SIZE DISTRIBUTION PREDICTION OF NANOPARTICLE AGGLOMERATES IN A FLUIDIZED BED

Andrea Fabre, Delft University of Technology, The Netherlands
A.fabre@tudelft.nl
Samir Salameh , Michiel T. Kreutzer , J. Ruud van Ommen , Delft University of Technology, The Netherlands

Nanoparticles have acquired considerable attention from academia and industry due to their unique properties arising from the large surface area to volume ratio. A promising method to process these particles is fluidization. Furthermore, it is worth knowing that nanoparticles fluidize as clusters called agglomerates, formed by the relatively strong adhesion forces among the individual particles (1).

These agglomerates are large, highly porous fractal structures; thus, easy to access but extremely fragile. During fluidization, agglomerates move, collide, break, reform, deform, and combine, which make them suitable for a wide range of applications. Nanopowders can fluidize with bubbles or uniformly, which show different dynamics that might affect the morphology of the fluidized agglomerates. In order to better understand the dynamic behaviour of the system, it is crucial to know the agglomerate size distribution within the fluidized bed. Therefore, we developed a model based on a simple force balance to predict the agglomerate size distribution, which enables the optimization of processing methods.

Fluidized agglomerates constantly experience adhesion and separation forces. Those forces that dominate include capillary and Van der Waals from the adhesion group, and collision from the separation one, which are the three forces considered in the model. From the separation-adhesion force balance, we use two key values to describe the distribution profile. One being the size at which the difference between the forces is maximum; and the second, the size at which the forces balance each other (Fig.1).

The model is validated using the size distribution data from experiments on six cohesive nanopowders, namely titania (TiO_2), silica (SiO_2), and alumina (Al_2O_3) on their hydrophilic and hydrophobic versions (Fig.2). These experiments use an in-situ technique that records agglomerates in a fluidized bed falling at their terminal velocity inside a black box, referred to as the settling tube (2). The model relies on fluidization behaviour, processing conditions, primary particle properties, and agglomerate characteristics for the size distribution prediction of nanoparticles agglomerates in a fluidized bed. While previous models just estimate the average agglomerate size, our new model can capture the whole size distribution of the nanoparticle fluidized agglomerates.

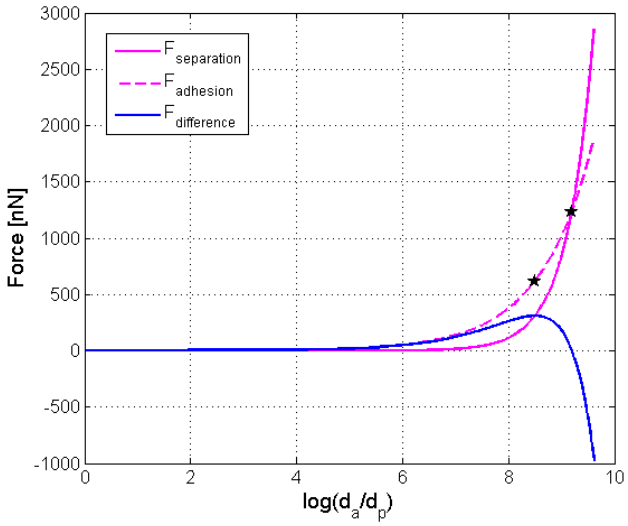

Figure 1: Adhesion and separation forces calculated by the model. The blue curve indicates the magnitude of the difference between the forces. The markers are placed at the size values of maximum and zero difference, which are used to determine the size distribution profile of the fluidized agglomerates.

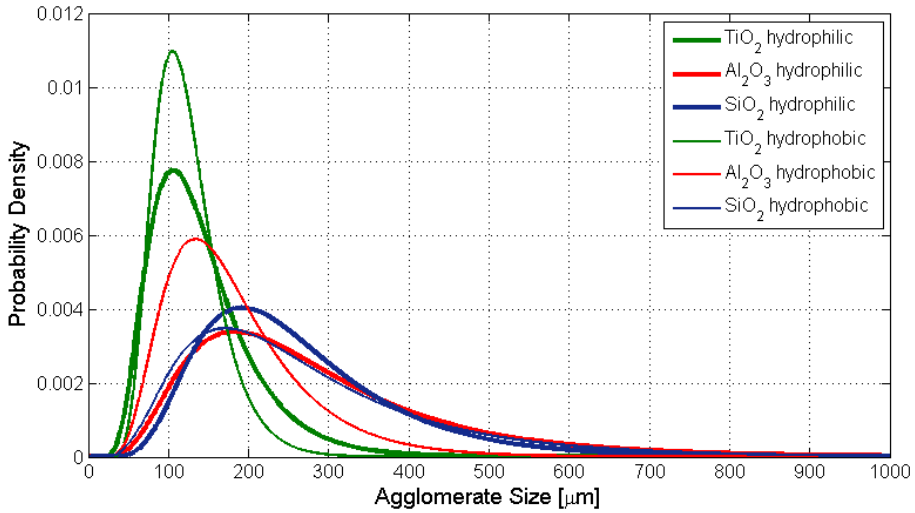

Figure 2: Log-normal size distribution of fluidized agglomerates obtained experimentally using the settling tube technique. Values are for hydrophilic and hydrophobic titania (TiO_2), alumina (Al_2O_3), and silica (SiO_2) nanopowders.

REFERENCES

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