Smart Automation and Monitoring for Water Treatment

Challenges and AAU Activities

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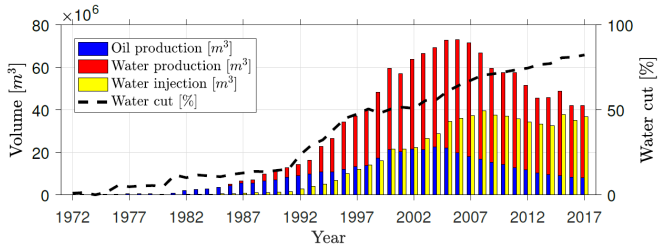
Introduction

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 (PWRI), the water quality needs to be strictly guaranteed either due to the hazardous environmental impact or sweeping effectiveness.

This poster sum up the latest activities and main achievements committed at AAU-ET OG research group, and some challenges and potentials in water treatment technologies are also pointed out.



Plant-wide Control for PW Treatment

The plant-wide control strategy combined with emerging AI technologies is employed for cost-effectively improving the PW treatment capability and performances. By particularly focusing on the hydrocyclone technology and membrane filtration technology, three solution categories are proposed:

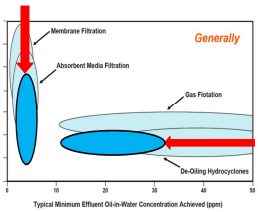


Fig.1 Typical PWT technologies

- **Software retrofit solutions:** only upgrading control algorithms
  - H_infty control
  - Nonlinear MPC
  - Control automatic generation using reinforcement learning
- **Combined soft- & hard-ware retrofit solutions**
  - Real-time Oil-in-Water (OiW) measurement
  - Sensor-fusion based MIMO control (see Fig.2)
- **Breakthrough technology solution** using zero-discharge ceramic membrane filtration (see Fig.3)

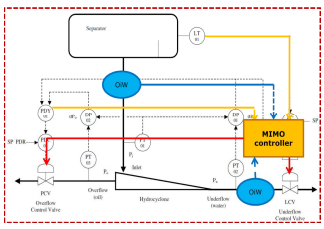


Fig.2 Sensor-fusion based MIMO control

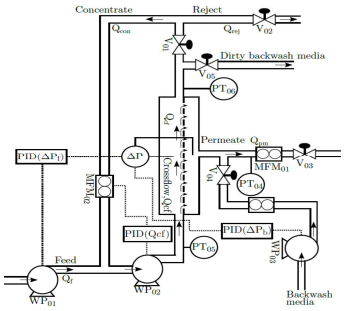


Fig.3 P&ID of a membrane filtration module

Acknowledgment

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OiW Monitoring in PW

It is well known that any reliable and online OiW measurement could provoke a brand new control paradigm for PW 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 method dependent, leads to numerous challenges, such as (i) how to verify the precision & accuracy of a specific method/instrument; (ii) how to handle and interpret the measured data; and (iii) how to keep a cost-effective on-site calibration and maintenance under the harsh offshore conditions. Our research exploit these challenges by focusing on the fluorescence- and microscopy-based OiW monitoring technologies.

Fig.4 Selected OiW sensing principles

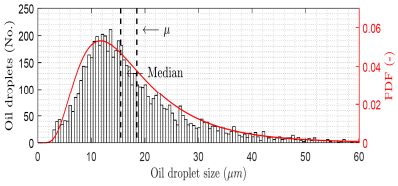
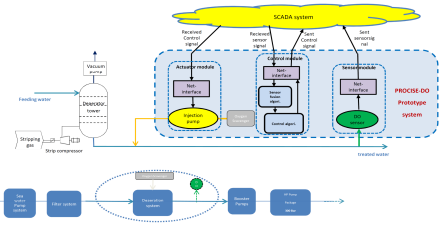


Fig.5 One observation of Droplet size distribution

Injection Water Treatment – Monitoring & Control

- **Real-time TSS monitoring** . The current online TSS monitoring mainly relies on the turbidity-based measurement, which is very sensitive to different operating conditions and can only provide rough estimation. Meanwhile, some more accurate offline technologies are facing challenges due to ”dead samples” caused by the time delay from sampling to lab testing. After extensive pre-investigations, we selected microscopy technology for further investigation in this topic.
- **Real-time Dissolved Oxygen (DO) monitoring & control**. The existence of DO in the injection water can easily cause facility corrosion and certain bacterial growths. While overdosing DO scavenger can risk H2S generation and sour corrosion. Thereby the DO concentration needs to be maintained within a extremely low range, subject to unknown disturbances and operating condition changes. This leads to following challenges we are handling:
  - Reliable and accurate online DO measurement at extremely low concentration level;
  - Precise DO scavenger injection control.



Anti-Slugging Control

- Multi-phase flow assurance
- Modeling & analysis
- Disturbance attenuation
- Bifurcation control
- Increased producability