# Materials Engineering Department
# General Materials Branch

**Casting Technology**

**Fourth Class**

**Lecture Nine :Foundry Practice**

**Class Code :ofp4npn**

# FURNACES

The types of furnaces most commonly used in foundries are

1. Cupolas,
2. Direct fuel-fired furnaces,
3. Crucible furnaces,
4. Electric-arc furnaces,
5. Induction furnaces.
6. Microwave Furnaces

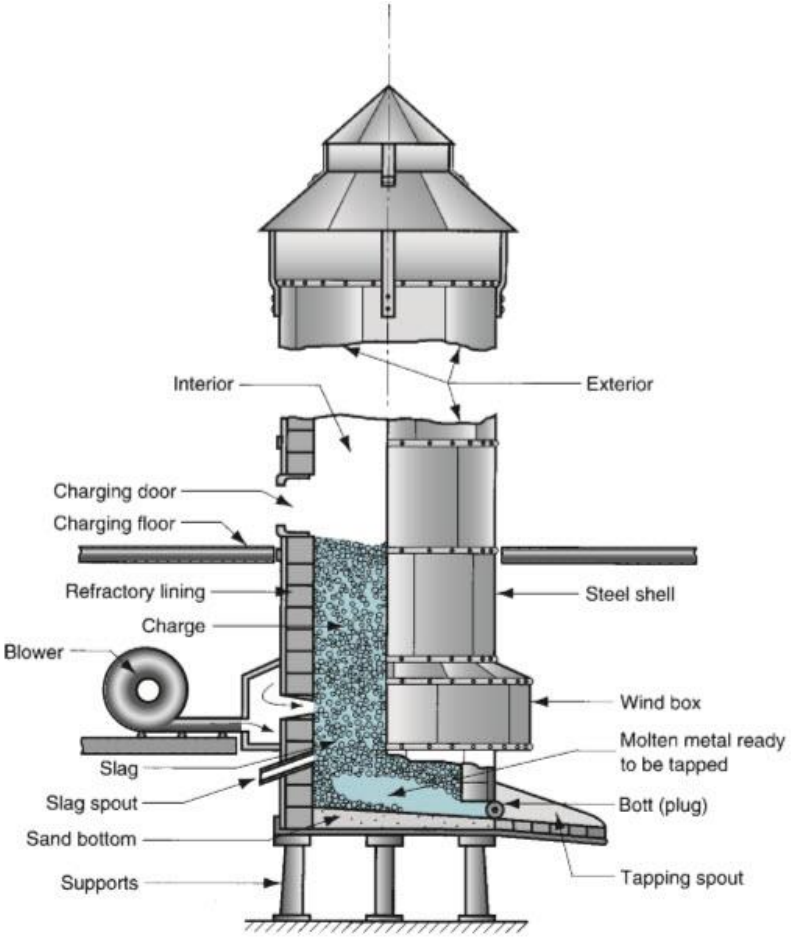
# Selection of Furnaces

Selection of the most appropriate furnace type depends on factors such as

1. The casting alloy i.e. its melting and pouring temperatures
2. Capacity requirements of the furnace ;costs of investment, operation, and maintenance
3. Environmental pollution considerations

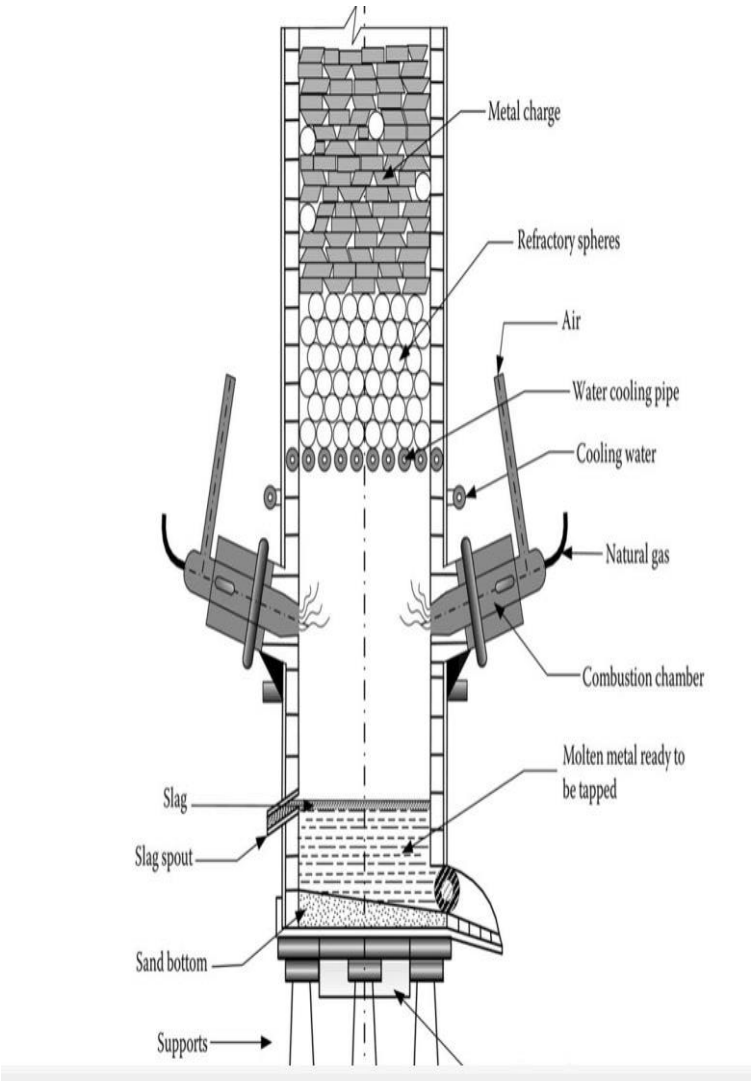
# Cupolas

- A vertical cylindrical furnace equipped with a tapping spout near its base .
- Cupolas are used only for melting cast irons
- Although other furnaces are also used, the largest tonnage of cast iron is melted in cupolas



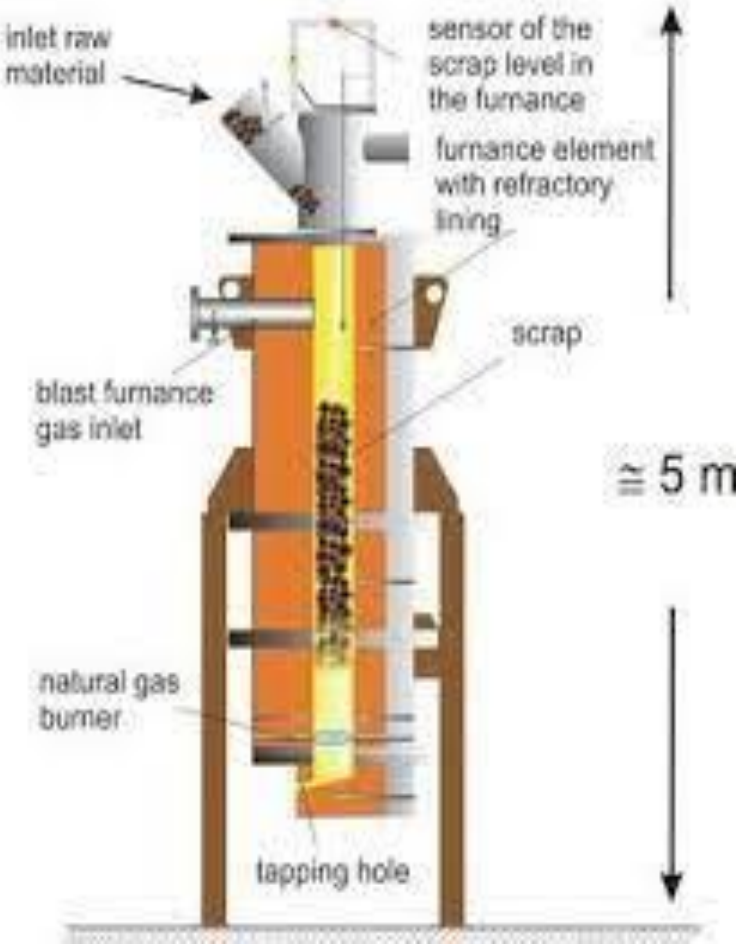
# Cokeless Cupola

- A cokeless cupola was developed about 30 years ago using fuels such as natural gas, propane, diesel oil, or pulverized coal instead of coke.
- This type has been adopted in some large foundries in Europe and India.
- The hot gases keep the spheres at high temperature to melt the scrap.
- The molten metal is collected in the well, and continually injected by a carburizer to control the carbon content.
- This technique eliminates CO emission considerably, and results in lower sulfur content in the metal and reduced slag production.



# Direct Fuel-Fired Furnaces

- A direct fuel-fired furnace contains a small open-hearth, in which the metal charge is heated by fuel burners located on the side of the furnace.
- Direct Fuel fired furnaces are generally used in casting for melting non-ferrous metals such as Copper base alloys and Aluminum Base Alloys



# Crucible Furnaces

- These furnace smelt the metal without direct contact with a burning fuel mixture. For this reason, they are sometimes called indirect fuel-fired furnaces. Three types of crucible furnaces are used in foundries:

A. Lift-out type,
B. Stationary pot furnace
C. Tilting pot furnace

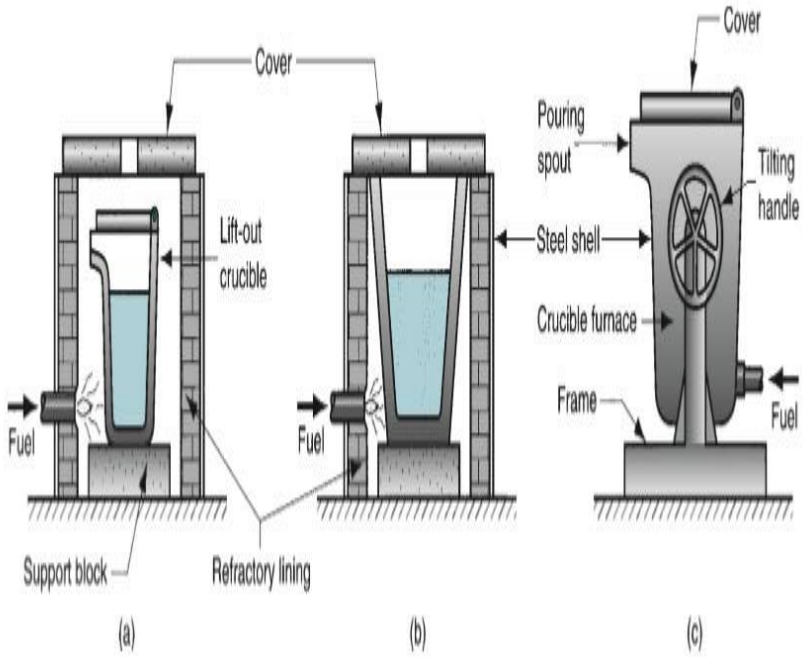



FIGURE 11.19 Three types of crucible furnaces: (a) lift-out crucible, (b) stationary pot, and (c) tilting-pot furnace.

# Electric-Arc Furnaces

- In this furnace type, the charge is melted by heat generated from an electric arc.
- Various configurations are available, with two or three electrodes Power consumption is high .
- But electric-Arc furnaces are the preferred method of melting in many foundries because of the

1. Rapid melting rates,
2. Ability to hold the molten metal for any desired period of time,
3. Greater ease of incorporating pollution control equipment

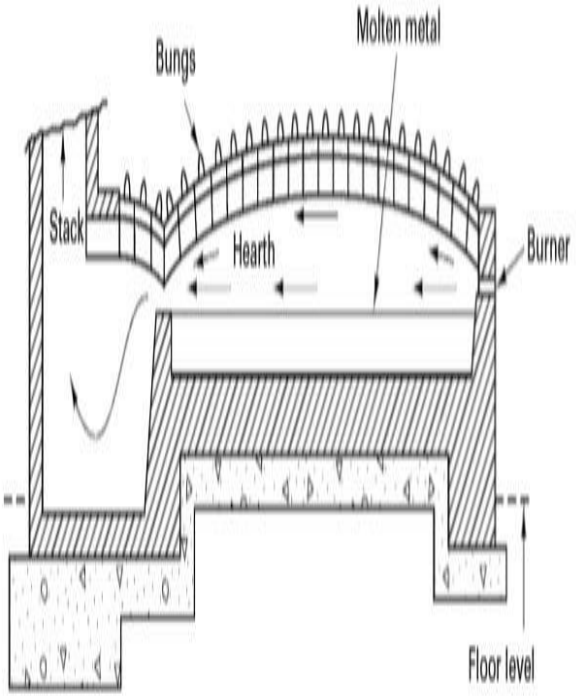



FIGURE 13-14 Cross section of a direct fuel-fired furnace. Hot combustion gases pass across the surface of a molten metal pool.

# Electric-Arc Furnaces

Arc furnaces are

1. Generally used with ferrous alloys, especially steel.
2. Provide good mixing and homogeneity to the molten bath.

- They are available in sizes up to about 200 tons (but capacities of 25 tons or less are most common),and up to 50 tons per hour can be melted conveniently in batch operations.

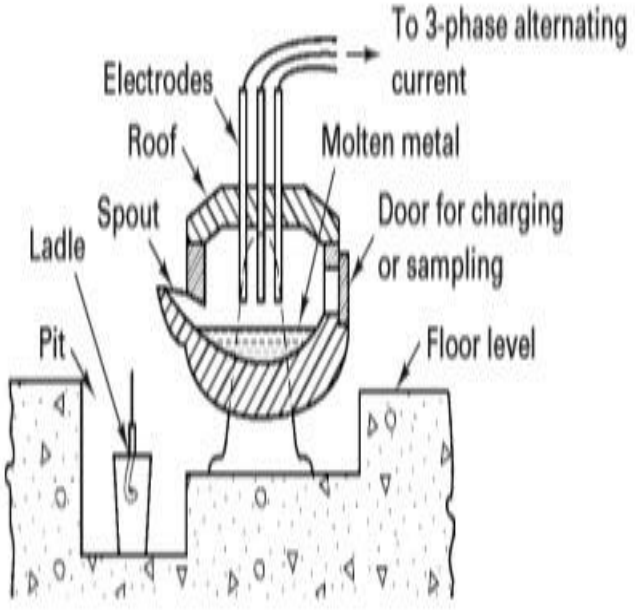
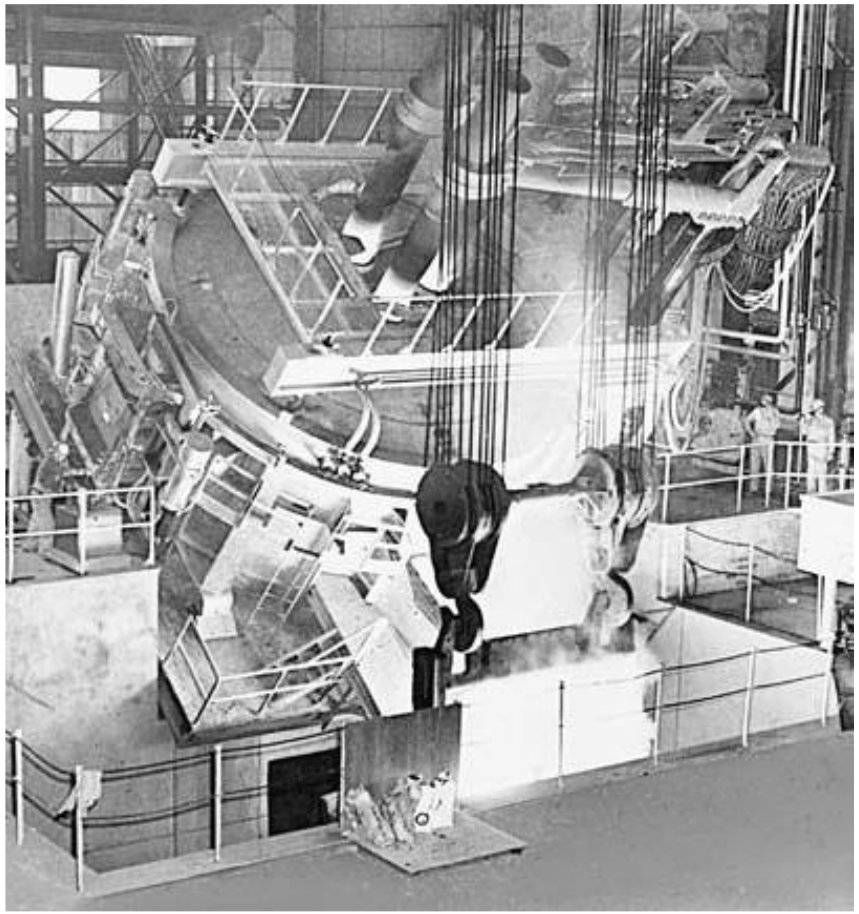



**FIGURE 13-15** Schematic diagram of a three-phase electric-arc furnace.

# Electrical Arc Furnace

Unfortunately, The Defects are

1. The noise and level of particle emissions can be rather high,
2. The Consumption of electrodes ,refractories and power results in high operating costs



# INDUCTION FURNACES (by Frequency)

There are Four Basic types of induction furnaces.

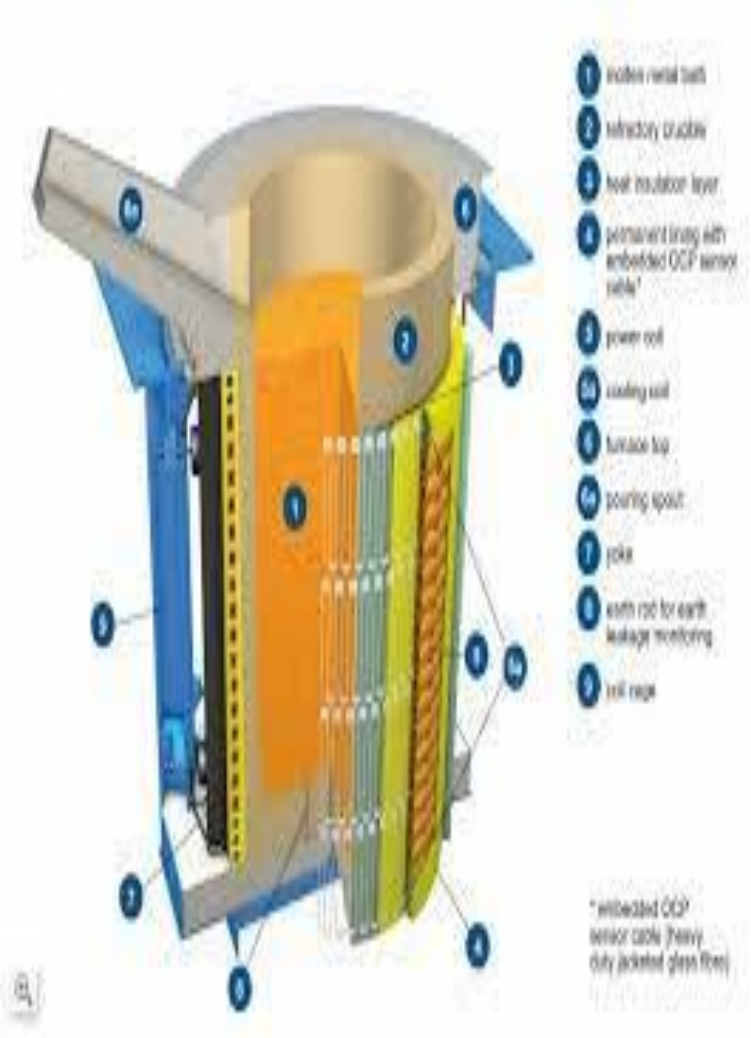
1. The high frequency, or Coreless units
2. Medium Frequency
3. Low (Main)Frequency
4. Triple Frequency

| Type | Frequency | Charge |
| --- | --- | --- |
| The High frequency, or Coreless units | > 2000 Hz | < 50kg |
| The Medium Frequency | (150-2000 Hz) | (<1000Kg) |
| Low (Main)Frequency | 50-60 Hz | >3000Kg |
| Triple Frequency | (150-180 HZ) | (1000-5000Kg) |

# The Medium Frequency

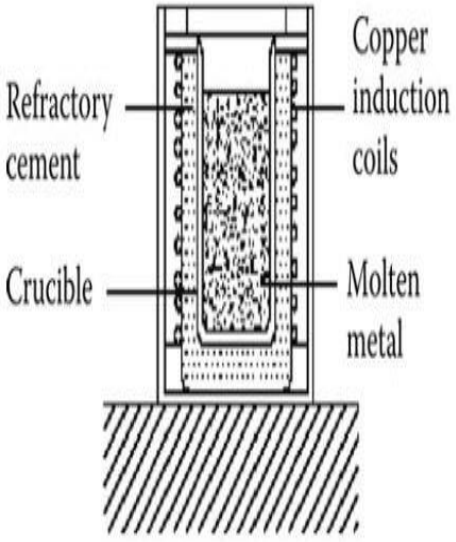
- Build By the use of the Static Frequency Converter .
- The Selection of this furnace depends upon

1. Frequency Conversion
2. Specific Furnace Power
3. Start up Operation .



# INDUCTION FURNACES

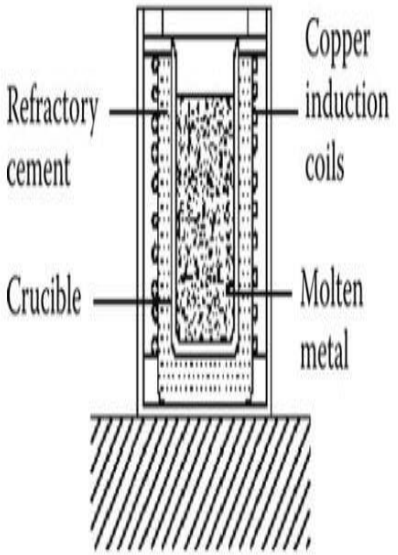
- There is a strong electromagnetic sti action during induc heating; hence, this furnace has excelle mixing characteristi alloying and for adc new charges to met this reason, it is esp adapted for alloyed production.




# INDUCTION FURNACES (by Design)

1. The high frequency, or Coreless units,

Shown schematically in consist of a crucible surrounded by a water-cooled coil of copper tubing.




# INDUCTION FURNACES

- Coreless induction furnaces are used for virtually all common alloys ,
- with the maximum temperature being limited only by the refractory and the ability to insulate against heat loss.
- They provide good control of temperature and composition and are available in a range of capacities up to about 65 tons.
- Because there is no contamination from the heat source, they produce very pure metal.

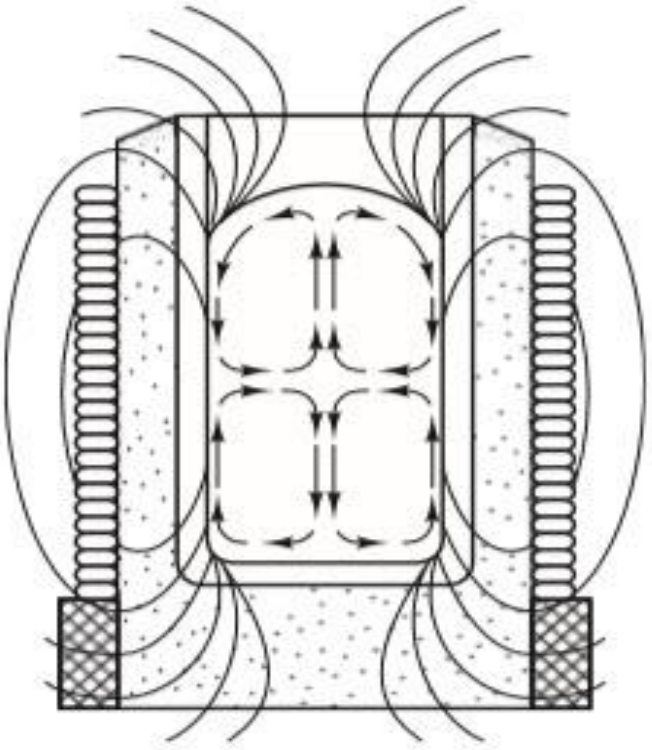


**FIGURE 13-17** Schematic showing the basic principle of a coreless induction furnace.

# INDUCTION FURNACES (By Design)

- Low frequency or Channel-type induction furnaces are also seeing increased use.
- Only a small channel is surrounded by the primary(current-carrying or heating) coil. A secondary coil is formed by a loop, or channel, of molten metal, and all the liquid metal is free to circulate through the loop and gain heat

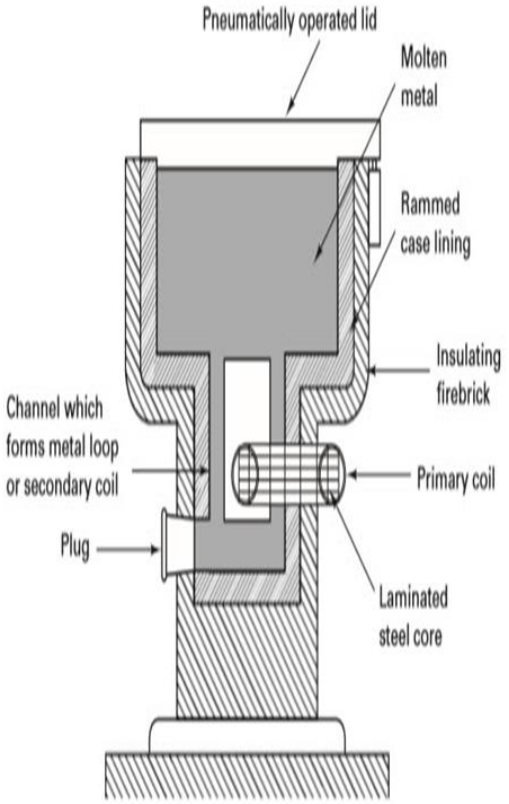
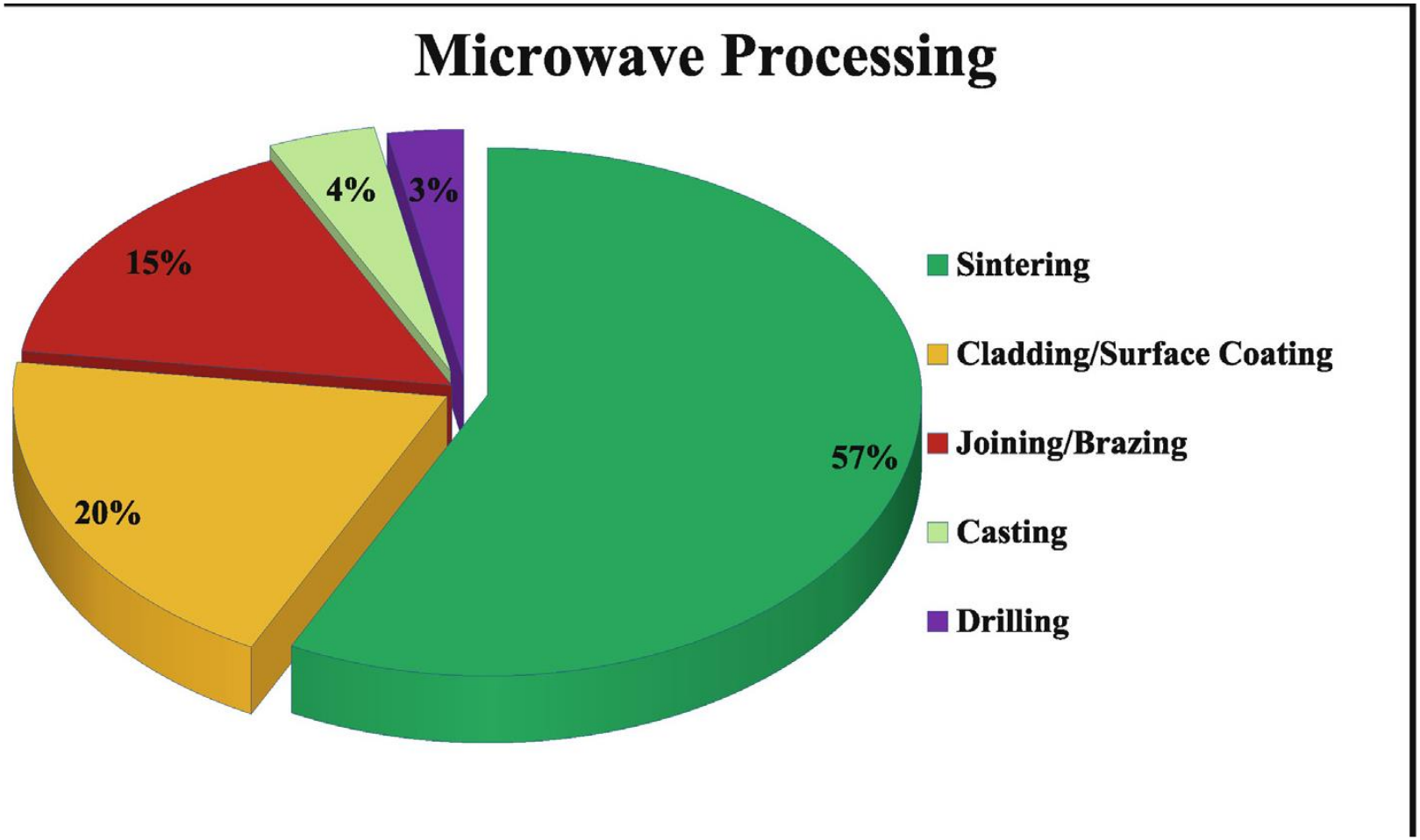
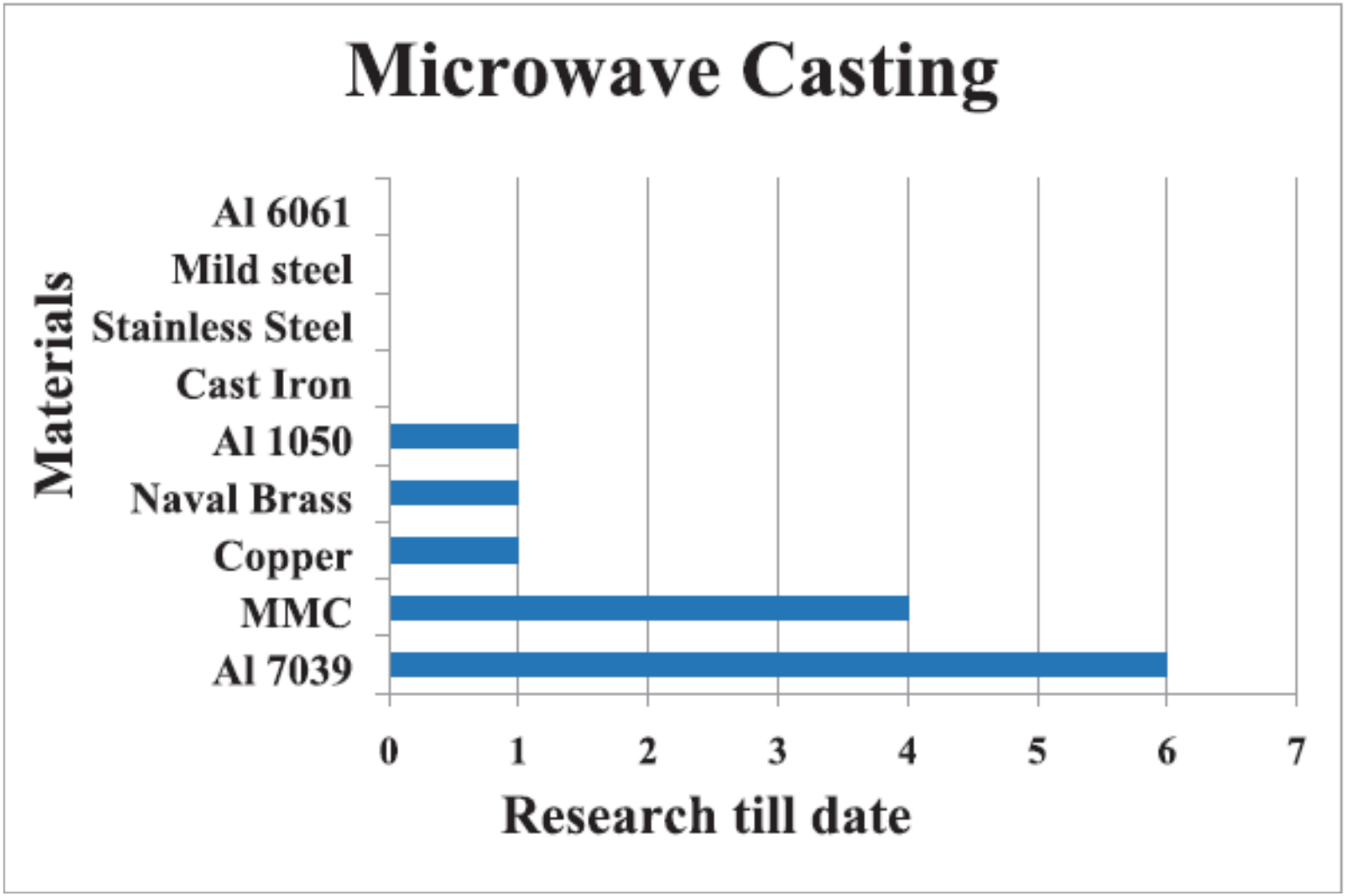



**FIGURE 13-18** Cross section showing the principle of the low-frequency or channel-type induction furnace.

# Microwave Processing



# Microwave Casting



# Microwave casting of different materials and their specifications.

**Table 1**
Microwave casting of different materials and their specifications.

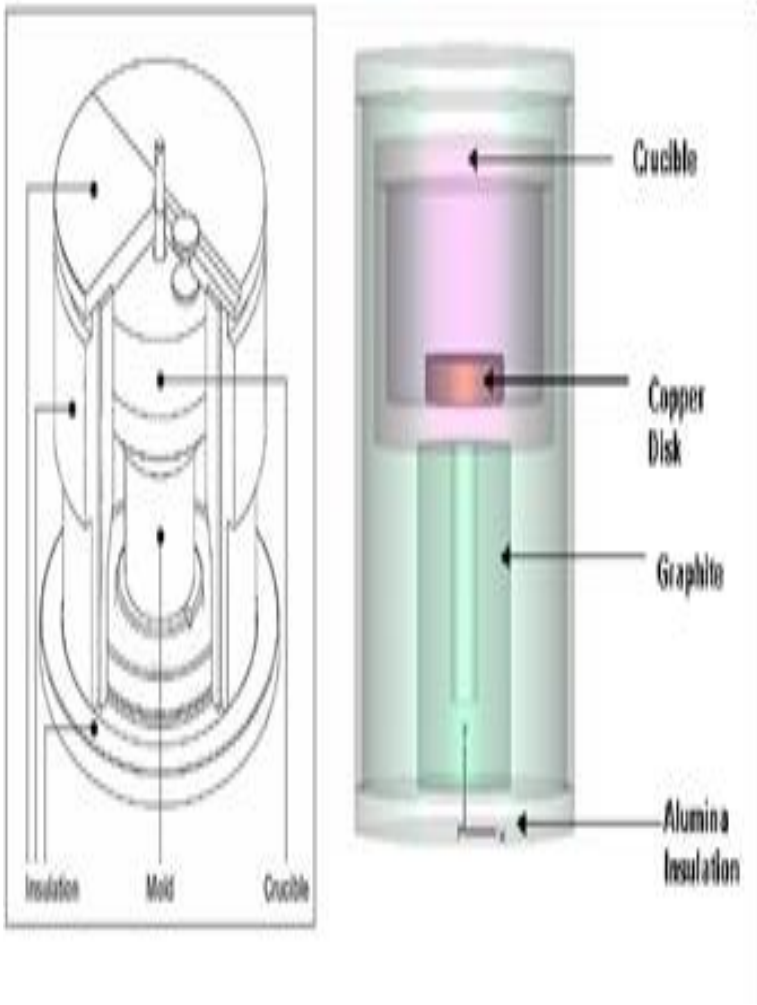
| Sr No. | Material | Type of casting | Material Specifications | Microwave specification | | Temperature measurement | Exposure Time (Sec/Min) |
|---|---|---|---|---|---|---|---|
| | | | | Applicator | Frequency and power | | |
| 1. | Al 1050 [12] | Ex-situ | 100 × 75 × 50 $mm^3$ and 240 g | Domestic microwave (LG Model) | 2.45 GHz 900 W | Type-K thermocouple (200 to 1260 °C) | 1200/20 |
| 2. | Al 7039 [13] | In-situ | Cylindrical Shape of 25 mm diameter and 100 g of mass | Industrial microwave (Model: MH-1514-101-V6) | 2.45 GHz 1400 W | Built-In IR Pyrometer (range 350–1800 °C) | 930/15.5 |
| 3. | Al-Zn-Mg (Al7039) [14] | In-situ | – | Industrial microwave (Model: MH-1514-101-V6) | 2.45 GHz 1400 W | Built-In IR Pyrometer (range 350–1800 °C) | 400/6.6 |
| 4. | Al 7039 [15] | In-situ | Cylindrical Shape of 25 mm diameter and 100 g of mass | Industrial microwave (Model: MH-1514-101-V6) | 2.45 GHz 1400 W | Built-In IR Pyrometer (range 350–1800 °C) | 525/8.75 |
| 5. | Al-Zn-Mg (Al7039) [16] | In-situ | Cylindrical Shape of 25 mm diameter and 100 g of mass | Industrial microwave (Model: MH-1514-101-V6) | 2.45 GHz 1400 W | Built-In IR Pyrometer (range 350–1800 °C) | 930/15.5 |
| 6. | Al-Zn-Mg (Al7039) [17] | In-situ | Cylindrical Shape of 25 mm diameter and 100 g of mass | Industrial microwave (Model: MH-1514-101-V6) | 2.45 GHz 1400 W | Built-In IR Pyrometer (range 350–1800 °C) | – |
| 7. | Al 7039 [10] | In-situ/Ex-situ | – | Industrial microwave (Model: MH-1514-101-V6) | 2.45 GHz 1400 W | Built In IR Pyrometer (range 350–1800 °C) | – |
| 8. | MMC [19] | In-situ | EWAC + 10%SiC (wt), 40 μm | Domestic microwave (LG Model) | 2.45 GHz 900 W | – | 108–1440/1.8–24 |
| 9. | MMC [20] | In-situ | 50 × 20 × 6 $mm^3$ EWAC(EN1004) + 5% and 10% SiC (wt) 40 μm | Domestic microwave (LG Model) | 2.45 GHz 900 W | – | 108–1440/1.8–24 |
| 10. | MMC [21] | In-situ | EWAC + 10%SiC (wt), 40 μm | Domestic microwave (LG Model) | 2.45 GHz 900 W | Non-Contact type pyrometer | 1320 ± 180/22 ± 3 |
| 11. | MMC [22] | In-situ | EWAC + 5%and 10% WC-8Co | Domestic microwave (LG Model) | 2.45 GHz 900 W | Non-Contact type pyrometer | 1440/24 |
| 12. | Naval Brass [24] | – | 59% copper, 40% zinc and 1% tin | Industrial microwave | 2.45GHZ 3300 W | Type-K thermocouple (200 to 1260 °C) | 1020/17 |
| 13. | Cu [25] | In-situ | Cuboidal | Industrial microwave (Model: MH-1514-101-V6) | 2.45 GHz 1400 W | Built-In IR Pyrometer (range 350–1800 °C) | 890 ± 10/15 ± 0.16 |

# Industrial Microwave Furnace for Metal Casting Applications

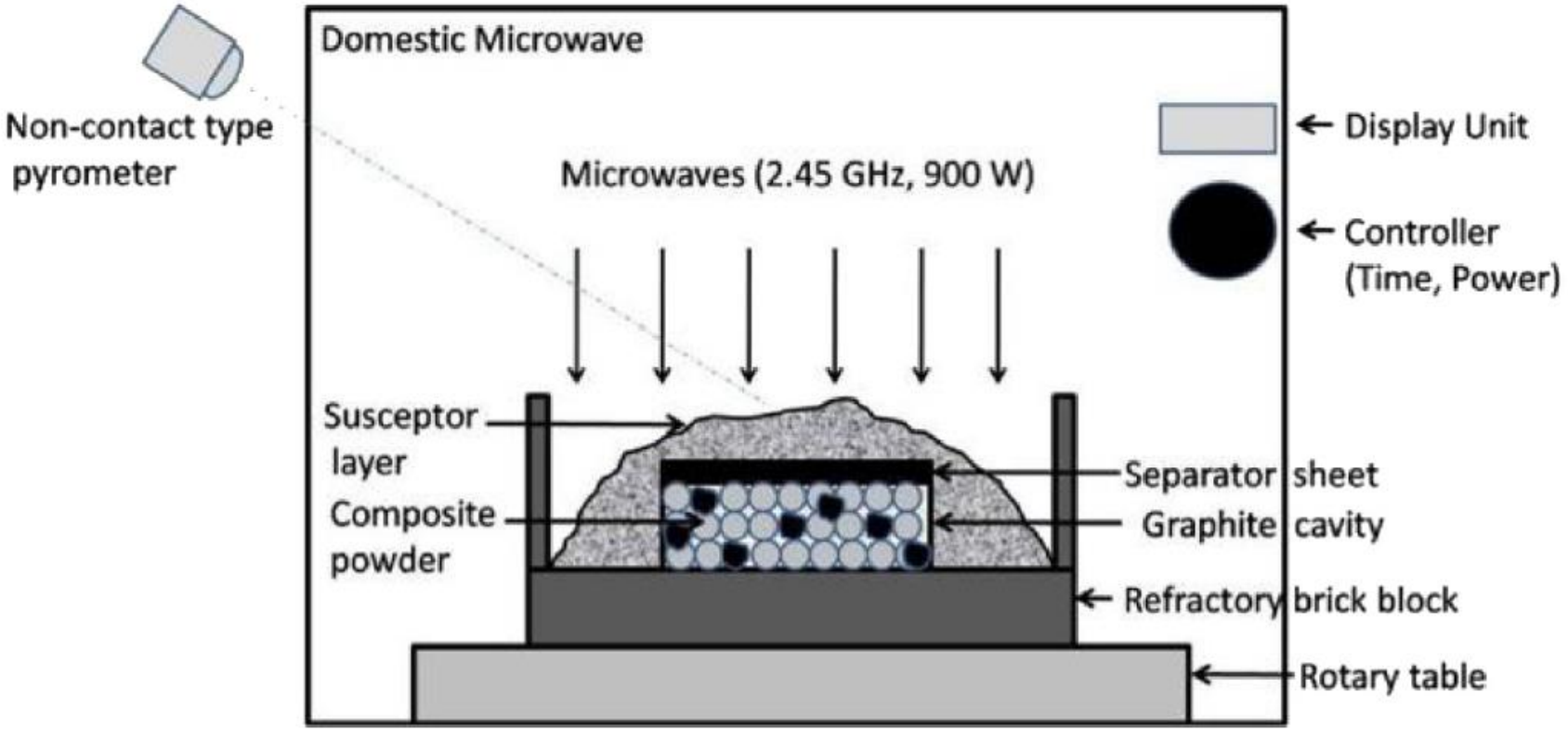
1.Microwave furnaces operation do not require any water cooling,

2. They can fit any specimen size

3. They can provide a controlled atmosphere for a cleaner casting process with no oxidization.



# Schematic representation of MHH for melting and casting of MMC



# Example 1

- Estimate the final composition of the cast iron produced with the following charge compositions and proportions.

| | *Carbon %* | *Silicon %* | *Mangmanese %* | *Sulphur %* | *Phosphorous %* | *Charge %* |
|---|---|---|---|---|---|---|
| Pig iron | 13.50 | 2.50 | 0.40 | 0.01 | 0.40 | 40 |
| Pig iron | 23.20 | 1.50 | 1.00 | 0.02 | 0.60 | 35 |
| CI scrap | 3.20 | 1.20 | 0.50 | 0.10 | 0.40 | 25 |

# Example 2

Estimate the final composition of the cast iron produced with the following charge compositions and proportions. Let us now analyze the total amount of elements present in 1 tone (1000 kg) of charge, assuming carbon pick-up as 15%, sulphur pick-up 0.05%, silicon loss as 10% and manganese loss as 20%.

| *Carbon %* | *Silicon %* | *Mangmanese %* | *Sulphur %* | *Phosphorous %* | *Charge %* |
|---|---|---|---|---|---|
| Pig iron 13.50 | 2.50 | 0.40 | 0.01 | 0.40 | 40 |
| Pig iron 23.20 | 1.50 | 1.00 | 0.02 | 0.60 | 35 |
| CI scrap 3.20 | 1.20 | 0.50 | 0.10 | 0.40 | 25 |