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Energy Audit Report
After Adoption of Zig-zag technology
in
Varanasi
Brick Making Cluster

Prepared for
Bureau of Energy Efficiency

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1.0 Introduction

Under the 11th Five Year Plan, the Bureau of Energy Efficiency (BEE) had carried out diagnostic studies in 25 SME clusters and prepared cluster specific manuals covering energy efficiency, process and technology, best practices, case studies, etc. These clusters represents various energy intensive industry sub sectors like ceramic, textile, paper, sea food, rice mills etc. The studies have provided information on technology status, best operating practices, gaps in skills and knowledge, energy conservation opportunities, energy saving potential, etc. for each of the intervening sub-sector. Detailed project reports (DPRs) were also prepared for the identified technological options. In the 12th Five Year plan, BEE is implementing National Program on Energy Efficiency. The major activities covered under the program include:

i. Sector-specific approach for energy efficiency and technology up-gradation through facilitation of implementation of DPRs on energy efficient technologies
ii. Technical assistance and capacity building of stakeholders
iii. Energy mapping of SME

Varanasi brick cluster is one of the clusters covered under the study. Zig-zag technology is one of the technology options identified to enhance energy efficiency of brick making units in the cluster. The Energy and Resources Institute (TERI) has been entrusted by BEE in implementing natural draft zigzag firing technology in the identified units in the Varanasi brick cluster.

The baseline audit of the ten brick kiln units participating in the project was carried out during April- May 2015. After the baseline audit, two brick kilns have retrofitted their kiln as per zig-zag technology. Out of these two kilns, one kiln was operated during brick making season (December – June 2016) and accordingly post-commissioning audit of the kiln was carried out in March 2016. The second kiln was operated during brick making season (December – June 2017) and post-commissioning audit of this kiln was carried out in May 2017.

2.0 About Varanasi brick cluster

In Varanasi brick cluster, there are about 300 brick kiln units. Some of the major sub-clusters in Varanasi includes Mohan sarai, Munari, Raichandpur, Haruhua and Sarnath. Int Nirmata Parishad (INP) represents the cluster level industry association. The cluster predominantly uses hand-moulding for green brick making and Bull's Trench Kilns (BTKs) for brick firing. It is estimated that about 60 brick kiln units in the cluster have adopted zig-zag technology.

The details of brick making units participating in the project are provided in table 2.0.

Table 2.0: Contact details of brick making units

S. No.	Name of the brick kiln	Contact Person
1	M/s Singh Int Bhatta, village Kharupur, Varanasi	Mr. Parikshit Singh
2	M/s R.B. Company, village Bandaha, Varanasi	Mr. Ramashraya Singh
3	M/s Khiladi IntBhatta, village ShainaKalan, Varanasi	Mr. MotiYadav
4	M/s Swarup Int Udyog, village Cholapur, Varanasi	Mr. Rajesh Singh
5	M/s Asim brick field, village Undi, Varanasi	Mr. Kamlesh Narayan Singh
6	M/s Shyam Int Udyog, village Jaipar, Varanasi	Mr. Inder Pal Singh
7	M/s Shail Int Bhatta, village Raichandpur, Varanasi	Mr. Chandershekhar Singh
8	M/s Sahara Brick Industry, village Sultanpur, Varanasi	Mr. VirenderTiwari
9	M/s Dilip Kumar, village Todarpur, Mohan sarai, Varanasi	Mr. Dilip Kumar Jethani
10	M/s B.S. Enterprises, village GosainpurMahauan, Cholapur, Varanasi	Mr. AkshyawarYadav

3.0 Energy Performance

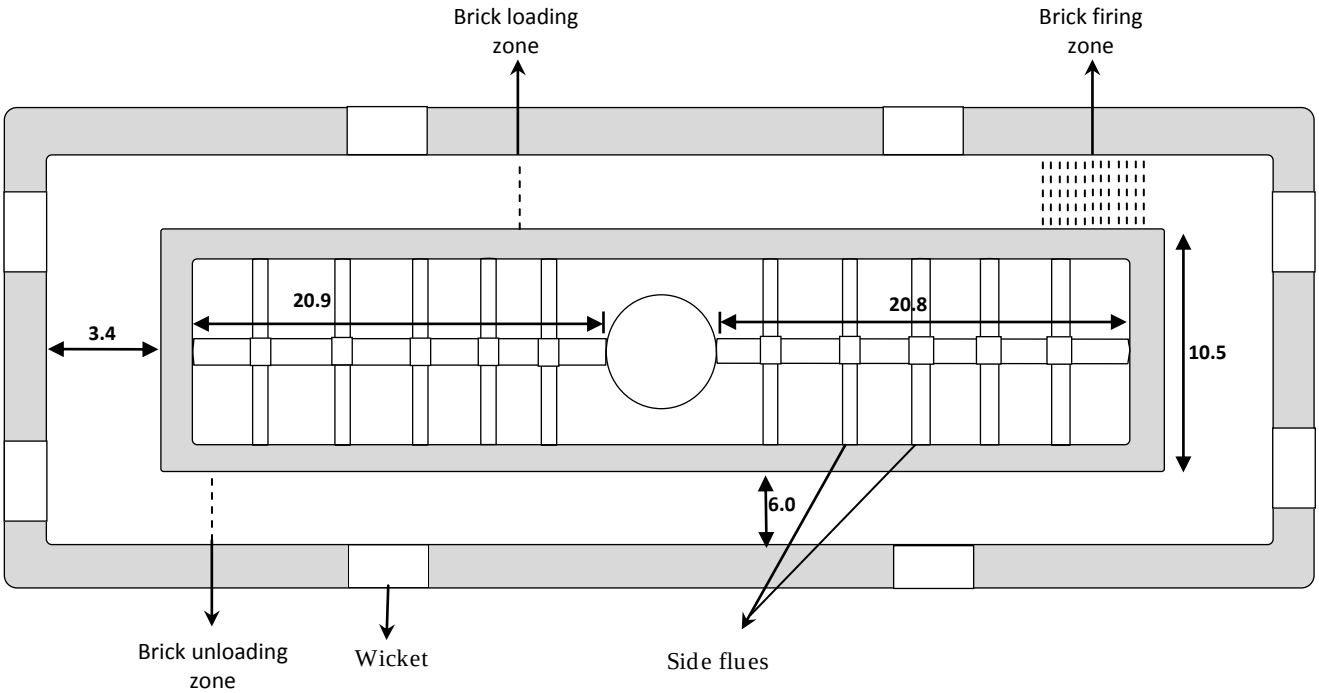
1. Basic information

Name of the kiln :	**M/s Shail Int Bhatta**
Location of kiln :	Village Raichandpur, Varanasi
Contact Person	Mr. Chandershekhar Singh
Contact No.	9918400421

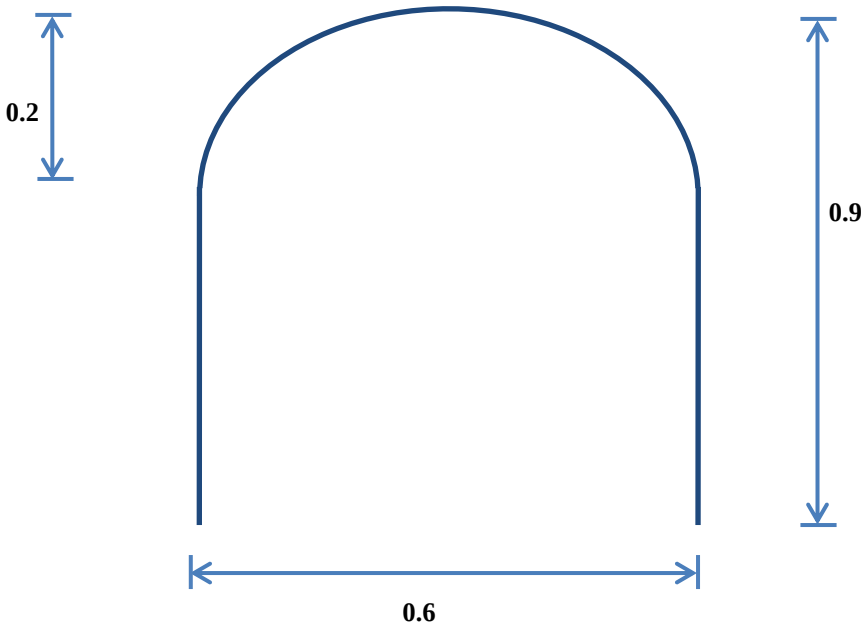
2. Details of brick kiln

Type of brick kiln	**Rectangular shaped kiln with natural draft zig-zag firing technology**
Green brick molding process	Hand molding
Production Capacity (lakh per circuit)	5.8
Size of trench	
- Width of trench	6.0 meter
- Height of trench	2.7 meter

3. Schematic Diagram



Note: *All dimensions are in meter (not to scale)*



Side Flue

All dimensions are in meter (not to scale)

4. Brick production

Number of bricks per chamber	9500
Number of chambers fired per day	2.2
Average Size of green brick (mm)	233 x 109 x 75
Average Weight of green brick (kg)	3.43
Average Size of fired brick (mm)	235 x 112 x 74
Average Weight of fired brick (kg)	3.31

5. Kiln Parameters

Parameter	Range
Ambient temperature (°C)	36.7 – 43.3
Flue gas temperature (°C)	115.5 – 141.2
O_2 (%)	14.4 – 17.7
CO(ppm)	271 - 423
Firing Temperature(°C)	963 - 1025
Feed hole cover temperature (°C)	248 - 270
Kiln surface temperature	
Preheating zone (°C)	51.4 – 84
Firing zone (°C)	103 – 122.7
Cooling zone (°C)	81.1 – 112.2

6. Energy consumption

Type of fuel used	Coal	Saw dust
Coal consumption (kg/day)	3350	1500
Specific Energy Consumption (MJ/kg-fired brick)	1.16	

7. Energy balance

Component	Energy consumption (MJ/ton of fired clay)
Surface heat loss from kiln (top surface and side walls)	120
Other heat components*	803
Heat required for removal of mechanically held water in green bricks	86
Heat loss in flue gases	130
Heat loss due to partial conversion of C to CO	6
Sensible heat loss in unloaded bricks	10
Total	1155

* Heat required for irreversible chemical reaction and losses such as trench bottom, periodic heating and cooling of kiln structure and due to un-burnt carbon in ash

8. Comparison with the earlier kiln

Some of the important parameters before and after adoption of zig-zag firing technology by the studied kiln are provided in following table:

Parameter	Before adoption of zig-zag technology	After adoption of zig-zag technology
Brick firing capacity per circuit (lakhs)	6.3	5.8
Clay fired per day (kg)	63,360	69,608
GCV Coal (Kcal/kg)	6380	6252
Length of firing zone (m)	1.6	10.7
Specific Energy Consumption (MJ/kg-fired brick)	1.33	1.16

Some of the factors that have resulted in higher specific energy consumption are:

- The length of pre-heating zone in the kiln was not adequate and this has resulted in more flue gas temperature and increased flue gas losses
- Due to kiln operational issues, the green bricks being stacked in the kiln were not dried properly and this has resulted in increased energy consumption for removing moisture from the green bricks

Few photographs before and after adoption of zig-zag technology by the kiln are provided below:

Before adoption of zig-zag technology

After adoption of zig-zag technology

9. Conclusion

The Specific Energy Consumption (MJ/kg-fired brick) of the kiln after adoption of zig-zag technology was found be lower than the original BTK. This highlights the fact that the brick kiln is benefitted by adoption of zig-zag technology.