IMPROVEMENT OF BEHAVIOUR IN THE EXTRUSION OF LOW PLASTICITY CERAMICS

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1. INTRODUCTION

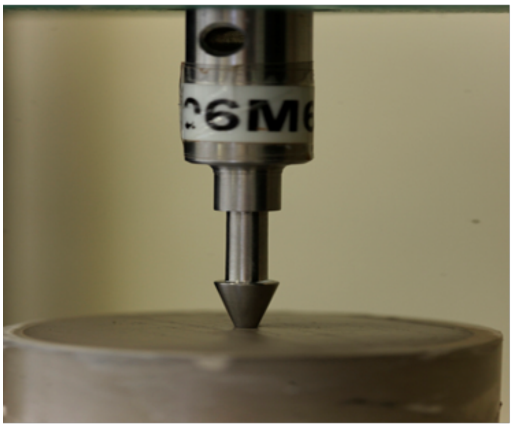
Shaping by extrusion may be used for the manufacture of tiles, bricks, and also refractory products. The three fundamental aspects that must be considered to achieve ideal extrusion conditions are the nature of the material, particle size and Plastic behaviour. Of these, obtaining a mass of adequate plasticity is essential during the processing in order to prevent defects such as cracks, laminations or migrations of the liquid phase [1]. Plastic behaviour depends on numerous factors [2]: size and shape of the particle, mineralogical composition, presence of electrolytes, organic matter, etc.

With regard to traditional ceramics, as is the case of the manufacture of ceramic tiles, clay materials are those with the necessary plasticity to carry out the extrusion process. However, in the absence of clays with sufficient plasticity or when the composition incorporates a high proportion of other non-plastic ingredients, the extrusion operation may be seriously compromised, particularly for the manufacture of large or complex tiles. In these cases it is necessary to add plasticizers or binders to the pastes to achieve rheological behaviour and plasticity enabling correct processing of the composition [3].

In this report the influence of different additives in different proportions on the plasticity index of a ceramic composition was evaluated and the variation of the plasticity index was related to the behaviour of the paste during extrusion.

2. EXPERIMENTAL PROCEDURE

The raw materials were kneaded with the amount of water necessary to perform the plasticity test and stored in closed containers for 24 hours in order to homogenize humidity. The plasticity of the samples was determined by the indentation method [4]. This technique is based on measuring, with a plasticimeter, the maximum force applied by a conical tip punch in the composition at different moisture contents. Representing the indentation force against humidity in logarithmic coordinates, a straight line is obtained from which the moisture values corresponding to the Atterberg limits are calculated and subsequently the plasticity index is determined as the difference between the liquid limit and the plastic limit, HLL and HLP respectively (Figure 1).



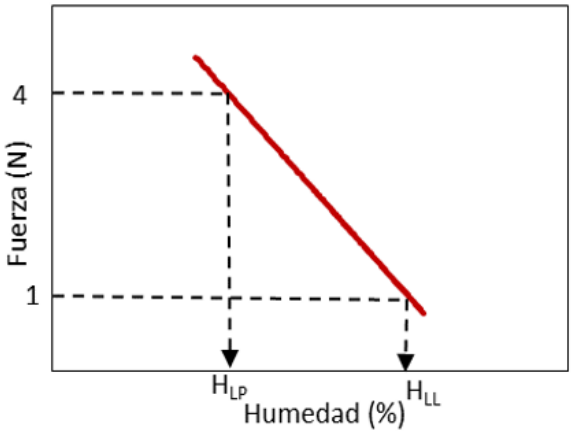


Figure 1. *Punch for measuring the plasticity index using the indentation method (left). Graph for the calculation of the Atterberg limits (logarithmic scale) (right).*

Plasticity tests were carried out incorporating different additives to the initial composition: inorganic substances with a high bentonite surface area, montmorillonite plastic clay, electrolytes (NaCl, NH_4Cl), cellulose derived polymers, and a polymeric plasticizer with a lignosulfonate base. The compositions that showed the best plasticity results were subjected to extrusion on a pilot scale in order to verify the effects on the final product.

3. RESULTS AND DISCUSSION

All additives tested modified the plasticity index of the initial composition (Figure 2).

The plastic raw materials (bentonite and plastic clay) increased the plasticity index. However, applicability was limited due to the high proportions required (5-10%) to achieve the desired plasticity value, which greatly modified the characteristics of the final product.

NaCl and NH_4Cl presented opposite effects: whereas when adding NaCl the plasticity index decreased, with NH_4Cl it increased significantly. However, it was found that the compositions extruded with NH_4Cl possessed low bulk density, which limited application of this compound.

As for the cellulose derived polymers, three of those tested greatly increased the plasticity index while excessively increasing viscosity of the paste, making it impossible to process correctly by extrusion.

Finally, the polymeric plasticizer of lignosulfonate base, added in very low proportion to the composition, increased plasticity to the values required by the process without modifying the rheological behaviour of the paste or the initial composition.

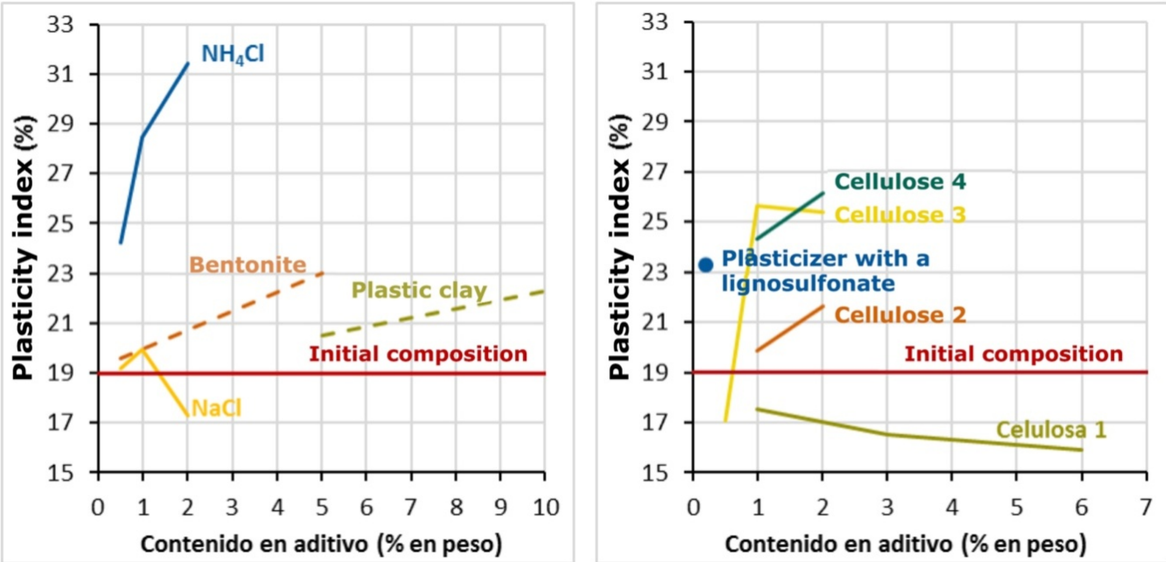


Figure 2. *Effect of additive content on plasticity index.*

The results of the pilot scale extrusion confirmed that the polymeric plasticizer of the lignosulfonate base reduced the appearance of cracks (indicated with arrows in Figure 3) and provided optimal extrusion conditions, maintaining the rest of the properties of the final product.

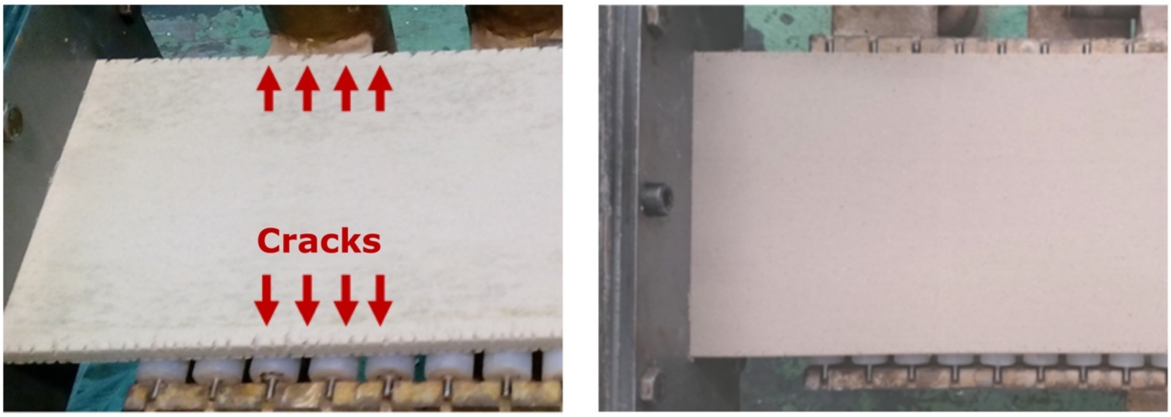


Figure 3. *Appearance of initial composition at output of extruder (left) and composition with polymeric plasticizer of lignosulfonate base (right).*

4. CONCLUSIONS

Measurement of plasticity of ceramic compositions constitutes a simple rapid method for selecting additives in order to improve extrusion behaviour of ceramic compositions. It was found that the polymer plasticizer in lignosulfonate base improved, both the plasticity index as well as the extrusion behaviour of the composition maintaining the characteristics of the final product.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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