REPORT

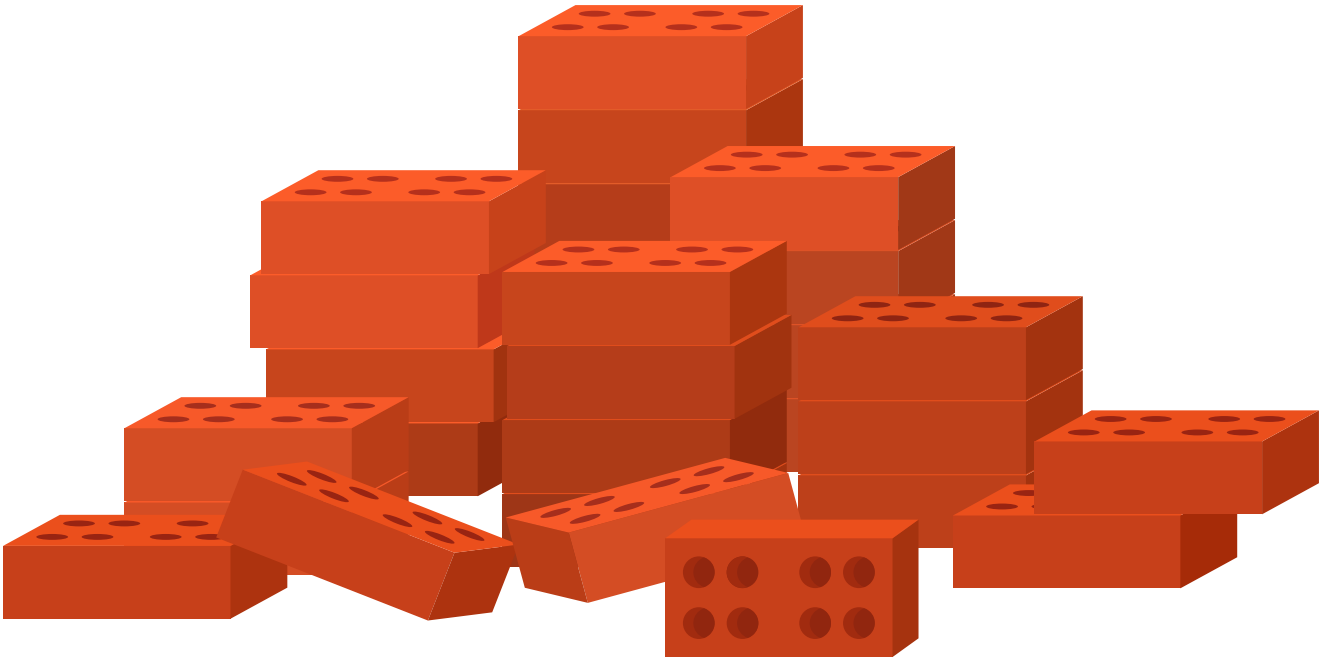
USE OF CLAY CONDITIONERS TO OPTIMISE PRODUCTION EFFICIENCY

Borregaard

CONTENTS

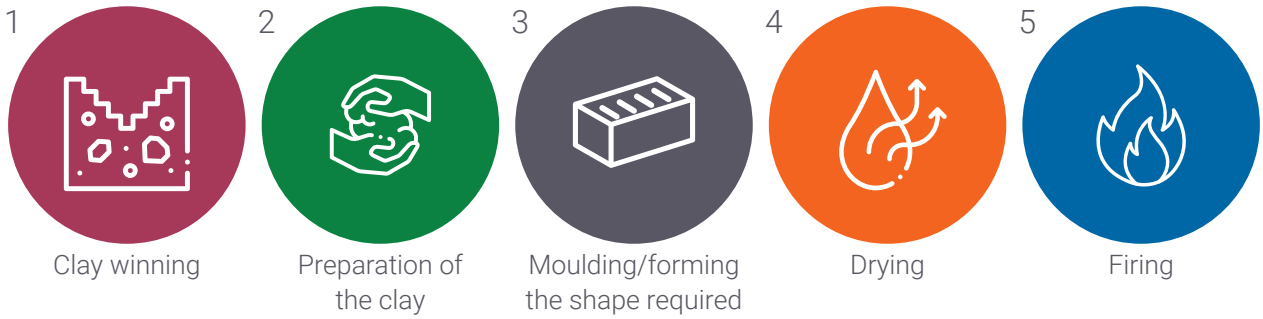
INTRODUCTION

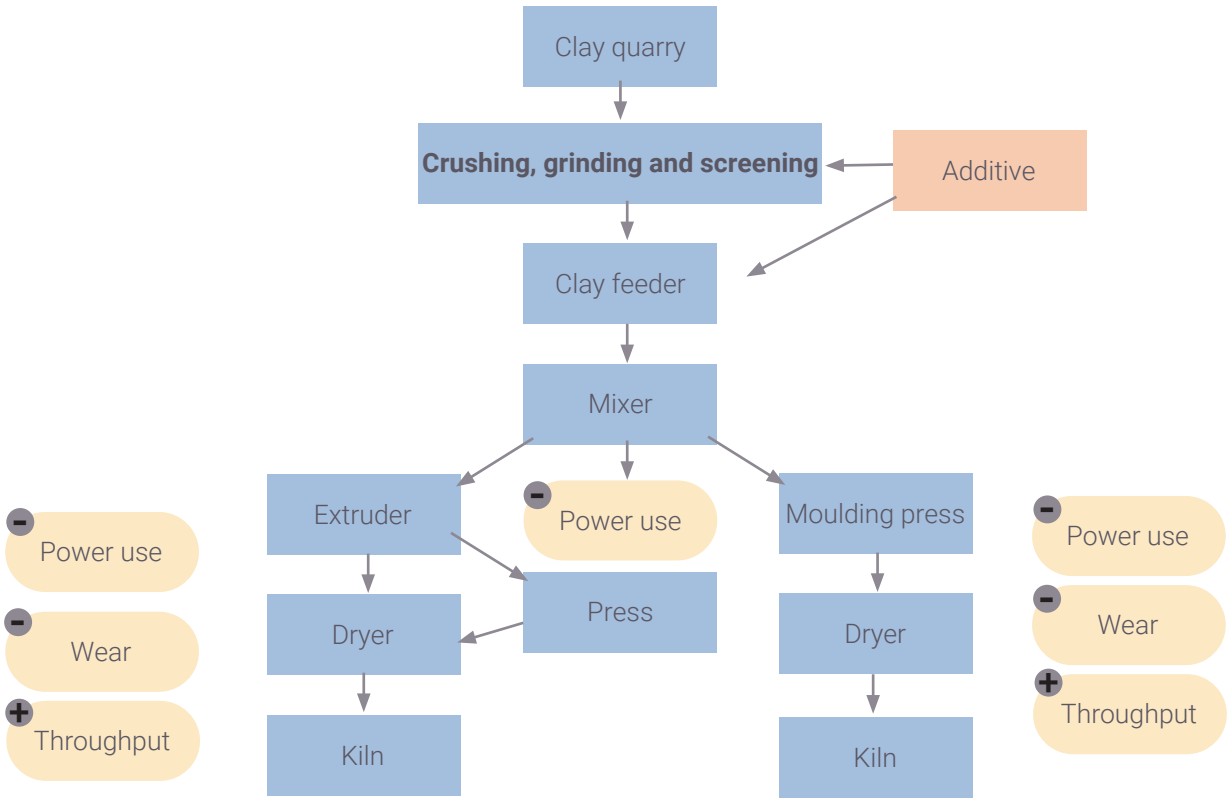
Mud bricks were among the first building materials, molded by hand and dried in the sun for days. Later, bricks and roofing products were made from clay and fired in kilns to create strong, lasting materials. The raw materials required to make these products were plentiful, and brick/tile-making quickly became an industry. Bricks and tiles are both commonly made from a combination of different clays and sand. The mineral content of the clay helps determine the colour of the finished product. For example, the presence of iron in the clay forms red bricks. Bricks, and later tiles have been used by every culture, from the Ancient Chinese to the Romans and ever since. People have viewed brick as more durable material than wood due to its resistance to fire, rot and pest attack. Bricks have been used to build everything from homes to barriers to tombs. In modern times, bricks and clay shapes have been used to create outdoor living spaces like patios and bars, as well as for decorative uses, including flowerpots, mailboxes and landscaping decor.



CERAMIC MANUFACTURING PROCESS

In general terms there are 5 steps in the production of a clay brick or roof tile:





Example of two types of structural ceramics manufacturing process and how using clay conditioners can optimise the process.

For the main purpose of this article we will concentrate more on the moulding/forming and drying of the articles with some references to clay preparation and firing.

PREPARATION

Once the clay has been won it has been the norm to produce a stockpile of these different clays and leave them open to the elements of the weather for long periods of time from a few months to over a year. This process is called weathering and allows for a more homogenized clay, the removal of unwanted soluble matter and breaking down of agglomerated particles.

When ready to use the clay will be fed through box feeders and placed in pens for storage, allowing for various body recipes. At this stage a number of "additives" can be used such as waste from paper processing, sawdust, coal dust, rice husks or similar cellulose based products. As a rule, although not exclusive the blended clays are then fed through a primary crusher to reduce the initial particle size. The clays can then be either dry processed through pendular or hammer mills, or wet processed via a wet pan or a type of disintegrator. The final process includes passing the clay through a series of high speed rollers set at different apertures to reduce the clay to the particle size required for production.

This final processed clay can now take one of two manufacturing routes – either straight to the forming machine or placed in large indoor storage silos. The latter option is commonly known as "souring," whereby water is added to the clay and it is then left for a period of days to months. During this rest period the water spreads via capillary action and the clay undergoes necessary changes resulting in a more homogenous body, ready to be worked.

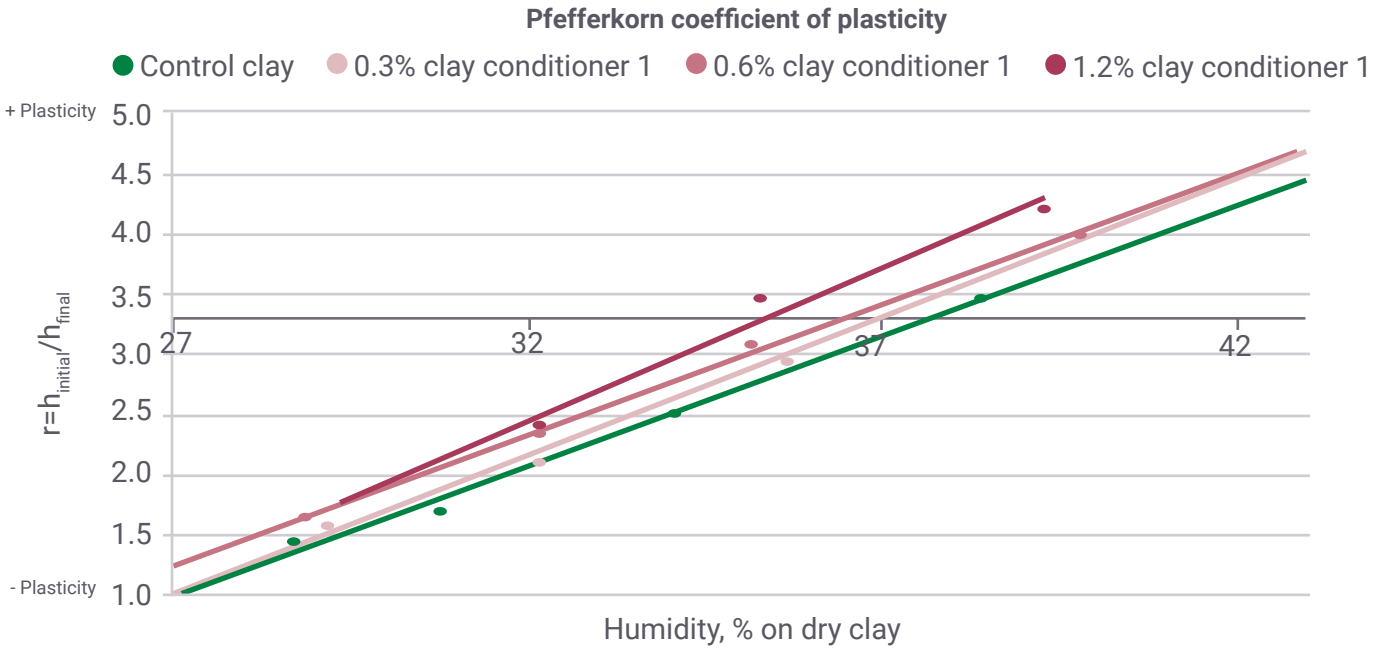
Depending upon your production requirements this period of souring may leave you working hand to mouth awaiting clay for your production. Should this be the case and you would still need the benefits of souring, but for a shorter time period, then the use of clay conditioners/biopolymers may provide a quick, cost effective solution. They work in the same way as water in that they spread via capillary action, lubricating the inner clay particles and improving workability. This in turn allows the clay to reach its optimum performance level much quicker than by traditional water souring.

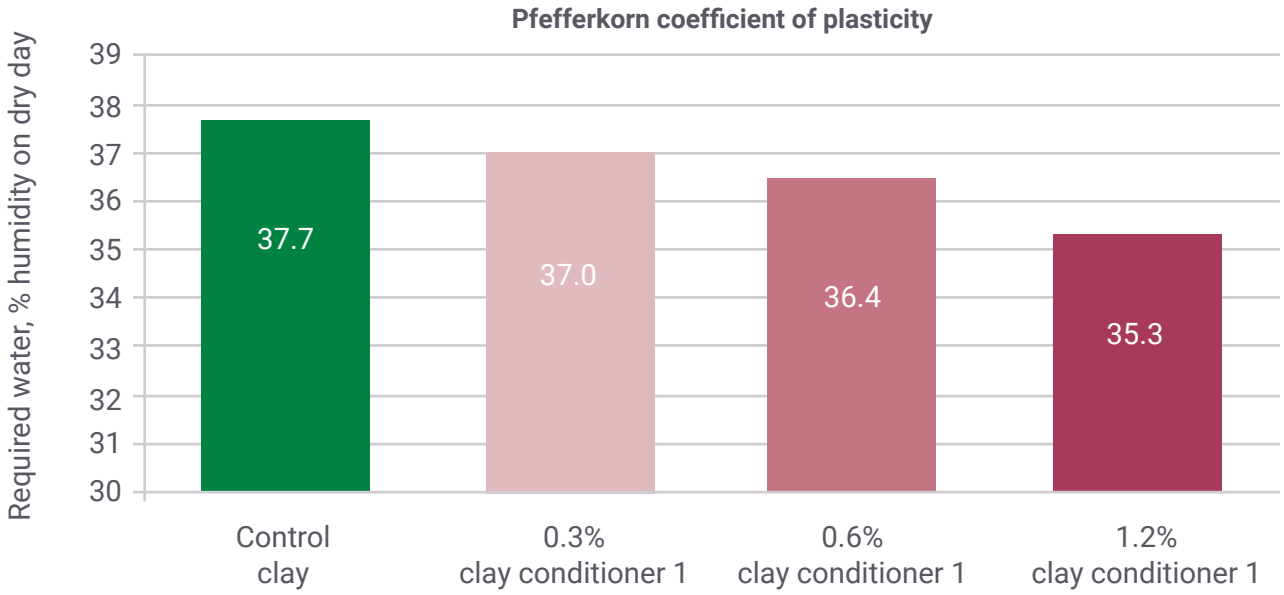
Low plasticity, cracked clay

High plasticity clay due to additive addition

INCREASED WORKABILITY AND PLASTICITY

The raw materials you have available may include a number of low plastic clays, high shale clays, sands and coarse inert minerals which may hamper the workability of the processed clay body. To overcome this, a number of companies have reverted to the purchase of expensive imported plastic clays, incurring extra production costs. Through the use of biopolymer clay conditioners the quantity of these expensive clays can be reduced or even replaced with lower plasticity clays. For those factories limited to use of low quality clays or high shale bodies, conditioners have been proven to increase workability. These products provide internal body lubrication of the particles to help increase workability and plasticity.





MOULDING OF THE CLAY

EXTENDED LIFE OF MOVING PARTS

Once your clay body is ready for production there are four common routes open to you for brick making - extruded, soft mud, water struck and hand thrown. For roof tile there are three common methods – extruded/ machine pressed, extruded and hand pressed.

1. Extruded clay bricks – these can either be solid or perforated, and the size and moisture content of the clay can vary depending on country and application. They can be sold as engineering (Class A and B, both red or blue), insulating, facing or common. Whichever type of finished brick, the extrusion process is quite universal.

2. Soft mud bricks – these can either be solid or frog, and can vary in both size and moisture content depending on mould size and application.

3. Water struck bricks – these will almost always be a solid brick using water to lubricate the mould and to strike the brick from its mould and give it a unique surface finish.

4. Hand thrown bricks – these are the original soft mud brick produced by hand and will either be solid or frog with a multitude of various finishes and appearances.

5. Extruded clay tiles – shape and dimensions are dictated by the extrusion die

6. Extruded and machine pressed clay tiles – slugs will vary both in size and moisture content dependent upon the size, dimensions and nature of the press being used.

7. Hand pressed tiles – the original pressed tile made by hand using soft clays with a variety of finishes, shapes and appearances.

The use of clay conditioners during these forming processes will provide internal body lubrication creating less friction on moving parts which the clay comes into contact with, hence extending their working life. These moving parts include blades in the single/double shafted extruder or mixer, the screen feeder, parts of the de-airing pug mill, the moulds and finally the extruder die.

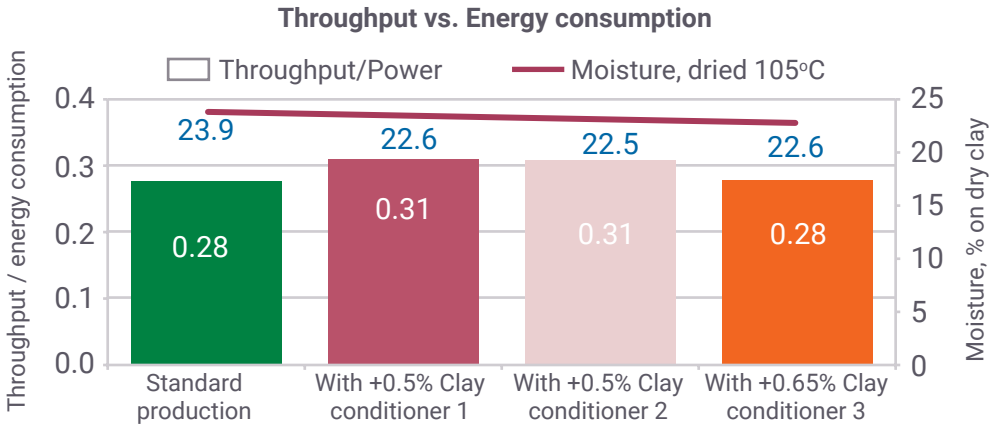
HIGHER THROUGHPUT AND INCREASED EXTRUSION RATES

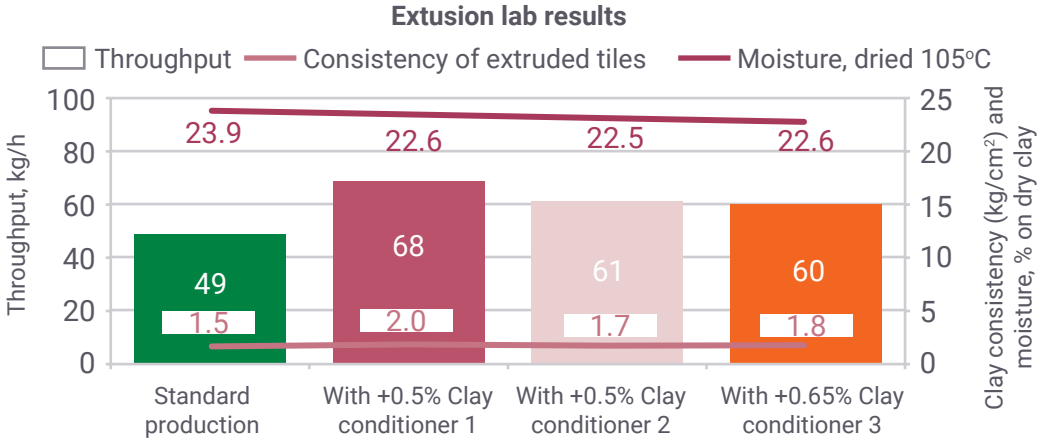
As this is the first major process in brick production, manufacturers need to ensure that all parameters are optimised including energy usage, output, water addition and moisture content, clay workability, use of lubricants, waste/losses and green strength. Optimising these parameters may seem daunting at first. However, experience for well over 60 years has shown that there are readily available products that can provide improvements in not just one, but all of these parameters. The table below provides an overview of the performance of a number of clay conditioners in a variety of clays.

-	Parameters						
Clay type and process	**1 Production rate**	**2 Extruder amperage**	**3 Power consumption**	**4 Relative green strength**	**5 Moisture content**	**6 Dry strength**	**7 Extruder efficiency**
Carboniferous shale – extruded	+5.8%	-15.6%	-20.5%	+9.0%	-0.1%	+11.8%	+26.0%
Carboniferous shale – extruded	NIL	-14.8%	-14.3%	+16.0%	NIL	+13.5%	+16.7%
Carboniferous shale – extruded/ pressed	NIL	NIL	NIL	+28.3%	-1.2%	N/A	+1.4%
Carboniferous Ref U/Clay – extruded	+9.9%	-10.2%	-17.8%	+14.6%	-0.6%	N/A	+22.6%
Carboniferous Buff Fireclay – extruded	+20.5%	-5.0%	-21.2%	+21.2%	-0.7%	N/A	+27.9%
Devonian Shale –extruded	+5.7%	-13.7%	-18.8%	+13.0%	-0.3%	+33.3%	+23.5%
Keuper Marl –extruded	+1.1%	-7.8%	-8.7%	+24.6%	-0.9%	+20.3%	+10.7%
Brickearth – extruded and repressed	+.1.1%	-21.2%	-22.4%	+26.2%	-0.6%	+23.8%	+29.7%
Etruria Marl – extruded	+7.0%	-15.5%	-20.8%	+23.9%	-0.1%	+16.4%	+26.4%
Non-clay refractory – extruded	+13.7%	-6.9%	-17.4%	+30.0%	-0.5%	N/A	+21.5%
Hastings beds – soft mud moulded	NIL	N/A	N/A	N/A	1.5%	+113.3%	N/A
Weald clay – soft mud moulded	NIL	N/A	N/A	N/A	-0.7%	+35.3%	N/A

Columns 1-4, 6 and 7 show % changes in stated parameters as a direct result of incorporating 0.5% by weight of clay conditioner into otherwise standard production. Column 5 shows the actual reduction in moisture content.

This table helps to show that the use of clay conditioners helps to optimise extrusion rates and increase throughput whilst reducing energy consumption, thereby optimising the manufacturing process. The two graphs below show how different clay conditioners have performed in a specific type of clay.

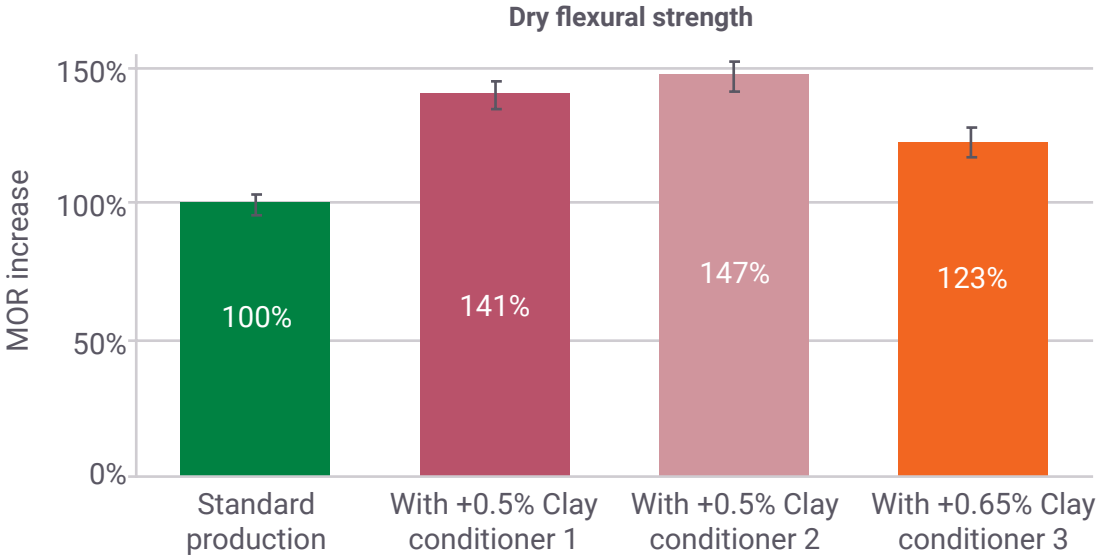




DRYING

INCREASED GREEN AND DRIED BODY STRENGTH

Once the shapes have been formed the next step is drying prior to firing. The shapes are either air-dried or mechanically dried. They can be hand or mechanically set directly onto kiln car bases or indirectly onto drier cartridges or similar. In all cases, you look to optimise drying times to meet production demands without incurring excessive losses from drying cracks, warpage, handling breakages and improper moisture content.



FASTER DRYING CYCLES

The addition of clay conditioners reinforces the inter particle bonding of the clay skeleton and thereby, can rapidly increase strength throughout the drying cycle. As such, dryer costs and times can be reduced as the heat can be applied more efficiently. When employing automated setting machines the dried more durable shapes allow the machines to work more accurately providing for more precise pack setting. This in-turn allows for better circulation of hot gases during the firing process. Specialized equipment to monitor parameters during the drying process such as weight loss against temperature, humidity and shrinkage enable a bigot curve to be drawn so optimum drying parameters can be set.

Monitoring tools used to track drying process

FIRING

REDUCE BREAKING AND CHIPPING

Having dried the products to the desired moisture content, the final process is firing. Kiln firing of brick and tile has evolved greatly over the centuries and although we still use clamp firing, Bull Trench and Hoffmann kilns the need for greater production capability has given us tunnel kilns and a new wave of kiln firing using VSBK technology.

As shown the addition of clay conditioners gives higher dry strength which reduces handling losses. The subsequent resultant tougher surface layer protects vulnerable areas from damage during transport, handling and firing.

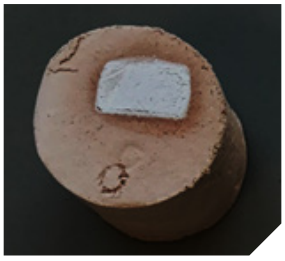
Below is a customer's testimonial on the use of clay conditioners within their production process showing increases in production, increased yields and higher profitability:

Without any additive	**With a clay conditioner/biopolymer**
50 million bricks per year	52 million bricks per year
95% best brick	97% best brick
2% general waste	0.5% general waste
2% cracking	0% cracking
20% perforation	25% perforation
Profit £900,000	Profit £1,050,000

ANTI-SCUMMING PROPERTIES

Dependent on clays being used, a major issue facing all producers is the effect of scumming on the fired bricks. The two major sources of this scumming are usually either sulphates or chlorides. However, we have also seen instances of scumming arising from fluoride and vanadium.

There are different solutions to reduce scumming such as a clay conditioner, a combined clay conditioner and anti-scumming product or a pure anti-scumming agent depending on the levels of salt in your clays. These additives are able to prevent scumming by inhibiting the migration of soluble salts to the surface of the drying clay structure. They are able to form insoluble compounds while still providing some lubrication and binding properties.



Example of fired product with no anti-scumming product available

The same clay sample with the addition of a number of clay conditioner and anti-scumming agents

CONCLUSIONS

The use of clay conditioners can help in many ways to optimise your brick and roof tile production. Clay conditioners act as a wetting agent, reducing surface tension of the aqueous phase and promoting more homogeneous mixing. When force is applied during shaping, clay conditioners lubricate and promote a better flow of particles thus reducing friction between the clay and the surface of the material applying the force. As water begins to vacate the shape, clay conditioners promote increased bond strength, resulting in a faster rate of strength gain. During the drying process the clay conditioner increases the strength of the clay mix and by forming a tighter surface layer hardens edges and other vulnerable points of the shape.

We highly recommend the use of these additives to gain the best performance from your production. We can assist you in analysing your clay, finding the best and most suitable clay conditioner for you. We are able to provide you full technical support for a factory trial and provide analysis of the results.

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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