Hydrophone Acoustic Receiver Modeling: Turbulent Flow Modeling and Acoustic Analysis

D. Groulx[1], A. Bharath[1], S. Campbell[1]

[1]Department of Mechanical Engineering, Dalhousie University, Halifax, NS, Canada

Abstract

The field of underwater acoustics research is growing constantly with the ongoing improvement of the measuring device capabilities to analyzing various aspects of the sub-marine system. Hydrophone acoustic receivers passively listen to sound propagating through the water and can be used to monitor marine life or other acoustics producing phenomenon in detail: shipping lanes for example. A major contributor to unwanted noise in the receiver signal is produced by near-field fluctuations from the medium in which it operates. This turbulent behavior created by the presence of the hydrophone causes pressure fluctuations which dominate the signal in high velocity flows. This work aims to understand the nature of the turbulent behavior and the propagation of acoustic waves near a hydrophone using COMSOL Multiphysics® software and look at design optimization to minimize turbulent acoustic noise generation.

In collaboration with OceanSonics, controlled tow tank experiments were conducted at Dalhousie University using icListen Smart Hydrophones (Fig. 1) to gather acoustic data at speeds generating Reynolds numbers ≤30,000 based on the receiver radius. Using the COMSOL CAD software, a model of the tow tank and hydrophone system was created to preform turbulent flow simulations matching the experimental parameters. The Shear-Stress Transport (SST) turbulent model was calculated on a mesh generated within COMSOL in order to accurately resolve the laminar flow separation near the hydrophone and the propagation of this turbulent behavior along the wake (Fig. 2). The integrated normal surface pressure on the receiver was calculated from transient COMSOL solution and are compared to experimental data to validate the turbulent wake. The turbulent behavior is characterized and the impact on the receiver surface pressure is shown as a function of Reynolds number.

Using the COMSOL transient acoustic-solid interaction module, the propagation of various frequency sound pressure waves are modeled in the tow tank - hydrophone domain. The acoustic-solid interaction module is used to study the impact the hydrophone has on the surrounding pressure field as well as the propagation of wave through the device itself. Results show the pressure field fluctuations measured by the receiver due to acoustic waves (Fig. 3). Coupling the results with those from the turbulence analysis, a complete analysis of the pressure field experienced by the receiver is given by this work.

Figures used in the abstract

Figure 1: OceanSonics icListen Smart Hydrophones (left) used as templates for the CAD design (right) used in the numerical domain.

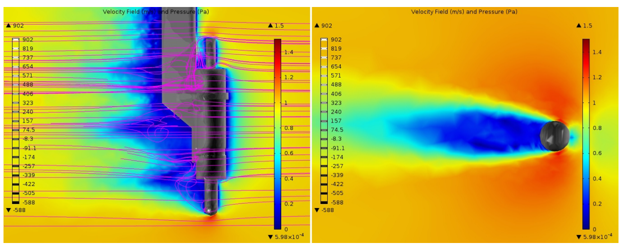

Figure 2: COMSOL simulation results of the flow along the height of the hydrophone (left) and around the receiver (right). SST turbulence model is used to resolve flow separation as a result of the hydrophone.

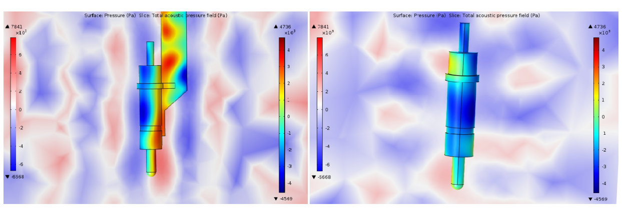

Figure 3: COMSOL simulation results of acoustic wave pressure fluctuations experienced by the surface of the hydrophone.