Process Intensification: A Study of Micromixing and Residence Time Distribution Characteristics in the Spinning Disc Reactor 2

Continued:
13. The use of mixing is a basic process involved with many industrial productions. It serves to homogenize a batch, reduce temperature and concentration gradients, and promotes mass transfer.
14. In many processes, the quality of mixing has a direct impact on overall production efficiency and the creation of undesirable byproducts.
15. The time that is required to achieve sufficient molecular level mixing can also have a significant impact on reaction performance when the time constant of the reaction is close to or less than that of the mixing time.
16. The primary goals of this study are to investigate, quote – (1) the fundamental science underlying the micromixing characteristics taking place within the thin films in the SDR and (2) the Residence Time Distribution of the film under a range of conditions – unquote.
17. Another benefit of process intensification not mentioned earlier, is the improved time to market. With an intensified process, the ability to produce product at a greater rate, and implement changes more quickly overs better market responsiveness.
18. Public and customer perception can also benefit from the implementation of process intensification. It is well understood that processes designed for overall efficiency can reduce resource requirements and offer a more sustainable business model.
19. Some of the challenges involved with process intensification include the need to replace batch processing equipment, company culture must transition from batch orientation to continuous orientation, and each reaction needs to be understood based on its intrinsic reaction time so that the proper process can be developed.
20. One process intensification design is called the multifunctional reactor which aims to combine two or more functions into a single step, for example, quote – the reverse-flow reactor which integrates reaction and heat transfer by periodic flow reversal – unquote.
21. Hybrid separation is another method which relies on the integration of membranes with at least one other separation technique to improve separation efficiency.
22. Alternative energy sources can also be used to influence the mixing, heat transfer, and mass transfer: quote – centrifugal fields, ultrasound, solar energy, microwaves, electric fields, microwaves, and plasma technology – unquote.
23. The final group of intensification methods include processes such as supercritical fluids and dynamic/periodic reactors.
24. The Spinning Disc Reactor is one design that utilizes centrifugal force to intensify the mixing of reactants producing better heat and mass transfer.
25. The thin films of liquid produced on the spinning disc can be as thin as 25 um or less. This film is very turbulent, but its turbulence is dependent on viscosity. Reactions of greater viscosity will resist distortion and turbulence but will not fully prevent it.
26. Previous works by Brauner and Maron indicated that the presence of waves in thin films was directly related to improved heat and mass transfer.
27. The centrifugal force acting on the thin film produced on the spinning disc of an SDR can induce forces 100-1000 times that of gravity.
28. NASA has done considerable research into the use of spinning discs to facilitate reactions that otherwise rely upon gravity to proceed in a reasonable timeframe.
29. Viscous thin films tend to dampen the ripples most responsible for the improved heat and mass transfer as such disc surfaces have been developed to induce greater turbulence.
30. Rotor Stator SDR's have also been developed and are comprised of two discs separated by only 1 mm. One disc spins while the other is held stationary, this creates a greater shear force and better liquid / solid and liquid / gas interaction.

Source: Al-hengari S. Process Intensification: A Study of Micromixing and Residence Time Distribution Characteristics in the Spinning Disc Reactor. October 2011.
https://theses.ncl.ac.uk/dspace/bitstream/10443/1771/1/Al-Hengari (12mnth).pdf

Review by: SP