REPORT

CRACKS: A TECHNICAL AND NATURAL SOLUTION

Borregaard

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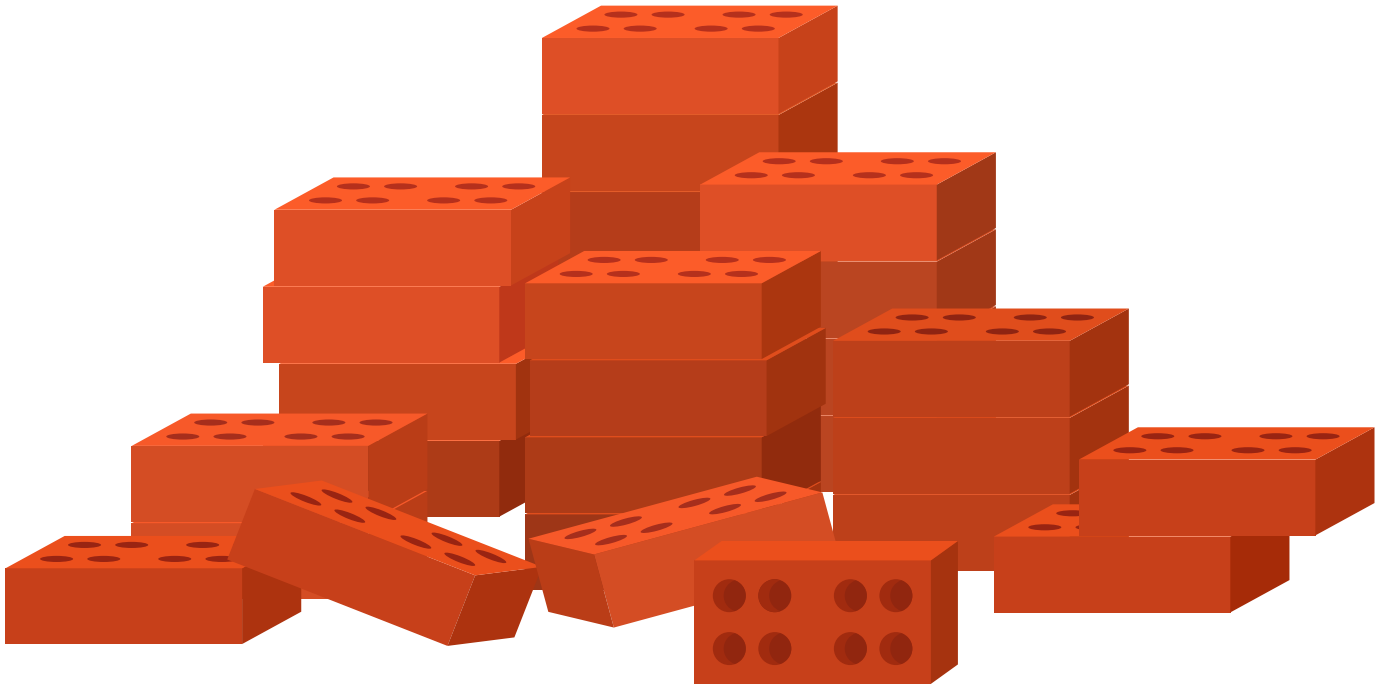
INTRODUCTION

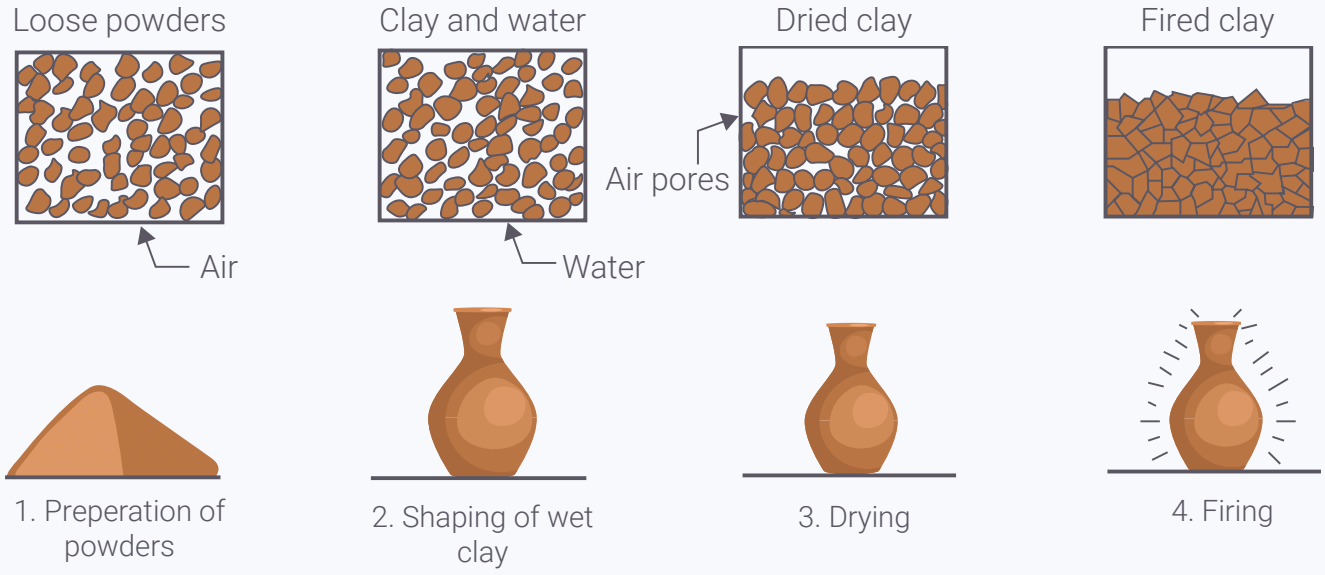
Cracks are a recurring problem in ceramic production. Causing an immediate shortfall in visual quality they originate from weakened mechanical strength and eventually result in the ceramic bodies not being able to perform the tasks expected of them.

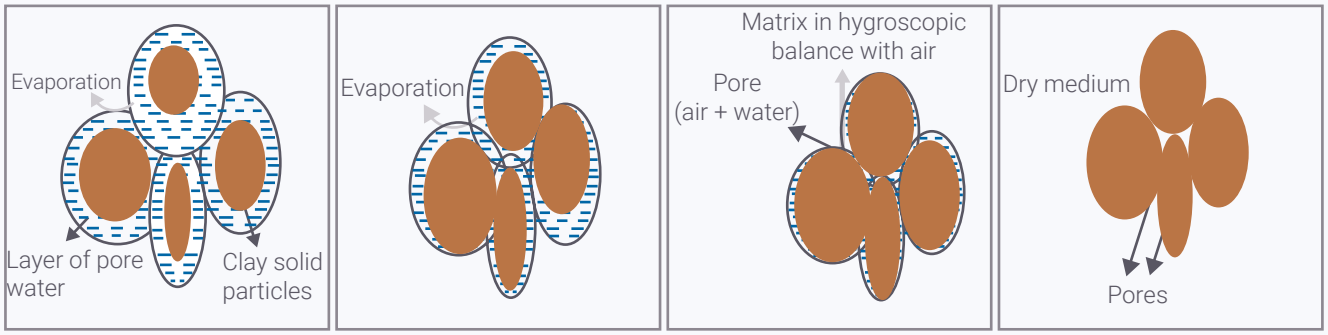
We are going to summarise some reasons why cracks appear and how to solve them.



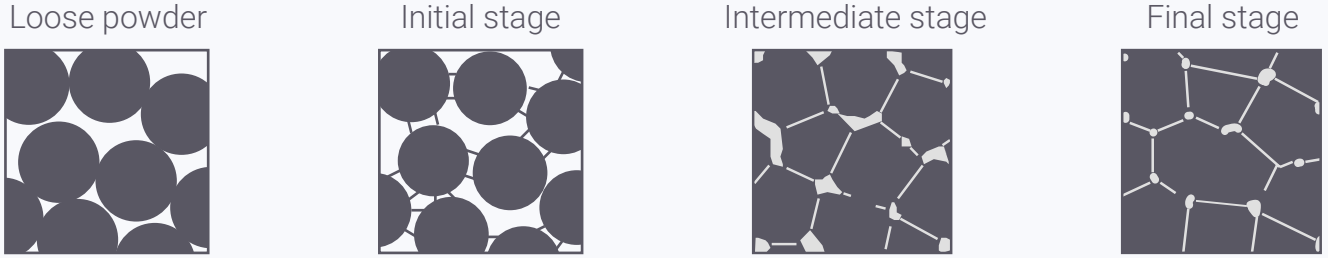
DRYING PROCESS

The drying process is always a challenge, keeping in mind that there are structural changes in the ceramic bodies as a consequence of the exiting of water from the structure.





Schematic representation of the shrinking mechanism in a clay matrix during drying.



As seen in the previous illustration, particles in the initial stage of a wet system process present better packing than the loose powder. However, when reaching the intermediate stage they shrink as a consequence of having lost water and some of the space occupied by the solid mass. If this shrinkage process does not occur in a gentle way, cracks may appear, causing loss of quality and functionality.

There are various methods of checking how critical the drying process can be - the Bigot curve being one of the preferred ones in the industry.

In order to determine such a Bigot curve, or drying curve, weight and shrinkage is measured during the drying process. Drying is completed when no further weight variation is detected at a certain temperature in the drying temperature range.

Once data is collected, we can plot the relationship between water content and time and the ratio between determined length vs. the final (dry) length and its relationship to the water content. This can be seen following the plant trial shown at the end of this report.

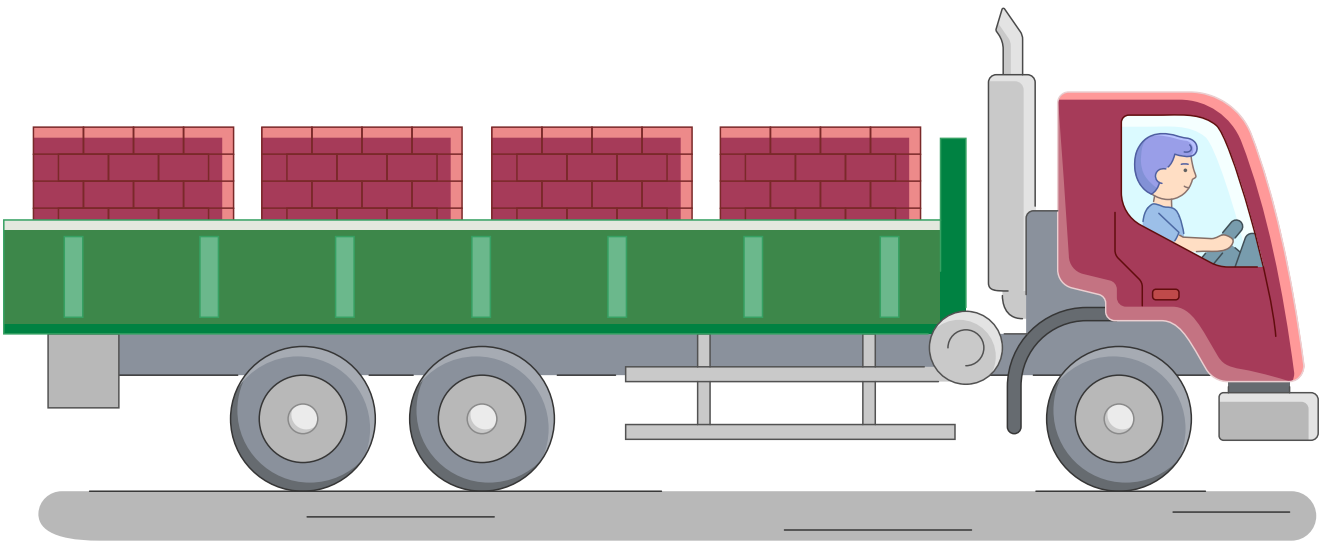
HANDLING IN GREEN/DRY

In many cases, handling is not performed in a gentle way, thus some pieces will be in rough contact with each other leading to potential cracking. It can be especially challenging when some work along the production process is performed mostly by hand, or where the full kiln cars suffer shocks while being transported.

Some of this contact may bring potential losses which might be easily remedied with automation or by use of strength enhancing additives well known to the industry.

CHANGES IN THE FORMULA

In some instances a change in the body formulation, including the use of non-plastic materials, may bring some relief from drying cracks, but extrusion will be much more complicated due mainly to the lack of plasticity.



CASE STUDY: ROOF TILE FACTORY

We started collaboration with a customer because the clay used in their production was not very plastic. To increase plasticity they had carried out work with several different chemicals, which although bringing plasticity generated cracks in the finished product.

These are examples of the cracks generated along the pressing stage, mainly due to the lack of plasticity of the clay.

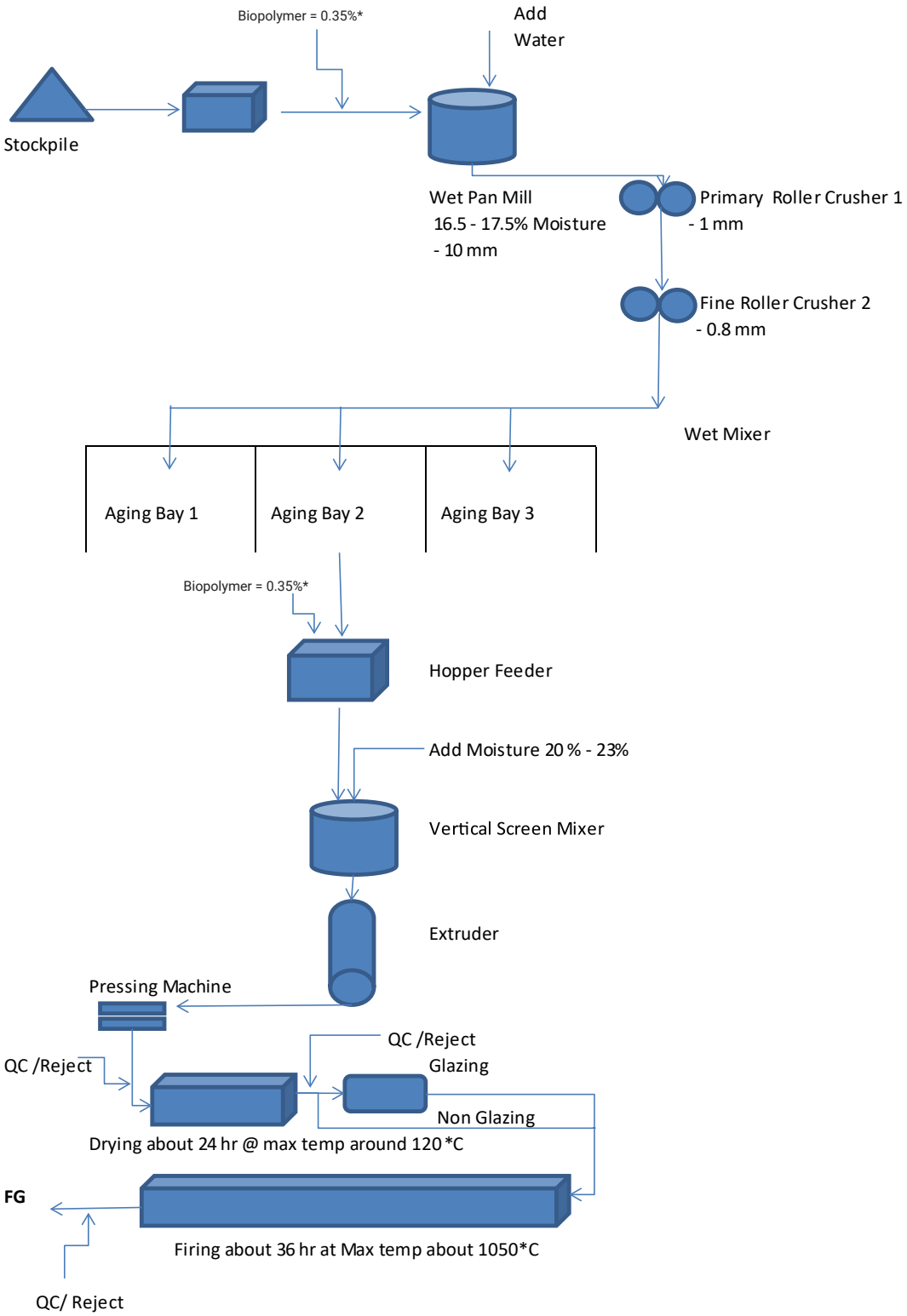
Compare with a tile manufactured with one of our clay conditioner additives we can see a huge difference.

Tiles will not necessarily exhibit cracks until fully dried, demanding another screening step along the production process

Rejection at this point was greater than 7%, but was completely eliminated through the use of our additive.

MOULDING OF THE CLAY

THE PRODUCTION PROCESS WAS LIKE THIS:



**Additive can be added at two different stages in the process - before ageing or after ageing.*

To check the improvement that our additives can bring to the process, a monitoring toolkit was used. A few parameters that were controlled using state of the art equipment:

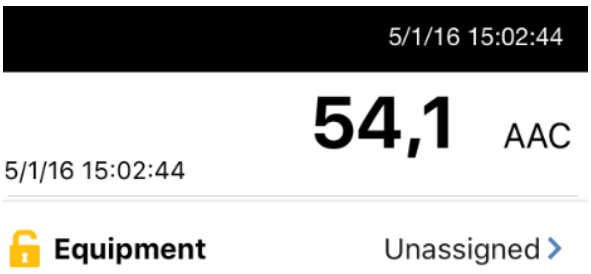
AMPERIMETER

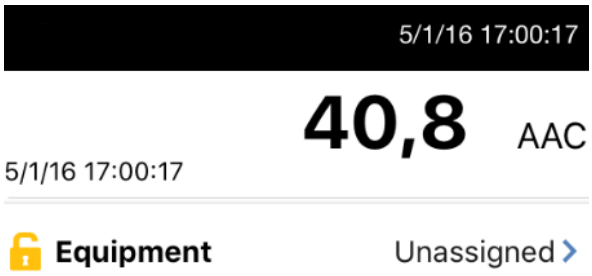
RETRACTOMETER

THERMAL SCALE

With these tools, required information was collected and it helped in preparation of the curves explained earlier.

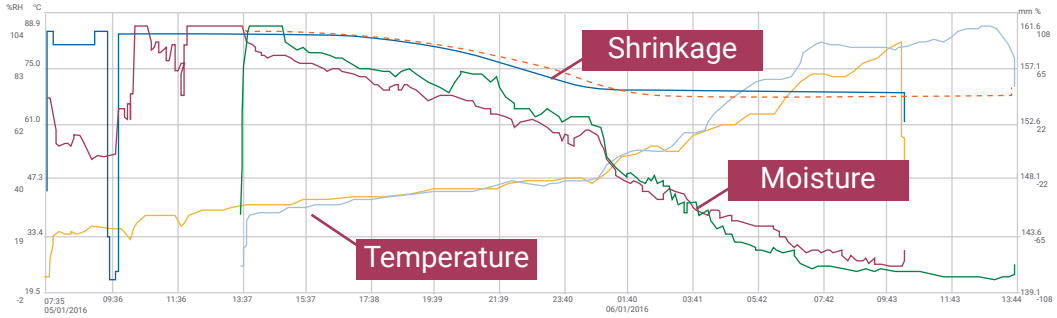
We were also able to monitor improvements in power consumption in the clay extrusion and later shaping of the clay:



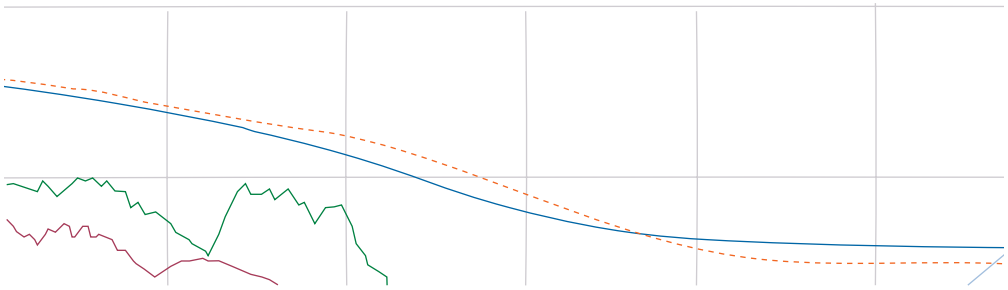


The information collected by retractometer and scale were plotted to check variations in the curves, which may indicate potential for crack generation:

In orange and discontinuous line: No BioKeram / In blue: BioKeram 215 @0.7%



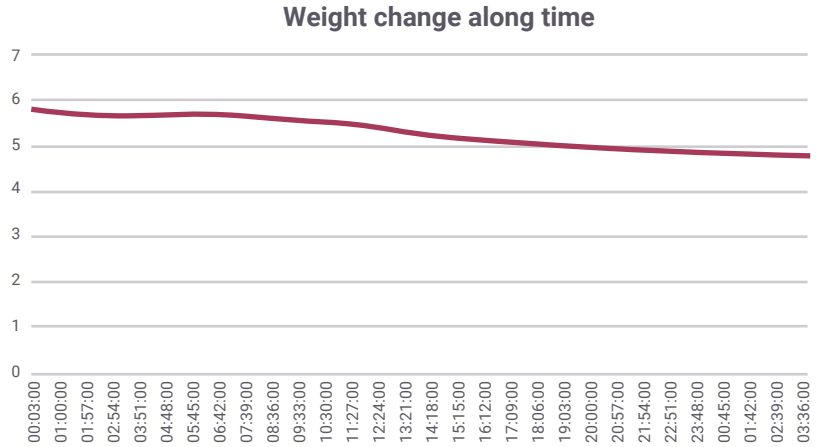
We magnify the area where main shrinkage occurs



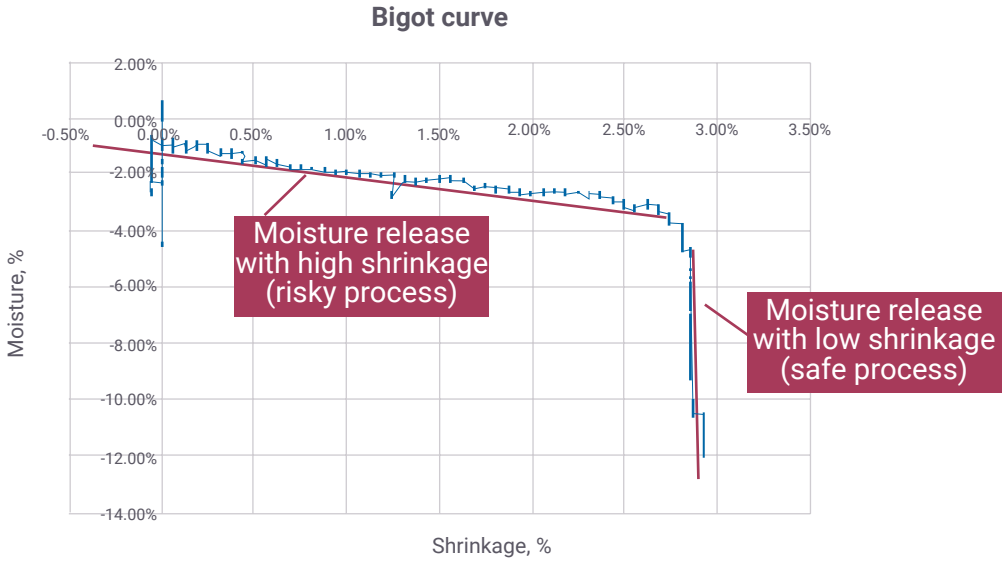
The “bumps” or “shoulders” in the standard production line show a non-linear behavior, meaning that some pyroplastic tension may appear, leading to potential cracks in the final products post drying and firing.
With the introduction of our additive the curve is much smoother, generating no tension in the tiles and reducing the potential for cracks through the drying process.

With all these points, we can plot the following curves:

- Relationship between water content and time:



- A Bigot curve, plotting moisture release vs shrinkage:



In the final graph, we can see the two different sections along the drying process:

- Initial drying: in this segment water that is free, or that has been added is removed. It is responsible for most of the shrinkage of the final product. Hence, it becomes the most critical part of the drying process.

- Final drying: at this stage, most of the water is vacated from the specimen, but not a large shrinkage will result as the body has already collapsed in the previous drying stage, allocating most of the free space.

- When using one of our clay conditioner additives there is almost no transition zone between risky and safe regions, where temperature variations can potentially cause a number of issues in the process.

CONCLUSIONS

With use of a Borregaard additive

- Power consumption at extruder is reduced ~10% average
- Shrinkage while drying is much smoother and more linear
- Weight loss has been tracked and it shows a bigot curve with two separated regions and good slopes to avoid cracks in the tiles after drying
- Raw surface appearance is much better, not presenting cracks or void areas in the tile
- Cracks are reduced from >7% to almost nil

ABOUT US

Borregaard operates the world's most advanced and sustainable biorefinery. By using natural, sustainable raw materials, Borregaard produce advanced and environmentally friendly biochemicals and biomaterials that replace oil-based products. Our world-wide network of production facilities and sales offices assures the very best local service and competence where you need it. For us, providing our customers with the most dedicated technical assistance is key. Therefore, the company invests considerable resources in research and development. We continuously strive to develop wood based renewable products for new applications, and through that we contribute to delivering present alternatives to oil based synthetic products in a wide variety of industries.

If you need more information please contact us:

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