Oscillatory Flow Reactors – A platform for process intensification

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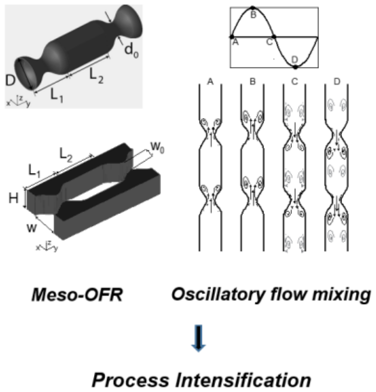

Process intensification demands the development of innovative and more sustainable process design alternatives in order to tackle the challenges related with mixing efficiency. OFR – oscillatory flow reactor – have been proposed as an alternative design to overcome these limitations. OFR, basically a column provided with periodic sharp constrictions, operated under oscillatory flow, have shown to improve significantly processes where mixing is relevant. The application of OFR to several processes will be presented and perspectives for its development discussed

Introduction

Process intensification (PI) has been receiving increased attention and importance because of its potential to obtain innovative and more sustainable process design alternatives. Several definitions have been proposed being one of the most "complete" the targeted improvement of a process at the unit operations scale, the task scale, and/or the phenomena scale [1].

It is well known that mixing efficiency is the key factor for the success of several processes and improper mixing can result in non-reproducible processing and lowered product quality. Stirred tank reactor (STR) is commonly used at the industry, however, problems associated with bad mixing, scale-up, product quality, and process reproducibility, are typically reported. In order to overcome these limitations, reactors with alternative designs have been proposed, including oscillatory flow reactors (OFR) [2,3] as shown in Figure 1 where a modular "LEGO" type OFR is presented.

OFR is basically a column provided with periodic sharp constrictions, called baffles, operating under oscillatory flow mixing (OFM). The liquid or multiphase fluid is typically oscillated in the axial direction by means of diaphragms, bellows or pistons, at one or both ends of the tube, developing an efficient mixing mechanism where fluid moves from the walls to the center of the tube with intensity controlled by the oscillation frequency (f) and amplitude (x0). The formation and dissipation of eddies, in these reactors, has proved to result in a significant enhancement in processes such as heat transfer, mass transfer, particle mixing and separation.

OFR have been applied to several systems like bioprocess, gas-liquid absorption, liquid-liquid extraction, precipitation, and crystallization, at different scales, and the advantages of its use demonstrated. OFR have also been proven to be very efficient in systems where a good solid dispersion must be achieved.

Results and conclusions

The most important characteristics related to mixing and mass transfer of OFR will be described and the effect of the oscillation frequency and amplitude will be highlighted. For the particular case of oxygen transfer, it will be clearly shown that OFR does allow for a several-fold increase in the transfer rate and the relative effect of the oscillation frequency and amplitude on the transfer mechanisms will be discussed. A particular emphasis will be given to the effect of the operating conditions on solids suspension and on the way how solids concentration acts on mass transfer in these type of reactors.

Several case studies describing the use of OFR will be presented going from cases where oxygen mass transfer is the rate-limiting to cases where mixing intensity defines the rate and yield of the process.

Finally, a discussion will be made on recent developments and future perspectives for the application of OFR

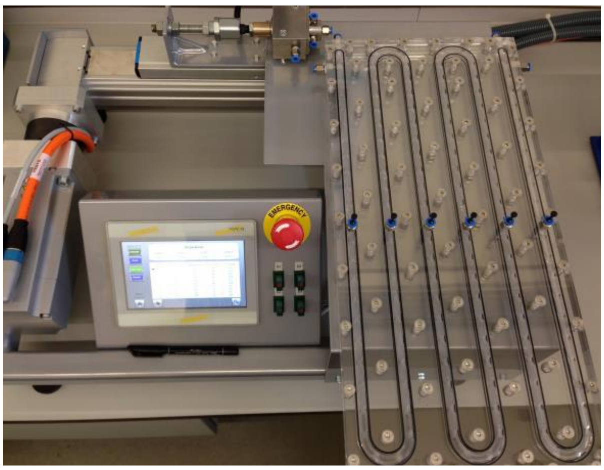

Figure 1. Modular "LEGO" type OFR

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