Automation in Clay and Thermal Industry Waste Products

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ABSTRACT: Construction is a part of infrastructure, which is essential to promote growth in the economy. India is one of the fastest growing economies in the world. The scope of Infrastructure industry is enormous, as the Indian Industry has been witnessing a large growth. As the industries tend to cluster around the cities and their suburbs, the local governments are pressed for providing facilities for Housing, Communication, Power, Water supplies and other facilities. A competitive, market oriented and rationalized construction tomorrow requires the development of automated and robotized construction system today. This includes industrialized process originating in a mining, construction material production, prefabrication of construction components, on site construction, facility management, and rehabilitation and recycling. In today's construction projects are characterized by short design and build period, increased demands of quality and low cost.

KEYWORDS: Clay Brick, Fly ash Brick, Automation

INTRODUCTION

The construction sector is an important part of the Indian economy and is registering an annual growth of 9%. Clay fired bricks are the backbone of this sector. The Indian brick industry is the second largest producer of bricks in the world after China. India is estimated to produce more than 14000 crores of bricks annually, mainly by adopting age-old manual traditional processes. The brick sector consumes more than 24 million tonnes of coals annual along with a huge quantity of biomass fuels. The per annum CO_2 emissions from Indian brick industry are estimated to be 42 million tonnes. Due to large scale construction activities in major towns and cities, a number of brick plants have been set up on the outskirts of these cities. These clusters are the source of local air pollution affecting local population, agriculture and vegetation. For the production of clay bricks, top soil to the extent of 350 million tonnes is used every year, which is a reason for concern. Since this brick sector is labour intensive, it limits its capacity to produce any other type of bricks. With the introduction of NREGA scheme in various states, these labour intensive industries are facing the shortage of manpower. Thus the brick industry has started exploring other options like the introduction of partial/full-scale mechanization in this sector.

The present day constructions have RCC (Reinforced Concrete Cement) columns and mainly bricks are used as partition walls. They are no longer being used as load bearing walls in majority of the buildings. A shift towards "Resource Efficient Bricks" (REB) would help save fuel and reducing pollution in the brick production process. There is also a significant reduction in the consumption of top (agricultural) soil which is the main raw material in brick making. Increased use of REBs in building construction would also help in reducing the energy consumption of buildings due to their better insulation properties.

HOW CLAY BRICKS ARE MADE

Clay bricks are used in a wide range of buildings for housing to factories, and in the construction of tunnels, waterways, bridges etc. Their properties vary according to the purpose for which they are intended, but clays have provided the basic material of construction for centuries. Brick is the oldest manufactured building material, and much of its history is lost in antiquity. The oldest burnt or fired bricks have been found on the sites of the ancient cities of Babylonia, some of which are estimated to be about 6000 years old. Brick is, after all, virtually indestructible. The industry developed on traditional lines, using a hand - making process for the most part. The first patent for a clay-working machine was granted in the year 1619. Mechanization, however, did not begin to take the place of manual methods until the middle of the nineteenth century. The moulded products were fired in relatively inefficient intermittent or static kilns until about 1858, when Hoffmann introduced a continuous kiln, which enabled all processes connected to the firing to be carried out concurrently and continuously. Since the introduction of clay working machinery and the Hoffmann Kiln, the Industry has made great progress, particularly since 1930, the output of bricks in Great Britain was doubled between 1930 and 1938.

BRICK INDUSTRY IN INDIA

TRADITIONAL BRICK FACTORY (65,000 units)

Figure 1: Traditional Brick Factory

Source:
http://www.resourceefficientbricks.org/pdf/icmb/Mech.pdf

SMALL SCALE INDUSTRY (20,000 units) AND MEDIUM SCALE INDUSTRY (13,000 units)

Figure 2: Small Scale Industry and Medium Scale Industry
Source:
http://www.resourceefficientbricks.org/pdf/icmb/Mech.pdf

LARGE SCALE INDUSTRY (10 units)

Figure 3: Large Scale Industry
Source:
http://www.resourceefficientbricks.org/pdf/icmb/Mech.pdf

THE INDIAN MARKET FOR BRICKS

The Indian construction industry is expected to grow at 25–30 % during the next period. This means a structural transformation of the Indian brick industry. It will change its face. This will create huge opportunities for machinery manufacturers and technology providers.

THE TRADITIONAL INDIAN BRICKS INDUSTRY

Figure 4: Traditional Indian Bricks Industry
Source:
http://www.resourceefficientbricks.org/pdf/icmb/Mech.pdf

INDIAN BRICKS INDUSTRY

Figure 5: Indian Bricks Industry
Source:
http://www.resourceefficientbricks.org/pdf/icmb/Mech.pdf

PROCESS TECHNOLOGY IN CLAY BRICK AND FLY ASH BRICK

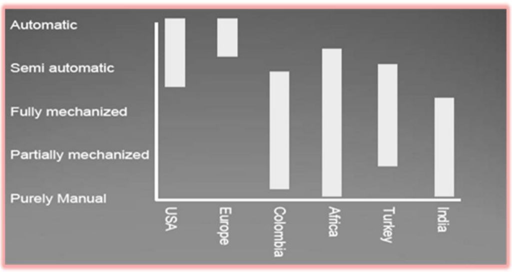

Figure 6: Process Technology in Clay Brick and Fly Ash Brick
Source:
http://www.resourceefficientbricks.org/pdf/icmb/Mech.pdf

INDIAN BRICKS INDUSTRY

Figure 7: Indian Bricks Industry
Source:
http://www.resourceefficientbricks.org/pdf/icmb/Mech.pdf

LINK BETWEEN PROCESS TECHNOLOGY AND PRODUCTIVITY

TABLE 1
LINK BETWEEN PROCESS TECHNOLOGY AND PRODUCTIVITY

Nature of processing method	Requested number of workers for producing 1 million standard bricks per year	Number of standard bricks per worker per year
Purely manual	20	50 000
Partially mechanized	14	71 400
Fully mechanized	6	166 700
Semi-automatic	1	1 000 000
Automatic	0,25	4 000 000

THE MANUFACTURING PROCESS OF CLAY BRICKS

Winning

Heavy earth-moving equipment such as bulldozers, scrapers and mechanical shovels are used to extract the clay and shales.

Crushing and blending

After being transported from the pit by truck or endless conveyor, the materials are stockpiled to enable blending of the various types of clay. The clays are fed separately by hopper or conveyor to the primary crushers – in South Africa rolls or hammer mills are commonly used. These reduce the particle size down to 3 – 5 mm or less. The mixing of clays follows, to impart to the desired properties, such as colour and strength.

Grinding

Conveyors carry the mixed clay away for secondary crushing, which is usually done by means of a pan mill. The pan mill has two heavy steel wheels on an axle that is connected to a central vertical spindle around which they rotate, crushing the clay against the base of the pan. The base is perforated to allow the crushed material to fall through. This process, when done with dry clay, shatters the brittle particles into smaller pieces. When the pan mill is used with wet clay, the plastic material is squeezed through the perforations and then falls between high-speed rollers which complete the grinding process.

Screening – dry processing

Before being shaped, the clay is screened and oversize pieces are returned to the pan mill for fur their crushing.

Shaping

Bricks are hand formed, pressed or extruded into their final shape. The method used to shape the bricks affects their final appearance and texture, and sets certain limitations on the handling methods employed during manufacture.

Extruded bricks

Clay with 18-25% water content is forced by an auger into a horizontal cone-shaped tube that tapers down to the die. Two compaction stages are commonly incorporated, with a vacuum chamber between them to remove any air in the clay that would reduce the strength of the end product. The extruded clay column is cut into brick-sized pieces by an arrangement of wires. Extruded bricks, although often smooth, may be mechanically patterned or textured. Most bricks of this type have anything from 3-12 perforations that, by increasing the surface area, reduce the required drying, firing, and cooling times. Any internal stresses are relieved by the perforations and prevent distortion of the bricks during firing.

Drying of bricks

In the brick-making process, the clay is refined and water is added in order to mould the brick. Before the bricks can be fired, they must be dried properly: the moisture content has to be reduced to 8% by volume for the clamp kiln. There is adequate sun for the drying operation and most clamp kiln brick makers make full use of this free source of energy by placing the bricks on open hack lines. This operation has the disadvantage that it may make the process time-consuming, especially in the rainy season. To reduce the drying cycle, brick makers have introduced some mechanical means of drying. The two most common methods are tunnel or chamber driers. The energy (heat) for the drying is produced in a supplementary coal heater or recycled off the kiln and the heated air is fed into the driers. These methods work as follows:

- **Tunnel driers:** The bricks are produced and then off-set on flat rail trolleys or kiln cars. The cars are pushed through the tunnel. This operation can take up to 40 to 50 hours, from green to dry.

- **Chamber driers**: Patented chamber driers are large rooms where bricks are packed onto pallets. The chambers may have a capacity of 50 000 to 60 000 bricks. Hot air is fed into the chamber. Drying time is between 30 and 45 hours – much quicker than the 14 to 21 days needed for solar drying.

Firing

Bricks are fired at temperatures between 1 000° and 1 200°C, depending on the clay. Light-coloured clays usually require higher firing temperatures than dark-coloured ones. Of the many known types of ceramic kilns, four types were used in South Africa: the Down Draught kiln, The Hoffman-type Transverse Arch kiln (T.V.A.), the Tunnel kiln and Clamp kiln. However, the Down Draught type of kilns has been discontinued because of their uneconomical firing procedure (labour, coal etc.). Downdraught kilns consist of a rectangular space with a barrel-vaulted roof and a slotted or perforated floor open to flues below. Green bricks (40 000 to 100 000 at a time) are stacked in the kiln. Fires are lit in fireboxes along the sides and the hot gases fire up to the curved roof, down through the bricks and from there to the chimney stack. Fires are fuelled by coal, gas or oil. When the desired temperature has been reached, the temperature is maintained for a specific period and the fires are then allowed to die. The kiln cools down, the fired bricks are removed and another batch of green bricks is placed in the kiln for firing. Firing in the T.V.A. kiln is continuous. Each day, green bricks are placed, in cleared chambers, in front of the fire and fired bricks are removed from behind it, with two or three adjacent wickets being kept open for this purpose. When a chamber is full, the wicket is bricked up and fuel (coal, oil or gas) is fed in between the bricks through holes in the crown or the roof of the kiln. The fire is made to move forward by "taking on" a row of fire holes at the front and dropping a row at the back, every 2 to 4 hours in an average sized kiln. In this way the fire moves right around the kiln every 10 to 14 days. The hot gases from the firing zone are drawn forward to preheat and dry out the green bricks, while the fired bricks are cooled down by the flow of air passing from the open wickets behind the firing zone. The tunnel kiln is also a continual kiln, but the fire is stationary while the bricks move past it on kiln cars. As in the T.V.A. kiln, the unfired bricks are preheated by the spent combustion gases. After the fire, the heat released by the cooling bricks may be drawn off for use in the associated driers. With this interchange of heat, the tunnel kiln uses less fuel than the intermittent type of down-draught kiln. It has several other advantages. For example, cars can be loaded and unloaded in the open factory, and always at the same loading points, so that handling problems are simplified; and the kiln car acts as a conveyor belt so the bricks are fired as they pass through the firing zone.

In clamp kilns, some fuel is placed into the body of each brick. The bricks are packed into a pyramid shaped formation. The clamp has a layer of coal, equivalent to two courses of bricks, packed at the bottom. This layer (scintle) is set alight, it ignites the fuel in the base layer of bricks and progressively, each brick in the pack catches alight. Clamp kiln firing can take up to three weeks and although the bricks might have finished burning in that time, it may take longer before they are cool enough to be sorted. Temperatures can be as high as 1 400°C in the centre of the clamp.

Delivery

Mechanical handling of bricks is a familiar sight in South Africa. In pack systems, sign ode strapped packs of +500 bricks are arranged in a suitable stack and bound together by bands or plastic wraps. The packs are lifted by forklift or crane truck. Handling on the site may be by hoist or brick barrows.

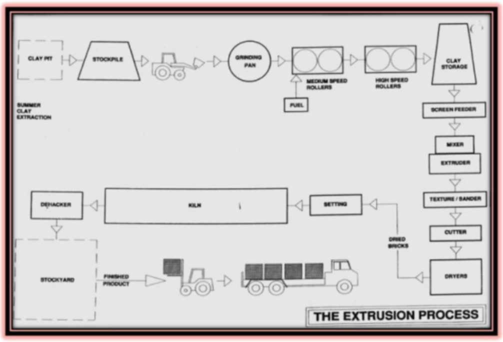

Figure 8: Manufacturing Process of Clay Brick
Source: IBSTOCK "Innovative in Clay"

PRODUCTION OF FLY ASH BRICKS

For production of good quality fly ash bricks, the quality of fly ash should be as under:

- It should be either dry or moist {containing moisture not more than 5 %}
- Visual appearance should be light steel grey or smoky grey in colour. The brownish or light yellowish gray colour fly ash is of inferior quality.
- The fly ash should be very fine and can pass through 200 mesh sieve.
- The un-burnt carbon in fly ash with negligible fraction is tolerable for use.

RAW MATERIALS

1. FLY ASH
2. LIME
3. SAND
4. KHEDA DUST
5. WATER

The process of manufacturing Stone waste fly ash bricks is based on the reaction of lime with a silica of fly ash to form calcium silicate hydrates (C-S-H) which binds the ingredients to form a brick. The quality of bricks obtained is highly dependent on the quality of fly ash. Stone waste Fly ash bricks have good compressive strength, low water absorption, high density and low shrinkage value as compared to burnt clay bricks as well as fly ash bricks.

1. **FLY ASH-** (Usage 60 -75 %)
2. **LIME-** (Usage 8 -10 %) Lime is a very important ingredient used for manufacturing of bricks; hence it should satisfy following minimum requirement. Lime, while slaking process should not attain less than 60^0 Celsius temperature and slaking time should not be more than 15 minutes.

- Availability of CaO should be minimum 60%
- MgO content should be maximum of 5%.

3. **SAND-** (Usage 15 %) Addition of sand is optional, but to enhance the gradation of the mix, addition of coarse sand is quite preferable. The addition of sand also enhances the resistivity of mix to the formation of laminar cracks caused due to entrapped air.
4. **KHEDA DUST-** Usages 15%
5. **WATER-** As per requirement for proper mixing

MANUFACTURING PROCESS OF FLY ASH BRICKS (MANUAL PLANT)

The manufacturing process of bricks broadly consists of three operations viz. mixing the ingredients, pressing the mix in the machine and curing the bricks for a stipulated period.

A mix of the ingredients is prepared by intimate mixing in the suitable blender / mixer. Manual mixing will not give the desired results and hence hand mixing should be avoided. This mix ultimately gives comprehensive strength of 80 - 110 kg/cm² fly ash bricks. The water, bricks mix ratio be maintained between 6 to 7 %. This percentage changes with different mix raw material ratio. For moulding the bricks many types of machineries of indigenous make are available.

They are:

- Manual press (with power)
- **Vibro press (with power)**
- Hydraulic press, with or without vibration.
- Tampering hand moulding machines

Selection of machinery depends on the bricks mix contents. For manufacturing fly ash lime stabilized bricks, the best suited machinery is virbo - press machine, which is an indigenous low cost machine and can be run by ordinary semiskilled worker. Its production capacity is 1000 bricks per shift and can be operated for two shifts without any operation/maintenance load. The maintenance cost is so low that it can be ignored. 15 lakh bricks can be produced for each machine in its life cycle.

CURING:

The stabilized bricks after moulding are further hardened by curing. The chemical changes occur in the bricks mix contents after moulding and heat of hydration are evolved. The rate of the effect of heat of hydration is mitigated and lowered with sufficient water in alkali solution is provided to accelerate the pozzolanic reaction. There are different processes of curing.

- Steam curing under high pressure {normally called autoclaved curing}
- Steam curing under normal pressure
- Hot water dip curing
- Hot water, air curing
- Water tank curing
- Water curing in the open air.

PROCESS:

Following is the actual brick manufacturing process followed by case study plant :-

1. Various raw materials of brick mix in desired proportion are blended intimately in dry or wet form. Water/brick-mix ratio is maintained as explained above.
2. The wet brick-mix is fed into the machine mould. The vibration is given for a while and the mould is again fed. The striper head is pressed and vibration is given simultaneously for about 8 seconds. The mould is lifted and bricks produced pallet is removed and kept on the platform for air drying.
3. Next day the bricks produced on the previous day are put in the stack. The stack is formed with care to see that curing water and air for drying reach to every brick.

4. After 3 days the hot water from the solar collector in small quantity is poured on the fresh stack without any pressure.
5. After 5 days the solar collector water is poured on the bricks stack for 2 times a day.
6. The bricks in stack after each watering are immediately covered with black PVC tarpaulin, with a clear space of 250 mm form the layers of the bricks, inside the closed cover.
7. The curing is continued for 15 days and the tarpaulin cover is removed. The bricks are then left in the stack for drying or heating the bricks stack.
8. The bricks are ready for dispatch after 22 days from the date of manufacture.
9. The comprehensive strength of the bricks produced from the brick-mix and the manufacturing process suggested here in will be 80 kg/cm² to100 kg/cm².

It is observed that the bricks produced are found to be superior than that of conventional Red burnt clay brick.

DIAGRAM OF FLY ASH BRICK MAKING PROCESS

Figure 9 .The manufacturing processes of Fly ash Bricks

MANUFACTURING PROCESS OF FLY ASH BRICKS (FULLY AUTOMATIC PLANT)

Figure 10 Fully Automatic Fly Ash Brick Making Machine

Source: hitechengineeringindia.com

There has been a great demand for fly ash bricks in the construction Industry due to the short supply of conventional Bricks. We have introduced the Fly ash Fully Automatic Brick Making Machine .This machine can produce superior quality of Fly ash Bricks – optimum production with less time, as per the standard size of Bricks: 230 x 110 x 75.

Figure 11. Fly ash Bricks Produce from the Fully Automatic Plant

Source: hitechengineeringindia.com

BENEFITS OF AUTOMATION

- Saves Time.
- Saves labour
- Fast Production.
- Eliminate Human Error.
- Gives Better Quality of Bricks

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