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Energy Conservation through Building Materials

Prof. S. K. Gupta, Ar. Dilip Singh Kushwaha

¹Dean & Director, ²Assistant Professor, Amity University Haryana, Panchgaon, Manesar, Gurgaon

Synopsis: Conservation & economic utilization of energy have become a complex issue in this decay. It is the most important contributing factors to the high inflationary trends the world over & advanced countries have already started taking effective measures for the conservation. However, India seems to be lagging behind in this respect & field.

Major sources of energy today are oil & natural gas, coal & nuclear plants. With oil & natural gas reserves getting depleted in all parts of the world, alternative sources of energy have to be developed fast even while conserving & extending the present availability of energy to the maximum possible extend.

In this paper I would highlight on overall view of the energy requirement in the production & development of different Building Materials & an account of the attempts made through research & development in reducing energy consumption in building materials production.

Demand for housing & building in India, is ever on the increase & the gulf of shortage is widening as the population increases every year by over 12 million. In India, this shortage is estimated to be 12 million houses in urban areas & 72 million houses in some 7, 00, 000 villages of the country. According to one UN estimated by the year 2000 there will be twice as many people living in the cities of the less developed countries as there are today. The total dwelling needs would be 268 million units of which 79 million units would be needed in urban areas & 189 million in rural areas. Since the building materials alone account for about 70% - 75% of the cost of a building thus we can understand requirement of huge quantities of building materials & therefore the idea of energy conservation in the development & Production of building materials is an important & rightly conceived idea.

I. INTRODUCTION

Today we are facing acute shortage of almost all building materials like bricks, cement, wood, steel & etc. as shown in Table – 1. Taking the example of bricks alone about 8 to 10 million tones of coal are required for firing 40 to 50 thousand million nos. of bricks that are presently required in the country. This amount of coal consumption was in the third largest consumption after railways (in old time) & thermal power plants. It would be seen from the table that conventional building materials are in short supply & therefore a range of new building materials have been developed not only to meet shortage but also to consume less energy than conventional materials. The whole lot of building materials could be divided into the categories one Inorganic building materials & second Organic building materials as shown in Table – 2.

Energy consumption in the manufacture of some of the common building materials is shown in Table – 3. There are several methods or renovation in the technological processes with a view to cutting down the energy consumption. For example the use of pre-calcinations in the dry processes of cement manufacture in gaining preference to the wet process, this consumes more energy. The use of industrial waste, much as slag & fly ashes reduces about 20% - 40% energy consumption in blended cements as compared to ordinary Portland cement.

Another way to reduce energy budget in the manufacture of building materials is the use of agro-industrial wastes, as fuel or as raw material. Now we take up actual energy consumption & conservation achieved through renovation for each building material one by one.

II. BRICKS & CLAYS PRODUCTS

Brick has been the most versatile & cheaper material of construction & still the most widely used construction materials. The brick & clay products industry is facing grave problems due to shortage of coal as fuel for burning the clay products. Variety of kilns is in operation for burning bricks tiles & other heavy clay products. These kilns vary in size, shape, mode of fire & hot gas travel, thermal efficiency & therefore the quality of products fired in them also vary.

Kilns as used for brick & tile burning in the country can be classified into three categories based on the direction of draught as air, flue gases & the product of combustion flowing into the kiln viz. (a) Up draught kiln, (2) Down draught kiln and (3) Horizontal draught kilns on the basis of the continuity of the firing operation, the first two types of kilns fall under the group of intermittent kilns while the latter is categorized under continuous kiln.

A. Intermittent Kilns

- 1) *Clamps*: Clamp kilns are most widely used kilns in under developed countries for burning bricks & tiles due to simplicity in operation & low initial cost. The time of firing & cooling of a clamp varies from one to four weeks depending on the spacing of fuels & quantum of loaded material.
- 2) *Up Draught Kiln*: Up draught kilns are basically similar to clamp kilns except that there is permanent brick masonry & burning of fuel is manually controlled. However these kilns are known for higher fuel consumption & the production of inferior throughout the setting.
- 3) *Organization (CBRI) up Draught Kiln*: A circular up draught kiln using cow dung cakes & fire wood as fuel for burning clay is superior to clamps & Orissa type up draught kiln as firing temperature of the product is largely increased & uniformly distributed throughout the setting.
- 4) *Down Draught Kiln*: The down draught kilns of various capacities, whether circular or rectangular in shape is one of the most satisfactory & efficient kiln amongst all the types of intermittent kilns generally used by ceramic industry for firing tiles, bricks, pipes, blocks, engineering & facing bricks etc. The results of firing indicate production of high quality tiles up to 80% & minimum firing losses consuming almost half the quantity of energy compared to other type of intermittent kilns.

B. Continuous Kilns

- 1) *Bull's Trench Kiln*: This kiln is most widely used in India. This kiln is continuous type & is essentially arch - less, circular or elliptical in shape where in the bricks are set within the trench. The coal is fed from the top of the setting & the required draught for burning of coal/fuel is created with the help of a pair of chimneys (10-12 m height) moving either on the brick bedding or on the side walls of the kiln. Those kilns are cheap to construct & easy to operate.
- 2) *Organization (CBRI) High Draught Kiln*: It has developed a high draught kiln for burning bricks, it is also aweless, top fed zig – zag type, which operates on high draught produces by an induced draught fan. The fan is operated by a 12 KW motor. Bituminous slack coal crushed to below 12 mm size & having a calorific value between 5000 to 6000 Kcal/g is used a fuel. The consumption of coal in this kiln is about 120 kg / 1000 bricks & in addition, 3.75 units of electric power are also required. A calculation shows that total energy required in this kiln is about 700 x 1000 per 1000 bricks as against 880 x1000 Kcal in the usual Bull's Kiln. As a result high draught kiln is becoming popular.
- 3) *Hoffman Kiln*: This is a continuous kiln consisting of a rectangular endless tunnel which is divided into a number of imaginary chambers connected to a fixed chimney through a system of flues. The advantages of this kiln is that firing, loading, unloading of products can be done simultaneously & there is minimum loss of heat & the kiln structure is fully covered with a masonry arch. Result of firing clay products in different kilns & energy requirements are given in Table – 5. This clamps are highly thermally inefficient though they are cheaper to install wherein city & agricultural waste can be utilized as fuel in rural areas.

Amongst intermittent kilns down draught kiln is more efficient while up draught kilns are intermediate between clamps & down draught in operation & fuel consumption.

Continuous kilns particularly high draught kiln is quite efficient easy to operate requiring less investment & consuming comparing energy as that of Hoffman Kiln.

III. ENERGY CONSERVATION THROUGH USE OF RICE HUSK AS FUEL IN BULL'S TRENCH KILN

Use of agricultural waste like rice husk, ground nut husk, and garbage & forest residues has been contemplated as one of the alternative fuel for saving of coal & production of bricks on cheaper rates. In India rice husk is obtained at the rate of 20 million tons per year.

This has been used in pre-boiling of the paddy & in cane crushing plants. As rice husk is not easily digestible to the cattle's & also it harbors injurious insects which damage crops large quantities of rice husk are available for firing bricks.

A technique has been developed by a organization (CBRI). Roorkee, for utilization of rice husk is used as fuel for economical burning of building bricks & saving in coal.

The technique has been tired for small scale as well as large scale production of bricks. Saving of coal up to 30% to 40% has been achieved. Rice husk has been used as partial substitution of coal & also for total replacement of coal & saving in fuel cost has been achieved as shown in Table – 6.

IV. ENERGY SAVING BY USING FLY ASH IN BRICK MAKING

About 20 million tones of fly ash is as available per year as industrial waste. Experiments & field trials have been done to establish that fly ash addition up to 50 tones per lakh of bricks from loamy alluvial soil & 90 – 120 tones per lakh of bricks from plastic red & black soil is advantageous to improve workability of clay & other desired properties required for the production of bricks. Economy in fuel consumption of the order of 18% - 35% has been achieved through commercial production of clay fly ash bricks at various continuous kilns as shown in Table – 7.

V. ENERGY SAVING THROUGH UTILIZATION OF COAL WASHER REJECT IN BRICK MAKING

On beneficiation of mind coal, about 3 million tons of coal washers produced from various washers in India. Results have shown that on mixing ground washer rejects up to 07 % in soil (W/W) contribution to saving of 30% to 40% coal consumption during firing.

VI. ENERGY CONSERVATION IN SAND LIME BRICKS

It has been realized that clay bricks alone cannot meet the heavy demand for building bricks & hence the potential for an alternate material such as calcium silicate (or sand lime) brick has been recognized. This brick is quite popular in countries like USSR, West Germany & Netherlands. There are over 200 factories in West Germany producing about 6500 million sand lime brick while India has only one factory producing about 03 million Basilicata bricks annually. Progress of this Industry in India is held up mainly due to non-availability of a suitable press. Organization (CBRI) has developed process known how & machinery for production of these bricks which are comparable & better in some respects than clay bricks. Sand & lime are thoroughly mixed on a blender in 90:10 ratio by weight & a little quantity of water is added. The mixture (which is semi dry) is filled in the moulds & pressed to 200-300 kg/sq cm pressure. The bricks are transferred to the steam curing chamber (autoclaves). The bricks are cured for 4 – 6 hrs. IN saturated steam at a pressure of about 14 kg/sq. cm. The cured bricks are now ready for use.

Total energy consumed in sand lime bricks

(Thermal & Electrical) = 690 x 1000 Kcal per 1000 bricks

Total energy consumed in burnt clay bricks

(Thermal & Electrical) = 1022 x 1000 Kcal per 1000 bricks

By comparing the two values we find that saving in total energy in the manufacture of sand lime bricks is 30%.

VII. ENERGY CONSERVATION IN CEMENT MANUFACTURE

Cement is a very important building material & its use is ever increasing. The process of Portland cement manufacture which includes quarrying, crushing, grinding & mixing of the raw materials, burning of the raw meal, grinding of the cement clinker & pacing of the cement consumes between 1350 to 1550 Kcal/kg of thermal energy & 102 to 123 KWh per tones of electrical energy. A break up of the energy consumptions is given in Table – 8.

Portland cement clinker is manufactured by two processes known as the wet process & the dry process differing, mainly the mode of processing of the raw materials. In the wet process the raw materials are wet ground to form the raw materials are wet ground to form slurry containing 30% to 40% water & this slurry is fed to the cement rotary kiln. In the dry process, the raw materials, in dry form are ground to a fine powder & mixed together in the required proportions to prepare raw meal.

Various measures to reduce energy consumption have been suggested from time to time as listed below: -

- 1) *Design of Raw Meal:* Burn ability of raw meal depends upon its chemical, physical & mineralogical properties. For example a new meal having higher Al_2O_3 is harder to burn & vice versa. Higher iron content ease burning & thereby leads to fuel economy. Similarly, a lower silica ensures easier burn ability. A finer raw material is easier to burn thus causing energy saving. A reduction of clinkering temperature by 20 degree C saves 20Kcal/kg of clinker, which is achieved by adjusting CaO, Al_2O_3 , SiO_3 , Fe_2O_3 meal ration for easy formation of liquid phase
- 2) *Reduction of Moisture in Raw meal Slurry:* The moisture in the raw meal slurry can be reduced by addition of chemical known as slurry thinners. Inorganic electrolytes such as Sodium Silicate, Sodium Carbonate, Sodium Sulphate, Sulphate lye available from paper factories as black liquor are used as slurry thinners. These are added in small amount (0.05% to 0.3%) & are known to reduce moisture content up to about 6.5%.
- 3) *Conversion of Wet to Dry Processes:* The conversion of wet to dry process cement plant requires changes in the raw meal & the rotary kiln. In view of big difference in thermal energy requirements, conversion of wet to dry process cement plant is expected to bring about 37 – 40 per cent reduction in fuel consumption. Total heat consumption in wet & dry process is about 1500 & 900 Kcal/kg clinker respectively.

- 4) *Use of Mineralizers*: The clinkering of raw meal can be enhanced by use of mineralizers which are classified as fluorides, fluorosilicates, sulphates, Phosphates, carbonates, oxides etc. An estimate of direct saving of thermal energy showed a reduction in heat consumption by 60 – 120 Kcal/kg of clinker due to lowering of burning zone temperature by 50 -100 degree C.
- 5) *Use of Grinding Aids*: A variety of grinding aids such as mono-di-and tri ethanol amines, glycols, glycerol, cetex, sulphate lye etc. improve grinding efficiency with saving in power consumption. Saving in power consumption with sulphate lye as grinding aid is shown in Table – 9.

VIII. ENERGY SAVING THROUGH UTILIZATION OF INDUSTRIAL WASTE IN BUILDING MATERIALS

Industrial waste such as fly ash, blast furnace slag, lime sludge, rice husk, mineral tailings have been used in producing blended cements & masonry cements causing considerable saving in energy. Table – 10 shows a variety of industrial waste & their use in production of different building materials. These blended cements are produced up to 2/3 of the total production of cement per annum.

A. Quick Lime

Quick lime is a basic material of significant importance. It is produced by the endothermic process of calculation of limestone at elevated temperature usually exceeding 900 degree C under atmospheric pressure conditions. Lime is being produced in the kilns of several designs 7 capacities. The stack (heap) & the rectangular batch kilns, popularly known as country kilns are by far the most commonly used kilns. Investigations carried out at organization (CBRI) have revealed that the conventional kilns are highly heat wasteful. The vertical shaft kilns are operated in a semi continuous ways. The lime stone & coal are laid one over the other in alternate layers in the country type kilns whereas a mixed feed of the same is loaded from top in the vertical shaft kilns & the firing operations are conducted in appropriate modes.

A lime kiln of improved design has been developed at particular organization. Basically it is tall cylinder conical structure constructed in masonry & the shaft lined internally with fire bricks. It is named as vertical mixed kiln.

The heat losses for the various types of lime burning kilns were established & the energy inputs based on one kg of quick lime are shown in Table -11.

IX. CONCLUSIONS & RECOMMENDATIONS

All above ways to make the bricks & quick lime are too good to energy conservation for building materials. There are huge energy conservation possibilities to do that. It is better if use indigenous & vernacular building materials. Saving the energy is a great achievement for the nation.



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