



Advances in Submerged Jet Mixing Technology & Sludge Resuspension

KnightHawk Industries Application Notes

Background

KnightHawk Industries has developed a next generation, tank cleaning device that is simple to install and highly reliable in operation. The device employs Submerged Jet Mixing Technology. SJM by itself is not new. However, the TurboMixer incorporates significant system improvements that proved highly successful in a recent application at a Texas refinery. In early 2016, the refinery's maintenance engineering group met with KnightHawk Engineers to discuss the Turbo Mixer application for a storage tank approximately 219 feet in diameter with an average of 8-12 inches of sludge build up & in isolated areas a couple feet. This tank needed to be cleaned quickly, and with minimum process interruption, while maintaining a high level of plant safety.

Challenges

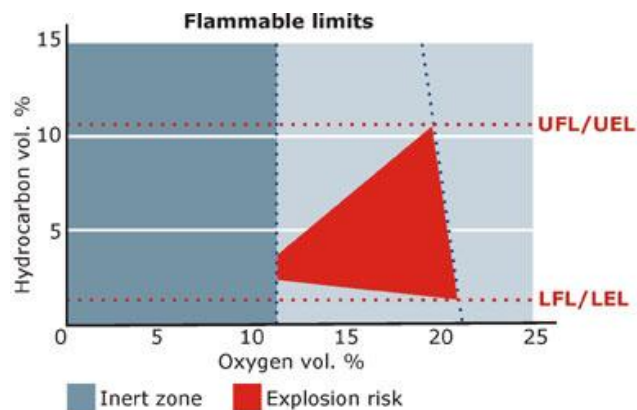
Tank cleaning is an extremely hazardous activity with many difficult to quantify variables. As a general rule, time spent by personnel inside a tank should be kept to a minimum.

Traditionally, tank cleaning has been accomplished by a typical mechanical process where the tank is taken out of service, drained and physically entered, followed by excavation of the existing sludge. This process is time consuming and involves significant exposure risk as personnel are required to operate inside the tank for an extended period of time.

Anytime a tank containing Crude Oil is taken out of service, plant safety personnel are concerned with the hydrocarbon rich vapor becoming diluted with air and the mixture approaches the flammable zone.

For a mixture of hydrocarbon vapor and air to ignite, the ratio has to be within certain limits. For most hydrocarbons the lower flammable limit (LFL) and the upper flammable limit (UFL) are typically 1% and 10% by volume respectively.

The requirement for man-entry into a tank containing flammable vapors is currently generally accepted as 10% of LFL. This means that in real terms hydrocarbon in air measurements are at or below 0.1%.



In this particular case, the tank was not scheduled to be taken down for several more years. However with the discovery of a leaking roof the tank was to be taken down immediately and cleaned in

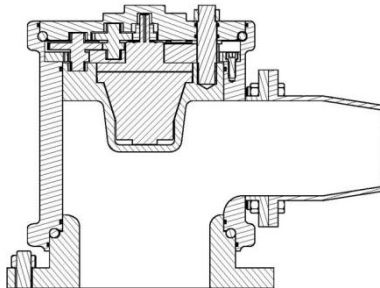
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preparation for necessary repairs. The Turbo Mixer was an ideal solution as it would minimize the time the tank would need to be down for proper cleaning.

Engineered Solution

The TurboMixer is a highly engineered tank mixer that utilizes a vector thrust drive system. Torque is generated by offset nozzles that are interchangeable, depending upon tank diameter and pump size. The system uses internal viscous controls to prevent over speed.

The flow field can be controlled by replaceable nozzles that will allow for up to a 175' cleaning / mixing radius.



Result and Findings

The refinery installed the Turbo Mixer on one of the man ways on the side of the tank and allowed it to operate for approximately 30 hours. Upon opening the man way, immediate improvement could be observed. After tank cleaning crews entered the tank it is estimated that the Turbo Mixer was



successful in agitating the contents of the tank up to ~125 feet (just over 50%) from the mixer nozzle and any sludge mounds within this distance had been completely eliminated, saving up to a week in cleaning efforts and down time. It should be noted that due to time constants, only a single mixer was available at the time. Ideally 2-3 mixers would be mounted equally spaced from each other to ensure complete agitation. Alternatively a single mixer could be mounted in the center of the tank for a more permanent cleaning solution.

KnightHawk TurboMixer Benefit for Above Ground Storage Tank Maintenance:

- **Cost efficient.** Significantly reduces tank T/A time and cost.
- **Product recovery.** Sludge is 95% recoverable hydrocarbons once re-suspended.
- **Environmental.** Significantly reduces hazardous waste & associated disposal cost.
- **Reduced Exposure.** Reduces plant personnel exposure during cleaning operations.
- **Safe Operation.** Reduces safety hazards vs. open air tank cleaning.
- **Industry Accepted.** SJM methodology is a recognized, non-intrusive tank cleaning method.

Typical Applications

- *Tank Cleaning & Sludge Recovery*
- *Crude Oil Blending*
- *Lube Oil Blending*
- *Clean Fuels Blending*
- *Carbon Black Oil Blending*
- *Asphalt Circulation*
- *Chemical Product Blending*
- *Sludge Resuspension*