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► To cite this version:

Eric Rondet, Maxence Denavaut, Sandra Mandato, Agnès Duri-Bechemilh, Bernard Cuq. Energetical approach of wet agglomeration process: methodology and measurements. 5. International Granulation Workshop, Jun 2011, Lausanne, Switzerland. 2011. hal-01601588

HAL Id: hal-01601588

<https://hal.science/hal-01601588>

Submitted on 3 Jun 2020

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Energetical approach of wet agglomeration process methodology and measurements

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Introduction & objectives

The study of the evolution of power consumption during wet agglomeration has been widely used to characterize the evolution of agglomerates properties [1, 2, 3]. Nevertheless, despite the **environmental and economic pressures**, no study aims in exactly quantify the energy consumption related to the agglomeration process with the objective to **reduce it**.

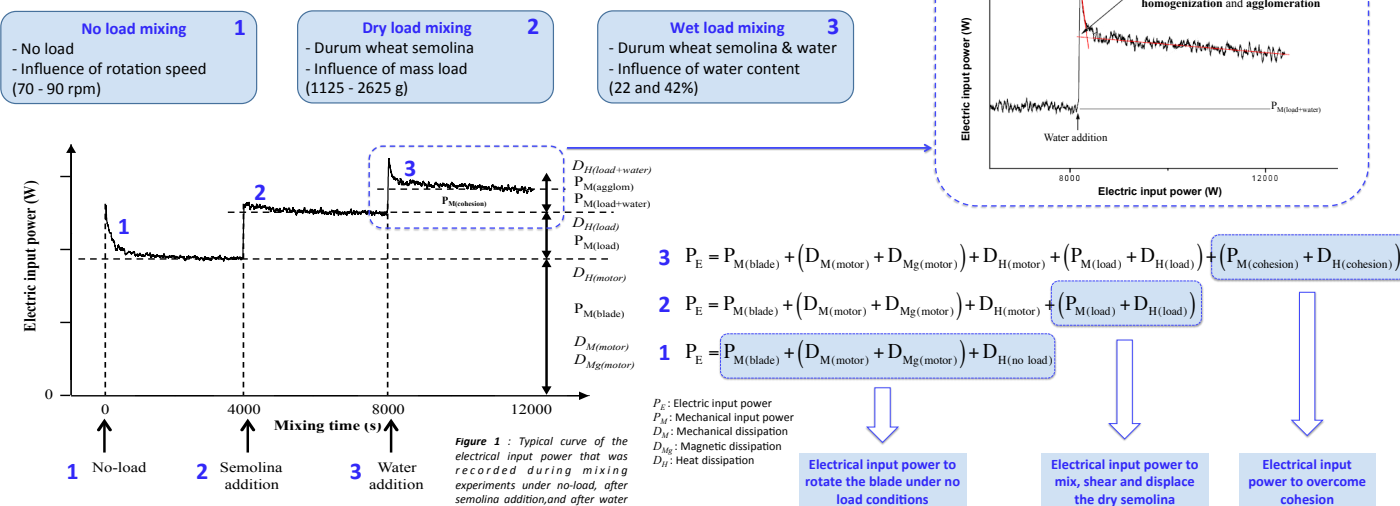
The aim of this work is thus to determine the **power consumed by the agglomeration process** of semolina in couscous grains. In that way, mixing was broken down into three phases in order to identify the energy consumption of each aspect of agglomeration process: (i) blade rotation, (ii) transport of granular material and (iii) agglomeration. Our study attempts to **follow the evolution of the energy consumption of a mixer according to its process conditions**: blade rotation speed, mass load, and water content of the mixed product.

Methods & experimental approaches

Agglomeration is carried out in a **planetary mixer** (Kenwood Major 1200), equipped with a 5 liters fixed bowl and a rotating K blade. The measurement of the **electric consumption** is continuously carried out via a wattmeter (WATTCOM®).



1. To evaluate the energy consumption by the motor **for no-load mixing**, we tested different rotation speeds (70, 80, and 90 rpm).
2. To evaluate the **influence of the mass load** introduced in the mixer bowl, we tested different semolina masses (1125, 1875, and 2625 g).
3. To study the energy consumption of the **agglomeration process** during mixing, water was added in the semolina to initiate the agglomeration mechanisms.



Results and discussions

No load mixing - An increase of the rotation speed (from 70 to 90 rpm) induces a slight increase of the electric input power.

Dry load mixing - An increase of the mass of the inert load (from 1125g to 2625g) induces an increase of the instantaneous electric input power, and a decrease of the specific mechanical energy consumed by the engine (from 230 to 140J.kg⁻¹).

Wet load mixing - A not linear relationship describes the effect of water content on the increase in electric input power overconsumption with a low effect of the water content until 35% and then a rough increase beyond 35% (figure 2). The share of energy consumed by the agglomeration process largely increases (from 8.8 to 26.6%) when water content varies between 22 and 42%.

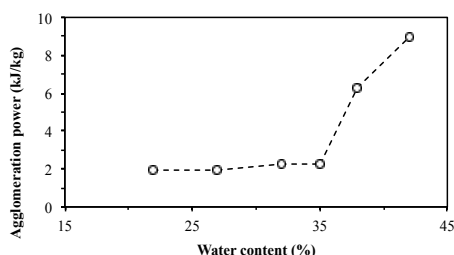


Figure 2 : Influence of water content on the electric input power overconsumption due to the agglomeration process during mixing of semolina after water addition at the plateau (blade rotation speed : 70 rpm, mass load : 1875 g)

During wet agglomeration - Energy is preferentially used for the rotation of the mixing blade. The share of energy necessary to the non-cohesive transport of the load decreases with increasing water content. Energy specifically consumed to overcome the cohesion increases with water content

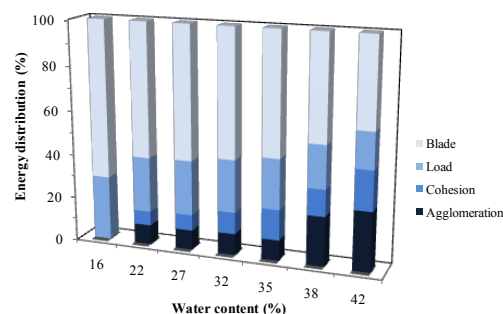


Figure 3 : Instant yields of the elements constituting the signal according to water content (blade rotation speed: 70 rpm, mass load: 1875g)

Great possibilities in term of optimization of the energy consumption during wet agglomeration process (for instance for couscous processing).

The energy necessary to shape and structure the hydrated product only represent (at the maximum) one third of the total energy consumed by the equipment.