Abstract

In this thesis, a wave propagation based analytical model is developed for an underwater towed array. The towed array is modeled as an infinite tube filled with a certain liquid and submerged in an infinite volume of water. This tube is excited by turbulent boundary layer (TBL) excitation which is modeled using both the Corcos and the Chase models. The acoustic response (self noise) of the towed array is found using the transfer function of the tube and the PSD of the turbulent excitation.

The acoustic response spectrum is compared with the results from the literature. This happens to be the main contribution of the work. This is so because very little literature is available on towed arrays. There is only one analytical work available and our results match exactly with theirs. With respect to experimental results, although there are several articles, numerical values of the tube material properties, the fluid properties and the tube dimensions have not been reported in full. This makes the comparison very difficult. Hence, by doing several parametric studies and investigating properties of materials that were applicable like rubber or Nylon, we have managed to narrow down the parameter ranges and made comparisons with the experimental results.

We have matched single hydrophone TBL response with experimental results from two separate groups. We have had to vary several parameter values in order to do this. The parameters include the Young's Modulus, density, Poisson's ratio and the thickness and diameter of the tube. Also included are the density and the speed of sound of the internal fluid. Sometimes a particular material from a handbook was chosen that gave a set of parameters.

After having matched with the experimental values, the idea was to conduct a

parametric study to decide the most influential parameters. We have done this using both the dimensional physical variables as well as non-dimensional variables. We non-dimensionalized the equations to help reduce the number of variables in the system and then studied the effect that each parameter has on the noise generated due to Turbulent Boundary Layer developed as a result of the tow.

The dominant parameter that influences the TBL response at the hydrophone location is the tube radius a, followed by the Young Modulus E, the density of internal fluid ρ_{f_i} and the thickness h of the tube. An increment in a, E and h reduces the TBL response, while an increment in ρ_{f_i} increases the TBL response.

In addition, several analytical studies were conducted to understand the dispersion characteristics of fluid-filled submerged tubes. This study is presented in the appendix in order to avoid cluttering the main document. The main idea that emerges from this study is that there is a single real wavenumber in this coupled fluid-structure system which responds at its resonance when the TBL spectrum wavenumber matches the wavenumber value. All other free waves are complex and hence under forced excitation, they do not respond.