Options to improve the performance: Brick clusters of Kolar and Malur, Karnataka

Background

Kolar region is located at about 70 kilometres from Bangalore city. It is one of the important brick clusters surrounding Bangalore, other beings Malur and Anekal. With large number of constructions on-going in and around Bangalore, there is large demand for bricks and is being met by these clusters, apart from few alternate building materials such as concrete blocks are also started being used in the construction.

There are more than 400 brick kilns operating in Kolar cluster. Brick making involves moulding, drying & storing and firing (figure 1). Manual moulding is practiced widely in the cluster with the moulding community is generally tracked down to Dharmapuri/ Salem in Tamil Nadu. The region generally experiences lot of intermittent rains, thus it is almost mandatory for all the units to adopt sheds for drying and storing. The dry bricks are manually stacked in kilns for firing. Downdraught kilns are used for firing of bricks. These kilns are of intermittent type. Generally, each unit has a minimum of two downdraught kiln with a common chimney so that each kiln can be operated alternatively.

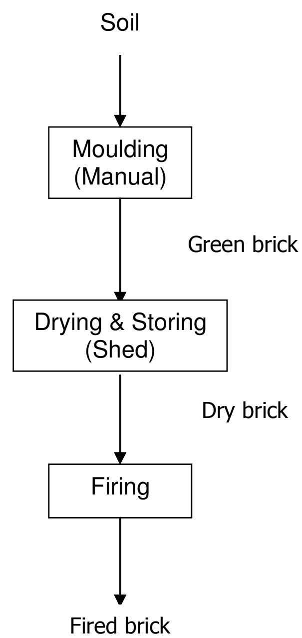

Figure 1 Brick making process

Issues related to brick sector

TERI started interaction with brick industries in the region along with Damle Clay Structurals Limited since 2004, under a project being supported by the Swiss Agency for Development and Cooperation (SDC). Interaction in the field led to identification of following issues relevant to Kolar brick industries:

- Improving operations of downdraught kilns

Figure 2 A view of downdraught kiln

- Enhancing drying of green bricks
- Better technological options for brick making

Addressing these issues was felt crucial for moving towards improved performance of the cluster. With this in view, TERI attempted to introduce changes in the cluster through demonstration.

Options to improve performance of brick kiln units

(1) Improving operations of downdraught kilns

Existing operating practices

In downdraught kilns, dry bricks are stacked, fired, cooled and taken out. These kilns are generally constructed with red bricks with the inner layer being refractory bricks. Thickness of the wall is about 5 feet. The total cycle time required for loading of green bricks to cooling of fired bricks is about 7 days. Production capacity of downdraught kilns range between 20,000 to 40,000 bricks per batch operation. There are about 12 fireboxes in a downdraught kiln, with 6 fireboxes located on each side. Figure 5 shows sketch of a downdraught kiln.

Figure 3 Existing firing practices

Dry bricks are stacked in the downdraught kilns. Generally, no gap is provided between bricks and the wall of the kiln. The openings are sealed off and firing is initiated. Eucalyptus branches and firewood are used as fuels for firing of bricks. Fuel is fed from all fireboxes from both sides; firing is continued till a temperature of about 500^{o}C is attained. Experiences of the operator judge the temperature by observing colour of bricks. Temperature monitoring is not in practice in the cluster. Upon reaching this temperature, fire boxes located on one side of the kiln are

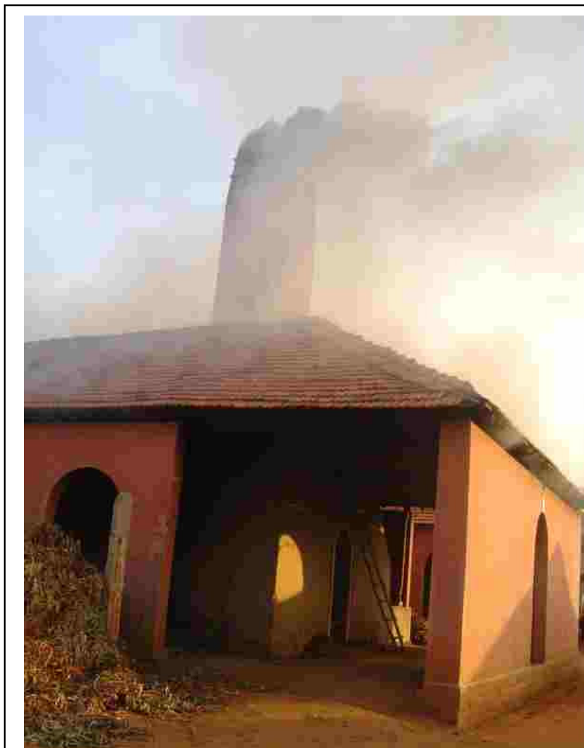

Figure 4 Stack emission from a downdraught kiln

completely shut off; fuel feeding is continued with fireboxes on the other side. Continuous feeding of fuel without monitoring temperatures results in deficiency in availability of combustion air, causing formation of unburnts and smoke. The key operating parameters in a downdraught kiln are shown in table 1.

Table 1 Key operating parameters of existing downdraught kiln

Production	32,500 bricks per cycle
Weight of bricks (average)	3.6 kg
Cycle period	Total : 7 to 9 days
	Heating :1 to 1½ days
	Stacking, cooling & unloading : 6 to 7½ days
Fuel consumption per production cycle	17.8 tonne per cycle
Specific energy consumption*	9.3 MJ/ kg fired brick
Saleable bricks	90-93 %
Total fuel costs	Rs 21,360 per cycle

Source: Based on actual monitoring carried out by TERI at Bagavahi Brick Industry, Malur

* *Specific energy consumption is the energy required to fire one kilogram of brick*

***Assumptions**:*

(1) GCV of wood = 2000 kcal/kg; (2) GCV of eucalyptus branches : 4466 kcal/kg (18.7 MJ/kg); (3) Cost of eucalyptus branch/ firewood = Rs 1200 per tonne

Sketch of Down Draft Kiln (DDK)

Sno.	Name of part
1	Top of DD kiln
2	Firing port
3	Flue gas chimney
4	Damper
5	Flue gas path
6	Brick loading space
7	Flue gas entering gap

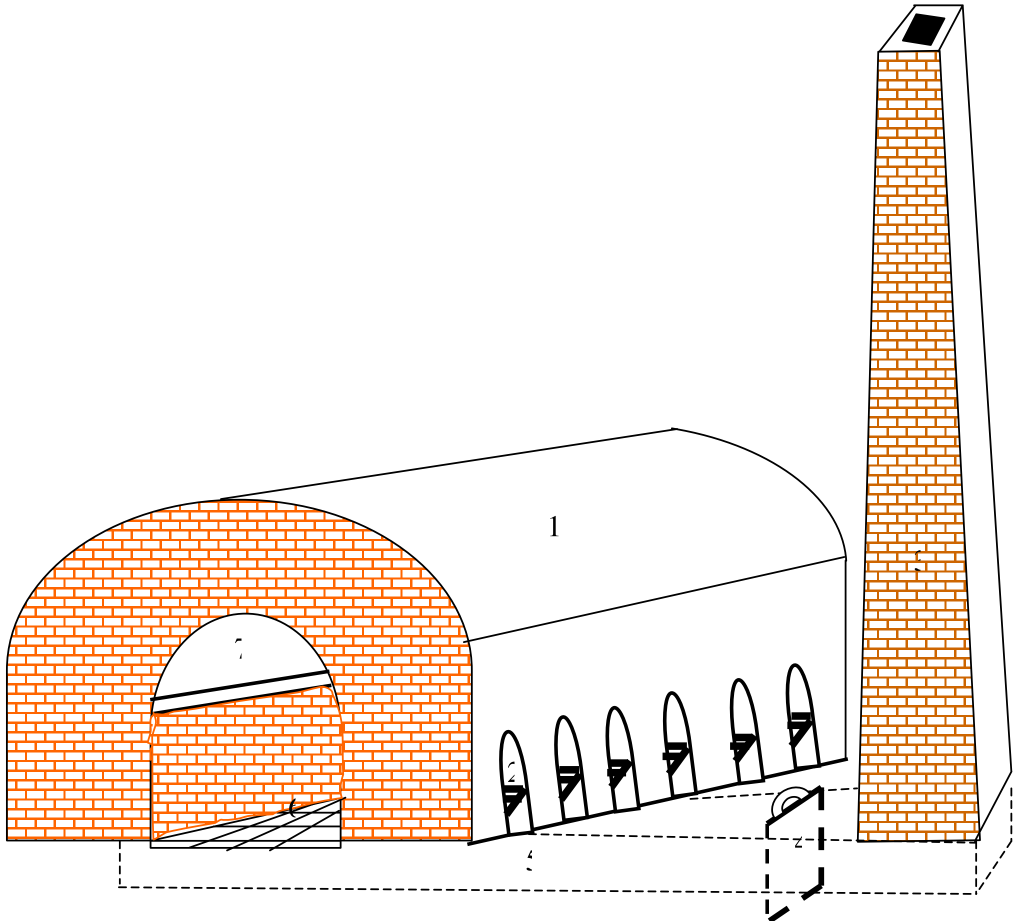

Figure 5 Sketch of a downdraught kiln

Improved or best operating practices

Improving the operating practices in a downdraught kiln was demonstrated in one of the units in the Kolar cluster, which involved the following:

- Quantification of various inputs such as weight of bricks and fuel consumption before and after firing.
- Adopting uniform fuel feeding pattern depending on temperature requirements to enable uniform distribution of heat and highest possible heat transfer.
- Continuous monitoring of temperatures of firing zone (in few selected locations) and flue gas temperature using thermocouples.

- Fuel savings upto 20%
- Reduction in firing cycle – 2 to 3 hours
- Reduced formation of over-burnt and under-burnt bricks

Adoption of best operating practices (BOP) helped in saving fuel (energy) consumption, upto the extent of 20%, improving product quality and reducing heat losses. Following observations were made while demonstrating best operating practices in downdraught kiln (table 2).

Table . Improved operating parameters with best operating practices

Fuel consumption per production cycle	15.8
Temperature of fired bricks	800-850^{o}C
Specific energy consumption	7.4 MJ/ kg fired brick
Saleable bricks	95-98%
Fuel savings	20%

Recommendations for best operating practices in downdraught kiln

Based on the demonstration carried out at Bagavathi Bricks, Malur, following operating practices are recommended which would help in improving the operating performance of downdraught kilns and attain fuel savings.

Recommendation-1: **Leave gap between bricks and kiln wall**

A gap of about 100 mm must be provided between bricks kept for firing and the wall of downdraught kiln. This would enable the fire to travel without obstructions and improve uniform distribution of heat between various sections of the kiln. Uniform distribution of heat would reduce over-firing or under-firing of bricks or formation of black cores.

Recommendation-2: **Operate fireboxes and damper based on requirements**

Upon initiating firing in a downdraught kiln, it is necessary to increase the temperature to release water from brick body and soak at temperatures based on composition of soil used to complete chemical reactions. To enable this, it is recommended to install thermocouples to monitor the temperature of the kiln inside.

(i) Operation upto 500^{o}C

Initial heating upto 500^{o}C is done gradually. This means measured quantity of fuel must be fed at constant rate for removal of mechanically held water and then chemically held water. Dampers must be open to aid this process. Fuel feeding is done through half number of the fireboxes, with remaining half must be kept closed until a temperature of 500^{o}C is reached. For example if the kiln has 12 fireboxes, 6 fireboxes must be used. It is also recommended that alternate fireboxes must be used during this phase.

(ii) Operation from 500°C onwards

With the removal of chemically held water, the firing rate is increased. Fuel feeding must be continued from all fireboxes on both sides of the kiln. Damper openings must be reduced to retain heat inside and temperature inside the kiln for maximizing heat transfer to the bricks. During this stage, flue gas heat losses are also reduced due to reduced air flow. The firing temperature of bricks in Kolar region is about 800-850°C.

Firing must be continued from all sides to enable soaking of bricks for about 3 hours in the same temperature range. Firing is stopped at this point and all fire boxes are closed. Figure 7 shows a typical temperature profile in a downdraught kiln in Kolar cluster.

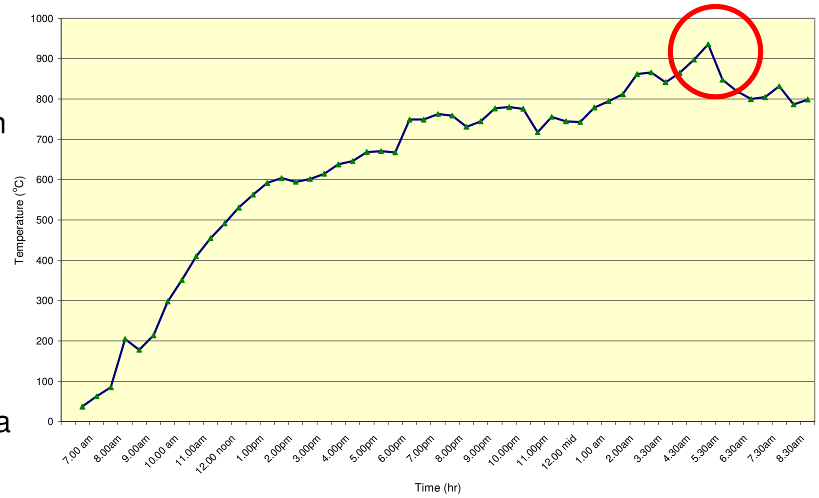

Figure 7 Typical temperature profile in downdraught kiln

(2) Enhancing drying of green bricks

Freshly moulded bricks contain lot of water which need to be removed to reach leather-hard conditions. This is required to ensure no deformation of shape takes place while handling as well as no breakage during heating. Typical conditions of bricks in Kolar cluster shows about 17% reduction in weight due to moisture removed from green bricks (table 3).

Table 3. Weight of bricks

Freshly moulded bricks or green bricks	:	4.54 kg
Dry bricks	:	3.76 kg
Fired bricks	:	3.58 kg
% weight reduction after drying	:	17.3%
% weight reduction after firing	:	4.6%

Existing drying cycle in Kolar and Malu clustersr

The total duration for complete drying of bricks is 8 to 25 days depending on climatic conditions, starting from green brick moulding to before feeding inside the kiln for firing (table 4). Time requirements for drying increase during monsoon season.

Table 4 Weight of bricks

Season		*Days*
Summer	:	6 – 10
Rainy	:	20 – 25
Winter	:	15 - 18

The needs and options for brick drying

Large duration required for drying indicates requirements of large sheds and green brick inventory required at kiln site. Use of separate dryers to remove moisture from green bricks would greatly help in reducing the duration for brick drying. Since these dryers are separate systems and use additional fuels to dry green bricks, they are known as "*artificial drying*". These artificial dryers would help in:

- Reducing duration required for green brick drying
- Enhancing productivity of the unit
- Reducing green brick inventory

However, adoption of artificial drying would require additional investments. With the use of additional fuel, it would also increase the overall operating costs of the unit. Depending on the scale of operation, individual units may choose any one of the methods for their benefits.

(i) Artificial drying

Artificial drying enhances availability of moisture-removed dry bricks for firing in the kiln. A number of dryers are available commercially, and the level of sophistication dictates the investments requirements. Most of the dryers also require power (electricity connection/ use of diesel generating sets) for operating blowers/ fans and/ or moving platform. Non-availability of quality power (availability and voltage level) may also be a constraint for majority of the brick kiln units which are generally located in rural areas. Figure 8 shows dryer will be used for removal of moisture from bricks before loaded inside the kiln. Types of artificial dryers available in the market are:

- Hot floor drying
- Tunnel dryer
- Waste heat dryer
- Chamber dryer
- Heap dryer

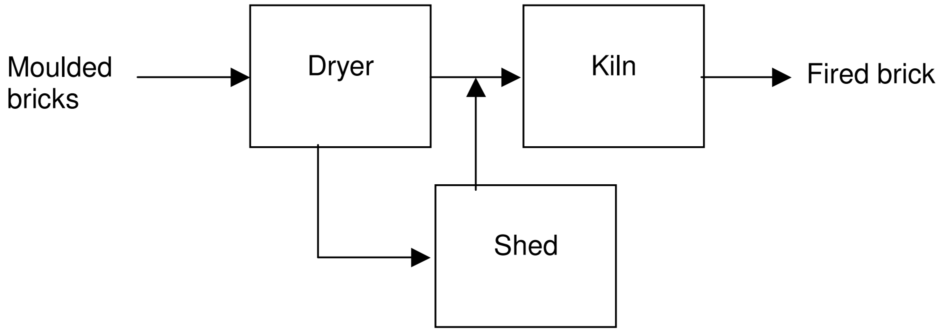

Figure 8 Use of dryer in a brick kiln

Efficiency levels of "hot floor drying" is very poor compared to other systems, and hence not preferable. Investment requirements for tunnel dryer are quite high for the level of brick production followed in Karnataka. Waste heat recovery system also may not be suitable as they would require continuous source of flue gases for supply of waste heat which is not generally available in a brick kiln unit.

Figure 9 Artificial stack dryer experimented by an entrepeneur at Malur

"Heap/ stack drying" is similar to clamp firing. Bricks are stacked and heated with fuel fired from sides. Figure 9 shows some trials conducted by one of the brick kiln units in Malur. However, the disadvantages of heap drying are:

- Low thermal efficiency i.e. require more fuel for drying
- Non-uniform heating of bricks

Chamber dryers are intermittent drying systems following batch process. This is suitable for a medium size brick kiln unit. Approximate investments for a chamber dryer for a capacity of 1200 bricks per batch are Rs 3.5 lakh. The total cycle time for the drying process in a chamber dryer is 50 hours.

(ii) Other options - Improving natural drying practices

Brick kiln units in Kolar and Malur use extensively sheds which are used for drying as well as storing of bricks. Figure 8 shows a typical shed used in a brick kiln unit. A close look on the sheds used in the cluster indicated scope for improvements to improve the drying process. TERI demonstrated the benefits of adoption of improved drying sheds in one of the brick kiln units at Malur.

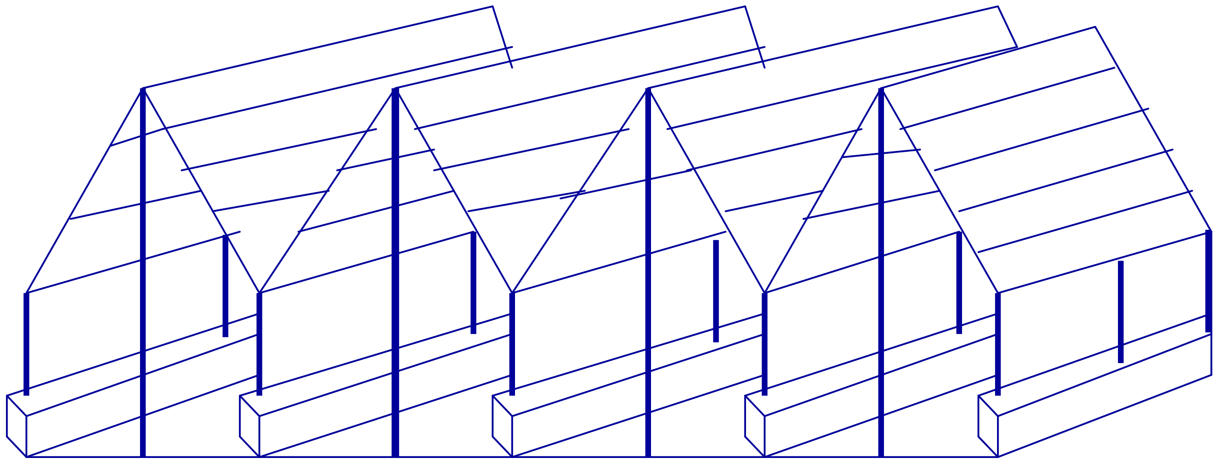

Figure 10 Drying sheds used in Kolar/ Malur brick kiln units

Recommindation-1: **Direction of sheds**

Drying sheds are located in North-South direction as well as East-West direction, depending on the convenience of the unit. These sheds must be relocating mainly in East-West direction, to match with the direction of wind flow that would improve the drying rates.

Recommendation-2: **Distance between adjacent sheds**

Most of the drying sheds inside a brick kiln unit are built close to each other with very little gap existing between. Closely located sheds reduce the rate of heat transfer. In each brick kiln unit, a space of about 5 feet must be left between adjacent sheds which would help in improving convection and hence removal of moisture.

Recommendation-3: **Enhancing solar heating with translucent/ glass tiles**

The sheds of brick kiln units in Kolar/ Malur are constructed with clay tiles. These tiles do not allow sun light to pass through. It is recommended that at least 3-5% of existing tiles in the sheds must be replaced with translucent tiles which would allow sunlight to pass through and help in increasing drying rates. These glass tiles must also be staggered (e.g. zigzag pattern) to ensure availability of heat across different sections of the shed.

Recommendation-4: **Provision of hoods in roof**

None of the sheds in Kolar is provided with exhaust system at the roof which would induce draught and circulation of fresh air inside the shed. The existing roof structure must be fitted with hoods for removing moist air and allow flow of fresh air to enter inside.

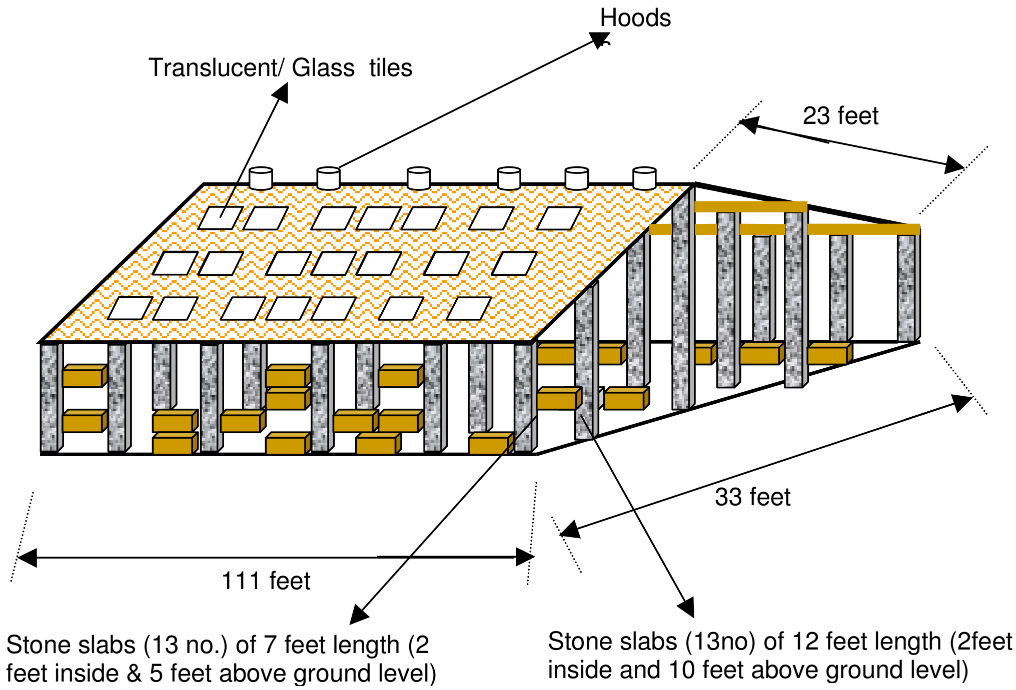

Figure 11 Improved drying sheds

Incorporation of changes in the sheds is expected to enhance the drying rate by about 30-35%. Figure 7 shows a sketch of an improved drying shed. These modifications would require a marginal investment of about Rs 25,000 per shed of storing capacity of 30,000 bricks.

(3) Use of additives to improve strength of green bricks

Trials were conducted by TERI for use of additives, mainly sodium silicate in green brick making in one of the brick kiln units in Malur. It was observed that particularly the number of handlings of green bricks is more in case of VSBK (vertical shaft brick kiln) as compared to traditional downdraught kilns. Therefore, the green bricks must have enough strength which otherwise leads to more rejections (10-15%) due to chipping of edges and warping of bricks. 2% sodium silicate (commercial grade) was added to the water and mixed with the body homogeneously in one of the brick kiln units. Trials conducted at the brick kiln unit at Malur led to following observations:

- Shape of the brick was perfect with no distortion
- Uniform surface finishing including edges (chipping reduced from 10% to 1%)
- Marginal improvement in the drying (upto the extent of 3%)

The results of the additives use are found to be very useful for the brick industry, which must be adopted to improve the quality and strength of green bricks.

(4) New technologies – VSBK (Vertical Shaft Brick Kiln)

Figure 12. VSBKs in Kolar and Malur

TERI introduced VSBK (Vertical Shaft Brick Kiln) in Kolar/Malur during 2005, which are more energy efficient and environment friendly (figure 12). The specific energy consumption of VSBK was the lowest among other types of brick kilns (figure 13).

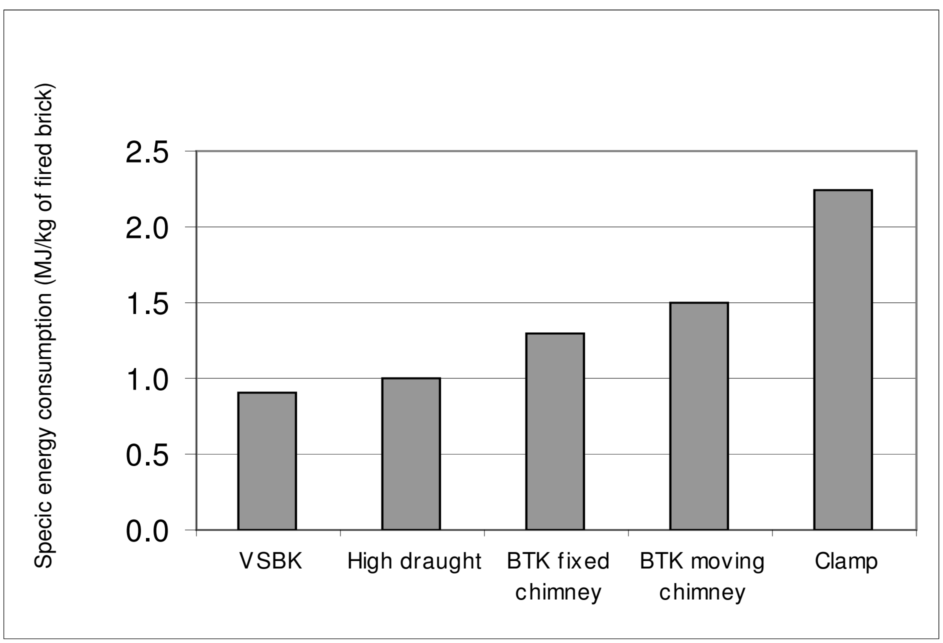

Figure 13 Comparison of specific energy consumption of different brick firing technologies

VSBKs in Kolar were operated for a brief period and the rejection rate was observed to be higher. Following modifications were incorporated in VSBK to reduce rejections.

Modifications incorporated in VSBK operation

Modification-1: **Changes in initial firing**

Either to the Initial heating of this kiln was being done by loading with green bricks, which was resulting in over-firing of initial batches. In the modified operation, the initial firing will be done using firewood without bricks loaded in the kiln. Upon reaching the required temperature, brick loading must be done which would help in reducing rejections. Experiment on reduction in initial charging of coal (from 20 kg to 16 kg) has also yielded better results and helped in reducing overburnts.

Modification-2: **Maintaining sufficient spacing between kiln wall and brick column**

The gap between the kiln wall and the brick column inside the shaft was slightly increased and uniformly maintained. This has resulted in avoiding falling of bricks which otherwise would lead to kiln stoppage and restarting. This problem has now been totally avoided.

Future directions for Kolar brick industry

Production of resource efficient products such as perforated bricks, hollow blocks and fly ash bricks and adoption by the market will help in enhancing energy efficiency, environmental improvements, soil degradation and profitability of the brick enterprises. This would require incorporation of appropriate equipment and systems like extrusion machines and a better understanding of the soil available locally (figure 14). For large scale brick production, adoption of tunnel kiln technology will be an appropriate option which would also help in enhancing the productivity and yield (figure 15).

Figure 14 Brick extrusion machines

Figure 15 Tunnel kiln for brick firing