15.9 CUPOLA

Using of Cupola to melt Cast Iron possesses the following advantages :

Advantages:

- The cost of melting is low.
- The control of chemical composition is better.
- Temperature control is easier.
- Molten metals can be tapped from the cupola at regular intervals.
- It consumes the easily available and less expensive fuels.
- Cupola furnace has low initial cost as compared to other furnace of same capacity.
- Continuous production can be obtained from the cupola furnace once started.
- Less floor space requirements as compared to other furnaces of same capacity.
- It has high degree of efficiency.

Disadvantages:

- The main disadvantages of Cupola is that it is not possible to produce iron below 2.8% carbon in this furnace. So for producing white cast iron (containing below 2.7% carbon) the duplex process is employed.
- Moreover, molten iron and coke comes in contact with each other, certain elements such as Si, Mn are lost while others are included in the metal.

15.9.1 Description of a Cupola

1. **Shell :** Shell is a vertical and cylindrical in shape. It is made with steel sheet 6 to 12 mm thick and lined inside with refractory bricks and clay. Refractory bricks and clay used for cupola lining consist of silica (SiO_2) and Alumina (Al_2O_3). Cupola diameter varies from 1 to 2 metres and the height is 4 to 6 times the diameter.
2. **Foundation :** The shell is mounted either on a brick works foundation or on steel columns. The bottom of the shell consists of a drop bottom door, through which debris consisting of coke, slag etc. can be discharged at the end of a melting.
3. **Tuyers :** Air for combustion of fuel is delivered through the tuyers which are provided at the height of between 0.6 to 1.2 metres above the working bottom.
4. **Wind Belt :** The air is delivered to the tuyers from a wind belt which is a steel plate duct mounted on the outer shell of the cupola.

5. **Blower :** A high pressure fan or blower supplies the air to the wind belt through a blast pipe.
6. **Slag Hole :** It is located at a level about 250 mm below the centres of the tuyers. It is used to remove the slag.
7. **Charging Door :** It is situated 3 to 4 metres above the tuyers. Through this hole, metal, coke and flux are fed into the furnace.
8. **Chimney or Stack :** The shell is usually continued for 4 metres to 5 metres above the charging hole to form a chimney.

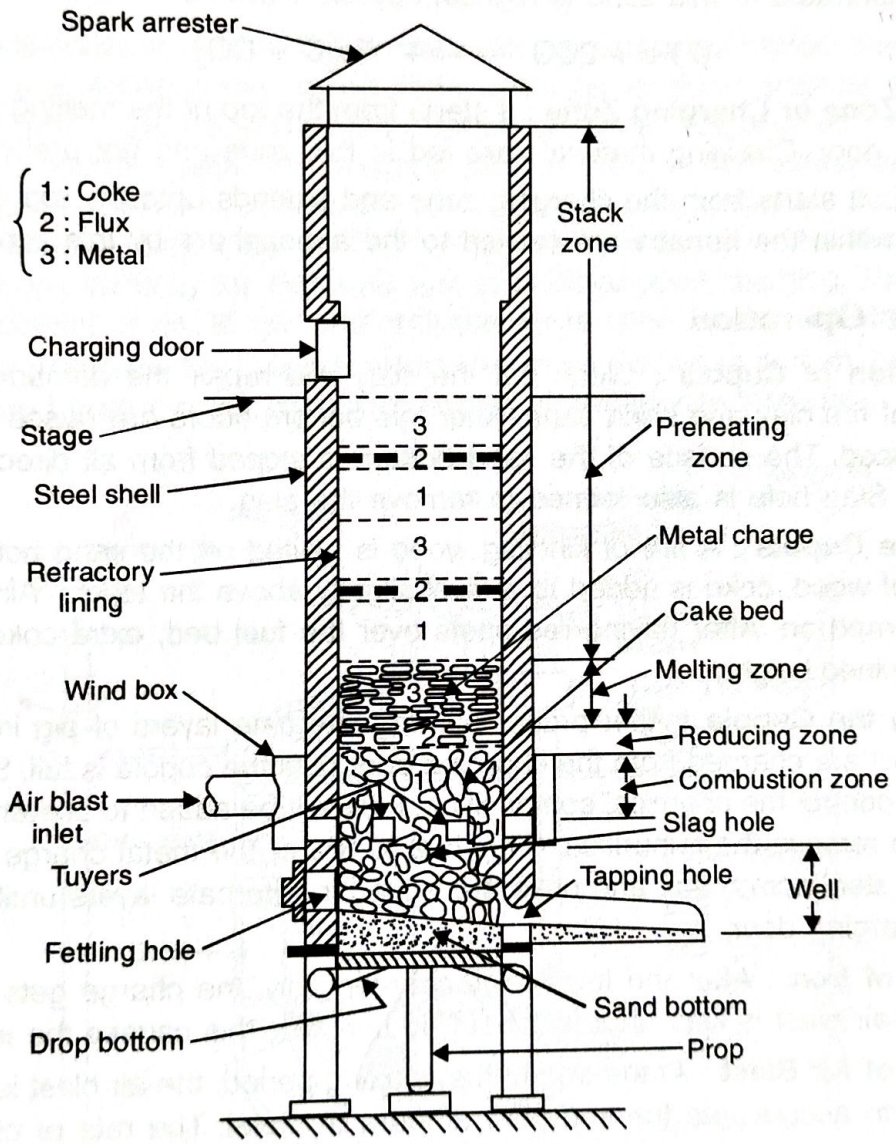

Fig. 15.25. *Cupola.*

15.9.2 Zones in a Cupola

The entire section of the cupola is divided into the following zones :

Crucible Zone : It is between top of the sand bed and bottom of the tuyers. The molten metal accumulates here. It is also called the 'well'.

Combustion or Oxidizing Zone : It is situated normally 150 to 300 mm above the top of the tuyers. Heat is evolved in this zone because of the following oxidation reactions :

$$C + O_2 \longrightarrow CO_2 + \text{Heat}$$

$$Si + O_2 \longrightarrow SiO_2 + \text{Heat}$$

$$2Mn + O_2 \longrightarrow 2\,MnO + Heat$$
$$Fe + O \longrightarrow FeO + Heat$$

Reducing Zone : This zone starts from the top of the combustion zone and extends upto the top of the coke bed. In this zone, the reduction of CO_2 to CO occurs and temperature drops to about 1200°C.

$$CO_2 + C(coke) \longrightarrow 2CO - Heat$$

Melting Zone : The zone starts from the top of the coke bed and extends upto a height of 900 mm. The temperature in this zone is highest approx. equal to 1600°C.

$$3\,Fe + 2CO \longrightarrow Fe_3C + CO_2$$

Preheating Zone or Charging Zone : It starts from the top of the melting zone and extends upto the charging door. Charging materials are fed in this zone and get preheated.

Stack Zone : It starts from the charging zone and extends upto the top of the cupola. The gases generated within the furnace are carried to the atmosphere by this zone.

15.9.3 Cupola Operation

1. **Preparation of Cupola :** Clean out the slag and repair the damaged lining with the mixture of fire clay and silica sand. After this bottom doors are raised and bottom sand is introduced. The surface of the sand bottom is sloped from all directions towards the tap hole. Slag hole is also formed to remove the slag.
2. **Firing the Cupola :** A fire of kindling wood is ignited on the sand bottom. After proper burning of wood, coke is added to a level slightly above the tuyers. Air blast at a slower rate is turned on. After having red spots over the fuel bed, extra coke is added to the predetermined height.
3. **Charging the Cupola :** After proper burning alternate layers of pig iron, coke and flux (limestone) are charged from the charging door until the cupola is full. Steel scrap is also added to control the chemical composition. Flux will be added to prevent the oxidation as well as to remove the impurities. (Flux is 2 to 3% of the metal charge by weight). Metal (pig iron, steel scrap) flux and coke are added in alternate layers until the cupola is full to the charging door.
4. **Soaking of Iron :** After the furnace is charged fully, the charge gets slowly heated up since the air blast is kept shut for about 45 minutes, this causes the iron to get soaked.
5. **Opening of Air Blast :** At the end of the soaking period, the air blast is opened. Tap hole is closed to accumulate the sufficient amount of metal. The rate of charging should be equal to the rate of melting so that the furnace remains full.
6. **Pouring the Molten Iron :** When sufficient metal collects in the well, the slag hole is opened, and the slag is removed. After this tap hole is opened to collect the molten metal.
7. **Closing the Cupola :** At the end of the operation, the charge feeding is stopped, air supply is cut off and the prop is removed (when the cupola is in operation, the bottom door is supported by a prop so that it may not collapse due to the large weight of the charge, coke etc., it carries). As soon as the prop is removed the door swing down providing a clear space for the coke fire, residue of the molten metal with slag and the sand bed to fall down and, thus, the fire inside ceases gradually.