On the effect of Powder Cohesion on the location of Geldart Group A to Group C Fluidisation boundaries

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Accurately predicting the hydrodynamic behaviour of a cohesive powder during aeration is essential in various industrial applications including flatbed drying systems. This study aims to advance the understanding of utilising the Geldart classification for wet cohesive particles by further considering additional flow properties beyond particle size and density alone. The significance of this subject was evidenced during flatbed drying of a starchy cohesive particulate food material, where the near fluidisation state was of great interest for maximising the thermal energy performance of the drying system. In this study, the morphology, size distribution and density of the product particles were measured at different stages of the drying process. The bulk properties of the product was also measured using shear cell testing and considering the impact of reducing water content as it further dried. A series of aeration experiments were conducted at both full-scale and lab-scale. Full-scale trials involved a column with a diameter of 1 m and a sample depth of 0.22 m, while the lab-scale tests utilized a column with a diameter of 0.15 m and a depth of 0.15 m. The fluidisation behaviour of the product was analysed in light of the scale up effect and using the analytical procedure to determine the permeability measures. A substantial deviation between Geldart classifications and results was noticed. When a decrease in density difference shifts the boundaries between the regimes A and C in Geldart charts, the cohesiveness of the particles has been demonstrated to have a significant impact, especially during the earlier stages of the drying process. Fieldwork observations indicated a diminishing trend in the maximum applicable superficial air velocity, decreasing from 8 to 4.6 cm/s as the drying process advanced from 0.46 to 0.2 kg/kg w.b. Concurrently, the gauge pressure beneath the material fell between 8 and 14 mbar. The scale-up implications became evident, with lab-scale trials demonstrating a notably higher value for the maximum applicable superficial air velocity, reaching 12 cm/s at 0.46 kg/kg w.b. The findings were evaluated collectively to establish a more realistic boundary between Group A and Group C in the Geldart chart. Relationships were sought between the impact of the powder's cohesiveness on the fluidization behavior of the powders by investigating the existing interparticle forces of Van der Waals and liquid bridges. These findings offer crucial insights for optimizing the design and operation of flatbed drying systems.