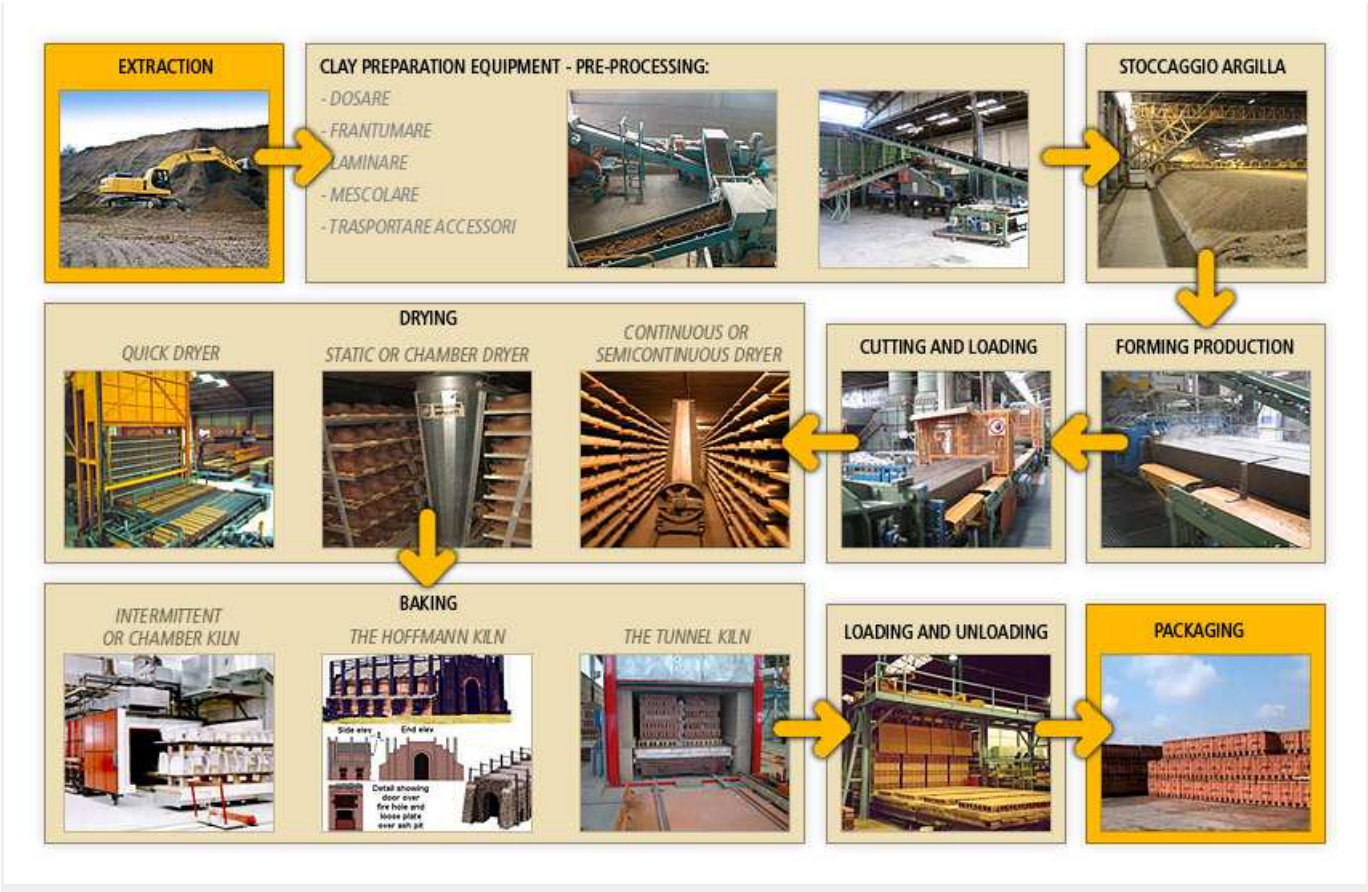



The production of bricks is based on a number of operations which, although highly industrialised and automated, have - as a principle - remained identical for millennia.

## EXTRACTION

Choosing the quarry is a crucial operation for the quality of the final product. The quality and potential of the deposit, possible impurities contained, minimum and maximum moisture of the material are all features that determine the ways of exploitation of the quarry itself, the most suitable machines for the excavation and transport, the technological line of the installation.

The systematic analyses on the nature of raw materials (chemical, mineralogical, granulometric, plasticity tests, attitude to drying and efflorescence tests, etc.) are always useful and sometimes necessary to prior establishing possible mixes or chemical correctives to be used.

## EXTRACTION MEANS

The clay is excavated using mechanical excavators and traditional earth-moving machines (quarry trucks).
The clay is extracted from one or more quarries and stored close to the plant using trucks and bulldozers. Generally, the amount of raw material is large enough to guarantee the quantity necessary for a one year production.
The material is picked from the heap with a power shovel that directly feeds the first machine of the cycle.

Quarry

**CLAY PREPARATION**

The clay coming from the quarry is often an uneven and not at all homogeneous natural product. This raw material must be transformed into a mixture as uniform as possible so as to guarantee, with a cost saving processing, a finished material having high technical value.
The various processing stages, which can be summarized in feeding-mixing-crushing-refining-wetting-homogenization, do not have a functional or chronological sequence: their sequence can be varied according to the different requirements.

## CLAY PREPARATION EQUIPMENT - PRE-PROCESSING

The preparation of clay, also called pre-processing involves processes that will transform the clay from the condition it is in at the time it is extracted to the final condition, optimal for the next stage of processing/moulding of the product. The aims of this phase are the following;

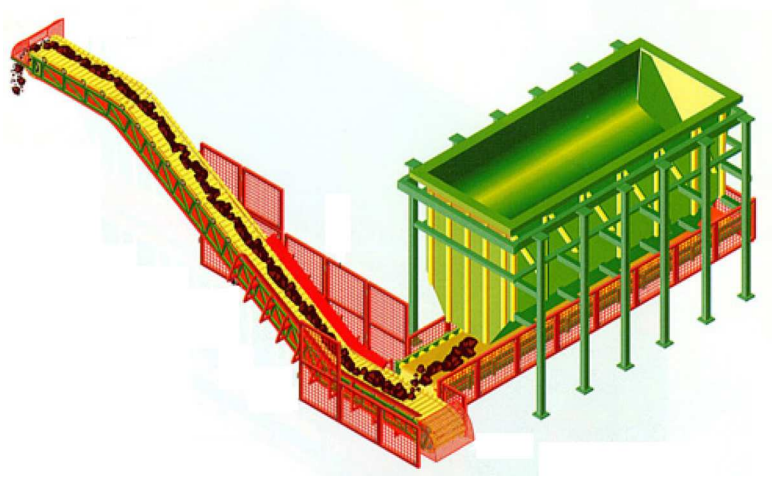
-UNIFORMITY AND CONSISTENCY IN THE COMPOSITION OF RAW MATERIALS
-UNIFORMITY OF SIZE, REDUCED TO FINE PARTICLES
-UNIFORMITY IN THE MOISTURE AND STORAGE OF SUFFICIENT QUANTITY TO ENSURE THE PLANNED PRODUCTION

The clay can be prepared with two different techniques:

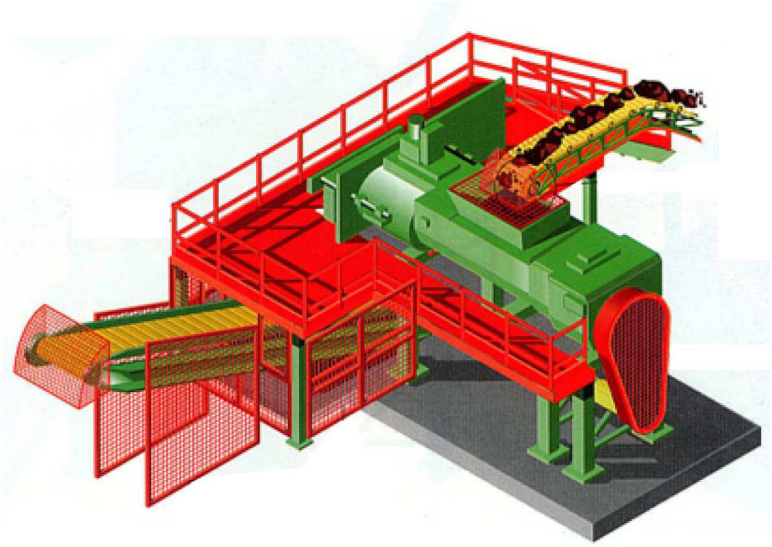
**moist preparation**
**dry preparation**

### MOIST PREPARATION

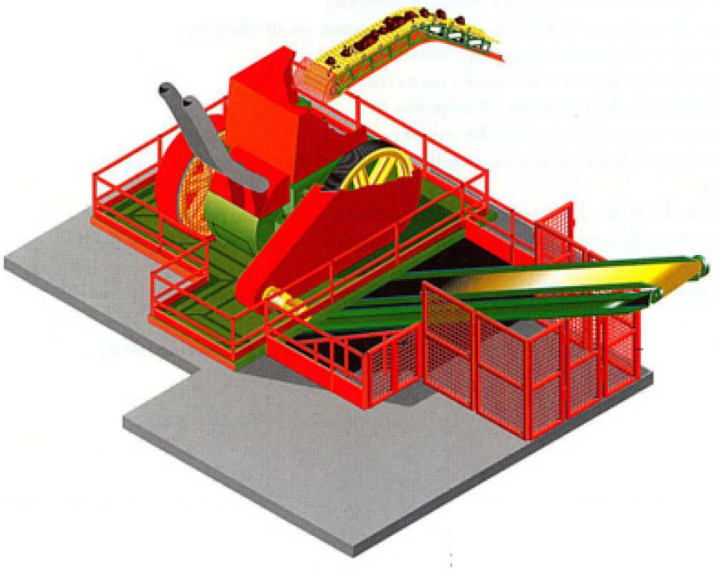
This technology is used where the clay coming from the quarry is wet, mostly in the areas where the climate is mild, with cold and rainy winters months and hot summers.
In this first phase, the clay comprising mainly of large clods is directed into **box feeders** which determine their quantity; after that is conveyed into the **crusher**: a machine where the clods are made smaller.
Then follows the **rough rolling mill**, consisting of two contra-rotating cylinders placed one in front of the other a few millimetres away one from the other, where the clay is further crushed in thin layers.
Lastly the clay goes through a **mixer** to then be stored in a large **silo**. The silo serves as a deposit for the clay material within the plant; it is useful to uniform the moisture and allows to be self sufficient within the working timing, between the two stages of clay preparation and production.
A masonry silo is essential in those areas where winter temperatures are so low that do not allow the clay to be extracted due to the hibernation of the raw material. The clay is directed to machines placed in sequence through suitably sized **conveyor belts** equipped with **deironing** and **levelling devices.**
In temperate climate zones, the silo may be replaced by a box feeder, named storage box, the capacity load of which is further dimensioned by a **robust hopper.**



Belt box feeder



Mixer with support structure and railing



Rolling mill with support structure and railing

**DRY PREPARATION**

This technology is used in hot countries, where the clay coming from the quarries is dry, with a moisture content not exceeding 10-20%.
The dry grinding line foresees for the raw material, coming from the quarry, from which it is extracted with dump trucks or loaders, to be loaded on a **box feeder** that feeds a **crusher** capable of feeding one or more **mills**, placed in sequence and able to gradually reduce the size to increasingly small dimensions. The selection of the clay based on the dimensions of the cold, can be made by means of a **vibrating mesh** that will divide the clay based on its size, forwarding it to the next processing stage.

1. Drying of raw materials with a moisture over 20%
2. Feeding and determination of the mix components through a weighing system
3. Primary pre-refining milling
4. Milling for the refining /drying/particle size selection stages
5.Control meshing and iron removal
6. Homogenization, moistening/granulation with moisture control
7. Storage and press feeding with rotating mesh homogeniser

8. Supervision and "clever" electricity management of the installation

**PRODUCTION - MOLDING**

The "production" stage includes the moulding of the product through

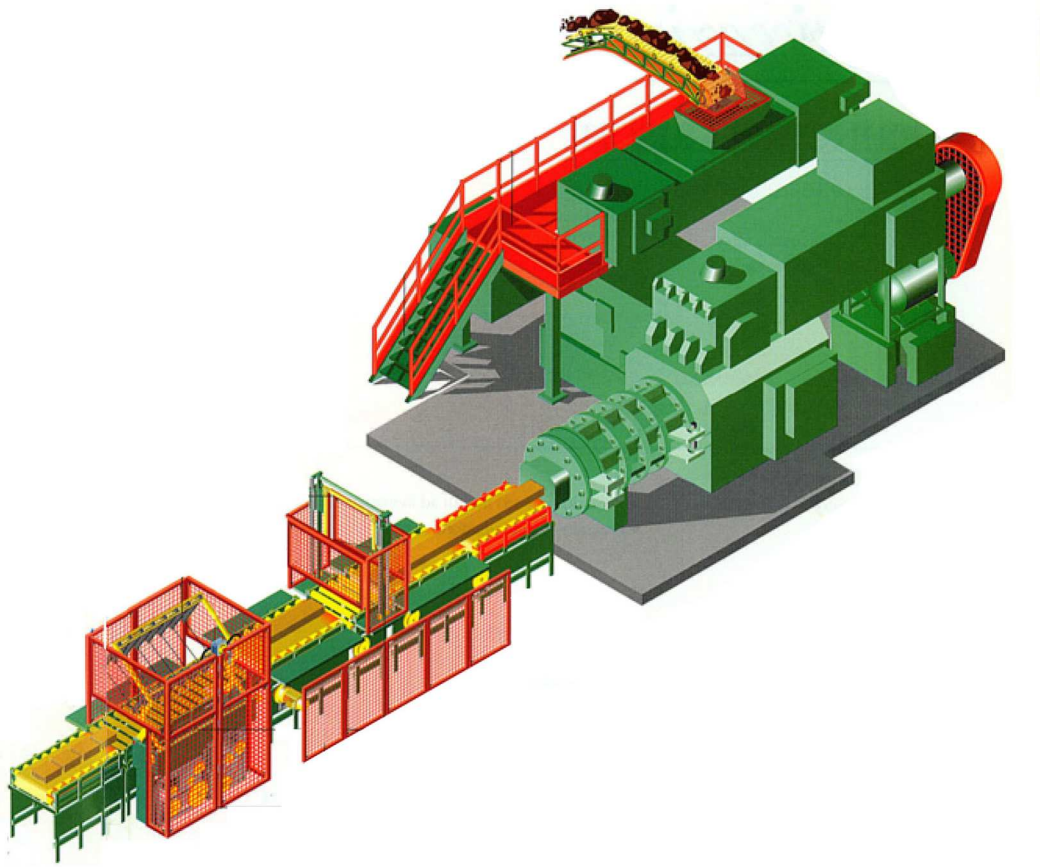
- extrusion,
- moist pressing,
- dry pressing,
- soft mix forming or moulding

and all the operations relating to the picking and loading of the produced material to be sent to the dryer.

Moist pressing is commonly used for the production of roof tiles and other accessory roof covering products.
Moulding may be "cold" or "hot" through the use of steam, with more or less hard mixes. After preparation of the mix, also common to other production processes, such as forming by extrusion, the mix obtained is subjected to pressing, through a **press**, which will give the shape of the brick based on the mould used, then cut into the required suitable size, grouped and automatically loaded on the support equipment to be sent to the next drying phase.

Dry pressing is suitable for niche products, less common in the brick building field. (Special face bricks or tiles)

Extrusion moulding by extrusion is the most commonly used process for the production of bricks for the construction of structures, hollow bricks, blocks, floors, supports, partitions, clay lines destined to the presses.
The extrusion is suitable for the processing of wet and plastic mixes that go through a die. The mixture is extruded under the shove of a rotating propeller placed in the extruder (the line and the cutting of the output mix are crucial to determine the type of brick).



Extruder and cutter

Soft mix forming is applied for face bricks or tiles. This technique allows to reproduce a brick that reminds of hand-made bricks.
The percentage of moisture in the mix, well above the other types of production, generates a brick having better aesthetic features, higher thermal insulation, greater resistance to the weathering agents. The mix shaped as a ball, is introduced in constantly washed and sanded moulds, and then turned over on special supports, intended to take the brick and feed it to the dryer.

**FORMING PRODUCTION PROCESS**

The mixture of pre-worked raw material is picked, using a **box feeder**, from the storage silos and is sent through the **conveyor belt** (equipped with a **removing iron device and clay levelling device**) into the **refining mill** that reduces it in even thinner layers.
Having done this the clay is mixed by means of a **mixer** with water or steam in order to make it acquire the plasticity characteristics necessary to end the processing cycle. The next phase consists in directing the raw material to an **extruder** having a "degassing chamber" obtained by means of a **vacuum pump**, where the pressure takes vacuum values being far less than the atmospheric pressure. These values are needed to eliminate the air molecules present in the mixture, of which the clay is enriched during the pre-processing.
The clay can be extruded when, through all the previous processing becomes compact. The extrusion consists in having the clay to go through a die placed at the end of a machine called "extruder". The clay forwards being pushed by the extruder augers and is drawn by a mould (called **die**), which negatively reproduces the pattern of the product to be obtained.
Coming out of the extruder, the still soft mixture is cut by means of the **cutter** and then deposited on the dryer shelves.

**DRYING**
The purpose of drying is to evaporate the moisture contained in the mix the brick is made with and definitively stabilising the geometric configuration of the products and giving them the necessary mechanical resistance in order to be stacked on cars and subsequently forwarded to the baking operations. A correct drying has a limited time, does not produce waste or deformation of the product.

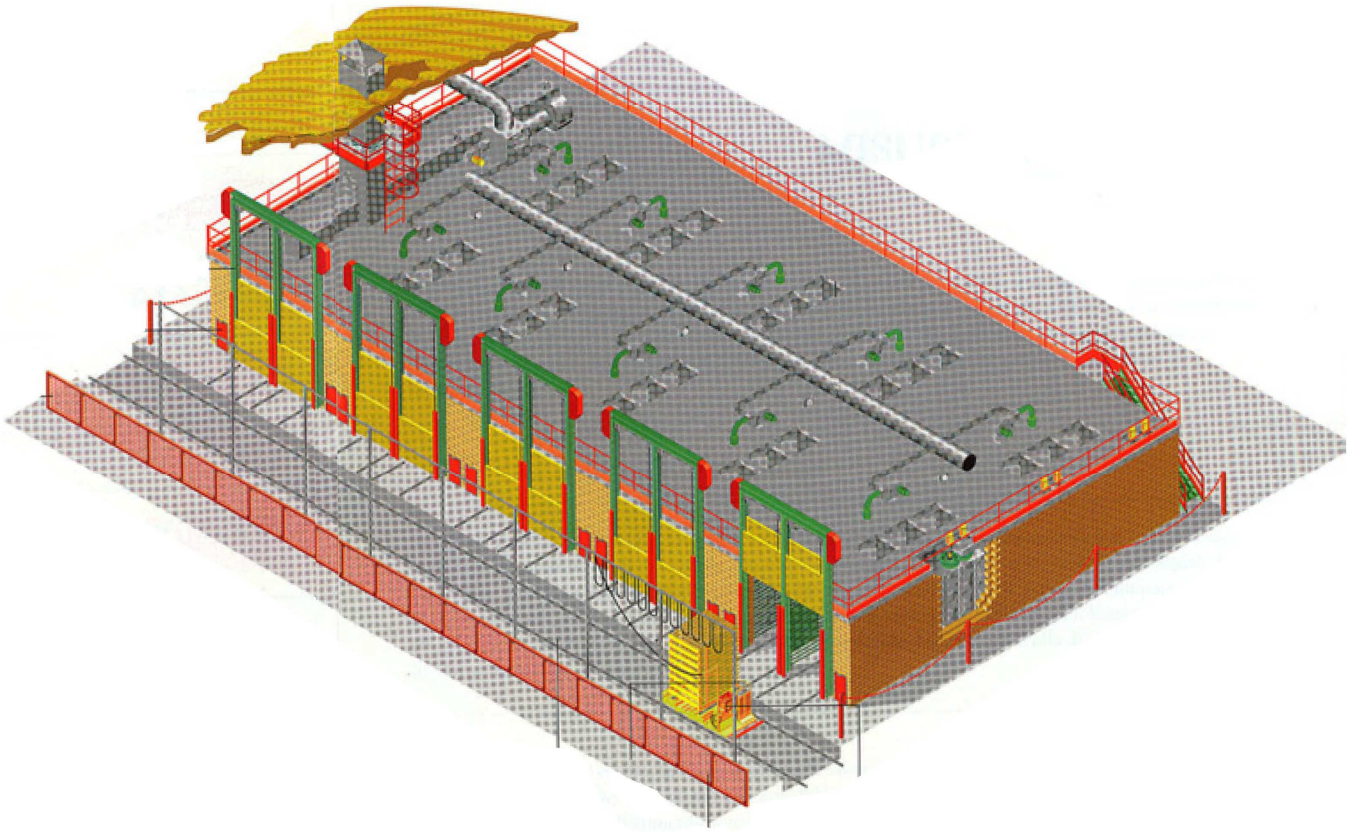
Depending on the production requirements dryers may be of different types, they can be:

continuous or semicontinuous dryer
static or chamber dryer
quick dryer

The **continuous dryer** is essentially made up a tunnel brickwork structure, containing one or more lines of cars loaded with green bricks (to be dried). The principle is based on the introduction of a car from one end (entry) of the tunnel and the exit of another car from the opposite side (exit).
In the case of continuous dryer, the material is constantly introduced over the 24 hours, while in the semi-continuous dryer the introduction of the material is limited to the working shifts, in the non working shift temperatures are set on a standby mode.
The thermohygrometric settings are regulated by a baking curve established in accordance with the chemical-physical characteristics of the brick to be dried, and by the production volumes.
Each zone of the tunnel is regulated with a constant temperature, the product going through the various areas gradually reaches the full evaporation of the moisture it contains.

The hot air produced in the thermal chamber through a make-up burner, is introduced in the dryer and shaken by means of forced ventilation, achieved through **fans or agitators.**

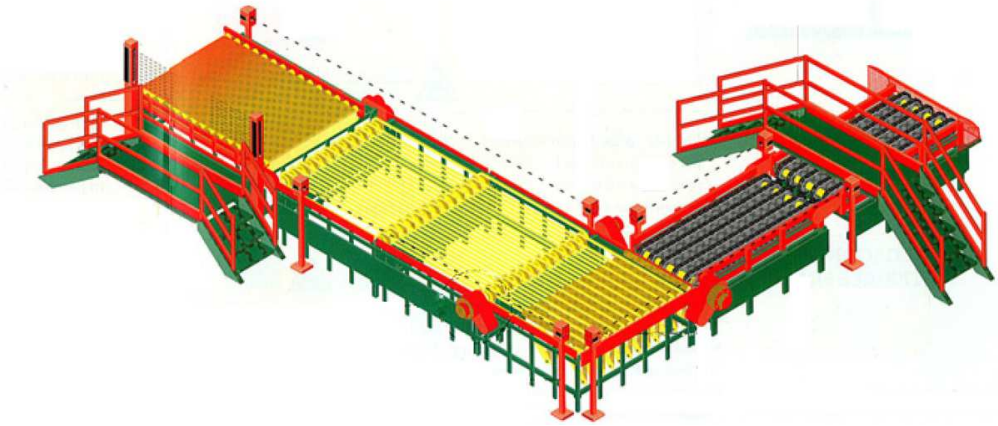
Heat release devices, adjusted through probes, shutters, suction systems, ventilation, heat units and expulsion of saturated air, managed by a management software, linked to detection tools, allow the monitoring of temperatures, which can be programmed with various recipes.
Part of the heat can be recovered from the kiln cooling zone, which suitably mixed with cold air, allows drying thus optimizing energy costs.
Recovery pipes should be suitably insulated, in order to avoid dispersion of heat.
Once the drying cycle is complete, the bricks can be unloaded manually or automatically by a robot driven unloading system from the dryer and loading into the kiln.



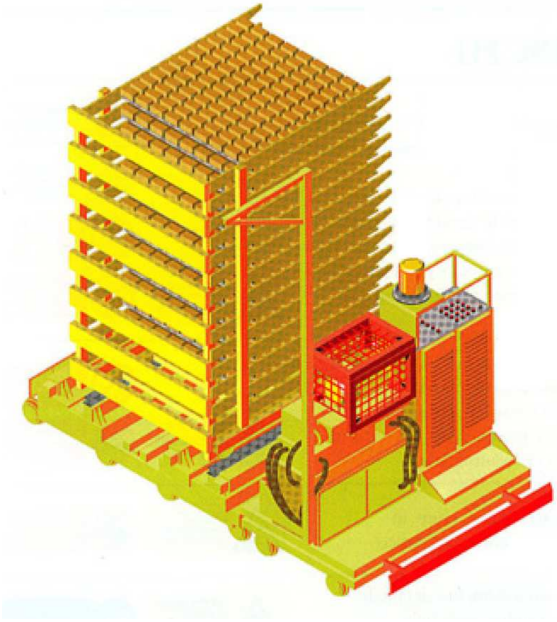
Chamber dryer

**Static dryer – cell dryer – chamber dryer.**

The  static or chamber dryer is composed of one or more chambers where the bricks to be dried are introduced, placed on supports on wheels or shelves.
When the chamber or cell is full of bricks it closes and may begin the drying process. In the static dryer the product remains still and the internal thermo hygrometric conditions are changed.
In accordance with the chemical-physical characteristics of the brick to be dried, the drying cycle will have a different drying recipe adjusting the temperatures and the cycle times.
The possibility to adjust the baking curve per each cell, is an important feature for small productions where the variety of the range produced allows to adapt the more appropriate drying process to each chemical-physical feature.
The use in sequence of the chambers, allows to recover at the end of the drying cycle part of the residual heat that is channelled in the chamber that has just been filled.
The devices for the production of heat and temperature adjustment are the same as the semi-continuous dryer ones.



Dryer loading line



Dryer car transfer

**Quick dryer – mangle dryer**

This type of dryer is composed of one or more overlapped tunnels, on which the bricks placed on metal shelves, hung to a chain, come forward being pulled by a pair of chains, which slide within the tunnel. This type of dryer requires constant feeding, since due to the speed of the cycle, possible stops in the loading may damage the product generating waste due to breakage or deformation of the product. The equipment to generate heat and control are the same used in other types of dryers.

**BAKING**

Processing of the "green" piece into stable brick defined as terracotta occurs through different physical and chemical changes that the mineral components undergo under the effect of temperature set to about 920° (the temperature is variable according to the type of raw material).

Kilns are divided in three main categories:
tunnel kilns
chamber kilns – intermittent kilns
Hoffmann kilns

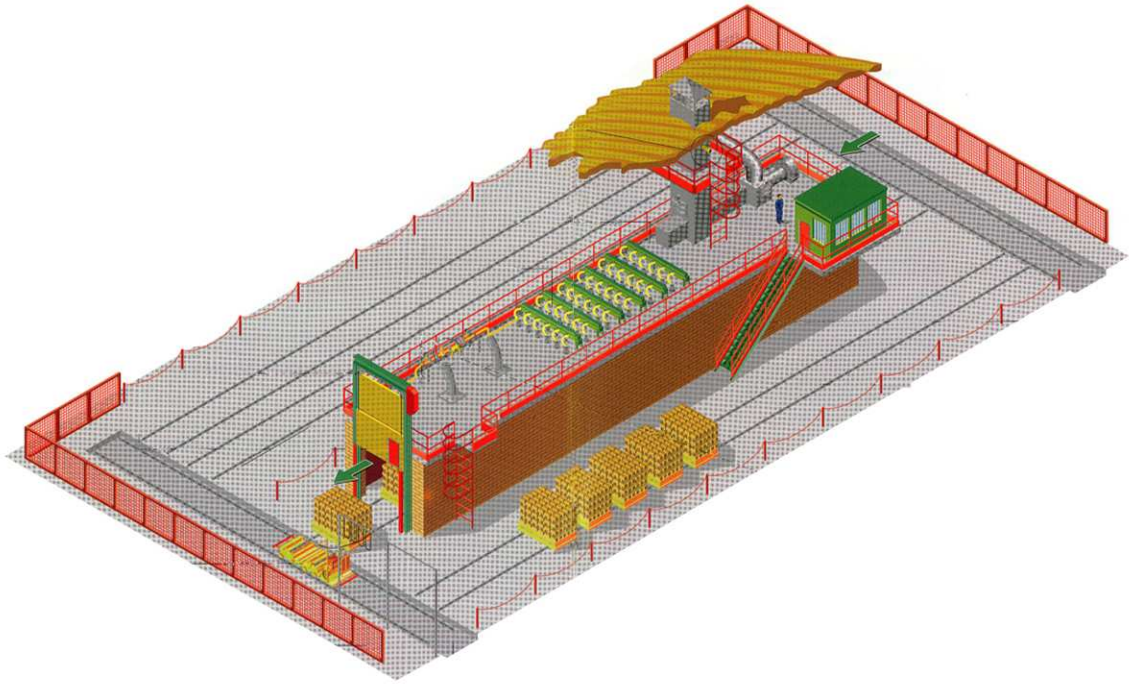
**The tunnel kiln** is structurally built as a tunnel with floor rails and doors on the stops. The tunnel kiln differs from other baking systems as it does not require manual work within the tunnel itself. The fire is still in the central area of the tunnel and the bricks placed on the cars go through it, warm up, bake and cool.
The bricks are therefore those to move within the tunnel, along their path the changes in temperature are adjusted by an ideal **baking curve**, adapted to the chemical physical type of the product, up to the completion of the cycle.

The kiln construction materials bear resistance and thermal insulation properties to withstand the high temperatures and limit the power consumption.

The kiln is divided into three areas:
**Pre-heating zone**
The first third of the tunnel starting from the entrance, which is heated through a piping that recovers the heat from the kiln exit zone, named as cooling zone.

**Fire zone**
Central part of the tunnel where the burners are located therefore being the fire zone
**Cooling zone**
Last third of the tunnel towards the exit, area where the heat is withdrawn to be partly channelled in the preheating area, partly to the dryer and part expelled through the chimney.
On the crown or on the outside walls, external piping to the tunnel feed the gas or diesel fuel and air, to the burners, these produce a combustion that generates the heat needed to achieve the baking temperature (max 1050° C).
All the equipment (chimneys, heat exchangers, ventilation, doors, shutters, transfers, burners) is controlled by instruments adjusted by means of a management software that allows the control of the baking following a default curve, set in accordance with the type of clay, the volume of the brick and the cooling curve.

In the tunnel the metal structure cars, equipped with special wheels, travel on the track line. The cars have a loading surface fitted with a refractory layer, that insulates the metallic structure of the cars from the upper zone where the brick will come into contact with the fire.
When exiting the kiln the products are unloaded from the cars, that go back into the cycle, and forwarded to the packaging area.



Tunnel kiln

**The Hoffmann kiln**, is based on a less modern principle than the tunnel kiln.
The structure is made up of two parallel tunnels - built with a sturdy brick-wall structure - which communicate on the ends so as to be a closed circuit. Along the tunnels there are access side doors and doors are present on the ends.
The brick work construction foresees volts and inlet and fume recovery ducts.
The doors on the ends allow the introduction of the material to be baked, packed in packages, and transported by lifting trucks.
Over the whole surface of the vault are fuel feeding inlets that based on the area of the fuel supply make the fire area rotate in the tunnel forming a circuit.
The raw material is introduced in the tunnel from the door, opposite to the fire area, taking care to extract the baked material before.
The features of the Hoffmann kiln allow a less accurate control of the baking curve in comparison to a tunnel kiln. It also involves a greater energy consumption because the whole tunnel must cyclically be brought at high temperatures and then cooled. It also implies for the operator, although supported by suitable means for the handling of the bricks, to go into the kiln thus having to bear the high temperatures.
The Hoffmann kiln has a lower cost of construction than the most modern tunnel kilns.

**Intermittent or chamber kiln.**

The intermittent kiln is made out of a prefabricated or masonry structure easily assembled and having small dimensions.
The baking chamber is built internally with refractory materials in order to be able to withstand the constant temperature changes due to start and cooling that make up the fundamental characteristics of the intermittent kiln.
The baking chamber is easily accessible for loading and unloading from a front gate and sometimes also a back gate. In the chamber cars loaded with bricks to be baked can be introduced. The car is simple to extract due to the it sliding on wheels.
Some spare cars outside the kiln may speed up the loading and unloading time of the material.
The baking curve adjusted with a management system may be adapted to different types of bricks to be baked, to the type of fuel, to the chemical-physical characteristics of the product to be baked. The intermittent kiln is to be considered suitable for limited productions but suitable for high value products due to operation features.
Its settings allow to have small productions without special constraints.
The tools to achieve the baking process are the same as other kilns but in much more limited dimension and quantity. It derives that the installation of an intermittent furnace has lower costs than a tunnel or Hoffmann kiln.

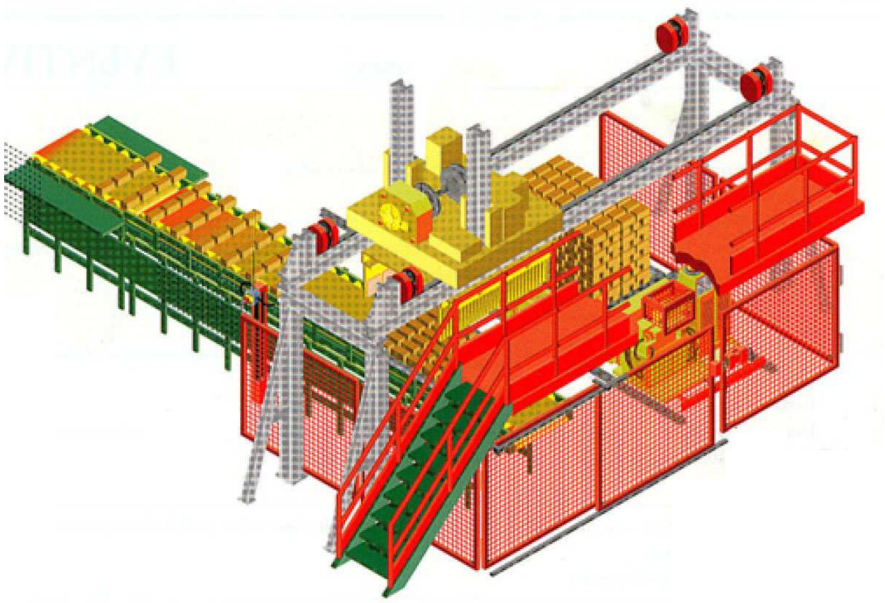
**LOADING AND UNLOADING**

Loading and unloading of the dryer and of the kiln, is mechanically carried out by means of stacking and unstaking machines, this equipment is necessarily installed in large production and technologically advanced plants.

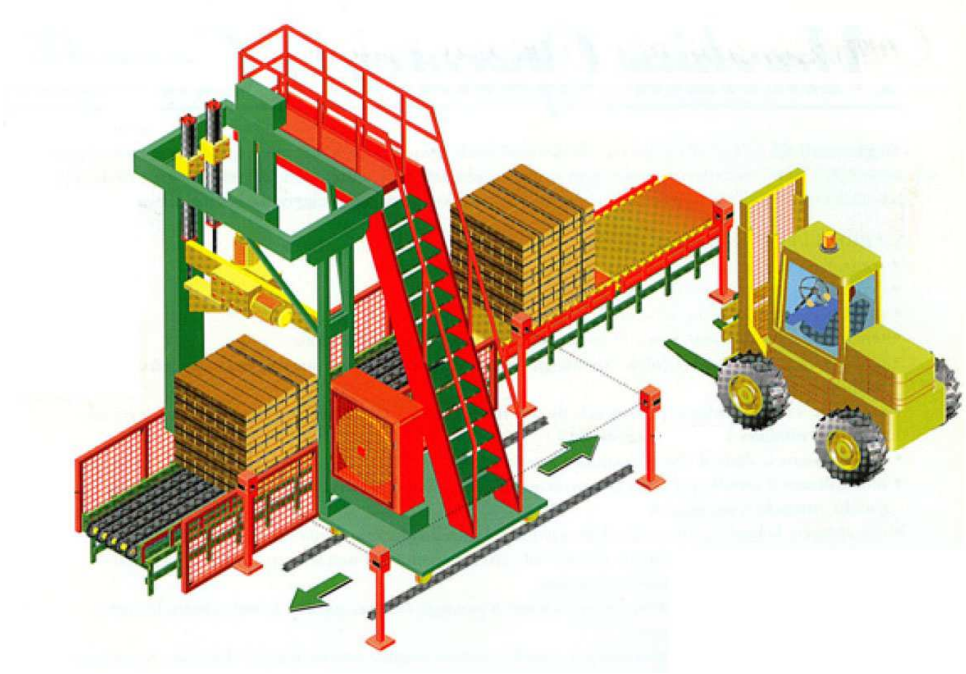
Unlikely, in smaller production plants with a lower technological content, these operations, (loading and unloading of the dryer and of the kiln) are still carried out manually, with the support of handling means on rubber (elevating trucks)

**PACKAGING**

During this phase the bricks are tied in bundles by strapping (metal or plastic), which is tightened using special equipment, or wrapped with shrink polyethylene.
The packs are then forwarded to the deposit area, or placed directly on the means of transport for delivery.



Brick packing line



Pallet packing line