

Mixed up About TWAS?

TWAS can be much harder to mix than primary sludge, leading to disappointment and redesign. Computer simulation combined with a viscous sludge fluid model came to the rescue.



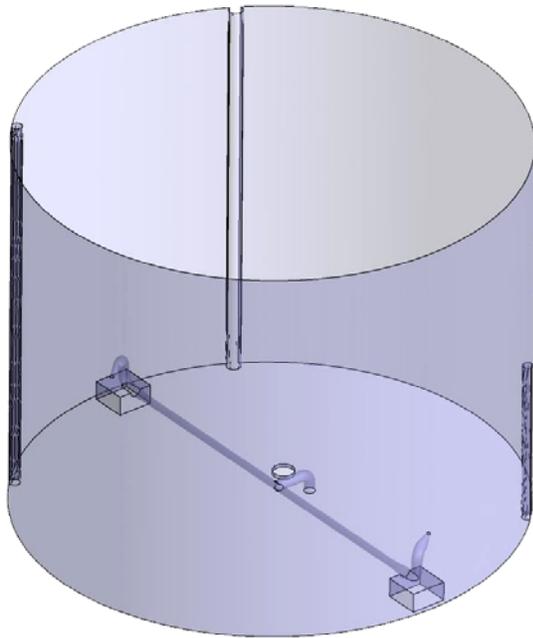
By Jeff McCormick, Carollo Engineers; Richard Bishop, CH2M Hill Engineers; John Peterson, Clark Regional Wastewater District; and Glenn Dorsch and Marilyn Pine, both of Vaughan Company, Inc.

The Vaughan Rotamix® mixing system for the blend tank at the Salmon Creek Wastewater Treatment Plant, Vancouver, WA, should have had plenty of mixing flow for stirring up the sludge considering the relatively small size of this tank. Rotamix® is a hydraulic jet mixing system with floor-mounted nozzles powered by a Vaughan Chopper Pump. The Rotamix system replaced a troublesome propeller mixing system in this tank. The blend tank is used to evenly mix primary and other sludges before they are pumped into the primary anaerobic digester. And yet the treatment plant was calling to report that the mixing system provided was not working to their satisfaction. They were seeing no upper surface mixing once the tank level got higher than about 6-8 ft. in this 23' dia. x 23' high, 70,000 gallon cylindrical tank. While the system worked "like a Jacuzzi" when mixing sludges that flowed similar to water, investigation by several Vaughan and consulting engineers and Vaughan's process specialist revealed two primary problems: (1) the polymer thickened waste activated sludge (TWAS) going into this tank was much more viscous than anticipated, and (2) TWAS, which floats, was being added through a standpipe located above the upper surface of the sludge in the tank, leaving the TWAS unmixed at the top of the tank.

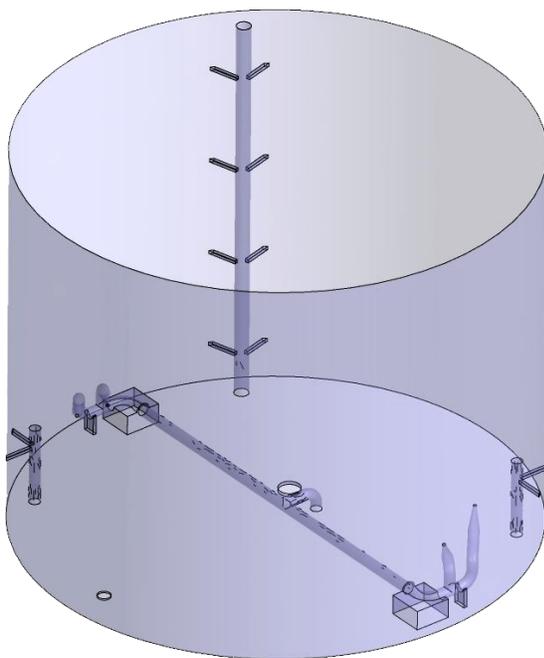
To find solutions to this dilemma Vaughan Co, the mixing system supplier and an experienced user of ANSYS CFX, modeled the tank and mixing system using a fluid model developed from sludge rheology data provided by a treatment plant in England. Vaughan Co. was uniquely prepared for this challenge, having modeled in excess of 700 large tank mixing systems using CFX, a computational fluid dynamics (CFD) computer program that simulates complex fluid flow. Many of these systems have been modeled with non-Newtonian fluids, such as sewage sludge. Within a few weeks eight different trials had been run showing that the system mixing velocity could be doubled by using the same pump, motor and mixing flow but by changing: (1) the number of mixing nozzles from two to four, (2) rearranging the nozzle angles to spread out and better distribute the momentum around the tank, and (3) lowering the sludge standpipe so that TWAS was dumped into the tank as close as possible to the nozzles.

The customer, understandably concerned after the first disappointment, wanted to know how the modified system would work with *his* sludge before any changes were made. To do this, Vaughan needed detailed data on the actual Salmon Creek blend tank sludges. Fortunately, an enterprising CH2M Hill engineer on this project was willing to use

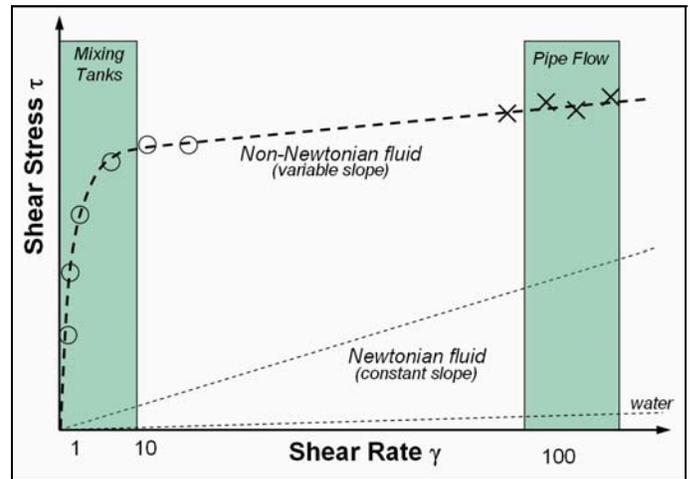
the plant's viscometer to obtain detailed shear stress vs. strain rate data for the different sludges blended in this tank. This data allowed Vaughan Co. to create a more accurate fluid model to use in the CFX simulation. This fluid model allowed for a much more realistic simulation of the original and the proposed mixing systems for comparison. The original mixing system with 2 single nozzles is shown below.



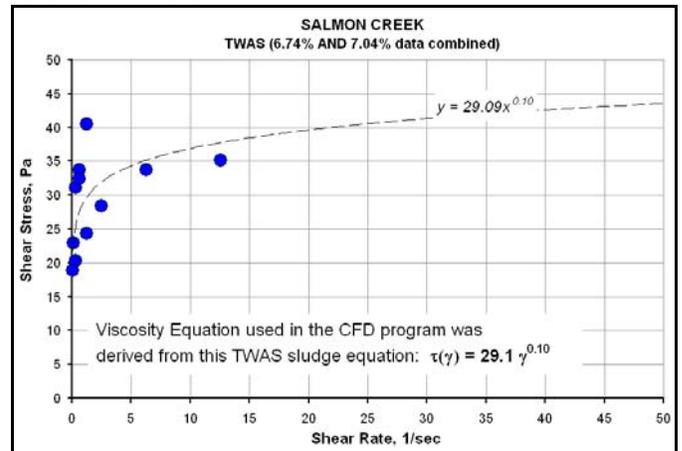
The improved mixing system with 2 dual-nozzles and additional tank detail is shown below.



The following graph illustrates the special problem confronted when simulating viscous fluids in mixing systems compared to that encountered in pumping/piping systems.



Fluid viscosity is related to the shear stress vs. shear rate curve shown above. Each plant's sludge, which is a non-Newtonian fluid (water is Newtonian), is going to have a unique curve. Of particular importance is obtaining enough data to construct an accurate curve. Data on the left side of the curve is especially important because of its impact on mixing systems. The shear stress vs. shear rate curve for the Salmon Creek TWAS sludge is shown below.



Data for the various sludges in the blend tank are characterized by the table on the following page. Note that the "K" coefficient for the TWAS is 29 times higher than the same coefficient for unthickened primary sludge coming out of the clarifier.

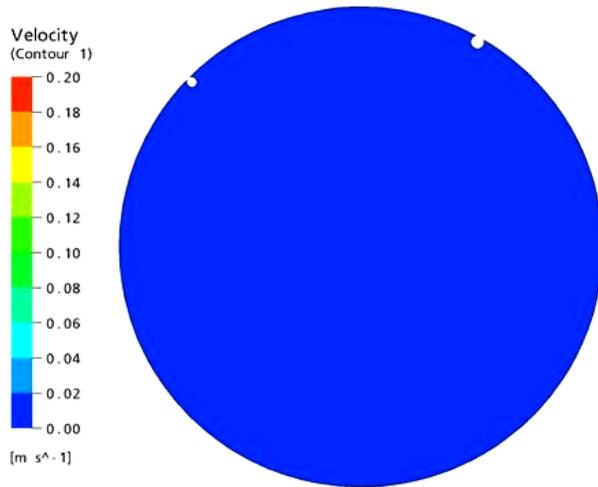
This illustrates how extremely viscous the TWAS is compared to another typical sludge.

$$\text{Shear Stress } \tau(\gamma) = K \gamma^n$$

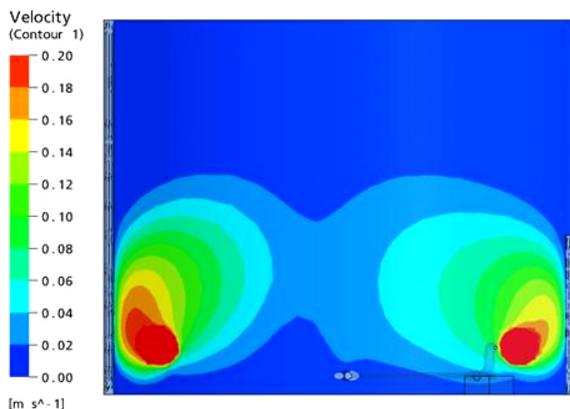
SLUDGE	COEFFICIENT K	EXPONENT n
Primary	1.09	0.09
TWAS	29.09	0.10
Blended (Digester Feed)	1.76	0.44
Digested	0.92	0.26

The originally installed system was simulated using the TWAS sludge fluid model. Top and cross-section elevation contour velocity plots are shown below, illustrating that the system was not providing good mixing velocities with this worst-case sludge except near the tank floor and the nozzles.

Original System, 2 Single Nozzles
TWAS Sludge
Velocity Contour Plot – Top of Water

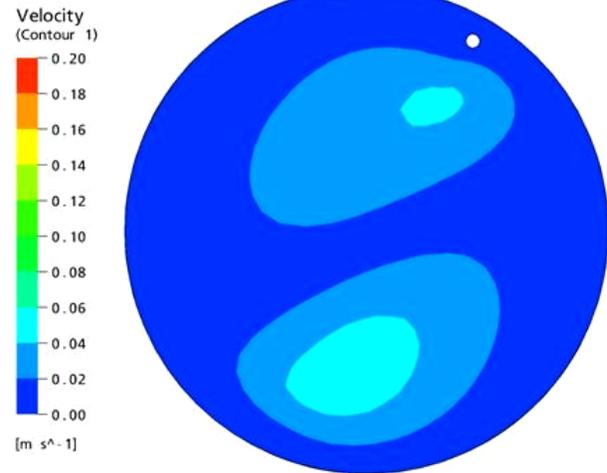


Original System, 2 Single Nozzles
TWAS Sludge
Velocity Contour Plot – Elevation Cross-Section

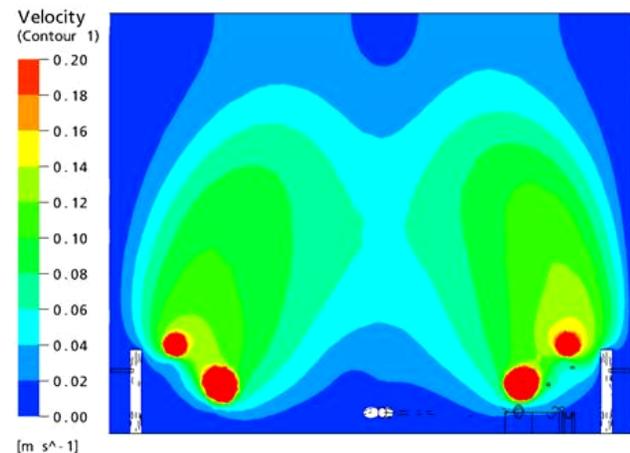


The contour velocity plots of the modified system with 100% TWAS fluid are shown below, showing that while the system still won't generate surface movement when completely full, the system is working much better, providing surface mixing velocity at about 15' of liquid level compared to about 6-8 ft. with the original system.

New Design, 2 Dual Nozzles
TWAS Sludge
Velocity Contour Plot – Top of Water

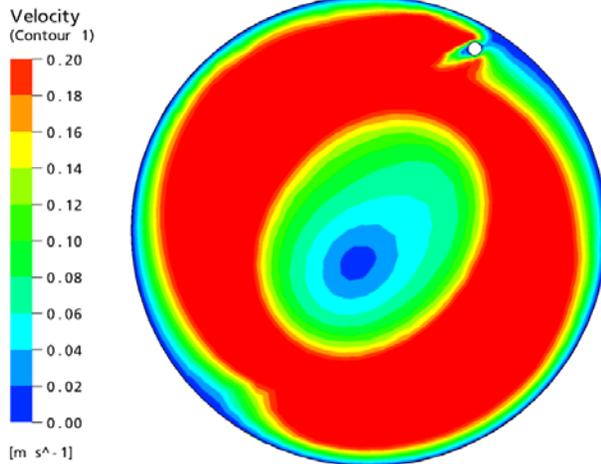


New Design, 2 Dual Nozzles
TWAS Sludge
Velocity Contour Plot – Elevation Cross-Section

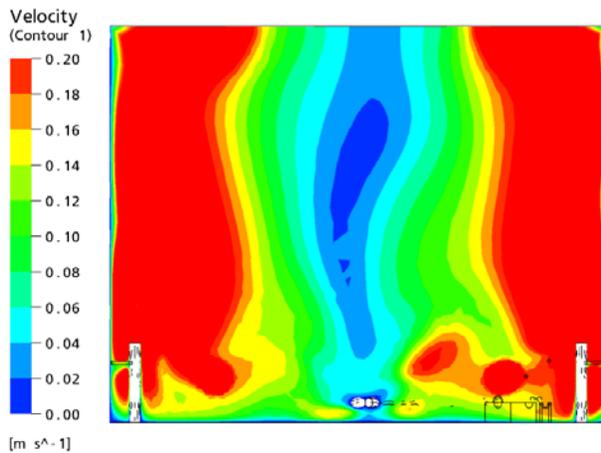


The modified system mixing a blend of TWAS and primary sludge provides much more impressive mixing results, as shown in the top view and cross-section elevation contour velocity plots on the next page. This blended sludge is much less viscous than 100% TWAS modeled on this page.

New Design, 2 Dual Nozzles
Blended Sludge
Velocity Contour Plot – Top of Water



New Design, 2 Dual Nozzles,
Blended Sludge
Velocity Contour Plot – Elevation Cross-Section



In response to Vaughan's CFD modeling the treatment plant officials agreed to the proposed system modifications. They were now more confident in the design changes since the simulation of the original system accurately described what they were observing.

Vaughan provided the materials and labor to make the system changes after the owner drained and cleaned the tank. The tank was out of service for less than one day because of excellent cooperation between organizations. After the mixing system modification, the physical mixing results essentially matched those predicted by the CFX simulation in 100% TWAS. Mixing was visible at the upper surface of the tank with levels all the way up to about 15 ft. high. At higher tank levels less upper surface motion was evident. Still, the plant operators understood that even if upper surface motion was not evident at the highest levels with the worst-case viscosity TWAS, mixing was still taking place throughout the lower two thirds of the tank.

CFX, combined with good teamwork between the equipment supplier and the consulting engineer, allowed Vaughan Co. to simulate a host of mixing system changes using various realistic fluid models while rebuilding customer confidence that the system could be made to work to their satisfaction. All this was done before any physical work was performed on the tank or mixing system. This approach saved considerable cost and generated significant good will between customer and supplier.

Jeff McCormick, P.E, is Staff Engineer, Carollo Engineers, www.carollo.com; Richard P. Bishop, P.E, is Principal Project Manager, CH2M HILL, www.ch2m.com; John M. Peterson, P.E, is Capital Program Director, Clark Regional Wastewater District, www.crwwd.com.

Glenn R. Dorsch, P.E, is VP/Chief Engineer and Marilyn C. Pine, P.E, is Sr. Engineer, both of Vaughan Company Inc, Montesano, WA, www.chopperpumps.com.

ANSYS, Inc, Canonsburg, PA; ansysinfo@ansys.com.