SCOPE FOR ENERGY EFFICIENCY IMPROVEMENT AND POLLUTION PREVENTION IN BRICK/TILE INDUSTRY – CASE STUDY

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Abstract Brick/tile making is an energy intensive process consisting of unit operations like clay preparation and mixing, wire cutting, drying and kiln firing which result in pollutant emissions too. After conducting energy and environmental audit of the brick/tile making unit, the measured data as well as the factory data have been analysed to make detailed estimations about specific thermal and electrical energy consumptions and specific pollution loads. In addition, energy and emission flow diagrams, material balance diagrams, thermal and electrical energy balance diagrams and costs of specific thermal and electrical consumptions have been analysed. Comparing with prevailing standard norms, wastage of energy and other deviations have been interpreted.

Keywords: Specific energy consumption, specific pollution load, energy efficiency, brick/tile making

INTRODUCTION

Fired clay brick is one of the most popular building materials in India. Brick/tile making is an energy-intensive process as well as a major source of air pollution. 97-99% of the total energy utilized is thermal energy, the remaining being electrical energy. Fuel cost accounts for about 30-40% of the production cost of bricks/tiles (TERI, 2000).

In small and medium scale brick/tile manufacturing factories, thermal energy is used for firing bricks/tiles in kilns. Electrical energy is utilized in motor-driven equipment like crushers, rollers, mixers, extruding machines, conveyors, blowers etc. For rural clamps, making country-made bricks, most processes are carried out manually and no electrical energy is used.

Greenhouse gases and dust are the major pollutants emitted from brick/tile making units. Depending on the type of fuel used, CO_2, SO_x, CO, CH_4, NO_x, N_2O, particulate matter etc. are emitted from the kilns as well as clay excavation process. Major fuels used in Indian brick kilns are biomass and coal. Solid wastes in the form of waste clay and substandard bricks/tiles are also produced from various unit operations.

Energy audit has been conducted in a brick/tile manufacturing unit. Basic data were collected on the energy consuming equipment and their operating parameters. The factory data as well as the measured data were analysed to identify specific energy saving potentials for various processes in brick/tile making. Also opportunities for pollution reduction have been identified, especially for the firing process in kiln.

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About the Candidate Factory

A small scale brick/tile making unit has been considered as a candidate for assessing the energy saving potential and pollution reduction opportunities. A few relevant details of the factory are given under:

- The unit produces bricks of size 229x102x76 mm and flooring tiles of size 229x229x17 mm.
- Installed capacity of the unit is 6000 bricks/day or 6800 flooring tiles/day.
- The unit produces 2000 bricks or 3000 flooring tiles everyday.
- The unit tonnes of firewood is consumed for firing in kiln every year.
- The unit makes use of chamber kiln for firing bricks/tiles.
- The unit uses 6751 GJ of thermal energy per year. Also it consumes 15,487 kWh and 13,236 kWh of electrical energy per year for tile making and brick making respectively.

UNIT OPERATIONS

Various processes involved in brick/tile making are illustrated in Fig. 1.

ENERGY AND EMISSION FLOW DIAGRAM

Amount of energy consumed and pollutants emitted during brick/tile making processes are shown in Fig. 1.

MATERIAL INPUT

7308 kg of wet clay is used for making 2000 bricks.
6000 kg of wet clay is used for making 3000 tiles.

ENERGY BALANCE

Thermal Energy Balance

As indicated in kiln losses are very high to the order of 75%. illustrated in Fig. 2 as well as Table 1. Low efficiency 25% of the chamber kiln may be due to poor utilization of heat in the form of inefficient combustion, structural losses as well as flue gas losses.

Proper temperature monitoring at various locations of the chambers and ensuring complete combustion responding to the flue gas analysis will indeed improve the kiln efficiency.

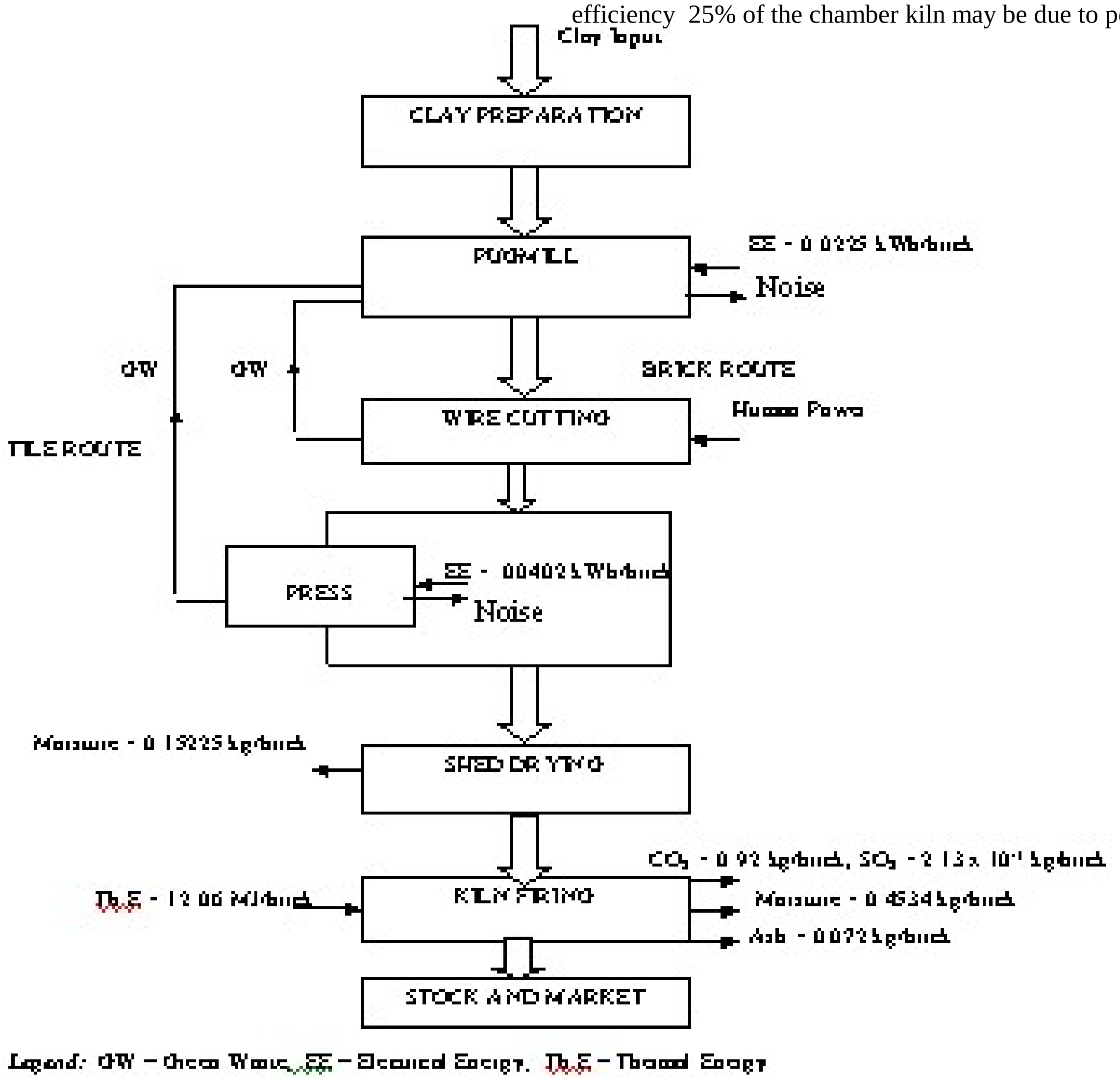

Fig. 1 Energy, emission and process flow diagram

ENERGY INPUT

24,111 MJ of thermal energy is used per day for firing in kiln.

47 kWh and 55 kWh of electrical energy is used per day for brick making and tile making respectively.

SOLID WASTES PRODUCED

For every 2000 bricks produced, 15 defective bricks each from natural drying and from firing in the kiln go as solid waste.

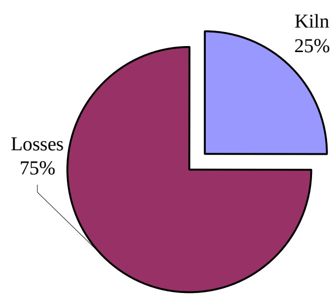

Fig. 2 Thermal energy balance diagram

Table 1. Thermal energy balance

Item	Brick making	Tile making
Heat taken by the products Losses	6028 MJ/day (25%) 18,083 MJ/day (75%)	6037 MJ/day (25%) 18,113 MJ/day (75%)
Total heat supplied by the fuel	24,111 MJ/day (100%)	24,150 MJ/day (100%)

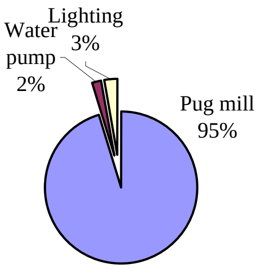

Fig. 3 Electrical energy balance diagram for brick making

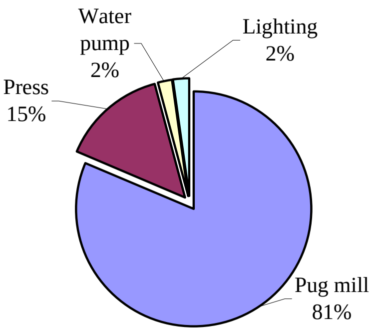

Fig.4 Electrical energy balance diagram for tile making

Electrical Energy Balance

Table 2. Electrical energy balance

Item	Brick making (kWh/day)			Tile making (kWh/day)		
	Useful consumption	Loss	Total	Useful consumption	Loss	Total
Pug mill motor	29.25	15.75	45	29.25	15.75	45
Tile press motor	---	---	---	5.63	2.41	8.04
Water pump motor	0.81	0.2	1.01	0.81	0.2	1.01
Lighting	1.13	0.13	1.26	1.13	0.13	1.26
	31.19 (66%)	16.08 (34%)	47.27	36.82 (66.6%)	18.48 (33.4%)	55.31

It is obvious from the electrical energy balance diagrams that pug mill and press motors are under-utilized to the tune of 65-70% efficiency only. Fig. 3 and Fig 4 give percentage-wise consumption of electrical energy for various equipment used in brick and tile making. Amount of electrical energy usefully consumed by and the losses incurred in each equipment are also given in Table 2. Overall efficiency of the electrical system falls in the range 66-67%.

MATERIAL BALANCE

Fig. 5 illustrates the weights at each intermediate stages of tile making. For making 3000 flooring tiles, 6000 kg of wet clay is used. 100 kg of green waste is recirculated. Total solid wastes produced weighs 96 kg. Moisture weighing 664 kg is removed from drying and firing processes. Weights of materials at each intermediate stage of brick making are provided in Fig. 6. 7308 kg of wet clay is utilized for making 2000 fired bricks weighing 6000 kg. Green waste in recirculation weighs 60 kg. Total weight of solid wastes produced from drying and firing operations is about 97 kg. During these operations, 1211 kg of moisture is removed.

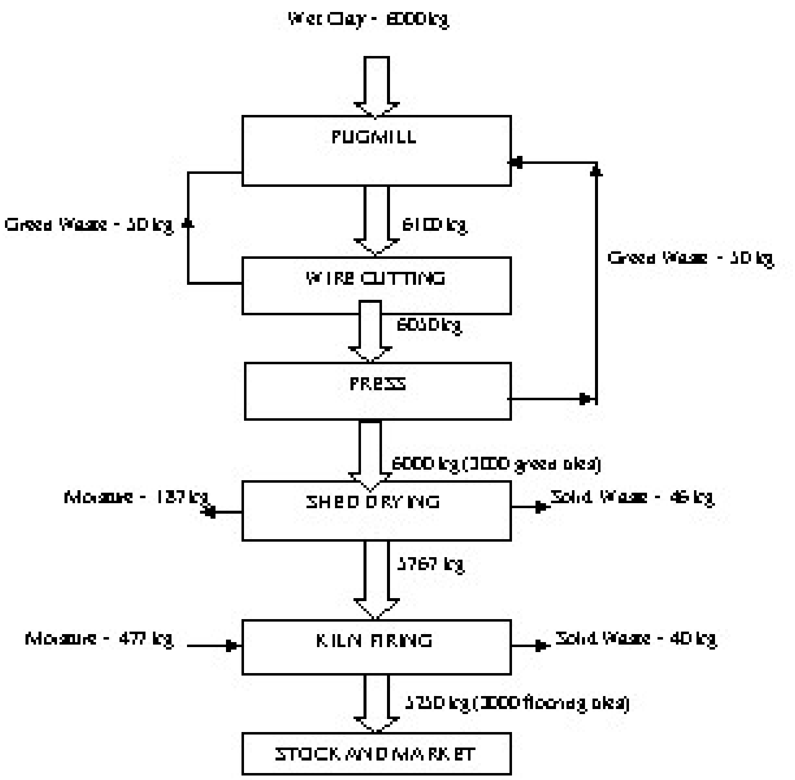

Fig. 5 Material balance for tile making (for making 3000 flooring tiles)

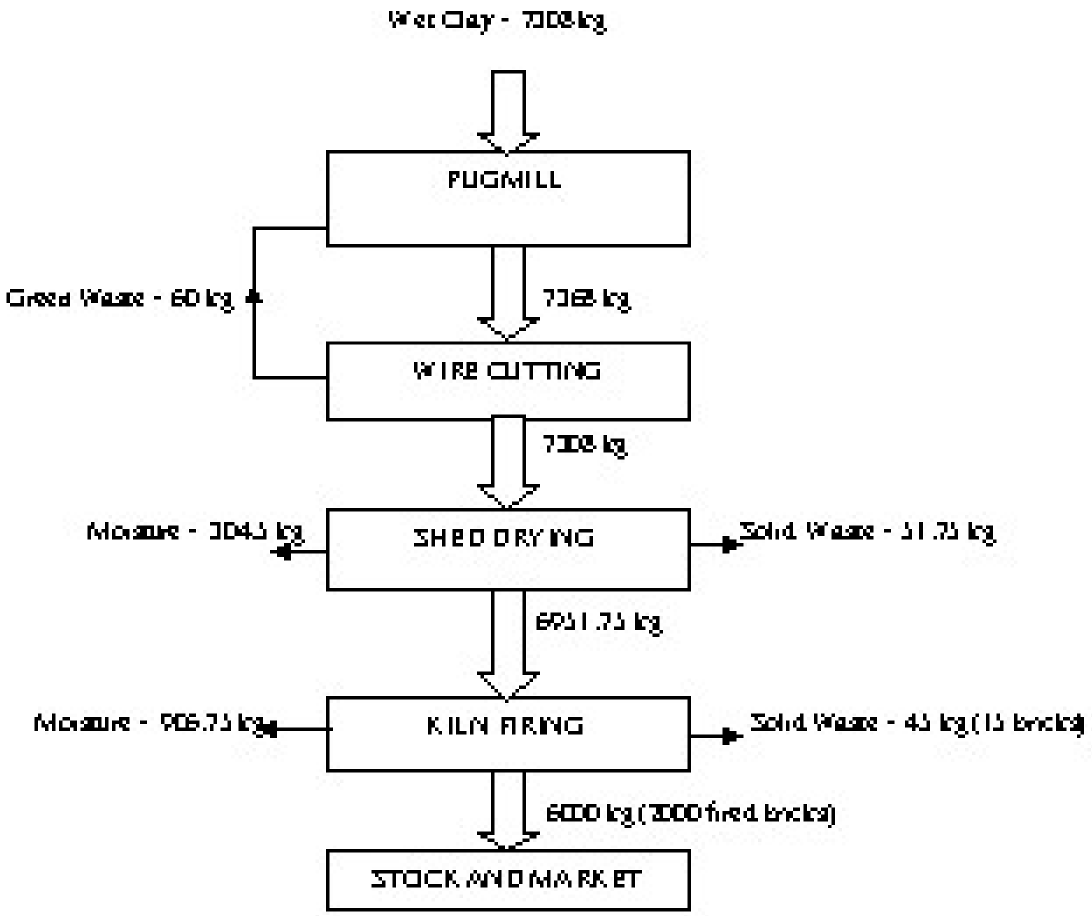

Fig. 6 Material balance for brick making (for making 2000 bricks)

ENERGY CONSUMPTION

Specific electrical energy consumption, specific thermal energy consumption and specific total energy consumption in both brick and tile manufacturing are given along with their corresponding costs in Table 3. Though electrical energy consumption is not significant, thermal energy consumed during firing of bricks/tiles is considerable, which is evident from the comparison with the benchmarks associated with each.

Factory Value Vs Bench mark

Here the lowest values of specific thermal and electrical energy consumptions observed so far with chamber kilns for firing bricks/tiles are taken as the relative indicators or benchmarks. Obviously process improvement, technology improvement and good house keeping are to be adopted to bring down the thermal energy consumption from 4.02 MJ/kg of fired brick to the relative indicator level of 2.3 MJ/kg of fired brick. Also eliminating under utilisation of electric motors and improving the power factor in the system will enable to bring down the electrical energy consumption from 0.011 kWh/kg of fired brick to the relative indicator level of 0.008 kWh/kg of fired brick. These are illustrated in Fig. 7 and Fig. 8.

Table 3. Specific energy consumption and cost for overall process

	Specific consumption		Cost of specific consumption	
	Brick	Tile	Brick	Tile
Electrical energy	0.0079 kWh/kg of fired brick	0.0105 kWh/kg of fired tile	Rs. 0.03/kg of fired product	Rs. 0.03/kg of fired product
Thermal energy	4.015 MJ/kg of fired brick	4.6 MJ/kg of fired tile	Rs. 0.32/kg of fired brick	Rs. 0.37/kg of fired tile
Total energy	1.125 kWh/kg of fired brick 4.05 MJ/kg of fired brick	1.2883 kWh/kg of fired tile 4.64 MJ/kg of fired tile	Rs. 0.35/kg of fired brick	Rs. 0.40/kg of fired tile

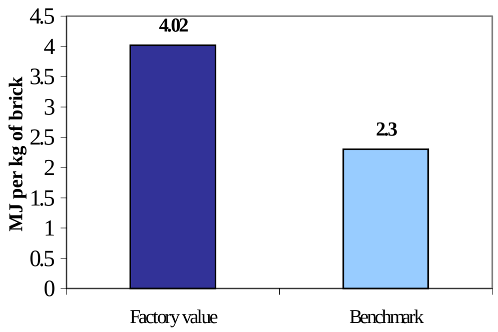

Fig. 7 Specific thermal energy consumption Factory value Vs Benchmark

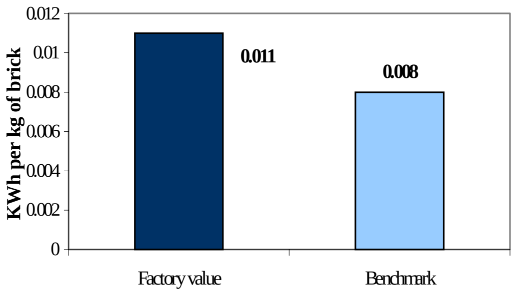

Fig. 8 Specific electrical energy consumption
Factory value Vs Benchmark

POLLUTION LOAD

Table 4. Specific and total pollution loads

	Specific pollution load (kg/brick)	Total pollution load (tonnes/year)
CO_2	0.92	515.7
SO_x	0.00213	1.19
CO	0.0167	9.4
CH_4	0.000251	0.14
NO_x	0.000837	0.47
N_2O	0.0000335	0.02
Ash	0.072	40.32
Dust (fly ash)	0.008	4.48
Solid waste (defective products)	0.606	339.15

The brick/tile kiln uses firewood consisting of about 40% carbon and 0.07% of sulphur. This accounts for the huge amount of annual CO_2 emission of 515.7 tonnes and meagre amount of SO_x emission of only 1.19 tonnes as illustrated in Table 4. CH_4 and N_2O emissions are comparatively negligible as is evident from Table 5.

Table 5. Pollution load per m^3 of flue gas

Pollutant	mg/m^3 of flue gas
CO_2	1,02,700
CO	1,864
SO_x	237.7
NO_x	93.4
N_2O	3.7
CH_4	28

DEVIATION IN ENERGY CONSUMPTION

Table 6. Percentage Deviation in Energy Consumption from Relative Indicator

	Brick	Tile	Relative indicator
% Deviation in electrical energy consumption	-1.25%	31.25%	0.008 kWh/kg of product
% Deviation in thermal energy consumption	74.6%	100%	2.3 MJ/kg of product
% Deviation in total energy consumption	73.9%	99.2%	2.3288 MJ/kg of product

In brick making, 74% excess energy consumption takes place, whereas in tile making, it is still higher, of the order of 99%. This is obvious from Table 6. This may be due to inefficient combustion in kilns, lack of monitoring of kiln parameters and improper composition of green bricks/tiles. Nominal reduction in electrical energy consumption in brick making with reference to the relative indicator is due to the absence of press used in tile making for moulding tiles. It is observed that utilisation of thermal energy is less efficient in tile making, consuming almost the twice the energy as is stipulated by the relative indicator.

Energy Efficient and Environmentally Sound Measures

i. Use of humidity dryer will lead to uniform drying of bricks, reducing drying time and breakage.

ii. Instead of firewood, LPG or propane or oil can be used as fuel in order to reduce the GHG emissions and increase in thermal efficiency.

iii. Temperature monitoring and alarm system may be installed in kiln enabling the firemen to feed only the optimal quantity of fuel, based on the temperature distribution inside various chambers of the kiln.

iv. High draught brick kiln reduce the fuel consumption by 25%, keeping the chimney exhaust within pollution standards (CBRI, 1999).

v. Changing the kiln to Vertical Shaft Brick Kiln leads to 30-50% more energy saving, the emissions being within pollution norms (Development Alternatives, 1998).

vi. Use of gravity settling chambers at the kiln exhaust will reduce the suspended particulate matter emissions.

vii. Depending on the production capacity, kiln stack should be at least 22-30 m high (Seminar, 2000).

CONCLUSION

Overall energy efficiency in brick/tile making process is very low. In addition, it is a source of huge air pollution in the form of GHG and dust. In order to overcome these flaws, the brick/tile factories have to adopt energy efficient and environmentally sound technologies through process improvement, good house keeping and equipment modernization.

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