Material Engineering Department
General Materials Branch

Fourth Class

Casting Technology II

Lecture Two: Die Casting and Die Casting Alloys.

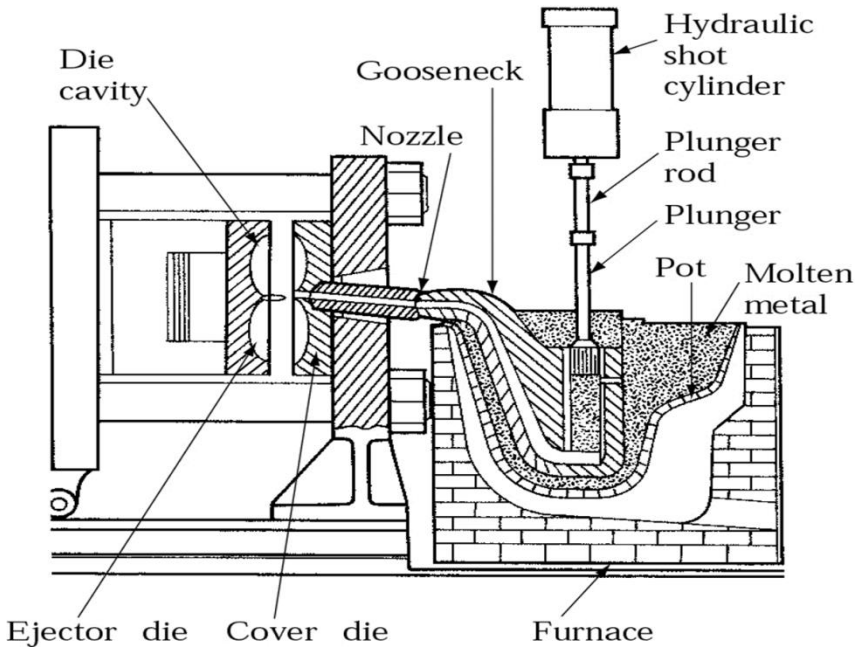
Die Casting

- Die casting is a Permanent-Mold Casting process in which the molten metal is injected into the mold cavity under high pressure. Typical pressures are 7 to 350 MPa .
- There are two main types of die casting machines:

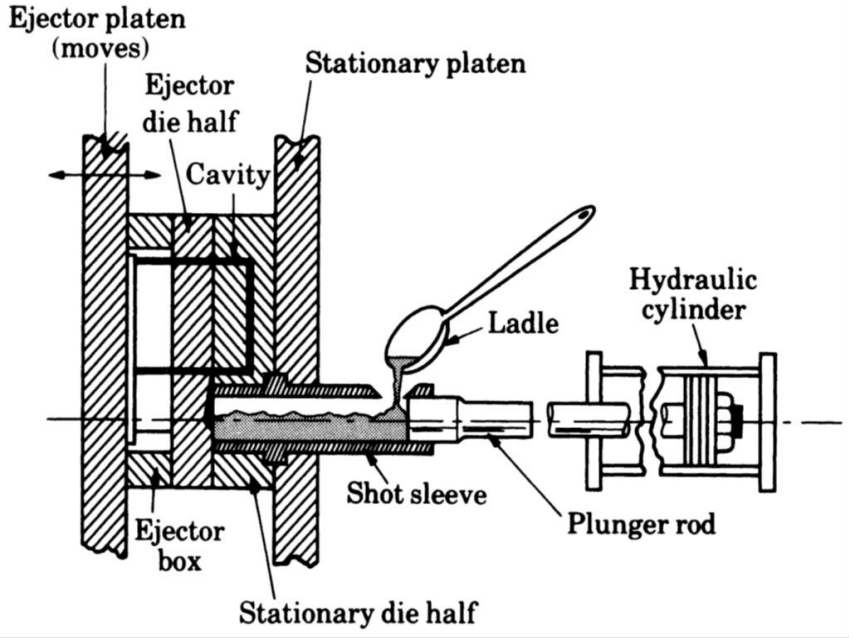
1. Hot- Chamber die casting Machine
2. cold-chamber die casting Machine .

Hot- and Cold-Chamber Die-Casting

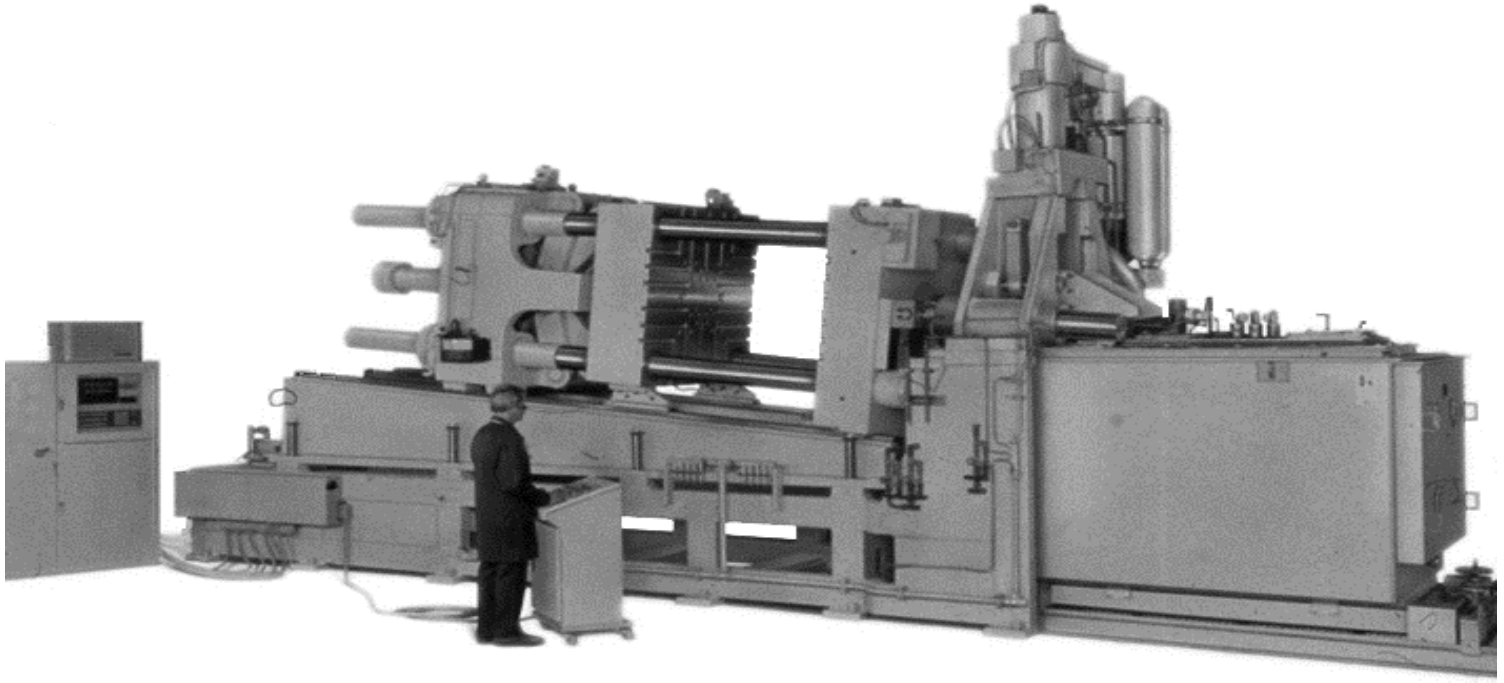
Schematic illustration of the hot-chamber die-casting process



Schematic illustration of the cold-chamber die-casting process.

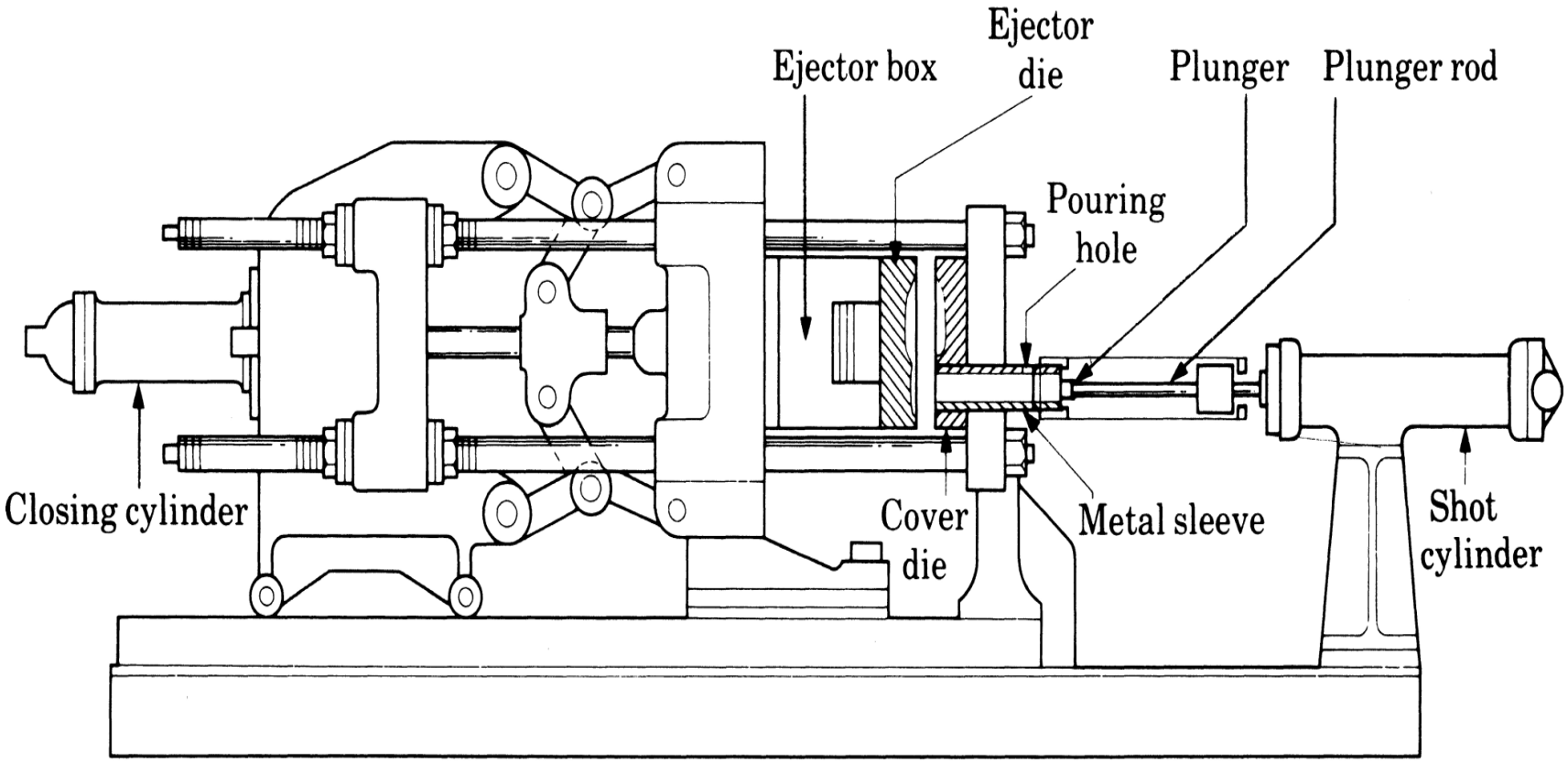


Hot-Chamber Die-Casting Machine

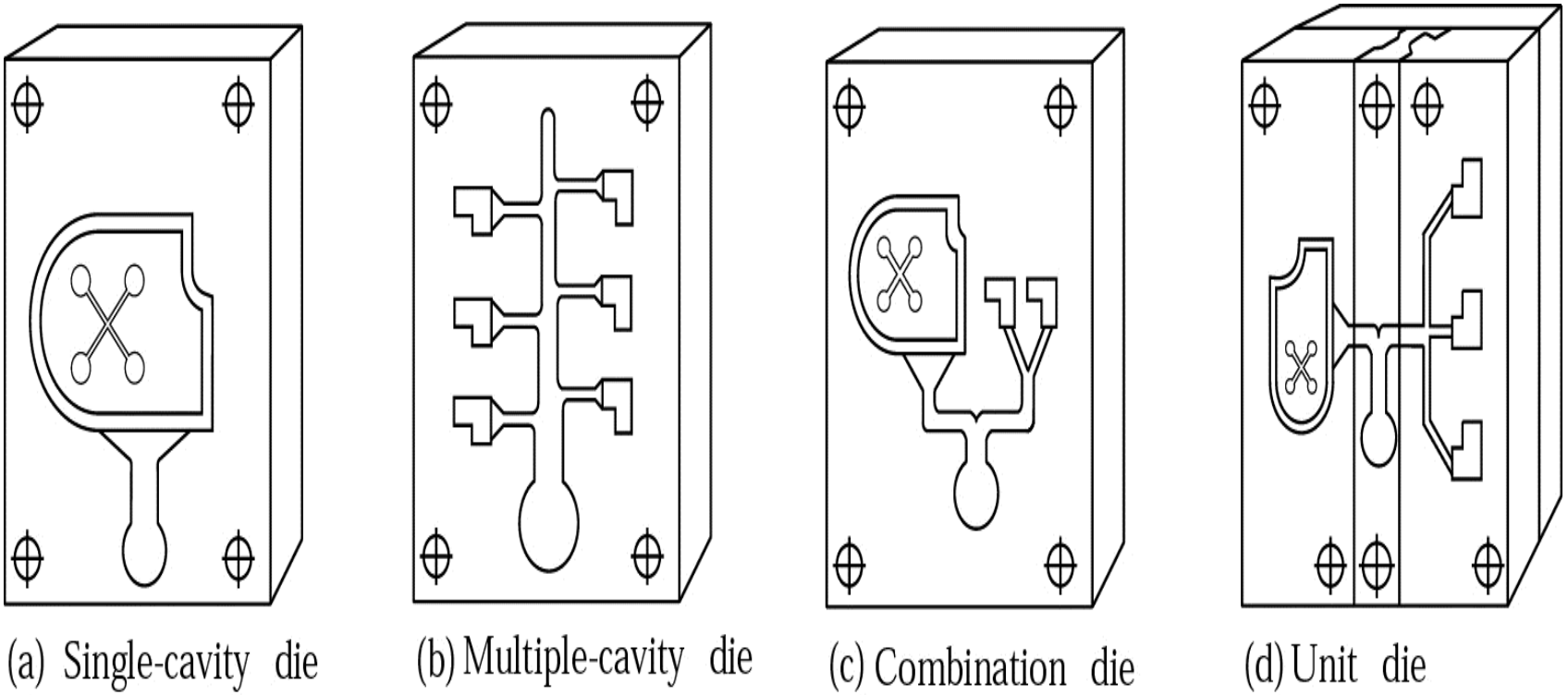


800-ton hot-chamber die-casting machine, DAM 8005 (made in Germany in 1998). This is the largest hot-chamber machine in the world
and costs about $1.25 million

Cold-Chamber Die-Casting Machine



Process Capabilities and Machine Selection

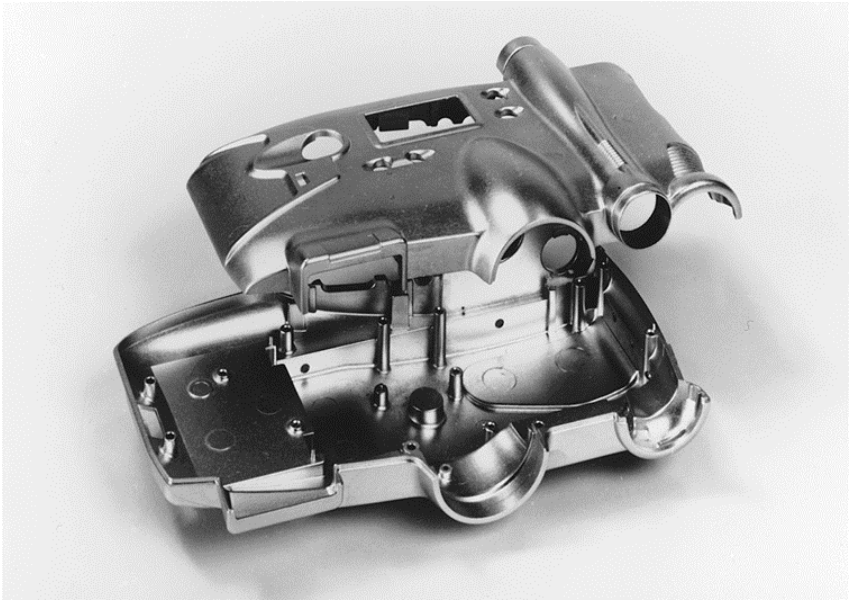


(a) Single-cavity die (b) Multiple-cavity die (c) Combination die (d) Unit die

Die-Casting Examples

The Polaroid PDC-2000 digital camera with a AZ91D die-cast, high purity magnesium case.

Two-piece Polaroid camera case made by the hot-chamber die Casting process.



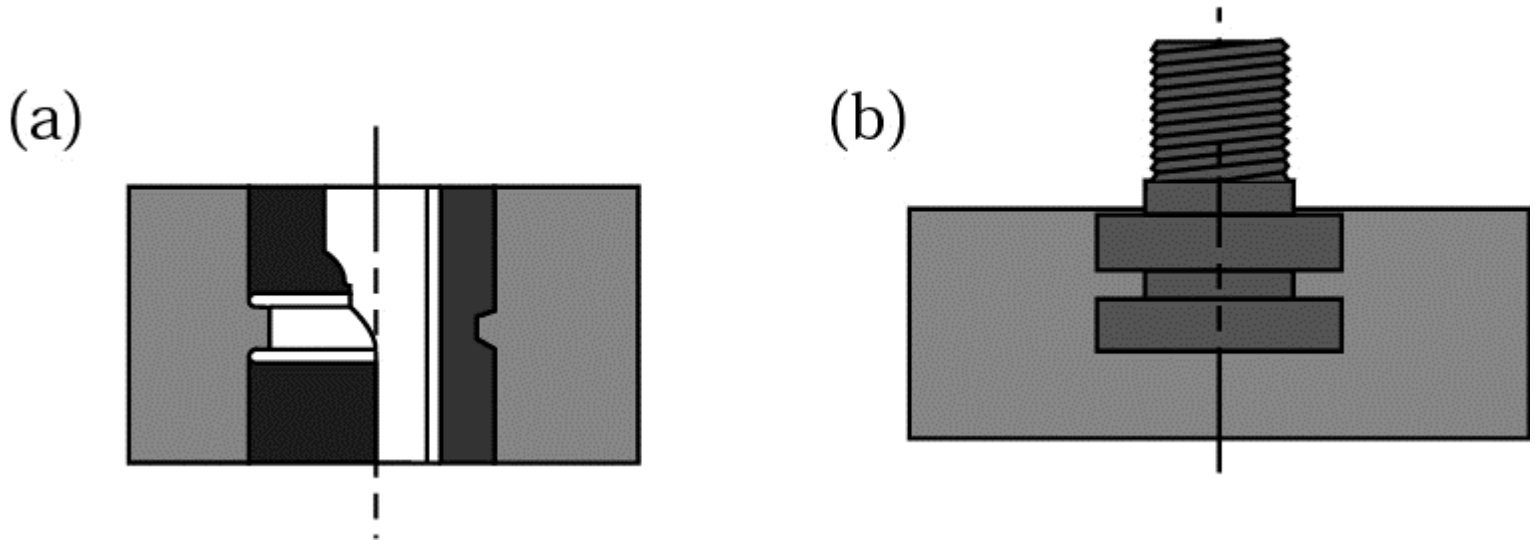
Process Capabilities and Machine Selection

Properties and Typical Applications of Some Common Die-casting Alloys

Alloy	Ultimate tensile strength (MPa)	Yield strength (MPa)	Elongation in 50 mm (%)	Applications
Aluminum 380 (3.5 Cu–8.5 Si)	320	160	2.5	Appliances, automotive components, electrical motor frames and housings
13 (12 Si)	300	150	2.5	Complex shapes with thin walls, parts requiring strength at elevated temperatures
Brass 858 (60 Cu)	380	200	15	Plumbing fixtures, lock hardware, bushings, ornamental castings
Magnesium AZ91 B (9 Al-0.7 Zn)	230	160	3	Power tools, automotive parts, sporting goods
Zinc No. 3 (4 Al)	280	—	10	Automotive parts, office equipment, household utensils, building hardware, toys
No. 5 (4 Al-1 Cu)	320	—	7	Appliances, automotive parts, building hardware, business equipment

Source: American Die Casting Institute.

Process Capabilities and Machine Selection



Examples of cast-in- place inserts in die casting.

(a) Knurled bushings.

(b) Grooved threaded rod.

Important Terms in Die Casting

- Biscuit
- Blister
- Casting rate
- Casting/shot ratio
- Casting yield
- Casting cycle
- Flash

Die Casting

- This Flash must be trimmed from the casting, along with the sprue and gating system. Advantages of die casting include

1. High production rates possible
2. Economical for large production quantities
3. Close tolerances possible, on the order of .076 mm(0.003inch)

Die Casting In Summery

- **Process:** Molten metal is injected into closed metal dies under pressures ranging from 10 to 175 MPa .Pressure is maintained during solidification ,after which the dies separate and the casting is ejected along with its attached sprues and runners. Cores must be simple and retractable and take the form of moving metal segments.
- **Advantages**: Extremely smooth surfaces and excellent dimensional accuracy; rapid production rate; product tensile strengths as high as 415 MPa .
- **Limitations:** High initial die cost; limited to high-fluidity nonferrous metals ; part size is limited; porosity may be a problem; some scrap in sprues, runners, and flash, but this can be directly recycled. Common metals :Alloys of aluminum, zinc, magnesium ,and lead ; Al so possible with alloys of copper and tin.
- **Size limits:** Less than 30 grams up through about 7 kg most common.
- **Thickness limits**: As thin as 0.75 mm ,but generally less than 13 mm .
- Typical tolerances: Varies with metal being cast; typically 0.1mm for the first 2.5 cm (0.005 in. f or the first inch) and 0.02 mm for each additional centimeter
- **Draft allowances**: 1°–3°. Surface finish: 1–2.5 µm rms

Al- Alloy Composition(Cast Alloy)

- 1xx.x Controlled unalloyed (pure) compositions, especially for rotor manufacture ·
- 2xx.x Alloys in which copper is the principal alloying element, but other alloying elements may be specified ·
- 3xx.x Alloys in which silicon is the principal alloying element, but other alloying elements such as copper and magnesium are specified ·
- 4xx.x Alloys in which silicon is the principal alloying element ·
- 5xx.x Alloys in which magnesium is the principal alloying element ·
- 7xx.x Alloys in which zinc is the principal alloying element, but other alloying elements such as copper and magnesium may be specified ·
- 8xx.x Alloys in which tin is the principal alloying element ·
- 9xx.x Unused and 6xx.x Unused ·

Mg Alloys Composition

- Magnesium-aluminum-manganese with and without zinc (AM and AZ)
- Magnesium-zirconium (K)
- Magnesium-zinc-zirconium with and without rare earths (ZK, ZE, and EZ)
- Magnesium-thorium-zirconium with and without zinc (HK, HZ, and ZH)
- Magnesium-silver-zirconium with rare earths or thorium (QE and QH)
- Magnesium-yttrium-rare-earth-zirconium (WE)
- Magnesium-zinc-copper-manganese (ZC)

Zinc Alloy composition

- Z No.3 Zn-4%Al
- Z No.5 Zn-4% Al-1%Cu
- ZA-8 Zn-8%Al
- ZA-12 Zn-11.5%Al
- ZA-27 Zn-25%Al

Copper Alloy Composition

- C82500 **(97.2Cu-2Be-0.5Co-0.25Si)**
- C83600 **(85Cu-5Sn-5Pb-5Zn)**
- C85800 **(63Cu-1Sn-1Pb-35Zn)**
- C87800 **(82Cu-4Si-14Zn)**
- C87900 **(Silicon yellow brass) (63Cu-1Si-36Zn)**
- C99750 **(**0.25 to 3.0 Al, 55.0 to 61.0 Cu, 0.50 to 2.5 Pb, 17.0 to 23.0 Mn, 5.0 Ni max, 17.0 to 23.0 Zn, 1.0 Fe max, **(***iron content shall not exceed nickel content***))**

Die Casting Metallurgy

- Al-Alloys

1. 380 and 383 aluminum–silicon–copper (Al–Si–Cu) system.
2. 413 aluminum–silicon (Al–Si) system.
3. 390 aluminum–silicon.
4. 360 aluminum–silicon–magnesium (Al–Si–Mg) system.
5. 518 aluminum–magnesium (Al–Mg) system.

Die Casting Metallurgy

- Mg Alloys

1. AZ91 D magnesium–aluminum–zinc (Mg– Al–Zn) system.
2. AM60 B magnesium–aluminum

- Zinc Alloys

1. No. 3 and No. 7 zinc–aluminum (Zn–Al) system.
2. No. 2 and No. 5 zinc–aluminum–copper (Zn–Al–Cu) system.
3. ZA8, ZA12, and ZA 27 (Zn–Al) system

Die Casting Metallurgy

1. C83600 **(85Cu-5Sn-5Pb-5Zn)**
2. C85800 **(63Cu-1Sn-1Pb-35Zn)**
3. C87800 **(82Cu-4Si-14Zn)**
4. C87900 **(Silicon yellow brass) (63Cu-1Si-36Zn)**
5. C99750 **(**0.25 to 3.0 Al, 55.0 to 61.0 Cu, 0.50 to 2.5 Pb, 17.0 to 23.0 Mn, 5.0 Ni max, 17.0 to 23.0 Zn, 1.0 Fe max, **(***iron content shall not exceed nickel content***))**