AMPHOS 21
COMSOL certified consultant
COMSOL CONFERENCE
2016 MUNICH

Hydrophobic Mesh Assessment and Design App for Oil Spill Recovery

Emilie Coene (emilie.coene@amphos21.com), Orlando Silva, Jorge Molinero
Amphos 21 Consulting S.L.

Introduction

Hydrophobic meshes are a new, promising technique for the recovery of spilled oil in the ocean (Figure 1). They allow to recover and store oil, while filtering it from the surrounding water. They are clean, efficient and can be used in continuously.

These meshes have one drawback, however: if they are submerged too deep under the water level, the high pressure will cause presence of water in the recovered oil. This means the oil would have to be processed before usage, increasing the cost of the oil recovery.

Objective

Accidental oil spills take place suddenly, have disastrous consequences and are best remediated as quickly as possible. The Comsol App presented here was developed with the purpose of offering a fast, customizable and easy-to-use tool for hydrophobic mesh designers and users in case of an oil spill.

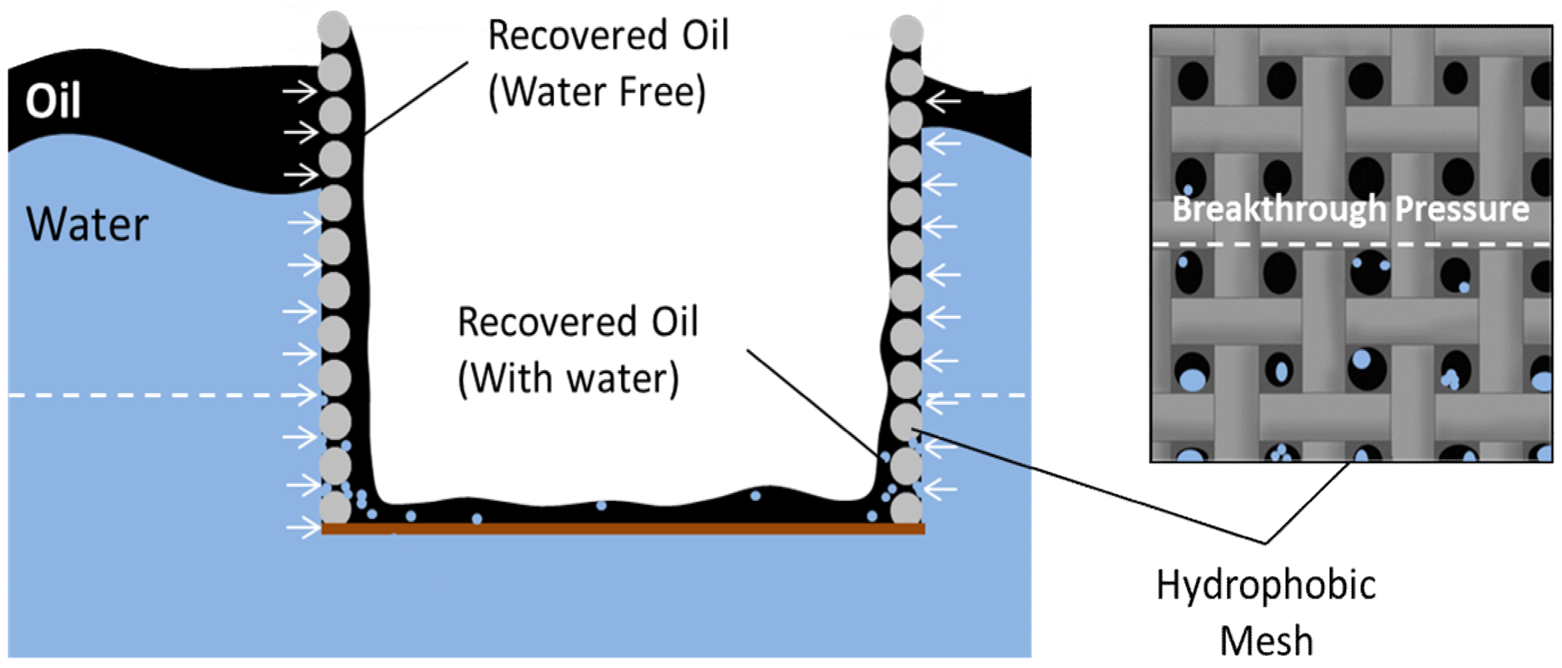

Figure 2. Scheme of a hydrophobic mesh recovering oil while retaining water.

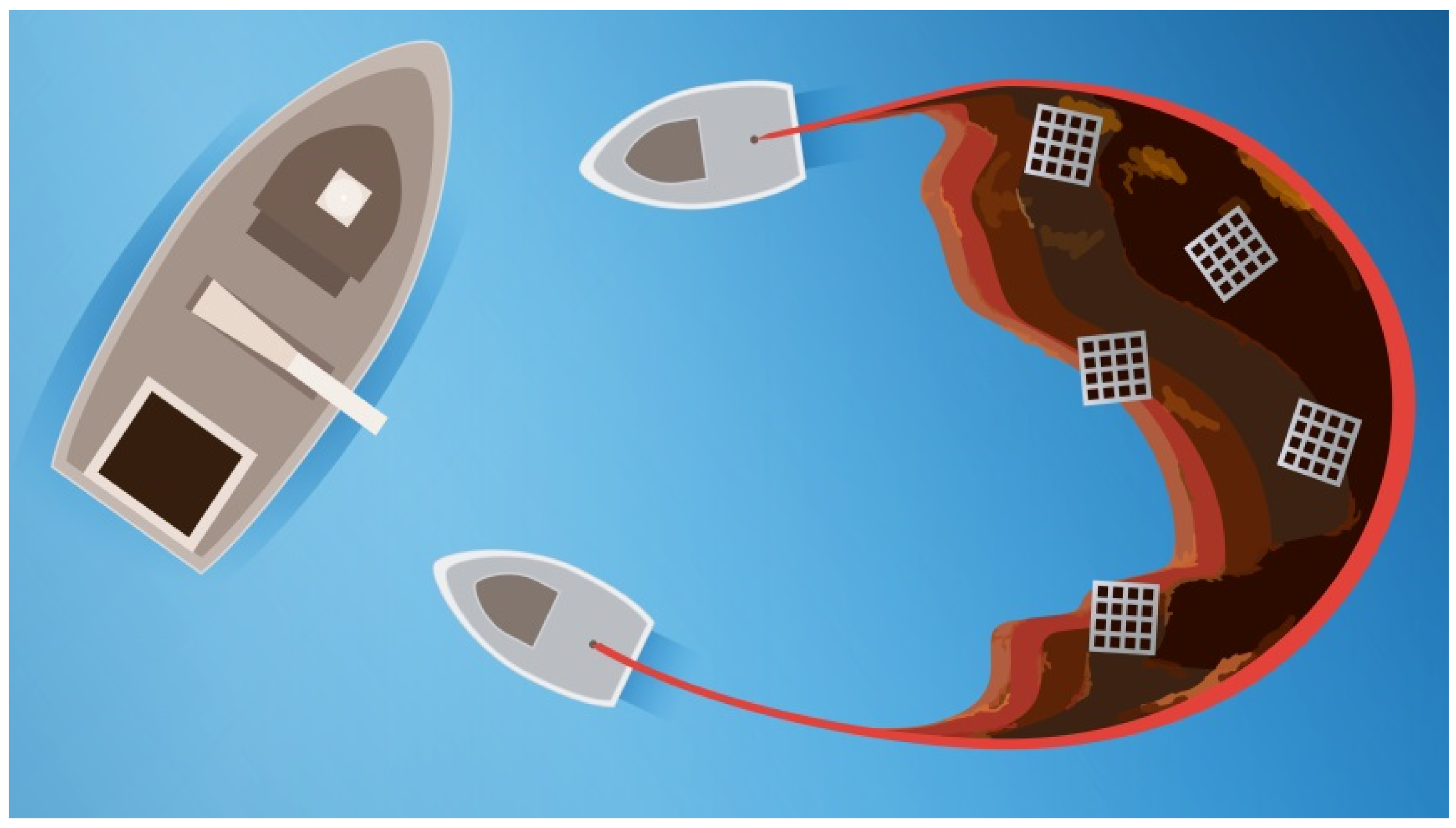

Figure 1. Oil recovery setup where booms keep the oil from spreading out and the hydrophobic meshes recover the oil simultaneously separating it from the water. Image credit: COMSOL

Modeling approach

- Concept: the hydrophobic mesh is conceptualized as a porous media, which, depending on the depth, will have oil flowing through it while retaining water (Figure 2).
- Governing equations: incompressible stationary 1D two-phase flow in porous media.

$$\phi \frac{\partial S_o}{\partial P_{c,ow}} \frac{\partial P_{c,ow}}{\partial t} + \nabla \left(\lambda_o k \left(\nabla P_{c,ow} - \nabla P_w\right)\right) = q_o - \nabla(\lambda_o\, k\, \rho_o\, g\, \nabla z)$$

$$-\phi \frac{\partial S_o}{\partial P_{c,ow}} \frac{\partial P_{c,ow}}{\partial t} - \nabla(\lambda_w k \nabla P_w) = q_w - \nabla(\lambda_w\, k\, \rho_w\, g\, \nabla z)$$

- COMSOL implementation: using the Coefficient's Form of the PDE module with multiple dependent variables.

Hydrophobic Mesh Model App

The developed Comsol App allows to change the various parameters of the hydrophobic mesh and the two phases, evaluating the oil recovery and oil/water selectivity. These depend on the mesh materials and the radius of wires and openings. In this case the phases are oil and water, but they can be replaced by any pair of wetting and non-wetting fluids for other applications.

The depth at which a mesh is operated affects oil purity, but also recovery speed: the deeper a mesh is submerged, the faster oil is recovered, but also the less pure this oil is. Something analogous happens with the size of the mesh openings. The App provides tools to choose a mesh opening radius and operation depth that provide satisfactory collection speeds and purities, for instance, as displayed in Figure 3.

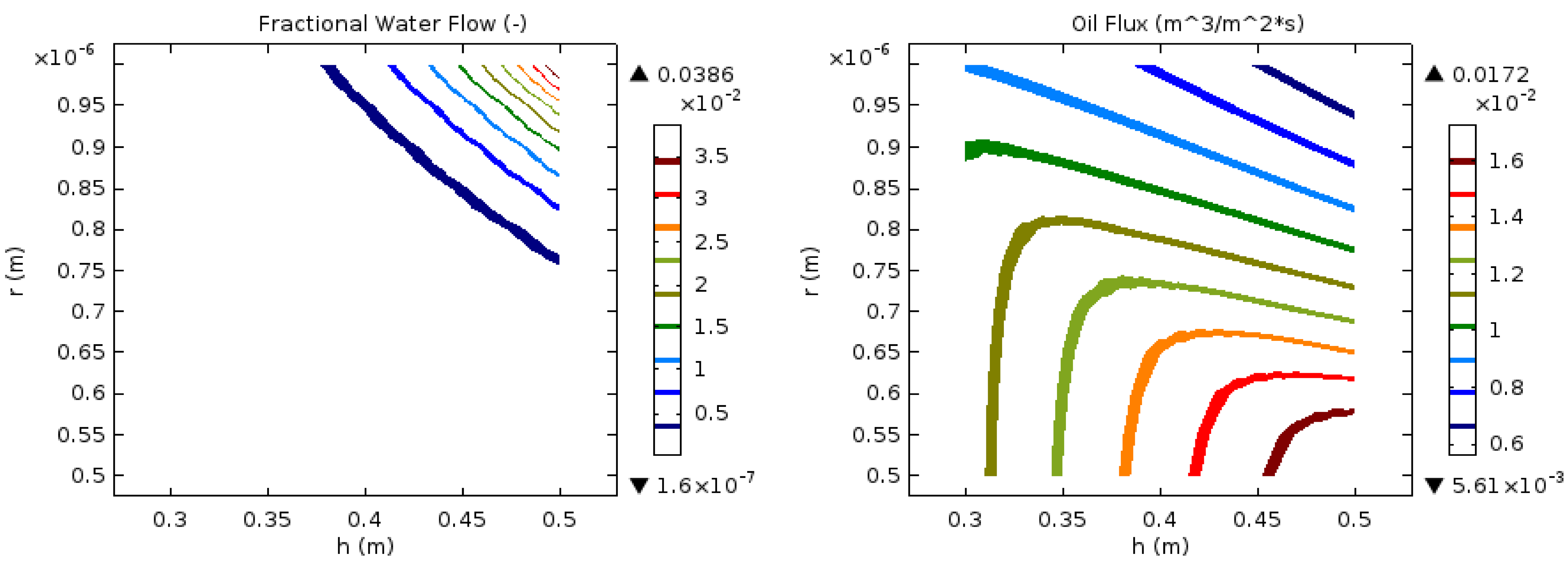

Figure 3. Oil purity and flux isocurves as a function of mesh opening radius and operation depth.

References

Deng, D., Prendergast, D.P., MacFarlane, J., Bagatin, R., Stellacci, F., Gschwend, P.M., 2013. Hydrophobic Meshes for oil spill recovery devices, *Applied Materials and Interfaces* 5, 774-781.
Carver, L., 2016. Addressing oil spill cleanup using hydrophobic meshes, COMSOL NEWS, The Multiphysics Simulation Magazine, 21-23.
Diaz-Viera, M.A., Lopez-Falcon, D.A., Moctezuma-Berthier, A., Ortiz-Tapia, A., 2008. COMSOL implementation of a multiphase fluid flow model in porous media. Proceedings of the COMSOL conference 2008 Boston.
Song, J., Huang, S., Lu, Y., Bu, X., Mates, J.E., Ghosh, A., Ganguly, R., Carmalt, C.J., Parkin, I.P., Xu, W., Megaridis, C.M., 2014. Self-driven one-step oil removal from oil spill on water via selective-wettability steel mesh, *Applied Materials and Interfaces* 6, 19858-19865.