7 TUNNEL KILN TECHNOLOGY

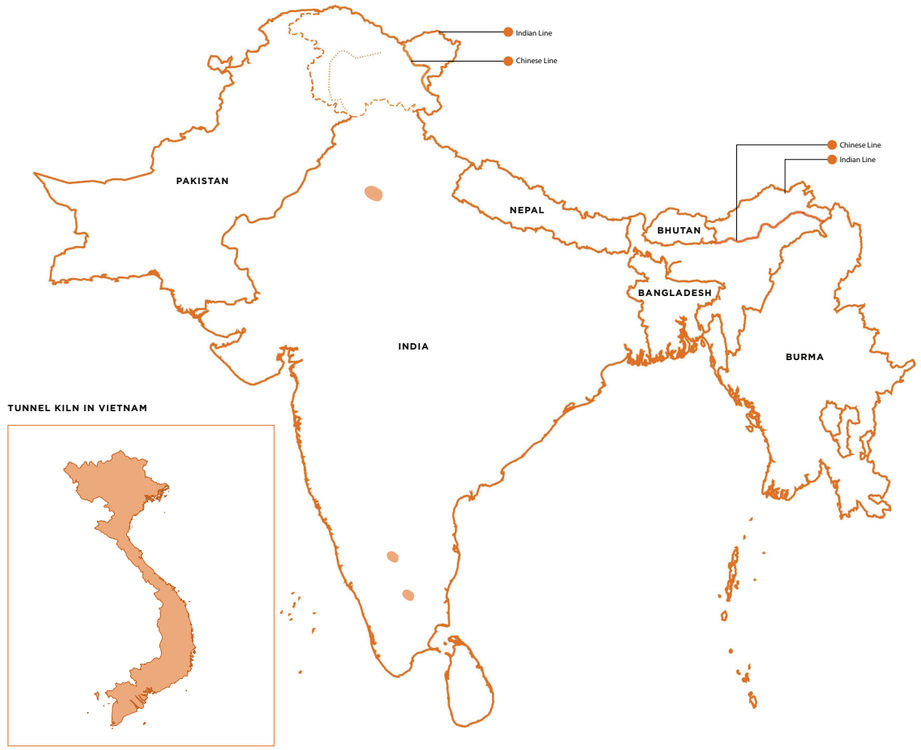
INTRODUCTION AND HISTORY[1]

Tunnel kiln is a continuous moving ware kiln in which the clay products to be fired are passed on cars through a long horizontal tunnel. The firing of products occurs at the central part of the tunnel. The tunnel kiln is considered to be the most advanced brick making technology. The main advantages of tunnel kiln technology lie its ability to fire a wide variety of clay products, better control over the firing process and high quality of the the products.

The tunnel kiln technology was developed around mid 19th century in Germany. However, the application of the technology for brick firing took place in the 20th century. After the Second World War, the technology was widely adopted and led to the transformation of the European brick industry from several thousand small and scattered brick making units into a few hundred large scale and highly mechanised tunnel kiln units.

In Asia, China and Vietnam started adopting the technology during the 1970's and now have several hundred tunnel kilns in operation. In India, there are very few (~5) tunnel brick kiln units.

GEOGRAPHICAL DISTRIBUTION



ABOUT THE KILN

Kiln

CONTINUOUS MOVING WARE

ENTERPRISES USING THIS TECHNOLOGY

Nature of enterprise

INDUSTRIAL

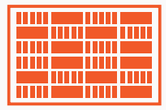
Level of mechanization

MECHANIZED

Brick produced

SOLID AND PERFORATED

Production capacity



LARGE >10 million bricks

Operational season

PERENNIAL

NUMBER OF OPERATIONAL ENTERPRISES AND TOTAL PRODUCTION*

Country	**Number of enterprises**	**Total production** billion bricks/year
Vietnam[2]	~700	~10.5
India[3]	~5	~0.08

*Numbers are estimates only

% CONTRIBUTION TO THE TOTAL BRICK PRODUCTION IN INDIA AND VIETNAM

~4%

Out of the total annual production of around 280 billion bricks in India and Vietnam only around 10.6 billion bricks are produced by tunnel kiln technology

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DESCRIPTION AND WORKING

1

In a tunnel kiln, a continuous moving ware kiln, the clay products/bricks to be fired are passed on cars (**1.1**) through a long horizontal tunnel (**1.2**). The firing of bricks occurs at the central part of the tunnel. The length of tunnel can vary from 60 m to 150 m.

2

Generally green bricks are produced by mixing powdered fuel with clay. Green bricks are then moved in the tunnel or chamber dryers on cars for drying. Heat from the hot flue gases coming out of the kiln is utilized for the drying of bricks.

3

The cars loaded with dried green bricks are pushed in the kiln. The cars are moved inside the kiln intermittently at fixed time intervals. The duration of the firing cycle can range from 30 to 72 hours.

4

Three distinct zones appear in an operating tunnel kiln:
4.1 Brick firing zone where the fuel is fed and combustion is happening,
4.2 Brick preheating zone (before the firing zone) where the green bricks are being pre-heated by the hot flue gases coming from the firing zone and
4.3 Brick cooling zone (ahead of the firing zone) where fired bricks are cooled by the cold air flowing into the kiln.

5

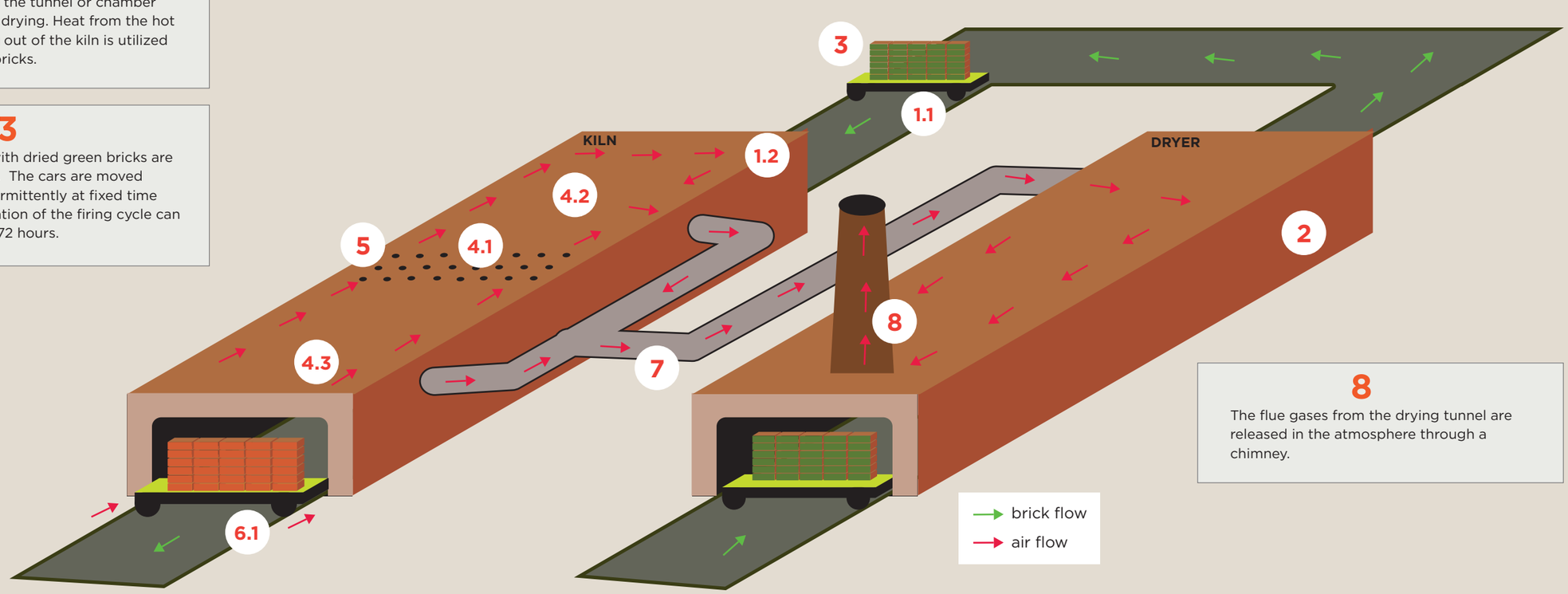
Fuel (granulated/pulverised coal) is fed into the firing zone of the kiln through feed holes provided in the kiln roof. The firing zone usually extends up to 8 cars. The temperature in the firing zone is maintained at 900 – 1050^{0}C.

6

There is counter current heat transfer between the bricks and the air. Cold air enters the kiln from the car exit end (6.1) and gets heated while cooling the fired bricks. After combustion, the hot flue gases travel towards the car entrance end losing a part of the heat to the green bricks entering the kiln.

7

Hot air/gases are extracted from the tunnel kiln at several points along the length of the kiln and are supplied to the drying tunnel/chamber. In some of the kilns, there is also provision of a hot air generator to supplement the requirement of hot air for drying.



8

The flue gases from the drying tunnel are released in the atmosphere through a chimney.

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AIR EMISSIONS AND IMPACTS

MEASURED EMISSION FACTORS[4,5]

g/kg of fired bricks			
CO2	Black Carbon	PM	CO
Average			
166.3	negligible	0.24	3.31
Range			
NA	NA	0.175 – 0.31	2.45 – 4.18

MEASURED PM EMISSIONS

Average: 41 mg/Nm^3

(Range: 21– 53 mg/Nm^3)

EMISSION STANDARDS

Notified for PM only

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

COMMENTS ON EMISSIONS

Better fuel combustion results in lower emissions from a tunnel kiln.

FUELS AND ENERGY

COMMONLY USED FUELS

Coal

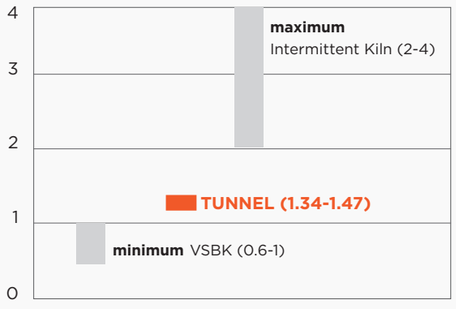
Petcoke

SPECIFIC ENERGY CONSUMPTION[6,7]

Energy consumed for firing 1 kg of fired brick

Average: 1.4 MJ/kg of fired bricks
(Range: 1.34 – 1.47 MJ/kg of fired brick)

MJ/kg of fired brick



Note: Measured at firing temperature of 950-1000^{0}C

The specific energy consumption in a tunnel kiln is slightly higher as compared to other continuous kiln technologies. This is mainly because the SEC also includes the energy utilised for the drying of bricks in the tunnel dryer.

MAIN CAUSES FOR HEAT LOSS

Heat contained in the kiln cars and fired bricks at the kiln exit and in hot flue gases are the main sources of heat loss in tunnel kilns.

FINANCIAL PERFORMANCE

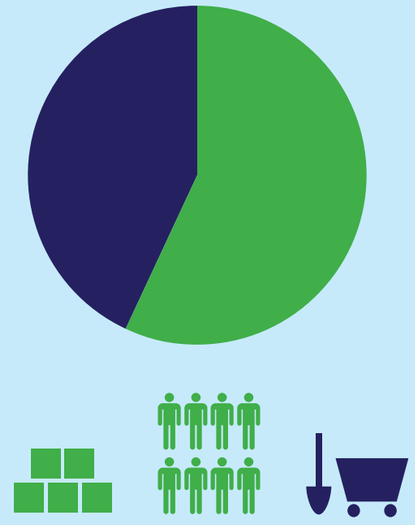
Capital cost of kiln technology

for an annual production capacity of ~15 million bricks, excluding cost of land and buildings

~1,000,000 USD

Capital cost breakdown

Construction Material + labour	57 %
Equipment	43%

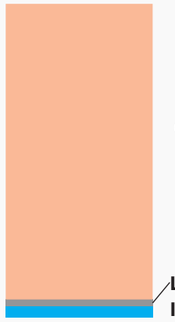


Production capacity	~50,000 bricks per day	
Brick size	230 mm x 115 mm x 75 mm	
Number of Operators required	~20	
Payback Period	Simple Payback	~2 years
	Discounted Payback (@ 6.5%)	~2.2 years

PRODUCT QUALITY

Product Quality

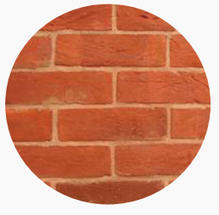
As per the local market perception



Better heat distribution results in uniform temperature across the kiln cross section in the firing zone thereby resulting in a higher percentage of good quality bricks.

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

GOOD BRICK



INFERIOR BRICK

under-fired and over- burnt

OCCUPATIONAL HEALTH AND SAFETY

Exposure to Respirable Suspended Particulate Matter[8]

The concentration of air pollutants in the surrounding environment of a tunnel kiln is low

The workers have low risk of developing respiratory tract infections and cardio vascular diseases.

Exposure to Thermal Stress[9]

Exposure of workers to heat from the kiln is quite low.

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

Risk of accidents

In a well operated tunnel kiln, the risk of accidents is low.

Low risk of injuries

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

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

Because of mechanisation of the processes, the working conditions of workers in tunnel kiln enterprises are relatively better.

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CONCLUSION

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

PARAMETERS		TUNNEL	FCBTK	COMMENTS
AIR EMISSION (g/kg FIRED BRICK)	CO_2	166.3	131	Tunnel kiln emits ~80% lower PM and negligible BC as compared to FCBTK. This is mainly because of better combustion and use of internal fuel. The emission of CO is higher in case of tunnel kiln, probably due to incomplete combustion of internal fuel.
	Black Carbon	0.00	0.13	
	PM	0.24	1.18	
	CO	3.31	2.0	
FUEL & ENERGY	SEC (MJ/kg fired brick)	1.4	1.30	Tunnel kiln consumes marginally higher energy as compared to FCBTK. It is to be noted that the SEC in tunnel kilns also includes the energy utilised for the drying of bricks in the tunnel dryer.
FINANCIAL PERFORMANCE	Capital Cost (USD)	~1,000,000	50,000-80,000	The capital cost of tunnel kiln is substantially higher as compared to FCBTK mainly because of mechanisation of brick production processes and considerably larger production.
	Production Capacity	~15 million bricks/year	3-8 million bricks/year	
	Simple Payback	~2 years	0.4 - 1.1 years	
PRODUCT QUALITY	Types of product	All types of products	All types of products	Both the kiln technologies are suitable for firing all types of product. However, the quality of bricks fired in tunnel kilns is better as compared to those from FCBTKs. Also while a tunnel kiln can be used exclusively for production of hollow bricks, in a FCBTK such exclusive production is not possible.
	Good Quality Product	95 %	60 %	
OHS	Exposure to dust			Tunnel kiln enterprise offers better OHS conditions as compared to a FCBTK enterprise.
	Exposure to Thermal			
	Risk of accidents			

REFERENCES

1 'Brick by Brick: The Herculean Task of Cleaning up the Asian Brick Industry' written by Urs Heierly and Sameer Maithel available at www.gkspl.in/Brick_by_brick.pdf.
2 Report on 'Brick Kiln Performance Assessment' available at http://www.unep.org/ccac/Portals/24183/docs/Brick_Kilns_Performance_Assessment.pdf
3 Based on interaction with tunnel kiln owners and professionals working in brick sector
4 Journal paper on 'Emissions from south Asian brick production' published in Environmental Science & Technology, 2014, 48 (11), pp 6477-6483 available at http://pubs.acs.org/doi/abs/10.1021/es500186g?journalCode=esthag
5 Report on 'Performance of Brick Kilns in Nam Dinh Province in Vietnam, 2005', TERI (Project Report No. 2004BE31).
6 Ibid 2.
7 Ibid 5.
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

ACKNOWLEDGEMENTS

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Note: In the initial stage of this initiative of developing factsheets on brick kiln technologies, factsheets are developed for South and South-East Asia and Latin America regions. Factsheets 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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