ABSTRACT

Granulation, the size enlargement process finds application extensively in pharmaceutical, food, fertilizer and mineral industries. This can be achieved in many methods such as fluid bed granulation, high shear granulation, drum granulation, etc. In fluidized bed granulation, granulation fluid in the form of – solution, suspension, slurry, melt – is sprayed on the surface of the particles which are fluidized by air. While the particles enter the spraying zone, it captures granulation fluid on its surface. When these particles collide, it may stick with one another and granulation fluid forms bridge among particles. These bridges are later converted into solid bridges while receiving sufficient heat to evaporate the solvent present in it. Thus, granules are formed. The necessary steps for this granule formation – collision, bridge formation, coalescence, drying – depend on operating conditions and physical and chemical properties of both feed particle and granulating fluid. The prediction of particle size distribution (PSD) and average size is difficult on the basis of theoretical considerations alone since exact mechanism by which this size enlargement occurs is not fully established. Hence, there is a need of experimental investigation to model this process. Experiments are carried out investigate the effect of process parameters – fluidizing air velocity, binder flow rate – on granule growth and the observations are used to model the process.

In this work, modeling is focused to describe the granulation phenomena on the basis of experimental observations of wheat powder granulation in fluidized bed. The experimental observations of PSD changes with time indicate that the evolution kinetics is analogous to elementary reversible series reaction. In this modeling, only three classifications of the granule size are considered and their evolution with time is described by differential equations. The parameters used in the differential equations are estimated using optimization technique.

EXPERIMENTAL

Experiments are carried out in a cylinerical column made of Perspex of 2.5”diameter and 8”height. A known quantity of fine wheat flour (50gm), size ranges from 5μm to 100μm, is taken in the bed and fluidized. After well mixing, binder (water) is sprayed by means of twin phase nozzle. Samples are taken at regular interval of time and the particle size distribution is analyzed by sieving. The evolution of particle size distribution of a typical run in differential and cumulative form is shown in Fig.1 & Fig. 2 respectively. Fig. 3 represents the evolution of three classes, (fine: < 125μ, intermediate: 125μ – 500μ, coarse, 500μ – 1000μ) with time.

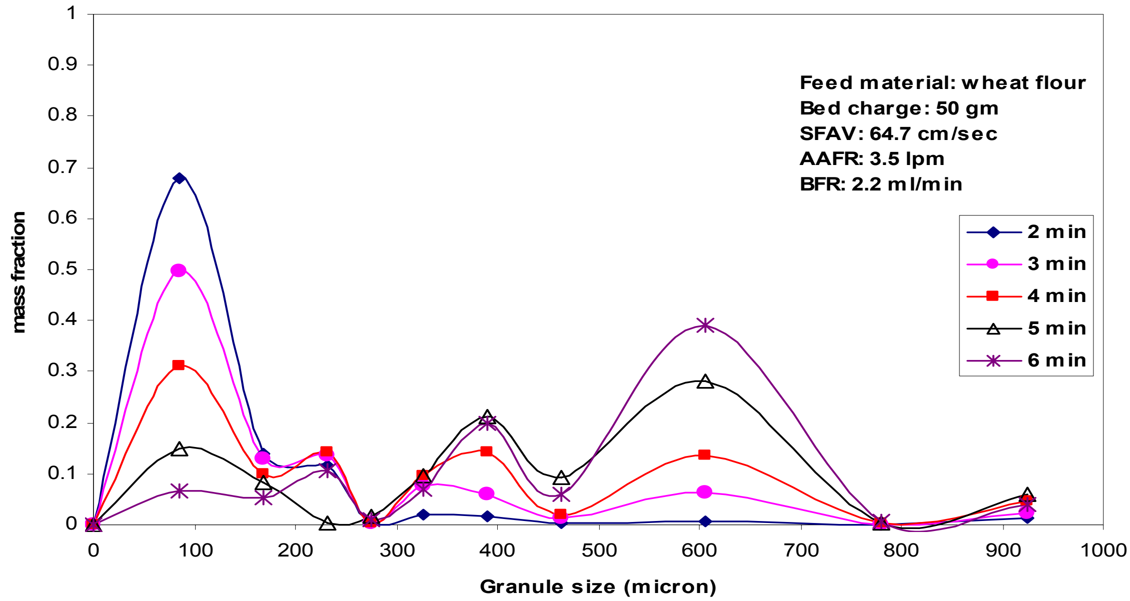

Fig. 1. Evolution of differential size distribution versus time

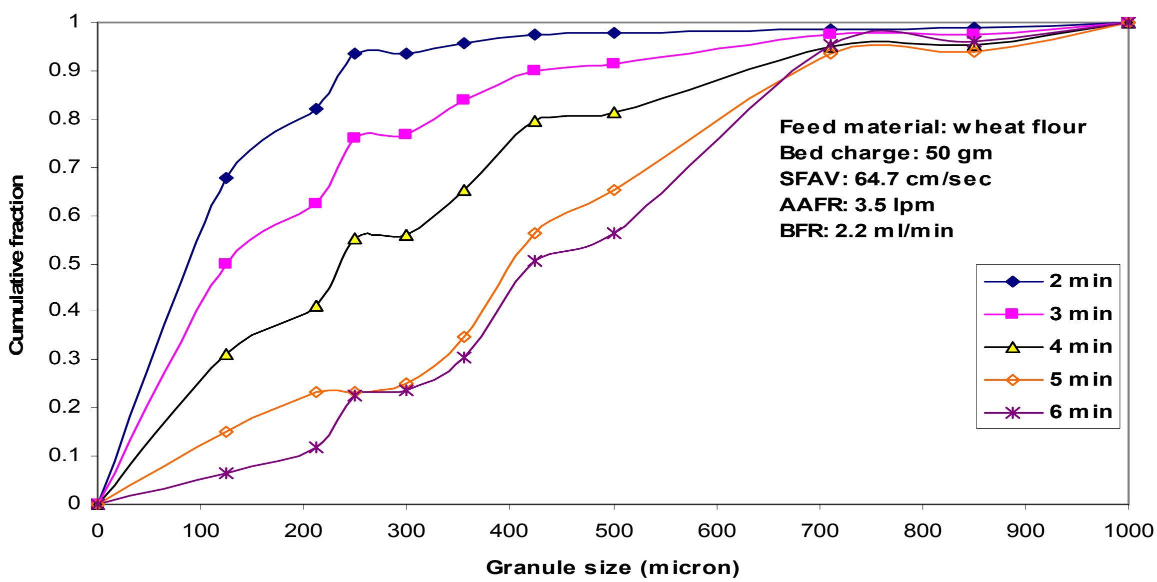

Fig. 2. Evolution of cumulative particle size distribution versus time

MODELING

The growth kinetics pattern of the three classes is analogous to that of concentration Vs time curves for the elementary reversible reaction, given in Equation 1. In this equation, A, B, R are analogous to fine, intermediate and coarse particles respectively. Therefore the mechanism of agglomeration may be expected as similar to that of reaction. The rate of change of mass fraction of particles belong to these three classes can be written in terms of differential equations corresponds to equation 1, and the suitable growth rate constant – $k_{1,}$ k_2 – and breakage rate constant, k_3 can be extracted from experimental data. In this model, it is clear that coarse particles are formed only by coalescence between intermediate size particles and coarse particles are ruptured only by colliding themselves. But, in principle, coarse particles may also be generated when fine particles mob up with intermediate size particles. Moreover, these rate constants are strongly influenced by the process parameters and the physical and chemical properties of binder and feed.

$$A \xrightarrow{K_1} B \underset{K_3}{\overset{K_2}{\rightleftarrows}} R \qquad \mathbf{1}$$

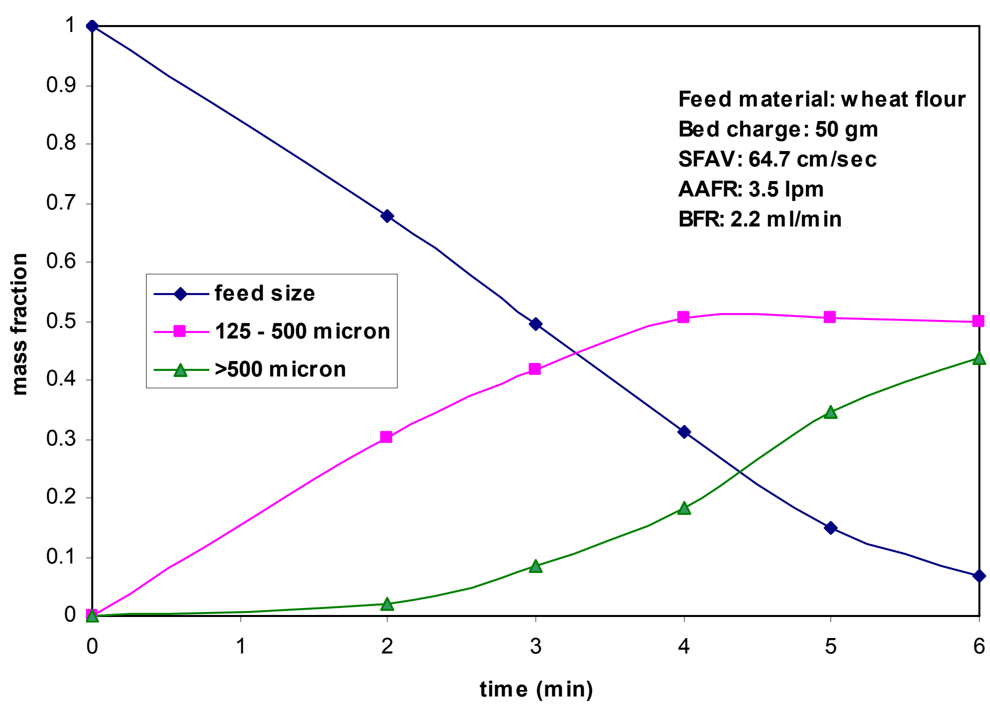

Fig. 3. Evolution of three characteristic classes versus time

CONCLUSION

Experiments have been carried out to granulate fine wheat flour in fluidized bed by spraying water as binder. The evolution of the growth, from the feed powder (5µm - 125µm), to the granulated particle (5µm - 1000µm) is analyzed.. The evolution of mass fraction of particles – fine, intermediate, coarse – are modeled on the basis of rate equation corresponds to elementary reversible reaction .

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