The Use of Finite Element Analysis in the Design of Oil-Water Separators

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Abstract

Oil-water separators play an important role in several industries and in waste water treatment. However, no basic rules or principles have been set to guarantee the designed separator would work according to the desired efficiency due to the presence of various factors that could positively or negatively interfere in the separation process.
This study aims to use the COMSOL Multiphysics® software to stimulate the performance of different Oil-Water separators, and study the effect of different operation and design parameters on the efficiency of the separation process. Hence, both time and money could be saved by simulating the separation process using the COMSOL® software without the need of building a prototype and before the fabrication of the desired separator.
To fulfill the study aim, a transparent cylindrical oil-water separator was built in the laboratory, the separator was designed as a cylindrical vessel with the possibility of adding vanes at different locations inside the separator. An oil-water mixture was pumped through the separator from an inlet nozzle. The separator had two discharge nozzles near its other end, water was collected from the bottom outlet nozzle and oil from the top one. The composition of water samples gathered from nozzle at the bottom the separator was used to calculate the separation process efficiency. The effect of different variables was studied: inlet velocity, feed composition and the presence and location of vanes inside the separator. The results of these laboratory tests were compared to the results obtained from the model built using the COMSOL Multiphysics® software at similar conditions. The resemblance of these results confirmed the success of COMSOL® to simulate the performance of the oil-water separator.
Moreover, the success of the COMSOL® software was further confirmed by comparing the experimental flow pattern using a tracer with the flow pattern direction and velocity gained from COMSOL® simulations.
Upon verification and validation, different conclusions were drawn from this study regarding the design criteria of oil-water separator and can help enhancing the separation process efficiency.

Reference

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2- James, P.W., et al., A Model for Liquid Film Flow and Separation in a Wave-Plate Mist Eliminator. Chemical Engineering Research and Design, 2005. 83(5): p. 469-477.
3- Simmons, M.J.H., et al., Residence Time Distributions and Flow Behaviour within Primary Crude Oil–Water Separators Treating well-head Fluids. Chemical Engineering Research and Design, 2004. 82(10): p. 1383-1390.

Figures used in the abstract

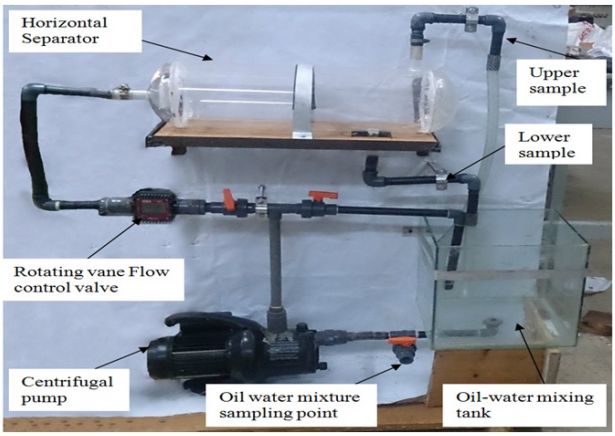

Figure 1: Separator prototype for comparison with simulation results

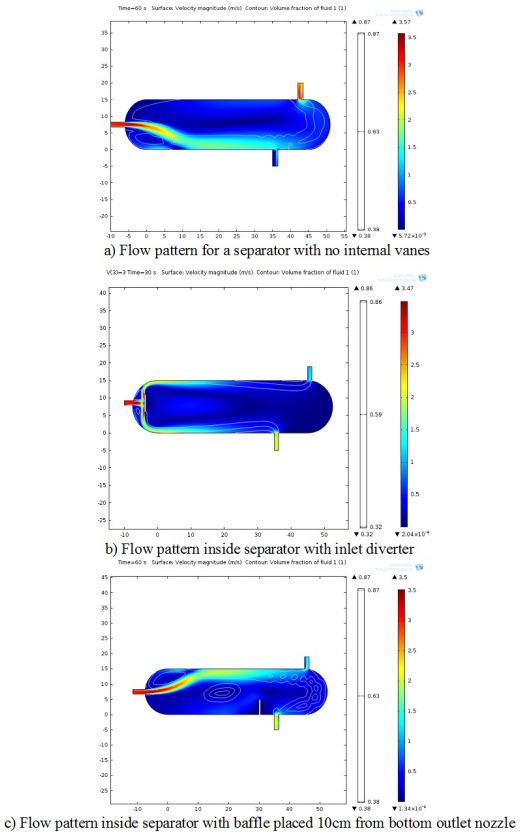

Figure 2: Flow patterns for different separator designs

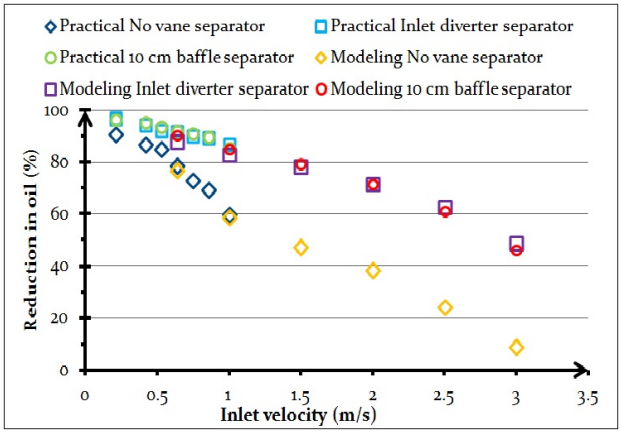

Figure 3: Comparison between experimental and simulation results using different separator internal designs

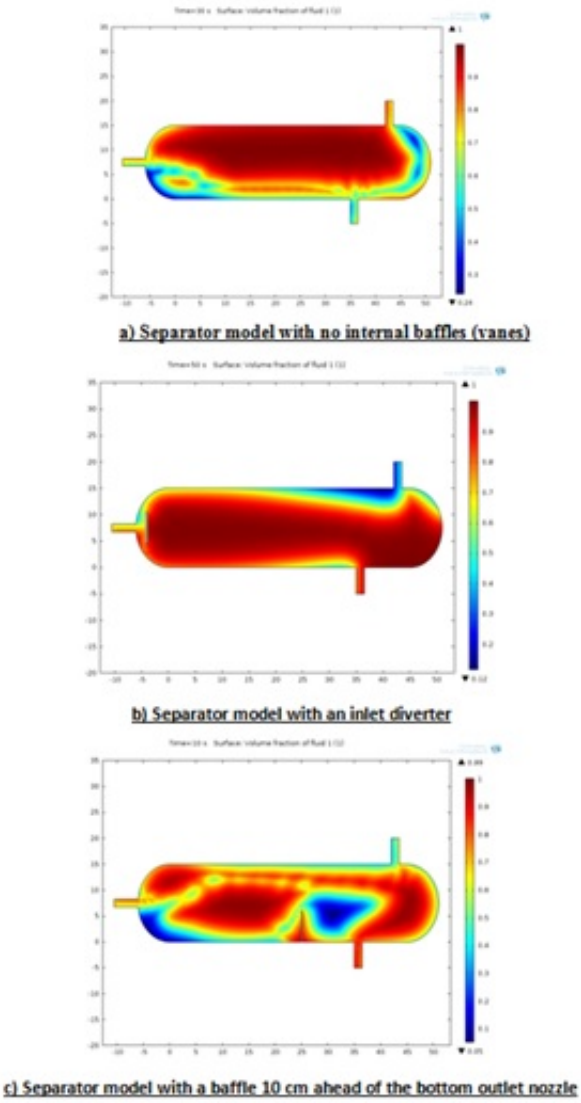

Figure 4: Modeling mixture composition for different separator designs