

The blending process needs to maximise the full potential of the tank contents in order to get the best financial return, and do so in the most energy efficient way

Cost-effective and energy efficient?

When evaluating the most appropriate process and technology, operators must be absolutely clear in their minds as to what they are trying to achieve: is it mixing, blending, homogeneity or preventing the build up of basic sediments and water (BS&W) in the bottom of the tank?

Mixing covers all process applications: liquid/liquid; gas/liquids; liquid/solids and solids/solids. Blending assumes two or more liquids are present to achieve a final state or third product within a given time. This can include solids suspension. Homogeneity typically involves only a single product.

Preventing BS&W involves maintaining water and solids in suspension within crude oil. All blending applications in large tanks are flow-related, so achieving the best solution has to be made by calculating the required flow and selecting the mixer(s) to achieve that flow.

Mixing and blending

There are a number of approaches that can be used for keeping the tank contents in a constant state of movement, including pumping, jet mixing and rotating impellers within the tank. Each of them has particular advantages and disadvantages and more often than not it will be the tank size and desired end product which will influence the selection.

Employing pumps to transfer the product from top to bottom looks feasible when first considered. However, it is inevitable that the flow of product will take the easiest and straightest route to the tank bottom, so a considerable



Gear drive swivel angle mixers on crude oil tanks in Ecuador

proportion of the tank's contents may not be mixed. Where there is a solid content, damage to the pump may occur, with solids building up in the tank bottom on areas not exposed to the flow. What must be remembered is that pumps are designed to transfer liquids by producing pressure. In addition, they consume large quantities of energy and require seals conforming to API 682, all of which contributes to high running costs.

Jet mixing, which has been around for a great many decades, is a proven mixing technology and one which because of its long history has a wide user base. That said, reports indicate that it uses a lot of power because the pumps that provide the liquid flow to the nozzles have to generate high pressures and high volumes at the jet nozzle. Jet mixers suffer significant energy losses at the pump, in the pipework, in the bends and most significantly in the nozzles. There is also the drawback that where very large diameter tanks are involved, 55m and above,

the jet flow may not reach the extremities of the tank.

Jet mixing is a regime that is reliant on pumps to produce the jet flow so the pumps have to be capable of handling the potentially corrosive and viscous nature of the product as well as being capable of constant operation. Even at times when the capacity of the tank is at a low level or maintaining homogeneity is the objective, it is necessary to keep the pump running at full capacity. The jet mixing process requires a substantial installation infrastructure in terms of pipework and pumps, which contribute to high capital and running costs, whilst access to any in-tank components for maintenance may be restricted and can only be undertaken when the tank has been drained and vented of gas. Jet mixers can only be used in one tank at a time as it draws the product from the tank and returns it to the same tank through the nozzles.

Side entry propeller mixers, both fixed angle and swivel angle, are used extensively

for the largest tanks because the flow can reach all parts of the tank. With a side entry mixer there is a physical element within the tank that forces the contents up and back down and it is this which performs the duties of blending, homogenising and temperature uniformity. Where side entry propeller mixers are used, the number of propellers operating can be reduced as the content of the tank reduces, thereby lowering energy costs. A swivel angle side entry mixer, where the propeller moves from side to side, is primarily used on crude oils and ensures the media at the bottom, middle and top is uniform. Where swivel angle mixers are used, they also ensure that the bottom of the entire floor is cleaned, so preventing the build up of BS&W. The advantage of this capability is that it frees up plant operatives for other duties and ensures more efficient tank cleaning.

To mix two or more distinct components together in order to obtain a consistent blend in a set time period at defined specifications demands complete bottom to top 'turnover' movement throughout the tank. Bottom to top 'turnover' would normally be required in order to aid heat transfer while heating or cooling, or to maintain temperature uniformity and complete fluid motion. Positioning of the mixers relative to the heating elements is also important to obtain the desired process results. These duties can be accommodated with the installation of fixed or swivel-angle mixers. There are two propeller systems that can be employed: mixing from 'stratified' tank conditions or



Fixed angle belt drive mixers including upward pointing unit on fuel oil blending in the Netherlands

mixing during 'pump up'. What must be remembered when opting for pumping up is that when a fixed angle impeller blade is used, it must be switched on at the minimum recommended level and must be maintained during the entire tank filling process.

To do the same job as propeller mixers, jet mixers would require a pump to develop 8 bar pressure at the nozzles and create large flows. Tanker unloading pumps are unable to supply this pressure and volume so cannot be used. The costs for delaying a tanker's departure for this application would be extremely expensive, even if it was allowed. It is not unusual to hear of pumps needing twice the motor power to generate the pressure and flow as the total calculated for propeller mixers.

Propeller design

When applying side entry propeller mixers to crude oil storage tanks it should be recognised that there are significant differences between blending and cleaning operations. The flow patterns established by blending mixers allow sediment accumulations. These 'dead spots' are not affected by increased running time or by ineffective reversal of propeller operation. They are removed only by the direct sweeping action of the propeller flow stream.

The performance of a tank mixer is dependent on the design of the propeller and its efficiency. Computational Fluid Dynamics (CFD) has contributed to the knowledge of how mixers work in large storage tanks, particularly when obstructions such as heating coils and internal distribution pipes are fitted. CFD enables designers and operators to predict flows

within tanks where these types of limitations are present and to select the optimum height and positions for the mixers.

The design of the mixer blade and the positioning of the mixers within tanks are the critical elements in obtaining optimum mixing and blending performance.

One option available is a true helical pitch propeller with forward rake, available from Plenty Mixers (an SPX Brand), which provides cavitation-free suction conditions whilst promoting maximum fluid pumping and entrainment for any installed power. Each propeller is accurately cast as a one piece component, thus eliminating the pitch setting variances and welding problems often present with fabricated designs.

Setting the angle of the shaft, both horizontally and vertically, is essential to the effective performance of the

mixer. When the mixer is horizontal, the flow hits the far side of the tank wall, which absorbs much of the power and flow making it more difficult to intermix various layers in the times required by refinery needs. This is cured by using additional energy. Pointing the impeller upwards even by just five degrees, means that the flow goes through all the layers when full energy is available. Thus, when the flow hits the far wall, much less energy has been used and there is sufficient energy to get to the top of the tank. By using upward tilting impellers, blending times can be reduced by as much as 50%.

On crude oil applications the horizontal angle does have to be adjusted at regular intervals to ensure an even contour pattern across all areas of the tank. This can be performed either manually or by using an automatic actuator which will sweep across the tank and back in approximately 10 hours without human intervention.

For upward tilting propellers there needs to be an additional switch-off at about half the liquid level to protect the floating roof. The remaining tank contents can continue to be mixed by using the horizontal mixers until a level of 2.5 x propeller diameters above the mixer shaft is reached. In this way, no damage is caused either to floating roof supports or any heating pipework elements in the bottom of the tank. This arrangement of horizontal and

upward tilting mixers means that the propellers are always clear of the floating roof and the operator is able to recover dead ullage within the tank and improve cash flow.

There is also a further financial advantage to be gained by using rotating impellers for blending purposes. Once the blend has been achieved it becomes possible to maintain the blend by using a reduced number of impellers. Thus, not only has it taken less time and energy to create the blend, but maintaining the status quo also becomes more economical.

In order to select the best and most appropriate regimes for blending hydrocarbons in large tanks, tank farm managers and tank designers should consult with equipment manufacturers at the earliest opportunity. Any form of selection procedure has to involve the physical parameters of the tank.

Selecting the most appropriate mixing and blending regime is far from straight forward, so it is essential that tank storage managers understand the various technologies available. At the end of the day, the goal should be to optimise the potential of products contained within storage tanks, minimise energy costs and maintenance, and get the best return on investment over the long term. ●

For more information:

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