TUNNEL KILN TECHNOLOGY

INTRODUCTION AND HISTORY

Tunnel kiln is a continuous moving ware kiln in which the clay products to be fired are passed on cars through a long horizontal tunnel. The firing of products occurs at the central part of the tunnel. The tunnel kiln is considered to be the most advanced brick making technology. The main advantages of tunnel kiln technology lies its ability to fire a wide variety of clay products, better control over the firing process and high quality of the products.

The tunnel kiln technology was developed around mid 19th century in Germany. However, the application of the technology for brick firing took place in 20th century. After second world war, the technology was widely adopted and lead to the transformation of European brick industry from several thousand small and scattered brick making units into few hundred large scale and highly mechanised tunnel kiln units.

In Asia, China and Vietnam started adopting the technology during 1970’s and now have several hundred tunnel kilns in operation. In India, there are very few (~5) tunnel brick kiln units.

GEOGRAPHICAL DISTRIBUTION

NUMBER OF OPERATIONAL ENTERPRISES AND TOTAL PRODUCTION

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of enterprises</th>
<th>Total production billion bricks/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vietnam</td>
<td>~700</td>
<td>~10.5</td>
</tr>
<tr>
<td>India</td>
<td>~5</td>
<td>~0.08</td>
</tr>
</tbody>
</table>

*Numbers are estimates only

% CONTRIBUTION TO THE TOTAL BRICK PRODUCTION IN INDIA

Out of the total annual production of around 280 billion bricks in India and Vietnam only around 10.6 billion bricks are produced by tunnel kiln technology

~4%
FACTSHEETS ABOUT BRICK KILNS IN SOUTH AND SOUTH-EAST ASIA

TUNNEL KILN TECHNOLOGY

DESCRIPTION AND WORKING

1. In a tunnel kiln, a continuous moving ware kiln, the clay products/bricks to be fired are passed on cars (1.1) through a long horizontal tunnel (1.2). The firing of bricks occurs at the central part of the tunnel. The length of tunnel can vary from 60 m to 150 m.

2. Generally green bricks are produced by mixing powdered fuel with clay. Green bricks are then moved in the tunnel or chambers dryers on cars for drying. Heat from the hot flue gases coming out of the kiln is utilized for the drying of bricks.

3. The cars loaded with dried green bricks are pushed in the kiln. The cars are moved inside the kiln intermittently at fixed time interval. The duration of the firing cycle can range from 30 to 72 hours.

4. Three distinct zones appear in an operating tunnel kiln:
   4.1 Brick firing zone where the fuel is fed and combustion is happening,
   4.2 Brick preheating zone (before the firing zone) where the green bricks are being preheated by the hot flue gases coming from the firing zone and
   4.3 Brick cooling zone (ahead of the firing zone) where fired bricks are cooled by the cold air flowing into the kiln.

5. Fuel (granulated/pulverised coal) is fed into the firing zone of the kiln through feed holes provided in the kiln roof. The firing zone usually extends up to 8 cars. The temperature in the firing zone is maintained at 900 – 1050°C.

6. There is counter current heat transfer between the bricks and the air. Cold air enters the kiln from the car exit end (6.1) and gets heated while cooling the fired bricks. After combustion, the hot flue gases travel towards the car entrance end losing a part of the heat to the green bricks entering the kiln.

7. Hot air/gases are extracted from the tunnel kiln at several points along the length of the kiln and are supplied to the drying tunnel/chamber. In some of the kilns, there is also provision of hot air generator to supplement the requirement of hot air for drying.

8. The flue gases from the drying tunnel are released in the atmosphere through a chimney.
**TUNNEL KILN TECHNOLOGY**

**FACTSHEETS ABOUT BRICK KILNS IN SOUTH AND SOUTH-EAST ASIA**

**Air Emissions and Impacts**

- **Measured Emission Factors**
  - g/kg of fired bricks
  - CO2: Black Carbon, PM, CO
  - Average: 166.3, negligible, 0.24, 3.31
  - Range: NA, NA, 0.175 – 0.31, 2.45 – 4.18

- **Measured PM Emissions**
  - Average: 41 mg/Nm³
  - (Range: 21– 53 mg/Nm³)

- **Emission Standards**
  - Notified for PM only
    - India: No emission standard has been notified for tunnel brick kilns
    - Vietnam: No emission standard has been notified for tunnel brick kilns

- **Comments on Emissions**
  - Better fuel combustion results in lower emissions from a tunnel kiln.

**Fuels and Energy**

- **Commonly Used Fuels**
  - Coal
  - Petcoke

- **Specific Energy Consumption**
  - Energy consumed for firing 1 kg of fired brick
  - Average: 1.4 MJ/kg of fired bricks
  - (Range: 1.34 – 1.47 MJ/kg of fired brick)

<table>
<thead>
<tr>
<th>MJ/kg of fired brick</th>
<th>TUNNEL (1.34-1.47)</th>
<th>VSBK (0.6-1)</th>
<th>Intermittent Kiln (2-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>1</td>
<td>0.6</td>
<td>2</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.4</td>
<td>1.47</td>
<td>4</td>
</tr>
</tbody>
</table>

**Construction Material + labour**

**Equipment**

**Capital cost breakdown**

- **Capital cost of kiln technology**
  - for an annual production capacity of ~15 million bricks, excluding cost of land and buildings
  - ~1,000,000 USD

**Production capacity**

- ~50,000 bricks per day

**Brick size**

- 230 mm x 115 mm x 75 mm

**Number of Operators required**

- ~20

**Payback Period**

- Simple Payback: ~2 years
- Discounted Payback (@ 6.5%): ~2.2 years

**Financial Performance**

- **LOSSES & BREAKAGES** - 2%
- **GOOD** - 95%
- **INFERIOR** - 3%

**Product Quality**

- As per the local market perception
  - **GOOD**
  - **INFERIOR**

**Main Causes for Heat Loss**

- Heat contained in the kiln cars and fired bricks at the kiln exit and in hot flue gases are the main source of heat loss in tunnel kilns.

**Air Emissions and Impacts**

- **EMISSION STANDARDS**
  - Notified for PM only
    - India: No emission standard has been notified for tunnel brick kilns
    - Vietnam: No emission standard has been notified for tunnel brick kilns

- **COMMENTS ON EMISSIONS**
  - Better fuel combustion results in lower emissions from a tunnel kiln.

**Capital cost breakdown**

- **Construction Material + labour**
  - 57%
- **Equipment**
  - 43%

**Types of product that can be fired in the kiln**

- Solid bricks
- Hollow/ Perforated bricks
- Roof tiles
- Floor tiles

**Product Quality**

- As per the local market perception
  - **GOOD**
  - **INFERIOR**

**Types of product that can be fired in the kiln**

- Solid bricks
- Hollow/ Perforated bricks
- Roof tiles
- Floor tiles

**Better heat distribution result in uniform temperature across the kiln cross section in the firing zone thereby resulting in higher percentage of good quality bricks.**

**Exposure to Respirable Suspended Particulate Matter**

- The concentration of air pollutants in the surrounding environment of a tunnel kiln is low.
- The workers have low risk of developing respiratory tract infections and cardiovascular diseases.

**Exposure to Thermal Stress**

- Exposure of workers to heat from the kiln is quite low.
- This reduces the thermal stress and consequent risk of eye & skin diseases and dehydration among workers.

**Risk of accidents**

- In a well operated tunnel kiln, the risk of accidents are low.

**Compliance with ILO standards and remarks on migratory labour and conditions of labour**

- Practices followed at tunnel kiln enterprises are not always complied with the International Labour Standards on occupational health and safety drawn up by ILO.
- Because of mechanisation of the processes, the working conditions of workers in tunnel kiln enterprises are relatively better.
TUNNEL KILN TECHNOLOGY

CONCLUSION

Performance of tunnel kiln is compared with the most commonly used continuous kiln technology in the region which is FCBTK.

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>TUNNEL</th>
<th>FCBTK</th>
<th>COMMENTS</th>
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</thead>
<tbody>
<tr>
<td>AIR EMISSION (g/kg FIRED BRICK)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂</td>
<td>166.3</td>
<td>131</td>
<td>Tunnel kiln emits ~80% lower PM and negligible BC as compared to FCBTK. This is mainly because of better combustion and use of internal fuel. The emission of CO is higher in case of tunnel kiln, probably due to incomplete combustion of internal fuel.</td>
</tr>
<tr>
<td>Black Carbon</td>
<td>0.00</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>0.24</td>
<td>1.18</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>3.31</td>
<td>2.0</td>
<td></td>
</tr>
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FUEL & ENERGY

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<thead>
<tr>
<th></th>
<th>TUNNEL</th>
<th>FCBTK</th>
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<tbody>
<tr>
<td>SEC (MJ/kg fired brick)</td>
<td>1.4</td>
<td>1.30</td>
<td>Tunnel kiln consumes marginally higher energy as compared to FCBTK. It is to be noted that the SEC in tunnel kilns also includes the energy utilised for the drying of bricks in the tunnel dryer.</td>
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FINANCIAL PERFORMANCE

<table>
<thead>
<tr>
<th></th>
<th>TUNNEL</th>
<th>FCBTK</th>
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<tbody>
<tr>
<td>Capital Cost (USD)</td>
<td>-1,000,000</td>
<td>50,000-80,000</td>
</tr>
<tr>
<td>Production Capacity</td>
<td>-15 million bricks/year</td>
<td>3-8 million bricks/year</td>
</tr>
<tr>
<td>Simple Payback</td>
<td>-2 years</td>
<td>0.4 - 1.1 years</td>
</tr>
</tbody>
</table>

PRODUCT QUALITY

<table>
<thead>
<tr>
<th></th>
<th>TUNNEL</th>
<th>FCBTK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of product</td>
<td>All types of products</td>
<td>All types of products</td>
</tr>
<tr>
<td>Good Quality Product</td>
<td>95 %</td>
<td>60 %</td>
</tr>
</tbody>
</table>

OHS

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<thead>
<tr>
<th></th>
<th>TUNNEL</th>
<th>FCBTK</th>
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<tbody>
<tr>
<td>Exposure to dust</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposure to Thermal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk of accidents</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

REFERENCES

1. ‘Brick by Brick: The Herculean Task of Cleaning up the Asian Brick Industry’ written by Urs Heierly and Sameer Maithel available at www.gkspl.in/Brick_by_brick.pdf.
3. Based on interaction with tunnel kiln owners and professionals working in brick sector
4. Ibid 2.
6. Ibid 2.
7. Ibid 5.
8. Report on ‘Occupational health and safety study (OHSS) of brick industry in the Kathmandu valley’ by Department of Environmental Sciences and Engineering (DESE), Kathmandu University, Nepal
10. International Labour Standards are instruments drawn up by ILO in the form of conventions (the basic principles to be implemented) and recommendations (more detailed guidelines). Details on the standards for OHSS can be found at http://www.ilo.org/global/standards/subjects-covered-by-international-labour-standards/occupational-safety-and-health/lang--en/index.htm. A list of all such instruments on OHSS with their status is available at http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12030:0::NO::#Occupational_safety_and_health