Automatic Dosage of Dispersant during Subsea Dispersant Injection (SSDI) - A New and Novel System Offering Improved Control of SSDI Effectiveness and Dispersant Dosage

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Introduction
The Macondo subsea blowout in the Gulf of Mexico in 2010 was the first incident where subsea dispersant injection (SSDI) was used as an oil spill response option, during which dispersants were injected directly into the rising flow of oil and gas.

During the release, no direct measurements were conducted in the rising oil plume that could be used to estimate or document the effectiveness of the dispersant treatment. Measurements of oil droplet sizes before and after dispersant injection would have been helpful to evaluate the different injection techniques and adjust the dosage of dispersants. Extensive video footage is available, but it is not straight forward to estimate changes in oil droplet sizes from video obtained during the release. The lack of documentation of the injected dosage and effectiveness of the treatment has later questioned the justification of SSDI.

However, surface monitoring during the Macondo spill showed that SDDI reduced surfacing oil forming persistent oil slicks that could reach sensitive coastal areas. This lead to a significant research effort to increase the understanding of the involved processes (dispersant oil interaction, oil droplet formation, dispersant injection techniques etc.). The oil and gas operators have today access to subsea dispersant injection equipment through Oil Spill Response Ltd. (OSRL), Wild Well Control (WWC) and Australian Marine Oil Spill Centre (AMOSC). This equipment is a crucial part of the capping and containment package offered in the event of a subsea well blowout and could both be used to ensure access to the spill site (remove surface oil), improve working conditions (reduce exposure to volatile oil components) and finally be used as a response option to reduce environmental impact from the spill (reduce surfacing & stranding of oil and increase natural biodegradation of dispersed oil as small droplets).

To include SSDI in the operators' oil spill response plans on the Norwegian Continental Shelf, a qualification of the dispersant application wands and a system to control dispersant injection (dosage) and document effectiveness was requested by the environmental authorities. The main objective with this study was to qualify a new concept for automatic dispersant dosage and monitoring by technology development and verification in both small- and full-scale.

Main Results
A significant part of the project was technology development focused on improving existing instrumentation to measure marine particles (SINTEF Silhouette Camera – SilCam) and developing a new deepwater dispersant regulator (10 – 120 L/min) that could be remotely operated from the surface.

<u>SilCam Development (SINTEF):</u>
The SilCam was earlier developed at SINTEF in the period of 2015-17 (Davies et al., 2017) mainly to measure oil droplets and gas bubbles (20 – 12 000 microns), but are now routinely used to monitor a wide variety of particles in the marine environment (sediments, gas bubbles, plankton, flocks, marine snow, salmon lice). In this project the focus has been on operationalization the SilCam to work with a standard offshore ROV (hardware/software adaption) and improving the real-time data handling to produce full-resolution distributions on oil droplets and gas bubbles.

Dispersant Dosage controller (Oceaneering):
With the existing equipment, dispersant dosage was controlled mechanically by the ROV opening/closing a valve located on the dispersant wand handle. This made both targeting a specific dispersant rate and post-spill documentation challenging. In this project a new pressure operated control valve was developed and used to regulate the dispersant flow. The regulator is controlled by an external hydraulic pressure line from the ROV and operates in the 10 – 120 L/min range. This range covers subsea releases up to 12 000 m^3/day (1% dispersant dosage). The dispersant dosage is remotely controlled by the ROV operator.

Small-scale testing:
Both individual wands and different release scenarios were tested in SINTEFs tower basin. This facility is three meter in diameter and six meter tall and contains 42 000 m^3 of natural sea water (see Brandvik et al., 2013 for details). Oil released from a blow-out-preventer (25 mm pipe), a ruptured pipeor directly from sea bottom, were simulated. An example, where oil was released directly from a pipe (BOP) and dispersant was injected into the pipe opening with a wand (insertion tool) is shown in Figure1. Untreated oil with large droplets (multiple millimetres, d_{50} = 1.8 mm) to the left and treated oil with significant smaller droplets (d_{50}=0.24 mm) to the right.

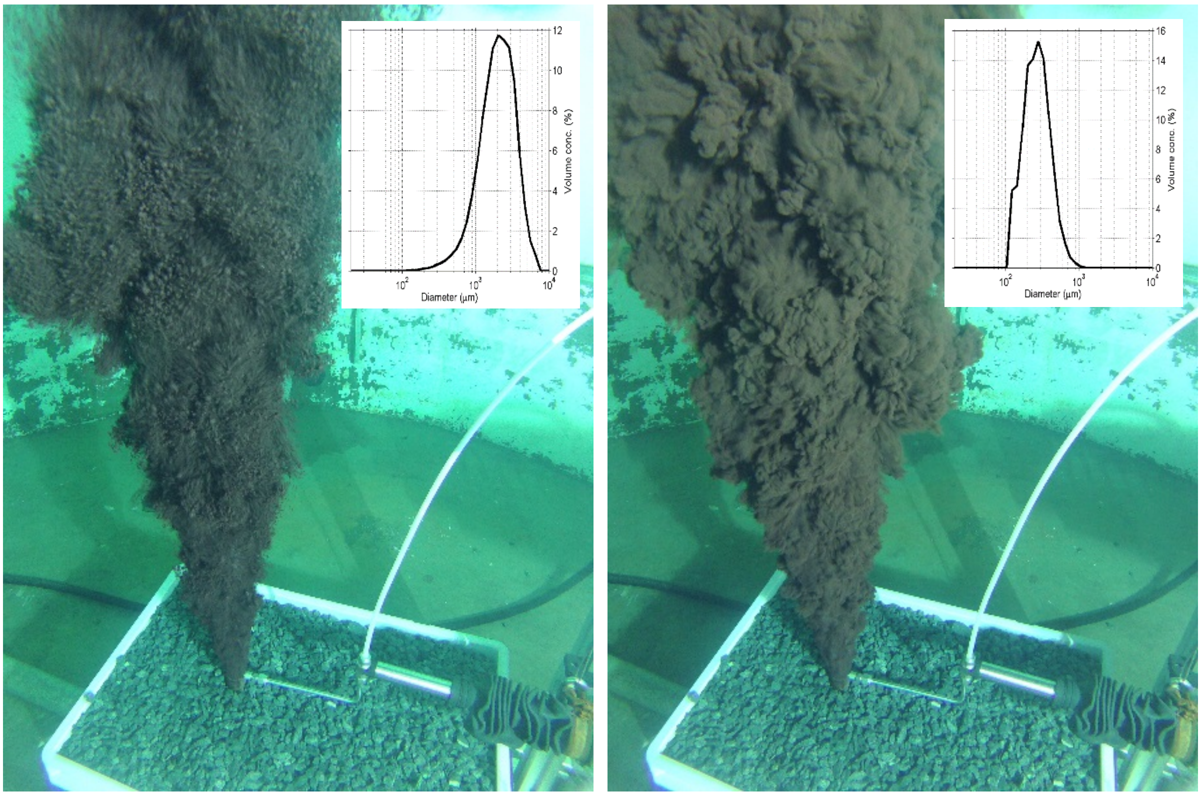

Figure 1: Untreated Oseberg blend released from the 25 mm nozzle at 120 L/min. Experiments were performed with both untreated oil (left) with a mean droplet size of 1.8 mm (d_{50}) and oil treated with 1% Dasic Slickgone NS (Right) with a mean droplet size of 0.24 mm (see inserted droplet size distributions).

Large-Scale Testing:
After down-scaled concept testing in the SINTEF Tower basin, full-scale verification with the actual regulator and a full-size offshore Remote operated Vehicle (ROV) was performed in Oceaneering`s ROV test pool in Stavanger (1 200 m^3), see figure 2. Both the down-scaled concept testing (with oil & dispersant) and the full-scale testing (with water & air) verified use of SilCam to monitor effectiveness and the use of this information for real-time dispersant dosage control.

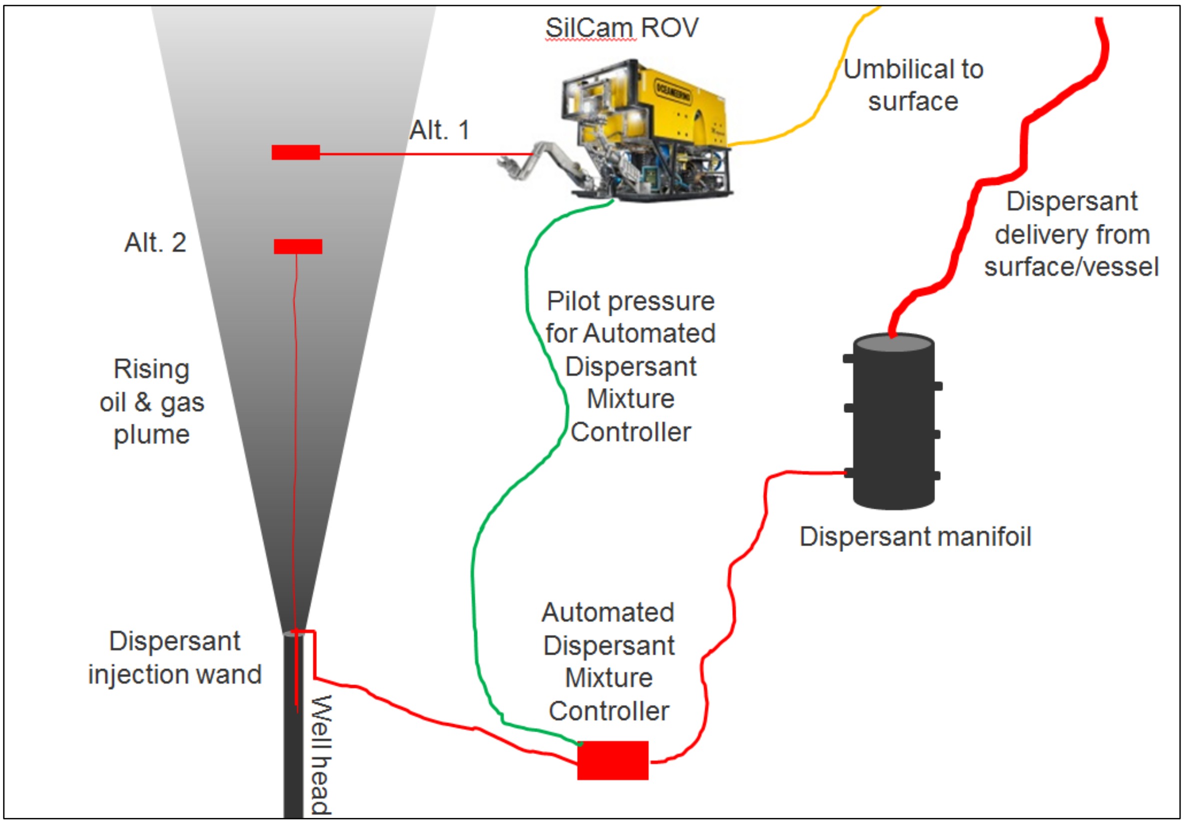

Figure 2: SSDI with automated dosage control and monitoring of effectiveness. Dispersant is injected into the well (Insertion tool), while the SilCam is used to monitor oil droplet sizes (SSDI effectiveness) and regulate dispersant dosage. The SilCam can either by positioned in the oil & gas plume by an ROV (alternative 1) or more permanently positioned in the plume (alternative 2).

Conclusion

This study tested both wands for subsea dispersant injection, a system to quantify treatment effectiveness (oil droplet sizes) and a new regulator for controlling dispersant dosage. The complete system can be used to automatically adjust dispersant dosage (0.5 – 2%) to obtain a pre-set droplet size (d_{50}), based on measured oil droplet sizes and it also offer documentation on dispersant usage and treatment effectiveness. The performance was verified by testing both, a down-scaled system (with dispersant & oil) and a full-scale version (water & air).

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