Process Intensification: A Study of Micromixing and Residence Time Distribution Characteristics in the Spinning Disc Reactor 5

Continued:
68. In another test, it was shown that acid concentration had a significant impact on the segregation index (Xs). As such, the initial concentration of reactants clearly has an impact on mixing as well.
69. By adding glycerol to the aqueous reactions, the author was able to control the viscosity of the reactants and investigate its effect on Xs. It was shown, quote – clearly that the segregation index is affected by the viscosity of the feed – unquote.
70. It was also observed that increasing the speed of the disc was able to partially overcome the negative impact of increased viscosity on micromixing.
71. Power dissipation is a measure of how much physical energy is transmitted to the fluid by the spinning disc. Higher power dissipation is typically associated with better micromixing and a lower segregation index. Testing indicated that increased disc speed, higher flow rate, and lower reactant viscosity were all associated with greater power dissipation.
72. Studies with the 30 cm SDR and differing flow rates brought up the realization that an optimal flow rate often exists based on process parameters. For the given test, Xs decreased as flow rate was increased from 3 ml/s to 9 ml/s, regardless of disc speed. At flow rates above 9 ml/s, Xs began increasing, indicating a decrease in micromixing efficiency.
73. The study author offers the explanation that at a certain flow rate, the fluid is not able to fully couple with the spinning disc at which point the Coriolis effect becomes a significant influence in the fluid movement. When this happens, less energy is imparted to the fluid and less micromixing occurs.
74. In an investigation of power dissipation using the 30cm SDR and varying flow rates and disc speeds it was also shown that while increasing flow rate will increase powder dissipation, it will at some flow rate also increase the segregation index (Xs) indicating less micromixing.
75. Experiments using a grooved 30cm disc showed the opposite results regarding flow rate and segregation index. Low flow rates displayed a higher segregation index on the grooved disc when compared to the smooth disc. At higher flow rates, the Xs was less with the grooved disc than the smooth disc.
76. The author explains this phenomenon with the idea that at a sufficiently low flow rate, the entire disc is not fully wetted. As such, the thin film forms rivulets at the bottom of the grooves rather than a uniform thinness across the whole surface. At higher flow rates the liquid is able to fully wet the grooved disc allowing for more surface area for mass and thermal transfer.
77. The author also undertakes several comparable investigations involving Narrow Channel Reactors (NCRs) to compare their efficacy with the SDR.
78. Results from the multiple tests, quote – confirm that the micromixing efficiency in SDRs at a given power dissipation is better than in SBR (Stirred Batch Reactor) and NCRs – unquote.
79. Comparison of results between the 10 cm and 30 cm SDRs, controlling for other variables, showed that, quote –the 30cm SDR performs better than the 10cm SDR as a result of a larger disc surface area available – unquote.
80. This larger surface area translates into greater residence times and therefore more opportunity for micromixing to occur.
81. Investigations of the residence time on SDR indicated that higher disc rpm led to shorter residence times, but more importantly a decrease in residence time variance. Lower residence time variance is associated with a more idealized plug-like flow with less back mixing. This likely indicates a more uniform thin film layer over the surface of the disc and more uniform micromixing.
82. Similarly, it was shown that increased flow rate also yielded a decrease in RTD variance and more uniform flow/mixing. This only appears to hold true until a certain flow rate is reached at which the benefit of additional flow rate is not seen.
83. RTD was also increased because of increasing the viscosity of the reactants, but this effect is somewhat overcome by increasing disc rpm and increasing flowrate.

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