Magnesium Pressure Die Casting

Dilip Panjikar
Partner
Trident Die Casting Solutions

Mr. Dilip Panjikar is a specialist in all facets and processes of Die casting (incl. Aluminium, Magnesium & Brass & management thereof. His professional interests are: Non-ferrous Die Casting Project Management; Training & Education Management; and Management of Green Field Projects from (planning to development of business). His professional objective is to bring about continuous improvement of die casting standards of businesses through exposure to global expertise. He also addresses the issues of such managements in India through exposure to global businesses.

With the consciousness of fuel efficiency (consumption) in automotive sector search for light metal suitable for cast products was first attempted. In fact, fuel consumption became a unique selling point among competitors. Similarly energy efficient white goods and hand-tool industry joined this endeavor. Aluminum was the metal to replace heavy ferrous materials in early1960s. First results were favorable but the search for lighter metals remained under scanner of researchers. Thus began the development of magnesium for the purpose.

Initially, handling magnesium alloys was observed to be a "risky" proposition due mainly to its inflammability during working at elevated temperature. Management of magnesium oxide and recycling scrap were the hurdles. Sustained research has yielded favorable results to the extent that magnesium can very well replace aluminum in times to come.

Inspiration to write this article emanates from the flabbergasting fact that Indian die casting businesses are completely unaware of the knowledge of these developments in technology and markets. There is no die casting unit operating in India that fits global requirement.

This is only an ardent effort to bridge the gap!

What are the major benefits of magnesium?

- Lightest of all structural materials
- 75% lighter than steel
- 33% lighter than aluminum
- High impact resistance
- High strength to weight ratio
- Can be cast to net shape
- Excellent dimensional stability /repeatability
- Abundant material supply
- 100% recyclable

Commonly Used Cast Alloys of Magnesium

Magnesium casting proof stress is typically 75-200 MPa, tensile strength 135-285 MPa and elongation 2-10%. Typical density is 1.8 g/cm^3 and Young's modulus is 42 GPa.[

AZ91D: Most commonly used alloy for high pressure die casting. It Offers good strength to weight ratio, very good corrosion resistance and excellent castability. This alloy is typically used for power-train and mechanical components where toughness is more important than deformation capability.

AM60B: Commonly used for automotive die castings for safety components such as instrument panel structures and seat frames. This alloy offers excellent ductility, energy absorbing properties, strength and castability.

Am50: With lower aluminum content than AM60 this alloy offers a further increase in ductility but at a slightly reduced strength and a slight reduction in castability. It is typically used where the performance requirements demand elongation properties beyond that of Am60.

Performance of Magnesium v/s Competing Materials

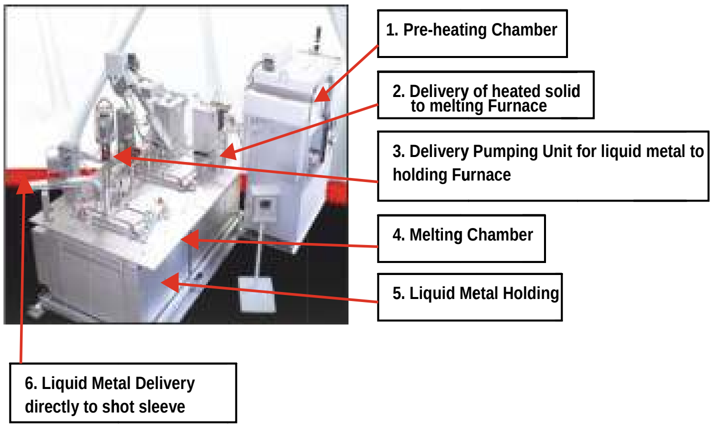
V/s. Aluminum:

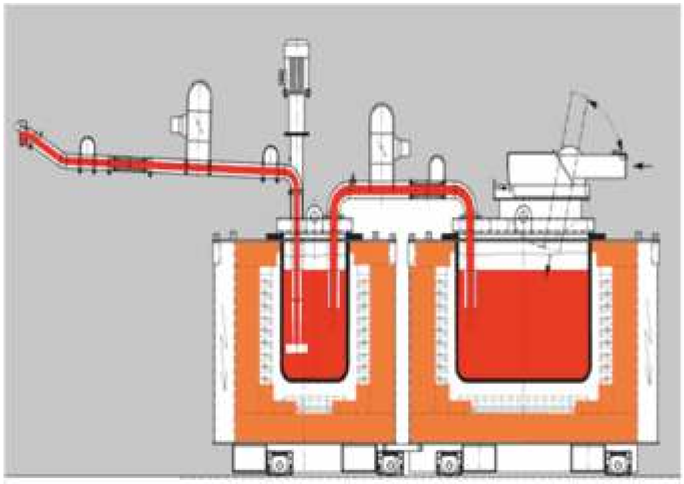
- 33% Lighter
- Superior Machining
- Greater Die Life
- Large thin-walled near net shape casting
- Similar or greater mechanical properties
- Greater general corrosion resistance

V/s. Steel:

- 75% Lighter
- Component consolidation/integration (No welding costs & less assembly costs)
- Significantly lower tooling costs
- High heat conductivity
- Complicated thin-walled near net shape
- Superior dimensional stability/repeatability

Magnesium Metal Dosing System





Market Prospects for Magnesium Castings

Typical Examples

1. Automotive (All over the World)


Power Transmission


Oil Sumps


Seat Frames


Dashboard Panel


Steering wheel


Cylinder Block

2. Railways Carriages (All over the World)


Seat Frames


Luggage Rack

3.Power Tools (Mainly in Western Market)

- Keep the furnace and the surrounding area free of moisture and iron oxide in the event of a runout
- Crucible interiors and covers free of iron oxide scale to avoid thermite reaction
- Inspect crucibles and melting pots regularly!
- Use of protective atmospheres can cause formation of iron scale above
- Fire Resistant clothing without pockets or cuffs
- Foundry Boots
- Safety glasses & face-shields when handling molten metal

Never Use Water To Extinguish Fire In Case Of Accident!!!!!!

Comparative Casting Parameters

Parameter	Mg	Al
Metal pressures for max. & min. gate velocities	40-85 m/s	25-50m/s
Plunger Speeds	9-11 m/s	2-4m/s

Cold Chamber Die Casting - Max. Fill Rate

$$Q_{max} = v_p \times \frac{\pi d_p^2}{4}$$

Q_{max} = maximum fill rate, in³/sec (cm³/sec)
v_p = max. dry shot speed, in/sec (cm/sec)
d_p = Diameter of plunger, in. (cm)
π = 3.1416 (constant)

The dry shot speed is determined by having the speed control valve wide open and making a "dry" shot (no metal). For

Cold Chamber Die Casting - Theoretical Fill Rate [3]

$$Q_{th} = \frac{V_{cav}}{t}$$

Q_{th} = theoretical fill rate calculated, in³/sec (cm³/sec)
V_{cav} = casting and overflow volume, in³ (cm³)
t = theoretical fill time, sec

$$V_{cav} = \frac{W}{\rho}$$

V_{cav} = volume of metal passing through the gates, in³ (cm³)
W = weight of metal passing through the gates, lb (kg)
ρ = molten alloy density, lb/in³ (kg/cm³)

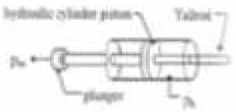
Cold Chamber Die Casting - Max Metal Pressure [1]

$$p_m = p_h \times \left(\frac{d_h^2}{d_p^2}\right)$$

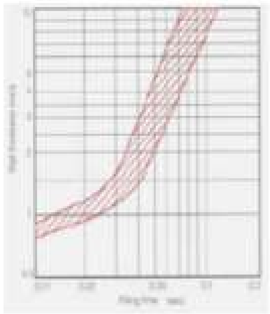
p_m = metal pressure, lb/in² (kg/cm²)
p_h = hydraulic pressure, lb/in² (kg/cm²)
d_h = effective hyd. cyl. diameter, in. (cm)
d_p = plunger diameter, in (cm)

$$d_h^2 = d_c^2 - d_r^2$$

d_h = effective hyd. cyl. diameter, in. (cm)
d_c = main hyd. cyl. diameter, in. (cm)
d_r = tailrod diameter, in (cm)



Cold Chamber Die Casting - Fill Time [3]



$$t = k\left(\frac{T_i - T_f + SZ}{T_f - T_d}\right)T$$

t = The ideal filling time, sec
k = empirically derived constant, sec/in. (sec/mm)
T_i = temperature of the molten metal as it enters the die, °F (°C)
T_f = minimum flow temperature of the metal, °F (°C)
T_d = temperature of the die cavity surface just before the metal enters, °F (°C)
S = percent solid fraction allowable in the metal at the end of filling, %
Z = Units conversion factor, °F/% (°C/%)
T = casting thickness, in (mm)

References:

·Buhler Mg Die Casting · Remarkable Magnesium the 21st Century structural alloy for small components; Bruce Mark, FisherCast Global · High Pressure Die Casting of Aluminum & Magnesium Alloys. Hans Ivar Laukli; Thesis submitted to Norwegian University of Science & Technology

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