STUDY OF THE INFLUENCE OF PROCESS VARIABLES ON THE PROPERTIES OF CLAY GRANULES OBTAINED IN A HIGH-SHEAR MIXER–GRANULATOR

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1. INTRODUCTION

The dry milling and granulation process for obtaining the granulate used in pressing ceramic tile bodies is a process that reduces the characteristic high water and energy consumption of wet processing. The adoption of powder granulation systems serves to provide the powder with sufficiently high flowability for appropriate press die filling in order to obtain tiles with a uniform bulk density distribution. This is of vital importance because it assures the dimensional stability of the tiles and minimises defects in the resulting fired tiles. Two yet unresolved issues in dry processing are the high hardness of the resulting granules, compared with those produced by spray drying, and granulation operation in regard to the influence of the different variables involved on granule characteristics.

This study was undertaken to determine the process variables that allow the particle size fraction between 500 and 200 μm to be maximised and that provide the granules with similar flowability to that of spray-dried granules, in addition to determining the influence of the quantity of water needed for granulation.

The study was conducted in a high-shear granulator in which it was very difficult to predict end-product characteristics, mainly because the granulation mechanisms (nucleation, growth, consolidation, and breakage) took place simultaneously and more than one mechanism could predominate at the same time. In addition, in this type of granulator, the high-speed stirring of the material raises the temperature and consequently causes the material to dry rapidly.

2. EXPERIMENTAL

The work was performed using a high-shear granulator (Eirich, M5R) in which the effect of the quantity of water used for granulating and of the granulation time was studied. These variables were analysed by characterising the agglomerates, determining the particle size distribution. The effect of the type of rotor, rotor speed, barrel speed, and granulation time was established in previous studies [1], Table 1. The material used in the study was a red-firing clay from Villar del Arzobispo (Valencia).

Variable	Value
Type of rotor	Pin1
Rotor speed (r.p.m.)	4800
Barrel speed (r.p.m.)	70

Table 1. Granulator variables.

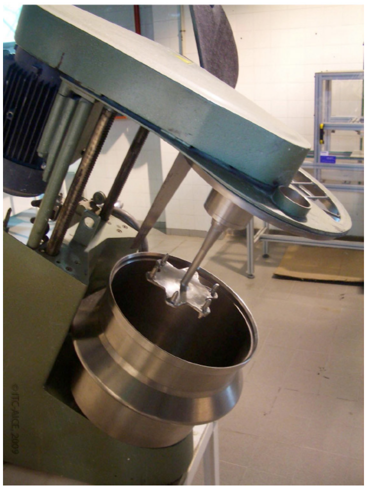

Figure 1. Image of granulator with rotor pin1.

3. RESULTS

3.1. INFLUENCE OF THE WATER ADDITION METHOD

The influence of the way the granulation water was added to the powder bed in the initial nucleation stage was evaluated by performing two tests, only varying the way the water was added to the clay being stirred:

- **Spraying**, using a pressure air gun that dispersed the water in small drops.
- **Direct pouring** of the water.

After performance of the tests, it was observed that the mass percentage of each granule fraction was practically the same at different stirring times, independently of the system used to add the water. It was therefore concluded that the water addition method, and consequently the resulting drop size and its dispersion in the powder bed, did not influence the particle size distribution of the agglomerates in the high-shear granulator.

3.2. INFLUENCE OF THE QUANTITY OF GRANULATION WATER

The purpose of this test was to determine the quantity of water needed to obtain a particle size distribution with a maximum agglomerate fraction between 300 and 500 µm, as this was similar to that obtained by spray drying a ceramic body. The percentage of granulation water (X in %) was defined as the real mass of water that the granulate contained in relation to the dry clay mass. The granules obtained with different additions of water, using a granulation time of 2 minutes for 10.5% and 1 minute more for each addition of 0.5% are shown in Figure 2. The enormous influence of this variable in the granulation process can be observed in the morphology and size of the granules.

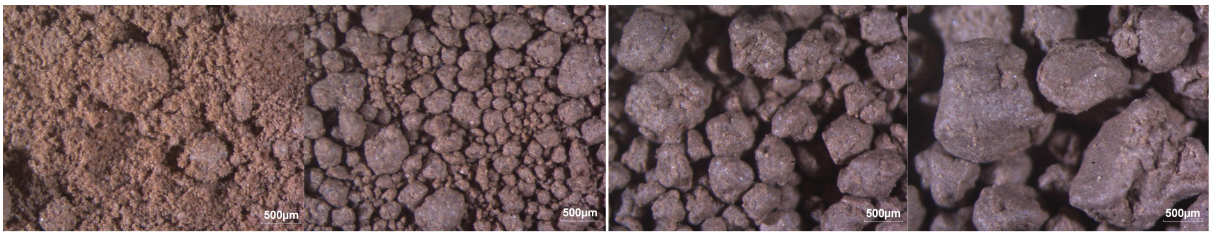

Figure 2. Pictures of granules obtained at different moisture contents (% on a dry basis). From left to right: 10.5%; 12.5%; 14.5%; 15.5%.

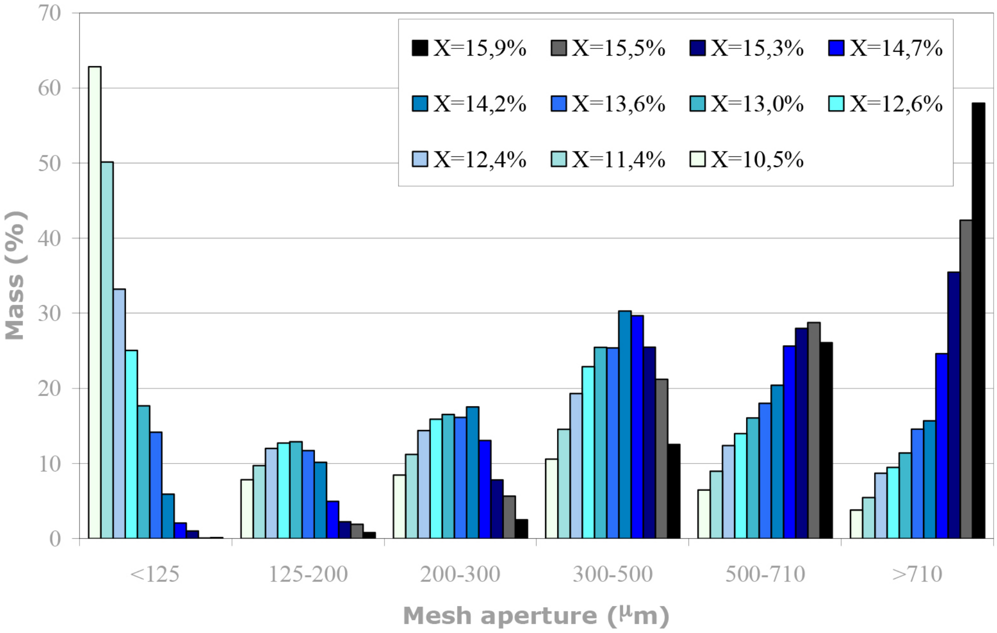

Figure 3. Evolution of the particle size fractions on modifying the granulation water addition.

The particle size distributions of the granulates obtained with different water additions are depicted in Figure 3. It shows that, while the fraction below 125 µm decreased when the granulation water addition increased, the fraction above 710 µm increased considerably. The other fractions displayed a maximum that shifted to higher moisture contents as granule size increased. These results indicate that the added water quantity favoured granule growth and determined granule content in each particle size fraction.

3.3. INFLUENCE OF GRANULATION TIME

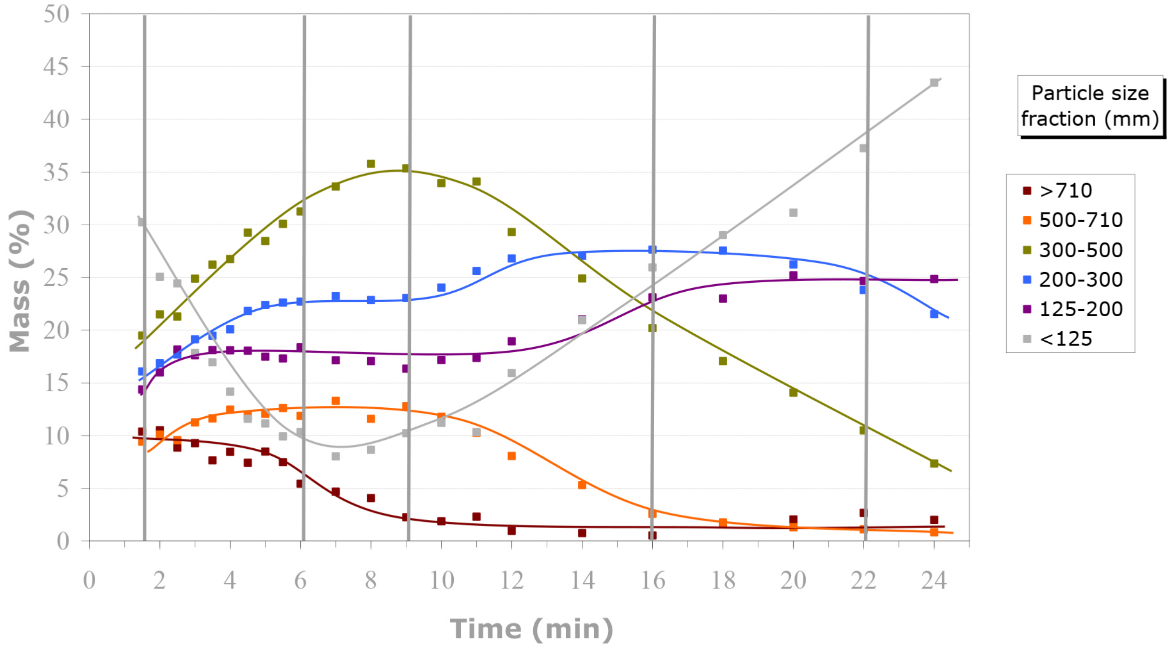

Figure 4. Test of granulation time at variable moisture content.

When the test was performed at different moisture contents, as time elapsed, the sample dried progressively, as occurs in the industrial process. The following agglomeration mechanisms were observed during the granulation, Figure 4:

During the first 6 minutes of stirring, the granule growth mechanism predominated, though it also broke up the weakest and largest agglomerates that had formed at the start of the granulation process.

Between 6 and 9 minutes, the granule growth and break-up mechanisms took place practically to the same degree.

After 9 minutes, owing to the continuous drying of the material as a result of the increasing temperature of the mixture under high-speed stirring, the break-up mechanism predominated, starting with the largest granules.

4. CONCLUSIONS

The study highlighted the importance of the process variables on the properties of the granules obtained in a high-shear mixer–granulator. The following conclusions were drawn:

- The water addition method did not influence granule size distribution.
- The optimum quantity of water for granule growth was about 14,5%.
- The mechanism that predominated under working conditions on an industrial scale was as follows:
  - Growth during the first 6 minutes
  - Growth and break-up between 6 and 9 minutes
  - Break-up after 9 minutes
- Under the tested conditions, the granule fraction between 300 and 500 μm maximised at a granulation time of 8 minutes.

5. ACKNOWLEDGEMENTS

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