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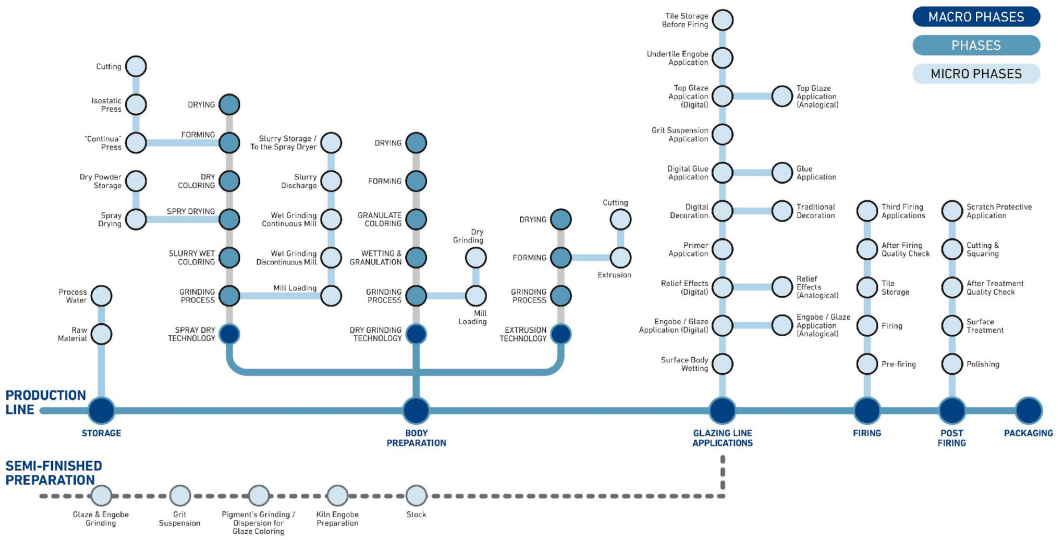
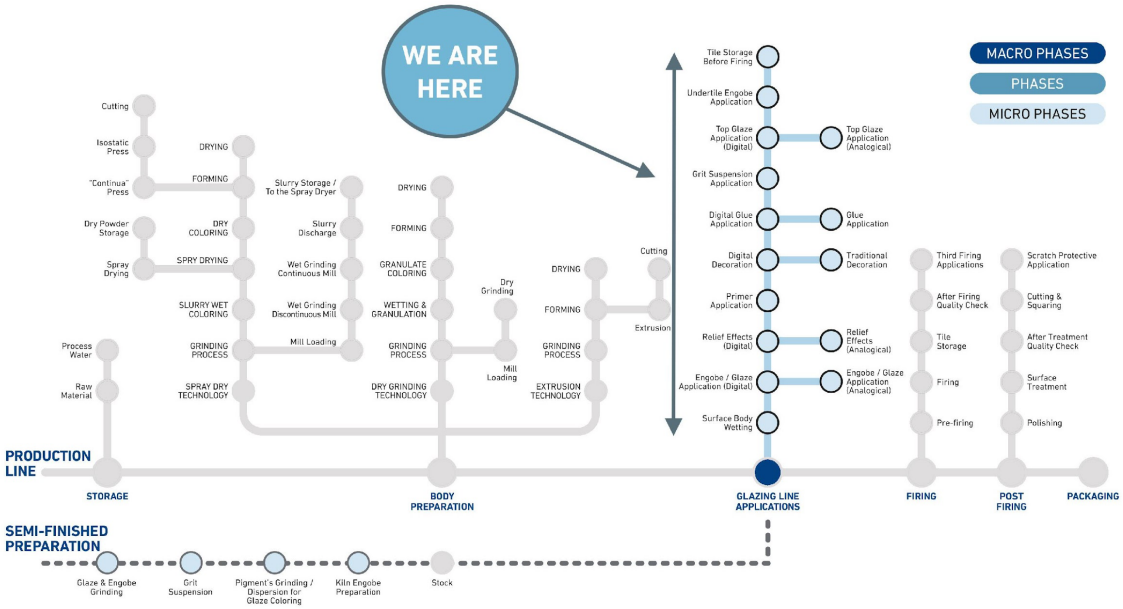
APPARENTLY INVISIBLE YET CONSTANTLY PRESENT

At every stage of the ceramic production process

A journey through problems & solutions



#47 3D SURFACES AND CERAMIC PRODUCTION: COMPARING METHODS



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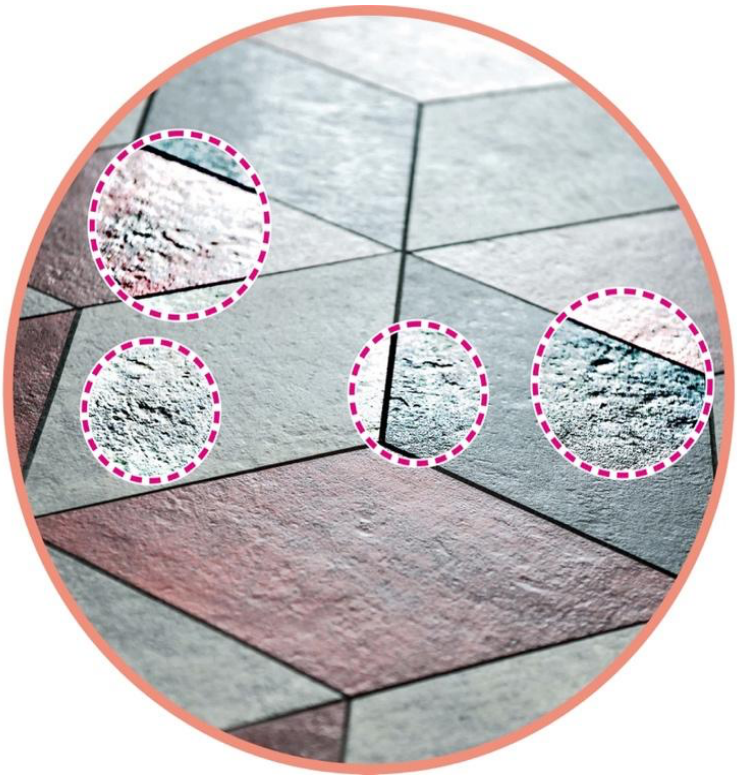
1. Introduction

Throughout its history, the ceramic industry has been a field characterized by continuous **research and experimentation**. Despite facing various challenges and setbacks, the sector has evolved from traditional, artisanal roots to a dynamic and innovative industry. Today, ceramics are not only valued for their technical performance but also for their high aesthetic standards, allowing them to compete with natural materials favored by architects and designers, such as wood, stone, marble, and resin.



A significant aspect of this evolution is the development of **non-planar, multi-level surfaces**—commonly referred to as 3D surfaces. These designs add a natural feel and expand the expressive potential of ceramic products. While the pursuit of three-dimensional effects began with traditional technologies, it has gained renewed momentum with the advent of modern digital techniques.

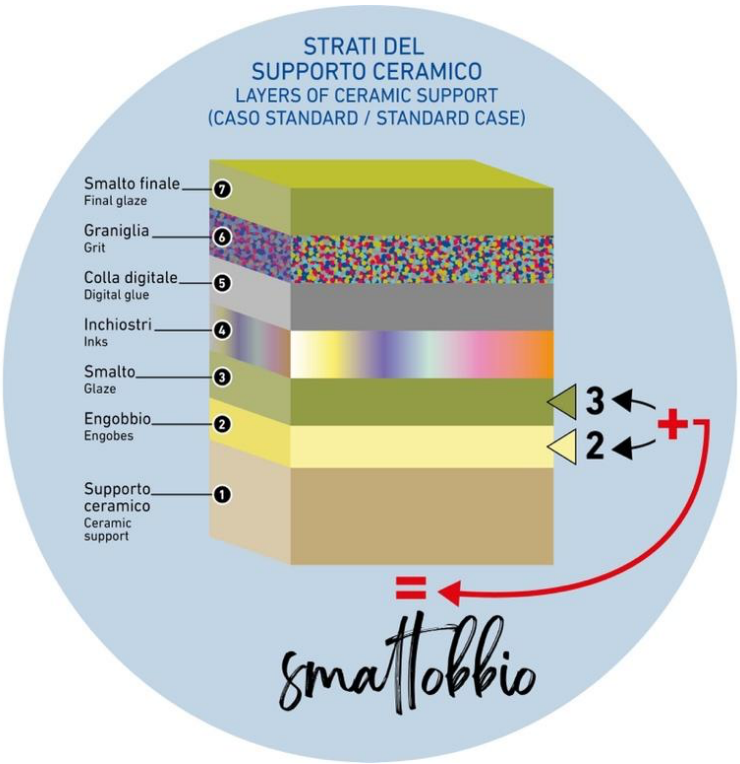
2. The logic of layers

To understand the various methods for achieving three-dimensional effects in ceramic production, it's essential to consider the sequence of application layers following the pressing or forming stage. The typical steps along the glazing line are:

1. (PRESSING)
2. ENGOBE*
3. GLAZE*
4. DIGITAL INK
5. DIGITAL GLUE
6. GRIT
7. FINAL GLAZE

Note: Steps 2 and 3 can be combined if smaltobbio is applied.

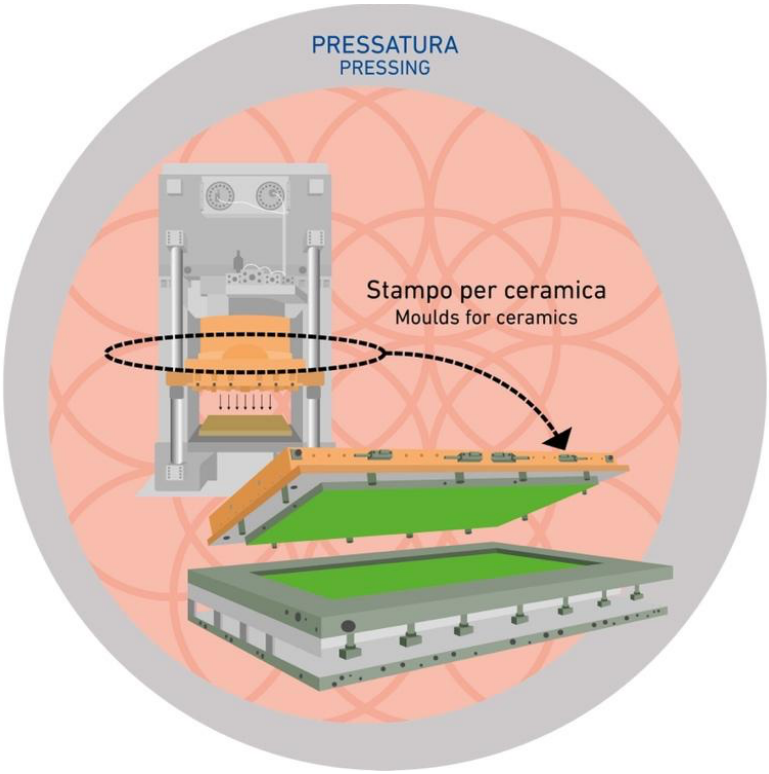
Pressing, application of engobes and/or glazes, digital decoration using pigmented inks, application of digital glues and grits, as well as salting. Each of these stages offers opportunities to incorporate techniques that produce three-dimensional effects on the finished product.



3. 3D effects during pressing

The initial stage of creating a structured surface begins during the pressing phase. Here, the raw ceramic body is shaped using molds or pads that provide the raw materials with the desired texture

or pattern, that lasts over time thanks to the clays' plastic features and the use of proper chemicals. This method allows for significant variations in surface height, emphasizing the three-dimensional aspect of the ceramic piece.
To avoid repetitive patterns in the final installation, multiple molds with different designs—referred to as "faces"—are used. Each mold creates a unique surface variation, contributing to a more natural and less uniform appearance.



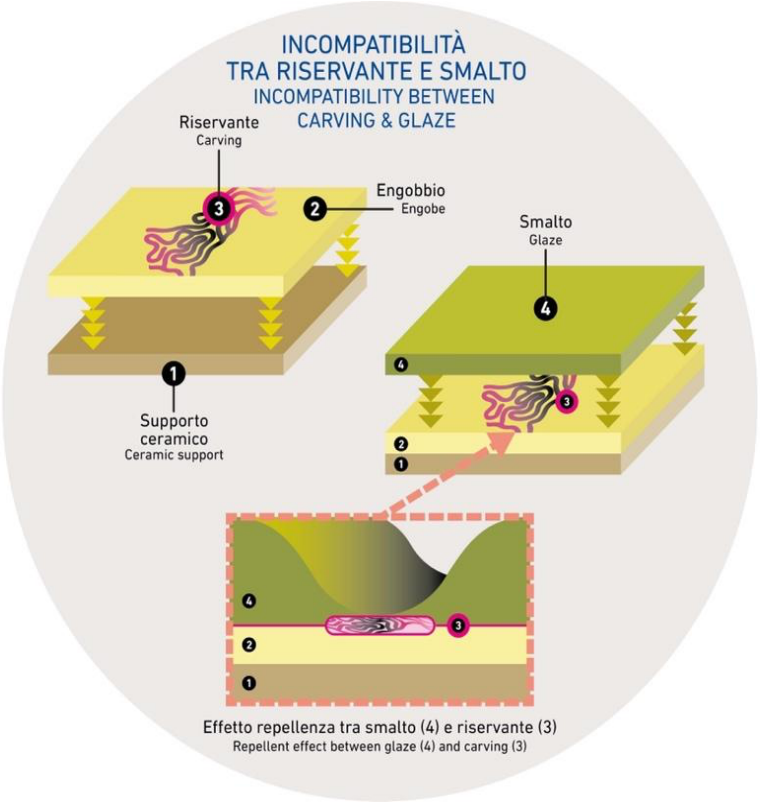
While this technique enables pronounced textural effects, it has certain limitations. That's why is not today very common. The use of multiple molds can be costly and is more manageable with smaller tile-size. Producing larger slabs or tiles with this method becomes complex and may be impractical. Additionally, despite using various molds, the final product may still show more repetition compared to the diverse possibilities offered by digital technologies.

4. Digital technology and new scenarios: water repellent agents & carvings

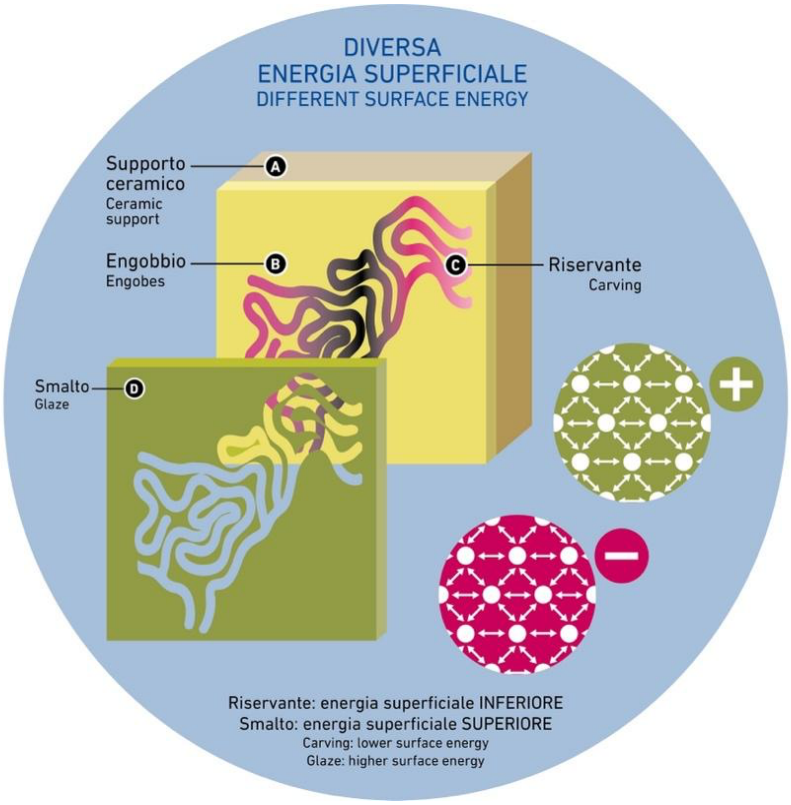
In modern ceramic production, digital printing technology plays a crucial role in creating three-dimensional structures. Digital printing machines and their applications are being integrated into various stages of the ceramic process, both upstream and downstream of the inks printing phase.
With the rise of digital technology, the market has seen the introduction of specialized products—alongside various adhesives and inks—that have unlocked new possibilities for creating three-dimensional effects. These products, applied using standard digital printers and commonly referred to as "effects," interact with the surface through specific chemical and physical reactions, helping shape unique textures and patterns.

Among these, two key categories stand out: **water-repellent agents** and **carvings**. While their final appearance may sometimes be similar, they function in fundamentally different ways.
Water-repellent agents, currently available mainly in formulations based on organic solvents, interact with the material layer applied to the surface after their use (such as engobe, glaze suspension, ink, etc.). They create a repelling or isolating effect that prevents the overlying material from adhering evenly, leading to a "lack of material" in the area where the water-repellent agent has been applied.

In other words, these products prevent the glaze layer from settling uniformly, disrupting its continuity and stopping it from forming a perfectly smooth surface. Instead, the glaze is displaced from the areas treated with the chemical agent, preventing proper adhesion. The final result is a kind of depression in the treated sections of the surface, which contrasts with the surrounding areas where the application adheres as expected.



The impact of the water-repellent agent is immediate and can already be seen as the raw ceramic piece moves along the glazing line. This effect is driven by several physical factors, with one of the most important being the difference in **surface energy** between the treated area and the rest of the surface.
Typically, the treated area has a lower surface energy than the surrounding sections, which influences how materials interact with it.



Carvings, unlike water-repellent agents, only take effect during the firing process inside ceramic kilns. They work by interacting with the material beneath them—usually the glaze—triggering a chemical reaction that increases its fusibility in specific, localized areas. This causes the glaze to sink, creating slight depressions on the surface. This process is driven by special melting / flux agents with a carefully designed inorganic composition. These agents selectively accelerate the melting of the glaze in targeted spots, rather than across the entire surface. As a result, a three-dimensional effect emerges in the treated areas, but it only becomes visible after the firing stage.

FOCUS: SURFACE ENERGY

In materials science, surface energy (also known as interfacial free energy or surface free energy) quantifies the disruption of intermolecular bonds that occurs when a surface is created. It can be defined as the excess energy present on the surface of a material compared to its mass, or as the work required to create a given surface area of a material. Materials with high surface energy tend to attract other molecules, affecting processes such as wettability and adhesion.

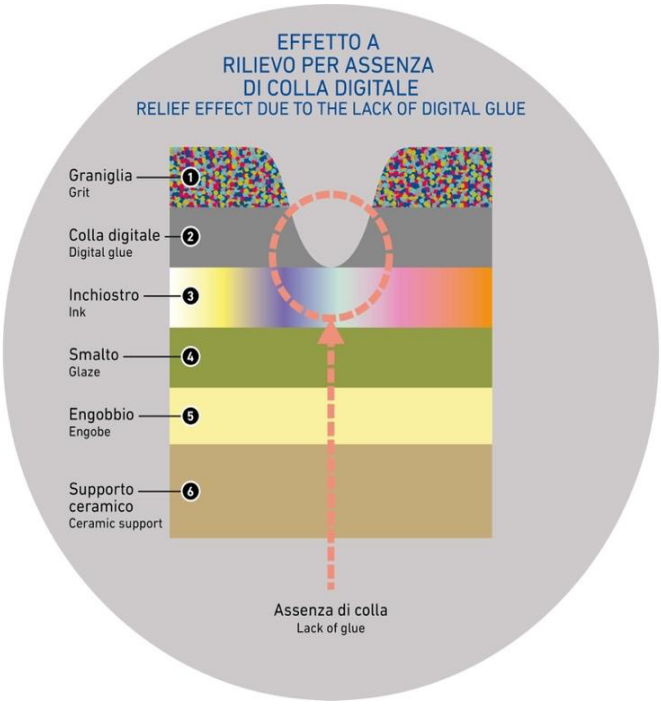
For example, when water comes into contact with a surface marked by high surface energy, like metal or glass, it maximizes contact by forming a thin film, resulting in a wet surface. In contrast, on surfaces with low surface energy, such as polyethylene or Teflon, water minimizes contact by forming spherical droplets, leaving the surface unwetted.

5. Water-repellent agents and carvings: application phases

The application of digital products like water-repellent agents and carving requires the use of digital printers. Depending on the printer's position within the production line, these products can affect different layers of the ceramic substrate.
For instance, some manufacturers put a digital printer before the dryer, allowing water-repellent agents to be applied directly onto the freshly pressed ceramic body. This approach directly influences subsequent applications, such as engobe or glaze. In other setups, multiple digital printers may be used to enhance the three-dimensional effect through the combined action of various products applied at different stages.
The choice of application points and the sequence of layers depend on the desired final effect. Without over-simplifying, applying products earlier in the line can result in more pronounced height differences, while applications closer to the final glazing stage may produce subtler textures.
To achieve the best results, or at least to maximize the effect of the water-repellent agent, it is essential that any subsequent applications—such as ink or grit—are precisely aligned with the structure formed in the earlier stages of the process.

6. 3D surfaces and digital glues

Another method for achieving three-dimensional surfaces involves the use of digital glues. Applied via digital printers, these glues—whether solvent-based or water-based—serve as adhesives for materials like grit. In this process, the glue is not applied uniformly but is precisely deposited according to a digital design. The grit adheres only to the glued areas, increasing the surface thickness where applied and leaving unglued areas recessed. This selective application creates a structured surface with varying heights.



A key advantage of using digital glue is the ability to control different thickness gradients based on the amount of glue applied, allowing for precise definition of the desired three-dimensional design.

The effectiveness of this method depends on the rheological properties of the glue, which must be carefully formulated to ensure good print definition and stability during processing. Not all digital glues are suitable for this purpose; their performance varies based on their specific characteristics defined within the labs.

Currently, the use of digital glue is a popular method for creating structured effects. The setup can vary, with the glue being applied immediately after digital inks, spaced between color applications, or just before the grit application using a dedicated digital printer. The optimal configuration depends on the specific product and desired outcome.

7. Textured Surfaces and 3D Glazing

Recent advancements have introduced digital machines capable of creating three-dimensional effects through calibrated glaze applications. In this method, glaze is applied to the substrate before digital ink decoration, following a specific design to impart the desired structure.
The glaze is then dried, maintaining the imparted texture. Subsequent applications are aligned with this structured design, and the material is then fired. Achieving a significant aesthetic effect requires precise alignment of all applications, including structure, graphics, and any additional layers.
As with digital glues, the glazes used for this purpose must possess specific rheological properties. The most important are:

Controlled leveling:
The machine precisely places the material on the tile surface, ensuring that the glaze forms a well-defined pattern. If the glaze spreads too much, the details can become blurred—droplets may expand excessively, causing a loss of sharpness and definition in the design.

Perfect rheological stability over time and no sedimentation:
These properties ensure that the glaze can be efficiently processed by the system and applied using the machine without issues such as clogging in tanks or hydraulic circuits, ensuring consistent quality.

Well-balanced lubrication:
This prevents the material from drying out inside the nozzles, ensuring smooth application during production.

Reasonable drying times:
Excessively long drying times can negatively impact subsequent applications, including firing, potentially leading to defects—and in some cases, even causing tiles to explode in the kiln.

While these are the key guidelines, each scenario must be carefully analyzed on a case-by-case basis to ensure the best possible outcome.

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