Vertical Shaft Brick Kiln - Technology Transfer
Indian Experience - 1

1 Introduction

Sectoral Context

Shelter forms one of the basic needs of humankind next only in importance to food and clothing. With rapidly increasing population in countries like India it is a colossal task to provide shelter to the teeming millions. Government and non-governmental organisations have tried to address this problem and come out with various schemes and technologies to bridge the ever widening gap between the need and availability of dwelling units in the country.

In meeting the walling material requirement for this quantum jump in construction of dwelling units, it is expected that burnt clay bricks will continue to be the principal walling material, in spite of various alternative technologies based on local and sustainable resources propagated for providing low cost housing to the millions.

The current technologies prevalent for firing clay bricks in the country such as intermittent clamps and continuous Bull’s trench kilns consume huge quantities of energy. The emissions from these kilns have high negative impact on the environment in terms of damage to the people and crops in the nearby areas, and contribution of CO2 emissions for global warming. Thus, any technology for augmenting supply of burnt clay bricks with lower specific energy consumption and promising lower negative impact on the environment would merit consideration for adoption.

VSBK technology in China

In China, a technology claiming high energy efficiency and consequent lower emissions has been developed over the past three to four decades and has had wide dissemination in more than ten provinces of the country. It is the Vertical Shaft Brick Kiln (VSBK) technology which has spread widely in recent times. VSBK essentially consists of one or more rectangular shafts within a kiln structure, where dried green bricks are loaded at the top along with powdered fuel - coal. These move down through the preheating, firing and cooling zones and are unloaded at the bottom. The details of concept, design and operation of VSBK’s have been covered in detail in other literature (References 1 to 5) and is not repeated here. It is reported that there are more than 50000 kilns operating in China now with more than 3000 in Fuzian county alone. The main reasons for the success of the technology are about 40 to 50% reduction in energy consumption, simplicity of operation and economic viability.

It was in this context that the transfer of VSBK technology from China to India and its dissemination after validating its suitability to Indian conditions was conceived.

VSBK technology route-from China to India

The first VSBK outside China is reported to have been established in Nepal. Subsequently VSBKs have been constructed in Bangladesh, Pakistan, Afghanistan and lately in Sudan. The projects in these countries have met with varying degrees of success and setbacks. The experiences have been documented in literature such as Reference 3 which deals with the experience in Pakistan. This information on lessons learnt from the earlier experiences was helpful in formulation of the current project. This case study tries to give an account of the Indian experience detailing the steps taken to ensure effective transfer of technology to India.

VSBK Project in India - Main agencies involved

Development Alternatives, a leading NGO with concerns for sustainable livelihoods, conceived an action research programme on sustainable production systems for construction material including kilns for burning bricks. The Swiss Agency for Development and Co-operation supported the project, within its ‘Energy Efficient and Renewable Energy Sources’ programme.

The Tata Energy Research Institute - a major Indian organisation in the field of energy and environment was another significant member of the project team, contributing to the energy aspects. SKAT and Sorame - two Swiss consulting organisations were assigned advisory and backstopping responsibilities for the project. A Chinese expert team from the Henan Academy of Sciences was engaged on a long term basis for providing the technology support.

2 Objectives - Strategy - Implementation

Four main steps and the role of the implementing agencies in the network as envisaged were:

1. Baseline studies for auditing the energy and environmental aspects of brick production in various traditional high volume brick production areas:
   - Energy Audit by Tata Energy Research Institute (TERI),
   - Environmental Audit by Environment Services Branch of Development Alternatives.
2. Design, construct and operate two pilot kilns in two distinctly different agro-climatic geographical areas:
   - association of Chinese Experts for the full period,
   - association of brick kiln entrepreneurs for construction and operation of the kiln,
   - advice of backstopping consultants through different milestones for periodic evaluation and mid course correction,
   - DA to undertake implementation and overall co-ordination.

3. Evaluation and Validation of technology:
   - Environmental Services Branch of DA for Environmental Audit,
   - TERI for Energy Audit,
   - DA for operational & economic audit and overall co-ordination in association with outside players in brick industry.

4. Market study and Large Scale Dissemination if the steps 1 to 3 pass the requirements as one moves progressively through a carefully planned decision tree.

Initially, the main objective of the sub project was to assess the potential of VSBKs against the Bull's Trench Kiln (BTKs) in terms of energy saving, environmental aspects and economic operation, and if found favourable, to study the market, validate the technology and plan for wide dissemination of the technology.

**Initial Implementation**

The first steps in the implementation of the project were carried out in 1995. These were the baseline studies of BTK operations in significant brick production areas in Bhognipur - Kanpur belt and in Pathankot area. Environmental Audit and Energy Audit were conducted by the respective agencies between April and October 1995.

In January 1996, a team consisting of DA coordinator and the backstopping consultants visited Peshawar, Pakistan to learn from the experience of VSBK technology transfer in Pakistan.

Main observations and recommendation which evolved out of the mission to Pakistan are given below. Observations in Reference 3 are also relevant in this regard:

- VSBK technology is not yet sufficiently developed as an alternative to large scale brick production.

- Further basic technology development is required to optimise operating parameters and economy.

- The VSBK probably operates most successfully in a decentralized set up where owner and family are fully and continuously involved.

- The project team should construct and operate a two-shaft VSBK, preferably on its own and/or in a protected environment independent of interference from kiln owners.

- The building up of local know-how as well as basic acceptance is vital for the dissemination and sustainability of VSBK technology. For this, two teams for construction and two firing crews should be trained. DA experts must lay their hands on and work on all phases of operation while learning from their Chinese counterparts and be responsible for the operation, especially for the firing.

- First audit the energy and environmental factors and evaluate overall performance and then plan for dissemination.

- The Chinese expert team - the technology provider - should be associated with the project on a long term basis.

With the strategy revised in accordance with the above, it was decided to set up the first VSBK in India in an area where clamps are prevalent for brick making. It was also decided that the kiln would be constructed and operated by the Development Alternatives team under controlled conditions so that the technology absorption and any adaptation necessary to meet the requirements under Indian conditions, identified by the project team, could be implemented.
Implementation

The implementation on the ground started with this background. A participative approach was adopted with all the team members involved in decision making and planning and significant aspects reviewed and guided by the consultant backstoppers.

Design

The designs and drawings were prepared by the Chinese team with the DA team actively participating in the process and providing all the required data relevant to Indian and local conditions of material availability, standardisation and construction methodology. Energy experts from TERI and environmental experts from DA made significant contributions not only in their respective fields but to the development of the overall concept.

It was decided to include as many alternative features in the design of the kiln as possible so that the Indian team got familiar with the various options available and as a result technology absorption is accelerated. Thus, the two shafts (both of 8 batches height) were of two different sizes 1m x 1m and 1m x 1.5m. The unloading device for the smaller shaft (Shaft no. 1) was to be of chain pulley block design, whereas the bigger shaft (Shaft no. 2) was to have single screw unloading mechanism. Loading platform had a monitor roof for better ventilation and two chimneys per shaft were provided to evacuate the exhaust gases (Fig. 1).

Site selection

A rapid survey was conducted in the clamp areas around Jhansi initially by the DA energy team which shortlisted about 11 locations. This was reviewed by the Chinese experts, DA project team and the backstopping consultants and final decision taken to locate the first Indian Vertical Shaft Brick Kiln at Dattia in Madhya Pradesh state of India. The site was to be leased / rented / bought by the project so that operations could be conducted under controlled conditions.

Construction

The construction activity was thoroughly planned with a detailed work breakdown structure and all the players in the team assigned their respective responsibilities and time schedules. In an interesting and effective planning seminar, the backstopper made sure what each team member would do and would not do.

The construction of the kiln started on 13 March 1996. Expert masons from DA and local labour formed the main construction force. Chinese craftsmen actively participated and guided the Indian team during all stages of construction. Constant supervision was provided by the Chinese experts and DA engineers. Energy experts from TERI and environment experts from DA made periodic visits to ensure compliance with their concepts and requirements (Fig. 2).

Specialized mechanical equipment was manufactured locally (Fig 3). DA engineers planned and executed all stages of work - procurement of materials and components, fabrication, assembly and testing. DA and Chinese engineers provided periodic advice and guidance to the local manufacturer. That the local manufacturers have imbibed thorough capability in manufacture is evident from the fact that later orders for the other kilns were executed by them without any hassle.

For the actual construction of the kiln and the operating room, a team of about 5 masons and 10 helpers was engaged (not all were working at the same time). The larger number was engaged to create a group of workers who have acquired the skills of constructing the VSBK (Fig. 4).
The construction had a smooth run apparently due to the thorough planning done in the beginning, and was completed in about 45 days. The first shaft was fired on 30 April 1996 (Fig. 5).

**Operation**

Green brick supply was planned through the conventional methods prevalent in the area, to enable evaluation of performance of firing in VSBK in comparison with the clamps, keeping the other parameters in brick production similar. The conventional method employs winning clay by manual means, mixing with wheat straw and coal ash (from power plants and foundries) with the clay, and hand moulding using wooden steel-lined moulds. Green bricks were dried in the open and carried to the loading platform using animal power - donkeys. Coal from Jharia fields was procured from local sources, of size less than 6mm. A team of about 18 firemen was engaged locally for operating the kiln, who worked under the guidance and supervision of the Chinese expert and technicians. Facilities were created for the Chinese and DA technicians to stay at site during the operation phase to ensure attendance throughout day and night.

Variety was adopted in initial firing also. The Shaft No. 1 was lighted from the bottom (on 30 April 1996) and Shaft No. 2 was fired from the top (on 10 May 1996).

The DA operating team members worked hand in hand with their Chinese counterparts, staying throughout the operation at the site. The Indian firemen had no difficulty in acquiring the requisite knowledge and skills for operation of the kiln and the confidence for facing any exigency arising therein. Those firemen who showed good performance and leadership qualities were upgraded as firemasters.

The operation of the kiln continued till 25 June 1996 when it was shut down for the rainy season. Various campaigns of operation, with different clays and various mixes of clay for moulding, were conducted. Environmental conditions were monitored by the ESB team of DA and Energy Audits conducted by the TERI team.

**3 Results and learnings from VSBK 1**

The overall findings after this phase of operation were as follows:

- Quality of bricks produced - better than those produced in nearby clamps in terms of ring and colour. But the
quality is not as good as in traditional BTK areas, ostensibly due to inferior clay quality.

- The compressive strength (between 65 kg/cm² and 110 Kg / cm²) and water absorption (around 15%) is functionally sufficient.

- The breakage of bricks during the firing is only about 2 to 4%.

- Lower level of emissions - within acceptable limits. But there is scope for improvement for working environment at the loading platform.

- Energy saving is confirmed (about 30% compared to BTKs and 60% compared to local clamps – see histogram attached - Table 1).

- Technology is viable with reasonable margins for the entrepreneur. As VSBK 1 is an experimental kiln, the cost figures obtained could only be indicators. Scope for increase in margin identified - by reduction in cost of green bricks, reduction in capital cost and increase in scale of operation.

- There is no problem envisaged in the absorption of technology by the Indian personnel.

Mid Course Review and Modifications

At this stage a workshop on "Status and Review of VSBK technology in India" was held on 27-28 June 1996 with participation of stakeholders, project team members and backstopping consultants. The group deliberated at length on all aspects of the technology transfer and performance of the project. Some ideas for further improvement in the energy and environment aspects evolved during the discussions and it was agreed to incorporate some modifications to the kiln to achieve these benefits. The major changes identified for implementation are:

- Open out the loading platform by replacing the walls with columns and grills,
- Increase height of shafts by one batch from 8 to 9,
- Increase height of stack by about 1 metre,
- Increase the gap in roof monitor from 350mm to 700mm,
- Provide flues and dampers at two levels at the top of the shaft,

Fig. 7: Kiln after completion of construction before modification

Fig. 8: Kiln after modification
Second phase of operation

The second phase of operation started by the end of December 1996. It is a measure of confidence in their learning that the DA team fired the shaft on their own pending arrival of the Chinese team.

The operation of the kiln was continued as in the first phase with various campaigns of different clays, different mixtures for green brick production etc. The energy and environmental aspects were monitored at different intervals. The kiln was shut down again for the rainy season by the end of May 1997.

The overall results show that the improvement in energy efficiency over the first phase is marginal whereas there is definite improvement in the environmental aspects at the work place which meet the national standards for the various parameters such as SPM, SO₂, NOₓ, CO etc.

Achievements

The following can be considered to have been achieved as a result of the VSBK technology transfer experience:
- Energy efficiency of VSBK established - other aspects of operation are also promising.
- Design improvements so that the working environment meets the relevant national standards.
- Groups of masons, firemasters, firemen and supervisors trained on the job.
- Indigenous capability built up for fabrication and manufacture of specialised mechanical equipment such as unloading device, trolleys, lid systems etc.
- An efficient energy monitoring and feedback system has been established with TERI and for environment monitoring with DA.
- Through this monitoring system, the needs and potentials for further improvement have been identified.
- R & D work was conducted to further improve energy and environment efficiency of VSBK and further possibilities identified.
- VSBK design, construction and operation guideline documents have been prepared.
- A very good project team and cooperation between different actors and organisations has been established.

Further work

The performance of the project was reviewed in the Analysis and Outlook Workshop held during 3-5 June 1997 with wide participation. It was mainly planned to continue the good work done with the aim of further improving the performance of VSBKs in terms of quality, volume of production and economic viability. Earlier a mission consisting of DA and TERI experts and backstopping consultant visited VSBKs in China mainly for understanding the factors leading to their wide dissemination and the methodology. The findings were presented in the workshop. Some of the actions agreed during the workshop are: improving the quality of green brick production by installing extruders, building kilns with larger shafts for higher volume of production in an area with good quality clay availability, and monitoring and optimising economic performance.

Conclusion

The project team received appreciation from the stakeholders and backstopping consultants during the periodic review and evaluation missions. This greatly encouraged the team to put in greater efforts to achieve the aim and objectives of the project. The concerned officials of DA, SDC and TERI provided constant support and guidance to the project team. The project team acknowledges this as of great value in successful implementation of the project.

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References

- The Basics of Brick Kiln Technology by Tim Jones published by GATE, 1996
- Technical Brief - The Vertical Shaft Brick Kiln by Tim Jones published by basin at GATE 1995
- Case Study - The Vertical Shaft Brick Kiln: A problematic introduction into Pakistan by Tim Jones published by basin at GATE 1997
- Chinese Vertical Shaft Brick Kiln (VSBK) Nepal by Heini Mueller
- Energy Saving Brick Kilns: Report by Henrik Norsker for Swiss Development Cooperation, April 1994
- Development Alternatives Newsletter - Sept. 1996
- Project Documents

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