***Al – Esraa University College***

***Building & Construction Technology Engineering***

***Technology of Construction Materials Industry***

***Second year***

***2hrs (Theoretical)***

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***Technology of Construction Materials Industry***

**Objectives:**

**The student must know the industry & production operation for almost materials used in construction, materials employed in production, choosing site of factory planning, & productivity.**

References:

1. Building Construction Metric Volume / J.K. Mckay .
2. Materials of Construction / R.C. Smith .
3. Chemical Process Industries / R. Norris Shreve .
4. Construction Materials & Processes / Dor. A. Wacton .
5. Pipind Handbook / Crocker & King.
6. Metals Production / ASME Handbook.
7. Manufacturing Processes / B.H. Amstead.

**Week 2&3**

**Production & industry operations for several types of clay bricks**

**(BRICK MANUFACTURING PROCESS)**

**Week 2&3**

**BRICK MANUFACTURING PROCESS**

The fundamentals of brick manufacturing have not changed over time.

Factors Contribute Brick Industry:

1- A more complete knowledge of raw materials and their properties,

2-Better control of firing,

3- Improved kiln designs and

4- More advanced mechanization.

**For brick manufacturing, clay must possess some specific properties and characteristics.**

1- Clays must have plasticity, which permits them to be shaped or molded when mixed with water;

2- They must have sufficient wet and air-dried strength to maintain their shape after forming.

3- Also, when subjected to appropriate temperatures, the clay particles must fuse together.

**Types of Clay:**

Clays occur in three principal forms, all of which have similar chemical compositions but different physical characteristics.

1- Surface Clays. Surface clays may be the upthrusts of older deposits or of more recent sedimentary formations. As the name implies, they are found near the surface of the earth.

2- Shales. Shales are clays that have been subjected to high pressures until they have nearly hardened into slate.

3- Fire Clays. Fire clays are usually mined at deeper levels than other clays and have refractory qualities. Surface and fire clays have a different physical structure from shales but are similar in chemical composition.

Al three types of clay ***are composed of silica and alumina with varying amounts of metallic oxides***.

OBJECTIVE : Metallic oxides act as fluxes promoting fusion of the particles at lower temperatures.

COMPOSITION: Metallic oxides (particularly those of iron, magnesium and calcium) influence the color of the fired brick.

The manufacturer minimizes variations in chemical composition and physical properties by mixing clays from different sources and different locations in the pit. Chemical composition varies within the pit, and the differences are compensated for by varying manufacturing processes. As a result, brick from the same manufacturer will have slightly different properties in subsequent production runs. Further, brick from different manufacturers that have the same appearance may differ in other properties.

MANUFACTURING: Brick are produced by:

1- Mixing ground clay with water,

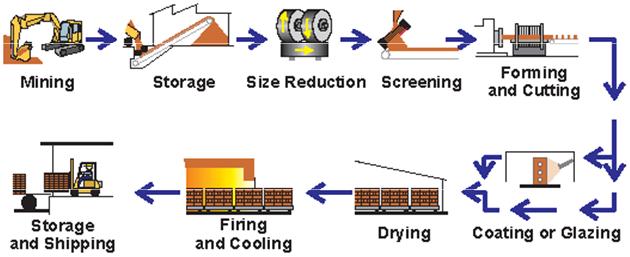
2- Forming the clay into the desired shape,

3- Drying and firing. In ancient times,

All molding was performed by hand. However, since the invention of brick-making machines during the latter part of the 19th century, the majority of brick produced in the United States have been machine made.

**Phases of Manufacturing:**

The manufacturing process has six general phases: 1) mining and storage of raw materials, 2) preparing raw materials, 3) forming the brick, 4) drying, 5) firing and cooling and 6) de-hacking and storing finished products (see Figure 1).



**Fig (1): Brick manufacturing Process**

**Mining and Storage**: Surface clays, shales and some fire clays are mined in open pits with power equipment. Then the clay or shale mixtures are transported to plant storage areas .Continuous brick production regardless of weather conditions is ensured by storing sufficient quantities of raw materials required for many days of plant operation. Normally, several storage areas (one for each source) are used to facilitate blending of the clays. Blending produces more uniform raw materials, helps control color and allows raw material control for manufacturing a certain brick body Preparation. To break up large clay lumps and stones, the material is processed through size-reduction machines before mixing the raw material. Usually the material is processed through inclined vibrating screens to control particle size.

**Forming:** Tempering, the first step in the forming process, produces a homogeneous, plastic clay mass. Usually, this is achieved by adding water to the clay in a pug mill (see Photo 2), a mixing chamber with one or more revolving shafts with blade extensions. After pugging, the plastic clay mass is ready for forming.

There are three principal processes for forming brick:

1- stiff-mud, 2- soft-mud and 3- dry-press.

Stiff-Mud Process - In the stiff-mud or extrusion process (see Photo 3), water in the range of 10 to 15 percent is mixed into the clay to produce plasticity. After pugging, the tempered clay goes through a deairing chamber that maintains a vacuum of 15 to 29 in. (375 to 725 mm) of mercury. De-airing removes air holes and bubbles, giving the clay increased workability and plasticity, resulting in greater strength.

Next, the clay is extruded through a die to produce a column of clay.

As the clay column leaves the die, textures or surface coatings may be applied (see PROPERTIES, Textures, Coatings and Glazes). An automatic cutter then slices through the clay column to create the individual brick. Cutter spacings and die sizes must be carefully calculated to compensate for normal shrinkage that occurs during drying and firing.

Soft-Mud Process - The soft-mud or molded process is particularly suitable for clays containing too much water to be extruded by the stiff-mud process. Clays are mixed to contain 20 to 30 percent water and then formed into brick in molds**. To prevent clay from sticking, the molds are lubricated with either sand or water to produce “sand-struck” or “water-struck” brick**. Brick may be produced in this manner by machine or by hand.

Dry-Press Process - This process is particularly suited to clays of very low plasticity. Clay is mixed with a minimal amount of water (up to 10 percent), then pressed into steel molds under pressures from 500 to 1500 psi (3.4 to 10.3 MPa) by hydraulic or compressed air rams.

**Drying**: **Wet brick from molding or cutting machines contain 7 to 30 percent moisture, depending upon the forming method**.

Before the firing process begins, most of this **water is evaporated in dryer chambers at temperatures ranging from about 100 ºF to 400 ºF (38 ºC to 204 ºC).** The extent of drying time, which varies with different clays, usually is **between 24 to 48 hours**. Although heat may be generated specifically for dryer chambers, it usually is supplied **from the exhaust heat of kilns to maximize thermal efficiency**. In all cases, **heat and humidity must be carefully regulated to avoid cracking in the brick**.

**Hacking**: Hacking is the process of loading a kiln car or kiln with brick. The number of brick on the kiln car is determined by kiln size. The brick are typically placed by robots or mechanical means. The setting pattern h

some influence on appearance. Brick placed face-to face will have a more uniform color than brick that are cross-set or placed face-to-back.

**Firing:** Brick are fired between 10 and 40 hours, depending upon kiln type and other variables. There are several types of kilns used by manufacturers. The most common type is a tunnel kiln, followed by periodic kilns. Fuel may be natural gas, coal, sawdust, methane gas from landfills or a combination of these fuels. In a tunnel kiln (see Photo 4), brick are loaded onto kiln cars, which pass through various temperature zones as they travel through the tunnel. **The heat conditions in each zone are carefully controlled, and the kiln is continuously operated.** A periodic kiln is one that is loaded, fired, allowed to cool and unloaded, after which the same steps are repeated. Dried brick are set in periodic kilns according to a prescribed pattern that permits circulation of hot kiln gases. Firing may be divided into five general stages: 1) final drying (evaporating free water); 2) dehydration; 3) oxidation; 4). Vitrification; and 5) flashing or reduction firing. All except flashing are associated with rising temperatures in the kiln. Although the actual temperatures will differ with clay or shale, final drying takes place at temperatures up to about 400 ºF (204 ºC), dehydration from about 300 ºF to 1800 ºF (149 ºC to 982 ºC), oxidation from 1000 ºF to 1800 ºF (538 ºC to 982 ºC) and vitrification from 1600 ºF to 2400 ºF (871 ºC to 1316 ºC). Clay, unlike metal, softens slowly and melts or vitrifies gradually when subjected to rising temperatures. **Vitrification allows clay to become a hard, solid mass with relatively low absorption.**

**Melting takes place in three stages:** 1) incipient fusion, when the clay particles become sufficiently soft to stick together in a mass when cooled; 2) vitrification, when extensive fluxing occurs and the mass becomes tight, solid and nonabsorbent; and 3) viscous fusion, when the clay mass breaks down and becomes molten, leading to a deformed shape. ***The key to the firing process is to control the temperature in the kiln so that incipient fusion and partial vitrification occur but viscous fusion is avoided.***

The rate of temperature change must be carefully controlled and is dependent on the raw materials, as well as the size and coring of the brick being produced.

Kilns are normally equipped with temperature sensors to control firing temperatures in the various stages. Near the end, the brick may be “flashed” to produce color variations (see PROPERTIES, Color). Cooling. After the temperature has peaked and is maintained for a prescribed time, the cooling process begins. **Cooling time rarely exceeds 10 hours for tunnel kilns and from 5 to 24 hours in periodic kilns.** *Cooling is an important stage in brick manufacturing because the rate of cooling has a direct effect on color.*

**De-hacking.** De-hacking is the process of unloading a kiln or kiln car after the brick have cooled, a job often performed by robots (see Photo 5). Brick are sorted, graded and packaged. Then they are placed in a storage yard or loaded onto rail cars or trucks for delivery. The majority of brick today are packaged in self-contained, strapped cubes, which can be broken down into individual strapped packages for ease of handling on the jobsite. The packages and cubes are configured to provide openings for handling by forklifts.

**BRICK PROPERTIES**: *All properties of brick are affected by raw material composition and the manufacturing process.* Most manufacturers blend different clays to achieve the desired properties of the raw materials and of the fired brick. This improves the overall quality of the finished product.

*The quality control during the manufacturing process permits the manufacturer to limit variations due to processing and to produce a more uniform product.* ***The most important properties of brick are 1) durability, 2) color, 3) texture, 4) size variation, 5) compressive strength and 6) incipient fusion and partial vitrification during firing.***

**SUMMARY:**

This Technical Note on manufacturing brick is the first in a series covering the manufacturing, classification and selection of brick. It provides a synopsis of the manufacturing process and discusses the various properties that are a function of this process. More detailed descriptions of the ceramic properties of brick are not within the purview of the Brick Industry Association. This type of information is more readily available through the National Brick Research Center, ceramic engineers and educators. The information and suggestions contained in this Technical Note are based on the available data and the combined experience of engineering staff and members of the Brick Industry Association. The information contained herein must be used in conjunction with good technical judgment and a basic understanding of the properties of brick masonry. Final decisions on the use of the information contained in this Technical Note are not within the purview of the Brick Industry Association and must rest with the project architect, engineer and owner.

**REFERENCES:**

1. American Institute of Architects, Environmental Resource Guide, The American Institute of Architects, Canada, 1998.

2. Campbell, J. W. P. and Pryce, W., Brick, A World History, Thames and Hudson, New York, NY, 2003.