Understanding Zig Zag Kilns
Schematic illustration of operations and firing zones of an FCBTK
Problems With FCBTK Technology
Problems With FCBTK Technology

• Air travels in a straight line and remains in the kiln for a shorter duration as the combustion zone is smaller. Therefore, the air does not get sufficient amount of time to properly mix with the fuel, resulting in incomplete combustion.

• Improper distribution of heat in different parts of the combustion zone is another major downside of an FCBTK. Green bricks stacked for firing are not exposed to a uniform temperature and only 60 per cent of the bricks fired turn out to be Class I (good quality).
Non-Uniform Temperature Distribution in the Kiln

Heat loss from top surface of the kiln to surrounding
900 °C

Heat loss from side walls to surrounding
1000 - 1050 °C

Low percentage of Class-I bricks – Annual loss of Rs 10-15 lakh/year

Class – I: 50-60%
Class – II: 30-35%
Breakages: 10-15%
Zig Zag Kilns

- What are the things to be taken into account
- Size and dimensions of each kiln component?
- Per day number of bricks to be produced?
- Time Requirement?
- Equipments required?
- Techno-economics?
Main Components of the Kiln

- Chimney
- Miyan
- Outer wall
- Wicket gate
- Flue duct and inlets
- Floor
Main Components of the Kiln

- Dug width
- Dug well height
- Chamber length
- Side nali spacing
- Gali width
- Miyan dimensions
- Kiln outer dimensions
- Flue duct system
- Kiln wall
- Wicket gate or dwari
- Kiln floor
- Chimney
Dimensions of a typical natural draft zigzag kiln

<table>
<thead>
<tr>
<th>Bricks/day</th>
<th>Trench/dug width</th>
<th>Chimney height</th>
<th>ID bottom*</th>
<th>ID top*</th>
<th>Height of main nali</th>
<th>Width of main nali</th>
<th>Galli size</th>
</tr>
</thead>
<tbody>
<tr>
<td>21,000</td>
<td>18 ft</td>
<td>120 ft</td>
<td>9 ft x 9 ft</td>
<td>3 ft x 3 ft</td>
<td>4 ft</td>
<td>2.5 ft</td>
<td>9 ft</td>
</tr>
<tr>
<td>25,000</td>
<td>22 ft</td>
<td>135 ft</td>
<td>9 ft 6 in x 9 ft 6 in</td>
<td>3 ft 2 in x 3 ft 2 in</td>
<td>4 ft</td>
<td>2.5 ft</td>
<td>11 ft</td>
</tr>
<tr>
<td>30,000</td>
<td>23 ft 6 in</td>
<td>135 ft</td>
<td>9 ft 6 in x 9 ft 6 in</td>
<td>3 ft 2 in x 3 ft 2 in</td>
<td>4 ft</td>
<td>2.5 ft</td>
<td>11 ft 9 in</td>
</tr>
<tr>
<td>36,000</td>
<td>26 ft</td>
<td>135 ft</td>
<td>10 ft x 10 ft</td>
<td>3 ft 4 in x 3 ft 4 in</td>
<td>4.5 ft</td>
<td>2.5 ft</td>
<td>13 ft</td>
</tr>
<tr>
<td>39,000</td>
<td>28 ft</td>
<td>140 ft</td>
<td>10 ft 6 in x 10 ft 6 in</td>
<td>3 ft 6 in x 3 ft 6 in</td>
<td>4.5 ft</td>
<td>2.5 ft</td>
<td>14 ft</td>
</tr>
<tr>
<td>41,000</td>
<td>31 ft</td>
<td>140 ft</td>
<td>10 ft 6 in x 10 ft 6 in</td>
<td>3 ft 6 in x 3 ft 6 in</td>
<td>4.5 ft</td>
<td>2.5 ft</td>
<td>15 ft</td>
</tr>
<tr>
<td>44,000</td>
<td>33 ft</td>
<td>145 ft</td>
<td>12 ft x 12 ft</td>
<td>4 ft x 4 ft</td>
<td>5 ft</td>
<td>2.5 ft</td>
<td>16 ft 6 in</td>
</tr>
<tr>
<td>48,000</td>
<td>35 ft</td>
<td>145 ft</td>
<td>12 ft x 12 ft</td>
<td>4 ft x 4 ft</td>
<td>5 ft</td>
<td>2.5 ft</td>
<td>16 ft 6 in</td>
</tr>
<tr>
<td>52,000</td>
<td>37 ft</td>
<td>145 ft</td>
<td>12 ft x 12 ft</td>
<td>4 ft x 4 ft</td>
<td>5 ft</td>
<td>2.5 ft</td>
<td>16 ft 6 in</td>
</tr>
<tr>
<td>58,000</td>
<td>39 ft</td>
<td>150 ft</td>
<td>13 ft x 13 ft</td>
<td>4 ft 4 in x 4 ft 4 in</td>
<td>5 ft</td>
<td>2.5 ft</td>
<td>16 ft 6 in</td>
</tr>
</tbody>
</table>
Dimensions of a typical induced draft zigzag kiln

- A minimum height of 27m (approximately 90 feet) has been mandated by MoEF&CC for brick kilns in its new draft standards.

- And for all other dimensions kept constant in the above table, generally 10000 more bricks per day can be produced in an induced draft Zig-Zag Kilns.

- In an induced draft kiln, the draft is created with the help of a fan. The capacity of the fan depends on the trench width and the number of bricks to be produced per day (Generally 12 – 15 HP fan is used).
Dimension of main components

DUG WALL HEIGHT

• The dug wall or miyan wall height is the height measured from the dug surface. It is generally 10–11 feet.

CHAMBER LENGTH

• In general, the length of the chamber varies from six to nine feet. Better zigzagging of the air flow can be achieved by decreasing the length of the chamber. Therefore, six feet long chambers are recommended for both induced and natural draft zigzag kilns.
The flue duct system consists of designing the size and dimensions of following components:

- Main nali (main flue gas inlet)
- Side nali (side flue gas inlet)
- Vertical hall or mangal
Schematic of a main nali
The cross-section of a side nali is about 70 per cent of the mail nali.
Side Nali Spacing

Side nalis are flue inlets placed at regular intervals along the length of the miyan. The spacing is defined by the length of the chamber.
Vertical Hall or Mangal

- Vertical hall is a rectangular structure that serves as connector between the main and side nalis and the shunt.
Vertical Hall or Mangal
Gali Width

- The gali is a narrow section on either edge of a zigzag kiln, always narrower in width than the dug width. It is generally half of the dug width and not more than 15 – 16 feet at max.
MIYAN DIMENSION

• The length of the miyan is decided according to the number of chambers to be set on one side of the trench length.

• In case the chimney is located at the center of the miyan, the width of the miyan should be able to accommodate the base of the chimney. In such cases, the width of the miyan usually varies between 18 to 30 feet.

• If, on the other hand, the chimney is located on one side of the kiln, the width of the miyan can be less (sufficient enough to accommodate the flue duct system)—about 16–18 feet.
MIYAN DIMENSION

Dimension of a miyan;

- Miyan length = 156 feet (26 chambers) or 192 ft (32 chambers) + 1 brick size
- Miyan width = 25–28 feet for natural and 18 ft for induced draft zigzag kilns
- Miyan height = 10–11 feet

- For a smaller kiln of 26 chambers, i.e., the miyan length should be 156 ft (26 ft x 6 ft chamber = 156 ft). If a kiln has 32 chambers, miyan length should be 192 ft (32 ft x 6 ft chamber = 192 ft)
Schematic of miyan wall

- Kiln’s miyan wall
- Main nali
- L-shaped steel bar
- 2½-brick thick wall
- 3-brick thick wall
- 3½-brick thick wall
- 4-brick thick wall
- Kiln floor
KILN’S OUTER DIMENSIONS

• A kiln’s outer dimensions can be calculated simply by adding dug width and gali width to the miyan wall’s dimensions

• Length of kiln (excluding outer wall thickness) = Length of miyan + 2 x gali width
  for example = 156 + 2 x 15 = 186 ft (for zigzag kilns with 26 chambers and 15 ft gali)

• Breadth of kiln (excluding outer wall thickness) = Width of miyan + 2 x dug width
  for example = 25 + 2 x 33 = 91 ft (for zigzag kilns with 33 ft dug width)
KILN’S OUTER DIMENSIONS
The outer wall and the miyan wall are the two key kiln walls. Since there is a lot of workers’ movement around the walls, they need to be strong and durable.

Miyan wall has already been discussed earlier.

**Outer Wall Design**

Generally, the outer wall is a double brick wall plastered with mud. The space between the walls is filled with mud and ash, for insulation. A three inch inclination is maintained from the bottom to the top of the outer on the outside of the kiln.
Cross-section of the outer wall

1½ bricks thick wall

2 bricks thick wall

2½ bricks thick wall

3 bricks thick wall

Fillings

2½-brick thick wall

3-brick thick wall

3½-brick thick wall

4-brick thick wall

Kiln floor

6' 6"

9"

11'

2' 9"

2' 9"
Outer wall of the kiln
WICKET GATE or DWARI

Wicket gates are provided in the outer wall of the kiln for transportation of bricks in and out of the kiln. There is no consistent design methodology to define size, positioning and number of wicket gates.

The following considerations must be taken into account while designing a wickerm gate:

• Heat loss must be minimized;
• It should be easy to transport green bricks into and fired bricks out of the kiln;
• It should be easy and to transport green bricks into the dug efficiently using any mode of transport, either human, animal, electric cars or trucks.
WICKET GATE or DWARI
WICKET GATE or DWARI

Space left for filling ash for better insulation

Two 18 inch walls are constructed and before and one after this space
Kiln floor design

Dug side

- Flat brick soling
- Brick on edge soling
- 6-inch-thick sand bed
- Aluminum foil/sheet
- 6-inch-thick sand bed
- Rammed earth
Chimney

• The chimney is the most important and costly section of a kiln structure. Hence, chimney design is of prime concern for all kiln owners.

• In retrofitting of existing kiln into High Draft zig zag kiln same chimney can be used but for stack monitoring, a port hole and a proper platform for placing the monitoring instrument should be provided.

• In Natural draft zig zag kiln the chimney is responsible for creating the draft and therefore the height of the chimney is decided depending upon the production capacity.
A typical Schematic diagram of a chimney base
Apparatus Required
The complete process of retrofitting an induced draft kiln where same chimney is used takes around 50-60 days, after which the kiln is ready for stacking and firing the next batch.

Conversion to a natural draft kiln takes approximately 30 days extra, since the chimney needs to be dismantled and reconstructed; here the entire process of conversion takes around 80-90 days.
## Techno-economics of retrofitting a FCBTK into zigzag brick kilns

<table>
<thead>
<tr>
<th></th>
<th>Initial FCBTK</th>
<th>Retrofitted zigzag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual production</td>
<td>40 lakh</td>
<td>40 lakh</td>
</tr>
<tr>
<td>Coal consumption per lakh bricks</td>
<td>16 tonne</td>
<td>12 tonne</td>
</tr>
<tr>
<td>Class I bricks produced (percentage)</td>
<td>55–60</td>
<td>80–90 per cent</td>
</tr>
</tbody>
</table>

### Break up of the cost

<table>
<thead>
<tr>
<th></th>
<th>Induced zigzag</th>
<th>Natural zigzag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour cost</td>
<td>Rs 5.5–7.5 lakh</td>
<td>Rs 5.5–7.5 lakh</td>
</tr>
<tr>
<td>Material (other than brick)</td>
<td>Rs 1–1.5 lakh</td>
<td>Rs 1–1.5 lakh</td>
</tr>
<tr>
<td>Equipment</td>
<td>Rs 2–2.5 lakh</td>
<td>Rs 2–2.5 lakh</td>
</tr>
<tr>
<td>Fan (with engine)</td>
<td>Rs 3–4 lakh</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Chimney</td>
<td>Not applicable (same chimney can be used)</td>
<td>Rs 8–10 lakh</td>
</tr>
<tr>
<td>Bricks @ Rs 3/brick</td>
<td>Rs 6–9 lakh (for additional 2–3 lakh bricks)</td>
<td>Rs 9–12 lakh (for additional 3–4 lakh bricks)</td>
</tr>
<tr>
<td>Total</td>
<td>Rs 17.5–24.5 lakh</td>
<td>Rs 25.5–38.5 lakh</td>
</tr>
</tbody>
</table>
## BENEFITS

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost 1 (Rs)</th>
<th>Cost 2 (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual coal savings 160 tonne @ Rs 10,000 per tonne</td>
<td>Rs 16 lakh</td>
<td>Rs 16 lakh</td>
</tr>
<tr>
<td>Increase in revenue due to higher number good quality bricks (considering 8 lakh additional Class-I bricks annually) @ Rs 1 per brick</td>
<td>Rs 8 lakh</td>
<td>Rs 8 lakh</td>
</tr>
<tr>
<td>Annual expenditure on operation and maintenance of fan</td>
<td>Rs 2.5 lakh</td>
<td></td>
</tr>
<tr>
<td>Total annual savings</td>
<td>Rs (16 + 8 - 2.5) = 21.5 lakh</td>
<td>Rs (16 + 8) = 24 lakh</td>
</tr>
<tr>
<td>Simple payback period</td>
<td>One brick season</td>
<td>One–two brick seasons</td>
</tr>
</tbody>
</table>
Thank you

Rahul Kumar
Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi – 110062
Tel: 011-40616000
Fax: 011-29955879
Website: www.cseindia.org