Identification of stress distributions in a laterally confined granular medium: Application to durum wheat semolina agglomeration

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During couscous production, the agglomeration of durum wheat semolina is controlled by a combination of surface reactivity properties and process designs related to the water distribution and the dissipated mechanical energy. The mechanical stresses have to be transmitted at the scale of the agglomeration mechanisms. A better understanding of the contribution of the mechanical energy input to the agglomeration mechanisms is needed to achieve a better control of the agglomeration at the industrial scale. We conducted an original approach to study stress distributions in a laterally confined semolina bed based on the development of a 1D mixing cell. Under static conditions, force measurements are carried out directly on the blade at various depths and allow to establish the vertical stress profile in the bed of semolina particles. The obtained profile displays a characteristic depth of 7.81 cm (function of the hydraulic diameter of the cell), below which the vertical stress reaches a plateau. This phenomenon is known as the Janssen's law and explained by the presence of (i) a force network between the grains and (ii) frictions between the grains and the wall, which both redirect vertical stresses laterally to the side walls. Under dynamic conditions, the upward blade motion at different speeds (10, 20, 30 and 40 mm.s-1) reveals two zones which are on both sides of the characteristic depth. The dynamic stress profiles depend on the blade speed and display periodical fluctuations below the characteristic depth. The influence of the particle size on the mechanical behaviour of the confined powders is presented and shows an increase in the characteristic depth with the particle median diameter. In the context of wet agglomeration, these results allow to consider the Janssen's length as an important criterion for the design of mixing devices.