Modelling of flow-induced vibrations in a thin towed antenna

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ABSTRACT

Sonar antennas consisting of arrays of hydrophones inside a towed cable are used by surface ships and submarines. Passive sonar operation deals with weak signals and low frequencies, and are sensitive to all sources of noise. "Self-noise" is the noise generated by the vessel and the towing itself, as opposed to external noise such as other vessels, fish, or background turbulence, and "flow noise" is the part of the self-noise that stems from the interaction between the towed cable and the surrounding fluid.

In order to understand the sources and mechanisms of flow noise, it is desirable to be able to model the process to obtain numerical results, which can be compared with experimental results. Traditionally, the modelling of flow noise in towed arrays is based on a model of the wall pressure spectrum [1], and analytical approximations for the transfer function to internal pressure [2]. The present approach takes advantage of the computational capability to perform numerical simulations of both the flow field and the structural vibrations in the cylinder. The coupling is a one-way fluid-structure interaction, where the backwards influence from the cable on the fluid is ignored.

The fluid flow simulations are performed using the open-source spectral element solver *NEK5000* in an annular domain to obtain a Large Eddy-type solution. Varying input parameters are the tow velocity, cable diameter, and cable curvature. The structural simulations of the cable are performed using the commercial finite element solver *NASTRAN* from MSC Software. The majority of the simulations were performed on a homogeneous cable model, but other models have also been used. Input parameters for the structural simulations are the cable diameter and its material properties, in addition to the time-dependent surface pressure field obtained from the fluid simulations.

Simulation data are analysed in terms of wavenumber-frequency diagrams and power spectral density of the pressure at the cable centreline, corresponding to data captured by an array of hydrophones placed inside a towed cable. The propagation speeds of the internal modes in the cable compare well with results from theoretical models. The pressure power spectra from the cable are also compared with experimental data from self-noise measurements on a range of towed antennas under controlled conditions in an inland lake. Even with the simplest antenna model and quite generic material properties, the main trends of the experiments are captured in the simulation results.

The significance of this modelling capability is the ability to model potential new antenna designs, but also to increase the understanding of the self-noise sources and mechanisms by modelling idealized cases, where different effects can be isolated, or excluded.

REFERENCES

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