CFX solves difficult mixing problem

by Steven Drury, Sharpe Mixers, USA

One of Sharpe Mixers' customers reported that their newly installed agitators could not provide the required mixing in a batch reactor. The mixer needed to rapidly blend thickener into the reactor charge to produce a highly viscous polymer without entraining air, which could negatively affect the material's density. Because of secrecy regarding the ingredient's proprietary nature, we had originally been asked to design the mixer for a material viscosity of 50,000 centipoises. We were confident that the mixer, which featured two large axial impellers and a smaller one at the bottom of the tank, should have worked well under these conditions, but it clearly was not achieving the desired results.

We were asked to fix the problem as quickly as possible. We first thought that it would be necessary to install a larger mixer capable of handling the highly viscous material, but then we noticed that the motor drew considerably less power than expected. This suggested the mixing of a shear-thinning material whose viscosity significantly decreased in the high-shear region around the impeller blades.

To verify our thinking, the customer created a material that behaved exactly like the one in the reactor. Tests in a viscometer confirmed the shear-thinning hypothesis, necessitating a new design. One approach would have been to build an experimental model, but we had only a small sample of material with which we could experiment. Instead, we solved the problem through CFD. Sharpe had previously selected CFX-ProMixus because it specifically addresses mixing processes in batch reactors. Starting from the intuitive GUI, we specified the existing reactor configuration from lists of tank, baffle and impeller templates, using the new material properties. CFX-ProMixus then automatically performed the CFD simulation, predicting the dead spots that were seen in the reactor.

Because the viscosity was lower at the impellers due to the shear-thinning rheology, we felt that the speed and size of the turbine could be increased to improve mixing without exceeding the torque limits of the motor. We ran a series of iterations with different motor speeds and impeller configurations, evaluating the fluid mixing and the amount of required torque. We found that replacing the small turbine at the bottom with a full-scale turbine and increasing the speed provided complete mixing. Additional improvements could also be achieved by removing the tank baffles, or for better results, we recommended that the existing baffles be replaced with adjustable baffles that could be disengaged for shear-thinning products and extended for products with lower viscosity.

The customer was invited to view the simulation and was very impressed. We showed how increasing impeller size and motor speed and disengaging the baffles would provide the optimal batch control. In fact, all that was necessary was minor changes, at a fraction of the cost of a new mixer, saving the customer about $15,000. We changed the impeller and a few gears in the speed reducer, and the customer made the modifications that we suggested to the baffles. The results on the plant floor matched the simulation perfectly. Our customer is now so happy that he has since ordered three more identical mixers.

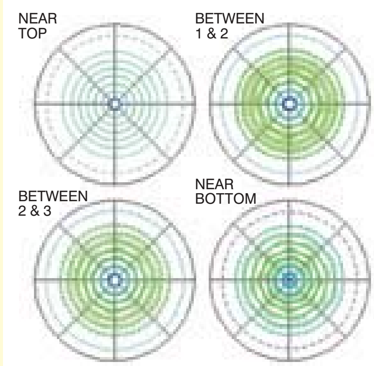
'The results on the plant floor matched the simulation perfectly'

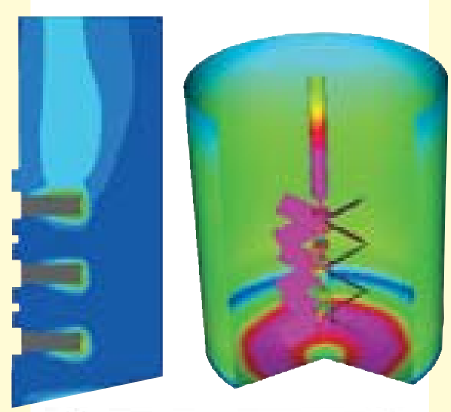
Top to bottom:

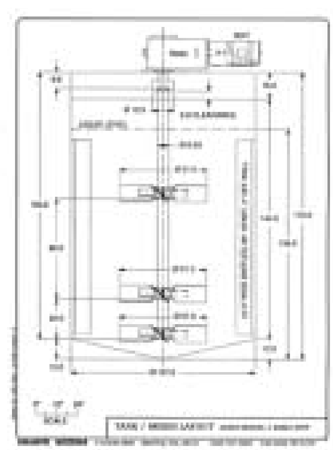
Normalized velocity on horizontal sections.

Normalized turbulence kinetic energy on a vertical plane; Tank and impeller geometry mapped by wall shear.

Layout of the mixer mounted on the tank.







Process