SINTEF Materials and Chemistry

NEWS no. 1 - 2005

Marine Environmental Technology

SINTEF SeaLab

New technologies for oil and gas exploration and production are continuously emerging to meet new and demanding challenges presented by exploration and production near-shore, in ice-infested and deep waters, and in other sensitive areas. Environmental considerations and requirements will be of major importance in the process of decision-making regarding activities in these areas. Important factors for these considerations are related to the fate and behaviour of the relevant oils if spilled, and to the potential impact to the specific environment (at sea, in water column, sea-bed, in ice, on shore etc.) and relevant marine organisms.

The coming years will be challenging with respect to the need for R&D studies related to many aspects of oil releases to the marine environment. This is connected to increased interest for exploration & production in coastal and sensitive areas (e.g. Lofoten / Barents Sea), in deep waters and in ice-infested waters.

Additionally, there is a significant increase in the transportation of oil along the Norwegian coastline.

In order to meet these future demands for related R&D studies, improvement in basic capabilities and extension of the flexibility of meso-scale basin facilities are essential. SINTEF has therefore relocated its marine activities (i.e the Fisheries and Aquaculture and Marine Environmental Technology activities) to a building at the water-front at Trondheim harbour (see figure on the last page) The laboratories and meso-scale facilities have been re-built in this new location. A high flexibility of operation is important for the new facility, since we want to carry out experiments associated with development of under-water production of oil, as well as problems related to oil spills for ice-infested and coastal waters with complex current patterns.

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SINTEF Marine laboratories (SeaLab) at Trondheim harbour (Sept. 2005)

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SINTEF Materials and Chemistry, Marine Environmental Technology news

Numerical Flow Models in Oil Boom Design

Why?

Oil booms are an important part of the equipment used in dealing with accidental oil spills. Whilst being easy to handle and deploy, booms should be able to retain as large an amount of oil as possible, in rough weather as well as calm, and facilitate the use of equipment to remove the oil from the water.

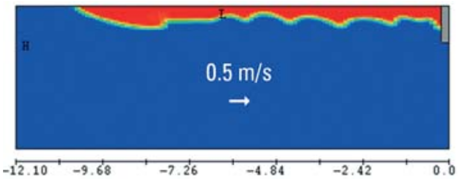
The design of booms has so far been based largely on experience and laboratory experiments. Numerical models are likely to add to our understanding of the flow of oil and water inside and round towed booms, and can be a cost-effective supplement to laboratory tests.

NOFO has financed a preliminary study on the feasibility of numerical flow models as design tools when creating new and improved oil booms.

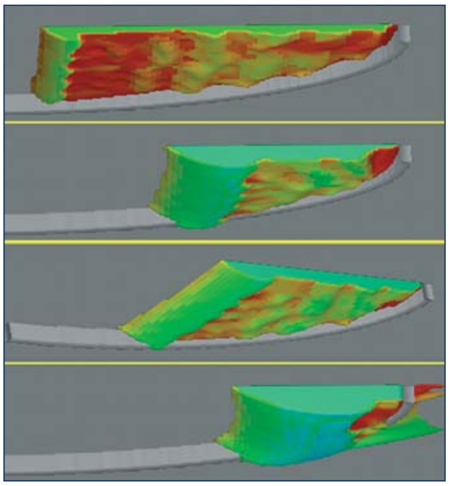
How?

Oil and water are immiscible fluids, and it was considered important to use a model capable of representing both fluids and the sharp interface between them.

The CFD code FLOW3D was chosen on account of this, being based on the Volume of Fluid (VOF) method which is good at capturing surfaces.

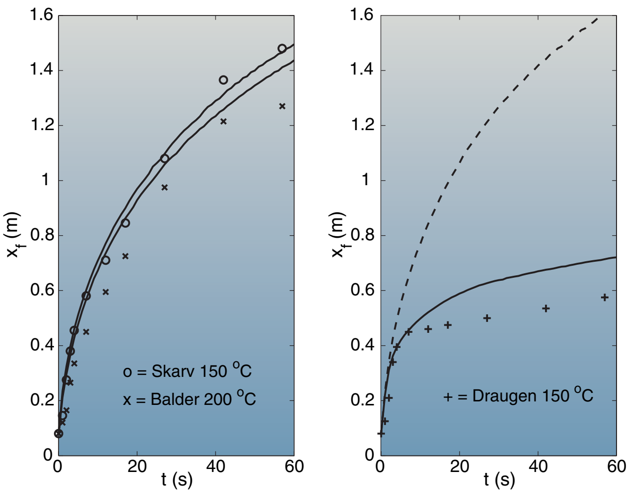


Snapshot from 2–D simulation with 970 kg/m3 oil (red) being held in a 1 m deep boom (grey) with 1000 kg/m3 water (blue) moving at 0.5 m/s from left to right.



The behaviour of oil contained in the right half of a U-type boom (seen from below) as the towing velocity is increased from 0.5 m/s to 1.0 m/s. The colour shows the x-component of flow velocity (red represents weak negative U velocity). The water is not shown.

It was considered important to have the oil phase represented in the simulations, because an oil – filled boom will produce a flow different from a water – filled boom.



Radius of oil release as a function of time, lines are simulations and symbols are experiments. The diagram to the right is for an oil with non – Newtonian behaviour.

Can numerical models be useful?

Most likely, yes. Our findings so far are promising. As a benchmark, the radial spreading of a small laboratory oil release was predicted with good accuracy (see figure below).

Simulations with two-dimensional cross sections with simple towed booms (an example is shown in the figure to the left, top) display a number of observed features: The front of the oil forms a raised "head", characteristic for a gravity current, followed by a long trailing section with waves moving along the oil/water interface towards the boom. Local effects are predicted in the vicinity of the boom.

Also shown is an example result from a three–dimensional simulation of oil held in a U – type oil boom(only one half of the boom is calculated due to symmetry). The picture series shows how the front of the contained oil is pushed back and deepens, and then escapes under the boom, as the towing velocity increases.

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Fieldwork with oil-in-ice on Svalbard

SINTEF Materials and Chemistry, Marine Environmental Technology has for the last two winters, in cooperation with the University Centre in Svalbard (UNIS), performed experiments with oil in ice on Svalbard. This work has been an activity in a larger project together with the Norwegian Atmospheric Institute (NILU) and the University in Bergen (UiB), and has been funded by the Norwegian Research Council, Statoil and Hydro.

The purpose of this three-year project has been to investigate weathering processes in marine oil spills under Arctic conditions. The focus has been on weathering of the bulk oil phase (evaporation, w/o-emulsification and dispersion), dissolution of water-soluble components, photo-oxidation and biodegradation processes of oil in ice.

The field activities this winter have focused on leakage of water soluble components from oil trapped in or under ice, and weathering properties of oil spilled in dynamic broken ice.

The leakage experiments have been performed with seven different oil types. The oils were frozen into the ice in February and samples (oil/ice) have been taken to determine the concentration of the water soluble components in the surrounding porous first-year ice.

Weathering experiments have also been performed in a meso-scale basin (6 x 4 m) cut into the ice. One oil type was used at three different ice conditions (0, 30% and 90% ice coverage). Weathering parameters such as evaporative loss, viscosity, water content, pour point and flash point were monitored during the 3-day weathering experiments. The weathering experiments were terminated with a burning experiment in an adjacent burn-basin.

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DREAM Course for Petrobras

Petrobras joined the Environmental Risk Management System (ERMS) program in 2004, and has now taken a major step towards actively implementing the dose-related risk and effects assessment models DREAM and ParTrack into its corporate toolbox. Seventeen employees participated in a 3-day course lead by Mark Reed and May Kristin Ditlevsen of SINTEF.

Participants' backgrounds varied from marine engineering and modeling to marine biology and chemistry. Everyone completed the course with flying colors, giving Petrobras a strong team for marine risk assessment for produced water and drilling discharges.

Course participants from left to right:
Front row: May Kristin Ditlevsen (course leader), Anna Maria Scofano, Leticia Falcão Veiga, Bárbara Prattes Maria de Fatima Meniconi, Guisela Matherson and Aline Rodrigues. Back row: Eduardo Platte, Carlos German , Marcelo Rocha Martinelli, Renato Parkinson, Ricardo Busolli, Gerônimo Dias, Heloísa Borges, Carlos Lacerda, Mark Reed (course leader), Teresinha da Silva, Uggo Ferreira and Carlos Henrique Marques de Sá

SINTEF SeaLab

Continued

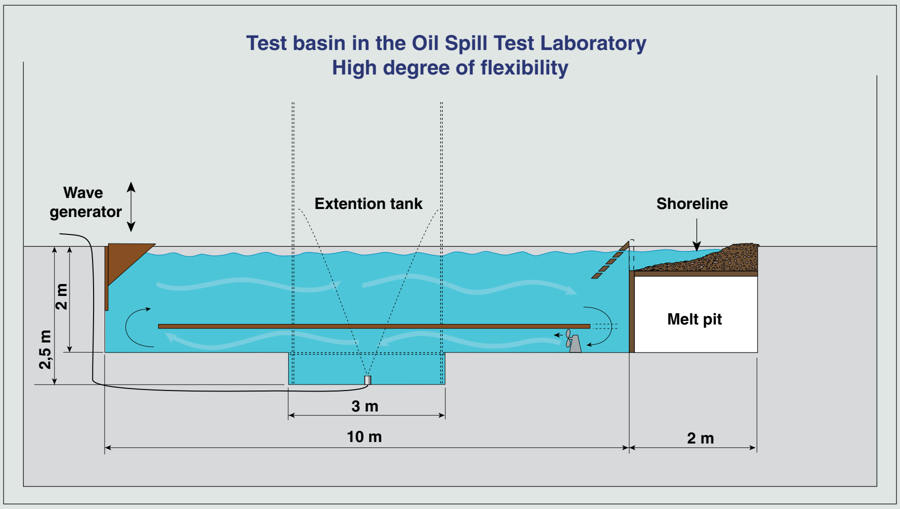
The new laboratory (SINTEF SeaLab) is intended to be a "national" laboratory as well as an international platform for oil spill R&D and related topics. SINTEF SeaLab includes the following facilities:

- Upgraded meso-scale oil /ice basin
- Upgraded meso-scale flume basin for studying oil spill weathering and behaviour
- Upgraded meso-scale shoreline basins
- Bench-scale laboratories for oil spill weathering studies
- Ecotoxicological facilities for bio-assay / toxicity testing
- Microbiological laboratories for biodegradation studies
- Oil spill and analytical laboratory facilities for:
  - Oil spill characterisation and testing of oil spill agents (dispersants, emulsion breakers etc.)
  - Oil spill identification / fingerprinting
  - Film thickness / "oil spill appearance" and spreading studies
  - Organic and inorganic analyses of chemical compounds in crude oils, produced water and drilling discharges

The new "oil/ice" basin will be the "back-bone" in the SINTEF laboratories, and is suitable for performing a wide
range of meso-scale R&D studies. Itwill be possible to carry out temperature controlled experiments, both with
different types of ice and with open water conditions.
Additionally a new and sophisticated flume basin will be installed in the premises enabling simultaneous simulation of all relevant weathering processes (e.g. evaporation, natural dispersion, dissolution, emulsification, photo-exidation etc.) and the behaviour of different oils under various environmental conditions.

SINTEF wishes to thank Statoil for a considerable financial contribution to the instrumentation and completion of the facilities.

Sketch of the upgraded meso-scale Oil/ Ice basin



New visiting address: Brattørkaia 17b, 4. etg. Trondheim, Norway

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