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Potential of using Real-time OIW Monitoring for Control of Produced Water Treatment in Offshore Oil & Gas Production

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Abstract
From the process control point of view, any reliable and online Oil-in-Water (OiW) measurement could provoke a brand new control paradigm for produced water treatment. However, the real-time OiW monitoring is still an open and ad-hoc situation in recent decades. The fundamental issue, i.e., the OiW measurement is methodology dependent, leads to numerous challenges, such as (i) how to verify the reliability and accuracy of a specific methodology/instrument; (ii) how to handle and interpret the measured data in a most objective manner; and (iii) how to keep a cost-effective on-site calibration and maintenance under the harsh offshore conditions etc. The paper reports our latest achievements and observations in usage of fluorescence- and microscopy-based OiW monitoring technologies for advanced Produced Water Treatment (PWT) control and evaluation, particularly by focusing on the de-oiling hydrocyclone installations.
Keywords: Oil-in-Water, produced water, real-time, monitoring, control

1. Introduction

The Produced Water (PW) is the largest produced fluid stream at most of the current offshore oil & gas production in North-sea. It is not uncommon that the water cut can reach 90% in many matured production fields. No matter whether the produced water will be eventually discharged to the ocean or reused for injection purpose in the field, the hydrocarbon content in the produced water needs to be strictly limited either due to the hazardous environmental impact or EOR sweeping effectiveness. For example, the current OSPAR limitation on the concentration of dispersed hydrocarbon in the discharged PW is 30 mg/l. The current OiW measurement for reporting to authorities is committed via offline approaches, e.g., GC-FID approach as recommended by OSPAR [Yang 2011]. There is no reporting requirement for real-time monitoring of OiW in the discarged PW yet, though many commercial products claimed for real-time OiW monitoring have been launched in the current market. From the technological point of view, it is well known that OiW measurements are methodolgy dependent [Yang 2011], and that the measuring accuracy also depends on the specific instrumentation configuration as well as oil compositions and process's operating conditions etc. [Durdevic et al 2017].

There is no doubt that some reliable and accurate real-time measurement of OiW in the PW can help change the game of the PWT in both process control and monitoring pespectives. However, a lot of open challenges need to be solved, such as how to verify/validate the reliability and accuracy of a specific methodology/instrument. This work reports what we have observed and achieved via laboratory experiments about some commercial fluorenscence-based and microscopy-based monitors for real-time OiW monitoring.

2. Testing Facility and Instruments

The compact PWT facility at AAU Offshore Lab is used as the evaluation platform and the relevant system configuration can be seen in Figure.1. More information about our testing facility can be found in [Durdevic and Yang 2018]. Two types of OiW monitors are tested, i.e., a UV fluorescence-based OiW monitor (TD-4100XDC) produced by Turner Designs Hydrocarbon Instruments Inc, and a (optic) microscopy-based OiW monitor (VIPA Particle Analyzer) produced by Jorin Ltd. More information about the used materials and testing scenarios can be found in our previous publications [Durdevic et al 2017, Hansen et al 2017].

3. Testing Results

3.1 Real-Time Capabilities

Both monitors considered can commit real-time measurement. However, the VIPA instrument cannot provide reasonable OiW concentration measurement partially due to its very poor SNR. Thereby the concentration measurement is only tested with TD-4100XDC, while the VIPA is mainly employed for droplet size measurement so as to retrieve the (oil) droplet size distributions, As shown in Figure.1, the OiW monitors are deployed in the testing system to continuously measure the oil concentrations in the inlet and underflow outlet of de-oiling hydrocyclone, such that the de-oiling efficiency of the hydrocyclone can be estimated in a real-time manner. The correlations of the de-oiling efficiency with the controlled variable of cyclone Pressure-Difference-Ratio(PDR) from the current

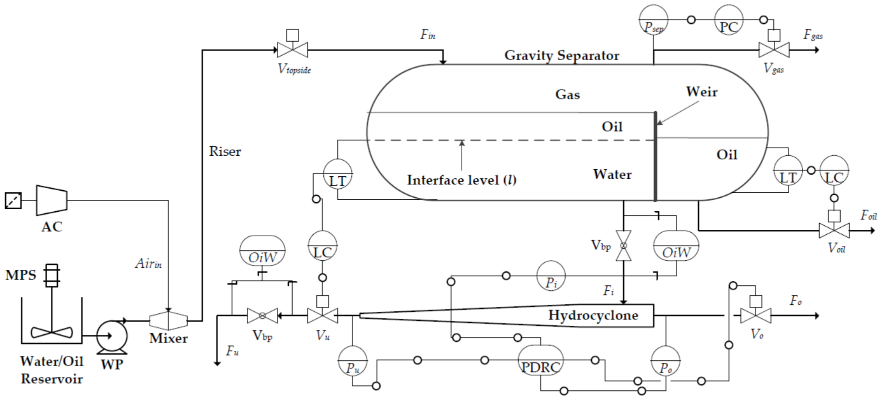

Figure 1. Testing Facility including a three-phase separator and a de-oiling hydrocyclone [Durdevic and Yang 2018]

hydrocyclone control scheme, as well as different operating conditions are tested and analyzed. Figure.2 illustrates the real-time efficiency and multi-step PDR curves, subject to the inlet flowrate is kept around 0.4L/s. this figure shows clearly that the different PDR set-points within this considered range (2.0-3.28) have little influence to the de-oiling efficiency.

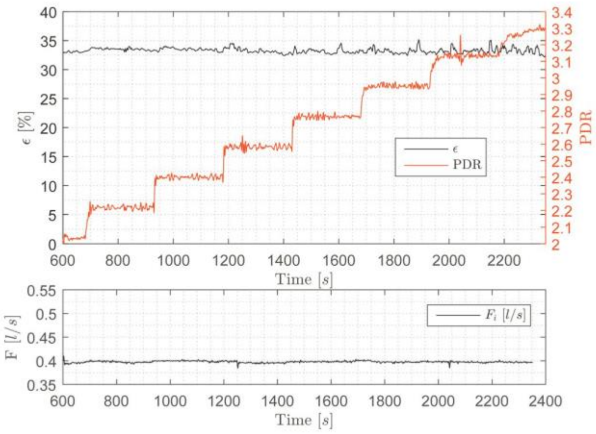

Figure.2 Efficiency vs PDRs [Durdevic et al 2017]

A systematical evaluation of different control solutions based on the OiW measurement has been committed recently. More details can be found in our publications [Dudevic and Yang 2018].

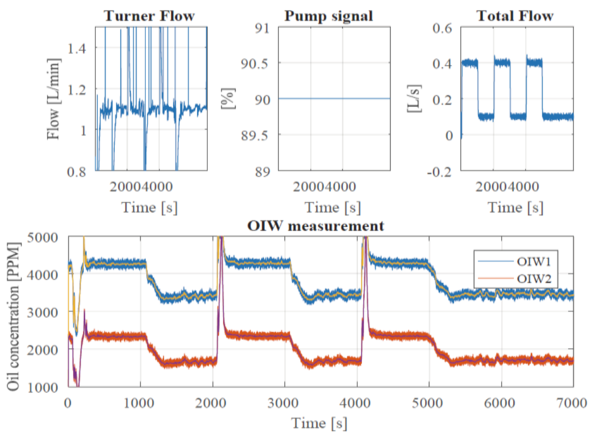

Figure.3 One example of OiW's flow-dependency

3.2 Accuracy and Reliability

Some of our recent work revealed that the OiW measurement could have potential correlations with different process configurations and operating conditions as well, such as the flow-dependent measurement, circulation pump affects and air buffer disturbances. One example is shown in Figure.3. More extensive investigations are undergoing.

4. Conclusions

Besides more systematical investigation about accuracy and reliability of OiW monitoring, some kind of novel interpretation and transformation of this type of measurement are also requested before they can be used for feedback control purpose.

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