CHAPTER II
THE TILE INDUSTRY IN KERALA -
AN OVERVIEW

INTRODUCTION

2.1 Ceramics

The discovery of ceramics ranks as one of man's earliest scientific achievements. The early history of man is traced mainly through his ceramics. Tile is a ceramic product made of clay. Ceramic materials are chiefly of a mineral nature, consisting mainly of silica, alumina, lime, magnesia, iron oxide, soda, potash and compounds of these substances.

The word 'Ceramic' is derived from the Greek word "keramikos", originally meaning burnt stuff (William Lee, 1961). In a general sense ceramics may be defined as 'materials and articles made from naturally occurring earths" (Searle and Grimshaw, 1960). According to Encyclopaedia Britannica (1973), "all production of which the final result is baked clay in different grades of hardness and purity is to be considered as ceramics". "Ceramics is the art and technology of making objects of clay and similar materials treated by firing" (Ceramics: The Random House College Dictionary, 1988). Ceramics is largely synonymous with pottery and other articles made of burned clay. The word "pottery in its widest sense includes all objects fashioned from clay and then hardened by fire" (Encyclopaedia Britannica, 1947). More recently, it was customary to define ceramic product as an article made from clay with or without the addition of other materials. It now includes cement, refractories, glass, whitewares and fired building materials and abrasives (R. Poornam, 1966).
2.1.1 Classification of Ceramic Products

Ceramic products are innumerable according to their physical and chemical properties. Ceramic products are generally classified into four groups, viz., structural clay products, refractories, pottery and miscellaneous ceramic products (Searle and Grimshaw, 1960). A general classification of ceramic products is given in Table 2.1.
### Table 2.1

**A General Classification of the Different Ceramic Products**

<table>
<thead>
<tr>
<th>Type of product</th>
<th>Structural Clay Products</th>
<th>Refractories</th>
<th>Pottery</th>
<th>Miscellaneous ceramic products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Building bricks of all types, Hollow blocks; Terra-cotta</td>
<td>Fireclay bricks and raw fireclay, Silica and siliceous-bricks and raw stone, Magnesite bricks, Chrome bricks, Chrome-magnesites, Dolomite bricks, Carbon bricks, Silicon carbide bricks and shapes, Insulating refractories, Sillimanite bricks, High (over 50 per cent) alumina bricks, Retorts, Crucibles, Ladles, etc., for metallurgical, gas-plant, scientific and other applications.</td>
<td>Glazed wall and earth tiles, Domestic and Sanitary Earthen-ware, Bone china (chinaware), Porcelain (domestic, laboratory, industrial) Stoneware, Glazes and Engobes</td>
<td>Fused silica, Special Refractories, Electrical ware, Cements, Glasses, Glazes, Enamels</td>
</tr>
</tbody>
</table>

According to this classification, all articles made chiefly from clay, used in building construction and other civil engineering works are included in the classification of structural clay products.

The ceramic products in Kerala are classified as follows.

TABLE 2.2

CLASSIFICATION OF CERAMIC PRODUCTS IN KERALA

<table>
<thead>
<tr>
<th>White ware Products</th>
<th>Stoneware Products</th>
<th>Refractory Products</th>
<th>Red Clay Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crockery ware</td>
<td>Stoneware pipes</td>
<td>Refractories and fire clay insulation bricks</td>
<td>Roofing tiles</td>
</tr>
<tr>
<td>Sanitary ware Plates</td>
<td>Stoneware containers</td>
<td></td>
<td>Flooring tiles and other types of tiles, Ridges, Wirecut bricks and other casual type bricks.</td>
</tr>
<tr>
<td>Plates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical-insulators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(L.T), etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


The classification of ceramic products shows that tile and brick form an important constituent of ceramic group. Clay is the basic raw-material of tile and brick making.

2.2 Clay Products as Roofing Materials

Clay products as roofing material began to replace straw and leaf thatching only in a much later era of human civilization. Tile is "a thin, flat slab, usually of burnt clay, glazed or unglazed, used either structurally or decoratively in building" (Encyclopaedia Britannica, 1947. ed). The American Educator Encyclopaedia (1962, ed.) defines tile as "a slab of baked clay used in covering roofs, paving floors decorating walls and carrying of drainage". Tile industry embraces a wide variety of terracotta clay products.
Tiles used for roofing purpose are generally known as roofing tiles. These sophisticated materials were first developed primarily with the intention of providing a somewhat permanent roofing to the sacred places of worship. Historical evidence goes to prove that the early man gave much priority in the matter of a permanent roofing to the abode of Gods.

2.2.1 Roofing Tiles in Different Countries

Roofing tiles of different size and nature are used in different countries. The Arabs and Moors produced beautiful tiles and used them in palaces and prayer halls (Lelitia Moneteiro, 1989). In ancient Greece, terracotta roofing tiles were used for common residential buildings. The Romans roofed their houses with clay tiles called Tegula (Lelitia Moneteiro, 1989). It is known that bronze roofing tiles were relatively common on the most monumental buildings of the Roman empire (Searle and Grimshaw, 1960). In 1851 Gilardine invented Marseilles tiles and France is considered as the place of origin of this pattern of roofing tile (Lelitia Moneteiro, 1989). In 1852, a kind of Marseilles tile called 'Mountain tile' was introduced by Sechmidturez in Switzerland (Moneteiro, 1989). There are evidences of wide use of roofing tiles named 'pantiles' in Italy. In India, it is evident that the houses in Mangalore used rounded roofing tiles in the seventeenth century. Clay roofing tiles used at present are substantially of the same form; improvements have been only in methods of manufacture and not in design. Tiles of different designs are used in England, parts of France, Italy, Spain, Greece, Turkey and the Mediterranean. Although the principle of the roofing tile of China and Japan is the same as that in the West, there are many differences, particularly in design (Searle & Grimshaw, 1960). The following Table shows the nature of tiles in different countries.
TABLE 2.3

WORLD CENTRES OF TILE PRODUCTION

<table>
<thead>
<tr>
<th>Country</th>
<th>Nature of Tiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia Minor</td>
<td>Persian</td>
</tr>
<tr>
<td>North Africa, Spain</td>
<td>Moorish, Spanish</td>
</tr>
<tr>
<td>North Italy</td>
<td>Faience</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Delft</td>
</tr>
<tr>
<td>Belgium</td>
<td>Handmade wall tiles</td>
</tr>
<tr>
<td>Germany</td>
<td>Poly chrome, machine pressed floor tiles</td>
</tr>
<tr>
<td>England</td>
<td>Gothic models</td>
</tr>
<tr>
<td>United States</td>
<td>Vitrified floor tiles, hand made tiles</td>
</tr>
</tbody>
</table>


For convenience of analysis and presentation, the chapter is organized in two sections. Section A contains an analysis of the origin and growth of tile industry in India and Kerala. This is followed by a brief description regarding the manufacturing process of the tile industry in Section B.

SECTION A

2.3 Origin and Growth of Tile Industry in India

It was in the year 1865 that the first tile making industry established in India at Mangalore by the Basel Mission. Mr. Karl George Andreas Plebst was the brain behind this venture who encouraged the Mission to start the first tile factory at Jeppo. The Missionaries introduced the pattern of tiles which were so far being produced in France and Germany. Therefore, the tiles of this pattern were known as Mangalore pattern tiles, wherever they were produced in India. The tiles manufactured by them have been found to be of immense use to the public and the Government, and the latter, as a mark of its appreciation, issued order to their Public Works Department to use Mission
tiles for all public buildings. The Government further evinced their appreciation by giving as an encouragement to this industry, a considerable quantity of firewood grates from their forests. The second tile factory was started at Calicut in the year 1873. Later it was deemed necessary to start new factories in other Mission stations as well. Accordingly in the year 1882, a factory was started at Kudroli. Another factory at Malpe, near Udipi was started in the year 1886; the fifth at Codacal was established in 1894 and the sixth at Palghat was started in the year 1887. The seventh factory was established at Feroke in the year 1905. The products of these seven factories were sold throughout the Indian Empire, Burma and Ceylon and were also exported to other foreign countries.

Till the year 1960, tile industry was concentrated in a few areas like Mangalore in Karnataka State and Calicut, Alwaye, Trichur and Quilon in Kerala State. Gradually, tile units came to be established in other parts also. The most important centres are Morvi (Gujarat), Godavari, Samalkot, Hyderabad, Jagganpet (A.P) and Kundapur, Mysore and Bangalore (Karnataka). The growth performance of the industry in India is presented in Table 2.4.
### Table 2.4

**Growth Performance of Tile Industry in India**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of units</td>
<td>266</td>
<td>345</td>
<td>509</td>
<td>560</td>
</tr>
<tr>
<td></td>
<td>(29.70)</td>
<td>(47.54)</td>
<td>(10.01)</td>
<td></td>
</tr>
<tr>
<td>Average No. of working days</td>
<td>270</td>
<td>279</td>
<td>280</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td>(3.33)</td>
<td>(0.36)</td>
<td>(0.00)</td>
<td></td>
</tr>
<tr>
<td>Productive capital (Rs. in lakh)</td>
<td>352.68</td>
<td>859.16</td>
<td>898.30</td>
<td>902.32</td>
</tr>
<tr>
<td></td>
<td>(143.61)</td>
<td>(4.56)</td>
<td>(0.45)</td>
<td></td>
</tr>
<tr>
<td>Fixed capital (Rs. in lakh)</td>
<td>246.55</td>
<td>627.77</td>
<td>713.84</td>
<td>790.24</td>
</tr>
<tr>
<td></td>
<td>(154.62)</td>
<td>(13.71)</td>
<td>(10.70)</td>
<td></td>
</tr>
<tr>
<td>Working Capital (Rs. in lakh)</td>
<td>106.12</td>
<td>231.39</td>
<td>284.43</td>
<td>312.23</td>
</tr>
<tr>
<td></td>
<td>(118.04)</td>
<td>(22.92)</td>
<td>(9.77)</td>
<td></td>
</tr>
<tr>
<td>Persons Employed</td>
<td>19,976</td>
<td>22,470</td>
<td>23,686</td>
<td>24,840</td>
</tr>
<tr>
<td></td>
<td>(12.48)</td>
<td>(5.41)</td>
<td>(4.87)</td>
<td></td>
</tr>
<tr>
<td>Gross Value of output (Rs. in lakh)</td>
<td>499.41</td>
<td>1290.20</td>
<td>2816.63</td>
<td>3415.21</td>
</tr>
<tr>
<td></td>
<td>(158.34)</td>
<td>(118.30)</td>
<td>(21.25)</td>
<td></td>
</tr>
<tr>
<td>Gross value of input (Rs. in lakh)</td>
<td>230.45</td>
<td>696.20</td>
<td>966.19</td>
<td>1012.12</td>
</tr>
<tr>
<td></td>
<td>(202.10)</td>
<td>(38.78)</td>
<td>(4.75)</td>
<td></td>
</tr>
<tr>
<td>Value-added (Rs. in lakh)</td>
<td>268.96</td>
<td>595.00</td>
<td>1850.44</td>
<td>1986.10</td>
</tr>
<tr>
<td></td>
<td>(121.22)</td>
<td>(210.99)</td>
<td>(7.33)</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** (1) Figures in parenthesis indicate the growth rate over the previous year. (2) Data are not available regarding latest statistics on Tile industry.

**Source:** Compiled from Annual Survey of Industries, Census Sector, Industrial Statistics, CSO.
2.4 Tile Industry in Kerala: Origin and Growth

If paradise is green, Kerala is truly the garden of Eden. It is appropriate to call it God's own country for reasons like nature's bounty, evergreen land with two monsoons, synthesis of various cultures and a land where there is a confluence of many religions. The peculiar development pattern of Kerala having high Human Development Index (HDI) at a low per capita income has attracted the attention of reputed development economists, anthropologists as well as scholars of different disciplines.

The State of Kerala was formed on 1st November, 1956 by integrating the princely States of Travancore, Cochin and the Malabar part under the Madras presidency. Kerala is a narrow strip of land along the western coast of India. Nature has been bountiful to this narrow strip of the country sandwiched between the Arabian sea and the Western Ghats. Kerala, a tropical paradise, is a land of colours and contrasts where yesterday, today and tomorrow blend in graceful harmony.

The development experience of Kerala received so much international acclaim that some scholars even encoded the "Kerala Model" of development, defined as a set of high material quality of life indicators coinciding with low per capita income through a set of wealth and resource redistribution programmes (Franke and Chasin, 1992).16

Broadly, Kerala passed through three phases of economic growth, (1) a period of slow growth in the sixties, (2) a period of stagnation from the early 1970’s until the late 1980’s and, (3) a period of revival and high growth thereafter. Its growth recovery during the nineties is remarkable and more impressive than the all India average. The State's GDP grew by 9.2 per cent in 2004-05 and by 11.8 per cent in 2005-06. Indeed one might characterize
Kerala's economy as a crouching tiger, harnessing its power and ready to leap (Arun Kumar, 2007).17

Kerala is an industrially backward State. There are two phases of industrialization in Kerala during pre-independence period. The first phase was characterized by the pondering of small and cottage industries which were dominated by agro-based units. The second phase started with certain policy initiatives of Government of Travancore. The changes in the industrial policies of Travancore are generally attributed to the Dewan of Travancore, Sir. C.P. Ramaswamy Aiyer.

In the post 1950 period, in Kerala, there have been three important players in industrial development; the Government of India, the State Government and the private sector. The real big push to industrialization of the State came in the seventies with big investment in modern industries and stabilization of traditional industries.

However, after 1950s, Kerala's industrial growth performance was worse than the all-India record and worse than the other three south Indian States. According to the Central Statistical Organisation's (CSO's) advance estimate, real GDP growth originating from the industrial sector was only 7.4 per cent in 2004-05 which increased to 7.6 per cent in 2005-06.

Kerala has been the traditional home of several small-scale industries in India. There has been a continuous increase in the number of small-scale units in Kerala. As on March 2006 there were 1,93302 working small-scale units in Kerala with an investment of Rs. 5,91439.65, providing employment to 7,10508 persons (Government of Kerala, 2006).18 This sector contributes to 40 per cent of industrial production and 35 per cent of direct exports. Tile industry is an important small-scale industry of Kerala.
Kerala has been an attractive destination for traditional industries. However, the industrial basket in Kerala has expanded in the last decade to include tea, ceramics, bricks and tiles, soaps, oils and fertilizers.

Easy availability of raw-materials and ensured market for the finished goods are the two essential pre-requisites for the development of industry. In this respect Kerala is favourably placed as far as clay products manufacturing industry is concerned. Tile industry is one of the traditional industries of Kerala. The first tile factory was established at Calicut in 1873. A review of the growth of tile industry in Kerala would suggest three distinct stages in its development. These stages correspond to a period prior to the First World War, the interwar period and post Second World War period. The establishment of the pioneer factories in Kozhikode and Quilon districts towards the end of the 19th century constituted the first stage. It was an Englishman by name Cameron who established the first tile factory in Quilon in 1880 (Pillai, 1958). The products of these factories were of high quality. The proliferation of tile factories, especially in Trichur area may be considered as the second stage in the development of tile industry in Kerala. The first tile factory in the erstwhile Cochin State was established by Chakola Kunju Vareed Davasy in 1900 at Manali in the present Trichur district. These factories were generally small in size. Their working was almost on a cottage industry basis, employing only hand presses and small pug mills often run by bullocks. These factories did not possess much of the tile making machinery and their products were inferior to the older factories at Feroke and Quilon with higher mechanisation. The third stage in the development of tile industry was the spread of quality consciousness among the smaller manufacturers and the introduction of machinery by them. This was partly due to the development of the local engineering industry. As a result, mechanisation could be implemented in most of the medium and small-scale factories in the State at a faster rate.
2.4.1 Status of Tile Industry in Kerala

The growth performance of the tile industry since the formation of Kerala State is presented in Table 2.5. The growth performance has shown ups and downs during different periods. The number of factories in Kerala rose from 154 in 1960 to 337 in 1985. The number of factories increased to 427 in 1996. In the mid 1990s, there were about 430 major and minor tile manufacturing units in the State spread over almost all the districts barring Idukky.

But the situation changed for the worse in the late 1990s. Various factors have forced the closure of many of the tile factories in the State and the industry is now confined to the four districts - Kozhikode, Trichur, Ernakulam, (Alwaye) and Kollam. In Trichur, out of the 253 units only 160 are functioning, while in Kozhikode the number has come down from 30 to 7, in Ernakulam from 26 to 12 and in Kollam from 40 to just 2 (District Industries Centre, Trichur).

The pattern of growth was rather uneven as shown by the quinquennial growth rates. The growth rate in the number of factories between 1960 and 1965 was 48.7 per cent which was only 0.87 per cent during the period between 1965-70. There was an increase in the growth rate during 1970-75; the growth rate being 23.38 per cent. However, the growth rates remained more or less constant during 1975-80 and 1980-85 (8.42 per cent and 9.06 per cent respectively). The growth rate in the number has become negative after 1995.
## Table 2.5

**Growth Performance of Tile Industry in Kerala**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>154</td>
<td>229 (48.70)</td>
<td>231 (0.87)</td>
<td>285 (23.38)</td>
<td>309 (8.42)</td>
<td>337 (9.06)</td>
<td>344 (2.07)</td>
<td>430 (25.00)</td>
</tr>
<tr>
<td>Employment (Workers)</td>
<td>13323</td>
<td>10287 (-22.78)</td>
<td>12460 (21.12)</td>
<td>11287 (-9.14)</td>
<td>11686 (3.54)</td>
<td>12174 (4.17)</td>
<td>11915 (-2.13)</td>
<td>30000 (151.78)</td>
</tr>
<tr>
<td>Productive Capital (Rs. in lakh)</td>
<td>154.62</td>
<td>216.75 (40.18)</td>
<td>201.50 (-7.04)</td>
<td>342.54 (69.99)</td>
<td>898.30 (162.24)</td>
<td>989.20 (10.12)</td>
<td>3467.30 (250.52)</td>
<td>6458.33 (86.26)</td>
</tr>
<tr>
<td>Value of Output (Rs. in lakh)</td>
<td>270.00</td>
<td>299.06 (10.76)</td>
<td>306.73 (2.56)</td>
<td>749.16 (144.24)</td>
<td>1806.63 (141.15)</td>
<td>1959.65 (8.47)</td>
<td>4375.32 (123.27)</td>
<td>9604.36 (119.51)</td>
</tr>
<tr>
<td>Value of Input (Rs. in lakh)</td>
<td>134.69</td>
<td>144.81 (7.51)</td>
<td>142.51 (-1.59)</td>
<td>325.19 (128.18)</td>
<td>866.19 (166.36)</td>
<td>950.55 (9.73)</td>
<td>2297.70 (141.72)</td>
<td>5545.05 (141.37)</td>
</tr>
<tr>
<td>Value - added (Rs. in lakh)</td>
<td>135.31</td>
<td>154.25 (13.99)</td>
<td>164.22 (6.46)</td>
<td>423.97 (158.17)</td>
<td>940.44 (121.81)</td>
<td>1009.10 (7.30)</td>
<td>2077.62 (105.88)</td>
<td>4059.31 (95.38)</td>
</tr>
</tbody>
</table>

Note: (1) Figures in parenthesis indicate the growth rate over the previous year.

Source: Compiled from (a) Government of Kerala, Economic Review, State Planning Board, Trivandrum.
(c) D. Anantha Subramanian, President, The Central Tile Manufacturers Association, Trichur.
An analysis of employment potentiality in tile industry reveals the fact that there has been a decline in employment over the reference period. This trend is more remarkable during the period 1985-1990, despite an increase in the factories during the same period.

Productive capital has shown a mixed trend which recorded a negative growth rate during the period 1965-70 and positive growth rate during the period since 1970. The output and value-added figures have shown the lowest growth rates during the period 1965-1970.

2.4.2 Spatial Distribution

Table 2.6 depicts the district-wise distribution of tile factories in Kerala. Even though there are tile factories in 12 districts of the State, the highest concentration of factories is now found in Trichur (90 per cent) followed by Kozhikode (5 per cent) and Alwaye (3 per cent).

The major factors influencing the location or concentration of tile industry were the easy availability of good quality clay and firewood in the near vicinity. Historical factors were also responsible for the concentration of tile industry in certain districts in the State. Transport facilities are equally important in the location of this industry.
Table 2.6

District-wise Distribution of Tile Factories in Kerala for the Period 1965-2006

<table>
<thead>
<tr>
<th>Districts</th>
<th>1965</th>
<th>% to total</th>
<th>1985</th>
<th>% to total</th>
<th>1990</th>
<th>% to total</th>
<th>1995</th>
<th>% to total</th>
<th>2006</th>
<th>% to total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trivandrum</td>
<td>1</td>
<td>0.4</td>
<td>2</td>
<td>0.6</td>
<td>2</td>
<td>0.55</td>
<td>3</td>
<td>0.69</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Quilon</td>
<td>33</td>
<td>14.4</td>
<td>49</td>
<td>14.5</td>
<td>57</td>
<td>15.57</td>
<td>40</td>
<td>9.30</td>
<td>2</td>
<td>0.71</td>
</tr>
<tr>
<td>Alleppey</td>
<td>3</td>
<td>1.3</td>
<td>7</td>
<td>2.1</td>
<td>5</td>
<td>1.37</td>
<td>3</td>
<td>0.69</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kottayam</td>
<td>5</td>
<td>2.2</td>
<td>19</td>
<td>5.6</td>
<td>20</td>
<td>5.47</td>
<td>3</td>
<td>0.69</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ernakulam</td>
<td>16</td>
<td>6.9</td>
<td>36</td>
<td>10.7</td>
<td>35</td>
<td>9.56</td>
<td>26</td>
<td>6.04</td>
<td>9</td>
<td>3.18</td>
</tr>
<tr>
<td>Trichur</td>
<td>120</td>
<td>52.4</td>
<td>157</td>
<td>46.6</td>
<td>180</td>
<td>49.18</td>
<td>253</td>
<td>58.83</td>
<td>253</td>
<td>89.40</td>
</tr>
<tr>
<td>Palghat</td>
<td>14</td>
<td>6.2</td>
<td>14</td>
<td>4.2</td>
<td>14</td>
<td>3.83</td>
<td>12</td>
<td>2.79</td>
<td>1</td>
<td>0.35</td>
</tr>
<tr>
<td>Kozhikode</td>
<td>26</td>
<td>11.4</td>
<td>33</td>
<td>9.8</td>
<td>32</td>
<td>8.74</td>
<td>30</td>
<td>6.97</td>
<td>12</td>
<td>4.24</td>
</tr>
<tr>
<td>Cannanore</td>
<td>11</td>
<td>4.8</td>
<td>10</td>
<td>2.9</td>
<td>11</td>
<td>3.00</td>
<td>9</td>
<td>2.15</td>
<td>3</td>
<td>1.06</td>
</tr>
<tr>
<td>Wayanad</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1</td>
<td>0.27</td>
<td>15</td>
<td>3.48</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kasaragod</td>
<td>--</td>
<td>--</td>
<td>----</td>
<td>--</td>
<td>8</td>
<td>1.86</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>*Pathanamthitta</td>
<td>--</td>
<td>--</td>
<td>2</td>
<td>0.5</td>
<td>2</td>
<td>0.55</td>
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<tr>
<td>Idukki</td>
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<tr>
<td>** Malappuram</td>
<td>--</td>
<td>--</td>
<td>8</td>
<td>2.4</td>
<td>7</td>
<td>1.91</td>
<td>28</td>
<td>6.51</td>
<td>3</td>
<td>1.06</td>
</tr>
<tr>
<td>Total</td>
<td>229</td>
<td>100.00</td>
<td>337</td>
<td>100.00</td>
<td>366</td>
<td>100.00</td>
<td>430</td>
<td>100.00</td>
<td>283</td>
<td>100.00</td>
</tr>
</tbody>
</table>

*, ** These districts came into existence since 1965 and 1975 respectively.
3. District Industries Centre in Kerala.
2.5 Clay

Clay is the most important raw-material required for the manufacture of tiles. Clay deposits vary so greatly in physical conditions and chemical compositions that it is extremely difficult to group them into classes. An attempt has been made in this section to describe the basic characteristics of different kinds of clay.

2.5.1 Different kinds of Clay

It seems impossible to give a definition for clay that is inclusive and yet free from exceptions. The best that can be done is to define clay broadly as a hydrated earthy material, containing a considerable portion of alumina or silica and showing the property of plasticity (Norton, 1949). The term clay is known as "ARGIL" in Latin and is applied to those fine-grained earthy materials whose most prominent properties are - plastic when wet, capable of retaining shape when dried and formation of hard rock-like mass without losing the original contour when fired at red heat (Bose, 1948). The term "clay" is applied to those natural earthy deposits which possess the singular property of plasticity (Felix Singer & Singer, 1963). A concise definition of clay by the American Ceramic Society is as follows: "clay is a fine grained rock which, when suitably crushed and pulverised, becomes plastic when wet, leather-hard when dried and on firing is converted to a permanent rock-like mass" (Searle and Grimshaw, 1960).

The term 'clay' is used both as a rock-term and as a particle - size term. As a rock-term, clay implies a natural, earthy, fine-grained material which acquires varying degrees of distinct plasticity when mixed with a limited amount of water, and becomes hard and stone-like when heated to a suitable temperature. As a particle-size term, the clay is used to designate the smallest
particles of sedimentary rocks and soils. The maximum size of particles in the clay size grade is commonly considered to be 2µ (0.002 mm in diameter).

Daniel Rhodes has defined clay in his own words - "The clay may be defined as an earthy material substance composed largely of an hydrous silicate of alumina which becomes plastic when wet and hard and rocklike when fired" (Daniel Rhodes, 1969). The clay is a product of decomposition of rocks, rich in alumino-silicate minerals. The decomposition may be due to superficial weathering by atmospheric factor or the hydrothermal action. Geologically clays are composed of various minerals of primary and secondary origin. The principal components in clay may be classed as follows: silica, alumina, alkali-bearing minerals, iron compounds, calcium compounds, barium compounds, magnesium compounds, titanium compounds, manganese and other compounds, complex alumino-silicates, carbonaceous matter, moisture and colloidal water and exchangeable bases. Clay material includes clay, shales and argillites.

Clay is a very common substance, abundant in nature, in a great many types and varieties with differing physical and chemical properties which make it suitable for an amazing variety of uses. The different geological conditions produce clay of various chemical compositions and physical properties.

2.5.2 Classification

Clay deposits may be classified according to their origin, uses or combinations of any or all of these. However, no classification can be perfect, for one clay may be adapted for several widely differing uses. Of greater industrial use is a classification according to the properties and therefore uses of the clay as given by Norton (Singer and Singer, 1963)²⁵:
(a). White burning clay (used in whiteware). (b). Refractory clay (having a
fusion point above 1600°C but not necessarily white burning). (c) Heavy clay product clays (of low plasticity but containing fluxes). (d) Stoneware clays (Plastic, containing fluxes). (e) Brick clay (Plastic, containing iron oxide) (f). Slip clay (containing more iron oxide).

The clay commonly found is generally classified into five kinds, viz., china clay, ball clay, fire clay, refractory clay and brick and tile clay.

i) China Clay

It is white burning clay. China clay is a white powdery mineral with specific gravity of 2.6 and fusion point of 1785°C (William Lee. p.1961). China clay is synonymous with Kaolin. The term 'Kaolin' is derived from the two Chinese words 'Kao-Liang,' meaning "high ridge," a local designation for the area where white china clay is found. Kaolins include the purest clay known, and consists of alumina, silica and water. The Kaolins are notable for their great resistance to heat, their whiteness when fired, and their slight plasticity (Alfred B. Searle, 1953). It is extracted from felspathic rocks having no iron oxide. China clay has the characteristic behaviour of less shrinkage because of its coarse grain structure. China clay is widely used for making high quality alumino-silicate refractories owing to its high purity and refractoriness. It is also used in industries like paper, plastics, insecticides, fertilizers, textiles, paint, rubber and many other industries.

ii) Ball Clay

Ball clay is secondary clay. It is transported from the place of its origin by natural agencies. It is sedimentary clay of fine-grain size usually containing some organic matter and having good plasticity, high green strength and white or cream colour after firing. "It is sedimentary white burning clay of fine particle size, excellent plasticity and dry strength" (Kingery, n.d). It is similar to kaolin in mineral composition but its physical
properties are quite different. Its common characteristics are the presence of organic matter, high plasticity and strength, long vitrification range and exceptional whiteness when fired. Compared to china clay, ball clay is richer in silica and powder alumina. It contains a larger proportion of alkalies, iron-oxide and carbonaceous matter. The ball clay is so called because it is usually mined in the form of balls. The main characteristic of ball clay is that it can be put into use directly after extraction from the mines. It is sometimes used in refractories but its greatest use is in whiteware to make the body more plastic and workable. Ball clay is now used in the making of pottery articles, table wares, white wall tiles, electrical equipments, iron enamelling clays and fillers for paints.

iii) Fire Clay

Fire clay is the backbone of refractories industry. The so-called "fireclays" include nearly all clays that have a fusion point above approximately 1600°C (about 2900°F) and are not white burning. Fireclay may be described as an earthy plastic, detrital material in which the percentages of iron oxide, lime, magnesia and alkalies are sufficiently low to enable the material to withstand a temperature of at least 1500°C and preferably over 1600°C (Rao, 1966). Fire clay may be regarded as a variety of impure Kaolin. Fire clay is generally greenish, grey in colour, compact and dense in structure and varies in degree of hardness. Fireclay is generally found beneath the coal seams. It varies widely in composition and properties. It can be roughly divided into three types (Rao, 1966).

1. Flint fire clay which usually occurs as rock like masses; 2. Plastic fire clay, which can be broken down by water in a mouldable plastic mass; 3. Shales which are generally found in close association with coal seams and grey or black in colour.
Classification according to fusibility is also of importance.

(a) Highly refractory clay fusing above cone 33; (b) Refractory clay fusing from cone 31-33 inclusive; (c) Semi-refractory clay fusing between cones 27 and 30; (d) Clay of low refactoriness, low heat duty clay fusing between cones 20 and 26.

Thus, the basic characteristic of the fire clay is refactoriness. Fireclay is used in large quantities, especially in the manufacture of glazed bricks and other sanitary appliances.

(iv) Brick and Tile Clay

These comprise wide varieties of clay of varying composition, the clay mineral being of the kaolinitic or illitic type. It is invariably high in iron content and often contains gross amounts of other impurity, notably calcium compounds. Because of the high impurity content, fluxing additions are not normally necessary and the clay can be fired at a relatively low temperature. Some deposits are high in organic matter, which ignites on firing and reduces the amount of fuel necessary to fire the ware.

For a judicious selection of brick and tile clay, more importance is usually given to its physical properties rather than to its chemical composition. The clay employed in the manufacture of bricks and tiles should be sufficiently plastic for being moulded into the required shape. It is generally found that clay containing mixed grains has better plasticity. There are two main types of tile clay deposits, viz. the lacustrine type and the flood plain type deposits. The clay is generally fine, plastic, dull, white or variegated. Certain organic substances like horse dung can increase the plasticity of the clay. Such clay shall retain its shape in both wet and dry states and that it shall be capable of being sufficiently vitrified at
950°C/1100°C to form hard bricks without excessive shrinking or deformation (Rao, 1966).³¹

If the clay is too plastic, the drying of tiles will not be even and they will shrink, warp and crack during drying and burning. On the other hand, mining too much of lean clay will make the tiles more porous and poor in strength and ring. Therefore, a judicious combination of lean and plastic clay is usually employed for tile manufacturing.

Clay suitable for the manufacture of tiles is found in Trivandrum, Quilon, Ernakulam, Trichur, Kottayam, Alleppey, Palakkad, Kozhikode and Kannur districts. A typical brick and tile clay may have the approximate chemical compositions as given in Table 2.7.

<table>
<thead>
<tr>
<th><strong>Table 2.7</strong></th>
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</thead>
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<tr>
<td><strong>CHEMICAL COMPOSITION OF TYPICAL TILE CLAY</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chemical Compositions</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica (SiO₂)</td>
<td>59.23</td>
</tr>
<tr>
<td>Alumina (Al₂O₃)</td>
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<td>Iron oxide (Fe₂O₃)</td>
<td>5.61</td>
</tr>
<tr>
<td>Lime (CaO)</td>
<td>1.39</td>
</tr>
<tr>
<td>Magnesia (MgO)</td>
<td>1.03</td>
</tr>
<tr>
<td>Potash (K₂O)</td>
<td>1.61</td>
</tr>
<tr>
<td>Soda (Na₂O)</td>
<td>0.92</td>
</tr>
<tr>
<td>Loss on Ignition</td>
<td>11.29</td>
</tr>
</tbody>
</table>

2.6 Manufacturing Process of Tiles

The manufacturing process of tiles consists of the preparation and processing of the clay, the making of blocks and slabs, the pressing of clay slabs into tiles, drying of green tiles and burning green tiles to the final product. The essential minimum equipment for running a tile factory must include the grinding rollers, pug mill, tile presses, drying racks and pallets and kiln. There are considerable variations in the efficiency of each of these items depending on the degree of sophistication.

2.6.1 Preparation of the Clay

Clay is usually obtained by open-pit methods. Usually the bed clay is covered by an overburden of gravel or earth, which may run as thick as 10 to 20 ft. (Norton, 1949). The first process is the stripping off the over burden in the most economical manner. The main bulk of usable clay below the over burden is then obtained by digging with spades and picks. When the clay deposit is too deep for stripping, underground mining is used. Practically all underground clay is taken out by drilling and blasting. Clay is usually transferred to the plant on rails with dump cars.

It is the usual practice to keep a comparatively large quantity of clay in store in the clay yards of tile factories so as to avoid shortage of clay during the rainy season. Storage of clay for a long time will lead to increasing plasticity, uniform distribution of moisture, workability, etc. due to proper weathering and aging.

2.6.2 Weathering

It is seldom that clay can be used without some kind of a treatment which shall enable it to mix easily with water, and to be easily worked. The
natural agencies of wind, rain and frost may well be made use of in this connection, supplemented, if necessary by washing, grinding and pugging.

Weathering is an essential process in the preparation of tile clay. The object of exposing the clay to the action of the weather, especially in the winter months, is to bring about its disintegration. The chief agents concerned in the weathering of clay are water, air and frost; the water soaks into the pores of the clay, and at a sufficiently low temperature is converted into ice. The disintegration of clay resulting from weathering makes the clay more homogeneous. Besides, exposure to atmospheric influences results in the oxidization of certain impurities. Weathering improves the plasticity of clay due to the decomposition of the organic compounds present. The characteristic red colour of red bricks and terra-cotta is usually enhanced by weathering the clay. However, excessive weathering should be avoided, or else the clay particles may be washed away by rain, leaving a non-plastic residue behind. A period of one year is considered sufficient for weathering tile clay.

After weathering, the clay may require purifying, if not, it may be sent direct to the crushing or tempering mill, or it may be thrown into pits and covered with water in order to further ripen and mellow it.

2.6.3 Sourcing

After proper weathering, the clay is removed from the clay yard to the souring pits. While storing clay in the sour pits, care is to be taken to see that each type of clay is formed into a separate layer one above the other. After one layer of particular clay is laid, water is sprayed and mixed well according to its particular requirements. It is desirable to mix several types of clay together so that the product may possess properties not possessed by any one type of clay and this is known as blending. A heap of clay is thus formed one
above the other and is allowed to sour for about fifteen days. Generally, there will be three or four such pits in a factory; each pit is capable of holding clays for the working of the factory for about a week. The clay-mix for each day's requirement is obtained by digging out the clay vertically from the souring pit. A certain proportion of sand is also mixed with the clay; if necessary to get the required consistency. When the sand content is more, water absorption is more, but shrinkage reduces. However, too high a percentage of sand leads to brittleness. Some factories have no souring pits for souring of clay. In such factories, clay is fed to the pan mills directly from the yard. Head-load workers are generally employed for the handling of clays in most of the small factories while in large factories this operation is highly mechanised and is done with the help of belt conveyors or excavators.

2.6.4 Pan Mill

Practically all types of clay must be crushed before it is taken to the tempering and brick making machinery. It is necessary to grind and mix the clay properly before it is used. Grinding is a term used to express two distinct processes, viz: the crushing of clay and the formation of a paste. The exact amount of grinding required will depend on the clay itself and on the articles into which it is to be manufactured. Limey clay and others in which the grinding must be carried out so as to produce a fine clay-are most suitably treated in edge runners, pan mills, or pug mills. The dry pan is used for grinding flint clay, ganister and burned grog. By the prolonged rubbing and grinding operations in a pan mill, the clay-mix is converted into a more homogeneous mass. For the plastic mixing and grinding of clay, water is added in required quantities.
2.6.5 Box Feeder and Mixer

The box feeder is an essential part of any sophisticated equipment employed in a tile factory. A proportionate and consistent supply of clay is made possible with the help of a box feeder.

It was noticed that the clay passes through double shaft mixer first and later through the coarse grinder. This is a wrong practice, for the clay being in comparatively hard lumps to begin with, if processed through the double shaft mixer directly, the blades of the mixer may get worn out too soon. The coarse grinder should precede the double shaft mixer, so that clay is broken up and some grinding has been already done when it is fed to the mixer.

The box feeder is the most popular machine which consists of a trough divided into as many parts as there are materials to be mixed. If there are three materials – lean clay, plastic clay and sand, for instance – the lean clay would be tipped into the end chamber of the trough, the plastic clay in the middle chamber and the sand into the chamber nearest the outlet.

The clay is properly mixed by means of a mixer. The mixer is provided with two shafts; each of which has a number of blades fixed to it. When the clay is fed to the mixer and worked, the two shafts will rotate in opposite direction. The blades provided on the shafts effect shaving, cutting and mixing of the clay.

2.6.6 Pug Mill

The pug mill can be considered as one of the most important devices used in a tile manufacturing unit.

From the mixer, the clay is conveyed to a high speed roller to achieve fine grinding and reduce limestone, if present to small pieces to render it harmless. High speed rollers enable fine particle size and thus contribute to
quality. The clay is then pugged in a pug-mill. Before pugging, the clay should be de-aired, if necessary. The de-airing is done to increase the workability of the clay by a vacuum pump attached to the pug mill. Clay of high plasticity does not require de-airing whereas for clay with average plasticity and also inferior quality, de-airing is an absolute necessity.

It is the pug mill which extrudes the clay in the form of blocks sliced into slabs of the required size for pressing them into tiles. At the pug mill, the cutting of the blocks is done manually in most cases. In this case, the block size is not consistent and slight variations occur. In order to avoid this, it is recommended that the pugged blocks be cut automatically.

The pug mill is provided with a double set of rollers, one at the top and the other at the bottom. The top pair is known as grinding and crushing rollers and the bottom pair, the feed rollers. Here the clay is again cut, kneaded, properly mixed and finally extruded in the form of square blocks in a continuous manner. In order to cut the blocks into slabs, an automatic cutter (wires) is installed at the mouth of the pug mill which controls the size of the block and ensures economy in the use of labour and clay. A certain amount of oil is smeared on the blocks to take off the stickiness of the clay and give it smoothness.

The blocks extruded from the pug mill will contain excess moisture. Hence, the blocks are kept for a day or two for curing. After curing, the blocks are taken to the press. The outer surface of the blocks is to be kept damp. For this purpose water is sprayed on the blocks occasionally. A de-airing pug mill is used to eliminate air pockets and prepare compact and homogeneous clay blocks. Slabs obtained from such blocks can be directly pressed into tiles. The process of de-airing helps to reduce warping and cracking. Some factories resort to double-pugging in the case of soft clays and heavy breakages.
2.6.7 Pressing of Tiles

The pressing of slabs into tiles is perhaps the most important operation performed in a tile factory. The sliced blocks (i.e. slabs), if de-aired, can go directly to the press. If no de-airing has been done, the blocks have to be cured. After curing, the blocks are taken to the press. The individual slabs are separated, placed on the table, beaten and oiled. Generally, the oil used for this purpose is a mixture of crude oil and other inferior types of oils or oil wastes. In certain places fish oil also forms part of the oil mixture.

Both power as well as hand presses is employed for pressing. In the hand-operated screw press, the pressing is done manually. The power driven revolver press generally has 5 dies and a speed of 15 strokes/min. This will give a capacity of 7000 tiles per 8 hours. The hand press generally gives about 3000 tiles per 8 hours. Apart from these two types some factories have crank press where the pressing is done by electric power. By using suitable dies, ceiling or ridge tiles can be made in the presses. The moulds used for pressing tiles have the name of the manufacturer and the distinctive trade marks inscribed on them. The green tiles coming out of the press have to be properly trimmed so that the extra clay is removed. Trimming the edges of the green tiles is to be done with utmost care and is considered to be a highly skilled operation. The trimming can be done either manually, or by an automatic trimmer which is attached to the power driven press.

2.6.8 Drying Tiles

Pressed tiles contain 25 per cent or more of their weight of water. This has to be reduced to below 10 per cent before the tiles are sent to the kiln.

Drying of tiles is a very delicate process, since it is necessary to dry them under such conditions that they will remain sound and free from distortion before they are sent to the kiln. The object of drying is to confer
sufficient rigidity to withstand the tile being placed in the kiln and to remove the excessive water in it, which may introduce difficulties during firing.

In ordinary plastic clay, the water present fills all the interstices between the clay particles but as the clay dries, this water evaporates and air takes its place. The actual removal of the water takes place at first on the surface of the clay. This is the first stage of the drying process. As soon as the loss in weight commences to be greater than the loss in volume of the block by shrinkage, the first stage of drying is complete. In the second stage of drying, evaporation takes place far more rapidly than the change in volume of the goods, and the completion of this stage is characterised by no further shrinkage taking place; the clay is then no longer plastic. In the third stage of drying, evaporation of the water takes place entirely from the inner parts of the clay, no shrinkage or change in volume of the clay occurs, and the spaces left by the removal of the water are filled with air; there is now little or no danger of distortion and the drying may be carried out as rapidly as desired (Searle, 1953).

Although various methods are employed for drying clay goods, they may be arranged in two groups, according to whether cool or warm air is used. They are natural drying and artificial drying. However, in both cases it is the air which acts as a vehicle for the removal of the water. The amount of air required depends upon (a) the dryness of the air; (b) the pressure; (c) the temperature of the air and the goods; (d) the volume of air and (e) the area of exposed surface of the goods. (Searle, 1953).

2.6.9 Kiln Firing

After drying, the next process is kiln firing. By this process the tiles are baked adequately and each of them attains sufficient hardness and strength. Since tiles are produced in large quantities, the kilns also should be
necessarily big with several chambers for the economic working of the factory. The tiles are removed from the pallets and arranged in sets inside the kiln chambers for firing. When the dried product is placed in a kiln and then heated, numerous physical and chemical processes occur, including oxidization of the organic impurities such as coal, decomposition of carbonates, sulphates and other salts, dehydration, which involves the removal of the physically bonded water and also the water of crystallisation in the clay. The firing process is not simply a matter of applying a steady supply of heat and then cooling. Different stages of the process require different quantities of heat input. The firing of the kiln and the regulation of heat require much experience and knowledge on the part of the concerned workers. The tiles are burned in kiln at a temperature varying from 800°C to 900°C (Nayak, 1988). A highly experienced kiln worker can judge the required temperature by simply watching the colour of the flame inside the chamber. The tiles are adequately baked by firing for 16 to 24 hours.

2.7 Different Types of Kilns

A ceramic kiln is an enclosed chamber where ceramic wares are fired. It consists of a chamber to hold the ceramic products, fire boxes to burn fuel, flues to carry the burnt gases and chimney to discharge waste gases and to create drafts (Ambigapathy, 1988). The efficiency of the kiln is usually defined as the ratio of the heat required to bring up the ware to its maximum temperature divided by the amount of heat supplied by the fuel. (Norton, 1949). It is obvious that the insulation of kilns will increase their efficiency.

The kilns used for burning of tiles are classified as 'intermittent' and "continuous" - the former term being applied to those which are lit, heated to the finishing point, and are then allowed to cool completely before being emptied; and the latter being used for what is really a series of "intermittent" kilns, all connected in such a manner that, although some portions are at the
full heat and others are heating, cooling, being filled or discharged, yet the fire is never allowed to die out in every part of the kiln. (Alfred. B. Searle. 1953).

Intermittent kilns are of three types (a) Top-draught or up-draught, (b) Down-draught and (c) Horizontal-draught. Down-draught kiln may further be divided into four main classes, viz:- (i) Rectangular kilns. (ii) Round kilns (iii) Round kilns with an upper chamber, and (iv) Round kilns with a lower chamber.

There are now two main classes of intermittent kilns. Firstly, the traditional ones. Secondly, the modern intermittent kiln. The traditional intermittent kilns, especially the up-draught bottle kilns compare so unfavourably with modern kilns as regards performance and life. Modern intermittent kilns, generally gas fired or electrically heated, have a number of points in their favour.

The traditional industrial intermittent kilns were originally all fired with solid fuel. The floor plan may be round, oval, square or rectangular. The round kiln has the advantage of low construction and maintenance cost compared with its capacity and more even temperature distribution; its snags are the uneconomical use of the site, more awkward attendance and setting, and that it is less adaptable to mechanical stoking. It is used extensively where the ware is placed in round saggars. The rectangular kiln has the advantage of full use of a site, easy transport arrangements for fuel and ware and the possibility of using suspended arches. The rectangular kiln is used for stoneware and sanitary ware that cannot be economically packed into a round one. Each kiln has one or two doorways or 'wickets' for access to place and draw the ware. The heating of kilns by burning fuels depends on establishing a draught.
2.7.1 Up-draught Kilns

In the simplest type of kiln the hot products of combustion are allowed to enter the main part of the kiln directly from the firebox, surrounded by only a low bag wall, and to make their way upwards towards the flue(s) which open(s) out of the top of the kiln. The introduction of dampers as well as the main central flue in the crown, if used skilfully, makes the fixing of an up-draught kiln much less crude than it seems. Nevertheless very much heat is allowed to go up the chimney in the gases and the fuel consumption and smoke emission is very high. Inspite of these disadvantages, most of the earthenware made in the country are still fired in up-draught kilns, which are simple in construction, easy to repair and satisfactory in results.

2.7.2 Down-draught Kilns

The most common type of kiln found in the tile factories is the down-draught country kiln. In the true down-draught kiln, flame and hot gases are to travel first to the top of the kiln and then be drawn down and away at the bottom. Strictly speaking, they should be termed "up and down-draught" as the heat has a strong upward direction before it descends. (Searle, 1953). This much greater length of travel is the cause of the high efficiency of this type in the matter of fuel, and it also helps considerably in the production of a uniform temperature. In this type of kiln, firing cannot be done continuously. Only certain number of chambers are fired at a time. When one set of chamber is fired, others will be free and tiles can be loaded or unloaded. Also, in this type of kiln, the flue gas cannot be delivered from one chamber to another. Therefore, considerable heat is wasted. Besides, in this type of kiln, fire has to be started in each set of chambers separately and this is done from the sides of kiln. Down-draught kilns are very uneconomic because of the higher firewood consumption.
2.7.3 Horizontal-draught Kilns

Horizontal kilns are characterised by the use of a single fireplace. It is placed at one end of a rectangular chamber through which the hot gases move more or less horizontally to the chimney. In this type of kiln, the floor may be solid or furnished with a perforated (false) bottom through which the gases may ascend or descend according to the design of the kiln. This class of kiln is far from economical but has the advantage of a sufficiently even distribution of temperature combined with a moderate first cost. It can be chiefly confined to the production of certain classes of bricks, tiles and quarries.

2.7.4 Continuous Kilns

With the pursuit for economy in firing came the invention of the continuous kiln in which a number of chambers are so connected to a system of flues that the heat from any one of them may be conveyed to the rest or not at pleasure. The first kiln built on this principle was the famous 'Ringo fen' designed by Hoffmann in 1856. Since its first introduction many modifications have been made but the underlying principle is the same in all cases. The simple Hoffmann kiln was originally circular in shape with chimney at the centre. Now it has been modified with a more or less ring-shaped tunnel in which the goods are set, the firing being so arranged that whilst part of the kiln is being fixed, other parts may be filled or discharged, the kiln being divided into a number of chambers by means of movable partitions. The number of chambers varies from 18 to 36 with a capacity of 3000 to 5800 per chamber. "Paper dampers" or large sheets of a specially made paper are used to separate the rooms while loading. These sheets are later automatically burned down by contact with the travelling fire. The interior of the modified Hoffmann kiln now most in use consists of an endless tunnel to which access is gained by 12 to 18 doorways, the space between
these being divided into 12 to 18 imaginary 'chambers', though no actual partitions exist.

The kiln proper consists of a circular or elliptical tunnel of suitable section, which receives the goods through doors placed in the circumference or outside wall and built up in the firing. The fuel is fed through apertures in the roof of the tunnel. The biggest advantage of this type of kiln is that the fire once started need not be put out and the flue gas can be regulated and directed from one chamber to the other. In this type of kilns, firing, loading and unloading of the tiles can be done in different chambers simultaneously. No heat is lost in the process since the flue can be directed to the appropriate chamber. The Hoffmann continuous kiln is the best kiln for maximum production (10,000 to 30,000 daily) of tiles and the firewood consumption is observed to be 0.4 to 0.5 M.T per thousand tiles burned. A saving of about 25 to 50 per cent of firewood is effected by employing this type of kiln. (Nayak, 1988).40

The Hoffmann kiln may be represented as in Figure 2(1) and 2(2). The circular form Figure 2(1) is now seldom constructed. The oblong annular form shown in Figure 2(2) is usually preferred.
Different Views of Hoffmann Kiln

Fig:2(1) Original

Fig:2(2) Annular
In Kerala, three types of kilns are generally found in the tile factories – intermittent, continuous and semi-continuous kilns (Nayak, 1988).

2.7.5 Semi-continuous Kilns

A new type of kiln combining the advantages of continuous and down-draught kilns has also been evolved. As in the case of continuous kiln, firing can be done on a continuous basis in this type of kiln, by directing the flues from one chamber to the other. The feeding of firewood is from the sides as in the case of down-draught kiln. A chief advantage of this type of kiln over the down draught kiln is that there is economy in the use of firewood. This type of kiln is ideally suited for the medium-sized factories because it involves less capital investment for its installation.

A comparative picture of the intermittent, continuous and semi-continuous kilns in terms of fuel consumption efficiency and capacity is given in Table 2.8.

**Table 2.8**

**COMPARATIVE PICTURE OF VARIOUS KILNS**

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Intermittent</th>
<th>Continuous</th>
<th>Semi-continuous</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuel Consumption:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Fire wood</td>
<td>0.8-1.0 MT/1000 tiles</td>
<td>0.4-0.5 MT/1000 tiles</td>
<td>0.5-0.7 MT/1000 tiles</td>
</tr>
<tr>
<td>ii) Coal</td>
<td>0.4-0.5 MT/1000 tiles</td>
<td>0.2-0.25 MT/1000 tiles</td>
<td>0.3-0.35 MT/1000 tiles</td>
</tr>
<tr>
<td><strong>Kiln efficiency</strong></td>
<td>15-20%</td>
<td>30-40%</td>
<td>20-30%</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>6000-20,000/Chamber</td>
<td>3000-15,000/Chamber</td>
<td>3000-5000/Chamber</td>
</tr>
</tbody>
</table>

Note: MT= Metric Tonnes

2.8 Fuel

The important fuels used in clay products manufacturing are wood, coal, coke, oil and gas. Fuels used in ceramic firing are classified as solid, liquid, gaseous and electric energy (Ambigapathy, 1983).\textsuperscript{42} It is recommended to use agricultural waste such as sawdust, paddy husk and coffee husk to get higher calorific values (Ambigapathy, 1983).\textsuperscript{43} All these materials vary greatly in composition, so that if the maximum efficiency is to be obtained, continuous watchfulness must be kept and frequent analyses of the fuel and of its combustion products made.

Wood, at one time the principal fuel for the potter, is now only used in those cases where it is absolutely necessary to avoid any chance of the goods being spoiled by the sulphur which is always present in coal. The total calorific power of all varieties of wood is practically the same, viz; 6000 B.T.U per pound of thoroughly air-dried wood. Oak, beech, hickory and maple are usually more economical than coal.

Coal is of many varieties and of varying compositions. In choosing coal for kiln-firing, it is very important to select a fuel with a large heating power. Coal with a high percentage of sulphur compounds yield a strong odour of burning sulphur. Another disadvantage possessed by coals rich in sulphur compounds is their readiness to catch fire spontaneously. However, coal gives better economy than firewood in the long run.

Coke is of little use in the kiln, as it produces too short a flame. Coke is excellent for stoves and dryers where a long flame is not necessary. It is also more economical than coal as combustion is more complete and little or no smoke is produced.

Oil is being increasingly used abroad as a fuel in connection with engines and kilns. It is not used to a large extent in this country as, at present, it has to be imported, and so is more expensive than coal or producer gas.
2.9 Sorting of Tiles

After burning in the kiln, the tiles are unloaded and sorted manually by judging the quality from the ringing sound produced when tapped by a thin iron rod. Usually tiles are sorted into different grades taking into consideration their metallic sound, colour and nature of cracks (Labour and Industrial Bureau, 1969).\textsuperscript{44} Tiles with defects or cracks are rejected and the good tiles are graded into four or six classes. The nature of the clay used, the sophistication of the machinery employed, the type of kiln and the general efficiency of production have all a bearing on the quality of the tiles produced.

The graded tiles are removed to the stockyard and stacked separately. They are then transported to different destinations by motor lorries and railway wagons.

The production flow chart for tiles is given below

\begin{center}
\begin{tikzpicture}
  \node (clay) at (0,0) {Clay Excavation};
  \node (preparation) at (4,0) {Clay preparation and Tempering};
  \node (forming) at (8,0) {Forming};
  \node (unloading) at (0,-2) {Unloading/stocking & Marketing};
  \node (firing) at (4,-2) {Firing};
  \node (drying) at (8,-2) {Drying};

  \draw[->] (clay) -- (preparation);
  \draw[->] (preparation) -- (forming);
  \draw[->] (unloading) -- (firing);
  \draw[->] (firing) -- (drying);
\end{tikzpicture}
\end{center}

Conclusion

In the foregoing analysis, we examined the origin and growth of the tile industry in India and Kerala. The manufacturing process of tile industry is also examined. The first tile factory in India was established in 1865 and that in Kerala was set up in 1873. Tile industry in Kerala has passed through different phases, affecting all aspects of manufacturing. At present the tile
industry in Kerala is mainly concentrated in three districts, viz: Kozhikode, Trichur and Ernakulam. An examination of the manufacturing process showed that preparation of clay, pressing, drying, firing and stocking are the various stages of manufacturing of tile.

**Notes and References**


8. Tile (1947), *Encyclopaedia Britannica*, *op. cit*.


