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► To cite this version:

Claire Mayer, Cendrine Gatumel, Henri Berthiaux. Experimental Investigation of the Scale up of Turbula Mixers on the Basis of Kinematic and Dynamic Similarities. Aiche 2012 spring meeting, Apr 2012, Houston, United States. , 8 p., 2012. <hal-01185882>

HAL Id: hal-01185882

<https://hal.science/hal-01185882v1>

Submitted on 3 Jun 2020

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Scale up in Turbula Mixers

Many processes from a wide range of industries (cosmetic, pharmaceutical, food) use powder as raw materials. In most of them mixing or premixing dry particles is a critical step in the process. Indeed the rate of mixing is known to have an influence on the taste of a food product or the bioavailability of a drug. Thus, in order to meet the specifications of the product the choice of the mixer and operating parameters is a key point for the process.

However, the complexity of granular materials leads to difficulties in predicting the behavior of powders inside a blender. Simulation could be used to understand, (for a perfect mixture, as glass sphere) mixing mechanisms inside the blender in order to improve design or operations. But these data are difficult to transpose to a real material, where shapes and sizes of particles are widely dispersed. Therefore the analysis and the optimization of a process mixing can not do without an experimental work for a given mixture. The cost and number of raw materials needed to conduct these studies imply that such work is often done at the laboratory scale. The main challenge then lies in the extrapolation of results from lab scale to pilot or industrial scale with the minimum tests in order to optimize cost. As systems of powder can not be accurately described by a dimensionless number scaling-up is based rather on the principle of similarities which can be, geometric [1], kinematic [2] or dynamic (use of Froude number) [3].

The work presented here concerned with the scaling-up of Turbula mixer, commonly used both in industry and research. The efficiency of the TURBULA[®] is achieved by the interaction of rotation, translation and inversion as per the geometric theory according to Schatz. This combination results in a three-dimensional chaotic motion to obtain homogeneous mixture rapidly for many granular systems.[4]

On the one hand, geometric, kinematic and dynamic studies were performed thanks to a Solidworks simulation of three Turbula scales (Laboratory Scale – Turbula T 2F, Pilot scale – Turbula T 10 B, Industrial scale – Turbula T 50 A). The geometric study showed that there is a constant ratio between two key lengths for the 3 Turbula sizes. Amplitude velocities and acceleration for a point at the bottom of the tank were extracted from simulations.

On the other hand, measurement campaigns of the mixture homogeneity of two different powder systems were conducted in the three Turbula sizes. Intensity of segregation [5] was compared for kinematic or dynamic similarities (i.e. equal velocities or acceleration for a point at the bottom of the tank). The dynamic criterion appears to lead to a better correlation between results obtained in terms of homogeneity of powder mixtures, in the three Turbula sizes.

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[3] Y. L. Ding, R. N. Forster, J. P. K. Seville and D. J. Parker, 2001, Scaling relationships for rotating drums. *Chemical engineering science*, 56:3737-3750

[4] Wohlhart, K., 1981, A Dynamic analysis of the Turbula, International Symposium on Gearing & Power Transmissions, Tokyo.

[5] P. Danckwerts, 1952, The definition, measurement and some characteristics of mixtures, *Applied scientific research. Section A*, 3, 279-296