

Produced Water Pump Case Study

A case study based on an actual produced water pump application has been performed to evaluate the operational and economic benefits of low shear and coalescing produced water pump types, compared to that of conventional produced water pumps.

The case study is divided into two parts. This first part presents the case and the considered pump types. The second part discusses process considerations, CAPEX and OPEX considerations, such as size and weight, mechanical and process safety, noise and maintenance, and operation.

Considered Case

The process and equipment specifications are provided by the operator. Figure 1 gives an overview of the process. Produced water is pumped from the LP separator to the LP hydrocyclone package by Pump A. Water from the electrostatic coalescer is pumped back to the LP separator, or directly to the LP hydrocyclones, by Pump B.

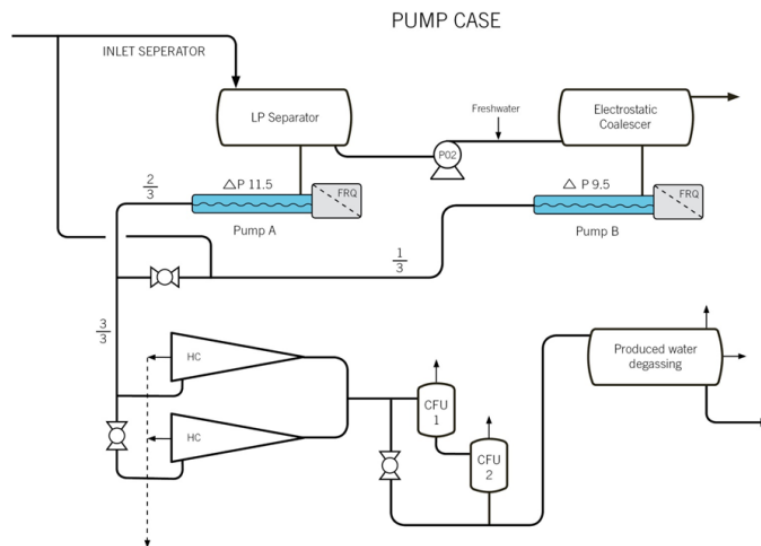


Figure 1: Process overview

At least $\frac{2}{3}$ of the water from the low-pressure separation system is handled by Pump A. The remaining water is either pumped by Pump B and/or Pump A, depending on where the water from pump B is routed. The differential pressure over both pumps is approximately 10 bar.

No actual process data has been made available by the operator at this stage. The oil-in-water (OiW) content used for this case study is therefore based on experience from similar fields in operation. The OiW concentration downstream the LP separator is estimated to be more than 200 ppm, whereas the OiW concentration downstream of the coalescer is expected to be less than 200 ppm. The crude involved is relatively light, with an API gravity of approximately 40° . Based on the concentrations and experience data, it is assumed that the mean oil droplet size (dv_{50}) is approximately 10 - 12 μm .

Considered pump types

The operator has installed eccentric screw pumps for both the A and B pump application. Eccentric

screw pumps are positive displacement pumps, which are among the most commonly used pump types to avoid excessive droplet breakage. In this study, Typhonix Low Shear and Coalescing pumps are compared to the eccentric screw pumps. The article [Low Shear Pump Selection Considerations for Produced Water Applications](#) is recommended for more information on produced water pump selection.

[Typhonix Low Shear Pumps](#) are multistage centrifugal pumps designed to prevent oil droplet breakage, and emulsification of oil and water, by controlling the level of turbulence within the pump. Figure 2 shows a photo of a Low Shear pump delivered for a produced water treatment package in the Far East.



Figure 2: Typhonix Low Shear Pump (photo: typhonix.com)

[Typhonix Coalescing Pumps](#) are multistage centrifugal pump designed to allow droplets to collide and merge (coalesce), leading to growth of the oil droplets dispersed in the produced water. [A study from 2015](#) shows how the Coalescing Pump increases d_{v50} by promotion collision based coalescence, and compares it to that of an eccentric screw pump and a single-stage centrifugal pump. The study also shows how the droplet growth further improves the separation efficiency of a downstream hydrocyclone. Figure 3 shows an illustration of the pump internals, where the main features are (1) the low shear pumping stages, (2) the coalescing impeller configuration, and (3) the coalescing diffuser structures.

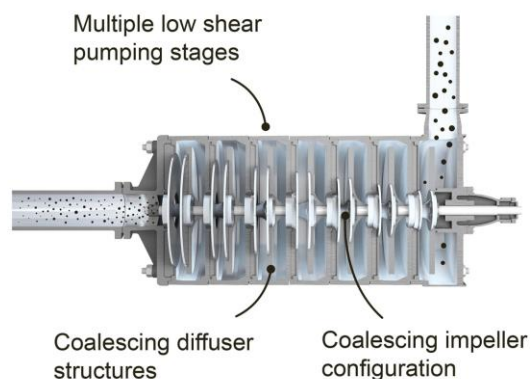


Figure 3: Typhonix Coalescing Pump internals

Process Considerations

Typhonix Coalescing pump is considered as a good alternative for pump A. As the OiW concentration is expected to be well above 200 ppm, this pump will have a positive effect on the separation efficiency of

downstream produced water treatment equipment, as it will increase the droplet size of the dispersed phase. Also, this pump will improve the processes capability to handle an upset as the increase in droplet size is linked to the concentration of the dispersed phase. An increase in concentration will result in a further increase in droplet size, which will further improve the efficiency of the downstream treatment equipment.

Typhonix Coalescing pump may also be considered as an alternative for Pump B. However, due to the low OiW concentration expected at this location (<200 ppm), the coalescing effect is expected to be limited. Typhonix Low Shear pumps are smaller and have reduced CAPEX compared to Typhonix Coalescing pumps. A Typhonix Low Shear pump is therefore considered more economically viable alternative for pump B.

CAPEX and OPEX considerations: Size and Weight

For obvious reasons no costs have been made available by the operator for the eccentric screw pumps. Evaluations for CAPEX and OPEX are therefore made based on the information available.

The size and weight of the respective eccentric screw pumps installed are given in Table 1. The data for the alternative Typhonix pumps selected for the applications is given in Table 2.

Pump Application	Size (l/w/h) [mm]	Weight (dry incl. seal) [kg]
A	4000/1570/2050	2460
B	3400/1565/2050	1690

Table 1: Eccentric screw pumps

Pump Application	Size (l/w/h) [mm]	Weight (dry incl. seal) [kg]
A (Coalescing)	3000/1420/2050	2280
B (Low shear)	2950/1320/2050	1230

Table 2: Typhonix pumps

Based on the data from Tables 1 and 2, it can be concluded that the Typhonix pumps are both smaller and lighter than the eccentric screw pumps for both application A and B.

CAPEX and OPEX considerations: Mechanical and Process Safety

Eccentric screw pumps are a positive displacement pumps. These pumps require blocked outlet protection to prevent severe damage to the pump and/or piping in such an event. Piping systems with positive displacement pumps are normally fitted with a pressure relief valve or rupture disc assembly to prevent over pressurizing the system in a block outlet situation. This requires additional piping to re-route the liquid to a safe location. For this specific case, a pressure safety valve (PSV) is installed for both pumps with the necessary redundancy, valves, pipework, and heat tracing. The necessity to install a pressure protection system has an impact on CAPEX by increasing the amount of equipment, and on the OPEX by increased maintenance requirements.

The Typhonix Low Shear and Coalescing centrifugal pumps are both rotodynamic pump types. These pump types do not cause over-pressurization of the piping system in case of a blocked outlet, as the system normally is designed to withstand the maximal pump head. A pressure relief system is therefore not required.

Both the eccentric screw pumps and the Typhonix pumps will be supplied with variable frequency drives (VFD). The required minimum flow is within the operating range of the Typhonix pumps and minimum flow lines are therefore not required. Minimum flow lines are not recommended in low shear pumping applications as the size of the droplets of the dispersed phase is likely to be reduced due to shear forces in the minimum flow control valves.

CAPEX and OPEX considerations: Maintenance and Operation

No maintenance experience of the eccentric screw pumps is made available by the operator. The maintenance considerations discussed here are therefore gathered from operators having these pump types in use in similar produced water applications.

The main part of the eccentric screw pump exposed to wear is the stator, which is manufactured from a type of elastomer. Though this pump type is often reliably used to pump slurries, particles can cause significant wear to the stator when the liquid viscosity is low, as normally is the case for produced water applications. Several cases have been reported by operators where particles caused severe problems with to the stator lifetime. Issues with incompatibility of the elastomer with the produced fluids is also a known issue. The eccentric screw pump is dependent on a liquid to lubricate the area between the stator and the rotor. Running this pump dry will, therefore, cause significant damage to the stator.

Particles cause erosion in centrifugal pumps as well. This risk can be mitigated with correct material selection for the exposed parts. In addition, the Typhonix pumps will be operated at low rpm and with low liquid velocities inside the pump. This will further reduce the erosion rate of the pump internals. Furthermore, Typhonix pumps are built in accordance with API 610 meaning that the pumps are designed for a minimum service life of twenty years, excluding normal wear parts, and at least three years of uninterrupted operation.

Noise

In generally, noise isolation is not desired, as it is costly, bulky and reduces accessibility for inspection and maintenance. A requirement for noise isolation will, therefore, have a negative impact on both CAPEX and OPEX.

In the considered case, both Pump A and Pump B are installed in areas having an 85 dBA noise limitation. Both eccentric screw pumps required noise isolation in this case due to high noise levels of the gearboxes needed for these pumps. The added weight of the noise enclosures is 200 kg for Pump A and 175 kg for Pump B.

The Typhonix pumps do not require noise isolation for the considered case. The maximum noise level for the Coalescing pump, recommended for application A, is 66 dBA. For the Low Shear pump, recommended for application B, the maximum noise level is just 63 dBA. Both pump types, therefore, operate well below the area noise level limitation.

Conclusion

As highlighted in these articles and in the article on pump selection, all pump types discussed have their pros and cons. Selection of a pump requires a holistic view and not just focus on CAPEX. Is low shear required for the application or can you use a conventional single stage centrifugal pump? What is the added benefit of using a coalescing pump, could this reduce the number of produced water treatment stages? Maintenance and inspection frequency, redundancy, reliability, footprint, etc. are all important factors that need to be taken into account when selecting a suitable pump for the application.

For this specific case the Typhonix low shear and coalescing pumps are viable alternatives for the eccentric screw pumps. The benefits of this would be lower MTBF, no need for noise isolation or PSVs, and reduced footprint and weight. The coalescing pump additionally increases the systems capability to handle upsets and potentially reducing the number of treatment stages required to reach the discharge OiW target.

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