This paper presents computational results of performance and acoustical spectrum of marine rotating systems. Conventional propeller having experimental results, namely P-4119, were selected to investigate the solution procedures where finite volume CFD calculations are used to validate available data. The effects of mesh generation, spatial and temporal discretization methods and turbulence model on the robustness of the numerical processes were examined. The flow over a cylinder is also taken as acoustical test-case. The results show that the methods and steps followed through this paper are capable of providing reliable solutions in acoustical problems. Hybrid noise prediction is presented by solving hydrodynamic field and computing acoustic field via monopole, dipole and quadruple sources. URANS solver is coupled to wave propagation method for cylinder test-case and LES is used to combine hydrodynamic quantities with acoustic radiation for marine propeller. Direct acoustical computations and FWH methods are compared with experimental results. Regarding flow over cylinder, there is encountered a frequency mismatching in spectral domain due to the insufficient capture of vortex shedding. However the harmonics and amplitudes are nicely matching with experimental results after phase shifting process. Spectral distributions of sound radiation at the farfield is achieved for marine rotating system. Blade passing frequency is the dominant characteristic in spectral density of rotating system. Harmonics and tonal noises are apparent in low band but farfield acoustics would not be resolved easily by using direct approach, because length scales of producing sound and turbulence have different orders of magnitude. Acoustical behavior is studied in this paper except in the case of cavitation. A cavitation phenomenon is a deep scope to simulate in unsteady turbulent solver which requires additional computations and modeling of bubble dynamics. As a further application, rotating systems subjected to inhomogeneous inflow may be studied which is quite different case.

A coupled-mode sound propagation model for ocean waveguide with three-dimensional topography

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The calculation of the sound propagation in ocean waveguide with three-dimensional topography is one of the most challenging problems in underwater acoustics. In order to calculate the acoustic field accurately and to analyze the 3D effects caused by the energy couplings along all the horizontal directions efficiently, a coupled normal-mode model for acoustic propagation in ocean waveguides with 3D topographies is developed. In this model, the coupling equations are derived for any conditions of the topography. Meanwhile, the non-horizontal bottom boundary condition is treated strictly instead of making an approximation. A correction of the bottom boundary is introduced by this
non-horizontal condition, which guarantees that the coupling coefficients are symmetrical and makes the acoustic field satisfy the energy conservation. Besides, the couplings corresponding to the effects of the varying environment are fully considered, and the numerical implementation is kept feasible by using the higher-order Padé approximation and the split-step method. By the numerical simulations in the waveguide with conical seamounts, it is proved that the model is capable to compute the acoustic field in 3D waveguides with complicated topography efficiently. The horizontal refraction and the diffraction of low frequency sound waves, which are induced by varying topography, can be accurately described in this model. Meanwhile, the transfer of the acoustic field energy in the horizontal plane is explained by the coupling between normal modes.

**Perfectly matched layer technique for parabolic equation models in ocean acoustics**

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In ocean waveguides, the ocean bottom is usually approximated as a half-space, and condition of radiation at infinity should be satisfied. In numerical solutions like parabolic equation methods, the depth domain has to be truncated, which can generate reflection waves from the truncated ocean bottom. To reduce the effect of reflection waves and to simulate an unbounded ocean bottom accurately, an artificial absorbing layer (ABL) (Tappert, Lecture Notes in Physics, 1977) was used. As was demonstrated, an ABL meets well the demand of accuracy in sound field calculation. However, both the sea-bottom layer and the artificial absorbing layer are needed to be set quite thick by using an ABL technique. Fortunately, a PML with thickness of several wavelengths can keep similar calculation accuracy with an ABL with thickness of dozens of wavelengths. In this paper, perfectly matched layer (PML) techniques for three parabolic equation (PE) models RAM, RAMS and a three dimensional PE model (Lin et al, JASA, 2012) in underwater acoustics are presented. A key technique of PML ‘complex coordinate stretching’ is used to truncate unbounded domains and to simulate infinity radiation conditions instead of the ABL in those models. The numerical results illustrate that the PML technique is of higher efficiency than the ABL technique at truncating the infinity domain with minimal spurious reflections in PE models.

**Distortion of the frequency dependency of bottom attenuation α(f) inverted from modal attenuation β_m due to bottom model-mismatching**

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