4 VERTICAL SHAFT BRICK KILN TECHNOLOGY (VSBK)

INTRODUCTION AND HISTORY[1]

Vertical shaft brick kiln (VSBK) is a continuous, updraft, moving ware kiln in which the fire remains stationary while there is counter current heat exchange between air (moving upward) and bricks (moving downward).

The VSBK technology has evolved from the traditional up-draught kilns in rural China during late 1950s; however, the widespread dissemination of the technology took place after the economic reforms. At its peak during the mid 1990s, thousands of VSBKs were reported to be operating in China.

Since 1990, under different technology transfer projects the technology has been transferred to several developing countries including India, Nepal and Vietnam. Whereas the dissemination of VSBK technology in India and Nepal has been relatively slow, the experience in Vietnam has been very positive. Vietnamese brick makers have been able to innovate and have added new features to the technology, and in the process have transformed a rural technology into an industrial technology.

ABOUT THE KILN

Kiln

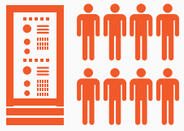
CONTINUOUS MOVING WARE

ENTERPRISES USING THIS TECHNOLOGY

Nature of enterprise

INDUSTRIAL

Level of mechanization



SEMI MECHANIZED

Brick produced

SOLID

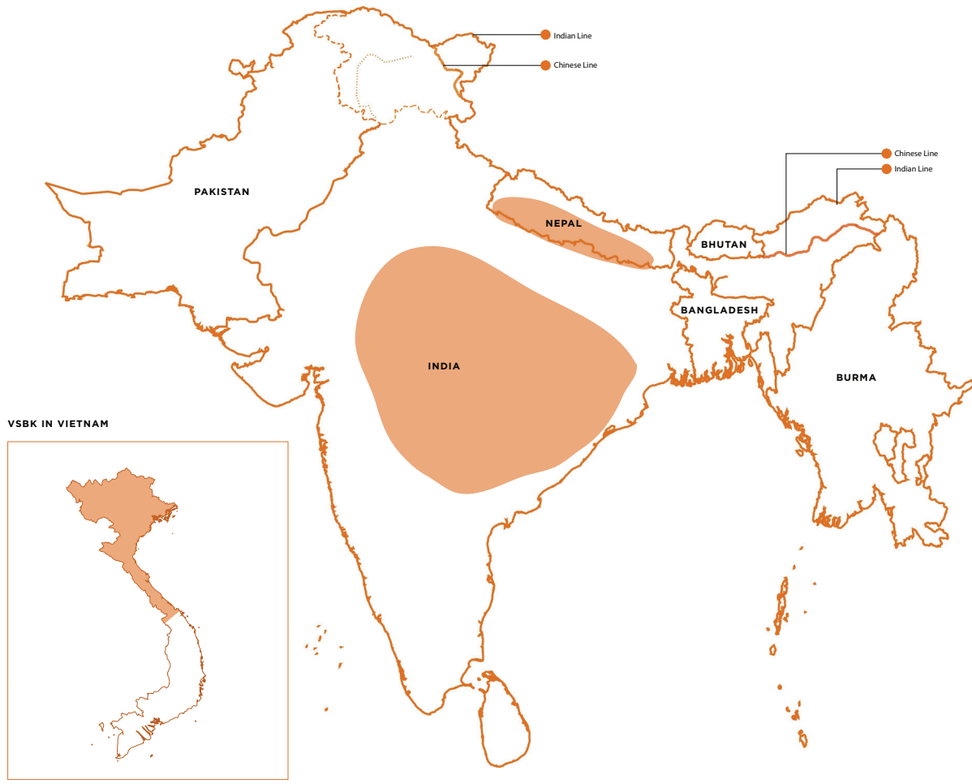
Production capacity

SMALL & MEDIUM
Between
0.5-10 million bricks

Operational season

PERENNIAL

GEOGRAPHICAL DISTRIBUTION



NUMBER OF OPERATIONAL ENTERPRISES AND TOTAL PRODUCTION* IN INDIA, NEPAL AND VIETNAM

Country	Number of enterprises	Total production billion bricks/year
India[2]	~110	~0.3
Nepal[3]	~25	~0.1
Vietnam[4]	~600	~1.8

*Numbers are estimates only

% CONTRIBUTION TO THE TOTAL BRICK PRODUCTION IN INDIA, NEPAL AND VIETNAM

~1%

Out of the total annual production of around 280 billion bricks in India, Nepal and Vietnam only around 2.2 billion bricks are produced by VSBK technology

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DESCRIPTION AND WORKING

1

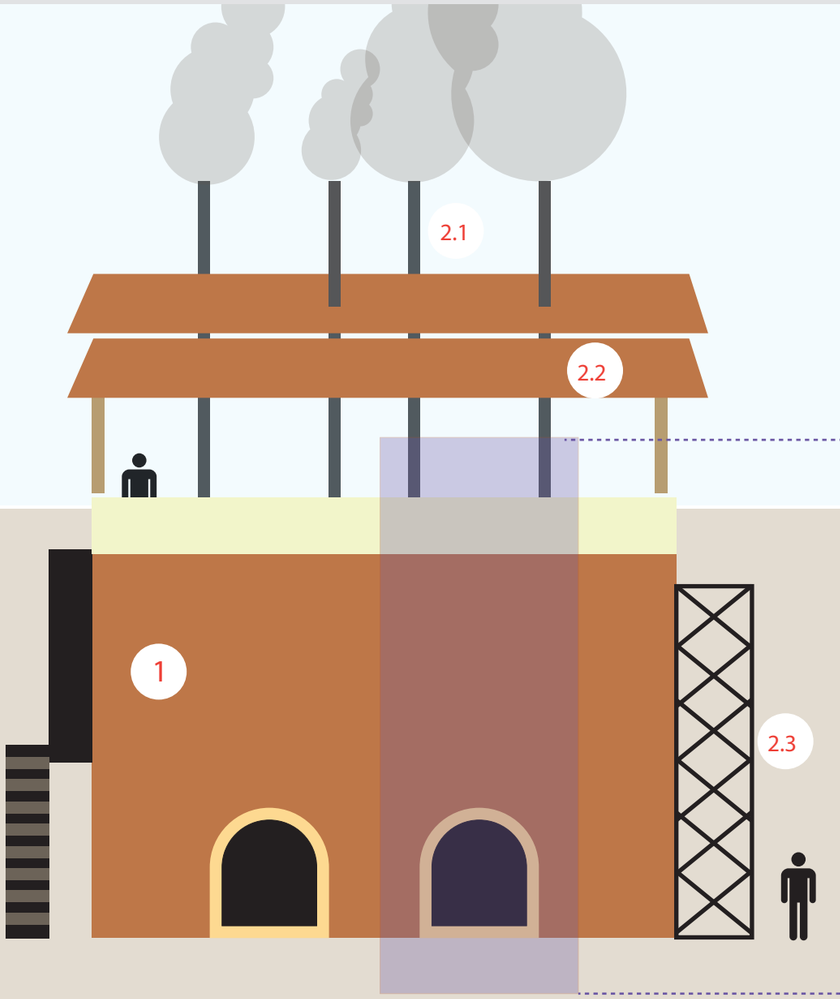
Vertical shaft brick kiln is a continuous, moving ware kiln in which bricks are fired in a vertical shaft of rectangular/square cross-section. The height of the shaft is around 6 – 10 m and the cross-section of the shaft can range from 1.0 x 1.5 m to 1.75 x 3.75 m. Mostly, the kiln consists of two or more shafts. The shafts are enveloped by an outer wall made up of bricks and the gap between the shaft and outer kiln wall is filled with insulating materials like clay, fly ash and rice husk. Some of the modern kilns in Vietnam are also using glass wool for insulation.

2

Generally each shaft is connected with two chimneys (2.1), located at diagonally opposite corners of the shaft. The working platform (the top of the shaft) is usually shaded by a roof (2.2). Green bricks and fuel, which are loaded in the shaft from the top, are lifted to the working platform using conveyors or lifts (2.3). However, in some of the traditional kilns manual transportation of bricks is also practiced.

3

Green bricks are loaded from the top of the shaft in batches. The fuel, generally crushed coal or briquettes, is laid along with the green bricks. In the modern VSBKs, mostly in Vietnam, use of internal fuel supplemented by a small quantity of external fuel is widely in practice.



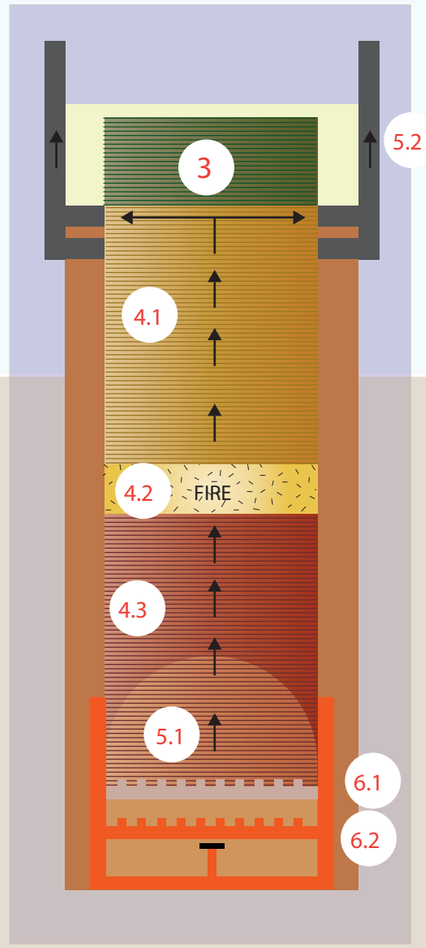
4

Green bricks loaded from the top gradually move down the shaft. The peak firing temperature is at the middle of the shaft, where combustion of fuel is taking place. Fired bricks after cooling are unloaded at the bottom. There are 3 distinct zones in an operating VSBK:

4.1 Brick preheating zone: It is in the upper section of the shaft where the green bricks get preheated by the hot flue gases on their way to the chimney.

4.2 Brick firing zone: It is located in the middle of the shaft where fuel combustion is taking place.

4.3 Brick cooling zone: It is in the lower section of the shaft where the hot fired bricks are cooled down by the cold ambient air entering into the shaft.



5

Air for combustion enters the shaft from the bottom (5.1). It gets preheated by the hot fired bricks in the lower section of the shaft (brick cooling zone) before reaching the combustion zone. After combustion, the hot flue gases preheat the green bricks in preheating zone before exiting the kiln through the chimneys (5.2). The kiln works as a very efficient counter current heat exchanger where the heat transfer takes place between the air moving up (continuous flow) and the bricks moving down (intermittent movement) in the shaft.

6

The brick setting in the shaft is supported on removable bars (6.1) provided at the bottom of the shaft. Brick unloading is carried out in batches from the bottom with the help of a trolley (6.2). Generally, every 2-3 hours, one batch is unloaded at the bottom and a batch of green bricks is loaded at the top. At any given time, there are typically 8 to 12 batches in the kiln.

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AIR EMISSIONS AND IMPACTS

MEASURED EMISSION FACTORS[5]

g/kg of fired bricks			
CO2	Black Carbon	PM	CO
Average			
70.5	0.001	0.15	1.84
Range			
62.2-78.7	0-0.002	0.12-0.19	0.85-2.83

MEASURED PM EMISSIONS

Average: 107 mg/Nm^3

(Range: 101 – 114 mg/Nm^3)

EMISSION STANDARDS

Notified for PM only

Country	PM (mg/Nm^3)
India	250
Nepal	600
Vietnam	No emission standard has been notified for brick kilns

COMMENTS ON EMISSIONS

Low fuel consumption and better combustion result in low emissions. Practice of using internal fuel, mainly in Vietnamese VSBKs, further helps in reducing the emissions.

FUELS AND ENERGY

COMMONLY USED FUELS

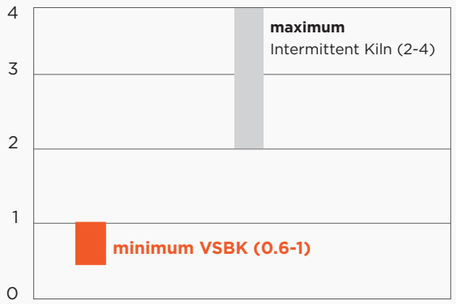
Coal
Most commonly used

SPECIFIC ENERGY CONSUMPTION[6,7]

Energy consumed for firing 1 kg of fired brick

Average: 0.8 MJ/kg of fired bricks
(Range: 0.54 – 1.1 MJ/kg of fired brick)

MJ/kg of fired brick



Note: Measured at firing temperature of 900-1050^{0}C

Because of proper combustion of fuel, efficient heat transfer and minimal heat losses, VSBK is one of the most energy efficient brick kiln technologies.

A very efficient counter flow heat transfer arrangement between air and bricks, uniform fuel distribution and sufficient insulation around the kiln attribute to the efficiency of a VSBK.

MAIN CAUSES FOR HEAT LOSS

The main sources of heat loss in a VSBK are the flue gases and fired bricks coming out of the kiln.

FINANCIAL PERFORMANCE

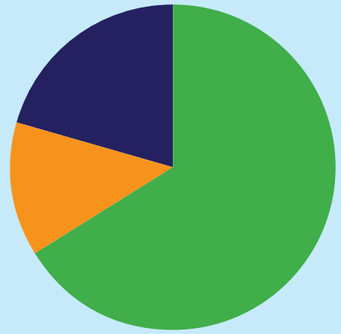
Capital cost of kiln technology

For a two-shaft VSBK with annual production capacity of 1.5 - 3 million bricks and excluding land and working capital cost

60,000 to 80,000 USD

Capital cost breakdown

Construction Material	65 %
Labour	15%
Equipment	20%



Production capacity	8000 to 12,000 bricks per day	
Brick size	230 mm x 115 mm x 75 mm	
Number of Operators required	10	
Payback Period	Simple Payback	0.9 – 1.8 years
	Discounted Payback (@ 6.5%)	1.3 – 2.0 years

PRODUCT QUALITY

Product Quality
As per the local market perception

GOOD ~ 90%

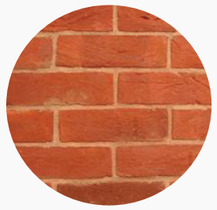
LOSSES / BREAKAGES ~ 10%

Fast heating and cooling of the bricks and high load in the lower section of the brick stacking are the main factors which can cause cracks and damages to the bricks in the VSBK. These factors are more prominent in case of hand moulded bricks which have low density and low compressive strength. However, with extruded or machine moulded bricks, breakages and losses are very low.

Types of product that can be fired in the kiln	Solid bricks	✓
	Hollow/ Perforated bricks	✓
	Roof tiles	X
	Floor tiles	X

VSBK is well suited for firing solid bricks. It can also be used to fire bricks with perforations, but is not suitable for firing hollow bricks or thinner products like tiles.

GOOD BRICK



INFERIOR BRICK

under-fired and over- burnt

OCCUPATIONAL HEALTH AND SAFETY

Exposure to Respirable Suspended Particulate Matter[8]

The VSBK has a permanent kiln structure and with introduction of the chimneys in the kiln (the initial VSBKs of China did not have chimneys), the air pollutants concentration in the surrounding environment is quite low and the exposure of workers to air pollution is less. However, the workers loading bricks in the kiln shaft are exposed to air pollutants.

The workers loading bricks can develop respiratory tract infections.

Exposure to Thermal Stress[9]

Because of shading and insulation of the kiln, workers working on the kiln are protected from the direct exposure to Sun and exposure to heat from the kiln is also very low.

This reduces the thermal stress and consequent risk of eye & skin diseases and dehydration among workers.

Risk of accidents

With properly constructed VSBKs having mechanised brick lifting and brick unloading processes, the exposure of workers to accidents is low. However, with VSBKs which are not properly constructed and involve manual lifting and unloading of bricks, the risk of injuries could be high.

Low risk of injuries

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

Practices followed at vertical shaft brick kiln enterprises do not always comply with the International Labour Standards on occupational health and safety drawn up by ILO[10] .

The working conditions in the Vietnamese kilns which involve local labour are better compared to VSBKs in India and Nepal, which employs migrant labour.

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CONCLUSION

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

PARAMETERS		VSBK	FCBTK	COMMENTS
AIR EMISSION (g/kg FIRED BRICK)	CO2	70.5	131	Vertical shaft brick kiln emits ~85% lower PM and negligible amount of Black Carbon as compared to FCBTKs. This is mainly because of better combustion of fuel and use of internal fuel. Emission of CO2 from VSBK is lower because of less consumption of fuel.
	Black Carbon	0.001	0.13	
	PM	0.15	1.18	
	CO	1.84	2.0	
FUEL & ENERGY	SEC (MJ/kg fired brick)	0.8	1.30	VSBK consumes ~35% less fuel as compared to FCBTK because of better combustion & heat recovery and low heat losses.
FINANCIAL PERFORMANCE	Capital Cost (USD)	60,000-80,000	50,000-80,000	Capital cost of setting up of a VSBK is around 1.5-2 times more as compared to FCBTK for the same production capacity. This is mainly because of the cost of equipments and construction of the kiln.
	Production Capacity	1.5-3 million bricks/year	3-8 million bricks/year	
	Simple Payback	0.9 – 1.8 years	0.4 – 1.1 years	
PRODUCT QUALITY	Types of product	Solid & Perforated bricks	All kind of products	VSBK is suited for firing only solid and perforated bricks; however, all types of product can be fired in a FCBTK. The quality of bricks fired in VSBKs are better as compared to those from FCBTKs.
	Good Quality Product	90 %	60 %	
OHS	Exposure to dust			Vertical shaft brick kiln enterprise offers better OHS conditions as compared to a FCBTK enterprise.
	Exposure to Thermal stress			
	Risk of accidents			

FOR MORE INFORMATION:

www.gkspl.in/whats_new.html; www.ecobrick.in

REFERENCES

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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

9 Ibid.

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 OHS can be found at http://www.ilo.org/global/%20standards/subjects-covered-by-international-labour-standards/occupational-safety-and-health/lang--en/index.htm. A list of all such instruments on OHS with their status is available at http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12030:0::NO:::#Occupational_safety_and_health

ACKNOWLEDGEMENT

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Note: In the initial stage of this initiative of developing factsheet on brick kiln technologies, factsheet are developed for South and South-East Asia and Latin America regions. Factsheet on brick kiln technologies of other regions will be developed over time.

Disclaimer: The country borders indicated on the map do not necessarily reflect the FDFA's official position. The red dotted line represents approximately the Line of actual Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

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