*Faculty Engineering Technology*
*Program Mechanical Engineering*

UNIVERSITY OF TWENTE.

# COLLOQUIUM

Group: **Engineering Fluid Dynamics**

As part of his MSc thesis assignment

## Thomas van der Meer

will give a presentation, entitled:

## Fouling of Ceramic Membranes during Oil/Water Filtration: A numerical and Experimental Study

**Date: Friday August 30, 2013**

**Time: 11:00**

**Room**: **N.109**

**Summary**:

One of the waste streams on offshore oil and gas platforms is an oil-in-water emulsion called produced water. After conventional treatment this stream consists of water with up to 1% volume fraction very finely dispersed oil droplets of about 5 µm. Separation of this oil from the produced water can be achieved by membrane filtration. A membrane is a tube with porous walls. A pressure difference over the wall results in permeation of water through the wall while retaining the oil droplets inside the tube. An important problem in the field of membrane filtration is the fouling of the membrane due to the rejected species (oil) that accumulates on and inside the membrane. Fouling causes a detrimental decline in the permeate flux. The goal of the present research is to investigate the effects of hydrodynamic parameters, like axial velocity and trans-membrane pressure, on the decrease through fouling of the steady-state permeate flux. For this a mathematical model has been developed and validation experiments have been performed.

The mathematical model has been implemented using the computational fluid dynamics (CFD) module of the finite-element package COMSOL Multiphysics. The turbulent flow field in the membrane tube is computed using the Reynolds-Averaged Navier-Stokes equations, closed by a modified $k$-$\varepsilon$ turbulence model by Abe, Kondoh and Nagano. The oil concentration field is described by the convection-diffusion equation. The membrane itself is modeled as a function for the velocity at the wall. This velocity function is Darcy's Law for the flow through a porous medium, adjusted with two additional resistance terms that depend on the oil concentration (representing the fouling of the membrane).

Filtration experiments have been performed utilizing an existing setup at the Shell Technology Centre Amsterdam. In order to sustain turbulent flow in a dimensionally similar membrane as applied in offshore installations, a laboratory-scale silicon carbide membrane has been developed by a membrane supplier. The model oil-in-water emulsion used in the laboratory set-up replicates the mixture in the offshore application. The steady-state permeate flux has been measured for various axial velocities and trans-membrane pressures.

The results of the numerical method are in reasonable agreement with the experimental results. The effect of the hydrodynamic parameters on the permeate flux are represented. Compared with experimental data from the membrane manufacturer the pressure drop along the membrane tube is under-predicted by the method. It is hypothesized that inclusion of suitable droplet deposition models in one of the resistance terms in the adapted Darcy's law may increase the accuracy of the results.

**Assessment committee:**

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Prof.dr.ir. A. Nijmeijer (mentor)
Prof.dr.ir. T.H. van der Meer
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d.d. _______________