Rapid Dry: the New Dryers Generation

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The recent and uncontrolled increases in the price of methane have made the need to drastically reduce the consumption of thermal machines even more urgent. SE.TE.C.-Group/IT, which has always been at the forefront of innovation in the ceramic sector, in recent years has focused its attention on various solutions aimed at saving energy; in particular, thanks to the European co-financing of the Life Program, both new formulations for low-firing sanitaryware (Life Sanitser Project) and a new generation of low-consumption intermittent and tunnel kilns (Life Economick Project) have been developed.
The latest Life Project, called Rapid Dry, started in June 2020 and is dedicated to energy saving in the drying process of sanitaryware and tableware. In particular, the project has two main topics: the construction of a low consumption dryer and the optimization of sanitary mixtures through the introduction of recycled materials. In this article, the authors focus their attention on the dryer. Before going into the details, it is useful to give a brief explanation on how the drying process takes place and what are the criticalities of current dryers.

Drying of sanitaryware bodies

Drying is an extremely important production phase for the elimination of non-chemically bond water from the body, which may be broken down as follows:
- interstitial water contained in the voids between the body particles;
- water deposited superficially around the various particles.

During drying, water is evaporated and air is used as a heating fluid that acts as the means for vapour evacuation. It is therefore fundamentally important to control the following air characteristics in order to regulate the drying process:
- temperature;
- relative humidity;
- speed.

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For a better understanding of the drying phenomena, a close analysis will be made of the related mechanism and controlling elements. As soon as the body particles are extracted from the mould, they are surrounded by a capillary lattice of water that during drying has to migrate to the surface of the piece in order to evaporate, without damaging the integrity of the semi-processed product. Therefore the two fundamental factors controlling drying are the water diffusion speed through the thickness of the piece and the evaporation speed.

Optimal drying conditions require an evaporation speed that is equal to or slightly slower than the diffusion speed. In this case, evaporation is superficial and the creation of evaporation phenomena inside the body thickness is avoided. These conditions are rarely respected in the industry.

The diffusion speed of water into the capillary canals depends on:
1) the temperature of the piece: diffusion speed grows with this;
2) body composition: the richer in plastic and very fine materials, the slower the diffusion. A more plastic body is also prone to greater shrinkage and therefore the water passage canals are obstructed to a greater extent with a consequent reduction in diffusion speed.

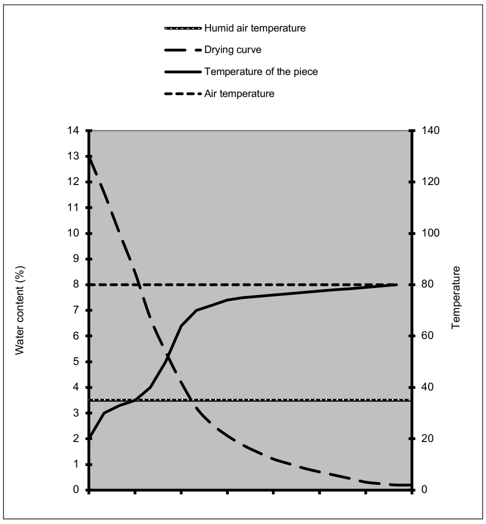

Fig. 1 Drying test

The water evaporation speed rises with the increase in:
1) the difference between its vapour tension in the piece and the vapour pressure in the drying air, therefore with its temperature;
2) the drying air speed;
3) the surface/volume ratio, or the specific surface of the product.

By carrying out drying tests on a sanitaryware body and by maintaining the temperature and air humidity constant, the drying curve shown in Fig. 1 is obtained.

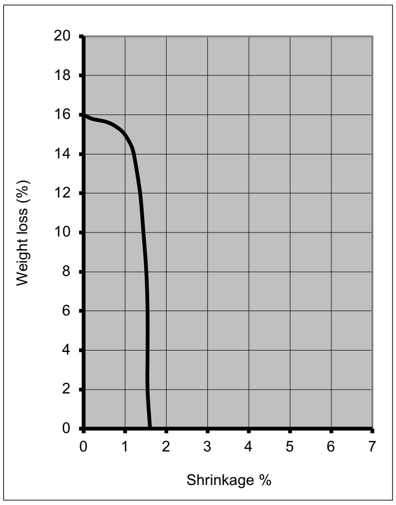

Fig. 2 Bigot curve

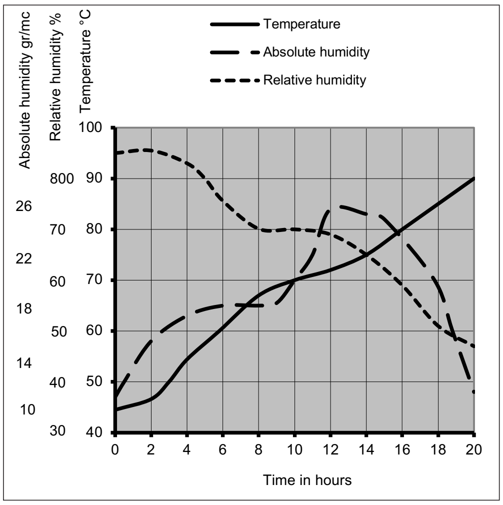

Fig. 3 Drying curve

An analysis of this curve easily identifies three distinct phases:

1) Constant drying phase speed: during this phase, the water migration speed to the surface is greater than the evaporation speed. A thin layer of water thus forms on the entire surface of the piece. In these conditions the piece brings itself to the humid air temperature. The water eliminated is interstitial that flows with relative ease to the surface of the piece causing it to shrink. Fig. 2 shows the dimensional variation of a sample as a function of its water content.
2) Decreasing speed phase: as the particles become closer there is a considerable reduction in the number of openings available for the passage of water and therefore the surface is no longer uniformly covered in liquid. The evaporation phenomenon begins inside the thickness of the ceramic mass with the consequent migration of vapour to the surface. The more the evaporation area moves towards the inside, the greater the reduction in the drying speed. During this period, shrinkage continues until the particles come into contact with each other and at this point, the contraction of the piece ceases and porosity formation begins.
3) Decreasing speed phase, tending towards zero: this part of the drying curve tends asymptotically towards zero and corresponds to the elimination of the residue interstitial water and of the film of water present on the surface of the solid particles.

Water evaporation occurs exclusively inside the piece; in this case, it is important not to provoke sudden rises of the internal water vapour pressure because if this exceeds the mechanical resistance of the material the piece could break violently. These are the "explosions" that occur when pieces that are still too damp are introduced into the firing kiln.

Therefore, even the best drying treatment, and as far as conditions and hot air distribution are controlled, they cannot guarantee homogenous drying of a sanitaryware appliance. This applies to a greater extent to pieces such as basins, bidets or WCs as large parts of their surface are "in the shadows" with respect to the hot air flow.

Non-homogenous drying translates into shrinkage rates that differ from one surface area of a piece to the other, causing tensions in the ceramic mass. When this stress exceeds the mechanical resistance of the body, cracks or fissures are formed. It is therefore necessary to conduct drying in such a way that the humidity gradients, although inevitable, are maintained within acceptable limits. This however means that with traditional forced convection drying, the cycle times are extended.

In fact, with traditional dryers it is necessary to heat the pieces with hot but very humid air, in order to make the temperature uniform in all the ceramic mass before the evaporation process begins. The relative air humidity is decreased gradually to activate evaporation; the result is a drying curve as shown in Fig. 3.

Standard dryers limits

Standard dryers usually don't have a real drying curve, but they are very similar to simple "heated rooms" in which temperature is the only controlled parameter. So there is not an humidity check and for this reason drying cycles very often are longer than 14 h and don't allow to introduce very wet pieces. Furthermore, inside the dryer the only way to have homogeneity is to introduce very big air flows rate that are distributed by mean perforated grids. This forces to oversize air fans and heat generator increasing energy consumptions.

Fig. 4 Rapid Dry – the new dryer developed by SE.TE.C.

Fig. 5 Rapid Dry in operation

Fig. 6 Dried sanitaryware products

In the new dryer Rapid Dry (Fig. 4–5), the aim of SE.TE.C. was to overcome old limits improving energy saving and reducing the drying cycle. How was it possible?

The SE.TE.C. team, thanks to its experience since more than 30 years in the ceramic sector, optimized dryer heat flows and designed a new to software to manage all drying parameters. In particular, now it's possible:

- To strongly reduce methane consumption by mean a fully automatic heat generator that limits by itself thermal power.
- To strongly reduce electrical consumption by means of a fully automatic air flow management that limits by itself electrical power.
- To set a real drying curve: in every step it is possible to control air temperature, humidity and turbulences. During the first part of drying, this is possible thanks to an improved water spray injection.
- To optimize humidity extraction and heat recovery.

Rapid Dry installation: final results

At the beginning of the year, Rapid Dry was finally installed at the company FA CERAMICA sanitaryware factory located in Civita Castellana/IT. Final results not only respect the Life Project aims, but are even better (Fig. 6). The authors can resume them as follows:

- Drying cycle lower than 8 h
- Thermal consumption is only 98 kcal/kg in respect to 288 kcal/kg of old dryers
- Electrical consumption only 0,003 kWh/kg in respect to 0,019 kWh/kg of old dryers.

These incredible energy savings are explained by the new technologies joined with a very fast drying cycle. Obviously, this means not only money saving, but also an important reduction of CO_2-emissions.

The SE.TE.C.-Group, thanks to the kind collaboration with FA CERAMICA, is able to show its new Rapid Dry all interested sanitaryware/tableware producers.

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