Novel fluidized bed reactors for more active catalysts

Juray De Wilde[1*]
[1]*Université catholique de Louvain (UCL), IMAP, 1348 Louvain-la-Neuve, Belgium*
*Juray.DeWilde@UCLouvain.be (corresponding author)

Introduction

The operating conditions in conventional, that is, gravitational fluidized bed reactors are limited by the use of earth gravity. Internal mass and heat transfer limitations can be encountered, the van der Waals forces becoming too important when trying to fluidize smaller size particles. External mass and heat transfer limitations can be encountered and are related to limitations on the gas-solid slip velocities. With heterogeneous (catalytic) reactions, as well external mass or heat transfer limitations as internal mass transfer limitations may impose limitations on reaction rates and on the activity of the catalysts that can be used.

Fluidization in a centrifugal field may allow overcoming the above mentioned limitations and may, as such, allow fluidized bed process intensification and in particular the use of more active catalysts [1,2]. Current technology for fluidization in a centrifugal field is based on a rotating fluidization chamber [1,2] and its industrial application faces challenges with respect to sealing, mechanical vibrations and continuous operation. Two novel routes to fluidization in a centrifugal field are presented that facilitate industrial process application and offer additional specific advantages.

Concepts

In rotating fluidized beds in a static geometry, the centrifugal field is generated by injecting the fluidization gas tangentially in the fluidization chamber via multiple gas inlet slots in its outer cylindrical wall [3,4,5]. A combined tangential-radial fluidization of the particle bed can be obtained by forcing the fluidization gas to leave the fluidization chamber via a central chimney. The fluidization gas flow rate influencing both the centrifugal force and the counteracting radial gas-solid drag force in a similar way renders rotating fluidized beds in a static geometry extremely flexible with respect to the fluidization gas flow rate and the gas-solid contact time. In particular, dense operation at high fluidization gas velocities is possible, allowing fast and highly endothermic or exothermic reactions to be carried out in a relatively small volume rotating fluidized bed in a static geometry.

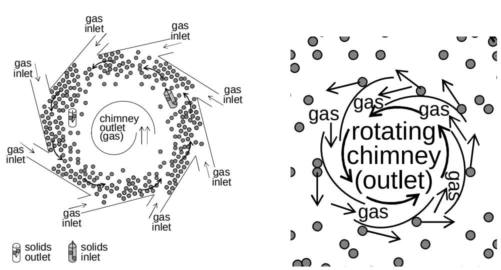

Figure 1. Rotating fluidized bed in a static geometry and rotating chimney concepts.

Rotating fluidized beds in a static geometry furthermore allow angular multi-zone operation, the fluidization gases injected via successive gas inlet slots hardly being mixed in the rotating particle bed. Such multi-zone operation opens perspectives for carrying out catalytic reactions and catalyst regeneration within the same reactor vessel.

In rotating fluidized beds around a rotating chimney [6,7], the centrifugal field is generated by a rotating chimney consisting of multiple blades and positioned centrally in the fluidization chamber. The fluidization gas being forced to leave the fluidization chamber via the chimney, a radial gas-solid drag force counteracting the centrifugal force is generated. Furthermore, both the fluidization gas and the particles obtain a tangential velocity by the action of the rotating chimney. This results in a combined tangential-radial fluidization of the particle bed.

The two novel technologies for fluidization in a centrifugal field can eventually be combined to obtain extremely flexible fluidization technology. In such case, the rotating chimney allows to increase locally, that is, in the vicinity of the chimney, the centrifugal force. This allows to drastically reduce solids losses via the chimney [7]. This is particularly advantageous when fluidizing small, micro- or nano-scale particles. In such case, the rotating chimney also allows to increase the particle bed density, the rotating chimney acting like a compressor on the rotating particle bed.

Results discussed

Experimental and numerical data on the fluidization behavior with different types of particles, the pressure drop over the fluidization chamber and the rotating chimney, the gas-solid mass and heat transfer characteristics in the fluidization chamber and the solids losses via the chimney are presented and discussed. The advantages of fluidization in a centrifugal field using the novel technologies presented are illustrated with potential applications. Perspectives for using more active catalysts and facilitating catalyst regeneration are highlighted.

Significance

Two novel technologies for fluidization in a centrifugal field have been developed that open perspectives for the intensification of industrial fluidized bed processes and in particular for using more active catalysts and multi-zone operation facilitating catalyst regenaration.

References

1. Qian, G.-H., Bagyi, I., Burdick, I.W., Pfeffer, R., Shaw, H., Stevens, J.G. *AIChE J.* 47(5), p. 1022-1034 (2001).
2. Watano, S., Nakamura, H., Hamada, K., Wakamatsu, Y., Tanabe, Y., Dave, R.N., Pfeffer, R. *Powder Technol.*, 141, p. 172-176, (2004).
3. de Broqueville, Axel : Belgian Patent 2004/0186, Internat. Classif. : B01J C08F B01F; publication number : 1015976A3.
4. De Wilde, J., de Broqueville, A. *AIChE J.*, 53(4), p. 793-810, (2007).
5. De Wilde, J., de Broqueville, A. *Powder Technol.*, 183:(3), p. 426-435, (2008).
6. de Broqueville, A., De Wilde, J., April 23, 2007: PCT/EP2007/053941, European and United States of America patent, Pub. No. WO/2007/122211.
7. De Wilde, J., de Broqueville, A. *AIChE J.*, 54:(8), p. 2029-2044, (2008).