CHAPTER 3

A SCENARIO OF UTILIZING CUPOLA AND INDUCTION FURNACES IN IRON FOUNDRIES SITUATED IN COIMBATORE DISTRICT OF INDIA

3.1 INTRODUCTION

As mentioned in the previous chapter, the results of the literature survey favored the assessment of the scenario prevailing in iron foundry cluster of Coimbatore. A preliminary discussion with the stakeholders indicated that cupola and induction furnaces are predominant in the iron foundry cluster of Coimbatore. In order to assess the extent of utilizing these furnaces, a questionnaire based survey was conducted in the iron foundry cluster of Coimbatore. After gathering the relevant data through the conduct of this questionnaire based survey, the author of this thesis visited a foundry in which both cupola and induction furnaces are used to gather information about the functional aspects about these melting furnaces. This survey and the information drawn by conducting it are presented in this chapter.

3.2 UTILIZATION OF FURNANCES IN FOUNDRIES: THE INDIAN SCENARIO

After the middle part of the twentieth century, the world community began to realize that, foundries consume larger amount of energy by melting the metals at high temperature and emit various kinds of pollutants which has become greater problem to the mankind. In order to overcome this
situation, several countries in the world promulgated laws stipulating the maximum level of pollutants that can be emitted by the foundries. These laws affected the functioning and growth of foundries. In order to sustain amidst these constraints, foundries began to install energy efficient melting technologies and PCDs.

With increasing stringent enforcement of pollution control norms that are stipulated by many countries in the world, many of the foundry units have started to adopt electrical melting technologies, especially through the utilization of induction furnace. However this effort is subjected to certain hurdles in India. Today due to insufficient production, many state governments of India have imposed severe restrictions on the use of electric power by the industrial sector. Companies now face load shedding of up to 40% of their maximum demand. These governments have also imposed strict time limits on the use of electricity by the industrial units.

With the restrictions on power usage and operational time, a majority of the foundries in India have been forced to cut down production drastically. In fact many foundry units in Coimbatore operate the induction furnace for only 18 days in a month. At the same time, the foundry units are under enormous pressure to meet their market commitments. Under these circumstances, the foundries situated in India continue to employ coke-based melting technology. Hence foundry engineers are keen to identify and adopt pollution control technologies that will enable them to operate coke-based cupolas while meeting required environmental norms. In effect, the current scenario presents a major opportunity for promoting DBC (to improve energy efficiency) and venturi scrubber (to reduce emissions) among the foundries situated in India.
3.3 SCENARIO PREVAILING IN IRON FOUNDRY CLUSTER OF COIMBATORE

In India several foundry clusters are located in places like Agra, Rajkot, Belgaum, Chennai, Pune, Ludhiana, Howra, Coimbatore and Kholapur. Currently, researchers working on studying the characteristics of foundries situated in India focus their studies towards the condition prevailing in different clusters. As mentioned in the previous chapters, such studies have not been carried out with regard to the employment of PCDs in the iron foundry cluster located in Coimbatore district of India. Hence, the focus of the doctoral work being reported here was directed towards studying the scenario prevailing in iron foundry cluster located in Coimbatore district of India.

Coimbatore district is located in the western part of Tamil Nadu State of India. Coimbatore is spread out in an area of 7469 square kilometer. Coimbatore is the second largest city in Tamil Nadu State of India (Vijayanand et al 2008). Coimbatore district is located at 411 meters above mean sea level. Average rainfall is about 612.2 millimeters. The district is situated on the banks of a river called Noyil. It has population of more than 1.6 millions. Due to the existence of several textile mills, Coimbatore is also known as Manchester of South India.

In Coimbatore, large number of companies produce products like wet grinders, pumps and motors. The needs of the iron castings used by these companies, are met by the iron foundry units functioning in Coimbatore. Increasing number of iron foundries in Coimbatore has improved the economy and quality of life of people of Coimbatore. However, the pollutants emitted by these iron foundries affect the healthy living of people in Coimbatore. Those pollutants are emitted due to poor production process, poor safety management and poor air pollution controlling practices
employed while carrying out the foundry practices (Mukerjee 2010). This has created a situation to install PCDs and adopt best melting practices. In order to assess this situation prevailing in the iron foundry cluster of Coimbatore, during the doctoral work being reported here, a survey was carried out. This survey was conducted with the aim to gather the data required for comparing the utilization of cupola and induction furnace as well as the PCD, in foundries located in Coimbatore.

3.4 GATHERING OF DATA

During the beginning phase of the survey being reported here, the procedure being narrated here was used by keeping the scope of doctoral work in view. A questionnaire was designed to gather data about the capacity of foundry, utilization of cupola or induction furnace, type of castings supplied, size, power capacity frequency of induction furnace. 40 copies of this questionnaire were mailed to cupola and induction furnace users of iron foundry units in Coimbatore district. 25 completed questionnaires were received. The relevant data were gathered from these completed questionnaires which were received from the iron foundries located in Coimbatore district.

After studying of the data presented in these questionnaires, it was found that 10 of the iron foundries responded employ cupola for melting the raw materials and 15 of them employ induction furnace to melt the raw materials. In this background, the details of construction, functioning, types of induction and cupola furnaces employed in these iron foundries are explained in following two sections.

3.5 ANALYSIS OF DATA

In the context of studying the characteristics of induction and cupola furnaces from both theoretical and practical perspectives, the data
gathered through the conduct of the questionnaire based survey were analyzed. To begin with these data were tabulated. These tabulated data are shown in Tables 3.1, 3.2 and 3.3. The information gathered by analysing of the data presented in these tables are presented in this section.

As shown in Tables 3.1, the foundries representing foundry cluster of Coimbatore are unique from the viewpoint of two aspects. In one aspect, all these foundries are captive in nature. This would mean that, the castings produced by these foundries are either used by themselves or supplied to their own sister companies. Quite interestingly, from the viewpoint of the other aspect, these castings are used to manufacture pumps. Except these uniqueness, in all ways, the characteristics of iron foundries responded during this questionnaire survey varied from each other.

As shown in Table 3.1, the characteristics of these iron foundries varied widely in terms of the tonnage of castings, weight of single piece of casting and type of furnace used. Out of the 25 foundries responded to the questionnaire, 10 of them use cupola furnace, while the remaining 15 of them use induction furnace for melting the metal charge. Even if these iron foundries are grouped under these classifications, the characteristics of them varied. As shown in Table 3.1, the tonnage of good casting capacity varied from 200 to 2500 in the case of iron foundries which use induction furnace. Like in the case of iron foundries using induction furnace, in the case of iron foundries using cupola too the tonnage of good casting capacity per month varied from 40 to 1000. This observation indicates that, this survey has widely covered the iron foundries situated in Coimbatore which varied with regard to their sizes and capacities. As shown in Table 3.1. The weight per unit of the casting also varied among the iron foundries which responded to this survey. Further among the iron foundries using induction furnace, the weight per unit of casting varied from 0.5 Kilogram (Kg) to 3000Kg.
Among their on foundries using cupola, the weight per unit of casting varied from 0.2kg to 60kg. These wide variations noticed also indicated that, the survey was uniformly spread across the iron foundry cluster of Coimbatore district.

In Table 3.2, the details of induction furnace used in foundries and the type of PCD employed in them are indicated. As shown in this Table, the power is supplied in mono, dual and tri tracks. The power capacity of all the foundries is also same with the exception of units 12 and 13, in which case it is considerable high with the values 1250kw. As shown in Table 3.2, Wet scrubber is used in as many as nine units, Bag filter is employed in four foundry units. In two foundry units, Venturi Scrubber is used. Thus, though wetscrubber is predominately used in foundry units, other type of PCD, are also used in iron foundry cluster of Coimbatore.

In Table 3.3, the details of the cupola used in the iron foundries which participated in the questionnaire based survey being reported here. As shown, one or two cupola units are utilized in these iron foundries varied from one to three tones of hour. These cupola have been developed by these foundry units. The different types of cupola and instruments used in them are narrated in section 3.7.

In consequence to the results of analyzing the data, in depth interview was conducted with managers of a foundry where both induction and cupola furnaces are used. This interview was conducted to understand practically the cupola design, metal consumption, refractory consumption, fuel consumption, operational controls, standardization and documentation. Further, iron foundries were also visited to observe the operation of cupola utilized in them. These visits were supplemented by the detailed discussion with the field experts. In order to obtain more information, correspondence was made with cupola experts, manufacturers, designers, manufacturers of instrumentation and auxiliary equipment.
Additional information were gathered from technical papers, reports, surveys, technical literature on equipment, refractories, alloys and published data on cupola accessories. Some other information such as cupola types, design details (including refractory), raw material, instrumentation, auxiliary equipment, operational norms, were also gathered by interviewing the field experts. The information thus gathered are briefly presented in the following subsections.

Table 3.1 Comparative analysis of cupola furnace and induction furnace

<table>
<thead>
<tr>
<th>Unit</th>
<th>Type of foundry</th>
<th>Location</th>
<th>Tonnage of good casting capacity (Tones/Month)</th>
<th>Product manufactured using the castings produced</th>
<th>Casting supplied to manufacture</th>
<th>Furnace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>Captive</td>
<td>Industrial</td>
<td>1000</td>
<td>750gm to 30kg</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 2</td>
<td>Captive</td>
<td>Industrial</td>
<td>1200</td>
<td>500gm to 80kg</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 3</td>
<td>Captive</td>
<td>Industrial</td>
<td>1200-1500</td>
<td>6kg avg.</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 4</td>
<td>Captive</td>
<td>Industrial</td>
<td>400</td>
<td>5kg</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 5</td>
<td>Captive</td>
<td>Industrial</td>
<td>400</td>
<td>6kg avg.</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 6</td>
<td>Captive</td>
<td>Industrial</td>
<td>800</td>
<td>0.5kg to 50kg</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 7</td>
<td>Captive</td>
<td>Industrial</td>
<td>700</td>
<td>1kg to 60kg</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 8</td>
<td>Captive</td>
<td>Industrial</td>
<td>550</td>
<td>0.5kg to 50kg</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 9</td>
<td>Captive</td>
<td>Industrial</td>
<td>200</td>
<td>0.5kg to 50kg</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 10</td>
<td>Captive</td>
<td>Industrial</td>
<td>800</td>
<td>5kg avg.</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 11</td>
<td>Captive</td>
<td>Industrial</td>
<td>1200-1500</td>
<td>6kg to 100kg</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 12</td>
<td>Captive</td>
<td>Industrial</td>
<td>1500</td>
<td>1kg to 3000kg</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 13</td>
<td>Captive</td>
<td>Industrial</td>
<td>1700</td>
<td>0.5kg to 3500kg</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 14</td>
<td>Captive</td>
<td>Industrial</td>
<td>250000</td>
<td>500kg to 21000kg</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 15</td>
<td>Captive</td>
<td>Industrial</td>
<td>500</td>
<td>10kg to 30000kg avg.</td>
<td>Pumps</td>
<td>Induction</td>
</tr>
<tr>
<td>Unit 16</td>
<td>Captive</td>
<td>Industrial</td>
<td>1000</td>
<td>750gm to 30kg</td>
<td>Pumps</td>
<td>Cupola</td>
</tr>
<tr>
<td>Unit 17</td>
<td>Captive</td>
<td>Industrial</td>
<td>60</td>
<td>0.2kg to 40kg</td>
<td>Pumps</td>
<td>Cupola</td>
</tr>
<tr>
<td>Unit 18</td>
<td>Captive</td>
<td>Industrial</td>
<td>500</td>
<td>400gm to 10kg</td>
<td>Pumps</td>
<td>Cupola</td>
</tr>
<tr>
<td>Unit 19</td>
<td>Captive</td>
<td>Industrial</td>
<td>200</td>
<td>400gm to 10kg</td>
<td>Pumps</td>
<td>Cupola</td>
</tr>
<tr>
<td>Unit 20</td>
<td>Captive</td>
<td>Industrial</td>
<td>500</td>
<td>400gm to 10kg</td>
<td>Pumps</td>
<td>Cupola</td>
</tr>
<tr>
<td>Unit 21</td>
<td>Captive</td>
<td>Industrial</td>
<td>500</td>
<td>7kg to 15kg</td>
<td>Pumps</td>
<td>Cupola</td>
</tr>
<tr>
<td>Unit 22</td>
<td>Captive</td>
<td>Industrial</td>
<td>624</td>
<td>4kg to 6kg</td>
<td>Pumps</td>
<td>Cupola</td>
</tr>
<tr>
<td>Unit 23</td>
<td>Captive</td>
<td>Industrial</td>
<td>40</td>
<td>200gm to 40kg</td>
<td>Pumps</td>
<td>Cupola</td>
</tr>
<tr>
<td>Unit 24</td>
<td>Captive</td>
<td>Industrial</td>
<td>600</td>
<td>1kg to 45kg</td>
<td>Pumps</td>
<td>Cupola</td>
</tr>
<tr>
<td>Unit 25</td>
<td>Captive</td>
<td>Industrial</td>
<td>100</td>
<td>5kg to 60kg</td>
<td>Pumps</td>
<td>Cupola</td>
</tr>
</tbody>
</table>
Table 3.2  Details of Induction furnace and type of pollution control devices used in foundries

<table>
<thead>
<tr>
<th>Unit</th>
<th>No. of furnace used</th>
<th>Power capacity</th>
<th>Details of furnace</th>
<th>Tapping</th>
<th>Pollution control device</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unit 1 4 1500kW Dual Track 2Sets</td>
<td>2T(4Nos.) Medium Frequency</td>
<td>Batch</td>
<td>Venture wet Scrubber</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 2 2 496kW Main Frequency</td>
<td>1.5T and 2T Dual Track</td>
<td>Main and Medium Frequency</td>
<td>Batch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 3 2 1000kW Dual Track</td>
<td>2T(4Nos.) Medium Frequency</td>
<td>Batch</td>
<td>Normal Wet Scrubber</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 4 2 1000kW Dual Track</td>
<td>1.5T (4Nos.) Medium Frequency</td>
<td>Batch</td>
<td>Normal Wet Scrubber with packed bed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 5 2 750kW Dual Track</td>
<td>1T Medium Frequency</td>
<td>Batch</td>
<td>Normal wet scrubber with packed bed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 6 2 1000kW Dual track 1.5T</td>
<td>1.5T (1N0.) Medium Frequency</td>
<td>Batch</td>
<td>Venture Wet Scrubber with packed bed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 7 6 2750kW Tri track 1.5T</td>
<td>2T Medium Frequency</td>
<td>Batch</td>
<td>Normal Wet Scrubber</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 8 6 2750kW Tri track 1.5T</td>
<td>2T Medium Frequency</td>
<td>Batch</td>
<td>Normal Wet Scrubber</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 9 2 1600lW Mono Track 3T</td>
<td>3T Medium Frequency</td>
<td>Batch</td>
<td>Normal Wet Scrubber with baffle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 10 6 1750kW Dual Track</td>
<td>1.5T Medium Frequency</td>
<td>Batch</td>
<td>Common Stack with swiveling hood wet scrubber</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 11 3 2750kW Tri Track 600 Cycles(600Hz)</td>
<td>2T Medium Frequency</td>
<td>Batch</td>
<td>Common stack with dry type with bag filter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 12 2 1250kW</td>
<td>4T Medium Frequency</td>
<td>Batch</td>
<td>Side Draught common stack dry type with bag filter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 13 6 1250kW</td>
<td>2.5T 2set Dual Track</td>
<td>Medium Frequency</td>
<td>Batch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 14 6 8000kW</td>
<td>12T 3Set Dual Track</td>
<td>Medium Frequency</td>
<td>Batch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 15 2 700kW 3.5T main frequency, 750kW 2T</td>
<td>3.5T Medium Frequency</td>
<td>Batch</td>
<td>Normal Wet Scrubber</td>
</tr>
<tr>
<td>Unit</td>
<td>Number of furnaces</td>
<td>Capacity (Tones/hr)</td>
<td>Size</td>
<td>Make</td>
<td>Type</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------</td>
<td>---------------------</td>
<td>------</td>
<td>---------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Unit 16</td>
<td>2</td>
<td>3</td>
<td>27”</td>
<td>Own make (TERI design Energy Efficient)</td>
<td>Divided blast Cupola</td>
</tr>
<tr>
<td>Unit 17</td>
<td>2</td>
<td>2</td>
<td>24”</td>
<td>Own make</td>
<td>Divided blast cupola</td>
</tr>
<tr>
<td>Unit 18</td>
<td>2</td>
<td>2</td>
<td>24”</td>
<td>Own make</td>
<td>Divided blast cupola</td>
</tr>
<tr>
<td>Unit 19</td>
<td>1</td>
<td>1</td>
<td>18”</td>
<td>Own make</td>
<td>Conventional cold blast</td>
</tr>
<tr>
<td>Unit 20</td>
<td>1</td>
<td>1</td>
<td>18”</td>
<td>Own make</td>
<td>Divided blast cupola</td>
</tr>
<tr>
<td>Unit 21</td>
<td>1</td>
<td>1</td>
<td>24”</td>
<td>Own make</td>
<td>Divided blast cupola</td>
</tr>
<tr>
<td>Unit 22</td>
<td>2</td>
<td>2</td>
<td>36”</td>
<td>Own make</td>
<td>Divided blast cupola</td>
</tr>
<tr>
<td>Unit 23</td>
<td>1</td>
<td>2</td>
<td>18”</td>
<td>Own make</td>
<td>Divided blast cupola</td>
</tr>
<tr>
<td>Unit 24</td>
<td>2</td>
<td>2</td>
<td>27”</td>
<td>Own make</td>
<td>Divided blast cupola</td>
</tr>
<tr>
<td>Unit 25</td>
<td>2</td>
<td>2</td>
<td>18”</td>
<td>Own make</td>
<td>Divided blast cupola</td>
</tr>
</tbody>
</table>
3.6 INDUCTION FURNACE IN IRON FOUNDRIES

An induction furnace is an electrical furnace in which heat is applied by the induction heating of metal. The induction furnace employs a clean, energy-efficient and well-controllable melting process. The superior characteristics of this type of furnace triggers the owners by most modern foundries and many iron foundries to replace cupola with it to melt cast iron, as the former emit lots of dust and other pollutants.

The capacity of induction furnace ranges from less than one kilogram to one hundred tones. Induction furnaces are used to melt iron and steel, copper and aluminum. Since no arc or combustion is used, the temperature of the material is no higher than that is required to melt it. This characteristic prevents the loss of valuable alloying elements. The construction and working principles are presented in the following subsections.

3.6.1 Construction of Induction Furnace

An induction furnace consists of an outer cylindrical steel shell hinged at the bottom to facilitate tilting of furnace during pouring. The inner surface of the shell is covered with an insulating material made of mica or asbestos, while the bottom surface is covered with refractory bricks. A refractory crucible which contains the metal charge rests on the brick work and surrounded by a helical coil made of copper tube.

The copper tube being a heavy tube requires active cooling and this is achieved by passing a flow of water through it. The space between the crucible and the shell is packed by a dry refractory mass that provides the necessary insulation.
3.6.2  Working Principle of Induction Furnace

The induction furnace works on the principle of a transformer in which the copper coil acts as a primary coil and the metal charge as secondary coil. When electric current is passed through the copper coil, a heavier secondary current is induced in the charge. Heat is generated due to the resistance of the metal causing it to melt.

With induction heating and melting, an electrically conducting object to be heated is situated in an alternating magnetic field. The object being heated need not be magnetic material to heat efficiently. This object can have a wide range of electrical conductivity so that most ferrous and non-ferrous metals can be heated and melted in this way. Direct induction heating and melting are possible only with conducting materials.

3.6.3  Types of Induction Furnace

Following five types of induction furnace are overcome in literature arena.

1. Coreless type induction furnace (high frequency)
2. Coretype induction furnace (low frequency)
3. Direct arc furnace
4. Indirect arc furnace
5. Resistance heat furnace

Out of all the above types, only coreless induction furnace is mainly used. In the following subsection, the construction, working, merits and demerits of coreless induction furnace are briefed.
3.6.3.1  Construction of coreless type induction furnace (High Frequency)

The construction by coreless type induction furnace (high frequency) is depicted in Figure 3.1. As shown, a crucible is impregnated inside with the refractory material. Impregnated refractories prevent the transfer of heat from the molten metal and damaging of the wall of the crucible. The outer side of the wall of the crucible is surrounded by an induction coil. This coil is made of copper. This induction coil is cooled by Cooling water channel which is centrally fixed.

![Figure 3.1 Construction of coreless induction furnace](image)

3.6.3.2  Working of coreless type induction furnace  (high frequency)

On connecting the induction furnace to the three phase electrical power line a high frequency current is passed through the water cooled copper induction coils. Now induction copper coils act as the primary coil of a transformer and the metal charge becomes the secondary coil of a transformer. This results in the inducing of heavy alternating secondary
current in the metal charge by the electromagnetic induction. This creates heat because the metal charge offers resistance to the passage of secondary current. This heat developed in the skin of metal charge reaches inside by conduction and melts the metal charge.

3.6.3.3 Advantages of coreless type induction furnace (high frequency)

Following are the advantages of the coreless type induction furnace:

1. A coreless type induction furnace can melt a wide variety of metals and alloys quickly.
2. On melting, molten metal requires uniform melt composition.
3. Compared to core type, the construction of coreless type induction furnace (high frequency) is simple in construction.
4. In coreless type induction furnace (high frequency), rate of energy input can be easily controlled.
5. In coreless type induction furnace (high frequency), the furnace atmosphere can be easily controlled.

3.6.3.4 Limitations by coreless type induction furnace (high frequency)

Following are the limitations of coreless type induction furnace (high frequency):

The initial cost of installing coreless type induction furnace (high frequency) is high.

1. High quality metals can only be melted using coreless type induction furnace (high frequency) in smaller quantities.
2. Despite the above two limitation
3. The capability of coreless type induction furnace (high frequency) is preventing the pollution attracts the owners of the foundries to employ it for melting the metals

3.7 CUPOLA AND FOUNDRIES

The information drawn about the cupola and their usage in melting metals in iron foundries are briefly presented in the following subsections.

3.7.1 Types of Cupola

It was found that, DBC is the most commonly used cupola used in foundry cluster of coimbatore. This statement holds good in the case of iron foundries situated in other parts of India too. Types of cupola used in foundries are auxillairy blast cupola, balanced blast cupola, conventional cold blast cupola and hot blast cupola.

Since only conventional blast cupola and divided blast cupola were commonly used in iron foundries located in Coimbatore, the characteristics of these types of cupola are discussed in the following subsections.

3.7.1.1 Conventional cold blast cupola

As shown in Table 3.3, only one foundry unit utilizes conventional cold blast cupola. It is stated that, if conventional cold blast cupola is designed scientifically and operated with standardized recommended practice, then the efficiency of the same and quality of melt could be high. The efficiency of this cupola can be further enhanced by using low ash coke.
3.7.1.1 Advantage

The advantages of utilizing conventional cold blast cupola are enumerated below

a. Installation cost of conventional cold blast cupola is low.

b. No specialized knowledge needed for running the conventional cold blast cupola once all operational norms are standardized.

3.7.1.2 Disadvantages

The disadvantages of utilizing conventional cold blast cupola are enumerated below.

a. Thermal efficiency of conventional cold blast cupola is low as un-burnt carbon monoxide gas leaves the stack.

b. Beyond certain limit, the temperature of the metal charge or degree of super heating of metal charge cannot be improved.

c. Coke consumption is more as compared to the DBC to get same degree of super heating of metal charge.

d. Carbon pick up is less in conventional cold blast cupola while melting scrap.

3.7.1.2 Divided blast cupola

As shown in Table 3.3, DBC is utilized in nine iron foundries which participated in the questionnaire based survey. In DBC, the secondary tuyere level is about 2 metres above the primary rows of tuyere. At this level the carbon monoxide produced at the main tuyere is burnt by the fresh
oxygen. This gives out more heat to increase coke bed temperature which in turn increases the temperature of metal charge. The hotter metal charge becomes more fluid and absorbs more sulphur.

3.7.1.2.1 Advantages

Following are the advantages of utilizing DBC

i. When DBC is used, higher temperature of metal charge is achieved with same or less coke consumption if increase in the temperature of metal charge is not needed as compared with conventional cupola.

ii. When DBC is used, metal grade could be improved as more steel scrap could be used. Metal with low sulphur and better carbon pick up could be produced even by using scrap.

iii. DBC could be run for long duration, without any trouble and with consistency in quality and composition of metal charge.

iv. As the exhaust gases coming out of DBC contain low carbon monoxide (0-5%), the temperature of the exhaust gases is low. The temperature of the exhaust gas coming out of DBC ranges from 200° C to 250° C.

3.7.1.2.2 Disadvantages

Following are the disadvantages of utilizing DBC

i. Design of DBC is complicated as compared to the conventional cupola and needs expert’s help to design the furnace.
ii. While operating DBC, in comparison to the other types of cupola, more coke is needed initially to prepare the coke bed due to the existence of secondary tuyeres. In order to compensate the consumption of this additional coke, the total duration of heating should be more, by at least 8 hours. The air quantities on each row are to be monitored continuously during the operation of DBC. Hence, one skilled supervisor is necessary to control and document all the working details of DBC.

Majority of the cupolas have been designed to suit the needs of the corresponding foundry units. The foundry units employing DBC which are cited in Table 3.3 are located in different foundry clusters of Coimbatore. The DBC employed in foundries located in a particular cluster are generally of the same size and design are utilized to practice similar type of castings.

The inefficient working of DBC is due to the poor faulty designs. However it is thought that, quality of metal charge and cokes used are the causes of inefficient working of DBC. Any modifications made in DBC at any foundry to improve its performance are immediately adopted in other foundries.

The effective DBC shaft height is from top of tuyeres upto the bottom of the charging door. It has been observed that it is either too high or too low in foundries wherein it is used.

The height of the shell above the charging door is known as the chimney height. The chimney height is always less than the recommended one. In some of the units, it is totally absent. The material is charged in the
DBC, right from the top. It becomes impossible to stand on the charging platform once the blower is on.

### 3.7.2 Cupola Instrumentation

As shown in Table 3.3, different types of instrumentation are employed in the iron foundries in which cupola is used. Yet the results of the questionnaire based survey reveals that, there is still too much dependence on skills and judgement of the cupola operator rather than using instrumentation. Very few iron foundries were found to be equipped with properly maintained instrumentation.

As shown in Table 3.3, the following instrumentation of cupola is employed in the iron foundries

1. Air pressure gauge
2. Blast volume meter,
3. Weighting scales for weighing charges,
4. Coke bed height gauge,
5. Immersion type pyrometer to measure temperature of molten metal.
6. Carbon equivalent meter.

The inefficient use of the above instruments retards the efficiency of the performance of DBC.

### 3.7.3 Quality of Coke

Nowadays, imported coke with ash content less than 7% are available in India due to the enactment of the new liberal economical policy.
Yet low ash coal is also imported to produce coke with about 10% ash content. However, both these varieties are not still very widely used. While the imported coke is mainly used by big foundries, the low ash coke is used in certain foundries which are situated close to the actual manufacturer. The majority of foundries, the option is to use Bee Hive coke or B.P coke with ash content rating from 25% to 35%.

It is noted that, the crushing strength of Indian coke is low and is highly reactive. In certain varieties of bee hive coke, the coking is not complete. The sticky tarry material that oozes out during melting coke leads to the blowing of molten metal.

3.7.3.1 Met coke in cupola

This met coke is a specially prepared metallurgical coke with low and more crushing strength. Met coke is a Bee hive coke coked in private colliers in Juharia belt of India. It may sometime be available with more volatile matter and very low crushing strength.

3.7.3.2 Refractories for lining cupola internal wall

In the case of cupola, the refractories act as the primary materials. Failure of refractory lining may lead to losses in terms of energy, material, time and man power. Segmented circular fire clay bricks which are locally made are popularly used in cupolas. These bricks do not meet the desired standard of IS6 and IS8 as claimed by the manufacturers. Also, care is not taken to confirm the chemical composition such as silica, alumina and iron oxide. The physical properties such as cold crushing strength, porosity,
spalling test and bulk density of the bricks are not known to many foundry men of iron foundry clusters of India.

### 3.7.3.3 Raw materials

Following raw materials are used while operating the cupola in iron foundries of India.

#### 3.7.3.3.1 Pig iron

Foundries in Coimbatore are dependent on the pig iron supplied by Steel Authority of India Limited (SAIL) for producing the castings. The demand for pig iron always used to be higher than the supply. Moreover it has been difficult to get low sulphur, low manganese and high carbon pig iron as SAIL is mainly run for producing pig iron for steel making. After 1991-1992, private companies were allowed to produce pig iron. Import of pig iron is also allowed.

Presently, in India, the availability of foundry grade pig iron is more than the demand. High carbon content of the particular variety of pig iron is one of the typical problems faced by few iron foundries of India. This restricts the use of pig iron proportion in the metal charge and makes the use of steel mandatory. Problem in getting higher grade cast iron from cupola can be caused by sulphur content found even in steel scrap.

#### 3.7.3.3.2 Ferro alloys

Foundrymen indicated that, ferro alloys produced indigenously are of poor quality. Particularly the chemical composition of ferro alloys is not
consistent. The price of ferro alloys is also higher than that at which it is sold in international markets.

3.7.3.4 Problem encountered during cupola operation

Some problems are encountered in iron foundries while operating the cupola. Particularly, erosion of refractories is high even when the heat is less. The reason for the high rate of erosion of refractory is attributed to the poor quality of refractory material used.

The coke bed required to be prepared by measuring the coke in volume. However, it is prepared by weighting the coke. Though foundry men are familiar with the importance of charge size, the appropriate charge size is often not rightly ensured in iron foundries of India. Pre-processing of scrap involving the removing of rust and dirt is not done. The chemical composition is checked leniently. Though chill test liquid metal is carried out, standardized procedures are not followed.

3.8 CONCLUSION

In iron foundries melting plays a crucial role. Though many furnaces are mentioned in literature arena, in the foundry cluster of Coimbatore, predominantly induction and cupola furnaces are employed. Out of the 25 iron foundries 15 of them use induction furnace and 10 of them use cupola furnace. The induction furnace is considered as the most efficient furnace for melting. Metal charge in iron foundries. Besides induction furnace emit less pollutants. Yet due to the strict regulation of state power utilities which have imposed a strict time limits on the use of electricity of these iron foundries, most of them are forced to use cupola furnace to meet the delivery
schedules. Hence, after gathering relevant information through the questionnaires based survey, the situation prevailing in iron foundries employing cupola in iron foundry clusters of Coimbatore were studied. The outcome of these studies have been presented in this chapter. After drawing these observations, the study on controlling pollution in iron foundries located in the foundry clusters of Coimbatore was carried out. The details of this study are presented in the next chapter.