SERIAL MIXING AS IT APPLIES TO THE MANUFACTURE OF HOT MELT ADHESIVES

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Mixing History

In the beginning, when people wanted to mix something, not much was available. Although I was not there, I can imagine sticks, boat oars, paddles and anything people could conjure up to move the products around in the vessel they were using. As mixing became more sophisticated, mechanical mixers were used. Turbine type agitators were used and mixing technology began to move forward as these mixers were studied and refined. Today, mixing equipment can be very sophisticated. Mixing systems now incorporate fully integrated controls and the operator can control and entire process from a personal computer.

High Viscosity Products

For the purposes of this paper I want to make some very general definitions of viscosity ranges. Low viscosity will be defined as any liquid in the range from 1 to 10,000 centipoise. Medium viscosity will be defined as 10,000 centipoise to 30,000 centipoise and high viscosity from 30,000 centipoise and up. Specific gravity will not play a part in this paper but should not be ignored as criteria for choosing a mixer.

High Viscosity Mixing

Low viscosity mixing is easily accomplished with conventional axial and radial turbine agitators. These agitators range in horsepower from 5 horsepower and up for production models depending on blade diameter, speed, and product characteristics. Medium viscosity mixing is also accomplished with the same type of mixers but this viscosity regime is where we see the conventional rules of thumb for mixing being broken. Blade diameters in relation to tanks diameter begin to grow as the viscosity increases. The primary reason for this is an attempt to accomplish serial turnover. As viscosity increases, serial turnover becomes increasingly difficult. The further away from the blade you get, the less the product is inclined to move. As blade diameters increase, so does the required horsepower. As you move out of the medium viscosity regime and into the high viscosity regime, the problems of serial turnover cannot be solved with conventional turbine agitators. The blades will move product in close proximity to the blades but any product below, in between, and above the blades will not move. If dry or liquid raw materials are to be added or the product has to be heated or cooled, the problems are compounded. These problems sent mixer designers back to the drawing board.

To solve the problem that occur in medium and high viscosity mixing, several different blades and blade arrangements were developed. The first blade I would like to speak about is the conventional anchor blade. One of the biggest problems with using conventional turbine type blades in medium and high viscosity mixing is the lack of product movement at the vessel wall. The anchor blade was developed to solve this problem. This blade was designed to work in close proximity to the vessel wall, thus enhancing heat transfer. There are several inherent problems with the design. The primary problem is the lack of serial turnover. Anchor blades are designed with two or three vertical arms that are often triangular in shape. Typical blade to wall clearance for the anchor blade is 0.75 to one inch. They typically just disturb the product at the vessel wall. To combat this problem, manufacturers have added all sorts of pumping blades to the design in an attempt to increase serial turnover. Some have even added second shafts with screw augers or gate blades in an attempt to increase serial turnover. All of this cause the mixer price, its installation and operating costs to go up.

This leads us to another question. Is there one blade design out there that will provide enhanced serial turnover, increase heat transfer at the vessel wall and assist in the incorporation of dry powders? The answer is yes, the helical blade. Instead of having straight vertical arms the helical blade is designed with curved vertical arms that incorporate a twist. The typical blade to vessel wall clearance is the same as the anchor blade. This design has proven superior in serial turnover. This is how it works. The helical blade takes a section of the material theoretically as wide as the blade itself and displaces it down and in as the blade rotates in the clockwise direction. This action leaves a void behind the blade which is filled by a new material. The basic flow pattern is down and in towards the center of the vessel and up the center shaft. This flow pattern is what we call serial turnover. Why is serial turnover so important? From the standpoint of hot melt adhesives, it's all about transferring the heat at the vessel wall quickly and evenly throughout the batch. Without serial turnover, the material at or near the vessel wall stays there and continues to get hotter and hotter. The closer you get to the center of the vessel the product is cooler, especially in larger vessels. If the product has insulating properties this can make heat up times even longer. Serial turnover allows a batch to have even heat distribution throughout the entire batch. This heat distribution will decrease batch time and increase product quality. The enhancement of heat transfer is the main reason why this blade should appeal to the hot melt industry.

At this point I would like to create a scenario that I have witnessed both in our pilot p mixer and in the field. You have a formula for a filled hot melt adhesive. The viscosity is in the range of 75 to 100,000 centipoises. The formula calls for the base adhesives to be heated to 375 degrees F. During this heat up time the filler has to be added to raise the final viscosity to its maximum. This scenario has two challenges. The first one is product movement off the vessel wall for heat transfer. Too little movement and you either run the risk of scorching the product with a high wall temperature or taking an exorbitant amount of time to get to temperature. With a blade design that is constantly moving the product away from the wall and allowing new product to move in behind it, this challenge is overcome. Heat can be added through the vessel wall at a faster rate therefore decreasing heat up time. The other challenge is getting the filler to fully mix in to the batch. The lighter they are the harder they are to mix in. Serial turnover solves this problem as well. Without the benefit of serial turnover this scenario could become a nightmare for a chemist, plant manager and an operator.

Independent tests on medium to high viscosity products proved the helical blade to offer anywhere from 5 to 10 times higher heat transfer coefficients than conventional agitators. One test was actually in a hot melt adhesive with a viscosity of approximately 30,000 centipoise. If you remember the general definition of viscosity ranges, this viscosity borders between medium and high viscosity. In this test the helical blade was tested against an axial turbine blade that the customer was currently using in production. The axial turbine provided an average heat transfer coefficient of 8. The helical blade provided an average heat transfer coefficient of 40. Heat up times were significantly faster with the helical blade. Clearly this indicated that serial turnover was the key to the results.

Conclusion

In conclusion, there are many ways and means to mix medium and high viscosity products. Some are not very effective while others offer more desirable results. In a perfect world all products would be thin and easy to mix. In the real world this is not the case. Depending on your application there are a number of variables to consider when choosing the right mixer.