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STUDY ON THE MECHANICAL RESISTANCE ENHANCEMENT OF PORCELAIN BODY FORMULATION BY BINDERS ADDITION

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Abstract: *The paper is focused on a study based on binders incorporation into the ceramic porcelain stoneware paste in order to replace the lack of plastic clays. Some ceramic suspensions containing binders have been compared to a standard composition by means of electrolytical, rheological and flexural strength values, obtaining a 70% increasing in flexural strength and keeping the rest of parameters similar to standard ceramic porcelain formulation.*
Key words: *Ceramic, porcelain, binder, flexural strength, black core*

INTRODUCTION

In the last years, the current ceramic trend is based on the production of big sizes tiles and also slim tiles with reduced thickness, needing ceramic body compositions adapted to produce sizes more than 60×60 cm with high quality, especially an adequate mechanical resistance to avoid breakage [1-4].

The improvement of the mechanical resistance in the course of the industrial ceramic process is a big challenge because depends directly on the kind of clays used in the process, in terms of plasticity [5, 6].

However, the ball clays characterized by a good plasticity, directly related to mechanical resistance, that are perfect to achieve an adequate behaviour from the conformation and manipulation in green until the glazing stage in the ceramic process, are expensive and not available in several countries. The lack of Ukrainian clay in Europe and other plastic clays around the world changes the necessity of the market, and open to look for other solutions [7, 8].

Consequently, since the ball clays are each time more restrictive, the additives suppliers have developed several chemicals able to improve the mechanical properties in green ceramic tiles, namely, tiles before being dried and fired. These additives are added in the ceramic suspension similar to the deffloculant [9, 10].

The present work is based on the study of influence of two very promising commercial binders for mechanical resistance enhancement of porcelain stoneware body formulation.

EXPERIMENTAL

The suspensions´ preparation has consisted of mixing a standard porcelain stoneware composition with water (70%-solid content) adding 0.7 wt% of deflocculant (sodium silicate) and the binder to study in order to improve the mechanical resistance. The suspension has been milled during 7 minutes in a planetary alumina ball mill to achieve 100% particles under 100 micrometres such as the industrial milling process for porcelain pastes.

The binders studied are designated as ”binder A”, presenting inorganic nature and ”binder B”, composed of organic chemicals. Both binders were delivered by ’’NEOS CERAMIC INNOVATION’’ [11].

The electrolytical parameters of the prepared suspensions have been tested by a ’’Eutech pH6+’’-pH-meter and ”Eutech Cond7”-conductometer, in order to control the binder addition. The rheological variables of each suspension have been obtained from a traditional control rate mode, which performs seven subsequent stages, shown in Table 1, measured by a Haake Viscotester 550. The first rheometrical cycle has been used to homogenize the testing time of all the suspensions and, hence, the dynamic viscosity and thixotropy have been extracted from the second cycle. The magnitude of thixotropy has been determined making use of a CR-rheometer and evaluating the hysteresis area contained in between the flowability curves (shear stress us shear rate) of the second cycle [12].

Table 1. Control rate mode program

Rotation speed (s^{-1})	Duration (s)
0-1000	120
0-0	1
1000-0	120
0-0	1
0-1000	120
0-0	1
1000 – 0	120

After being tested, each suspension has been dried at 110ºC for 24 hours and the obtained powder has been moistened at 6 wt% of water to be pressed with a Nannetti uniaxial press up to a pressure of 300 kg/cm^2, obtaining rectangular pieces ready to be dried and tested. The flexural strength of the unfired pieces has been determined by means of a HOYTOM plasticinometer with a load cell of 5000 N and a force threshold of 16N. The rest of pieces has been fired at 1185ºC, the typical industrial ceramic furnace temperature, in order to achieve the correct sintering stage in the pieces and to study the organic matter presence due to the binder organic composition. The fired pieces are split in half to observe visually (visual %) the inner area where organic matter in the form of so called “black core” could appear [13] in Figure 1.

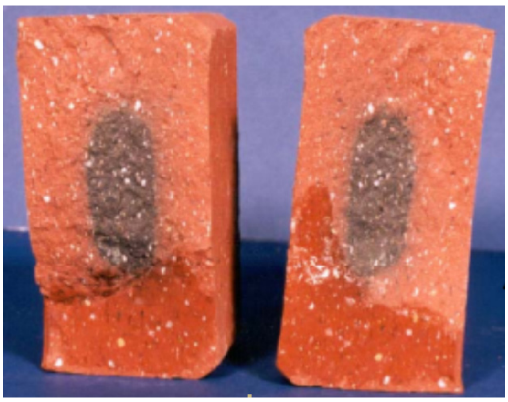

Fig. 1. Thermal treatment used to fire the ceramic pieces at 1185ºC
(black core test)

RESULTS AND DISCUSSION

The electrolytical parameters of the suspensions with different binder content (1, 3 and 5 wt%) are shown in Figure 2, together with the suspension free of binders (standard, STD). In general, the addition of binders increases both the pH and the conductivity of original suspension, being directly proportional to the binder content, because of their basic nature and their content in electrolytes. However, since binder A is inorganic, it causes higher values of conductivity and pH than the organic binder B. These parameters are also a way of controlling the binder addition in each test in order to assure the accurate addition of each chemical.

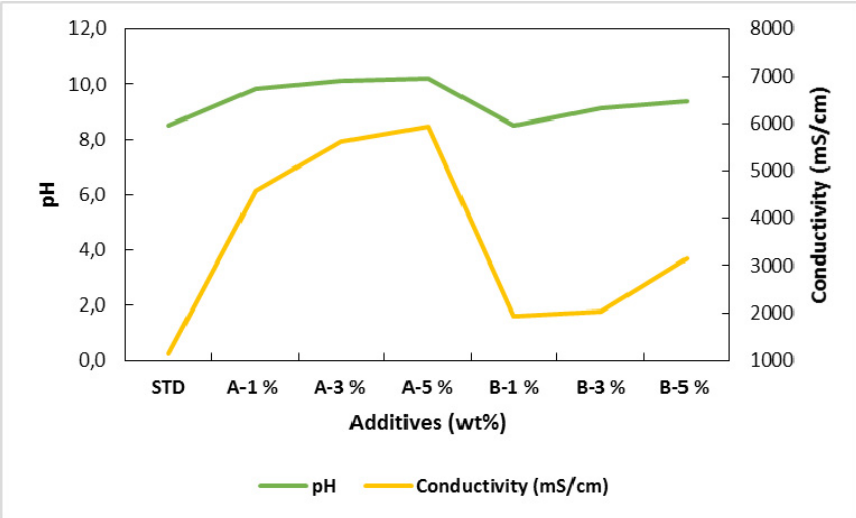

Fig. 2. Electrolytical parameters of prepared suspensions adding A and B binders from 1 to 5 wt%: pH and conductivity

Figure 3 exhibits the dynamic viscosity and the thixotropy of the suspensions containing binder. Both binders cause the increasing of these parameters, suggesting they suppress the deflocculant action. Although B-1% presents similar values to A additions, B-3% and B-5% submit higher values of dynamic viscosity and thixotropy, not recommended in industrial exploitations.

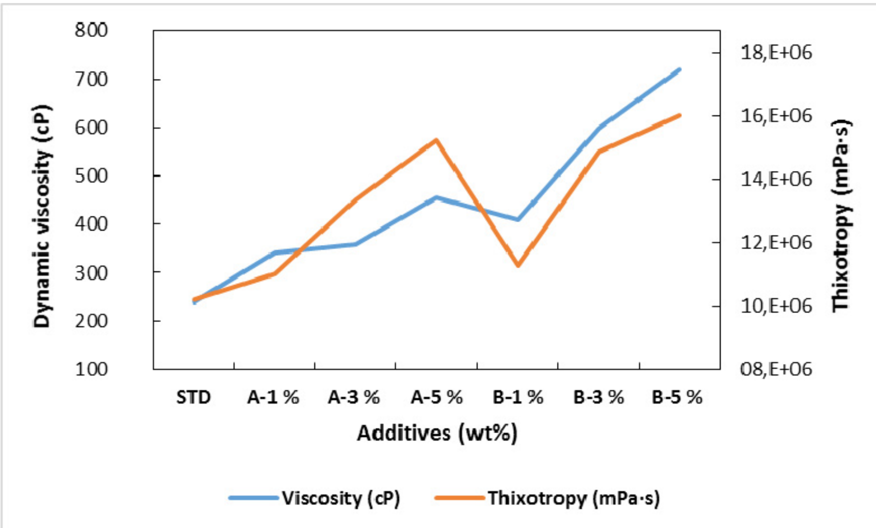

Fig. 3. Rheological parameters of the suspensions containing the binders A and B from 1 to 5wt%; dynamic viscosity and thixotropy

While the binder A produces an increment of the flexural strength of 70% respect to the binder-free suspension, in all percentages, it is necessary to add at least 5wt% (B-5%) to achieve the maximum value of flexural strength corresponding to 130% of increasing, as plotted in Figure 4.

However, the binder B produces more “black core” than the binder A, surely because B has an organic nature.

Consequently, the best result of this work corresponds to the A-1% because it allows a 70% increasing of flexural strength exhibiting similar values of pH, conductivity, dynamic viscosity, thixotropy and “black core” than standard suspension.

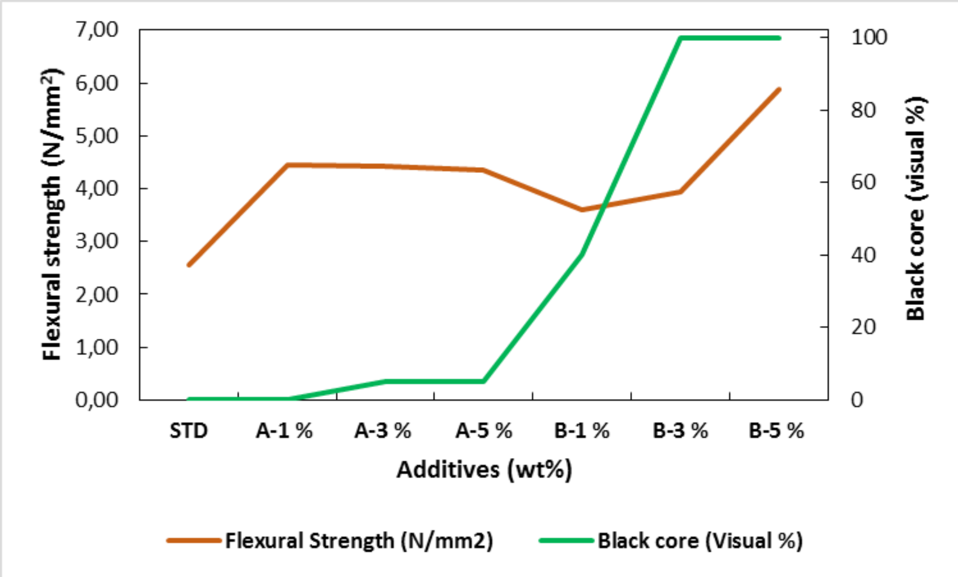

Fig. 4 Flexural strength of non-fired pieces and black core test of fired pieces made of prepared suspension powder.

CONCLUSIONS AND FUTURE WORK

The characterisation procedures used in the present study have revealed that the binders used undoubtedly improve the ceramic production quality, enhancing the intermediate product strength without any detrimental effects on the final product quality.

Thus, the addition of binders to the ceramic porcelain paste is a good solution to increase the flexural strength of unfired pieces in pastes with low quantities of plastic clays content, without enhancing the “black core” appearance, nor rheological and electrolytical parameters deterioration. Consequently, the binders proposed in the present brief study enable elaboration of reliable industrial production regimes for the needs of the ceramic industry sector.

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