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Energy Saving in Firing of Building Bricks

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A saving of 2.17×10^4 *MJ* of energy is effected through the designing and fabrication of a High Draught kiln for firing building bricks. The new kiln consumes 100-120 kg/1000 bricks of coal as compared to conventional kilns like the Bull's kiln which consumes 160-180 kg/1000 bricks of coal. The energy requirements of the new kiln work out to be 2300 *MJ*/1000 bricks.

The Bull's trench kiln, introduced in this country about a century ago, still continues to be extensively used by the brick industry. This kiln has low thermal efficiency which is reflected in the high fuel consumption in burning bricks. On the average, 16 to 18 tonnes of slack coal are consumed for burning one lakh bricks while in some regions, such as West Bengal, Assam, consumption rates as high as 25 to 30 tonnes per lakh bricks are also reported. The flow efficiency of this kiln is inherent in its design and method of operation. Though marginal improvement can be achieved by adopting the improved standard design incorporated in IS:4805-1978 (*Guide for Construction of Brick Kiln*) and using crushed coal as fuel, it is doubtful if any significant improvement can be achieved without radically changing its design.

Till the mid '50s, coal and firewood were comparatively easily available at cheap rates. They have become scarce now and their prices have shot up manifold in the past two decades. If all the 30,000 brick kilns in operation all over the country were to work at full capacity, then the total requirement of slack coal would be around 10 million tonnes/yr. At the prevailing market rates, the bricks industry may have to spend larger amounts on fuels alone. Realising the gravity of the present situation, the kiln owners, who previously showed little concern if a few extra tonnes of coal were wastefully burnt or a considerable proportion of bricks (up to 40 to 50%) were either under or over burnt, are now interested in saving as much fuel as possible and at the same time reducing the proportion of substandard bricks.

Following the identification of this basic problem of the industry the Central Building Research Institute investigated the basic factors that led to low thermal efficiency of continuously fired brick kilns[1]. The investigations showed that the efficient performance of a kiln was largely governed by the following parameters: Design of the kiln; control of the combustion process which includes control of feed rates, draught, air-fuel ratio, etc; pattern of setting of bricks ensuring uniform distribution of heat over the entire chamber cross-section; efficient recuperation of heat from the cooling zone and transferring it to the combustion and preheating zones; control of known sources of heat losses and protection of the kiln against rain, high winds, etc; and the quality of coal used, i.e., its calorific value, volatile matter content, ash, size grading, caking property, etc.

An analysis of the data collected during thermal studies on the common Bull's kilns and a close study of its operation brought out the basic faults inherent in the design, the pattern of setting, firing and control of the kiln. It was obvious from the study that the present design of the kiln permitted only limited control of the firing process and wastage of fuel was inevitable unless the design was radically changed. This study also indicated the ways of developing a kiln of an improved design.

In the development of the new kiln (now designated as the High Draught Kiln) effort has been made to maintain simplicity of design and operation and at the same time achieve high thermal efficiency. Information collected from published literature on the subject and in-plant observations made on the modern Hoffmann, tunnel and zig-zag kilns of various designs in operation in developed countries brought out the significant fact that any kiln developed to meet the requirements of the brick industry in India must be low in capital investment and at the same time should not require high technical skill in its construction, operation and control.

Design features

The kiln developed in this Institute (Fig.1) is basically an archless, top-fed, coal-fired, continuous kiln in which the fire follows a zig-zag path. The setting area is divided into 24 chambers by partition walls. The partition walls are built with unfired bricks and are dismantled at the time of unloading bricks from a chamber. Depending on the design capacity of a kiln, a chamber can hold from 7,500 to 15,000 bricks. As normally two chambers are burned per day (24 hours) outputs of 15,000 to 30,000 bricks per day can be obtained. A kiln with a capacity of burning 30,000 bricks per day has an overall dimension of 3445 × 2270 × 260 cm. The height of the setting from the kiln floor is 245 cm. The

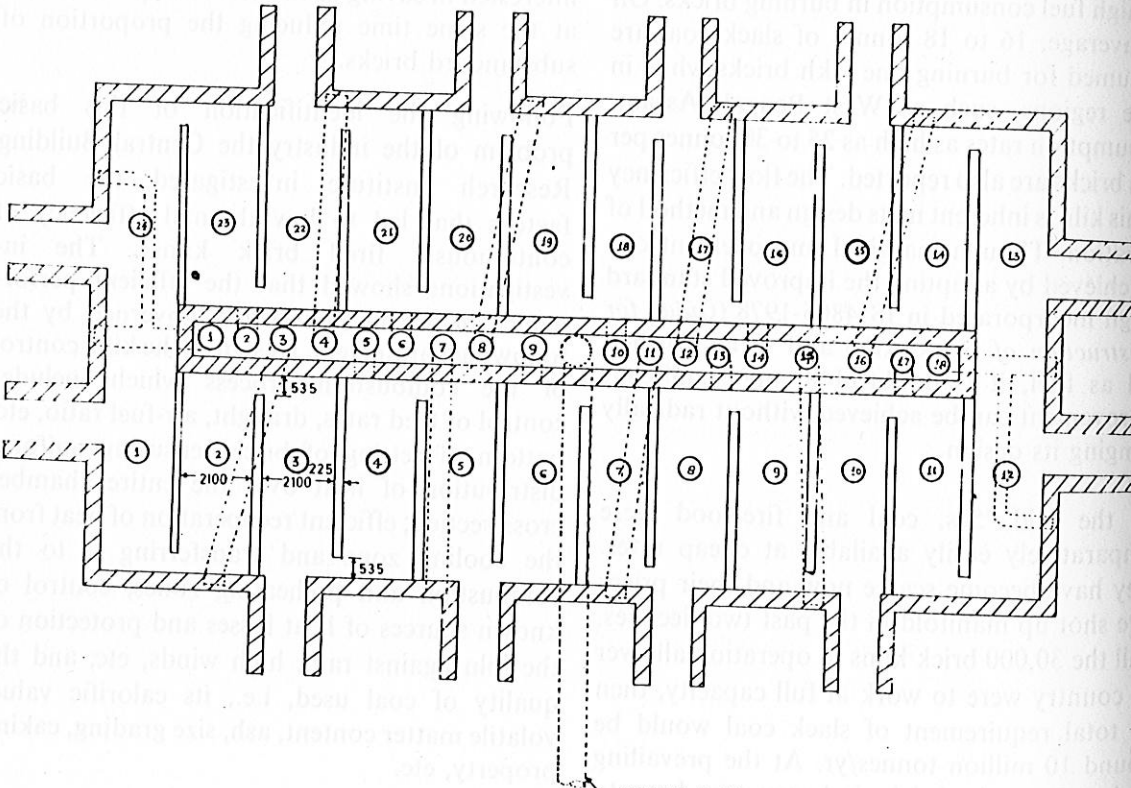

Fig. 1—Internal arrangement of a high draught kiln

effective burning length over which the fire travels is 170 m. Each firing circuit is completed in 12 days producing 3.6 lakh burnt bricks. The average setting density is maintained at about 1100 kg/m^3 excluding the bricks set in the partition walls. In a chamber holding 15,000 bricks 18 feed-holes are provided so that the area covered by each feed-hole is 0.844 m^2.

In this kiln draught is provided by an induced draught fan located at the far end of the exhaust flue. The discharging capacity of the fan is 425 m^3/min. It is worked by a 12 kW motor. The products of combustion, steam, etc. are channelised through a system of flues, the flow of gases being suitably controlled by cast iron dampers. The damper shaft is provided with a hand-wheel for easy operation. An additional plate damper is provided in the flue connecting the kiln with the fan for controlling draught. When brought to full firing order, the kiln operates on a draught of 50 mm (w.g.). During operation, a very fast rate of fire travel of 17 to 18 m/day is maintained which is three times as fast as in the Bull's kiln.

Working results

In actual firing compaigns, the kiln has proved highly efficient. Coal consumption has been as low as 100 to 120 kg per 1000 bricks as compared to 160-180 kg in the Bull's kilns. The thermal efficiency achieved is thus comparable to that of the modern Hoffmann and tunnel kilns of equivalent capacities. The uniformity of burning indicated even distribution of heat over the entire cross-section of each chamber. Kiln setters and firemen with experience of firing conventional kilns acquired the necessary skill to operate this kiln within a very short time.

The principal factors which contribute to the attainment of high thermal efficiency of this kiln can be summarised as follows:

Use of a powerful ID fan; the strong draught produced by it creates turbulence which ensures complete combustion of the fuel through efficient mixing of the preheated air and fuel. Provision of dampers at suitable points ensures perfect control on the movement of gases within the chambers.

Fast removal of moisture from bricks in the drying and preheating chambers, thus preventing moisture condensation in any part of the kiln.

Fast rate of fire travel ensuring minimum loss of heat from the kiln structure.

Prevention of leakage of cold air through feed-hole pots of improved design.

Maintenance exhaust flue gas temperature at as low as 90° to 100°C ensuring maximum recovery of heat from the waste gases.

Specially designed pattern of brick setting ensuring uniform heat distribution within the setting as well as fast rate of transfer of heat from one chamber to the next.

Use of coal crushed to below 10 mm size.

Use of control instruments.

It may be mentioned here that apart from high thermal efficiency, the kiln has an added advantage of being almost smokeless even when high volatile coal is used. This is in sharp contrast with the Bull's kiln in which dense black smoke is invariably formed after each feed of coal or firewood.

As the kiln is covered by a shed, it provides more congenial working conditions for the firemen, kiln setters and unloaders in all seasons compared to the conventional kilns where working conditions are very harsh. Again in the Bull's kilns high winds adversely affect draught and movement of fire (often leading to collapse of the portable chimneys), whereas the firing of the High-Draught kiln is completely independent of weather conditions and therefore no wastage of fuel or of bricks occurs due to changes in wind velocity or its direction of flow.

Operation of kilns in production

At the moment four High Draught kilns installed by the parties named below are in regular production:

(i) M/s Raj Clay Products, Ahmedabad

(ii) Thein Dam Township Project, Govt. of Punjab, Pathankot.

(iii) M/s Kadri Brick Mfg Co., Ahmedabad

(iv) M/s Gold Mohur Ceramics, Indore.

Whereas the first three parties mentioned above have installed kilns of 30,000 bricks/day capacity, the last-named has a kiln of 20,000 bricks/day capacity.

The average coal consumption in all the kilns has been in the range of 10 to 12 tonnes per lakh of bricks. It is remarkable to note, however, that M/s Raj Clay Products, who have been firing this kiln since 1977, have succeeded in bringing down their coal consumption from an initial 12 tonnes/lakh to 9.6 tonnes/lakh of bricks in 1981, despite the fact that the party is obliged to purchase low grade coal supplied from M.P. collieries and that no combustible matter is being admixed with the clay. This record performance has been possible through (i) continuous operation of the kiln at full capacity, (ii) skillful setting, firing and controlling by workmen who have now become well trained and (iii) efficient kiln management. Availability of uninterrupted supply of electric power for continuous running of the ID fan has also been an important contributory factor. For some time the rate of firing of this kiln was accelerated to $2\frac{3}{4}$ chambers per day thus exceeding the designed capacity of burning by 10,000 bricks/day.

Energy savings

The induced draught fan required for this kiln has a displacement capacity of 425 m^3/min (15,000 ft^3/min) and is worked by a 15 hp motor. At a daily production rate of 30,000 burnt bricks, the energy consumed in running the fan works out to 32 *MJ* per 1000 bricks.

Assuming also that the average CV of coal used is 5500 Kcals/kg, energy required for burning works out to 230 *MJ* per 1000 bricks at a consumption rate of 100 kg of coal per 1000 bricks. Thus the total energy required to fire 1000 bricks in the HD kiln is 2332 *MJ*.

Against this, the energy requirements in a Bull's kiln consuming 180 kg of coal of similar quality per 1000 bricks works out to 4500 *MJ*/1000 bricks. There is thus a net saving of 2168 *MJ* of energy per 1000 bricks in the HD kiln or nearly 2.17×10^4 *MJ* per lakh of bricks. Although no reliable figures of the total production of bricks fired in Bull's kilns all over the country are available it may be roughly estimated at around 3000 crores per year. Therefore, if even half the number of Bull's kilns are replaced by HD kilns, it would be possible to save about 3.2×10^9 *MJ* of energy per season.

Economics

The capital cost of installation of a HD kiln is admittedly much higher than that of the Bull's kiln. Including the shed, a HD kiln with a capacity of 30,000 bricks per day costs around Rs 3 lakhs against only Rs 40,000 for a Bull's kiln of similar capacity. However, a little consideration will show that from the savings made in coal (8 tonnes per lakh of bricks), at the current rate of about Rs 500 per tonne, the extra investment of Rs 2.8 lakhs on the HD kiln can be recovered in burning about 65 lakh bricks, i.e. within $7\frac{1}{2}$ months of continuous firing of the kiln.

The estimated cost of firing 1000 bricks in the HD kiln is Rs 77.00 which includes the cost of coal, power, interest and depreciation of the total investment on the kiln, maintenance and labour for loading, firing and unloading of bricks. Against this, the total cost of firing 1000 bricks in a Bull's kiln comes to Rs 104.60. Thus there is a net saving of Rs 27.60 in the cost of firing 1000 bricks. In the case of the Bull's kiln again, there is a recurring expenditure on the portable steel chimneys which get corroded by acid vapours produced by the combustion of coal or due to the presence of corrosive salts in the clay or water used in making bricks. Taking the average life of a pair of chimneys as one season, i.e., about 8 months, the net saving in cost per season is around Rs 7500. That is to say that over a period of ten years (the average life of a fan) a net saving of Rs 75,000 can be effected.

Conclusions

Continuous operation of several High Draught kilns on commercial scale has conclusively established that its high thermal efficiency leads to a saving of 6 to 8 tonnes of coal for every lakh of bricks burnt as compared to the fuel consumed in the conventional kilns. As the country is passing through a serious fuel crisis gradual replacement of the Bull's kiln by the new kiln can go a long way in saving substantial quantities of coal and at the same time make available to the building industry bricks of high strength and durability.

Apart from the saving in fuel, the HD kiln has the additional advantage of remaining in operation all through the year, thus increasing the annual turnover from a kiln by about 20%. It may be pointed out here that the main restraint in the way of adoption of the new kiln by the industry on a large scale has been the non-availability and irregularity in the supply of electric power for running the kiln fan which must work continuously around the clock. In most cases it becomes necessary to instal a diesel engine or generator as a stand-by but this is not a satisfactory solution considering the soaring price of diesel.

In the HD kiln both hand-moulded and machine made, wire-cut bricks of the conventional and modular size have been fired. Canal lining tiles and similar products have also been burnt with good results.

Acknowledgement

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