Radiation Impedance of a Piston on a Rigid Sphere Located in an Ocean Waveguide

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Baffled pistons such as a circular piston are useful to model a variety of acoustic sources. A circular piston on a rigid baffle of infinite extent is a classical problem, for which analytical solutions have been obtained (L. E. Kinsler et al, Fundamentals of Acoustics, Wiley, 2000) to study the radiation impedance. Analytical solutions have been obtained for radiation of curved spherical caps set on a rigid prolate spheroid (R.V. Baier, JASA 51, 1705-1716, 1972) and a similar problem with rectangular piston (J.E. Boisvert and A.L. van Buren, JASA 111, 867-874, 2002). Numerical methods such as the BEM and FEM can readily be used to model baffled pistons of arbitrary geometry in a heterogeneous acoustic medium. An associated problem is the radiated field of baffled pistons in an ocean waveguide. The present paper is concerned with the study of a piston set on a rigid axisymmetric body located in a heterogeneous ocean waveguide. The azimuthal field in a cylindrical waveguide is expressed in the form of a Fourier series. Then, a 2D FE model for the Helmholtz equation for a given harmonic has been formulated. The FE model involves a truncation boundary on which radiation boundary conditions have been imposed following Vendhan (C.P. Vendhan et. al, JASA 127, 3319-3326, 2010).

For the purpose of numerical study, a depth dependent waveguide of 100 m depth has been considered. As a specific example, a rigid sphere with a spherical piston has been chosen. A uniform time harmonic velocity is imposed on the piston and the resulting radiated acoustic field is obtained by solving the FE equations. The acoustic pressure field in the waveguide and the radiation impedance of the piston, which is obtained by integrating the acoustic pressure on the piston, are computed. Results have been obtained for an isovelocity waveguide and the one with a depth dependent sound speed. For comparison, results have also been obtained for the piston radiating in an unbounded domain. The salient feature of this paper is the radiation problem is coupled with the scattering problem in the waveguide channel. This coupling is particularly important for radiation sources immersed in heavy fluids.