No Half Measures

Graham Barker, Tracerco Ltd, UK, argues that accurate measurement is an essential element of controlling and improving offshore operations.

In offshore oil and gas production, the output from the reservoir is a mixture of oil, gas, water and sand. As these constituent parts enter the separator, pressure is reduced as gas is released, which can result in foam generation. An inability to measure this can have a catastrophic impact on process vessels downstream of the separator.

The presence of foam also affects the performance of the separator. When a large layer of foam is present, liquid levels must be reduced to stop liquid carry-over. Due to its high volume/weight ratio, foam can occupy a large amount of the vessel space, reducing the space available for gravity separation. The presence of a layer of foam in the separator results creates incorrect level readings, generally indicating higher quantities than are actually present, from conventional level control instrumentation. The false high-level readings result in the actual levels being too low, causing gas carry-under and/or poor oil and water quality.

Oil-water emulsions can also form due to surface active molecules attaching themselves to the oil-water interface. Many conventional interface measurement systems are only able to measure the mid-point of such an emulsion and not the extremities. The inability to measure the extent of such emulsions can have an impact on process equipment downstream, with excessive water being carried over to subsequent process vessels. This can have environmental consequences, as oil being carried under may lead to possible unregulated discharge into the sea.

Sand deposition can greatly reduce the volume of the separator, resulting in a reduction in residence time for the fluids passing through the separator. This reduction in time means that fluids are not able to separate into the constituent parts, therefore reducing separator efficiency. For bridle and moving-part based level instrumentation, this leads to incorrect levels being indicated due to fouling caused by the presence of the sand deposition.

Tracerco Ltd, part of Johnson Matthey PLC, has developed and deployed numerous Tracerco Profiler™ systems to allow operators to see in real time the formation of such foam, emulsion and sand – allowing for actions to be implemented to reduce the impact on plant operation and the environment.

Technology overview

The instrument is comprised of a two (or three) dip pipe assembly, similar to a thermowell that protrudes into the vessel from a flanged vessel connection. The dip pipe assembly is supplied in accordance with the vessel design criteria and ensures the items placed within are free from contact with the process. In one of the dip pipes houses mentioned there is a vertical array of radioactive sources, similar to those found in domestic household smoke detectors. In domestic smoke detectors it is the alpha particle that is stopped by the presence of smoke, which activates the alarm; however, the source also emits a weak gamma energy 60k eV. This weak gamma energy passes through the dip pipe assembly and process fluids and is detected by a radiation sensor installed in the other one (or two) dip pipe(s).

Three things can affect the amount of radiation being detected:

- Type of isotope being used, which stays constant.
- Distance between emitter and detector. Due to the equipment design, again this stays constant.
- Density of material between the emitter and detector.

It can therefore be assumed that for this configuration radiation intensity is directly proportional to material density.

In order to obtain the required measurement accuracy, the system adopts a collimated design which ensures the detecting element is focused at a particular elevation. This collimated design also allows for ease of isolation, with a single movement isolating the system. This provides safe access into the separator for routine maintenance and inspection.

The premise of a gravity separator is that over the length of the vessel the individual component parts will disperse, with the heaviest parts sinking to the bottom and the lighter components rising to the top. Due to the fact the foam, oil, emulsion, water and sand are all of a different density, the profiler has the ability to identify the extent of each of these phases when present in the vessel. The output of the equipment is displayed as per the right-hand side of Figure 1.

Driven by clients' needs for a 'no moving parts, no maintenance' solution, the technology can be utilised in a number of subsea separation applications in accordance with ISO 13628-6 subsea production and control systems.

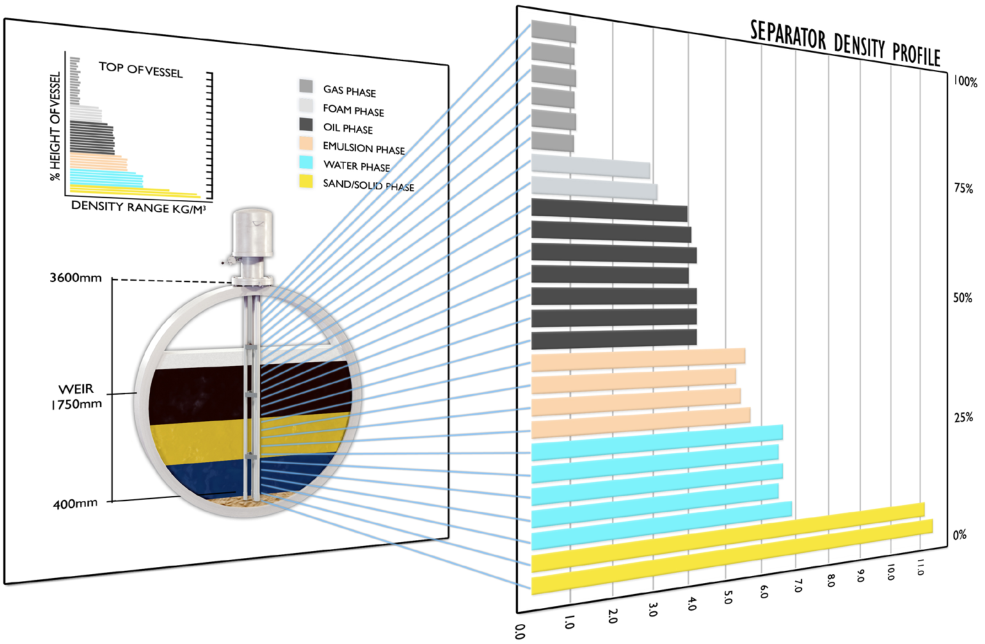

Figure 1. *Separator density profile using the Tracerco Profiler.*

Emulsion monitoring

As mentioned previously, oil-water emulsions can also form due to surface active molecules attaching themselves to the oil-water interface. Any emulsion that goes undetected in the process can place a larger demand on the water treatment facilities and create issues further down the separation chain. Being aware of the presence of an emulsion and being able to control an emulsion is key to ensuring on spec product and environmental compliance. The system provides a real time 'window' into the vessel, allowing operators to see the extent of any emulsions that form due to changes in control parameters. It allows them to apply instantaneous action to minimise the impact on the process. Although this guarantees sustained production and therefore increased revenue, it also allows the quantification and control of the chemicals and demulsifiers used to manage the emulsion. The correct volume of chemicals is critical to ensuring optimum performance, and actual overdosage can lead to adverse effects on the depth of any emulsion. Not understanding the performance of such chemicals can lead to issues in production, with major financial implications.

The results shown in Figures 2 and 3 have been taken from an asset that has utilised the profiler to quantify not only the volume but also the type of chemical that works best with the reservoir fluids.

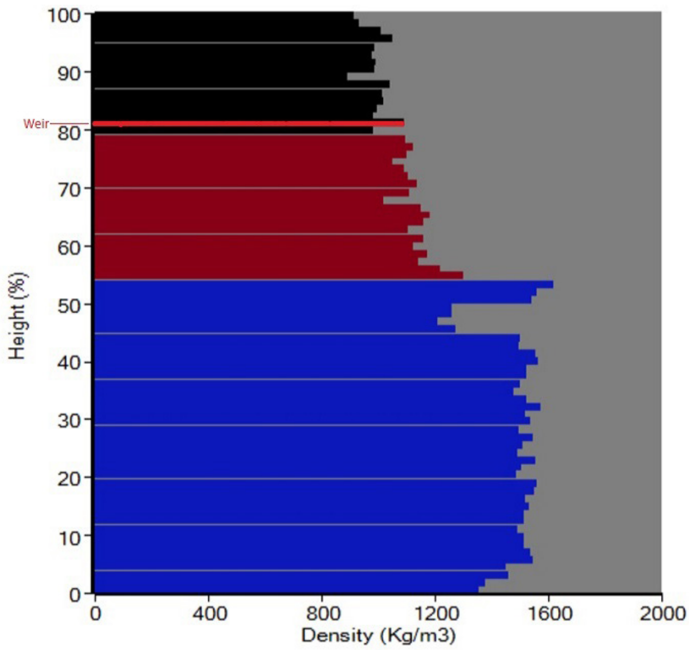

Figure 2. *Vessel performance without the Tracerco Profiler.*

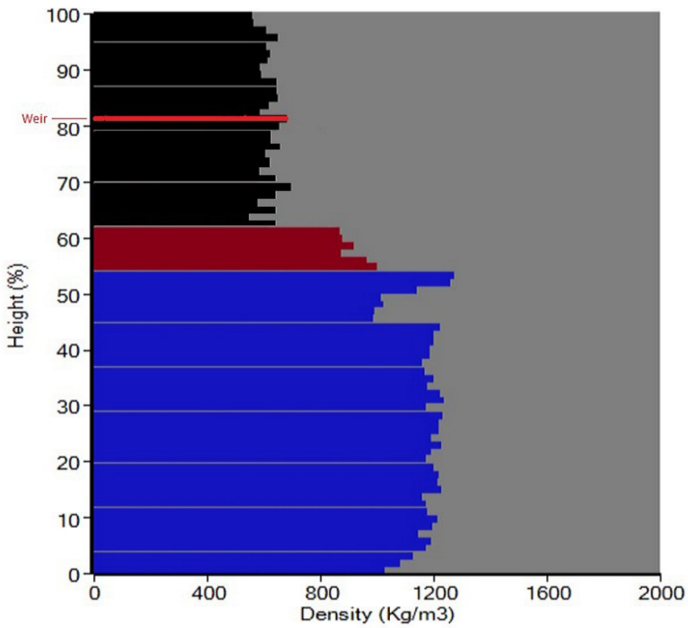

Figure 3. *Vessel performance after the Profiler installation.*

The initial graphic shows the performance of the vessel, with the system showing three distinct phases present in the vessel: water (blue), emulsion (maroon) and oil (black). The red line denotes the height of the weir; the vessel is controlled so that only the oil cascades over the weir height, with all other mediums kept upstream.

Manipulation of chemicals and the installation of a vessel internal electrostatic coalescer allowed the client to significantly reduce the amount of chemical being used to perform better separation.

The typical savings were a reduction from 10 ppmv to an estimated 2 ppmv, which resulted in a saving of approximately £375 000/yr.

It is not only chemical volumes that can be reduced but also the type of chemicals used by operators, who have found that incumbent chemical suppliers do not necessarily supply solutions that are fit for current production fluids. This ability not only to see the performance of the chemical but also to achieve a better understanding of the volume required allows for significant improvement and optimisation within the separation process.

Reliability

In addition to emulsion monitoring, repeatable and reliable measurement is key to the operation of any vessel, even more so than accuracy. Reliability ensures that when changes happen within the process, these events are captured, allowing for either operator intervention or safe and automated shutdown, with the shutdown system needing to be even more reliable than the control system.

The system was deployed in numerous vessels on an asset located in the Norwegian sector of the North Sea to perform a shutdown function for both the oil-water interface and bulk liquid level. Historical problems with existing technology and potential environmental issues concerning the large volume of hydrocarbons within the vessels, which could flow to the produced water treatment plant if interface control was compromised, demanded that high integrity instruments were selected for this application. This was the main contributing factor in justifying the installation of the system within these vessels. The 'zero operator intervention' application also fitted in well with the client's minimum intervention philosophy.

Conclusion

As the same measurement technology could not be used for level control and shutdown functionality, capacitance-based measurement solutions were deployed for level control. During initial commissioning of the systems, both technologies appeared to work satisfactorily. However, over time the capacitance technology was deemed to be unsuitable for this type of measurement application. Approximately 3 years after the initial commissioning of the systems, the capacitance technology was removed and replaced with three additional nucleonic solutions that have operated now for approximately 13 years with minimal intervention. The vessels now operate with the same measurement principle being used for both level control and shutdown. This philosophy has been adopted by numerous operators across the globe. This high reliability factor was a key driver in taking the technology subsea, where it has been deployed on a number of subsea separation and storage projects.