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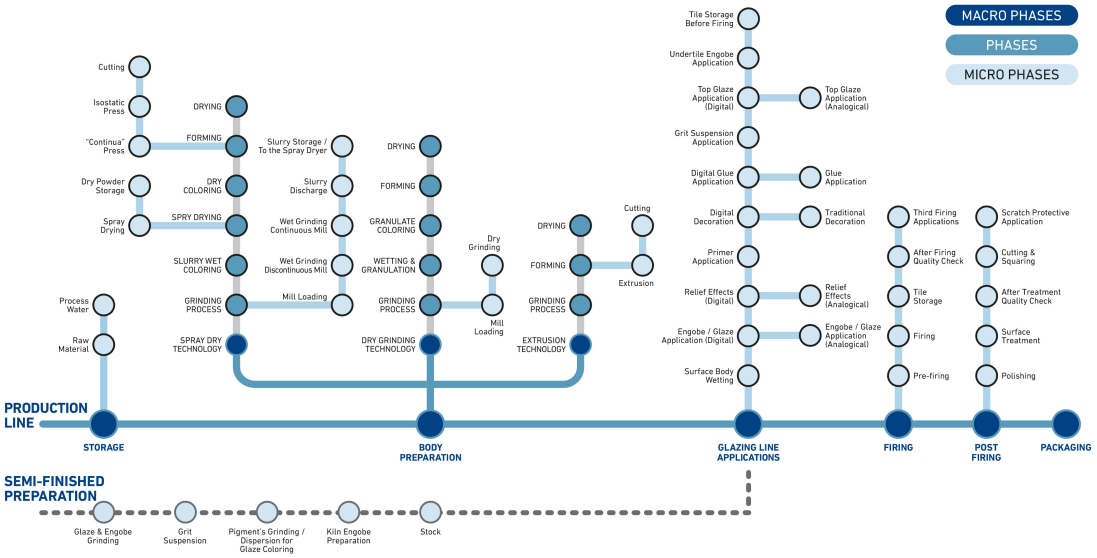
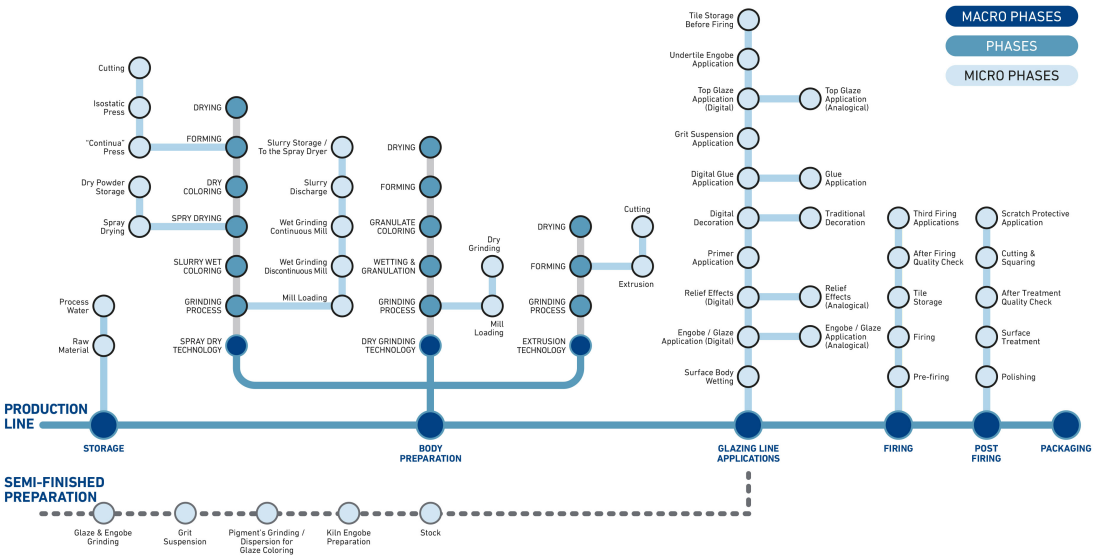
APPARENTLY INVISIBLE YET CONSTANTLY PRESENT

At every stage of the ceramic production process

A journey through problems & solutions



#37 PLASTICITY OF CERAMIC MIXTURES: VALUES & APPLICATION FIELDS



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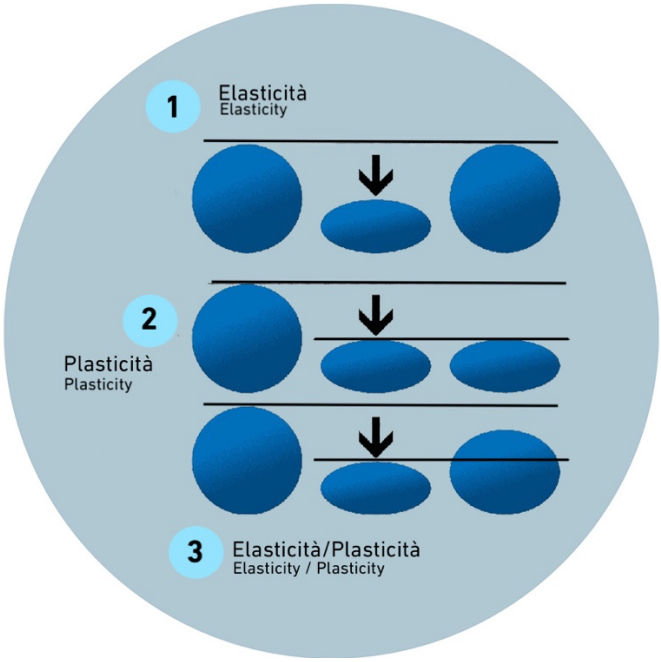
1. INTRODUCTION & DEFINITION

Clays - which together with feldspar, sand, other raw materials, and water form the basis of ceramic mixtures - are marked by several and different properties. **Plasticity** is perhaps one of the most surprising: a feature that makes the clays extremely ductile, to the point that it is possible to give them unimaginable shapes without reaching their breaking point.



DEFINITION

Let's start with a textbook definition.

In physics and materials science plasticity, or plastic behaviour, is the ability of a solid to undergo large irreversible changes in shape in response to applied forces.

In the case of some metals, low forces applied to the sample may cause an elastic reaction: with each increase in load corresponds to a proportional increase in deformation but when the load is removed, the sample returns exactly to its original shape.

However, once the load exceeds a certain resistance threshold (technically called yield stress), the deformation more significantly increases and, when the load or force is removed, the sample continues to keep the deformation effect: this is what is called plastic behaviour.

The transition phase between elastic and plastic deformation is called yield strength.

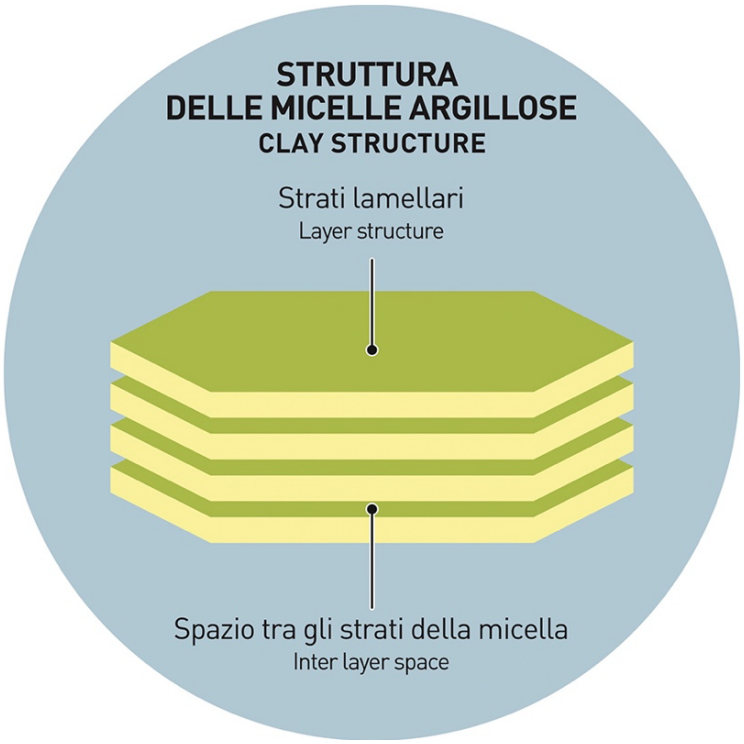
In this regard, the plasticity of ceramic mixtures is a very sensitive data that can negatively or positively affect some production phases of the ceramic production process. It is, for example, a very important property for the proper creation of the ceramic support during pressing or forming.
In the ceramic field, the degree of plasticity required can (and must) change according to the type of product that has to be produced.

2. WHAT DO AFFECT PLASTICITY VALUES?

Plasticity is a property whose values depends on several elements.
These include:

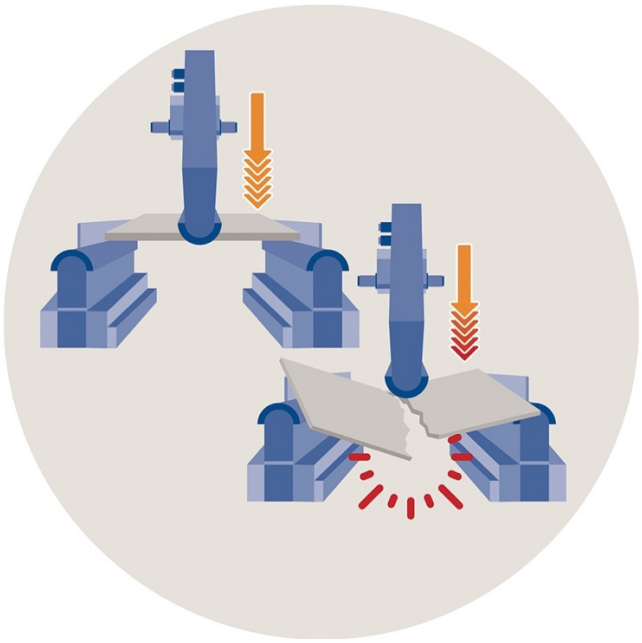
- Kind and internal structure of the material
- Condition under which the deformation is applied
- Size and shape of material's particles
- Mineralogy of the material
- Presence of impurities in the matrix

In the specific case of clay, the electrolytic feature of the overlapped flat particles (that form the lamellar structure of micelles) plays a decisive role in providing the clay with an important plastic power, with all due distinction between one type of clay and the other.
The interaction between clays and water makes the clays moldable and their plasticity is what makes possible the formation of the support that, once it has been dried inside the dryers, keeps its new shape.



Of course, not all clays are the same: each of them can be marked by a different degree of plasticity and therefore ceramic mixtures may present, also in this respect, different properties depending on the features of the materials that make-up the mixture.
In general, we can say that more fatty clays are present, the greater will be the plasticity of the ceramic mixture.
Fatty clays, in fact, stand out for their important plasticity, being marked by a higher concentration of clay minerals and a low concentration of siliceous clays. Lean clays, on the contrary, are well known to the ceramic producers for significantly being less plastic, we could say more "sandy" and therefore more brittle and more difficult to process.

This is the reason why it is important to add a detail about the relationship between clay's plasticity (and therefore ceramic mixtures) and mechanical strength of raw ceramic supports (both green and dried).
The mechanical resistance of raw tiles, in fact, almost entirely derives from the presence of plastic clays inside the mixture that, however, can be the main responsible for the difficult fluidization of the suspension.
Plastic clays, in fact, since they absorb significant amount of water, force producers to increase the quantity of water inside the system (the barbottina) in order to let the clay to more easily flow.
An excessive reduction of plastic clays - which could be useful to increase the density of the barbottina, also thanks to the simultaneous decrease in the water volume - is however not advisable and in some ways not feasible, unless you want to negatively affect the mechanical resistance of raw tiles. This is a rather delicate balance that has to be controlled to reach the right compromise between the parameters of the production line and the different needs of each ceramic producer. The important thing is to give the piece the right and desired shape, preventing it from deformation during the firing stage (and this is true not only for the tile production field).



Lean clays can negatively affect mechanical resistance but sometimes they must be chosen and necessarily used.

3. CERAMIC MIXTURES MARKED BY LOW PLASTICITY VALUES

A low plastic ceramic mixture can be more difficult to handle, and once dried, it is more easily exposed to cracks, since the mechanical resistance values are surely lower than those of a mixture composed of a greater percentage of fatty clays (more plastics).
A less plastic ceramic mixture is also marked by a lower capacity to absorb water, and this is not necessarily negative. This feature, in fact, can positively affect the drying times: a lower water content is synonymous with a shorter evaporation time, which in terms of energy consumption is not entirely negative.

4. INTENDED USE OF LOW PLASTIC CERAMIC MIXTURES

The scenario may suggest a poor use of low plastic ceramic mixtures but this is not the case. Beyond the changes ad adjustments in rheological parameters by using proper and specific chemicals (temporary binders, dispersants, etc.) and required for a proper application process, this type of ceramic mixtures can be sometimes perfect for some kind of production fields (surely not in tile production). What are these fields?
For example, technical ceramics which are widely used in many industrial applications. Technical ceramics, in fact, are somehow changing some industry sectors thanks to their high-performing properties in terms of resistance, thermal conductivity, electrical insulation, and chemical stability. These qualities make these materials suitable for several sectors of engineering, automotive, aerospace fields, and even for some areas of renewable energy.

Because of this wide and heterogeneous variety of applications, ceramic mixtures can be marked by very different features and properties and this is the reason why it is always important to make a choice according to the intended use of the material.
Simplifying, it is possible to say that in this field ceramic powders are used unmixed: a single component or at most a mix of very few components (and the range of materials is very wide: alumina, silicon carbide, zirconium oxide, etc.).
Depending on the chosen material, the ceramic mixture will be characterized by some properties rather than others but, in general, there is always a common denominator: low plasticity.

Low plasticity values necessarily call into question the use of chemicals that aid the production process by making the material processable and providing it with the parameters required by the application.

It is also important to add that the forming techniques used in this field are heterogeneous. For example, isostatic pressing, injection moulding, computational numerical control, film casting or extrusion processes.

5. HOW TO IMPROVE PLASTICITY VALUES

If plasticity values of ceramic mixtures depends to a large extent on the raw materials, it is clear that in the production of ceramic tiles and sanitaryware sometimes the clays involved are marked by not very plastic features. Especially when raw materials are hard to find.
Once again, the process required chemicals able to play a decisive role by adjusting the requested parameters. A role that, however, may not be decisive if no collateral actions are taken (raw materials and main production parameters).
In general, the main actions of these chemicals provide ceramic mixtures with a greater binding and tenacity power.
In other cases, plasticizers may be used, facilitating the forming or pressing process.
In general, it is important to underline that these different products have often to be combined, and that dosages can significantly affect the final result.