Drying of clay bricks and tiles

Introduction

This third "Technical Brief" of four deals with drying of bricks and tiles. The other briefs are concerned with "Preparation" and "Moulding of Clay", and "Firing of Bricks and Tiles".

Drying is only one of several stages in the process of brick- and tilemaking, however, the importance of this stage should not be underestimated. Drying of green bricks (freshly moulded) often results in cracking and/or deformation as can be observed in many brick and tile producing enterprises. This observation applies to natural drying methods in the open or under sheds, as well as to artificial drying in chamber and tunnel dryers. Emphasis is laid in this technical brief on the description of the complex process of drying with the intention to guide brick producers in small-scale and medium sized enterprises to master this stage of production. The drying process should be completed with a minimum loss of products.

Basic Drying Processes and Terms

Drying of "green" bricks and tiles is a process in which the water needed for proper moulding is eliminated from the clay product, which shrinks in the process. Pores and capillaries of the green bricks and tiles are filled with water during moulding - solid clay particles are coated with films of water, absorbed into the surface of the particles (Fig.1). The clay body shrinks to varying degrees as water receeds during the drying process. Stresses are building up within the green product, influenced also by the the properties of the clay, its degree of plasticity and possible "ring textures" provoked when using an extruder for moulding. According to the type of clay and the method chosen for moulding the amount of water to be eliminated should be maximum 40% by mass. A certain portion of moisture will, however, always remain in the product.

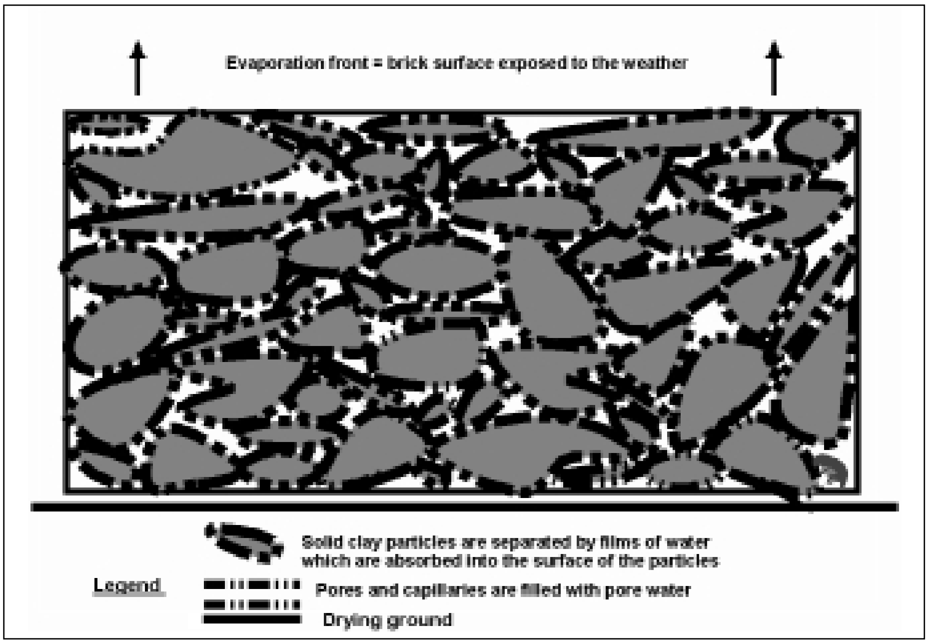

Fig. 1: Schematic drawing of clay particles enveloped in a moisture film surrounded by pores and capillaries

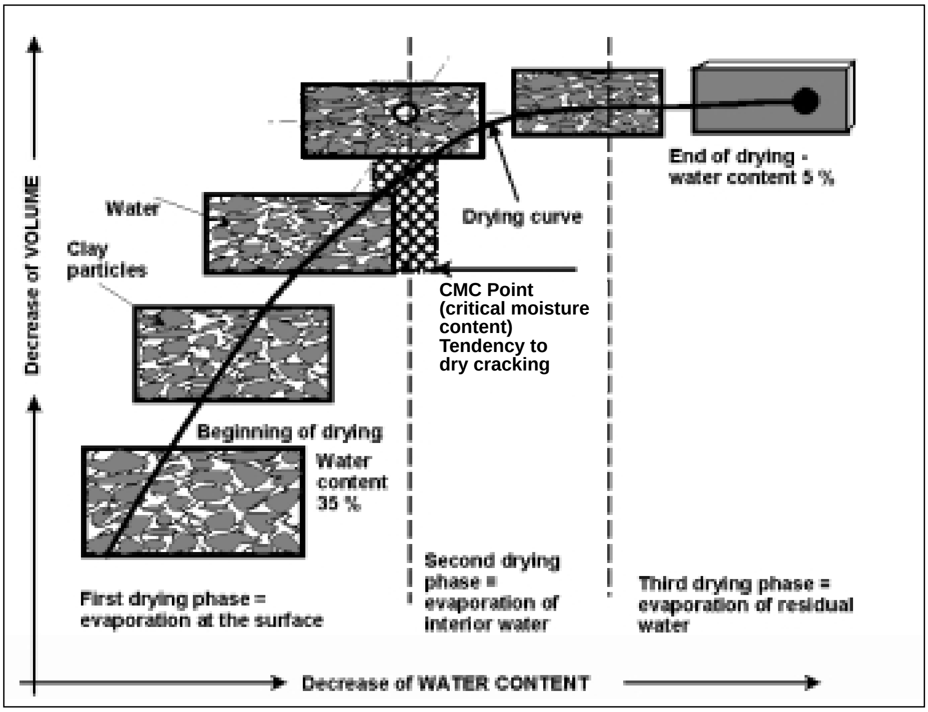

Fig. 2: Schematic drawing of drying in three phases

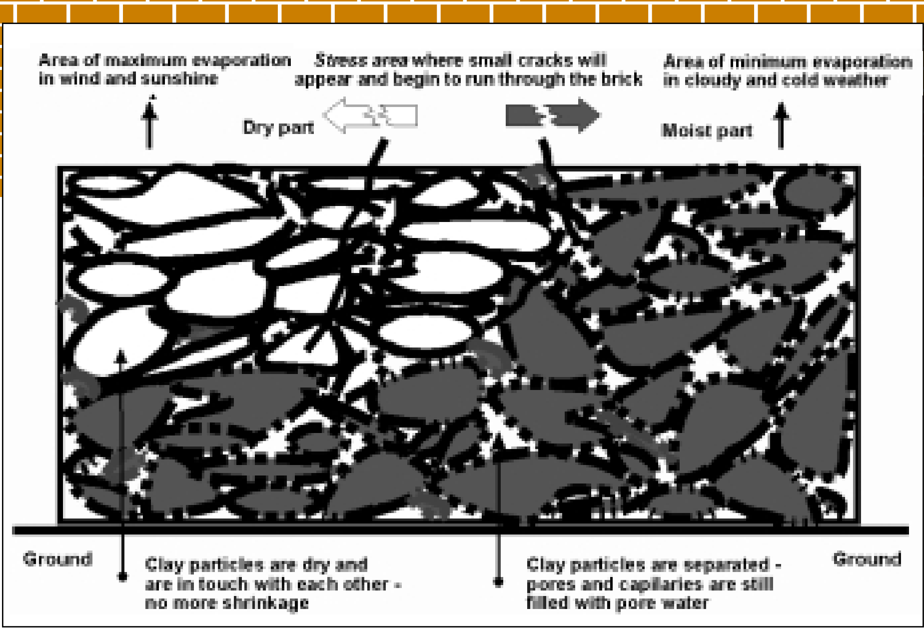

Fig. 3: Schematic drawing of "unbalanced" drying

The complete drying process takes place in three phases.

• *The first drying process:*

In the beginning of the drying process water evaporates first on the surface of the product. During the continuing drying phase pore water and that from capilliaries is transported from the interior to the surface of the green brick. The rate at which water is transported to the evaporation surface ("front") depends entirely on the intensity of warm drying air moving over and around the green brick. As more water evaporates on the product's surface, increasing the transportation speed of water from the interior, a state is eventually reached where the evaporation front moves towards the interior of the product. Heat is migrating in this process from the surface to the interior so that water vapour diffuses by capillary action to the surface. This process is accompanied by a sudden change of colour on the product's surface. The "green" product turns leather-hard.

• *The second drying process:*

At this stage of the drying process water which envelops the clay particles evaporates. The clay has reached the so-called critical moisture content (CMC). It is at this moment that bricks or tiles can suddenly crack, or the clay particles begin to bond (Fig.2).

It cannot be foreseen or calculated at which point in the drying process the clay products reach their CMC level. A laboratory test can only transmit an approximate picture of defined drying conditions. For this reason brick and tile producers should shield green products from direct sun radiation, exposure to different heat sources, from wind and any other drafty conditions to avoid "unbalanced drying" (Fig. 3).

• *The third drying process:*

During this phase the evaporation of the residual moisture takes place. At this stage the drying rate can be increased by providing maximum heat and draft in order to reach the *minimum moisture content* (MMC) of approx. 3 - 5%. Cracks appearing together with the change of colour mean that the process is either too quick or too intensive. If the colour of the green product does not change at this stage, the drying was too slow and with insufficient heat and draft (Fig. 4 and Fig.5).

Practical hints:

- Slow drying is a cautious way to avoid drying damage.
- The brickmakers have to gain sufficient practical experience to find the best drying method.

Drying Methods

Drying of green clay products is necessary to remove water from the solid clay body. After the drying process the products should be of such quality that they can withstand:

- transportation to the kiln for firing,
- setting in the kiln,
- and pre-heating for the firing process.

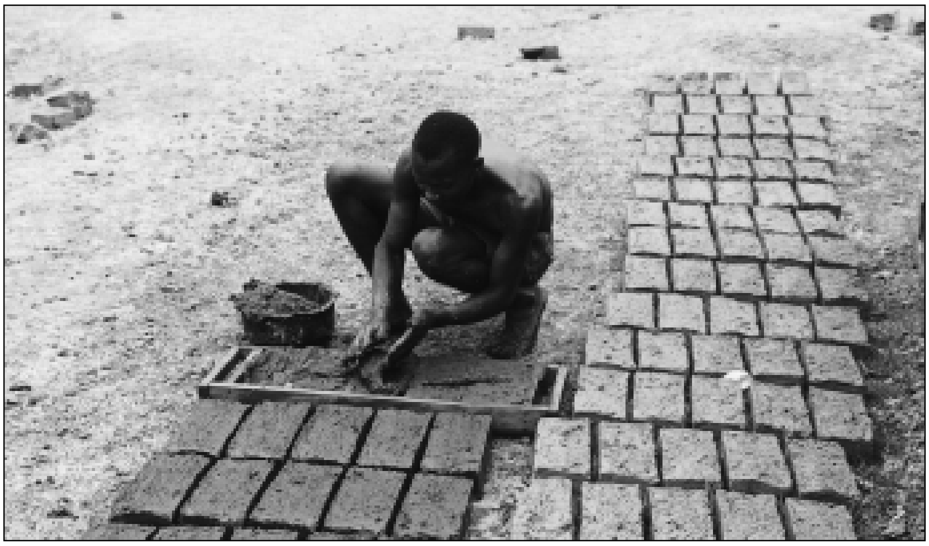

Fig. 4: Correct drying process: green bricks dry slowly in the open in cloudy weather, thus developing no cracks and deformation

Green clay products can be dried "naturally" or artificially". The drying process must be planned in such a way that only minimum losses of bricks and tiles occur through cracking and deformation (Fig. 6, Fig. 7 and Fig. 8).

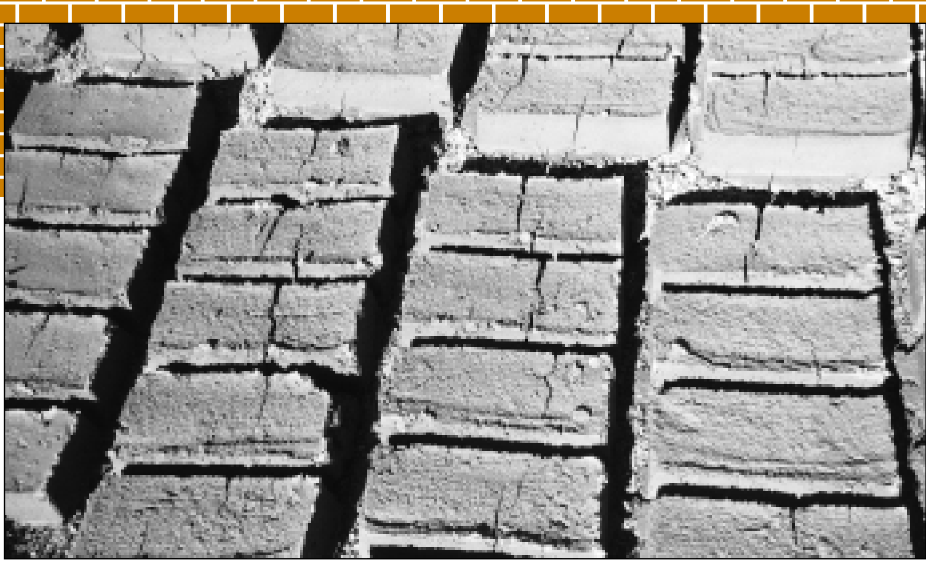

Fig. 5: Wrong drying process: green bricks are exposed to sun and wind, cracks develop on the surface

1. Natural drying:

Green bricks and tiles are placed in the open on an even, clean and sandy ground, fully exposed or covered with grass, or they are placed in drying sheds with a permanent roof (Fig. 9). The energy involved in this type of drying process is a "natural" source: sun and wind. Open-air drying is commonly used in seasonally operated small-scale brick/tile producing units. However, clays with a high sand content over 50% and those prepared with a high water content of 40% have a tendency to develop cracks when dried completely exposed to the sun. They should therefore be covered with grass.

Fig. 6: Simple method of drying floor tiles on racks under a grass roof

As a small-scale brick production is often seasonal (no bricks can be dried "in the open" during the rainy season), brickmakers can increase their output by drying green bricks and tiles in sheds with help of a blower which applies more draft to the stacked products and can easily be moved within the drying shed, if access is available to an electrical energy source. The drying speed is considerably increased by intensive and selective air distribution. Any natural drying process has to be supervised carefully and regularly.

2. Artificial drying:

Artificial dryers are used in large-scale automatically operated brick and tile works, where the kiln is designed in such a way that waste heat is conducted to the dryer. Artificial drying always involves mechanically induced air circulation and is practised in specially constructed *chamber and tunnel dryers* which are equipped with racks or drying cars, fan, channels, valves, and special controlling systems. The energy input is either waste heat from the kiln or produced in a heating system.

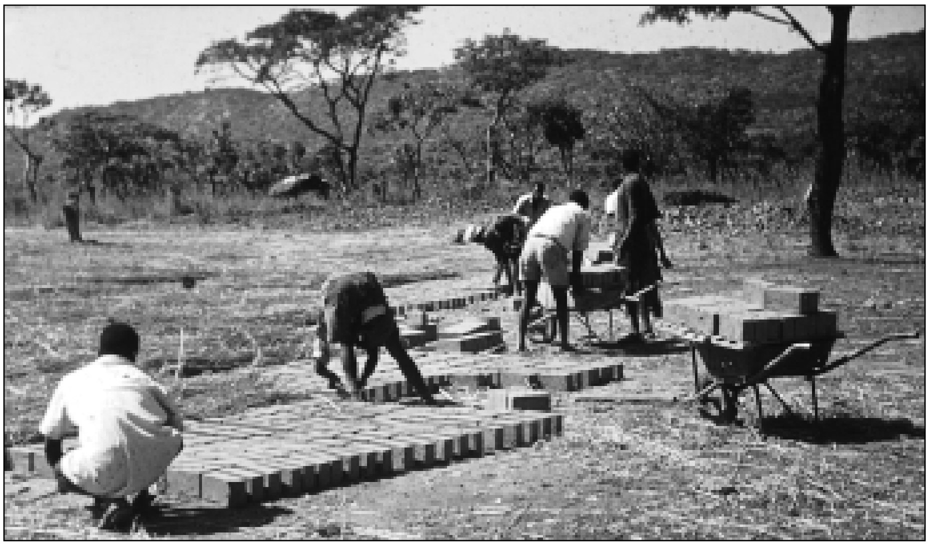

Fig. 7: Bricks are taken by wheelbarrow to the drying ground and turned on edge, covered with grass

Fig. 8: Rack drying under cover: moderate drying conditions for perforated bricks

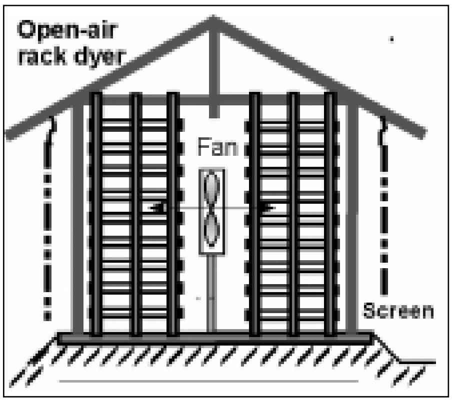

Fig. 9: Schematic drawing of natural drying: rack drying under cover

Chamber dryers: Air is blown from below the drying charge through the bricks or tiles placed in racks on pallets. Equal air flow over the entire chamber is ensured by an inclined floor and ceiling as well as correct spacing of the bottom and upper grates (Fig. 10). An automatic conveying systems is part of chamber dryers (Fig. 10a).

Tunnel dryers: Cars which are packed with bricks and tiles are pushed on rails through an one-way tunnel and pass on their way through changing temperature zones - at the entry warm and humid and at the exit: hot and dry. The change in direction of rotation of the fan ensures intensive air flow over the entire tunnel (Fig. 11).
Drying time and drying intensity are well controlled in both dryers. In such dryers the rate of "drying damage" in the clay products is normally rather low. Minimum drying time is twelve hours.

Surface Treatment

In order to reduce building costs the treatment of fired brick and tile surfaces is of great importance. Brick walls need not to be plastered externally if the surface is durable enough to withstand long-term weathering. Roofing tiles remain free of moss or any other organic growth, if their surface is sealed with a slip coat (known as *engobe*). Floor tiles are abrasion resistant when covered with suitable glaze.

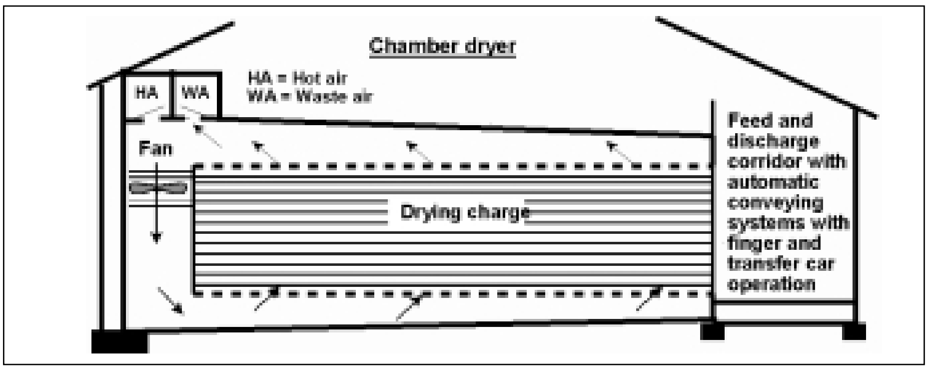

Fig. 10: Schematic drawing of artificial drying: chamber dryer with vertical air flow and with drying charge staying idle

While bricks are normally weather resistant when fired at maximum temperature, roofing tiles need special surface protection. Coating of roof tiles with engobe is done after the green product is totally dry. Floor tiles are glazed after the first, low firing. As a rule, glaze compositions are available already mixed in powdered form. The powder is mixed with water at a ratio that depends on the desired surface finish and porosity. Engobe and glazes are effectively applied to the tiles by means of spraying. Precise specifications for the use are normally provided by the supplier.

Note: Brickmakers are sometimes disappointed when their bricks do not turn out red after firing, despite high firing temperature. The reason for this can be found in the components inherent in clays such as lime and iron. The amount of the oxide in clay determines the brightness of the colour after firing: Iron oxide in clay will always turn red, whereas the presence of lime oxide will give bricks a yellow colour.

Drying Tests

The following simple drying tests are, if carried out regularly, not only of help to master the drying process but also for judging the final quality of the product.

- *Water vapour test:*

  - *Steps:* Select any brick considered to be dry, expose it to the sun, strip a fairly big transparent plastic bag over it, seal the bottom of the bag, leave the wrapped brick for three hours;
  - Process and reading: The brick will warm up. Any water resident in the brick will evaporate. If moisture appears on the inside of the wrap, this shows that the selcted brick is not yet properly dry.

- *Breaking test:*

  - *Steps:* Select any brick considered to be dry; break it into two halves, look at the surfaces of the broken parts and check their colour;

- *Reading:* The brick is totally dry and ready to be placed into the kiln, if the colour of the broken surfaces is the same as that of the other surfaces of the chosen brick.

• *Weighing test:*

- *Steps:* Weigh several green (undried) bricks, list their weights; number them before drying. When they are totally dry, weigh and list them again.
- *Reading:* The differences between wet and dry weight can be used to determine the rate of drying.

Choice of Drying Method

Before choosing a drying method some problems should be considered. Open-air drying is an economic choice, where climatic conditions are suitable and no artificial heat can be utilized from a kiln. The same applies to artificial dryers, if energy is reasonably cheap and the local market demands products of high quality. However, any clay product producer, whether in small-, medium- or large-scale works faces the same daily problems:

- how to shorten the drying time with a minimum of breakage,
- how to reduce energy consumption, and at the same time,
- how to improve the quality of his products.

Any solutions to these problems must be based on the exact knowledge of the prevailing local situation: Climate, market demand, availability and cost of energy sources, economy, etc. Their positive and negative aspects have to be considered. Drying time and product quality are very closely linked. Faults within the freshly moulded green clay product which are deriving from an incorrect preparation and moulding of the clay can partly be remedied or sometimes eliminated by prolonging the drying time. Close monitoring of the preparation and moulding is therefore very important and must be guaranteed.

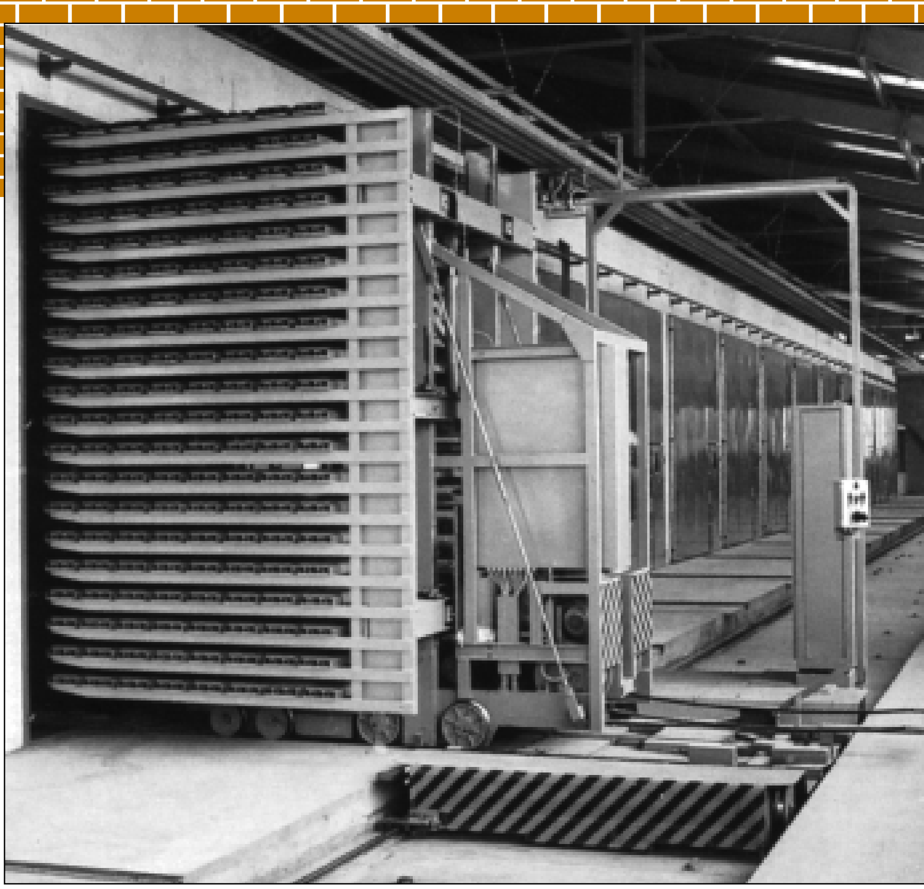

Fig. 10a: Chamber dryer for roofing tiles: automatic conveying system with finger and transfer car operation

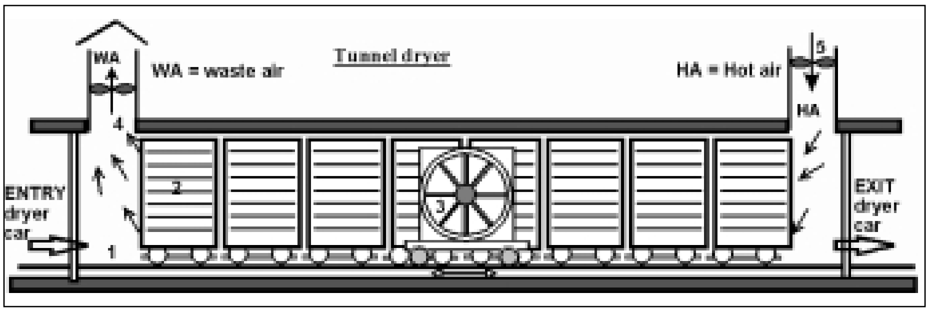

Fig. 11: Schematic drawing of artificial dryer: tunnel dryer with drying charge pushed on dryer cars through horizontal air flow

Only experts with long practical experience in clay product drying and know-how of the relationship between energy consumption, temperature and humidity should attempt to construct artificial dryers (Table 1).

Economics and Flexibility

Only economic and at the same time flexible drying methods should be applied and dryers chosen accordingly, to be independent and prepared for any sudden changes in the locally prevailing situation. A possible change of climate has to be considered when drying in the open. A combination of open air drying with rack drying in sheds which are equipped with simple fans is an economic and flexible choice, if electric power is available.

In large-scale brick works with artificial dryers it is economic and flexible to have access to open air drying and drying sheds in case that waste heat from the kiln is not available.

Drying faults	*Natural drying* **Cause**	*Natural drying* **Remedy**	*Artifical drying* **Cause**	*Artifical drying* **Remedy**
Tendency to cracking at the beginning	- Sun & wind too intensive - Clay content too high	- Cover up; lower side screens - Mix with sand	- Temperature too high - Air flow too intensive	- Modification of automatic controlling system
Appearing of cracks despite optimal drying conditions	- Faulty clay preparation - Incomplete moulding	- Check homogeneity - Ensure proper moulding - Turn brick on edge	- Faulty extrusion - Incomplete moulding	- Change extruder's end screw - Check die cores
Drying cracks at end of shrinkage	- Unbalanced drying	- Turn bricks on side and head	- Unbalanced drying	- Modification of air flow - Perforation of drying support (pallets)
No drying on the ground or drying support	- Product lies on wet ground	- Turn product - Ensure dry ground	- Insufficient air flow	- Increase air flow
Wet pockets	- No air flow	- Reduce the lee side	- No air flow	- Diminish the lee side - Reverse air flow
Slow drying speed	- Brick spacing too narrow - Insufficient air flow and heat - Perforated bricks	- Increase setting space - Remove side screens	- Dense setting - Insufficient air flow and heat	- Increase air flow - Increase brick perforation - Check controlling system
Softening of green ware	-//-	-//-	- Humid air outlet blocked	- Control drying system
Condensation on green ware	- Difference in tempe-rature and humidity	- Protect during night	- Difference in temperature and humidity	- Increase air circulation - Ceck drying cycle
Multiple distortion	- Different causes - Unseasonable rain	- Check moisture rate - Reduce mass - Cover up - Avoid wet ground	- Different causes	- Reduce mass - Reduce humidity - Balanced drying - Check drying cycle
Increase of energy consumption	-//-	-//-	- Different causes	- Check insulation of construction - Ensure constant supply of green ware - Remove dry ware

Table 1: Table of drying faults, possible causes and remedies

What is basin ?

References

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Text, drawings and photographs by:

Gerhard Merschmeyer, Consulting/ Planning/Training
Theodor-Fontane-Str.13
D-26160 Bad Zwischenahn
Germany

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German Appropriate Technology Exchange
Dag-Hammarskjöld-Weg 1 - 5
Postfach 51 80
D-65726 Eschborn Germany
Phone + 49 - 6169 - 79-3095
Fax + 49 - 6196 - 79-7352
(2000)

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