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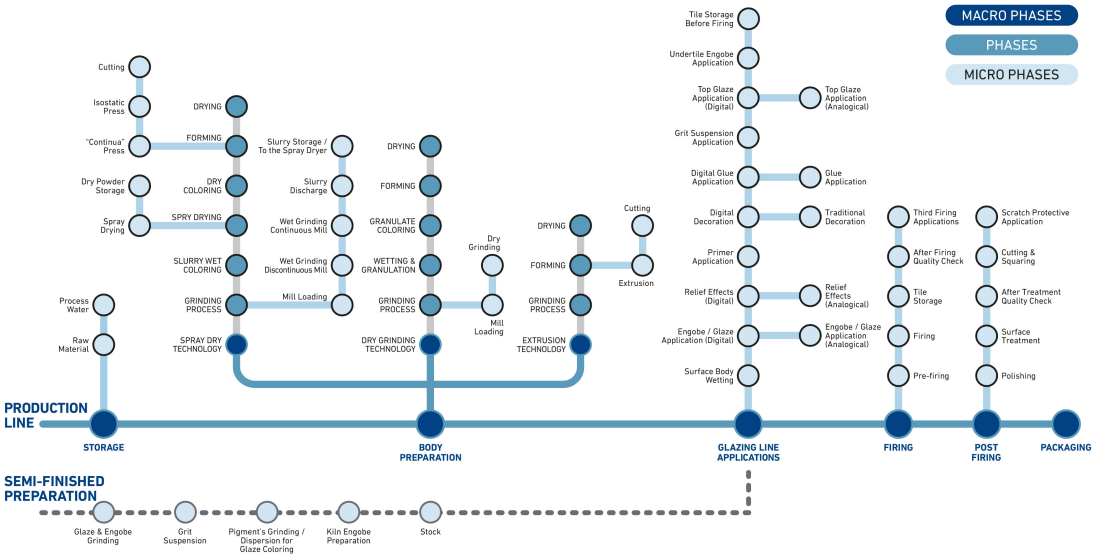
CERAMCO

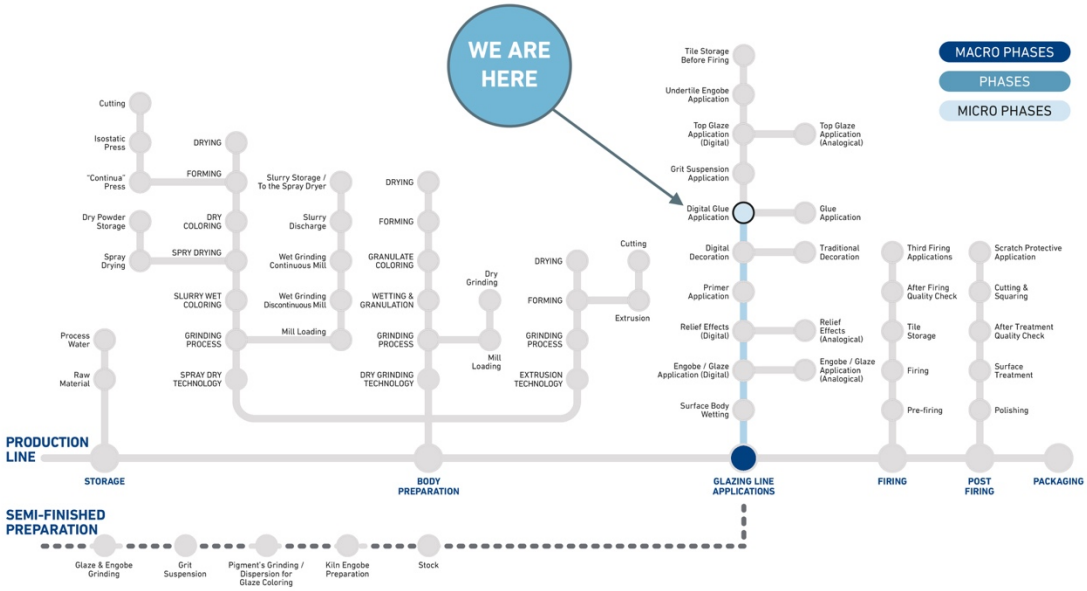
APPARENTLY INVISIBLE YET CONSTANTLY PRESENT

At every stage of the ceramic production process

A journey through problems & solutions



#20 CERAMIC PRODUCTION, CHEMICALS & ENVIRONMENTAL IMPACT



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INTRODUCTION

This dissertation aims to refocus, from a special and provocative perspective, the role of chemicals involved in ceramic production: from the beginning to the end of the entire process, that is from the grinding of the clays that form the basis of the ceramic mixture up to the firing cycle.
We will use a specific and clear filter, that is *chemicals and environmental impact*.
We will try to break the preconception about the word *chemistry*, that too often is a synonym of pollution, contamination, infection.
We do not want to belittle or deny the wrong use of potentially dangerous products by some industrial producers but, for sure, we want to fight against another word – *chemophobia* – that is the irrational fear or idea that all chemicals are dangerous and harmful.

If we looked closer at chemicals for ceramics production, we would discover that their alleged danger does not make any sense. On the contrary, sometimes they can promote some environmental improvements that should not be underestimated or even disclaimed.

We will proceed along the production line, highlighting the combo *sustainability and chemicals* by showing their positive contribution.

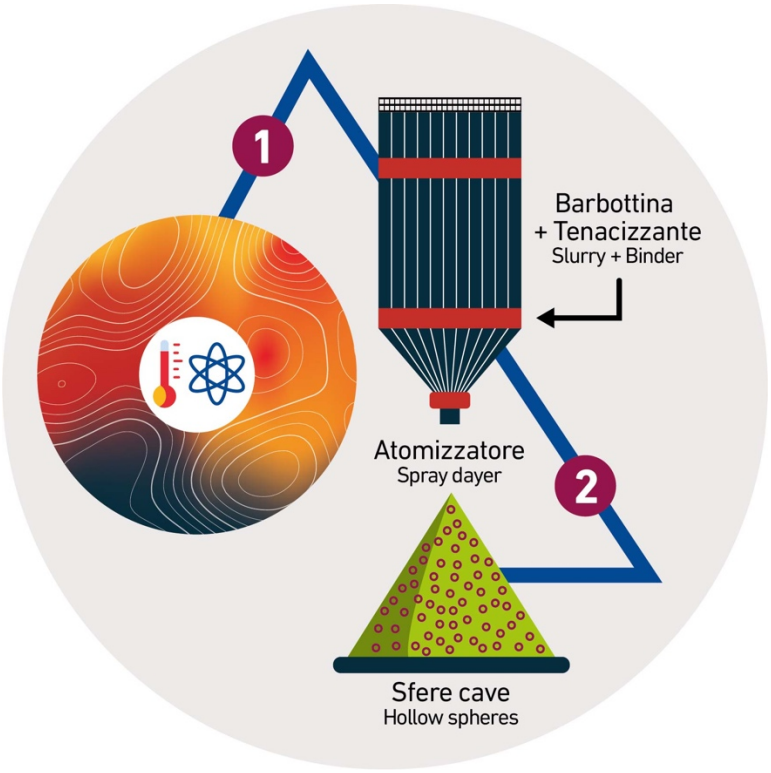
Is this a provocation? Probably.
Is this food for thoughts? Surely.

- **STEP 1** – Grinding of ceramic mixture

Ceramic mixtures basically consist of clays (more or less plastic) and hard materials such as feldspars and sands. Once they have been selected, raw materials are grinded by using a proper amount of water, involved to properly develop the process. Raw materials, together with water, forms the slurry (the so-called barbottina).
Even if slurries can be very different one from each other, they usually contain the same water amount (usually about 35%). A percentage that ceramic producers try to reduce with different action, to increase the solid amount of the suspension.

Why?

After the milling process, the slurry enters the atomizer to lose by evaporation the liquid part of the suspension (except for a low amount of residual humidity that is about 5/7%), producing the atomized ceramic powder that, under the weight of the press, will form the raw ceramic tile.
The water evaporation takes place thanks to the use of **high energy amounts**: the higher the water content, the greater the energy to be used, increasing environmental impact and production costs. This is the reason why producers always need high-density slurries, marked by high solid content and low water content.

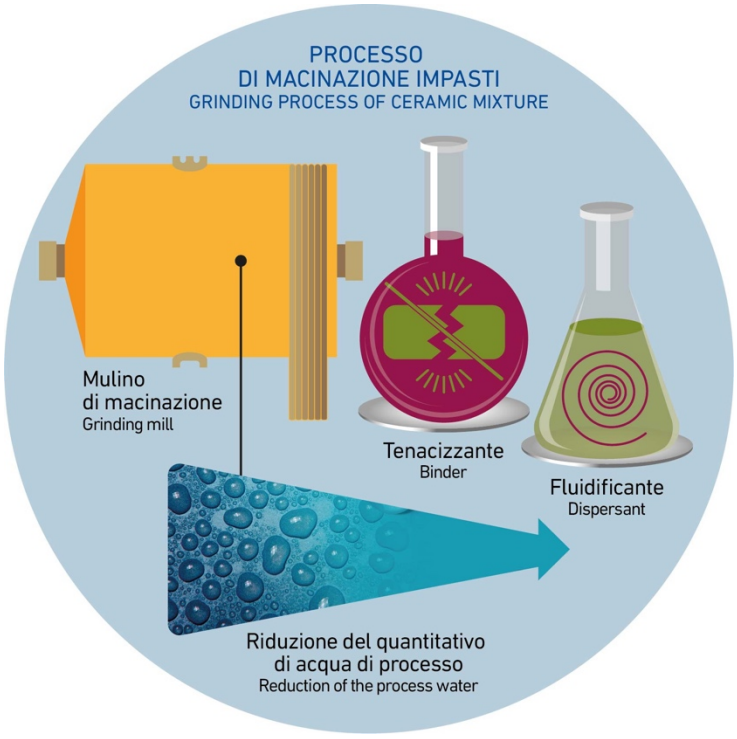


The combo *more solid and less water* also allows you to produce higher amount of atomized powder (for the same volume of slurry).
To put it shortly: the lower water amount decreases the environmental impact thanks to the reduction of gas/energy inside the atomizers and at the same time it increases the productivity by generating greater amounts of atomized powder.

At this stage of the production process, how can chemicals promote an environmental impact reduction?

The use of proper **DISPERSANTS** – specifically studied to provide the slurry with the right viscosity values – allows you to correctly develop the production process and to reduce the water amount in the suspension: their fluidifying action, in other words, is synonymous with energy reduction.

The latter can also be improved thanks to the use of **TEMPORARY BINDERS.**



Why?

Tiles' mechanical resistance almost entirely derives from the presence of plastic clays that, however, can make difficult the fluidization of the ceramic mixture.
In fact, since they absorb significant amounts of water, plastic clays force producers to increase the water amount inside the system (barbottina) to improve the flow (the movement) of clay micelles.

The excessive reduction in the use of plastic clays could be useful to increase the slurry's density values but it is surely not recommended if you do not want to negatively affect the raw tiles' mechanical resistance.

Nevertheless, temporary binders can rebalance most of the values, also reducing the environmental impact. How do they do it?

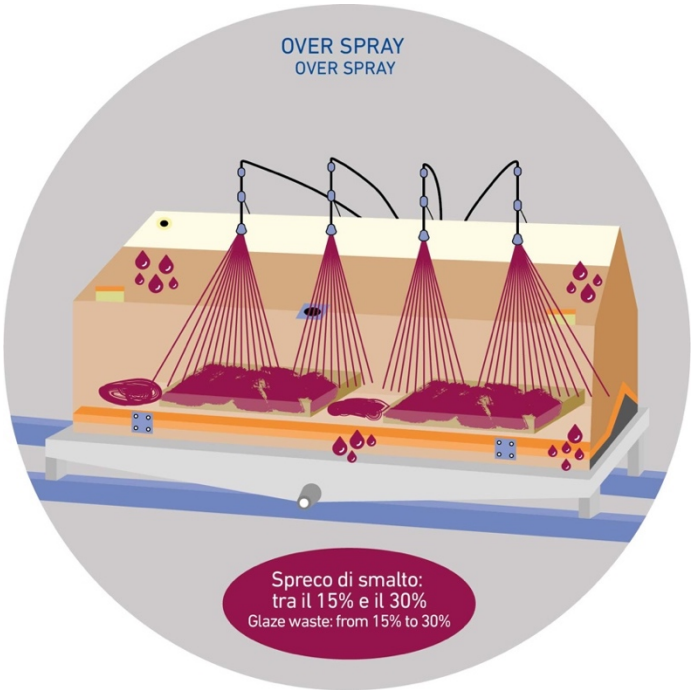
a) They restore the mechanical features to avoid tiles' breakage
b) They reduce the use of plastic clays
c) They increase the density values (resulting in the reduction in the use of water)...
d) ..that turns into a reduction in energy consumption (and into a productivity increasement)

• **STEP 2** – Glaze applications

INTRODUCTION

Ceramic glazes can be applied by means of several systems, but the airless spray application is surely the most common. This system is excellent and usually easier to manage, but it can be critical in terms of **material waste** and maintenance.

In what way?



The spray cabin must be provided with very powerful suction systems, capable of collecting and recovering the so-called *over spray* that could spread in the working environment as well as inside the cabin, where it could encrust or improperly drip on the tile.
The amount of material collected by the suction machines (discarded and non-recoverable glaze) can usually range from 15% to 30% of the glaze (or engobe) applied. This rate also includes the wasted glaze inside the cabin that is normally (and optimistically) washed at each work shift.
Waste material is clearly synonymous with environmental impact.
Together with these topics, airless applications are also marked by other interesting criticalities.

The machine management and the spray nozzle deterioration play from this perspective an important role. Nozzles, in fact, tend to widen their diameter over time, increasing both the weight of glaze applied on the tile and the material waste. Since the glaze is improperly applied, the tile can be easily compromised. Moreover, their temporary obstruction can affect the industrial yield, forcing producers to discard the defective material that have been produced.

How can we handle these problems and **what has this to do with the environment?**

Let us proceed step by step, broadening the perspective.

In recent times, several manufacturers have entered the market with new types of glazing machines based on a highly innovative application system. Among the several characteristics, the most significant is the possibility (or ability) to discharge the glaze exclusively on the ceramic support, drastically reducing waste and at the same time offering an automated management by using control and automation systems (like digital printing machines).

THE ROLE OF CHEMICALS

As happened in the past with traditional application systems, even with this new technology it is important to previously define the glaze's rheological parameters to develop the best performance. Depending on the glaze's discharging system, it is very fundmantal a detailed study of the rheology, surface tension, pH, etc., and in this respect the role of chemicals - whether they are surfactants, rheological modifiers, wetting agents, lubricants, or dispersants - is decisive.

The reliability of the new glazing technology – together with the proper values of the glaze – promotes, a productive continuity, allowing you to apply on the raw tile a minimum amount of glaze, avoiding **waste of material** and reducing the maintenance of machine (**waste of water**).

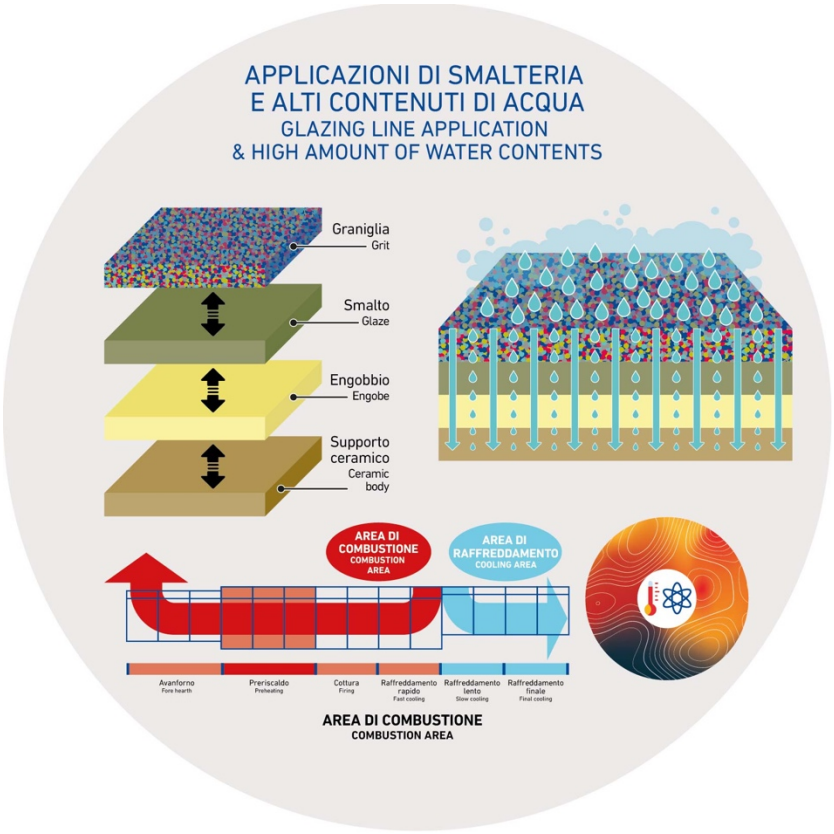
The washing times of the tools together with water consumption, in fact, can negatively impact on both productivity and ecosystem.

This dissertation does not want to promote any application technology. We just offer a vision about what is entering the market to highlight how the choice of the right chemical – in the different scenarios – instead of being harmful can lead to important benefit.

REDUCTION OF WATER AMOUNT ALONG THE GLAZING LINE

How chemicals applied along the glazing line can reduce the amount of water-consumption, decreasing the environmental impact?

Since we are talking about watery suspensions, the ceramic glaze application obviously involves a significant use of water that, once it has been discharged on the raw tile, it is partially absorbed by the support and partially evaporate due to the temperature of the tile. A temperature that is important not only for the proper development of the evaporation process but also for the proper leveling of the glaze.

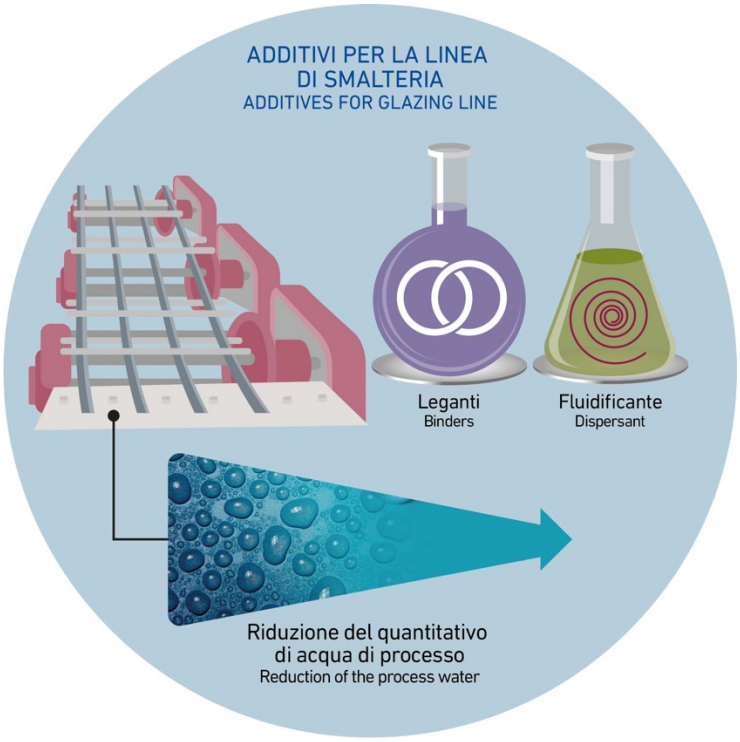


The water absorbed by the support must evaporate in the preheating phase of the firing cycle. Even this process (like it happens inside the dryers) implies an **important use of energy** (evaporation = energy).
Normally, the greater amount of water is absorbed by the support, the longer will be the time of the ceramic material in the preheating stage, leading to a greater energy consumption (that is gas) required to gradually evaporate the residual moisture, avoiding breakage of the material.

We can also add that if we decreased the amount of water along the glazing line, we could also potentially reduce the temperature of the tiles (first reduction of energy consumption) and the energy released inside the **kiln** (second reduction of energy consumption).

Going backward, what actions can be taken to reduce the glazes and engobes' water-amount?

To reach the same application performance, the reduction of water must go hand in hand with an increase in the glaze (or engobes) density and to make this happen it is necessary to previously study all chemicals that will be used both in the grinding and application phase.
More specifically, during the **grinding phase** DISPERSANT and BINDERS must be added to get a high-density value during application: it is therefore important to be aware of what will happen later on along the glazing line.



Once we have taken the proper decision at the grinding stage, we can also act (to reduce the amount of water) by using LEVELING AGENTS or other kind of chemicals able to act on glaze's drying and drainage time.
The action promoted by these chemicals affect the glaze performance, causing good result even with glazes marked by very high-density values.

- **STEP 3** – Digital printing

For this section, please read the text (Did you know that?) or listen to the episode of the podcast: *What benefit can you get by using water-based digital glues?*
In this episode all benefits, even those about environmental impact, are pointed out.

- **STEP 4** – Grit application

Let's start with a long introduction to frame the topic.

In the last decades, the rapid technology development has completely changed the production scenario, expanding the aesthetic and technical possibility of ceramic surfaces. Just think of the slabs now available or of what the digital technology has introduced in terms of aesthetic options such as, for example, the reproduction of woods and marbles.

WET APPLICATIONS

The production of these marbles that must be lapped after firing to reproduce the original and natural material, for example, involves the formation of a glass surface marked by a significant thickness (often more than 300 microns).
This glass - noble, hard, transparent, and resistant – is made with grits or frits suspended in water (slurry) and with the addition of ORGANIC CHEMICALS that promote a proper application by means of airless systems: good nebulization, perfect drying process on the support, levelling action and binding power. Just to mention the most important.

THE WATER'S ROLE

Beside the use of suitable DISPERSANTS and WETTING AGENTS, it is important to use a significant water-amount to ensure a proper grit wettability.

Why?

Low water contents would not promote a proper circulation of the grit within suspensions, both inside the conveyor systems (the pipes that connect the tanks to the sprayer) and during the glaze discharge. A significant water-amount is also important to reach low-viscosity levels, therefore to develop a proper nebulization.

For example, an adequate amount of slurry (in preparation for a following lapping process) should be about 1kg per m^2 (500/600 grams of grit and 500/400 grams of water and chemicals).
This amount cannot be increased because an excessive water amount could lead to critical issues in the pre-heating phase, such as tiles' explosion or increased drying time inside the kilns.

Speaking of costs and environmental impact, the massive use of water on the tile surface can lead to the following problems:

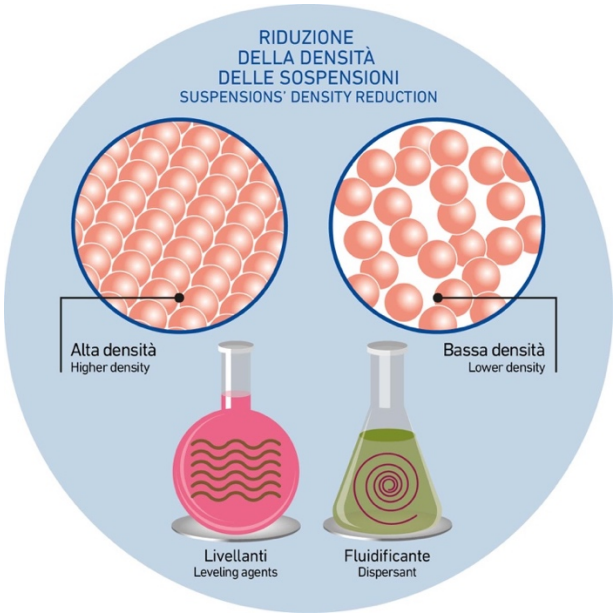
1. Maintaining of tile's high temperature along the production line to promote a better water evaporation process and to reduce the water-absorption by the support → **increased energy spent on temperature maintenance**
2. Presence inside the kilns of material with a high water-amount that turns into an **increased energy consumption** to properly develop the evaporation process
3. **Increased production times** during the pre-heating stage

Is it possible to improve this scenario, also decreasing the environmental impact by using proper chemicals?

→ THE ROLE OF CHEMICALS

In general, even at this stage of the production process, the use of CHEMICALS FOR GRITS, LEVELING AGENTS, and DISPERSANT positively acts on the density of the slurry and, therefore, on the water-content.

What do they do?



In simple words: while some compounds or chemicals promote a non-associative behavior in respect of grits and other inorganic materials, the formula is provided with other substances capable of increasing the wettability of the system (the grit suspension) even in case of water shortage. This double action, which results in a lower interaction of the suspended particles, is important to make grits free to properly move.
Glass particles, in fact, are electrically active and exposed to a form of attraction / interaction that reduces their mobility in suspension, compromising the process. Chemicals, among other properties, can screen or isolate particles by limiting interactions, promoting grit applications with low water content, therefore reducing environmental impact.

DRY APPLICATIONS

Grit applications can also be developed by means of dry technology that involved a previous application of glue (both digital or analogical) and, when necessary, a final low-weight application of glue on the grit.

A three-steps process:

1. Liquid glue application
2. Dry grit application
3. Low-weight application of glue

These application systems promote, by their very nature, not only technical benefits but also some **interesting environmental improvements**.

The most significant is about the important decrease of water-amount:

a) The grit is not in suspension and the liquid part does not exist (we are not talking about slurries)
b) The amount of applied glue (natural derivative product in water) usually ranges from 200 and 300 gr/mq (low quantities)

These is reflected in a lower energy consumption and in a lower environmental impact

→ THE ROLE OF CHEMICALS

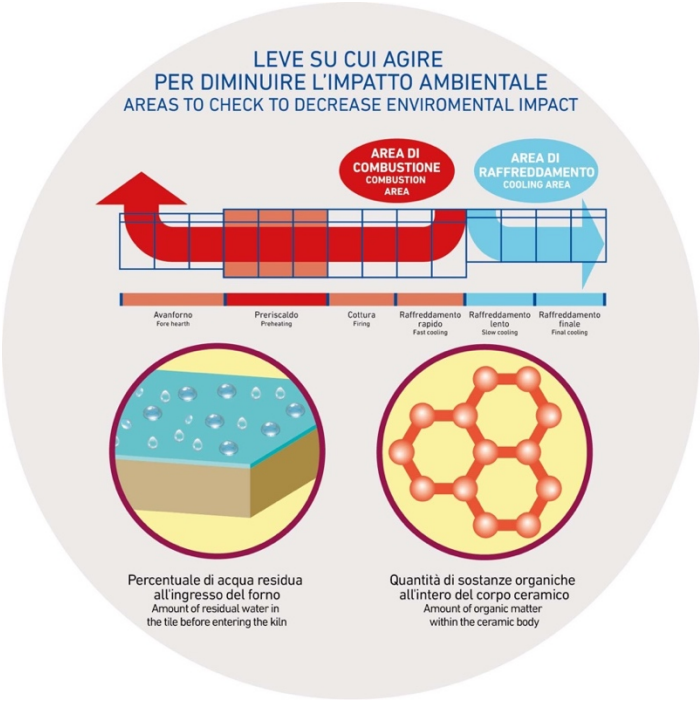
If dry applications by their very nature promote a lower environmental impact, it is also true that the proper formulation of chemicals involved in the process are useful to further reduce the impact on the environment.

How?
Through the study and development of glue formulations with attention to their possible impact during combustion.
This occurs to a large extent with the maximum reduction in the use of organic matter and in the appropriate choice of chemical compounds. In this perspective, glues' formulation must be based on molecules that develop an adequate binding power and simultaneously promote an optimal combustion process.
At this step of the production cycle, it is important to create the conditions to reduce in the following stages the serious impact promoted by the kilns.

- **STEP 5** – The firing process

The firing phase is the most energy-intensive of the entire ceramic production process and at the same time it is the most responsible of pollutants and CO_2 emissions.

All actions we have been talking about (at least most of them) are basically intended to decrease the emissions and to reduce the energy consumption that usually takes place in this last and important stage of the process.



What are the issues to be addressed?

a) PERCENTAGE OF MOISTURE OR RESIDUAL WATER IN THE TILES BEFORE ENTERING THE KILN

It should be the lowest as possible.
The water within raw tiles leads to two different problems. If the temperature gradient is not calibrated and constant, pressure phenomena, expansion and finally bursting of the tile may occur (check episode #01).
To ensure a gradual evaporation, it is essential to properly manage the times of the firing cycle that affect energy consumption and industrial productivity.

b) AMOUNT AND KIND OF ORGANIC MATTER WITHIN THE TILE

Many different gases (organic molecules) may be produced at the firing and pre-firing stages. This means that not only chemical components but also parameters and set-up of the kilns are decisive to get the best conditions and balance between energy and emissions.

What does that mean?

Just like old generation cars, older generation kilns (or even the new ones when improperly managed) are responsible for increased energy consumption and an inaccurate combustion, that turns in an increased amount of organic matter and CO_2 in the atmosphere.

The use of CHEMISTRY that minimizes emissions of pollutants and odors is a cornerstone.

For example, there are organic molecules (organic chemicals) that, due to their structural conformation, can thermally break down during the pre-firing phase only producing CO_2, small amounts of aldehydes, organic acids, and molecules with a high olfactory threshold (perceivable only at high concentrations).
In an eco-sustainable setting, it would be advisable to replace, or at least reduce, molecules that during degradation produce strongly harmful molecules such as, for example, aromatic compounds or benzene derivatives.