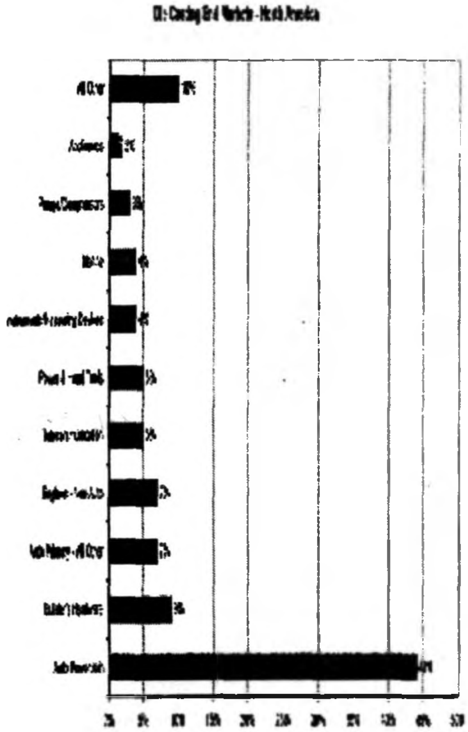

Fig.2. Die Casting End Market-North America [20].

4. PROCESS STEPS [1,20]

The process involves a number of basic steps which can be broadly divided into the following:

a) Producing a die or mould which is symmetric about its axis of rotation.

b) Cores, if required, can be used in the die; may be of sand or shell or plaster.

c) The die is placed at the top of crucible holding furnace.

d) The die is then connected with the molten metal by means of feed tube or stalk tube.

e) The crucible, which holds the molten metal, is pressurized by the introduction of air above the surface of the molten metal, causing it to rise steadily in the stalk and quietly fills the mould.

f) The low pressure on the metal completely eliminates the turbulence and air aspiration. The air in the mould cavity is expelled through suitably positioned vents in the die and when the cavity is filled, solidification commences.

g) Directional solidification, commencing at the extremities and terminating at the sprue (nozzle), is affected by correct die design and eliminates the need for conventional feeding system (riser).

h) When the metal has solidified as far back into the sprue as is required, the pressure is released in the crucible and molten metal left in the riser tube returns to the holding furnace.

i) A further short cooling period is allowed to ensure that all sections of the casting are solid, the mould is opened and the casting removed (ejector pins are provided to remove the casting).

j) After closing the die, the cycle is repeated.

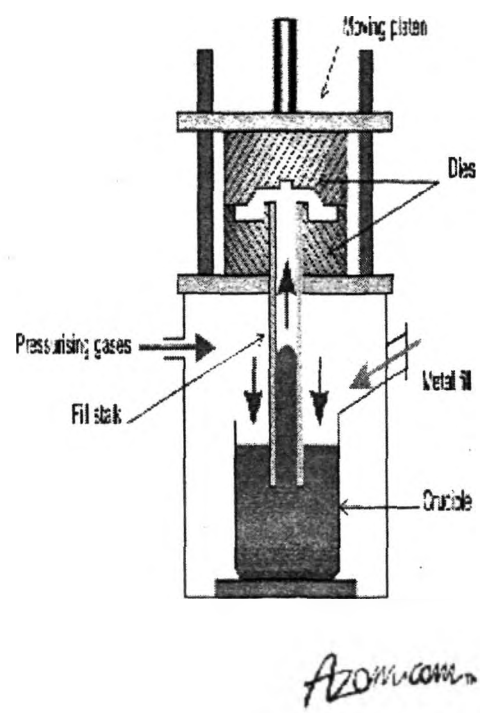

Fig.3. Schematic view of a low pressure die casting machine [18]

5. PROCESS CHARACTERISTICS [1,20]

Low pressure die casting solves many problems associated in high pressure die casting and gravity die casting. Actually it is an intermediate process between the high pressure die casting and gravity die casting. In automobile sector in India as well as others countries; LPDC provides some advantages over HPDC and GDC.

The main advantages of Low Pressure Die Casting process can be enumerated as:

1. The casting produced by this method is dense, free from porosity and surface cavities.
2. The low pressure on the metal completely eliminates the turbulence and air aspiration.
3. The chances of entrapment of oxide inclusions are reduced to a minimum.
4. The need for runners and risers is completely eliminated, so the yield is always more than 90% or so.
5. The moulds of LPDC are less expensive than those of HPDC and are comparable to those of GDC.
6. Reduced capital costs for machinery compared with high pressure die casting.
7. Modern low pressure die casters use a number of sophisticated methods to automate the process and provide continuous quality control.
8. Minimum operator fatigue due to sophistication of the process.

Some of the probable limitations or difficulties faced during low pressure die casting are:

1. Operational cycle somewhat longer than that of gravity die casting.
2. Limited flexibility of the process.
3. More complexity in the die design.

6. APPLICATIONS [1]

Although this process has been known to the foundry men and has been carried out for many years, it is only the last three decades that this process has made rapid progress and was clearly established itself in non-ferrous foundry industry. Now-a-days low pressure die casting process finds its use in making most sophisticated engineering appliances and parts [20]. This process can be used for producing casting of various types and size, covering very simple state forward shapes to highly complex shapes ranging weights and sizes from and ounce with all thickness of about $\frac{1}{16}''$ to as large as 1500lb with wall thickness of more than 4". Almost all grades of aluminum alloys can be successfully cast by this process and as aluminum and its alloys are the most used materials for automotive, this process has more significance in Indian automobile industry. This process is widely used to produced automotive parts like alloys wheels for race and rally cars, sector, cylinder heads, engine blocks, engine pumps, cover plates, crank case halves, valves, isolated bosses and webs, oil filters, cam shaft gear, carburetor body, lid and covers, manifolds, gear box and clutch housings etc. Apart from this, it can also be used economically for magnesium and zinc alloys and also, not surprising, for ferrous casting.

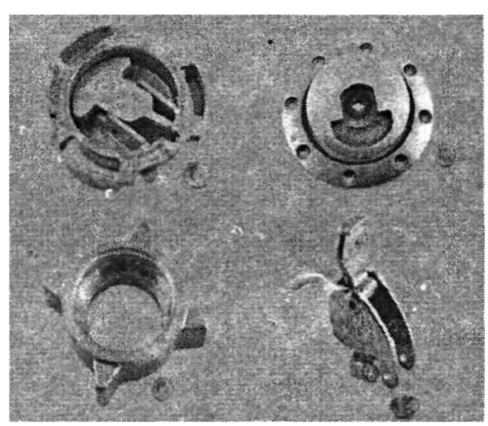

Fig.4. Automotive parts produced by LPDC Process [25].

Except in automobile industries, this process is also use in for electrical industries, examples are rotors and stators, coil housings, motor and end shells, Cable studs, cable clamp and electric motor housings etc. for building and general engineering industries, the examples are window furniture, rain water goods, water pump bodies, timing case, lamp holder, bush holder, air valve bodies. Critical aerospace casting and domestic kitchenware such as pressure cookers are some other application of this process.

7. CONSCLUSIONS

The LPDC process, both technically and economically, bridges the gulf between GDC and HPDC process. It is only the last few years in our country, a revived interest in this process has been shown. With the globalization as well as the expanding of the existing automobile industries and the coming up of new ones, there will be enormous scope for this process to be adopted by these industries to cope up with their increasing demand in terms of both quantity and quality of the automotive components. As such, there is a great future for this LPDC process for explaining by the die casting industry of the country, particularly in the automobile industry.

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