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In This Issue

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Energy Efficient and Environmentally Sound Brick Kilns

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Introduction

The brick industry in Asia is diverse, ranging from very small manually operated seasonal units to very large mechanized units with year round operation. This sector employs more than two million persons directly in production *(Table 1)*, and many more are employed in related activities such as transportation of clay, fuel and bricks, sales, as well as in the construction industry as brick layers. Wood, gas, oil, coal and agricultural residues are the main fuels used in brick making in these small/medium factories which are usually family-based.

Table 1. Data on Brick Industries in Some Asian Countries

	Bangladesh	India	Indonesia	Nepal	Pakistan
No. of brick making units	>3,000	115,000	>45,000	442*	>3,000
Production (million)	3,000	>50,000	4,100	627*	11,000
Labors '000	130	1,500	125	50	250
Brick use/capita	27	61	23	34	102
Energy use '000 t/Y					
Fuel wood	2,000	300	1,000	N.A.	75
- Oil/Gas	N.A.	N.A.	6	N.A.	N.A.
- Coal	108	14,000	N.A.	N.A.	3,120
- Agricultural residues (rice husks)	N.A.	N.A.	600	N.A.	N.A.

Source: *Koopmans and Joseph (1993)*
Note: *N.A. : Not available; *Denotes formal sector only*

Brick making involves a number of processes: clay extraction and its preparation, mixing, moulding, sun drying and firing in a kiln before it is sold. A typical brick-making process giving the raw material input, emissions and product is shown in *Figure 1*. The process starts from extraction of clay, which could be near (or far) from the factory after which it is tempered and mixed with water and moulded in the form

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of the required brick shape and size. This requires a machine (powered by electricity or diesel engine) or in small family units, it is done by human power. The moulded brick is then sun dried and is then fired in the kiln at high temperature. The fired brick is cooled, stored and sold. The pollution generated during the production could be listed as follows:

i) Clay extraction: In this process, emission is produced from diesel machine used for clay excavation. Transportation of clay to the brick-making sites could result in spilled clay (clay waste). For example, in a small scale brick factory in peri-urban area in Africa, 17280 liters of diesel are used to excavate 6891 m^3 of clay, resulting in gaseous emission and 124.82 mg dust per m^3 of clay [9]. Large-scale extraction of clay from the soil causes land degradation and associated pollution;
ii) Clay preparation and tempering: Dust is generated during this process at the brick making site;
iii) Clay mixing: Spilled wastewater during the mixing of clay and water occurs during this process;
iv) Kiln firing: Emissions (CO_2, SO_2, CO, etc.) from fuel combustion, either fossil fuel or biomass, are the main pollution generated during this process. Tawodzera and Matirekwe (1996) noted that 459.6 tonnes of coal are used to produce 2,782,000 fired bricks, resulting in 1265.1 tonnes of CO_2 and 11.58 tonnes of SO_2; and
v) Transportation of clay to the factory as well as the transportation of fired bricks to the user/dealer requires additional energy and generates pollution.

Of the various processes in brick making, firing in the kiln is the most energy consuming process. The other energy issues related to brick kilns are influenced by the availability of fuel and due to inefficient combustion of fuel and heat transfer. For example, inefficient use of wood causes higher consumption of wood, deforestation, as well as environmental pollution, such as, smoke, dust, etc. It is estimated that the ceramics and brick industries in Vietnam consume approximately 73,170 tonnes of wood annually, equivalent to 487 hectares of 7-8 years old eucalyptus. The air pollution from the brick kilns contains dust, CO_2, SO_2, NO_X, and VOC that may affect the health of population surrounding the brick-making site, especially if the brick factories are located in residential areas. Considering the importance of kiln in the brick making process, energy efficient and environmentally sound technology brick kilns are discussed below:

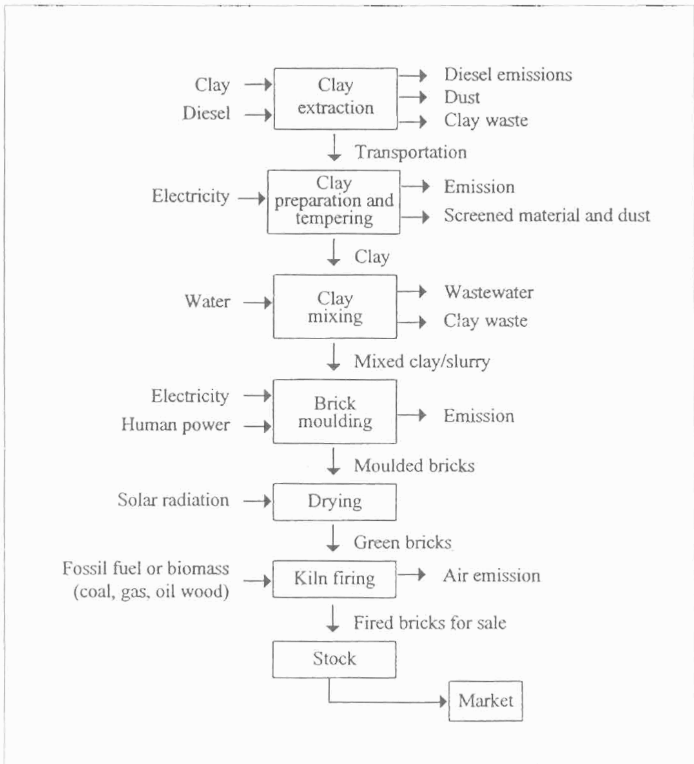

Table 2. Fuel types, specific energy consumption, and energy efficiencies for different types of brick kilns

Types	Category	Fuel Type	Specific energy consumption (MJ/kg of fired brick)	Energy Efficiency (%)[a]
Intermittent kiln	Traditional Clamp	Biomass	3-8[a]	10-28
			5-11[b]	
	Intermediate Clamp	Coal, Coke	3.5-4.5[a]	19-25
	Scove Kiln	Biomass	1.14[c]	
	Scotch Kiln	Biomass	1.5-7[a]	12-59
	Four chamber down-draft kiln[d]	Biomass	2.3[d]	62.6
Continuous kiln	Vertical Shaft Brick Kiln (VSBK)	Coal	0.9-1.4[a]	60–93
			1.98[b]	
	Bull's Trench Kiln	Coal	1.8-4[a]	21-47
			4.2[b]	
	Hoffmann Kiln	Coal, gas, oil	1.5-4.3[a]	20-56
	Tunnel Kiln	Oil, gas	1.5-2[a]	45-76

Source: [a]Schilderman (1998), [b]Kumar et al., (1998), [c]Nillson and Nystrom (1998), [d]Prasertsan and Theppaya (1997).

Brick Kilns

Brick kilns can be classified into two major types depending on the operation of the processes: intermittent and continuous kilns.

In the *intermittent type*, a kiln is heated up before the green bricks are filled and cooled before the bricks are drawn out, while in a *continuous kiln*, the firing zone moves through the bricks in the kiln. Fired bricks are continuously removed and replaced by green bricks in another part of the kiln, that is then heated. *Table 2* presents the common kiln types and the fuels used, their specific energy consumption (ratio of energy consumed per unit production) and their energy efficiencies. Among these, high specific energy consumption is found in traditional clamp, intermediate clamp, and Scotch kiln (intermittent kilns). Bull's trench kiln and Hoffmann kiln (continuous type) have comparable specific energy consumption values. Though the scove kiln consumes less energy, the quality of the brick is not satisfactory since all the bricks are not burnt thoroughly [3]. Traditional and intermediate clamp kilns are not efficient. Vertical shaft brick kiln (VSBK), four-chamber downdraft kiln and tunnel kiln have efficiencies greater than 60%.

Selected Energy Efficient and Environmentally Sound Technology Brick Kilns

1. Vertical shaft brick kiln

Vertical shaft brick kiln (VSBK) is a high-energy efficiency up-draft continuous kiln which was first developed in China in the late 1960s [4]. This kiln comprises of a top lid for loading, firing shaft of about 6-8 meters, insulation fill, tile roof with ventilation opening and chimney. The smallest unit has two shafts, each with a capacity of about 200-240 bricks.

During loading, green bricks are stacked in four layers, in a shaft of 1 x 1 meter in the upper part of the firing shaft. For the first batch of brick firing, the green bricks are first stacked from the bottom, with coal (fuel) placed between each brick layer. Fire lighted at the bottom of the stack will move upward along the shaft. When it reaches the middle, a batch of bricks is unloaded from the bottom of the shaft. A batch of these bricks is taken out at a time with a special unloading device every 1.5-2.5 hours. The combustion should always be in the middle of the shaft and this position is maintained by the appropriate rate of removing and loading bricks. The combustion temperature is about 750^{0}C while the exhaust flue gas temperature is less than 70^{0}C due to efficient heat transfer [7].

VSB kiln requires less land area, and has 30%-50% lower specific energy consumption compared to Bull's trench kiln. Furthermore, its firing temperature produces consistent quality of bricks. Compared to other kiln types, it generates less emissions and it can be operated during rainy seasons as well. However, this kiln requires high initial investment.

2. Four-chamber downdraft kiln

Prasertsan and Theppaya (1997) have developed a four-chamber downdraft kiln to suit the needs of small brick producers in Thailand. This kiln consists of four interconnected chambers where, all the processes, namely, cooling, firing, preheating and drying, take place in each of the chambers. The combustion air of the firing chamber is preheated by the cooling process in the preceding chamber. The exhaust gas from the firing chamber is channeled to preheat and dry the bricks in the next two chambers. Both the bricks and the combustion air are preheated, resulting in low fuel consumption in the firing process.

Pilot tests have shown that the energy efficiency of this kiln was about 62%. The prototype kiln had a capacity of 2200 bricks. The external size of the kiln was approximately 5 x 5x 2 m^3 and the internal effective volume was about 1.6 x 2 x 2 m^3. Compared to conventional open top updraft kiln which is commonly used in Thailand, the fuel consumption was about 60% less and the required area was four times less. The firing time was about 8.5 hours while for traditional kilns it is about 7-15 days per batch [7]. However, the kiln operation is quite complicated and training may be needed for the operators. This kiln is still under development.

3. Tunnel kiln

Tunnel kiln consists of a long straight tunnel in which the green bricks are stacked on cars which travel through the kiln. The kiln is heated by burning fuel (coal, natural gas) in the middle section. The combustion gases travel forward towards the car entrance where they are removed through a series of exhaust ports in the side walls. As the combustion products pass down the kiln, they preheat the green bricks placed on the cars travelling towards the firing zone. Cold air drawn in or blown at the car exit cools the fired bricks. The heated air passes to the firing zone for combustion purposes. At intervals, cars of fired bricks are withdrawn from the kiln and replacement cars of green bricks are pushed into the kiln at the opposite end. The combustion temperature in this kiln is about 1100^{0}C. The temperature of exhaust gas and cooling air leaving the kilns are in the ranges of 100-450^{0}C and 50-200^{0}C respectively [10]. The new generation of tunnel kilns have specific energy consumption of about 0.94 MJ/kg of fired bricks [11].

The capacity of a tunnel kiln is about 50,000-150,000 bricks per day. It requires less labour than other kilns. These kilns are suitable for mass production and are widely used in USA and Europe. This is also used in some high capacity brick making factories in Indonesia [1]. However, this kiln requires high investment and needs more maintenance since the components (cars) moving at high temperatures require regular attention.

Conclusion

Most brick kilns used in Asian developing countries are energy inefficient and threaten the environment by generating air pollution and by causing deforestation in case where fuel wood is used. Many energy efficient and environmentally sound technology brick kilns are available and are being developed. Comparison of different types of kilns shows that VSBK, four-chamber downdraft kiln, and tunnel kiln are energy efficient. Quantitative and qualitative data on construction, capacity, specific energy consumption, energy efficiency, etc., have been described.

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References

1. *Koopmans, A., and Joseph, S., 1993. Status and Development Issues of the Brick Industry in Asia. GCP/RAS/131/NET field document No. 35. RWEDP, FAO. Bangkok.*
2. *Kumar, A., Vaidyatan, G., and Lakshminathan, K.R., 1998. Cleaner Brick Production in India: A Trans-sectoral Initiative. UNEP Industry and Environment, January-June 1998.*
3. *Nillson, J. and Nystrom, J., 1998. Kiln Efficiency in Tanzania, Renewable Energy For Development: Vol 11, No. 11, pp. 2.*
4. *ODA (Overseas Development Administration) 1993. Report on an Evaluation of a Continuous Vertical Brick Kiln in China. Project No. R5420A. London.*
5. *Prasertsan S., and Theppaya, T., 1995. A Study towards Energy Saving in Brick Making: Part 1- Key Parameters for Energy Saving. RERIC International Energy Journal: Vol. 17, No. 2, Page 145-156.*
6. *Prasertsan S., and Theppaya, T., 1997. Development of an Energy-efficient Brick Kiln. International Journal of Energy Research: Vol. 21, 1363-1383.*
7. *RAP (Regional Office for Asia and the Pacific), 1999. Combustion and Gasification of Biomass. Rural Energy in the Asia Pacific Region. RAP Bulletin, FAO, Bangkok.*
8. *Schilderman, T., 1998. Sustainable Materials Production: A question of Energy? The Intermediate Technology Development Group's experience with brick and lime production.*
9. *Tawodzera, P., and Matirekwe, D., 1996. Environmental Impact of Brick-Making in Zimbabwe. IT Zimbabwe, Harare.*
10. *ETSU (Energy Technology Support Unit), 1979. Building Brick Industry: Energy Conservation and Utilisation in the Building Brick Industry. Energy Audit Series No. 2. Department of Energy and Department of Industry, UK.*
11. *http://europa.eu.int/en/comm/dg17/atlas/html/.body_rkexmple.html.*