Pollution Reduction and Waste Minimization in Brick Making

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1.0 Introduction

Fired clay brick is one of the most important building materials in the country. The current (2001) annual brick production in the country is estimated at 140 billion bricks. Brick making is a predominantly rural industry with brick making units belonging to small and informal sector. The number of brick producing units in the country is estimated to exceed 100,000.

The process of brick making is shown in figure 1. It consists of clay preparation, shaping, drying and firing operations. In India, good agriculture soil is preferred as the raw material for making bricks. It is estimated that the brick industry consumes around 400 million tons of good quality soil every year. The burning of fuel for firing bricks results in emissions of gaseous pollutants and ash into the environment. Brick firing being an energy intensive process, brick industry is one of the largest consumers of coal (around 24 million tons/year) in the country and hence is also an important air polluter. Air pollution and use of good quality agriculture soil are the major environmental concerns related with brick industry in the country.

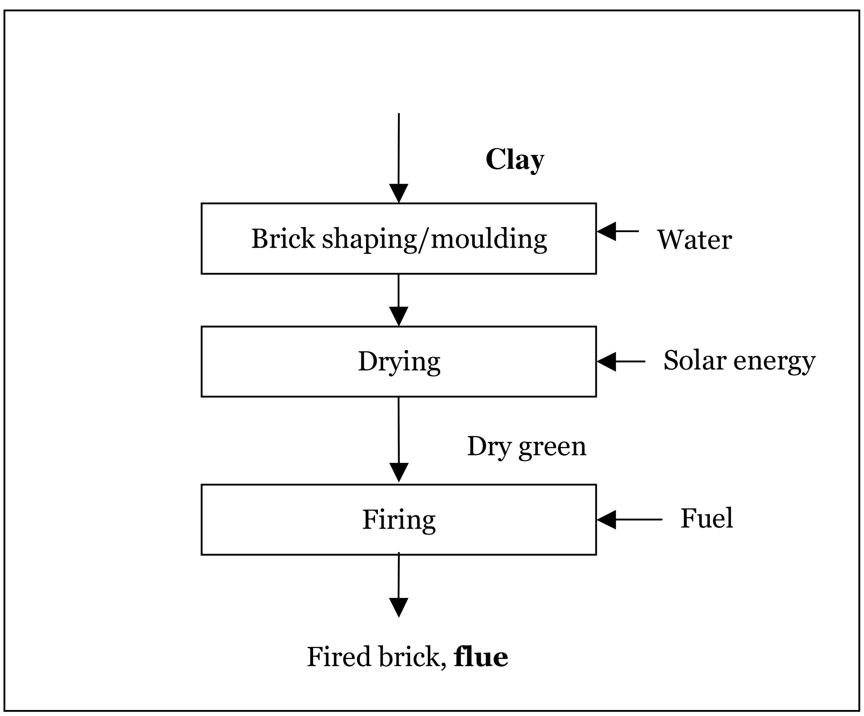

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Figure 1 Process of brick making

2.0 Air Pollution

The air pollution is defined as the presence in the atmosphere of substances in such amounts as to affect humans, vegetation, animals, or material adversely. Large scale burning of fuels — coal, oil, gas etc. to supply energy to industries, households and means of transportation is the main cause of air pollution. It is estimated that almost 90% of the air pollution are related with the combustion of fuel. The major pollutants are particulate matters (smoke, dust), gases (Sulphur dioxide, Nitrogen oxides, carbon monoxide, carbon dioxide etc.), metals (e.g. lead) etc.

Air pollution could have local as well as global impacts. All living beings inhaling or exposed to the polluted air gets affected by it. Particulate matters such as smaller dust and smoke particles penetrate deeply into the lungs and get deposited there. Sulphur dioxide causes irritation of the respiratory system. Carbon monoxide inhalation also causes dizziness, vomiting and in higher concentrations it can be fatal. Plant health is also adversely affected by air pollution. Pollutants like fluorine, lead and mercury cause damage to plants.

The harmful effects of air pollution are not only confined to the living beings directly exposed to the pollutants near its source, but are felt in a large area around the source of pollution. Acid rain is one such phenomenon, which is a cause of concern in heavily industrialized areas. Acid rain is caused because sulphur dioxide and oxides of nitrogen combines with water vapour in the atmosphere and forms mild acids. These acids then return to earth as rains, which have given, rise to the term acid rains. It causes extensive damage to plant life, to buildings and pollution of lakes and rivers. Fog is another phenomena whose effect can extend to nearby areas. Areas surrounding several cities in south Asia like Delhi are affected by fog every winter. Fog formation is accelerated due to air pollution. Normal life particularly transportation gets seriously hit due to fog and growth of crops is affected by reduction in sunlight.

Some of the effects of air pollution are not confined to local or regional environment but have the potential to affect all of the humanity. One such effect is global warming, which is resulting in a permanent change in the global climate. Scientists believe that increase in concentration of carbon dioxide mainly due to burning of fossil fuels (coal, petroleum products) is causing a global rise in temperature of the atmosphere and the earth's surface. Even a few degrees rise in temperature can cause change in climate patterns world-wide, such as -- melting of ice in polar regions resulting in rise in sea water levels which can submerge low lying coastal areas, change in rainfall pattern etc. Realising the threat from global warming, control of greenhouse gases (carbon dioxide, methane etc.) has now become an important issue in the global diplomacy and is expected to gain importance in near future.

2.1 Air Pollution from brick kilns

Being one of the largest consumers of coal in the country, it is one of the important sources of carbon dioxide emission in the country.

Other air pollutants from brick kilns are:

a) SPM in the flue gases which is generated mainly due to incomplete combustion of fuel (black smoke) or comes from fine coal dust, ash present in coal and burnt clay particles.

b) Hydrocarbons and carbon monoxide due to incomplete combustion of fuel.

c) Sulphur oxides, concentration of which mainly depends on the amount of sulphur present in the coal and is significant where high sulphur content coal is used (e.g. Assam coal, Kutch lignite.

d) Dust pollution generated during removal and laying down of ash layer on the top of the kiln and also due to blowing of ash stacked on the top and sides of the kiln

While the local impact of pollution caused by small isolated brick kilns located in rural areas is not likely to be significant, it is the large brick kiln clusters, located in the vicinity of large brick demand centres (towns and cities) that are important cause of concern. Rapid urbanisation has resulted in expansion of these clusters. Air pollution in these clusters affects the workers, local nearby residents as well as crops in the vicinity.

Among the various categories of workers working on brick kilns, the firemen (*jalai walha*), unloaders (*nikasi walha*) and workers, which handle ash (*rabish walha*), has the maximum exposure to the pollutants. Inhaling of these pollutants causes irritation of skin and eyes and can cause pulmonary diseases such as pneumoconiosis and silicosis, which are caused by inhaling siliceous dust. Interactions with traditional firemen by the TERI team show that the incidence of skin, lung and eye diseases are very common in this community of workers. Pollution also has an affect on agricultural crops and fruit plantations. The damage caused to mango and other fruit plantations due to pollutants from brick kilns is well known.

2.2 Measures to reduce air pollution from brick kilns

The measures to control air pollution can be classified into two categories:

a) Measures to reduce generation of pollutants at source or energy efficiency measures.
b) Measures to control or reduce the impacts of the emissions

- To use an “add on” device to remove pollutants from the stack gases e.g. gravity settling chamber

- Planned dispersion to control local air quality e.g. provision of taller chimneys

2.2.1 Measures to reduce generation of pollutants

Improving combustion

As already mentioned, one of the important source of air pollution is incomplete combustion of fuel. Roughly about 10% of the fuel supplied to a BTK remains unburnt or partly burnt. Considerable scope exists for improving combustion in BTK and other traditional kilns. The main causes of incomplete combustion in a BTK are insufficient air supply and improper feeding of coal. By improving the kiln operation, particularly by increasing the draught, improving air control and improving fuel feeding practices, the unburnts can be reduced to a large extent.

Energy efficiency measures

Any measure that saves fuel also helps in emission reduction as the total amount of fuel burned is reduced. Apart from the improvement in combustion process, it is possible to reduce energy consumption by 10-15% in a BTK by making small improvements in kiln design, construction and operation. Better kiln insulation and increase in fire travel rate is the key to energy conservation in fixed chimney brick kilns.

Use of fly ash/internal fuel

One of the causes of SPM generation is the high ash content in coal. Some of the ash is carried by flue gases. It is possible to mix a part of the fuel in the powdered form with the clay during clay preparation. This fuel is referred as internal fuel as it is present inside the brick. As the brick is heated in the kiln, combustion of internal fuel takes place. However, in this case as the fuel particles are entrapped in the brick, the ash associated with them remains inside the brick and does not come out. This helps in reducing the pollution. Use of internal fuel is prevalent in parts of central and western India. It is also quite common in countries like China.

Adoption of efficient kiln designs

Apart from improvement in fixed chimney kiln technology, the other way to reduce pollution and energy wastage is to shift to more efficient kilns such as zigzag fired kilns, Vertical Shaft Brick Kiln, Tunnel kiln etc. In terms of energy consumption these kilns are more or less comparable. While VSBK technology is particularly useful for lower production volumes of 5,000 to 15,000 bricks per day and has the potential of reducing energy consumption by about 30 % compared to a top class moving chimney kiln. Archless zig zag kilns and fixed chimney BTKs (with gravity settling chamber) are more useful in the production capacity of 15,000 to 50,000 bricks per day. With tunnel kilns it is possible to go up to a production capacity of 1,00,000 bricks per day.

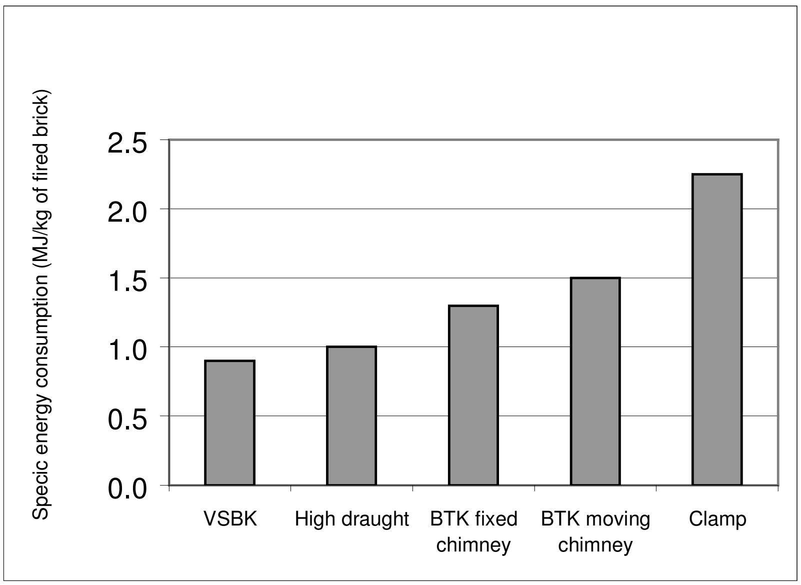

Figure2. Specific energy consumption in brick kilns

2.2.2 Measures to control/reduce impact of pollutants

Add-on devices - Gravity settling chamber

Reduction in pollution generation at source by better utilization of fuel is the best way to control pollution. However, it is not always possible to reduce the emissions to a level below the acceptable limit just by improvement in combustion and energy conservation measures. In these circumstances techniques to arrest pollutants before they are released in the atmosphere are employed. These techniques involve use of filters, scrubbers, gravity settling chambers etc. In case of fixed chimney kilns gravity-settling chamber, the most basic technique for arresting SPM is employed. It should be kept in mind that all the techniques for arresting pollutants result in pressure loss and hence require additional energy. Low flue gas velocities and draught in fixed chimney kilns make it virtually impossible to use any other add-on device other than gravity settling chamber.

Planned dispersion - Tall chimney

The harmful effect of pollutants locally can be reduced by reduction in concentration of pollutants through dispersion of pollutants in a large area. That is why recommendations for taller chimneys are given. Tall chimneys ensure release of pollutants at a higher height, which gives more time to pollutants to disperse in the atmosphere before reaching the ground.

3.0 Energy efficiency measures in BTK

3.1 Energy losses in a fixed chimney BTK

In general, the efficiency of fixed chimney BTKs in north India is of the order of 35 - 50 %. In other words, in a BTK, 50-65% fuel is wasted in energy losses.

The main energy losses in a BTK are:

a) Energy loss associated with incomplete combustion of the fuel. A part of the fuel fed into the kiln remains unburnt. The incomplete combustion of the fuel can be observed in the form of black smoke coming out of the chimney as well as in the form of unburned char accumulated at the floor of the kiln. The energy loss associated with incomplete combustion generally ranges from 5-10 % of the total energy input in a BTK.

b) Energy loss associated with hot flue gases flowing out of the chimney. The flue gases flowing out of the chimney are at a temperature of about 60-120 ^{o}C. The energy loss associated with hot flue gases is about 5% of the total energy input to the kiln.

c) Energy loss associated with hot-fired bricks at the time of unloading. At the time of opening a new chamber for unloading, the temperature of the fired bricks is in the range 50 – 120 ^{o} C. The energy loss associated with hot-fired bricks at the time of unloading is also of the order of about 5% of the total energy input to the kiln.

d) Surface heat loss from the kiln. The BTK has large surface area in the form of the top surface area (ash layer) and sidewalls. Heat from inside the kiln is conducted to the outside surface, from where it is lost to the atmosphere through convection and radiation. The surface heat loss can contribute to almost 10-15% of the total energy input to the kiln. The surface temperatures and the surface heat losses are highest in the firing and the heat- soaking zone of the kiln.

e) Heat loss to the ground. The ground below the kiln, continuously exchange heat with the kiln. Most of the heat absorbed by the floor of the kiln is conducted to ground below; only a small part of the heat stored in the kiln is given back to the kiln. The amount of energy loss depends to a very large extent on the properties of the ground. Higher moisture content in the soil or presence of sub-soil water/ water bodies near the kiln results in higher ground heat losses. The heat loss to ground generally ranges from 10-20% of the heat input.

A summary of the energy losses occurring in a BTK is presented in table 1.

Table 1. Energy losses in a BTK

Heat loss component	% of the energy input
Incomplete combustion	5-10%
Sensible heat in flue gases	5%
Sensible heat in fired bricks	5%
Ground heat loss	10-20 %
Surface heat loss	10-15%
Miscellaneous	5 - 10 %

3.2 Energy Conservation in a BTK

Based on the discussion above, the key principles for saving fuel in BTK are as follows:

a) Load only completely dry bricks in the kiln
It is important to load only completely dried bricks in the kiln. A reduction in 1% in the moisture content results in savings of 400 kg of coal/ lakh bricks or in other words a saving in production cost of about Rs 1000-1500/ lakh bricks.

b) Ensure high efficiency of heat recovery in the kiln
A BTK is based on the principles of heat recovery. In the brick cooling zone, the air entering the kiln from the unloading end, recovers heat contained in the hot-fired bricks. In the brick pre-heating zone, the hot flue gases heat up the green bricks. For ensuring high efficiency in the heat exchange process, the mass of air flow (kg/day) in the kiln should be equal to the mass of fired bricks (kg/day). In other words, a BTK producing 30,000 bricks per day i.e. firing 90,000 kg of bricks per day would require an air flow of close to 90,000 kg of air per day. Thus it is important that the chimney of the kiln should be of sufficient height and cross-section to ensure necessary draught at all times for achieving the desired airflow. For ensuring high degree of efficiency, it is also important that all the air should enter only from the unloading end and there should not be any air leakage in the kiln. Air leakage in the kiln results in excessively long cooling zone, creation

of dead pockets (pockets with very less airflows) in the kiln resulting in slow fire travel and high-energy consumption (figure 3)

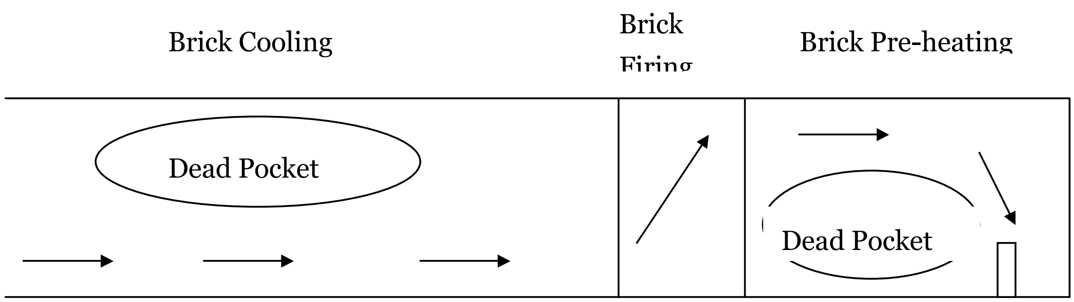

Figure 3. Air flow in a BTK

c) Achieve high combustion efficiency:
The two stages in the combustion of coal are:

- Devolatisation and combustion of volatiles.
- Char combustion

When coal is heated to a temperature of 350 °C, volatiles (gases such as methane, hydrogen, carbon monoxide etc.) are released from the coal. The process of devolatisation extends till a temperature of about 700 °C. The volatiles mix with hot air, and once this mixture has attained the ignition temperature, some time is required (ignition delay) before the mixture can ignite. The combustion reactions are faster at higher temperatures i.e. ignition delay is lower at higher temperatures. The burning volatiles are observed as flames in the kiln. The char (solid part) that remains after the release of volatiles can burn only at temperatures in excess of 700 °C . Smaller coal particles burn faster compared to bigger coal particles. Therefore, the conditions for achieving high combustion efficiency in the kiln are:

a) Feed coal only when the temperature in the firing zone is above 700 °C.

b) Keep sufficiently long firing zone (coal feeding zone of atleast 3-4 lines) so that the volatiles get sufficient space (high temperature zone) to mix and burn.

c) Use coal with particle size smaller than ¾ inch.

The combustion efficiency can be judged by observing the colour of the smoke during the coal-feeding period (dark black smoke signifying poor combustion efficiency) as well as by the amount of char accumulated at the bottom of the kiln setting.

d) Optimum utilisation of the kiln production capacity
In general in a BTK, increasing the throughput (daily production) helps in lowering the specific fuel consumption and the fuel cost per brick. For a given kiln, the surface and structure heat loss per day is almost constant and it is almost independent of the fire travel rate or production rate of the kiln. It means that by increasing the fire travel rate the specific energy consumption of the kiln can be decreased.

4.0 Reducing the wastage of good quality agriculture soil in brick making

Use of good quality agriculture soil in large quantities for brick making is also a grave area of concern. In geographical regions (e.g. parts of Mahrashtra) having thin topsoil, this result in reduction in the productivity of land and in extreme cases the land does not remain fit for agriculture use. To reduce this wastage following steps can be taken:

a) Promoting deep mining of clay for brick making instead of surface mining.
At present only top surface (3 ft to 10 ft) is utilized for brick making, resulting in large surface area being affected due to excavation of soil for brick making. Deep mining of clay can reduce the area affected due to excavation of soil for brick making.

b) Promoting use of waste materials like fly ash in brick making.
Use of waste materials such as fly ash, boiler ash, stone dust etc. can reduce to use of good quality agriculture soil in brick making.

c) Promoting use of perforated and hollow bricks.
A reduction of up to 40% in the material use is possible by going for perforated/hollow bricks instead of solid bricks. Perforated/hollow products require less energy for firing and produce less pollution per unit. Perforated and hollow bricks also has better insulating properties resulting in reduction in air conditioning and heating loads inside buildings made from perforated and hollow bricks.

All the above mentioned measures would require mechanization of some of the processes in brick making. Development of appropriate low cost machinery for making perforated/hollow products as well as support for popularising these products on large scale are essential for reducing wastage of agriculture soil in brick making.

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