The effects of high efficiency mixers and critical process variables in the optimisation of demulsifier injection rates

Crude production plants use equipment focused on separating the crude oil into a pure stream, while the gas and water obtained from this separation are diverted to a gas processing plant and water treatment facility, accordingly, remarks Raul Gonzalo and Gregory Hallahan of ProSep

Crude oil is extracted from the wells containing a percentage of gas and water, as well as other components. The combined multiphasic stream is then processed in a crude production plant (CPP) to separate the different phases into purer products: oil, gas, and water, separately. The separation of the different phases into pure streams in the CPP requires different equipment and processes, which can be challenging depending on the process conditions and characteristics of the fluids.

The gas is easier to be separated in the first stages of crude processing due to the gravitational forces and density of the different streams, while the water could be more challenging to separate due to the similarity in density with the crude oil and the presence of emulsifying agents as solids, surfactants, resins, waxes and asphaltenes, which contribute to water-in-oil and oil-in-water emulsions. The emulsifying agents coat the water droplets, increasing the surface tension of these and avoiding the coalescence of the droplets. Small water droplets, which are not able to coalesce into bigger water droplets, are then carried out with the crude oil and therefore not separated.

Demulsifier chemical is injected in the CPPs to promote the coalescence of the water droplets in the crude oil. Enhanced coalescence is achieved due to the construction of the demulsifier's oleophilic tail and hydrophilic head, which help reduce the surface tension in the water droplets and stimulates these to coalesce, creating larger water droplets that can separate from the crude.

Proper demulsifier mixing and usage allows the CPPs to achieve lower Basic Sediments & Water (BS&W) at the crude oil outlet of the dehydrators and improves effects of wash water in the dry crude to achieve lower salinity.

Figure 1: Time evolution of main process parameters before installation of high efficiency mixers.

Four (4) x 18" Multiphasic Adjustable Xtreme (MAX) high-efficiency mixers (HEMs) were installed in a gas and oil production plant in Middle East. One mixer for each desalting train (1, 2, 3, and 4), installed upstream of each of the four dehydrators, replacing the conventional mixing valves previously installed. HEMs were installed to optimise the usage of demulsifier and achieve a reduction of demulsifier injection, while achieving in-spec salt outlet concentration in the desalting trains.

Technology description

The HEMs are designed to inject and disperse demulsifier into the crude-water flow to efficiently expose the demulsifier to the water droplets and without generating additional small, non-separable water droplets. The mixer allows the intensity and pressure drop to be adjusted and controlled by an actuator, or manually operated gear box. The injection part of the mixer can handle any flow rate of the injected fluid relevant to the application.

The channels at the mixer inlet side are arranged such that the generated jet-flows are directed towards a common focus line. A shear stress is induced for the break-up of the dispersed phase. With the channel arrangement, high shear flow conditions in the whole mixing chamber are enabled and efficient mixing can be achieved with a low, or moderate pressure drop. At the outlet side, the channels are designed for a lower pressure drop exceeding the frictional forces in the pipe surface, and the flux of the homogeneous multiphase flow mixture will be distributed evenly over the pipe cross section.

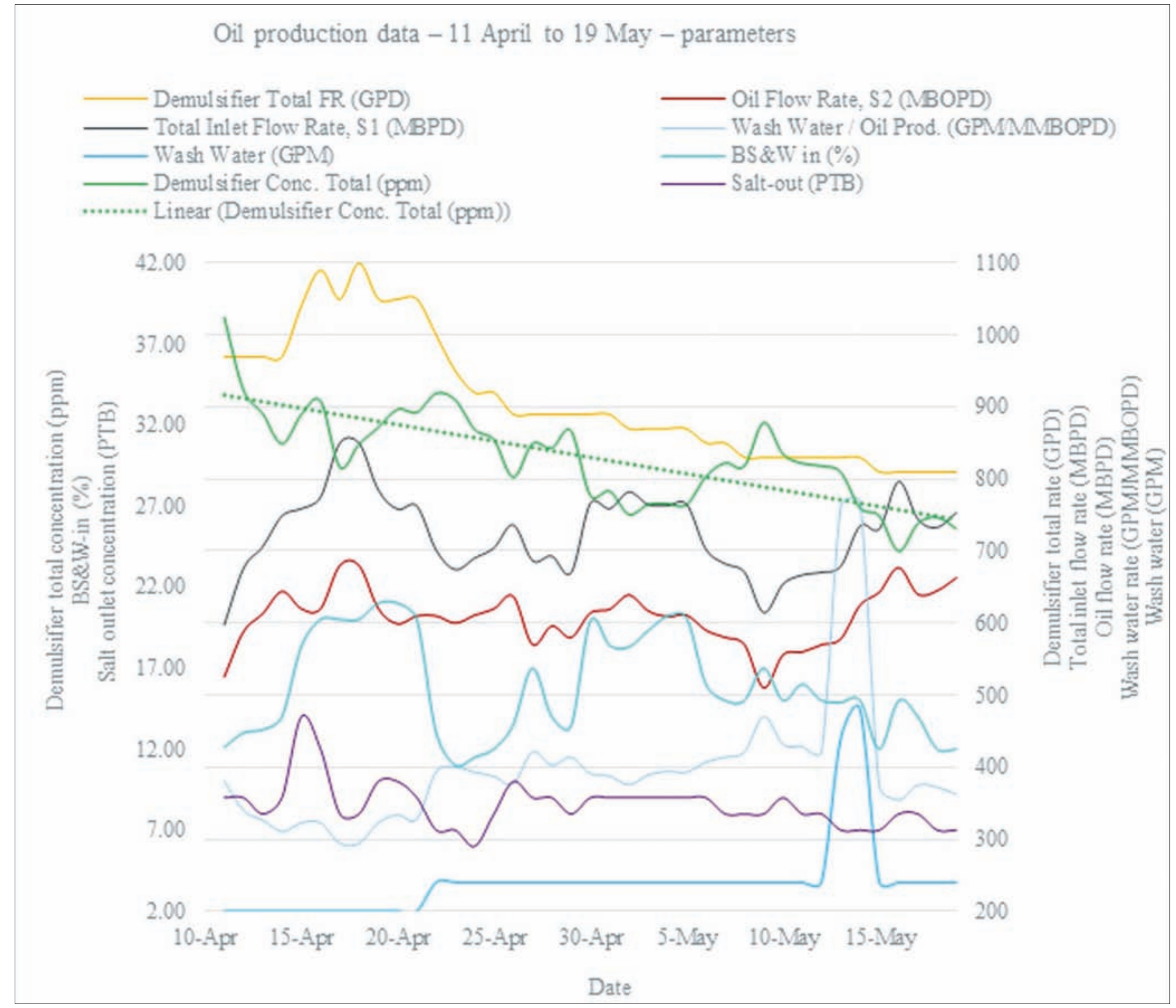

Figure 2: Time evolution of main process parameters after installation of high efficiency mixers.

Field testing

The data collected during the test was compared to the data collected before the installation of mixers when the conventional mixing valves were installed. The criteria for evaluation of mixing efficiency was based on the lowest rate of demulsifier per rate of crude oil, while maintaining an acceptable salt outlet concentration below 10PTB (Pounds per thousand barrels of crude).

Before the installation of the HEMs, the crude processing plant used conventional mixing valves for the injection of demulsifier chemical. The demulsifier chemical was injected in the injection points D1 and D2. The type of demulsifier used required longer residence times for full dispersion intro the crude.

Demulsifier injection was manually adjusted by the operators at the three different locations of injection: upstream low-pressure production traps [(LPPTs) (D1)]; upstream of charge pumps, and downstream degasser (D2); and upstream of dehydrators, into the mixers (D3).

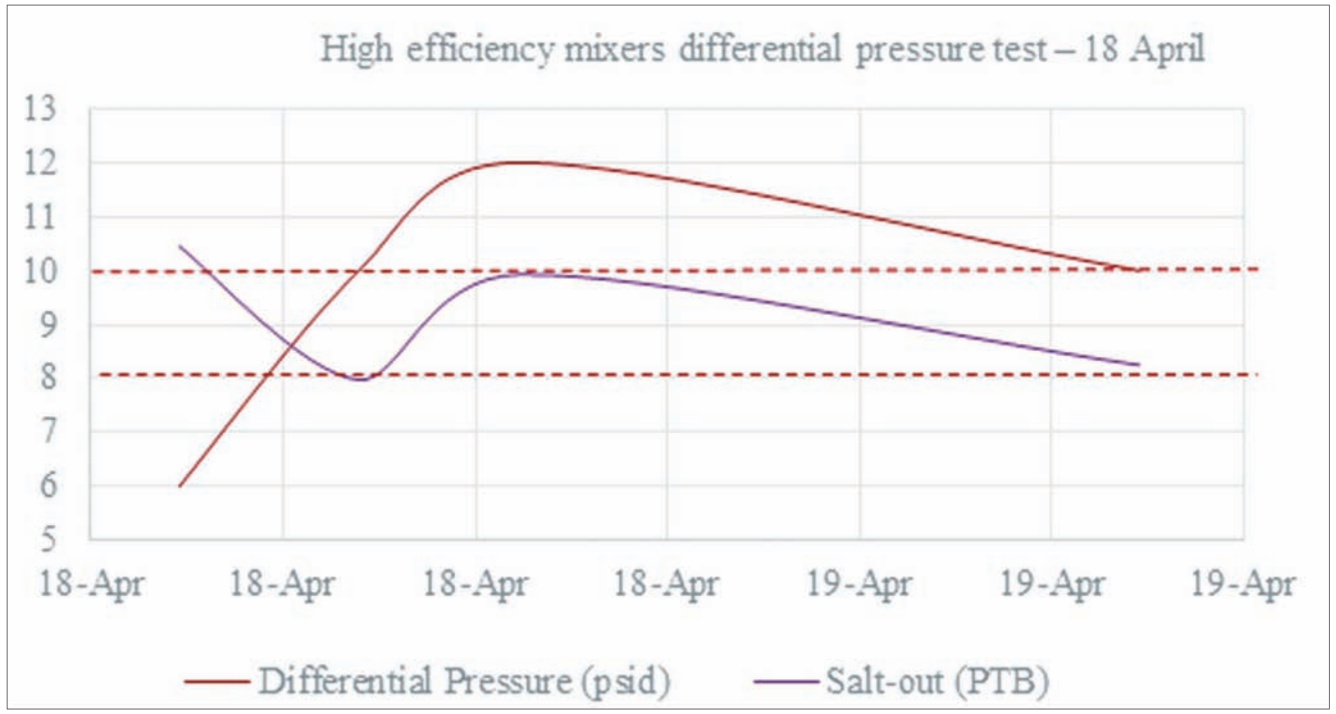

Figure 3: Salt outlet concentration behaviour after adjustment of differential pressure across high efficiency mixers.

Fresh wash water was injected on each train between the first stage desalter and the second stage desalter. The wash water injection rate was manually adjusted by operators when required. Water exiting the second stage desalter was sent to the first stage desalter. And, water exiting the first stage desalter was injected upstream of the degasser. Water exiting the degasser was sent to utility water plant.

After the installation of HEMs, the fresh wash water injection configuration was maintained the same and wash water flow rates were adjusted slightly to make up for an increase on production flow rate.

The efficiency of the desalting trains (dehydrators, first stage desalters and second stage desalters) was measured as the capacity of the whole system to achieve the required outlet specifications and was influenced by many parameters such as: crude oil rate, BS&W, electrostatic fields, wash water injection, demulsifier injection, mixing efficiency, and interface levels.

Variations on any of these parameters could affect the performance of the desalting trains. For this reason, it was critical to observe closely all the trends and study the parameters that affect (positively, or negatively) the performance.

Test results

This report includes the results of the optimisation test realised after installation of mixers, from 11 April 11 to 12 May, compared to the performance before the installation, from 7 February to 10 April.

Data previous installation of mixers: In Figure 1, we can appreciate the behaviour of the main parameters of the oil production trains during the period of evaluation 'before mixers': inlet flow rate (oil and water) ranged from 617 MBWPD-712MBWPD; the salt outlet concentration was stable between 8PTB-10 PTB; demulsifier injection, sum of D1 and D2, was increased from 970GPD to 1,075GPD; demulsifier concentration, D1+ D2/oil flow rate, trends upwards from 32.41ppm to 39.74ppm; water injection, W1, averaged 236GPM; and water injection, W1, rate ranged between 323GPM and 461GPM per MMBOPD.

One additional parameter worth considering was the average crude temperature as hotter crudes have lower viscosity and separate easily compared to colder crudes. Temperatures can affect the stability of an emulsion as well. Given that the plant was provided with enough heat capacity, the process temperature was maintained at a stable rate with less than 10°F variation.

Data after installation of mixers: In Figure 2, we can appreciate the behaviour of the main parameters of the oil production trains during the period 'after mixers': inlet flow rate (oil and water) ranged at higher rates, between 676MBWPD and 850MBWPD; the salt outlet concentration ranged between 6PTB and 10PTB; demulsifier injection, D1 and D2, was decreased from initially 970GPD to a record low of 810GPD; demulsifier concentration, D1+D2/MBOPD, trends downwards from 38.67ppm to 30.21ppm with a best concentration achieved of 26.48ppm; water injection, W1, was slightly lower than previous, averaging 225GPM; and water injection rate, W1/MMBOPD, ranged between 294GPM and 470GPM per MMBOPD.

During this period, the crude flow temperature was stable with maximum variation delta of 10°F. The period between 11 April and 29 April shows an upset condition due to sudden feed flow increase affecting the test results for a limited period. Trains were stabilised back to the initial conditions soon after the upset.

Differential pressure test: On 18 April, a differential pressure (DP) test was completed to determine the optimum DP set point for operation of the HEMs. During the test, the flow rates were kept stable with less than 5%

fluctuations to avoid erroneous results. DP was adjusted to different set points and salt in crude outlet concentration was evaluated after each adjustment. Figure 3 represents the response of salt outlet concentrations to each DP adjustment. After the test was completed, it was decided that the optimum DP set point was 10psid as during this adjustment, the lower salt outlet concentration (7.9PTB) was achieved compared with other adjustments. All four HEMs were set to 10psid for the remaining of the optimisation test.

Comparison before and after installation of mixers: Figure 4 shows an overview of process parameters before and after installation of HEMs. Demulsifier injection usage was reduced after installation of mixers and optimisation of the desalting plant. This was achieved while maintaining acceptable salt outlet concentrations.

In Figure 4, we see that after the installation and optimisation of HEMs, the demulsifier injection volume was reduced during average higher inlet flow rates; this effect is reflected and evaluated in the trending of the total demulsifier concentration (ppm).

Figure 5 provides a clear understanding of the demulsifier efficiency before and after the installation of the HEMs by showing the salt concentration achieved with different rates of demulsifier injection during the two different periods. The data after the installation of mixers (blue) trends towards the lower demulsifier injection rates while achieving improved salt outlet concentrations, while the data before the installation of mixers (red) is spread among higher rates of demulsifier injection and achieving acceptable salt outlet concentrations.

The demulsifier injection and wash water injection rates directly affect the desalting efficiency of the oil production plant as demulsifier injection assists the separation of water from the crude process stream, while the wash water injection contributes to the dilution of the salts to lower concentrations.

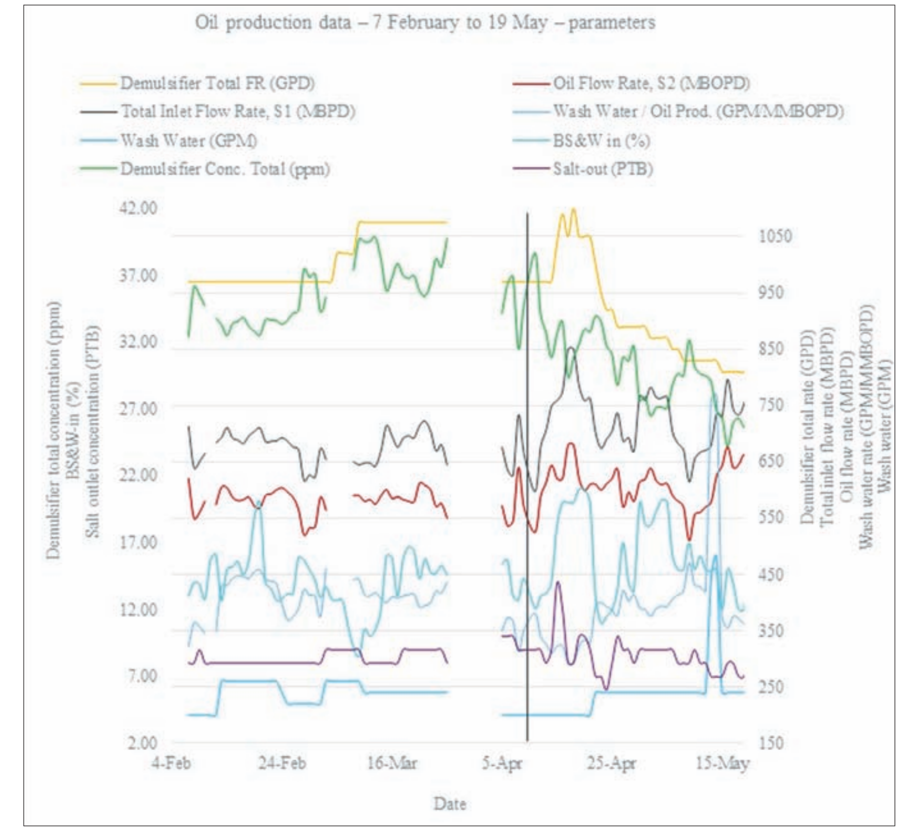

Figure 4: Time evolution of main process parameters before and after installation of high efficiency mixers.

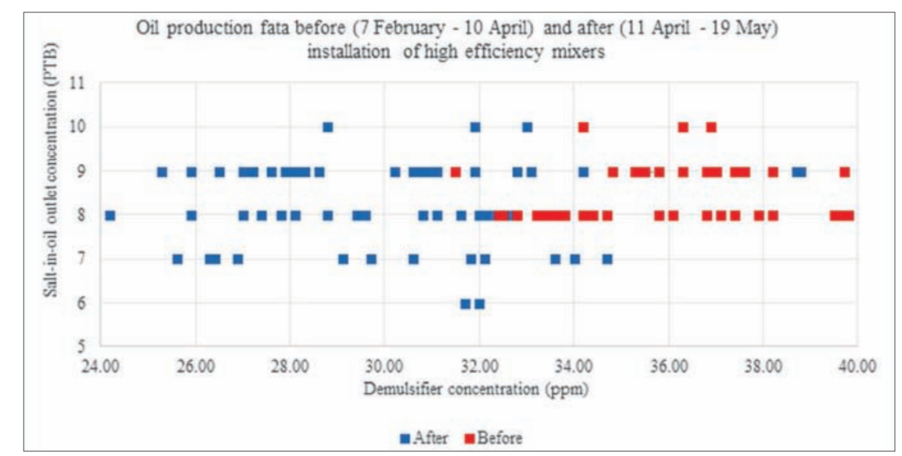

Figure 5: Demulsifier injection and salt outlet concentration data points before and after installation of high efficiency mixers.

Conclusion

After optimisation of the demulsifier injection in a crude processing plant by replacing the conventional mixing valves with HEMs, we can conclude the following: (i) HEMs can increase crude desalting trains efficiency by achieving lower salt-in-crude concentrations; the demulsifier usage (ppm) can be reduced by 22% after increasing the chemical mixing efficiency; increased mixing efficiency of demulsifier allowed a reduction of two percent wash water consumption; HEMs require lower energy input to improve mixing efficiency in comparison with conventional mixing valves (in this case, energy consumption was reduced by 1,440kWh); HEMs can improve mixing efficiency in high viscosity crude oil applications (27 API); and use of HEMs upstream the oil production plants (in the production header) could optimise the demulsifier usage further by increasing the injected fluid dispersion and mass transfer at the most critical location. RPME