Furnaces can also be classified according to the molten metal

1. Gray Cast Iron

- Cupola
- Air furnace
- Rotary furnace
- Electric arc furnace

2. Steel

- Open hearth furnace.
- Electric furnace.
    - Arc furnace
    - High frequency induction furnace
- Converter

3. Non-ferrous metals

- Crucible furnaces (Al ,Cu)
    - Pit type
    - Tilting type
    - Non-tilting or bale out type
    - Electric resistance type (CU)

- Pot furnaces (fuel fired) (Mg & Al)
    - Stationary
    - Tilting

- Reverberatory furnaces (fuel fired) (Al & Cu)
    - Stationary
    - Tilting

- Rotary furnaces
    - Fuel fired
    - Electrically heated

- Induction furnaces (Al & Cu)
    - Low frequency
    - High frequency

- Electric Arc furnaces (Cu)

CUPOLA FURNACE

- For many years, the cupola was the primary method of melting used in iron foundries. The cupola furnace has several unique characteristics which are responsible for its widespread use as a melting unit for cast iron.

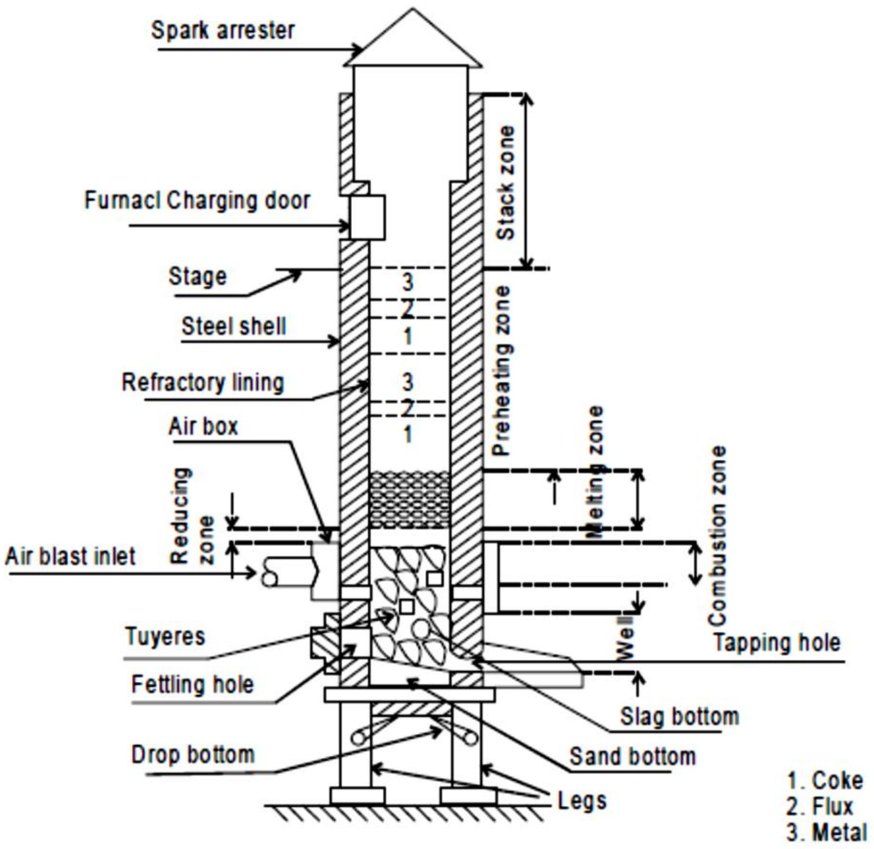
- Cupola furnace is employed for melting scrap metal or pig iron for production of various cast irons. It is also used for production of nodular and malleable cast iron. It is available in good varying sizes. The main considerations in selection of cupolas are melting capacity, diameter of shell without lining or with lining, spark arrester.

Shape

A typical cupola melting furnace consists of a water-cooled vertical cylinder which is lined with refractory material.

Construction

- The construction of a conventional cupola consists of a vertical steel shell which is lined with a refractory brick.
- The charge is introduced into the furnace body by means of an opening approximately half way up the vertical shaft.
- The charge consists of alternate layers of the metal to be melted, coke fuel and limestone flux.
- The fuel is burnt in air which is introduced through tuyeres positioned above the hearth. The hot gases generated in the lower part of the shaft ascend and preheat the descending charge.



Various Zones of Cupola Furnace

Various numbers of chemical reactions take place in different zones of cupola. The construction and different zones of cupola are :

1. Well

The space between the bottom of the tuyeres and the sand bed inside the cylindrical shell of the cupola is called as well of the cupola. As the melting occurs, the molten metal is get collected in this portion before tapping out.

2. Combustion zone

The combustion zone of Cupola is also called as oxidizing zone. It is located between the upper of the tuyeres and a theoretical level above it. The total height of this zone is normally from 15 cm. to 30 cm. The combustion actually takes place in this zone by consuming the free oxygen completely from the air blast and generating tremendous heat. The heat generated in this zone is sufficient enough to meet the requirements of other zones of cupola. The heat is further evolved also due to oxidation of silicon and manganese. A temperature of about 1540°C to 1870°C is achieved in this zone. Few exothermic reactions takes place in this zone these are represented as:

$$C + O2 \rightarrow CO2 + Heat$$
$$Si + O2 \rightarrow SiO2 + Heat$$
$$2Mn + O2 \rightarrow 2MnO + Heat$$

3. Reducing zone

Reducing zone of Cupola is also known as the protective zone which is located between the upper level of the combustion zone and the upper level of the coke bed. In this zone, CO2 is changed to CO through an endothermic reaction, as a result of which the temperature falls from combustion zone temperature to about 1200°C at the top of this zone. The important chemical reaction takes place in this zone which is given as under.

$$CO2 + C\ (coke) \rightarrow 2CO + Heat$$

Nitrogen does not participate in the chemical reaction occurring in his zone as it is also the other main constituent of the upward moving hot gases. Because of the reducing atmosphere in this zone, the charge is protected against oxidation.

4. Melting zone

The lower layer of metal charge above the lower layer of coke bed is termed as melting zone of Cupola. The metal charge starts melting in this zone and trickles down through coke bed and gets collected in the well. Sufficient carbon content picked by the molten metal in this zone is represented by the chemical reaction given as under.

$$3Fe + 2CO \rightarrow Fe3C + CO2$$

5. Preheating zone

Preheating zone starts from the upper end of the melting zone and continues up to the bottom level of the charging door. This zone contains a number of alternate layers of coke bed, flux and metal charge. The main objective of this zone is to preheat the charges from room temperature to about 1090°C before entering the metal charge to the melting zone. The preheating takes place in this zone due to the upward movement of hot gases. During the preheating process, the metal charge in solid form picks up some sulphur content in this zone.

6. Stack

The empty portion of cupola above the preheating zone is called as stack. It provides the passage to hot gases to go to atmosphere from the cupola furnace.

Charging of Cupola Furnace

- Before the blower is started, the furnace is uniformly pre-heated and the metal and coke charges, lying in alternate layers, are sufficiently heated up.
- The cover plates are positioned suitably and the blower is started.
- The height of coke charge in the cupola in each layer varies generally from 10 to 15 cms. The requirement of flux to the metal charge depends upon the quality of the charged metal and scarp, the composition of the coke and the amount of ash content present in the coke.

Working of Cupola Furnace

- The charge, consisting of metal, alloying ingredients, limestone, and coal coke for fuel and carbonization (8-16% of the metal charge), is fed in alternating layers through an opening in the cylinder.

- Air enters the bottom through tuyeres extending a short distance into the interior of the cylinder. The air inflow often contains enhanced oxygen levels.

- Coke is consumed. The hot exhaust gases rise up through the charge, preheating it. This increases the energy efficiency of the furnace. The charge drops and is melted.

- Although air is fed into the furnace, the environment is a reducing one. Burning of coke under reducing conditions raises the carbon content of the metal charge to the casting specifications.

- As the material is consumed, additional charges can be added to the furnace.

- A continuous flow of iron emerges from the bottom of the furnace.

- Depending on the size of the furnace, the flow rate can be as high as 100 tones per hour. At the metal melts it is refined to some extent, which removes contaminants. This makes this process more suitable than electric furnaces for dirty charges.

- A hole higher than the tap allows slag to be drawn off.

- The exhaust gases emerge from the top of the cupola. Emission control technology is used to treat the emissions to meet environmental standards.

- Hinged doors at the bottom allow the furnace to be emptied when not in use.

Type of Molten Metal

- Cupola is employed for melting scrap metals or (over 90 %) of the pig iron used in the production of iron castings.
- Gray Cast iron, nodular cast iron, some malleable iron castings and some copper base alloys can be produced by Cupola Furnace.

Heat Energy Source

- The cupola is a tubular furnace which produces cast iron by melting scrap and alloys using the energy generated from the oxidation (combustion) of coke, a coal derivative.

Advantages

- It is simple and economical to operate.
- A cupola is capable of accepting a wide range of materials without reducing melt quality. Dirty, oily scrap can be melted as well as a wide range of steel and iron. They therefore play an important role in the metal recycling industry
- Cupolas can refine the metal charge, removing impurities out of the slag.
- From a life-cycle perspective, cupolas are more efficient and less harmful to the environment than electric furnaces. This is because they derive energy directly from coke rather than from electricity that first has to be generated.
- The continuous rather than batch process suits the demands of a repetition foundry.
- Cupolas can be used to reuse foundry by-products and to destroy other pollutants such as VOC from the core-making area.
- High melt rates
- Ease of operation
- Adequate temperature control
- Chemical composition control
- Efficiency of cupola varies from 30 to 50%.
- Less floor space requirements comparing with those furnaces with same capacity.

Limitations

- Since molten iron and coke are in contact with each other, certain elements like si, Mn are lost and others like sulphur are picked up. This changes the final analysis of molten metal.
- Close temperature control is difficult to maintain