The Vertical Shaft Brick Kiln

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Introduction

The vertical shaft brick kiln (VSBK) is classed as a continuous updraft kiln and represents a comparatively new and unique method of firing bricks. It was developed in China in the late 1960s during the cultural revolution, when there was a large demand for bricks in the rural areas of China. There are thousands of this type of kiln currently operating in China, but only a few proto types have so far been built in other countries.

It is a revolutionary type of brick kiln, combining the simplicity and low cost of updraft firing with very impressive fuel economy, plus the benefits of continuous operation. It is used in China as a single or double shaft kiln by small scale seasonal brickmaking entrepreneurs, wherever there is an abundance of good brickmaking clay and a reliable supply of coal fines. Its operation is very similar to that of a vertical shaft lime kiln, with coal and bricks being loaded at the top, and fired bricks combined with a small amount of ash being unloaded at the bottom.

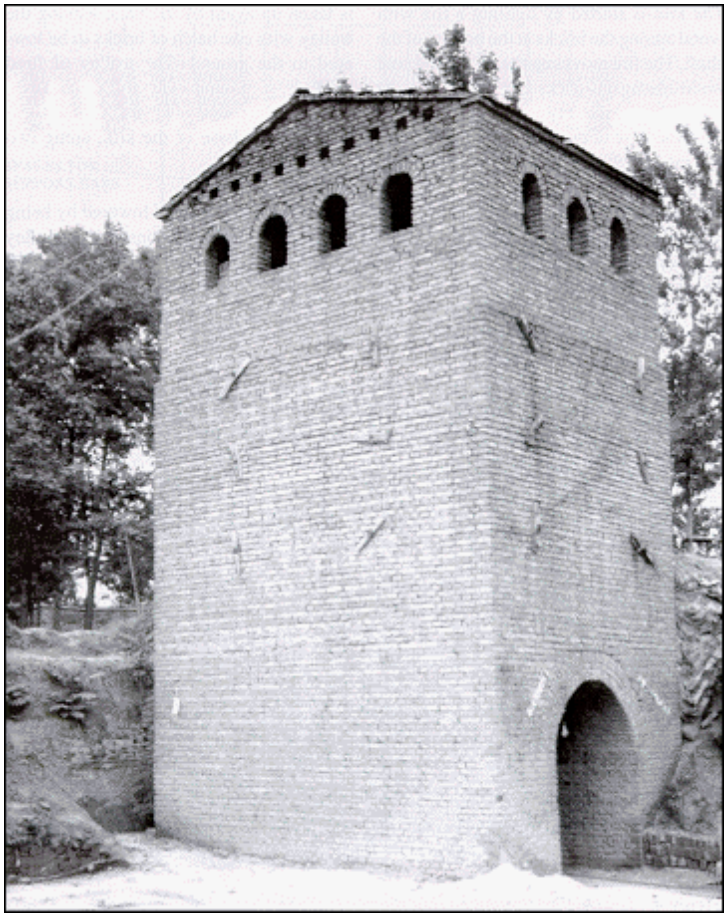

Figure 1

A single shafted vertical brick kiln in China

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Kiln design

Within a roofed and buttressed rectangular support building is a well insulated fire-brick lined firing shaft, open at the top and bottom. This shaft is approximately 6.5 metres in height with the central 4 metres being lined with a single layer of firebrick. There are two versions of the kiln currently in use: a single shafted model with a 1.5 x 1 metre rectangular shaft and a double shafted model where the shafts are 1 metre square.

At the base of each shaft is an arched unloading tunnel running through the centre of the kiln. This tunnel allows access to both sides of the base of the firing shaft and contains the brick support and unloading equipment.

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Loading the kilns

Bricks and coal, a batch at a time, are loaded at the top of the shaft, the coal fines being sprinkled among the green bricks one layer at a time.

In the single wider shaft kiln, each batch of bricks is made up of four layers making a total of 320 bricks, and

the shaft holds twelve batches to give a firing capacity of 3840 bricks every 12 hrs. The bottom layer of bricks in each batch, which is the first loaded, consists of 68 bricks arranged in 7 rows to provide six open channels running across the firing shaft. These channels are to allow the placement of the steel beams that support the bricks in the kiln. The second layer of 84 bricks is placed at right angles to the first layer bridging the channels. The third and fourth layers, each of 84 bricks, are added at alternating right angles to make up a complete batch. The bricks in each layer are carefully spaced apart to provide a gap of 1 to 1.5 cm around each brick. Coal is spread evenly on top of each layer of bricks, except the first layer with the cross channels. It is then brushed off the top surface of the bricks into the gaps around the sides before the next layer of bricks is added. A fresh batch of bricks is added each time a batch of fired bricks is removed from the base of the kiln.

With the double smaller shafted kiln the shafts are loaded and unloaded alternately with 188 bricks in each batch, 12 batches per shaft, making a total firing capacity of 4512 bricks every 12 hrs. Ideally a batch of bricks is unloaded every 45 minutes to 1 hour, but the usual practice is to unload and load 3 or 4 batches at a time. The number of batches and the time of unloading is decided by the fire master, who judges this by the colour and position of the firing zone in the shaft. The quantity and quality of the coal fines and condition of the green bricks will determine the speed of firing.

Figure 2

View down the firing shaft showing firebrick lining (China)

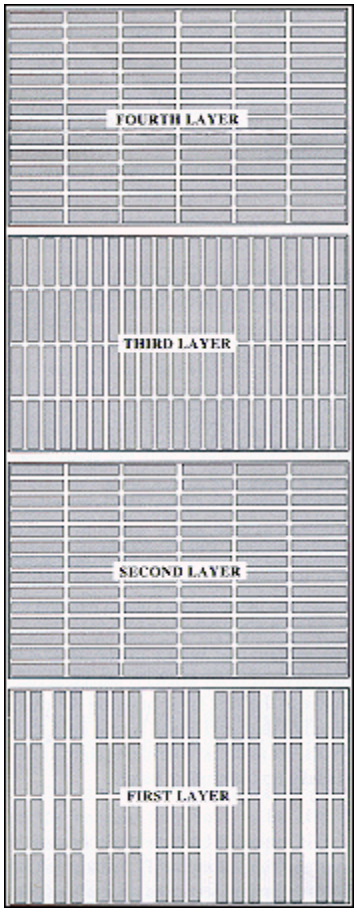

Figure 3

The four layers of a batch

Figure 4

Loading bricks and coal in the vertical shaft brick kiln (Pakistan)

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Firing the kiln

The kiln is started by lighting a fire with wood among the bricks at the bottom of the shaft. The fire moves up the bricks and coal in the shaft until it reaches the middle. At this point a batch of fired bricks is removed from the base of the shaft and a fresh batch of green bricks and coal loaded at the top.

The position of the fire in the shaft is maintained by the rate of removing the fired bricks and reloading with green bricks. The firing temperature is controlled by the amount of coal fines added to each batch of bricks loaded. In China, 33 kg of coal fines was added to each batch of bricks, 0.103 kg per brick. The calorific value of the coal was 26.6 MJ/kg resulting in an average energy consumption of 975 MJ/kg per 1000 bricks. In Pakistan, a two shafted kiln had an energy consumption 1287 MJ/kg per 1000 bricks. When this is compared with the figures for coal firing Hoffmann kilns at 2800 MJ/kg per 1000 or Bull's Trench at 3116 MJ/kg per 1000 bricks, the efficiency of vertical shaft kilns is very impressive.

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Unloading the bricks

Bricks are removed a batch at a time by raising an unloading trolley until it just takes the weight of all the bricks in the shaft. This allows the six steel brick supporting bars to be removed from the channels running through the bottom batch of bricks. With the weight of the whole shaft of bricks on the trolley, it is slowly lowered by the depth of one batch, so that the six support bars can be replaced in the six channels in the next batch.

By continuing to lower the trolley, the weight of the remaining batches in the shaft is taken up again by the bars, leaving the trolley with one batch of bricks to be lowered to the ground. The trolley of fired bricks is uncoupled from the lifting gear, so that it can be pulled out from the unloading tunnel at the base of the kiln, along two steel rails.

The trolley is raised and lowered by being attached to either a 5 tonne chain pulley system or a screw jack

arrangement. The pulley system is less expensive to buy and install, and can be quickly replaced if a fault occurs. It is easier to operate, though potentially slower than the screw jack system. The screw jack is more substantial, and will last longer, if made from good quality steel.

The kiln is straightforward and not too expensive to construct. The single shaft kiln is easier and less expensive to build as only one set of unloading gear is needed, though its output per 24 hour operating period is lower than the two shafted model. The unloading equipment is the most expensive part of the kiln, representing 40% of the total construction costs. With a pair of chain pulley blocks, instead of the screw jack unloading system, the overall cost of the kiln is further reduced, as the chain blocks can be purchased off the shelf at a quarter of the cost of the screw jack unloading system.

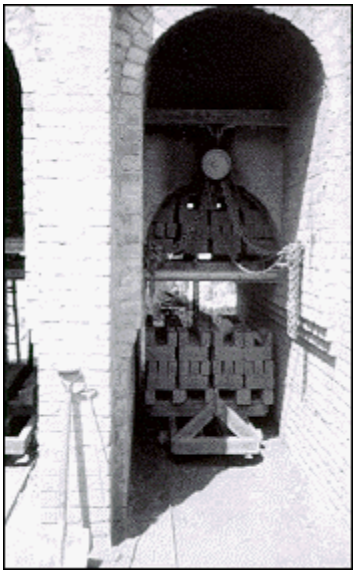

Figure 5

The chain pulley unloading system (Pakistan)

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Kiln efficiency

Despite there being no controllable fireboxes and the kiln working on the normally least efficient updraught system, it is extremely fuel efficient. This is because the firing shaft creates just enough natural draught for complete and efficient combustion of the fuel spread evenly throughout the firing zone. The packing of the bricks restricts the draught enough to limit the amount of excess air not required for combustion. The cooling bricks below the firing zone heat up the air for combustion. The hot exhaust gases from the firing zone pre-heat the green bricks and fuel prior to combustion. The firing shaft is very well insulated on all four sides, so heat loss is minimised. Once the kiln is up to temperature, all the heat from the coal fines goes into the firing of the bricks. Very little heat is 1ost in the exhaust gases or in steady state heat loss through the fabric of the kiln.

Brick wastage is very low when compared with the Hoffmann and Bull's Trench kiln, being 2 to 5% in China and 5 to 7% in Pakistan. This is mainly due to the fact that the kiln fires so evenly, with no over or under-fired bricks. Any wastage results from careless brick handling and low quality green bricks being loaded.

Kiln maintenance is low, because the only machinery involved is the basic unloading system

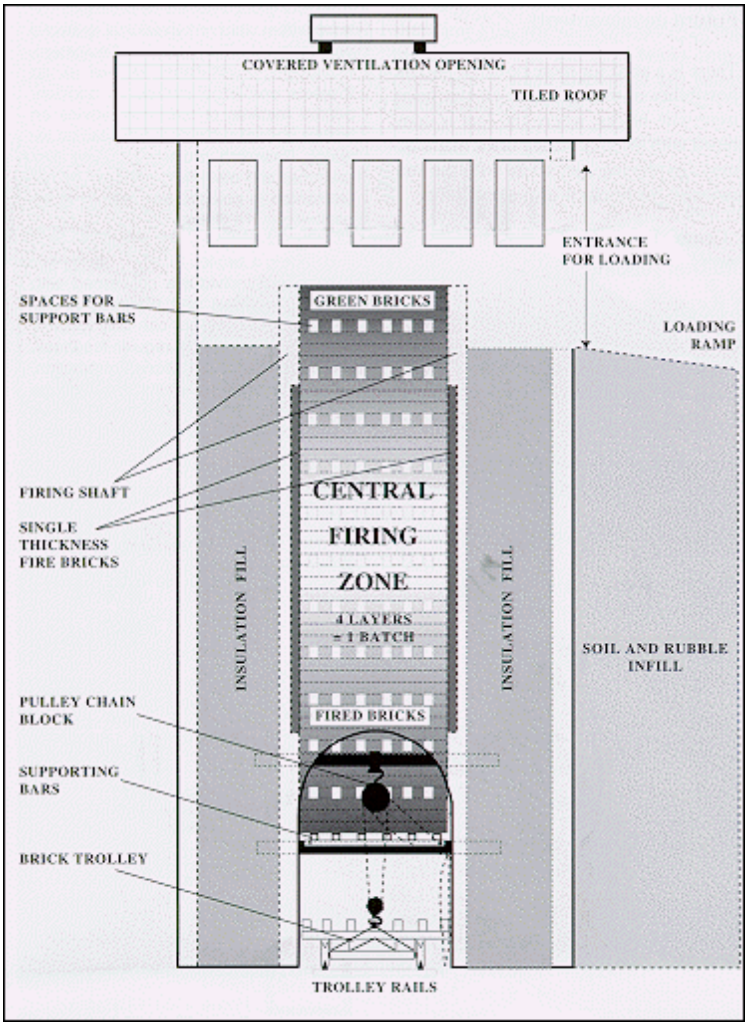

Figure 6

Cross-section of a VSBK with single shaft, chain block unloading.

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Advantages of the vertical shaft brick kiln

- It represents a very energy efficient low cost method of firing bricks on low grade coal fines. Its efficiency is twice that of Hoffmann or Bull's Trench kilns running on coal. The fired quality of the bricks is high with a low wastage.
- The kiln is cheap and straightforward to build, and requires very little maintenance once constructed. It does not require an external power source, except for electric lighting during night operation.
- The kiln is very compact, not requiring a large area of land and can be built near to the clay source. It is small and straightforward enough to be considered for rural brick production, where coal fines are available, to replace the less efficient coal and wood burning brick clamps used in many countries. In China, the kilns are easily taken apart and rebuilt with the original materials, when the clay source in one location is worked out, so it has the flexibility, in this respect, to be used in a similar manner to brick clamps.
- The construction cost is low and several shafts can be linked together in a row to cope with larger capacity brick works.
- The kiln is not effected by variations in the weather, as long as dry green bricks are available.

- Because of the highly efficient combustion of coal in the kiln, localised air pollution is minimal. There is little or no visible smoke while the kiln is running. Steam and combustion gases are quickly dispersed from the top of the firing shaft, which is well ventilated.
- More than one shaft allows for firing flexibility to cope with seasonal and economic variations in brick production and demand.
- Labour requirements are low, requiring one man to load and two men to unload, during an 8 or 12 hour shift. The labourers are not working continuously, as there are 3 or 4 hours between each loading/unloading session.

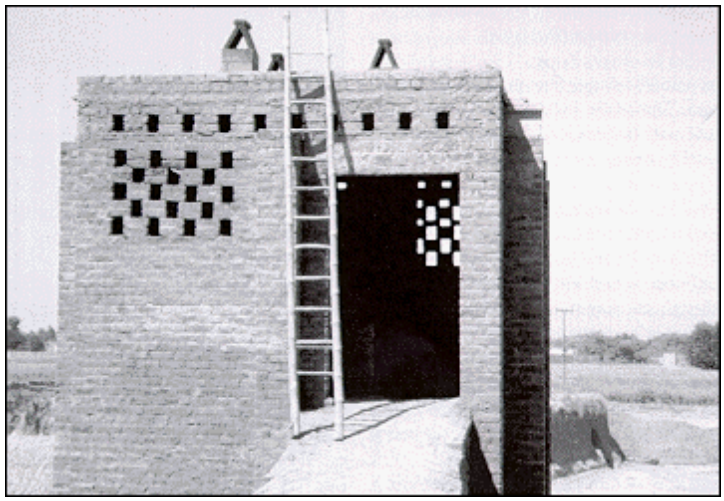

Figure 7

View of the top of the vertical shaft brick kiln (Pakistan)

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Disadvantages of the vertical shaft brick kiln

- It is a new type of kiln and method of firing bricks that has only recently been introduced to countries outside China. Despite there being thousands of this type of kiln operating in China, the technology has not yet been adopted anywhere else in any quantity.
- The kiln requires good quality green bricks, because they have to be able to withstand being stacked 5 metres high in the firing shaft. This does not exclude hand moulded bricks, as has been demonstrated in Pakistan, where all the bricks were slop moulded.

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Future developments

There is a need for more research into the possibility of the vertical shaft kiln being used with bricks, where the fuel is combined with the clay during brick manufacture. Combining agri-waste with the coal amongst the bricks is also a possibility.

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Further reading

There has been very little published about the vertical shaft brick kiln, apart from internal reports commissioned by GTZ the ODA and World Bank, which are not available for general circulation.

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