Ceramic Industries

Part 2:
Ceramic Products

Reference:

Shreve's book, Chapter 9 (pp. 155 – 169)

Ceramics

A wide ranging group of materials whose main ingredients are clays, sand, and feldspar

Types of Ceramics

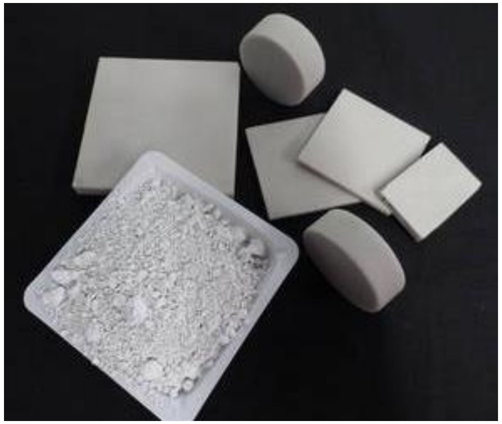
- White wares
- Structural Clay Product
- Refractories
- Vitreous Enamels
- Glasses

White Wares

White Wares

- White ware is a generic term for ceramic products which are usually white and of fine texture.
- They are based on selected grades of clay bonded together with varying amounts of fluxes and heated to a moderately high temperature in a kiln (1200 to 1500 °C).



White Wares

- **Different amounts and kinds of fluxes are used, leading to variation in the degree of vitrification among white wares.**
- **White Ware Classes:**
  - **Earthenware (semivitreous dinnerware)**
  - **Chinaware**
  - **Porcelain**
  - **Sanitary ware**
  - **Stoneware**
  - **Whiteware Tiles**

White Wares Classes

- **Earthenware (semivitreous dinnerware)**
  - Porous and nontranslucent dinnerware with a soft glaze

- **Chinaware**
  - Vitrified translucent ware with a medium glaze
  - Resists abrasion to a degree
  - Used for nontechnical purposes

White Wares Classes

- **Porcelain**
  - Vitrified translucent ware with a hard glaze.
  - Resists abrasion to the maximum degree.
  - Includes chemical, insulating, and dental porcelain.

- **Sanitary ware**
  - Formerly made from clay and was porous
  - Vitreous composition is presently used

White Wares Classes

- Stoneware
  - One of the oldest ceramic wares
  - May be regarded as crude porcelain fabricated from raw material of a poorer grade
- Whiteware Tiles
  - Floor tiles
    - Resistant to abrasion and impervious to stain penetration
    - May be glazed or unglazed
  - Wall tiles
    - Have hard, permanent surface
    - Comes in variety of colors and textures

Manufacture of porcelain

- There are three lines of porcelain production:
  1) Wet-process porcelain

     Used for production of fine grained, highly glazed insulators for high-voltage service
  2) Dry-process porcelain

     Employed for rapid production of more open-texture low-voltage pieces
  3) Cast porcelain

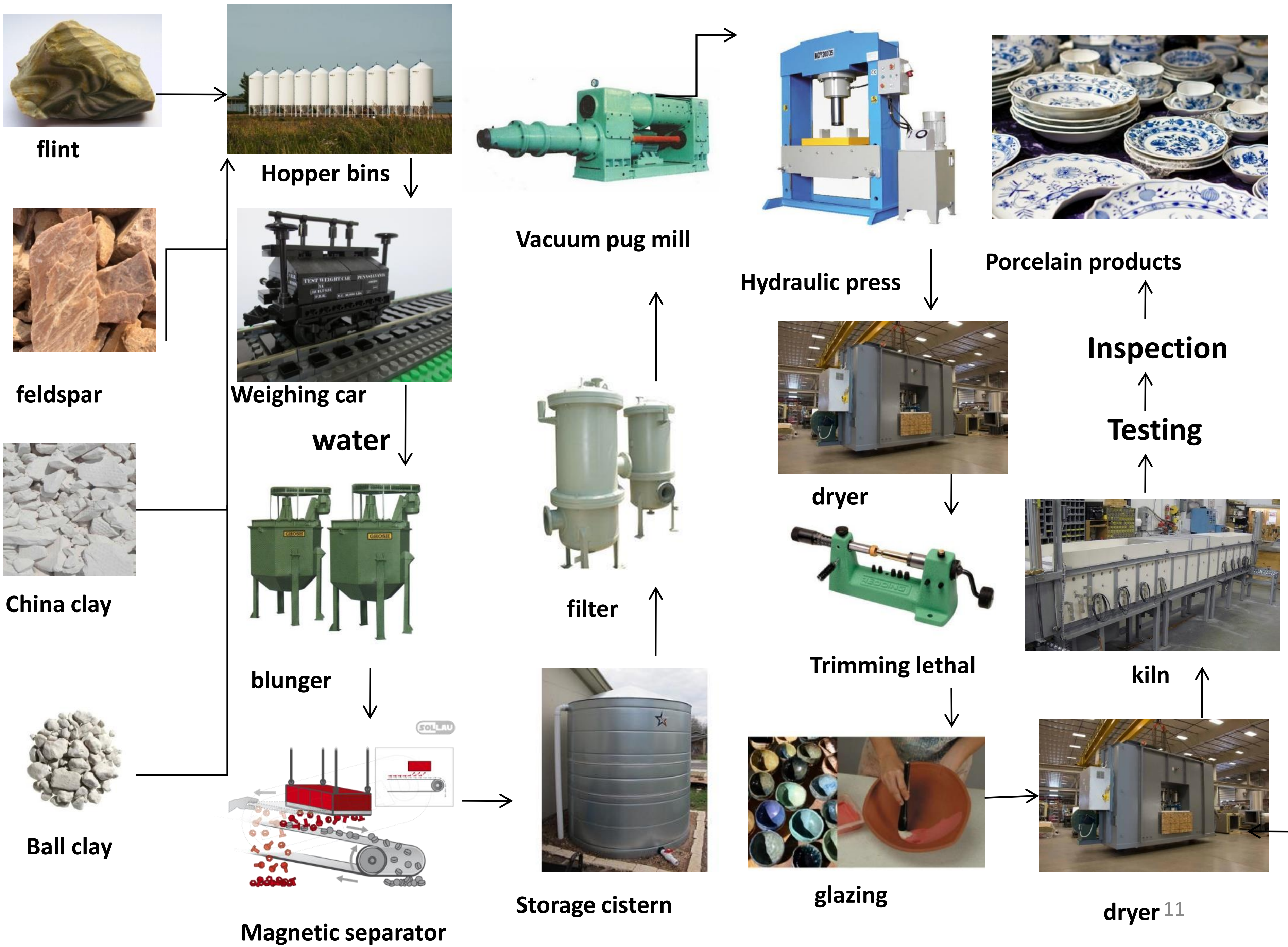
     Necessary for the making of pieces too large or too intricate for the other two methods

- The difference between these three processes is in the drying and forming (shaping) steps

White Wares

- **High Voltage Porcelain Insulator**

- **Low Voltage Porcelain Insulator**


flint
feldspar
China clay
Ball clay
Hopper bins
Weighing car
water
blunger
Magnetic separator
Storage cistern
filter
Vacuum pug mill
Hydraulic press
dryer
Trimming lethal
glazing
dryer
kiln
Testing
Inspection
Porcelain products

Porcelain Manufacture by Wet Process

1. Raw materials (feldspars, clays, and flint) of proper proportions and properties are weighted from **overhead hoppers** into the **weighing car**.
2. Feldspars, clays, and flint are mixed with water in the **blunger** and then passed over **magnetic separator**, screened and stored.
3. Most of the water is removed (and wasted) in the **filter press**. All the air is taken out in **vacuum pug mill** assisted by slicing knives. This results in denser, more uniform, and stronger porcelain.
4. The prepared clay is formed into blanks in a **hydraulic press**, or by **hot-pressing** in suitable molds.

Porcelain Manufacture by Wet Process

5. The blanks are preliminary dried, trimmed and finally completely dried under carefully controlled conditions.
6. A high surface luster is secured by **glazing** with selected materials.
7. The vitrification of the body and the glaze is carried out in **tunnel kilns,** with exact controls of *temperature* and *movement*.
8. The porcelain articles are protected by being placed in **saggers** fitted one on top of the others in cars. This represents a **one-fire process** wherein *body and glaze are fired simultaneously*. The porcelain pieces are tested electrically and inspected.

Other Manufacturing Methods

1. **Hand throwing on a potter's wheel**

2. **Slip casting in molds**

   Used to produce complex shapes such as art-ware and laboratory-ware

3. **Jiggering**

   Used for mass production of simple round objects, like cups, saucers, and plates.

Glazing

- A glaze is a thin coating of glass melted onto the surface of more-or-less porous ceramic ware.
- It contains ingredient of two distinct types in different proportions.
    1. Refractory materials

        such as feldspar, silica, and china clay.
    2. Fluxes

        such as soda, potash, fluorspar and borax.

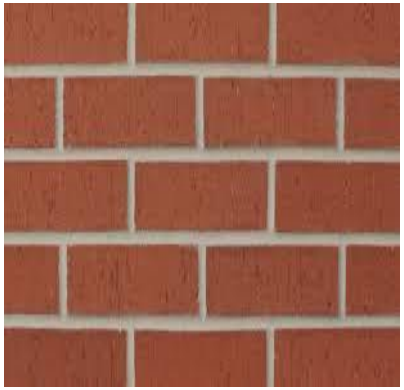
- Different combination of these materials and the different temperatures at which they are fired give a wide range of texture and quality.
    - Earthenware should be glazed at 1050 – 1100 °C
    - Stoneware should be glazed at 1250 – 1300 °C

Glazing

- To avid defects such as “crazing” and “shivering”:
  - The glaze must be bonded to the ware.
  - The glaze coefficient of expansion must be sufficiently close to that of the ware.

- The glaze may be put on by
  - dipping
  - spraying
  - pouring
  - brushing

Structural-Clay Products



Structural-Clay Products

- Low cost, but very durable products, such as:
  - Building Brick
  - Face Brick
  - Terra-cotta
  - Sewer Pipe
  - Drain Tile
- Structural-clay products are frequently manufactured from the cheapest common clays with or without glazing.
- The clay used generally carry sufficient impurities to provide the needed fluxes for binding.
- When the clay is glazed, as in sewer pipe or drain tile, this may be done by throwing salt (salt glaze) upon the kiln fire.
  - The volatilized salt reacts to form the fusible coating or glaze

Structural-Clay Products

- Face Bricks

- Sewer pipe

- Building Bricks

Structural-Clay Products

- Terra-Cotta

- Drain Tile

Manufacturing of Building Bricks

- Raw materials are clays from 3 groups:
  1. Red burning clay
  2. White burning clay
  3. Buff burning clay, usually a refractory.

- Requirements for face-brick clay:
  1. freedom from warping
  2. absence of soluble salts
  3. sufficient hardness when burned at moderate temperature
  4. general uniformity in color upon burning

Bricks Manufacturing Processes

- Requirements for brick are much less stringent than those of face-brick.
- Red burning clay is usually used.
- There are three bricks manufacturing processes:
    1. The Soft-mud process
    2. The Stiff-mud process
    3. The Dry-press process

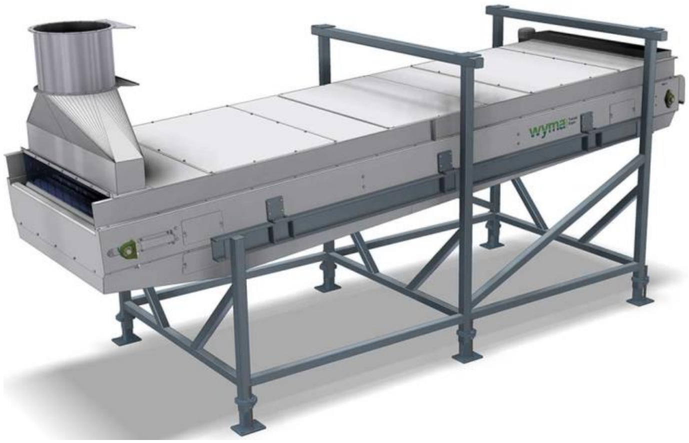
Stiff-Mud Process

- In this process, the clay is just wet enough (12% to 15%) to stick together when worked.
- The clay is forced out through an extruder.
- De-airing increases the workability, plasticity, and strength of undried brick by reducing voids.

- Bricks may be re-pressed to make face brick;
    - Re-pressing ensures a more uniform shape and overcomes the internal stresses set up by the extruder.

Bricks Drying and Firing

- Bricks are dried in various ways:
  1. Outdoors
  2. In sheds
  3. On tunnel dryers



- After drying, the bricks are fired in kilns at a temperature from 875 °C to somewhat above 1000 °C.

Stiff-Mud Process

- Stiff-mud process is employed for the manufacture of practically every clay product.
- The clay in some cases can be worked directly from a bank into the stiff-mud machine
  - More desirable product will result if the clay is ground and tempered before use.

Refractories

Definition

- Refractories are termed acid, basic, neutral, and super-refractories.
- Refractories are used to withstand the effect of thermal, chemical and physical effects met with in furnace procedures.
- Refractories are sold in the form of:
  - firebricks
  - silica, magnesite, chromite and magnesite-chromite brick
  - silicon carbide and zirconia refractories
  - aluminum silicate and alumina products.
- The fluxes required to bind together the particles of the refractories are kept at a minimum to reduce vitrification.

Properties of Refractories

- In making the refractory best suited for a definite operation it is necessary to consider:
  - the materials
  - the working temperature of the furnace where the refractory is needed
  - the rate of temperature change
  - the load applied during heats
  - the chemical reactions encountered
- Generally, **several types of refractories** are required for the construction of any one furnace, because usually **no single refractory can withstand all the different conditions** that prevail in the various parts of furnaces.

Chemical Properties

- Commercial refractories are divided into acid, basic and neutral groups
  - Silica bricks are decidedly acid
  - Magnesite bricks are strongly basic
  - Fire-clay bricks are generally placed in the neutral group
- It is usually inadvisable to employ an acid bricks in contact with an alkaline product or vice versa.
- Both of chemical reactions and physical properties should be considered as criterion of acceptable behavior.
  - Chemical action may be due to contact with slags, fuel ashes, and furnace gases, as well as with products such glass or steel.

Porosity

- Porosity is directly related to many other physical properties of brick, including resistance to chemical attack.
- The higher the porosity of brick, the more easily it is penetrated by molten fluxes and gases.
- For a given class of brick, those with the lowest porosity have the greatest strength, thermal conductivity, and heat capacity.

Fusion Points

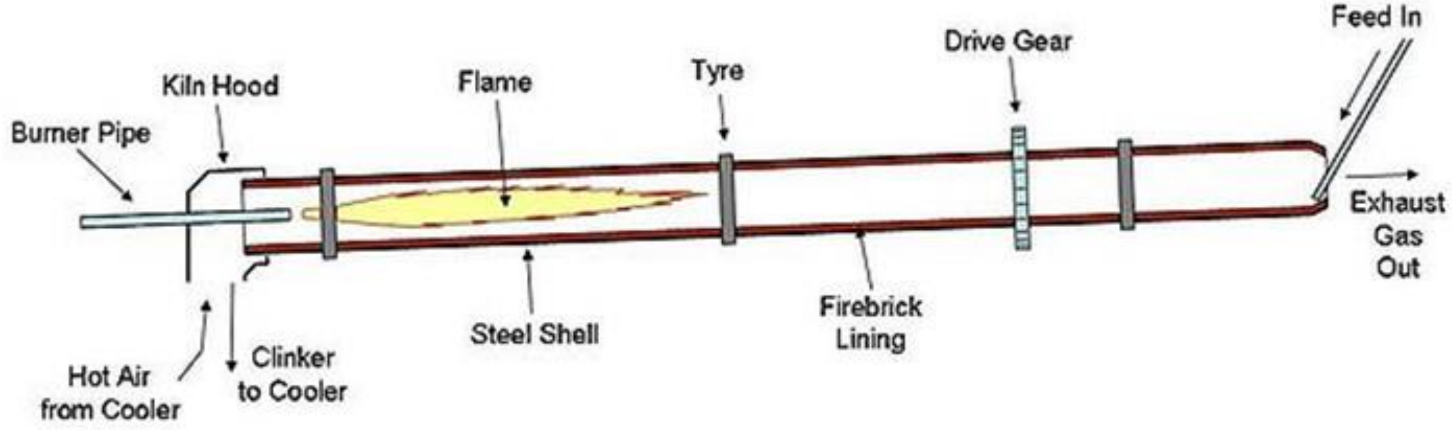
- Most commercial refractories soften gradually over a wide range and don't have sharp melting points because they are composed of several minerals (amorphous and crystalline)
- Fusion points are found by the use of pyrometric cones of predetermined softening points.

Spalling

- It is a fracture that happens to a refractory brick due to uneven heat stresses or compression caused by heat.
- Bricks usually expand when heated.
- Bricks that undergo the greatest expansion at the least uniform rate are the most susceptible to spalling when rapidly heated or cooled.

Strength

- Cold strength has only a slight bearing on strength at high temperatures.
- Resistance to abrasion or erosion is also important for furnace constructions such as:
    1. by-product coke-oven walls
    2. lining of discharge end of rotary cement kilns



Resistance to Temperature Changes

- Bricks with the lowest thermal expansion and coarsest texture are the most resistant to rapid thermal changes, and less strain develops.
- Bricks that have been used for a long time are often melted to glassy slags on the outside surface.

Thermal Conductivity

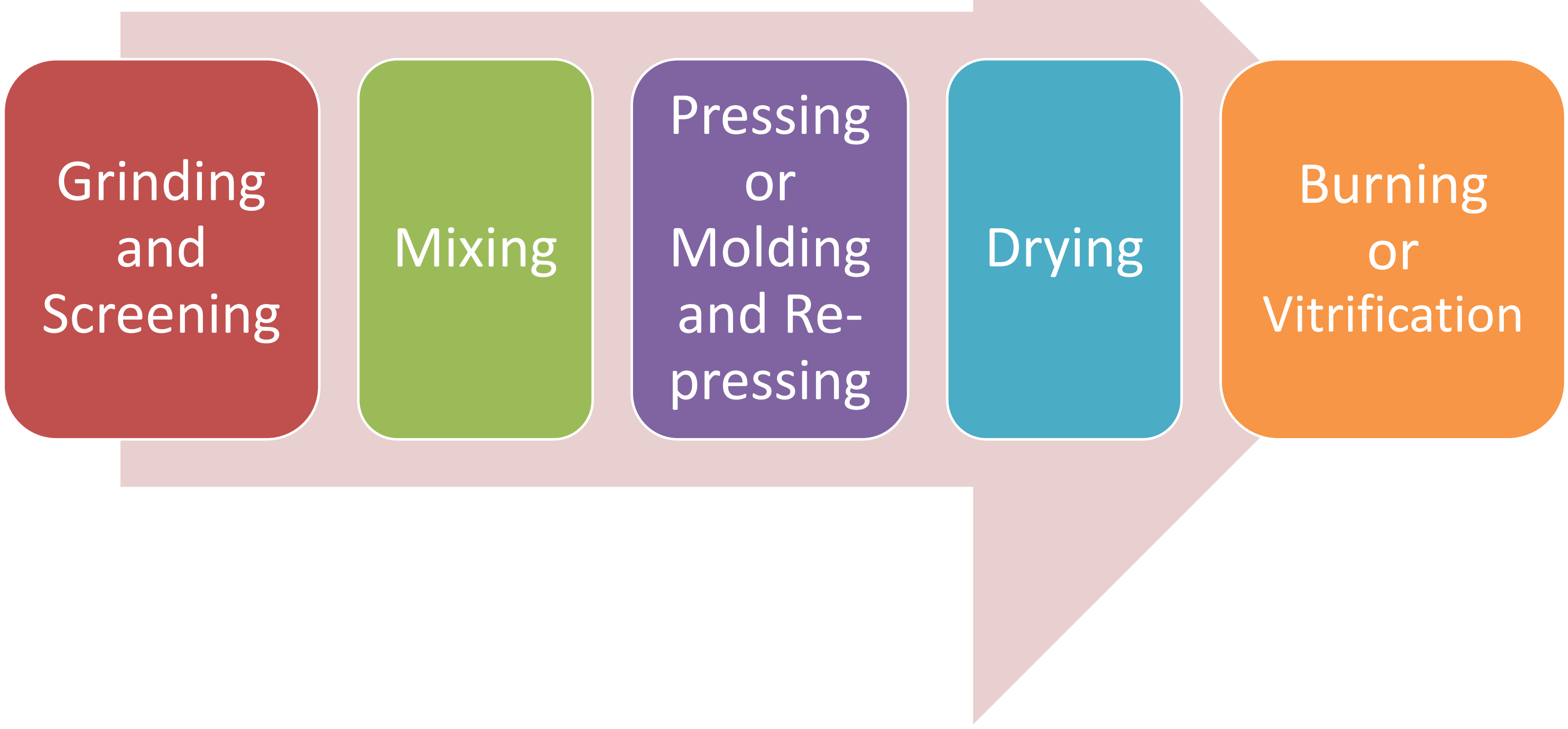
- The densest and least porous bricks have the highest thermal conductivity.
- High heat conductivity is not always desirable as some cases require resistance to firing and insulation.

Heat Capacity

- Furnace heat capacity depends upon:
  1. thermal conductivity of the refractory
  2. specific heat of the refractory
  3. specific gravity of the refractory
- Low quantity of heat absorbed by lightweight bricks works as an advantage when furnaces are operated intermittently, because the working temperature can be obtained in less time and fuel.
- Conversely, dense and heavy fire-clay brick is best for regenerator checkerwork, as in coke ovens, glass furnaces, and stoves for blast furnaces.

Manufacture of Refractories

Physical operation and chemical conversion used in the manufacture of refractories:



Manufacture of Refractories

- **High bulk density** is the most important single property because it affects many of the other important properties such as:
    1. Strength
    2. Volume stability
    3. Slag or Spalling resistance
- For insulating refectories, porous structure is required, which means low density.

Grinding

- One of the most important factors is the sizing of the particles in the batch.
- A mixture in which the proportion of coarse and fine particles is about 55:45, with only few intermediate particles, gives the densest mixture.
- Careful screening, separation and recycling are necessary for close control.

Mixing

- Purpose of mixing :
  1. Distribution of the plastic material so as to coat non-plastic material thoroughly.
  2. This coating provides a lubricant during the molding operation.
  3. Mixing permits bonding of the mass with a minimum number of voids.

Molding

- Dry-press method of molding is adopted to get bricks of greater density, strength, volume, and uniformity.
- Dry-press method is particularly suited primarily for batches consisting mainly of non-plastic plastic materials.
- In this process bricks are de-aired to avoid laminations and cracking when the pressure is released.

Drying

- Drying is used to remove the moisture added before molding to develop plasticity.
- The elimination of water leaves voids and causes high shrinkage and internal strains.

Burning

- Burning may be carried out in

Typical round down draft kilns	Continuous tunnel kilns

Burning

- Two important things takes place during burning:
  1. Development of permanent bond by partial vitrification of the mix.
  2. Development of stable mineral forms for future service.
- Changes that take place during burning are:

Removal of the water of hydration	Calcinations of carbonates	Oxidation of ferrous iron

- During these changes, the volume may shrink as much as 30%, and severe stains are set up in the refractory.
- Shrinkage may be eliminated by pre-stabilization of the material used.

Varieties of Refractories

- Fire-Clay Brick
- Silica Brick
- High-Alumina Refractories
- Basic Refractories
- Magnesia Refractories
- Insulating Brick
- Silicon Carbide
- Electrocast or Corhart Refractories
- Pure Oxide Refractories
- Refractories from Crystalline Alumina or Aluminum Silicate

Varieties of Refractories

- About 95% of refractories manufactured are non basic, with silica (acid) and fire-clay (neutral) brick predominant.
- Refractories rarely fail due to heat only, they usually fail by the chemical action at the operating temperature.
- Steel industries are the largest consumers of refractories for the linings of blast furnaces, stoves, open hearths and other furnaces.
- Other industries: glass furnaces, brass and copper furnaces, continuous ceramic and metallurgical kilns and boiler.

Fire-Clay Brick

- Most widely used of all available refractory materials for their versatility of application.
- They range in chemical composition from large excess of free silica to high alumina content.

Silica Brick

- Contains approximately 95 – 96% SiO_2 and about 2% lime is added during grinding to furnish the bond, and the rest could be iron oxide.
- It undergoes permanent expansion under firing which is caused by an allotropic transformation in the crystalline silica.
- When reheated, silica bricks expand about 1.5% but they return to size when cooled.
- Silica bricks are manufactured in many standard sizes by **power pressing**.

Silica Brick

- Silica bricks have very homogenous texture, free from air pockets and molding defects, and have low porosity.
- Physical strength of silica bricks when heated is much higher than that of clay bricks, therefore they are suitable for arches in large furnaces.
- They are utilized in by-product coke ovens and gas retorts because of their high thermal conductivity.

High-Alumina Refractories

- Can withstand severe conditions for which fire-clay and silica bricks are not suitable.
- Made from clays rich in bauxite and diaspore.
- Inert to carbon monoxide, and are not disintegrated by natural-gas atmosphere up to 1000 °C.
- Bricks with high % of alumina are classified as super-refractories.
- Bricks made of almost pure alumina (+97%) are considered "**special refractory**" termed as ***pure oxide***.
- High-alumina bricks are employed in the cement industry, paper-mill refractories, and in the lining of glass and oil fired furnaces.

Basic Refractories

- The important basic bricks are made from magnesia, chromite and forsterite.
- To achieve the required strength and other physical properties, basic bricks are power-pressed and either chemically bonded or hard-burned.
- The disadvantages of lack of bond and volume stability in unburned basic or other bricks have been overcome by three improvements in manufacturing :
  1. Interfitting of grains by using only selected particle sizes combined in the proper proportions to fill all voids.
  2. Forming pressure has been increased to 70 MPa, and de-airing equipment are used to reduce air voids between the grains.
  3. Use of a refractory chemical bond.

Magnesia Refractories

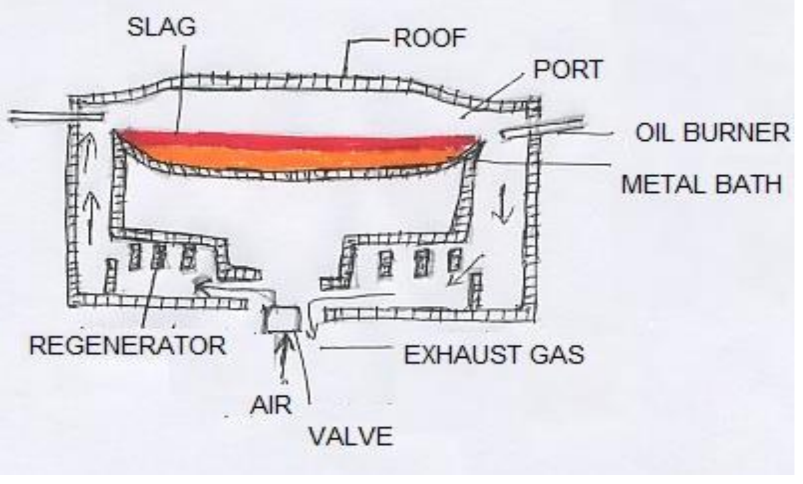
- Magnesia refractories are made from domestic magnesite, or magnesia extracted from brine.
- Magnesia bricks do not stand much load at elevated temperature
  - This difficulty has been overcome by blending with chrome ores
- Chemically bonded magnesite-chrome bricks are frequently supported with mild steel to:
  1. hold the brickwork
  2. minimize spalling loss

Magnesite-chrome bricks

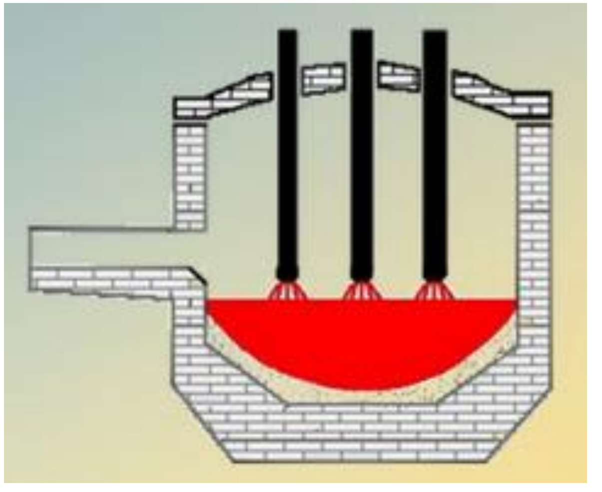
Magnesia Refractories

- Magnesia refractories are used in:

1- Open-hearth furnace walls

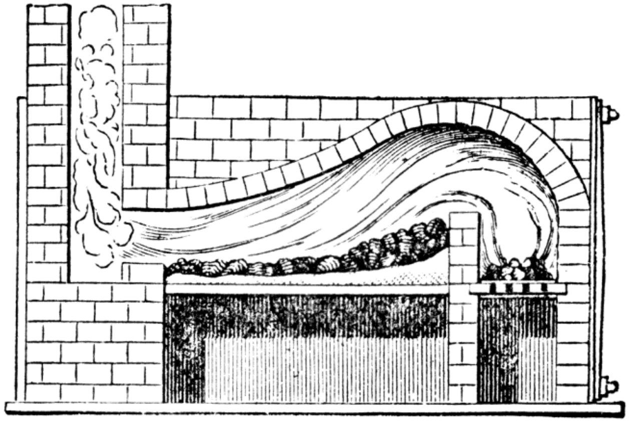


2- Electric furnace wall



Magnesia Refractories

3- In the roofs of non-ferrous reverberatory furnaces



Reverberatory furnaces

4- In the burning zone of cement kilns

Insulating Brick

- Is of two types:
  - For backing refractory bricks
    - Made from naturally porous diatomaceous earth
  - for use in place of regular refractory bricks (lightweight refractories)
    - Similar in composition to heavy bricks and owe there insulating value to the manufacturing method

Insulating Brick

- Manufacturing method of Lightweight refractories:
  - Waste cork is ground and sized, then it is mixed with fire clay, molded, and burned.
  - In the kiln the cork burns out, leaving a highly porous, light bricks.
- These lightweight refractories may be used safely for temperatures of 1350 to 1600 °C.
  - Diatomaceous-earth brick are not suitable above 1100 °C under ordinary conditions

Silicon Carbide (SiC)

- Superrefractories are noted for their chemical resistance and ability to sudden temperature changes.
- In their manufacturing:
  - Crude material from SiC furnace is ground
  - Less than 10% ceramic bond (clay or finely divided SiC itself) is added
- These bricks are extremely refractory, have high thermal conductivity, low expansion, and high resistance to abrasion and spalling.
- They are mechanically strong and withstand load in furnace to temperatures up to 1400 °C.

Silicon Carbide (SiC)

- These refractories are used in muffles because of their thermal conductivity.
- They are replacing carbon and aluminosilicate in iron-making blast furnaces because of their
  - stability under reducing conditions
  - good alkali resistance
  - excellent thermal transfer properties
- Other uses:
  - Rocket nozzles
  - Furnace and radiant heater tubes
  - Combustion chambers for ceramic-based gas turbine engines

Refractories from Crystalline Alumina and Alumina Silicates

- Mullite and corundum have high slag resistance and remain in the crystalline state at 1600 °C and higher
- Those refractories are used where severe slagging occurs.

Electrocast or Corhart Refractories

- Are made from electrically fused mullite
- They are manufactured by introducing a mixture of diaspore clays of high alumina content into the top of an electric furnace.
- Molten aluminum silicate at 1800 °C is tapped from the furnace at intervals and run into molds built from sand slabs.
- The molds containing these blocks are annealed from 6 to 10 days before the blocks are usable.

Electrocast or Corhart Refractories

- The refractory obtained from this process has a vitreous, non porous body.
- The blocks cannot be cut or shaped, but may be ground on Alundum wheel.
- Alundum: a variety of high-temperature products made from alumina and used furnaces, insulators.
- Electrocast refractory has only 0.5% voids, in contrast to the usual 17 – 29% of fire-clay blocks.

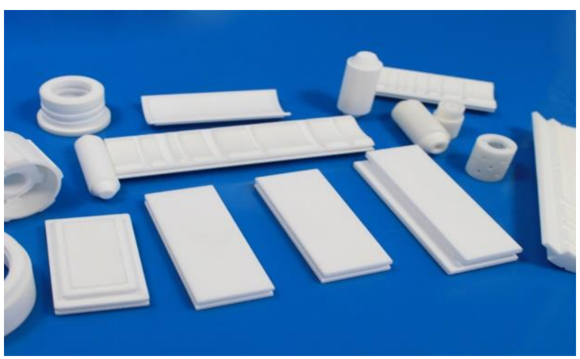
Electrocast or Corhart Refractories

- Cast refractories are employed in:
  - glass furnaces
  - modern boiler furnace
  - metallurgical equipment such as forging furnaces

- These refractories have the advantages of long life and minimum wear, but they have high initial cost.

Pure Oxide Refractories

- Their superior qualities are based mostly on freedom from fluxes.
- Alumina, magnesia, zirconia, beryllia and thoria: All have been developed commercially for light refractory products.
- Alumina, magnesia, zirconia have certain properties in common:
  - high purity and
  - principally composed of electrically fused grains.



beryllium

magnesia zirconia

Pure Oxide Refractories

- Beryllia is not used commercially for heavy wear because of
  - its high cost, and
  - volatilization above 1650 ° C in the presence of water vapor.
- Thoria has a number of disadvantages, particularly since its radioactivity places it under the control of the Atomic Energy Commission.

Pure Oxide Refractories

- *Sinter alumina* has the widest application among other pure oxide refractories; it is used successfully at temperatures up to about 1870°C.
- Magnesia is a basic refractory and is easily reduced at high temperatures. Its applications are limited to oxidizing atmospheres at temperatures not much over 2200°C.
- Processing temperatures in the range of 2550 to 2600° C are now commercial with available fused stabilized zirconia.
  - One large-scale use is as kiln furniture in the firing of barium titanate resistors, but future substantial usage seems probable.

Vitreous Enamel

Vitreous Enamel

- **Porcelain or vitreous enamel** is a ceramic mixture containing a large proportion of fluxes applied cold and fused to the metal at moderate red heat, where complete vitrification takes place.
- The enamel is used in the old ancients as a coat to gold, silver and copper.
- Enamel has come to commercial use because
  - it provides a product of great durability and wide application
  - it is easy to clean
  - it is corrosion resistance

Vitreous Enamel Uses

- Plumbing fixtures

- Cooking utensils

- Industrial equipment

- Glass-enameled steel for chemical use

Raw Materials

- Characteristics of raw materials:
  - High purity
  - Fineness
  - Suitable mineral composition
  - Proper grain shape
- May be divided into six different groups:

Refractories | Fluxes | Opacifiers | Color

Floating agents | Electrolytes

Refractories

- Include such materials as quartz, feldspar and clay.
- Contributes to the acidic part of the melt and give body to the glass.

Fluxes

- Include such products as borax, soda ash, cryolite, fluorspar
- Basic in character and react with the acidic refractories to form the glass.
- Tend to lower fusion temperature of enamels.

Opacifiers

- Compounds added to the glass to give it the white opaque appearance.
- **They are of two principal types:**
  - Insoluble (titanium dioxide, tin oxide, zirconium oxide)
    - Titanium dioxide gain general acceptance in the industry because of its:
      - High opacity
      - Good acid resistance
  - Devitrification (cryolite, fluorspar)
    - Also acts as fluxes, rendering the enamel more fusible.

Color

- May be oxides, elements, salts, or frits
- It may act either as refractories or as fluxes.

Floating agents

- They are chosen to suspend the enamel in water, such as: clay and gums

Electrolytes

- Added to peptize the clay and properly suspend the enamel.
- Examples: Borax, soda ash, magnesium sulfate, and magnesium carbonate .

Manufacture of the Frit

- Frit is a homogeneous composition of multiple raw materials, mostly of inorganic origin , and is produced by melting and quenching in water.
- The preparation of the enamel, or frit, is similar to the first stage of the manufacture of ordinary glass.
- To begin the process, the raw materials are mixed in the proper proportions, and charged to the melting furnace maintained near 1370 °C, from 1 to 3 hr.
- After the batch has been uniformly melted, it is allowed to pour from the furnace into a quenching tank of cold water, shattering the melt into millions of friable pieces, called frit.

Manufacture of the Frit

- Enamel is normally made in a wet process by grinding the ingredients, principally a mixture of frit and clay (as a suspension aid) in a ball mill, and then passing through a 200-mesh screen.
- A major step in process simplification has been the development of electrostatic powder spray application.
  - The powder is supplied ready to use, eliminating the need for in-plant milling.
  - This technology also saves the energy used to remove the water in the conventional wet processing.

Preparation of Metal Parts

- The success of enameling depends on the uniformity of the metal base to which the enamel is fused and on obtaining a parallelism between the coefficients of expansion of the enamel and the metal.
- In cast-iron enameling industry casting are frequently made in the same factory in which they are enameled.
- Sheet-metal enameler usually purchases sheets to meet a definite specification.
- Before the liquid enamel (suspension in water) is applied to the metal, the surface must be thoroughly cleaned of all foreign matter.
- Sheet metal is cleaned by pickling in dilute hydrochloric or sulfuric acid at 60c after the iron has been annealed.

Application of the Enamel

- Sheet-iron coats are generally applied by:
  1. Dipping or Slushing
  2. Draining
  3. Spraying
  4. Powder process

  - Slushing differs from draining in that the enamel slip is thicker and must be shaken from the ware.
- After coating, the enamel is air dried and colors are brushed and stenciled on.
- The enamel is usually applied in two coats for premium ware.

Application of the Enamel

- In the powder process the steel is coated by electrostatic spraying.
- This process is evolving to a two-coat, one-fire system, consisting of a thin powder base coat and a powder cover coat.
- Both coats are cured at once in a single fire.
- This produces a quality product at much lower cost than the conventional process.

Firing

- All enamels must be fired on the ware to melt them into a smooth, continues, glass layer.
- The requirements for successful firing of a good enamel are:
    1. Proper firing temperature (730 to 800 °C)
    2. Time (1 to 15 minute)
    3. Proper support of the ware
    4. Uniform heating and cooling of the ware
    5. An atmosphere free of dust

Kilns

- The vitrification of ceramic products and the prior chemical conversions dehydration, oxidation, and calcination are carried out in kilns.
- There are two operations of kilns:
  - Continuous kilns
  - Periodic kilns
- All the newer installations are continuous-tunnel kilns.

Continuous Kilns

- **Advantages (over Batch Kilns)**
  - Lower labor cost
  - Greater fuel efficiency
  - Shorter processing-time cycle
  - Better operating control
- Coal, gas, and oil are the most economical fuels, hence are more commonly used for firing

Continuous Kilns

- The most important kilns are the **continuous car *tunnel kilns*** used for firing of brick, tile, porcelain, tableware, and refractories.
- There are two general types of such kilns:

Direct-fired tunnel kiln

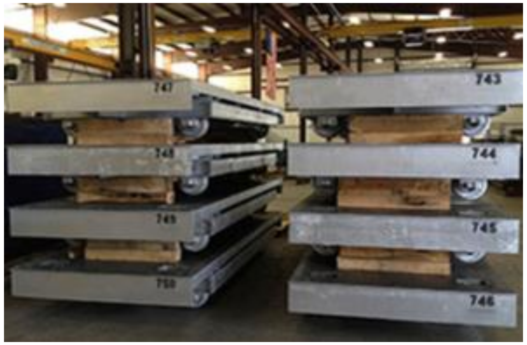
- combustion gases burn directly among the wares.

Indirect (muffle) tunnel kiln

- the products of combustion are not allowed to contact the wares.

Continuous Kilns

- The wares are loaded directly onto open cars or enclosed in saggers which keep them clean.
- The cars pass through the tunnel counterflow to the combustion gases from the high fire zone.
- The wares may be loaded on rolls in a **roller hearth kiln** instead of into cars that move through the kiln.

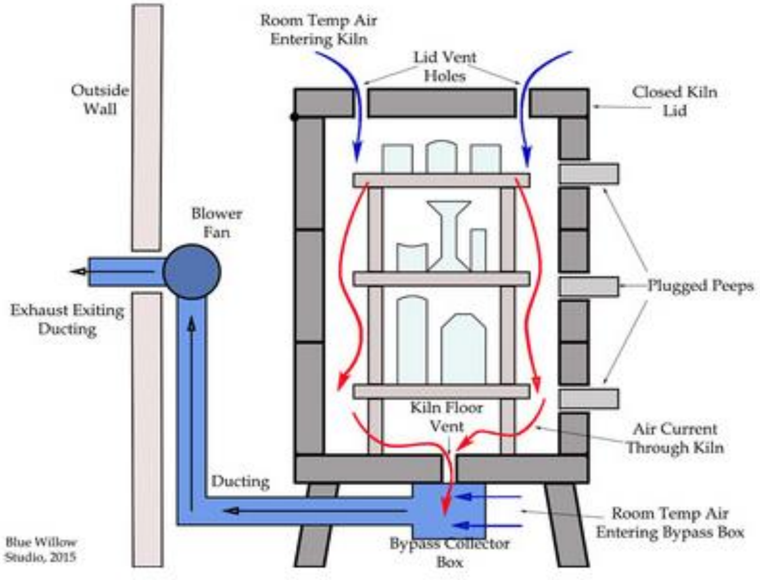


Continuous Kilns

- The continuous *chamber kiln* consists of a series of connected chambers; the heat from one chamber is passed to another countercurrent to the wares.
- The reason that this operation called **continuous kilns** is that the chambers are burned in succession.
- There is always one chamber cooling, another being fired, and another being heated by the waste heat of the two other chambers.
- This type of kiln is used to burn brick and tile.

Periodic Kilns

- Periodic kilns is less fuel efficient than continues kilns, but are more versatile.
- The most common types of periodic kilns :
  - Downdraft kilns
  - Updraft kilns



Downdraft Kilns

Downdraft Kilns

- It may be round or rectangular in shape.
- The heat is raised from room temperature at defined rate to reach the finishing temperature (1,650 °C).
- It is used in burning:
  - face brick
  - sewer pipes
  - stoneware
  - tile
- It is named so because the combustion products go down in passing over the wares set in the kiln.

Updraft Kilns

- It has been most commonly used In burning pottery ware, but replaced by tunnel kilns.
- Although an updraft kiln tends to be less fuel efficient than a downdraft kilns, most commercially built fuel-burning kilns are updrafts. This is mainly due to their simplicity to build, and ship.
- Common bricks are burned in scove kilns, which are really variation of the updraft kiln.
- The kiln itself is built from green brick, and the outside walls are daubed or “scoved” with clay in order to save heat.