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Dynamic Imaging Based Oil in Water Monitoring System Challenges and Solutions

Alan O'Donoghue, JM Canty International Ltd., Dublin Ireland

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1 INTRODUCTION

Discharge and re-injection of Produced Water from oil production is becoming increasingly challenging for the oil producers as the world's oil wells mature and the water cut increase. At the same environmental regulations govern the allowable contamination levels within the discharged water, meaning that it is critical to perform thorough analysis of Produced Water.

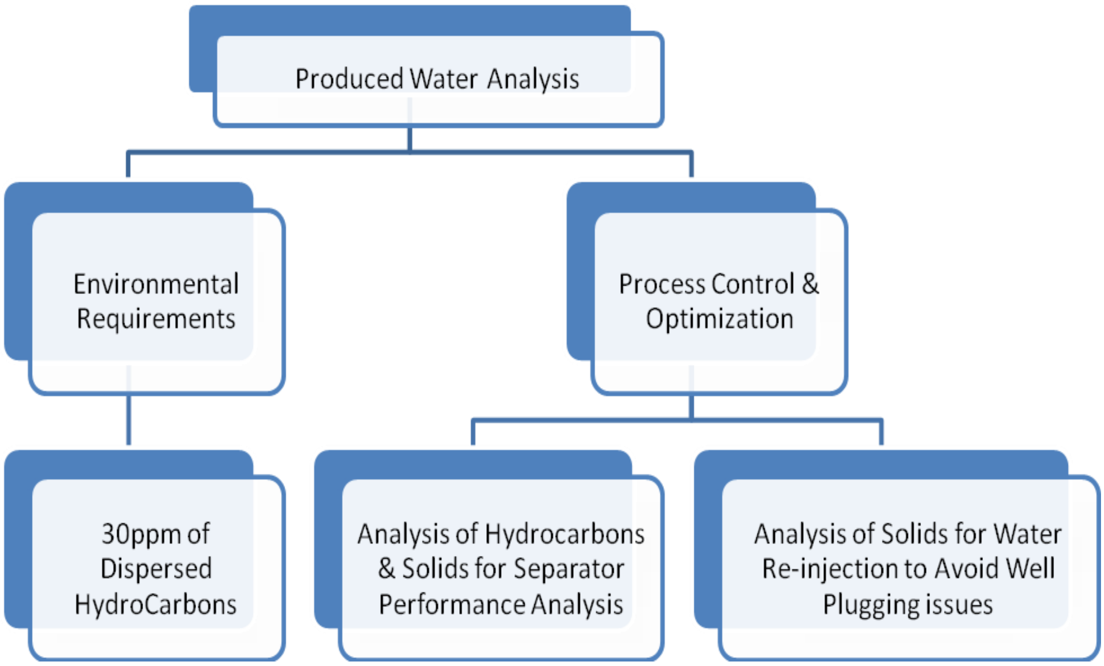


Fig. 1 – Justification for Produced Water Analysis

Environmental regulations target 30ppm of dispersed hydrocarbons in offshore discharged water. The official OSPAR oil in water analysis is based on ISO9377-2 (analysis by GC-FID). This method is difficult to implement in an offshore environment due to the cost and complexity of the instrumentation and the need for cylinders of hydrogen. This has resulted in OSPAR accepting alternative methods, with the condition that the "alternative" method can be calibrated against the official OSPAR method.

Through the use dynamic imaging based oil in water analysis, independent analysis (size and concentration) of oil droplets, solids particulate, and air bubbles can be achieved. However, to consistently achieve this during process operation, there are a number of challenges which must be overcome including representativeness, reliability & speed of measurement, and fouling of the system optics.

Through the application a various technologies, it is demonstrated how JM Canty's dynamic imaging system has overcome these individual problems to provide a complete system allowing the operator to optimize and control their process, and monitor their produced water discharge in order to meet the applicable environmental regulations.

2 DYAMIC IMAGING TECHNOLOGY – CHALLENGES & SOLUTONS

With the advancements in vision technology from both a hardware and software perspective, dynamic imaging has become a most powerful tool for produced water analysis. Dynamic imaging works on the basic principle of presenting the produced water between a high intensity light source, and Ethernet camera. The captured images are analysed by the software, with the criteria for analysis being defined by the user.

However, as with any process measurement to be taken, there are a number of technical issues which much be addressed, particularly if the measurement is to be taken online in the actual process;

- Representativeness of Measurement
- Speed of Measurement
- Reliability of Measurement
- High Flow Rates
- Fouling of the Process Barrier

2.1 Representativeness of Measurement

In order to be most representative of what is happening within the produced water pipeline, the ideal location for measurement is fully inline. This avoids sampling issues (degradation of sample over time), and necessity for extra equipment (sampling system). Within the pipeline, in order to be most representative of what is in that line, the measurement should ideally be taken as close to the centre of the pipeline as possible.

The Canty InFlow and Particle Probe (pipelines above 12”) both achieve this by mounting directly in the process line to capture real time images of the Produced Water as it flows through the system. Each system contains a gigabit camera, with high intensity light guided from the opposite side of the flow stream to allow the capture of high quality images for analysis.

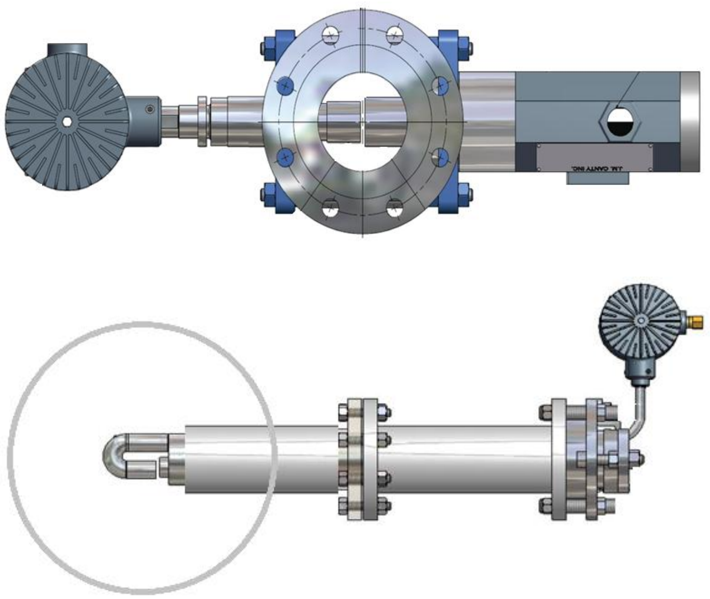


Fig. 2 – Canty InFlow and Particle Probe

2.2 Speed of Measurement

In order to successfully take the place of traditional lab testing, the online measurement needs to provide instantaneous data to the controls system. The Cantyvision software which performs the image analysis achieves this by providing a real time oil / solids concentration measurement on a per frame basis (typically 2-3 measurements per second). The oil droplet size / solid particle size is updated every 250 frames (2-3 minutes) to ensure the distribution outputted is statistically representative.

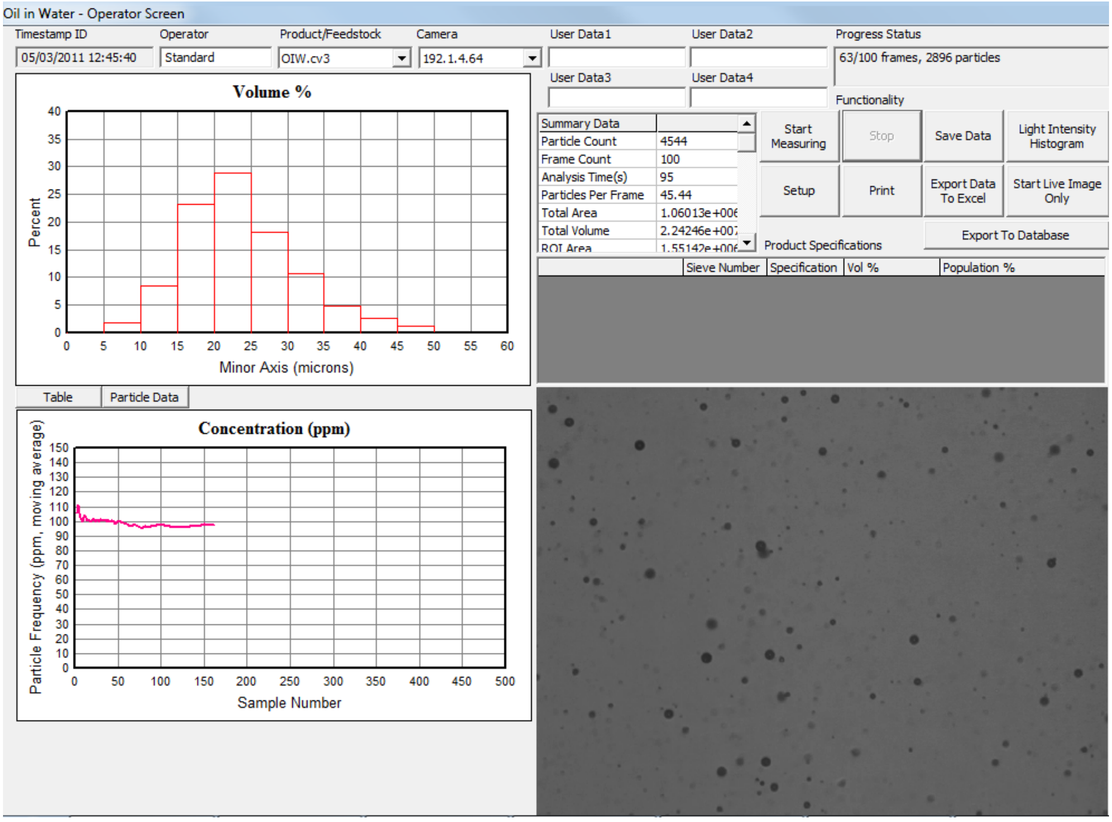


Fig. 3 – Cantyvision Software Output Screen

2.3 Reliability of Measurement

Within any produced water stream there will be various types of particulate suspended (oil droplets, solid particles, air bubbles), so it is important to have a certainty that what the system is measuring is correct. For example, if the system was incorrectly reading some non oil particles as oil, it may be outputting a concentration value exceeding the level permitted by the governing environmental regulations, when in fact what is in the pipeline is below the required limit.

Within the Cantyvision software there are a number of software algorithms used to characterise the size and shape of each particle analysed. Based on the varying characteristics of the types of suspended particulate, the software can make the same distinction as the human brain would, and therefore output simultaneous but independent data for the size and concentration of the oil and solids within the stream.

Also, going back to the basics of the system being vision based, it means that the operator will always have visual verification of any control output, which differentiates this type of system from traditional “blind” instrumentation.

2.4 High Process Flow Rates

For a vision based system's image analysis to function in both an accurate and repeatable manner, the images gathered must be of a high quality. This is critical as it is the size and shape characteristic of the particles which allow the software to define whether it is oil / solids / air bubbles. To be able to perform this recognition, the imaging sensor needs to capture the suspended particulate in "freeze frame" as they move at speed past the camera within a pipeline. When the shutter speed of the camera is increased, more light is required in order to capture an image.

The Canty high intensity lighting system used in the range of Dynamic Imaging systems, consists of a quartz halogen light source, focused through the use of a light guide into the area on which the gigabit camera is viewing. Typically it is an 80W light source, originally designed for the illumination of large pressure vessels that is used. All the light energy is focused into the area which the gigabit camera is monitoring. Currently the camera can capture particulate moving up to 2.75m per second within a pipeline. See table 1 for details on maximum flow rates for various pipeline sizes.

Table 1 – Inline Flow Rates

Pipe Line Size	Low Flow Rate	Max Flow Rate
1"	18 l/m	83 l/m
2"	74 l/m	335 l/m
3"	167 l/m	750 l/m
4"	297 l/m	1340 l/m
6"	670 l/m	3000 l/m
8"	1190 l/m	5300 l/m

2.5 Fouling of the Process Barrier

For any vision based system, it is critical that the barrier between the active process and the imaging sensor remains clean and free from fouling. The insurance of a clear view / accurate measurements is provided through a combination of hardware and software.

The process interface is made up of a unique fused glass to metal barrier. Fusion of glass and metal is a unique process whereby a one piece construction component is produced. BoroPlus™ glass in its molten form is poured into the centre of a metallic ring where it flows to the metal wall. At that point due to the chemical make up of BoroPlus™ glass, the glass fuses to the metal. As the unit is then cooled, the metal, having a higher coefficient of expansion than the glass, contracts onto the solidifying glass putting it under uniform radial compression. This fused glass and metal surface can then be finely polished to produce a smooth even surface with no crevices.

Due to the fact that there are no crevices or spaces between the fused glass and metal, there is no where for product to begin to build up. Non-fused glass and metal systems would not have a smooth transition from glass to metal, and it is in this step area that product (oil / solids) would inevitably build up (see figure 4). The fused glass also allows higher pressure operation of the systems (up to 600 Bar) due to the fact there is no danger of the glass and metal separating into 2 separate components.

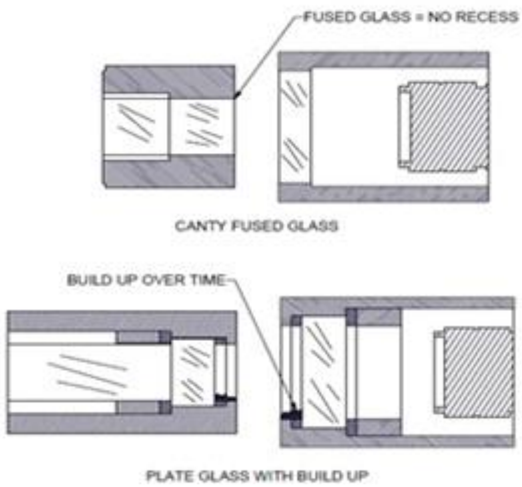


Fig. 4 – Fused vs Non Fused

The second piece of hardware utilised to ensure a clear view into the process pipeline is the Canty jet spray ring. Originally design as a cleaning system for vessel sight glasses, it has been modified and integrated into the oil in water analysers. The jet spray ring works by pumping a fluid compatible with the main process onto the fused glass, which dislodges any particles that may have adhered to the glass due to a slow down / stoppage in flow. The traditional jet spray ring has been modified so that it does not create a step in front of the fused glass barrier, and therefore the advantage of the fused glass to metal barrier is maintained.

Finally, if the situation arises that an oil droplet / solid particle does become lodged on the glass, and the cleaning system cannot be activated for some reason, the software ensures that the "stuck" particle is only analysed once and does not continue to be analysed and cause a bias to the data.

3 RELEVANT FIELD WORK

As mentioned, for a produced water analyser to be acceptable, it must be able to correlate to the OSPAR gas chromatography method based on ISO9377-2.

Case Study 1:

A test was conducted offshore on the western part of the Dutch continental shelf where samples were taken to compare to the live analysis performed by the Canty system. A set of samples was analysed locally with an IR analyser, and a set of samples was also sent to an external laboratory for analysis by the OSPAR approved method (the OSPAR results were available within 1 week which meant that by the time over limit values would be detected, produced water would have already been discharging for 1 week.

For the purposes of the test the Canty analyser was connected to the discharged sampling point downstream of the skimmer tank (see Fig. 5 below).

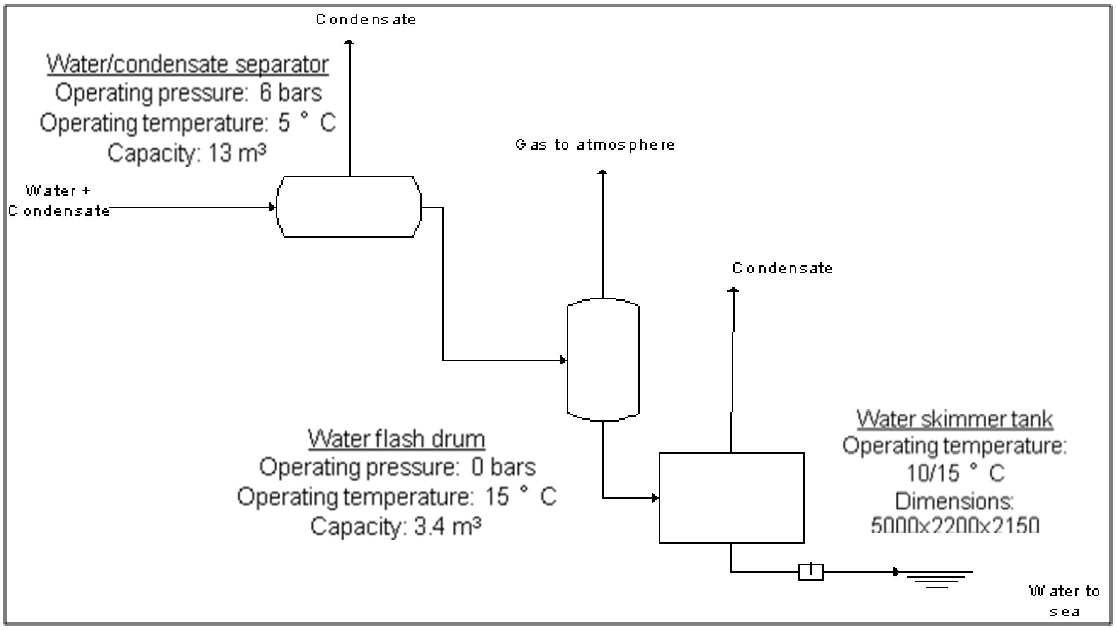


Fig. 5 – Field Work Setup

As can be seen in figure 6 there is strong correlation between all 3 methods, highlighting the fact that the dynamic imaging system can be used in place of the OSPAR method to provide real time data to the control system.

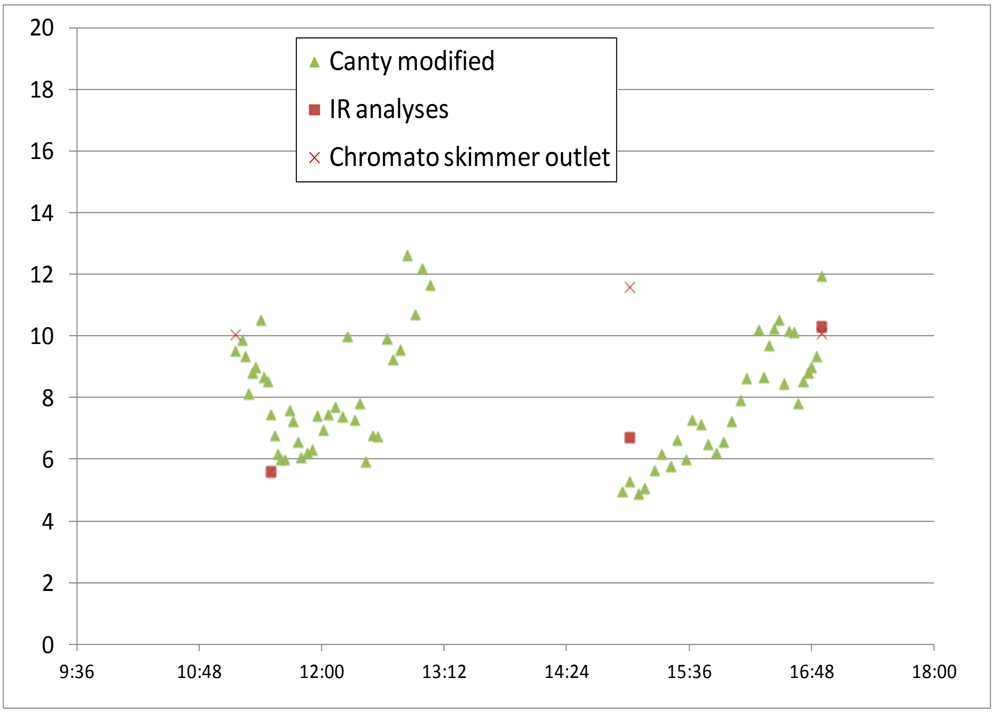
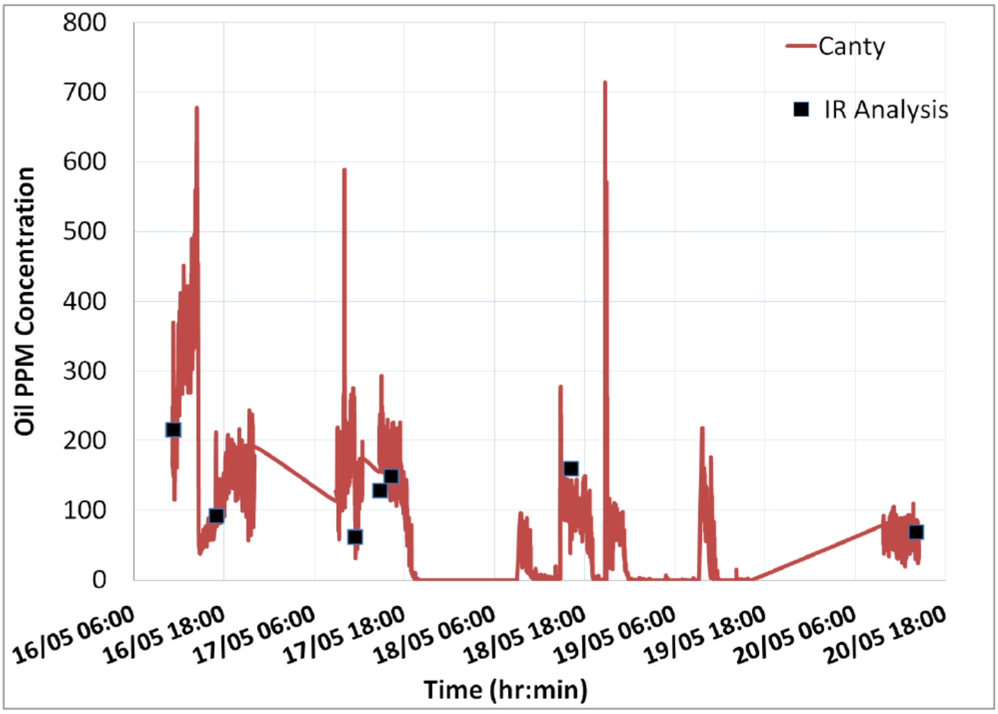


Fig. 6 – Field Work Results

Case Study 2:

A Total project took place at an onshore facility in France to monitor the performance of the JM Canty analyser versus lab IR analysis over a longer term



4 CONCLUSION

There are clearly a number of difficult challenges to be overcome to enable fully online analysis of produced water to take place. However, through Dynamic Imaging the technology is available to combat each of these challenges to provide real time reliable information.