Tank cleaning is a dirty business

by Brian Warshaw

It might take a year, maybe three or even five years; but at some stage in their operating life, storage tanks will need to be cleaned

Vertical storage tanks, particularly those holding crude oil, heavy fuel oil, slops oil or catalytic cracker residue, will accumulate a collection of stones, grit, sludge and mechanical items swept down the pipeline or from the tanker making a sea delivery. Tank cleaning is neither an easy, nor an inexpensive operation, but it is necessary. The contents of the tank have to be reduced to a minimum level, new entries might have to be formed, a secondary storage facility made available to receive the residual product, services and utilities provided close to the tank, and if physical entry is required it must be gas free.

According to James Ilsley of Oil Pollution Environmental Control (OPEC), one of the best ways to extend the time period between cleaning is to install a submerged rotary jet (SRJ) mixer system as a permanent fixture. A similar unit can also be used as a temporary device fitted to the storage tank to enable it to be cleaned at any time.

As a permanent feature of the tank's maintenance system, the SRJ mixer is mounted in the centre of the tank, and used on an intermittent basis to control the formation of sludge – how frequently will depend upon the condition and characteristics of the oil, and the frequency of loading and discharge. The unit can direct a single jet, or two opposing jets of oil horizontally across the tank while it slowly rotates at a programmed rate. This action cuts into the sludge that has settled on the tank floor, re-suspending and homogenising the hydrocarbons that have become trapped in the sludge.

PECO P43 submerged rotary jet mixer

About nine years ago OPEC was involved with a project for the Formosa Petrochemical Chemical (FPC) company. At stake was the potential to supply 28 centre mounted SRJ mixer systems for installation in vertical floating-roof storage tanks of 87 metres diameter, and a capacity of up to 700,000 barrels of crude oil. FPC undertook a detailed study of available equipment, including the use of side entry propeller mixers (SEPM), and compared the benefits and disadvantages of employing each of the systems commercially available.

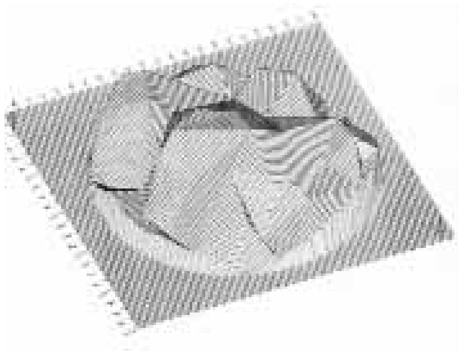
Ilsley says: 'The most notable reason that FPC gave for choosing to go with the SRJ mixer technology was its ability to eliminate the build-up of sludge in the tanks, thereby maximising the amount of storage capacity available at all times.'

Other reasons FPC gave OPEC for its decision were that the units would only have to operate infrequently, and that the existing cargo and recirculation pumps could be used without the need for additional energy use. The water drainage system in the tank also works more effectively and reduces the potential for corrosion, so there is less chance of damage to the floating roof when it is lowered to the maintenance position, due to a smaller volume of fluid residual sludge on the tank bottom. FPC found that after settling time, following the use of the SRJ mixer system, the crude oil sent to the refinery was more homogenised than had been their experience with tanks using SEPMs.

Despite the conclusion of the design study, FPC retained some concerns by not having any first-hand experience of SRJ mixer systems. The company decided to install a static nozzle in the tank shell, connecting it to the external pumping system through a divert valve. It was only used on one occasion, and because of the effect from the crude oil flowing to a specific set point in the tank, the sludge built up to a peak, damaging the floating roof when it landed on it.

'Currently it is FPC's policy for all crude oil flowing into the tanks from the cargo pumps to be partially diverted through the SRJ mixer installed in the centre of each tank, using a valve manifold,' explains Ilsley. The 28 systems operating at Mailiao, Taiwan, have done so for eight years without need of maintenance or repair, and FPC has expressed its confidence in the SRJ mixer technology by ordering a further 12 units for other parts of the company across Taiwan.

SRJ mixer technology does not eliminate the need to clean the tanks; but it does enable the remaining sludge



Development of a topographical image of sludge mound

to be more easily treated than oil that has not been jetted, and pumping it out becomes an option for the cleaning contractor. The reduced volume of sludge also means that the tank will be back in operation quicker, and the cost of waste treatment is reduced.

As a result of the study, FPC reduced the number of tanks that it had originally intended to build. 'Initially the company wanted to construct 36 tanks; but settled on 28, a saving of $20 million (€14.8 million), partially as a result of the additional storage volume that the SRJ mixer system would make available,' he explains.

The OPEC tank cleaning system is also used by contractors on tanks that do not have permanent SRJ mixer systems installed. In this case, normal or swan neck type SRJ mixer units are inserted in manway flanges – the number being determined by the diameter of the storage tank. The task is simple, although a significant amount of information must be gathered before the procedure for cleaning can be put into operation.

A topographic survey should be carried out before work on tank cleaning commences, although this can be done whilst the tank is in service. The physical shape and characteristics of the sludge is then determined with soundings taken from the tank top to the height of the sludge. The measurements are loaded into the OPEC bespoke topographic software, and the levels of the sludge become graphically available to the cleaning team, which can then determine if the manway flanges can be used to install the temporary SRJ mixer units. If the sludge is higher than the manway flanges, then an actuating nozzle or nozzles with rotation indicators must be fitted to the tank in order to reduce the high points on the sludge mound. An external source of clean crude oil is pumped through the nozzles and the peaks blown off the sludge, thereby allowing the manway flanges to be opened. It may be necessary to cut holes in the tank to accommodate the actuating nozzles at the correct height to achieve this.

The SRJ mixer units are bolted to the manway flanges and fresh crude oil is circulated. OPEC provides a mobile zone 1 hazardous area diesel pump unit capable of despatching 800 cubic metres per hour of crude oil, at 10-bar pressure for use with the actuating nozzles and SRJ mixer units. If the tank diameter is less than 45 metres, just one SRJ mixer, with or without a swan neck, unit is needed. However if it is greater than this then a second opposing unit will be required. The jet on the SRJ mixer unit is designed to close as it passes the tank shell, so ensuring that no damage is caused to the tank wall, and only one nozzle is fully open at a time.

Pumping continues for at least 48 hours, or more if the topographical survey indicates a need. During this time the contents of the tank are thoroughly mixed and blended by the energy provided in the discharging oil and the rotary action of the SRJ mixer. One rotation of the unit can be set to between three-and-a-half and six hours. The effect is to blast all the components of the sludge into the overhead oil; soluble hydrocarbons go into solution, while organic materials remain in suspension.

When the pumping operation is concluded, a period of 48 hours is left for the basic sediment and water to settle at the bottom of the tank. The re-suspension and recovery of the soluble hydrocarbons is complete and the oil is pumped out, then the OPEC equipment removed from the tank. This marks the end of the first phase.

In many cases this is sufficient for the site, as the residual sludge may be minimal. OPEC claims that as much as 90% of the original total volume of the sludge is reclaimed. So for a 92,000 cubic metre storage tank with a sludge quantity of 5,000 tonnes, the recovery of soluble hydrocarbons may be as much as 4,500 tonnes, leaving just 500 tonnes of sludge for further treatment or retention. This is the equivalent of permitting an additional 1,300 cubic metres of oil to be stored, a major increase in inventory per tank.

If the overall plan for the tank requires the tank to be cleaned for inspection or repair and left in a gas-free state, the second phase is to remove the sludge and treat the waste. For OPEC this is not a shovel and bucket process, and it is important to reduce the need for personnel entry whenever possible. The company has two types of minidozers to scrape and remove the sludge. Both types of minidozer are hydraulically operated, one controlled remotely from outside the tank; the other with a driver/operator inside the tank. The driver is equipped with breathing apparatus and has an observer stationed outside the tank keeping watch during the

Blabo equipment on site in Mexico

whole time that the operator is in the tank.

The function of the minidozer is to move the sludge to the inlet suction pipe of the sludge pump, where it flows to a variety of buffer tanks before being separated into oil for return to storage, water and solids for additional treatment before being disposed of in an environmentally acceptable manner. According to OPEC, phase I of the process, cleaning the tank might take up to 10 days; while the second phase could take up to 25 days to treat the 500 tonnes of oily waste when such factors as health and safety, pipe routing and obstacles in the tank are taken into consideration.

Oreco's Blabo cleaning system

A more high-tech approach to tank cleaning and oil recovery is provided by the Danish equipment manufacturer Oreco. Oreco has developed its Blabo system as a fully automated, non-personnel entry system that is suitable for both fixed and floating roof tanks up to 200,000 cubic metres capacity. It is the manufacturer's claim that more than 95% of the hydrocarbons in the sludge are recoverable.

Blabo comprises a number of process modules built into 20-foot containers. The four main units, which are built to hazardous area specification, provide suction, recirculation, skimming, and separation functions. Located in a safe area are the Oreco container-based modules that produce inert gas, stream, and power generation, as well as an office and laboratory unit.

Each of the modules is transported to the site on the back of a flatbed lorry, where they are off-loaded, and the pipes, hoses and valves are linked together close to the storage tank to be cleaned. A connection is made at a low point in the tank, where the sludge resides. From the clean oil outlet on the recirculation module a flow line is taken to the top of the tank where it is connected to a distribution manifold into a series of special tank cleaning nozzles that the contractor fits in the tank roof.

An important part of the set-up is the positioning and installation of the cleaning nozzles in the roof. The number of nozzles is dependent on the diameter of the tank, and the need to ensure full coverage of the internal surfaces. If possible, nozzles are fitted in existing openings; but if necessary, new openings are made using the Oreco SafeTap cold-tap cutting tool. The cleaning nozzles are a patented Oreco design, with a single outlet that produces a high impact jet with a long throw, while operating on a low inlet-pressure oil.

Inside the Blabo separation module

To eliminate all potential risk of fire and explosion, the storage tank is filled with nitrogen or other inert gas. All guide poles, legs, valves and other potential leak points on the tanks are sealed to prevent any loss of nitrogen. The oxygen content within the tank is reduced to below 8%, a level which is maintained throughout the operation.

During the cleaning operation, which is now ready to start, built-in warning systems, constant monitoring and progress reporting ensure safety throughout the entire process. Desludging is the first stage, and depending on the type of sludge, which might contain a mixture of resins, asphaltenes, wax, solids, water, and trapped liquefied oil, it may be necessary to add a cutter stock at the start of the process.

The residue at the bottom of the tank is sucked out by the pump and passes through pre-filters to remove any foreign bodies such as stones, nuts, bolts and welding rods, before entering a vacuum tank. Non-condensable gases are removed and returned to the oil storage tank, thereby minimising emissions and reducing the nitrogen consumption. The module has the facility to bypass the vacuum tank if the residue is non-volatile.

Oil continues on into the recirculation module, where, if it is of high viscosity, the temperature is raised as it passes through a plate heat-exchanger before entering a bank of hydro-cyclones, which separate out the heavy solid particles from the clean oil. This clean oil is returned through a booster pump to the cleaning nozzles at the top of the tank.

The action of the cleaning nozzles is vital to the whole process, and a programmable logic controller (PLC) in the recirculation module is able to ensure that they focus on areas that need a more intense effort to remove the sludge. Jetting the sludge with the clean oil and cutter stock continues until all the sludge has been fluidised and re-liquefied. The conversion of the sludge to oil is complete and this stage of the cleaning process is over.

Concurrent with the desludging operation, separation takes place to a degree that enables the refinery to specify the outcome. The Blabo process is operated and monitored by a few trained operators using PLCs and user-friendly control panels, giving them the ability to vary the processes based on the regular laboratory tests that are performed during the cleaning operation. Typically the laboratory analysis will result in additional oily-water or extra liquids/solids separations, until the required oil fraction is available at the outlet of the hydro-cyclones. The recovered oil is transferred to the pipeline, and wastewater to the foul drains for subsequent treatment.

If required, the tank, which at this stage will have a thin layer of clean oil on the wall and bottom, can be washed with water that is introduced via the nozzles, which will be treated in the skimming module to separate the oil from the water. The nitrogen in the tank is vented and the manways opened so that, after a gas check, the internal condition of the tank can be inspected.

The Blabo system is disconnected from the tank, cleaned, packed and loaded on trucks ready to move to the next site. For a typical 50,000 cubic metre tank, the timescale is in the order of three to four days hook-up, two to three weeks cleaning and waste treatment, and then a further three to four days for removing the equipment from site.

Marc Schindler, managing partner at France-based C&S International Services, says he likes Oreco's technology due to its safety, efficacy, and versatility. Schindler explains that when he started in the tank cleaning industry 15 years ago, there was nothing like the Oreco technology available in Europe, except in Germany. As a contractor, his need was for 'a system that was reliable, could cut total operating time, and produced a good result for the customer.' Of the client, he said, 'It was most important to them that nobody had to enter the tank, and that the cleaning was achieved with minimum disruption to the site. As an added bonus we can recover 98% of the oil in the sludge to be set against the cost of the service.'

Another company that offers tank cleaning, and is soon to take delivery of a complete non-personnel entry system, is Colt Industrial Services Limited, in the UK. The new system uses

Source: BP Ineos

Directing cutting operations inside the tank

powerful 950-litre water or diesel cannons that are remote controlled via CCTV, and includes the latest Xenon lighting which conforms to the current ATEC electrical safety standard.

Tank cutting

Equally, Colt provides a worldwide tank-cutting service using a hydro abrasive cutting system capable of parting 150mm thick steel plates. The typical work that Colt is involved with includes the cutting of tank floors, roofs and doorways. Hydraulic manipulators enable the cutting nozzle to form a wide variety of weld preparations, angles and profiles for subsequent re-working.

Traditionally this type of work has been performed using oxyacetylene cutting torches, with all the associated risks to the health of employees and to the environment, although high-pressure water-jet cutting technology was first patented in 1968. The abrasive used by Colt for cutting all types of metallic material is garnet. Garnets show a range of hardness on the Mohs scale of between 6.5 and 7.5 – diamond is designated 10. As an inert mined mineral, garnet is silica-free, and if not contaminated during the cutting process, can be safely disposed of in a landfill site. The variant is in the selection of grit size, based on a rough calculation of three adjacent pieces of grit passing through the jet nozzle. Thus a cutting nozzle with a 1.6 mm diameter orifice will use grit from 450 to 850 microns. As the abrasive is never propelled without being in complete water saturation, the cutting nozzle is suitable for use in a Zone 1 hazardous area, while the control system itself must remain in a Zone 2 area.

Colt's cold cutting systems are generally considered to be low-pressure devices, operating at 350 bar or less. Ian Telford, the company's technical director says: 'We have an unrivalled knowledge of hydro abrasive cutting and are continually developing our systems. A typical tank floor of 50 metres diameter that requires complete removal will be completed in less than nine days. There is no heat, no sparks and the cutting system will accommodate over plating where it occurs. There is not a part of a tank or vessel that we have not cut, from fixed roofs, floating roofs including pontoon chambers, ribbed and even plastic, fibreglass or composite lined tanks. The process offers a rapid turnaround and a marked improvement in the safety in contrast to alternative methods.'

At the higher pressure end of the hydro abrasive cutting systems are the Ragworm machines, designed, manufactured and operated as a specialised service for contractors by Jetset Hydro Technics of the Netherlands. Mounted on a small caterpillar robot, the water jet cutter nozzles are designed to operate at 2.800 bar and discharge water at a rate of only four litres per minute, ensuring a minimum impact on the underlying terp or ground on which the tank is mounted.

The manufacturer claims that the unit, which is equipped with two nozzles, can cut through 6 mm thick carbon steel at an average speed of 60 metres per hour with only two operators, one controlling the diesel generated power-pack and high pressure pump located outside the tank, the other within the tank with the cutter unit. This is a claim recently put to the test at the BP-operated Ineos Finnart Ocean Terminal in Scotland, where Jetset Hydro was undertaking a tank renovation project.

With the contract running eight days behind schedule when they gained access to the tanks, Jetset Hydro, employing two Ragworm machines simultaneously, finished four days ahead of schedule. The two teams had cut the 70-metre diameter tank bottom into six by two metre plates in less than 100 hours, gaining the thanks of the main contractor and site management.

Sonia Grijpstra-Muir, commercial director of Jetset Hydro, said the company was operating successfully in several European countries, and was now turning its attention to the US, where it believed the Ragworm technology with its improved safety, speed and efficiency will be welcomed.

Tank cutting and cleaning are in many ways complimentary site services. A choice of systems and methods is available to the site operator, and fortunately they all have two things in common, an improvement in safety and in protecting the environment.

Source: BP Ineos

Cutting jet passing through the tank