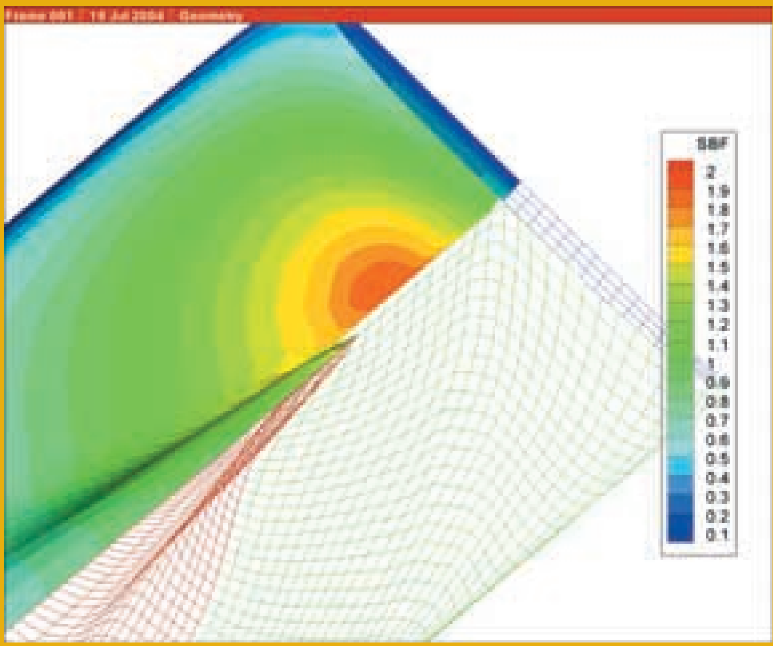
Figure 1: Solid Boundary Factor (SBF).



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EXCALIBUR cuts thr

MARIN's acoustic panel code for propeller source strength determination lives up to the legend.

In maritime engineering, whenever one speaks of hydro-structural interaction, reference is usually made to the interaction between floating bodies and gravity waves, leading to ship motions and internal loads. However, the field of hydro-structural interaction is broader, also including hydro-acoustic loads interacting with ship structures. This article is about one such interaction problem, namely propeller-induced pressure pulses causing fluid-loaded hull plate vibration.

In many ways the acoustic diffraction problem is comparable with the more familiar gravity wave diffraction problem, where one tries to find the ship motions which result from wave encounters. Such motions may be in the form of rigid body modes. The hull surface pressure distribution that causes them is built up of several components. Initially, there is the pressure due to the incoming wave and then there is the diffracted pressure wave. Together they form the 'blocked pressure' load that would be exerted on the rigid, immobile ship. The other components to the pressure field are due to the pertinent, rigid body modes and can be regarded as reaction forces. The problem of determining the body motions, including fluid loading, is a well-posed interaction problem when the blocked surface pressure field is known.

A similar situation occurs when the afterbody structure is excited by hydro-acoustic pressure pulses that originate from cavitating propellers. Each blade passing top dead-centre carries a hydrodynamic pressure field with it. Here, blade thickness and loading are the main contributors. In addition, the blade supports a cavity in the form of a sheet or tip vortex that fluctuates in volume when passing through the ship's wake peak and acts as an acoustic source. The forces that are exerted on the hull, if the latter is rigid, constitute the excitation force (viz. the 'blocked pressure') that cause the afterbody to vibrate. The resulting vibration modes cause reaction pressures, which in turn, change the vibration behaviour. The main physical difference being the fact that in the first case, gravity is the driving factor, while in the second, the compressibility of the fluid governs the physics.

Solving acoustic scattering and radiation

Within MARIN's Co-operative Research Ships' community the PRECAL panel code is a well-established tool for the computation of gravity wave diffraction and radiation problems. Not so well-known is the fact that MARIN has also developed a panel code for acoustic diffraction and radiation[1]. The latter panel code implements a so-called direct, improved boundary, integral equation formulation for the exterior domain. It solves the acoustic radiation problem by computing the acoustic pressure in a 3D exterior domain given a prescribed, complex velocity distribution on the closed radiating surface. At a set of frequencies the amplitude and phase of the pressure in the fluid and on the bounding surface, are determined. In case an incident pressure wave is given instead of surface velocity distribution, the programme solves the acoustic scattering problem.

Within the scope of the PRES2 Working Group this code – called EXCALIBUR – was further developed so as to enable the computation of acoustic wave diffraction around ship hulls and radiation from vibrating ship structures. Recently, the solver underlying EXCALIBUR was extended with an option for computing inverse diffraction and radiation problems in the frequency domain. In inverse diffraction problems the pressure field on the bounding surface is given. It becomes possible to find the acoustic source strength of the cavitating propeller, based on pressure measurements made on the hull.

Excalibur put to the test

Here, Report looks at EXCALIBUR's ability to solve the scattering problem. In the test case a fictitious single-screw vessel was used. The underwater stern part is panelled, using about 4,000 panels, which are mirrored in the free surface.

A point source of unit strength pulsating at a typical blade rate frequency of 2 Hz in the vicinity of the upper part of the propeller disk, along the ship's centre line, should be assumed. Figure 1 shows the Solid Boundary Factor (SBF) for this case. The SBF is defined as the absolute value of the ratio of computed blocked and free field pressure. Figure 2 gives an example of an inverse diffraction problem.

ough acoustic problems

The coloured squares are hull surface pressure amplitudes at blade rate and the coloured circles show the pertinent distribution of point sources in the fluid that constitute the best match to the measurement.

1) H.C.J. van Wijngaarden, On solving the Helmholtz equation numerically by the BEM, MARIN Report No. 51013-1-RF, October 1990.

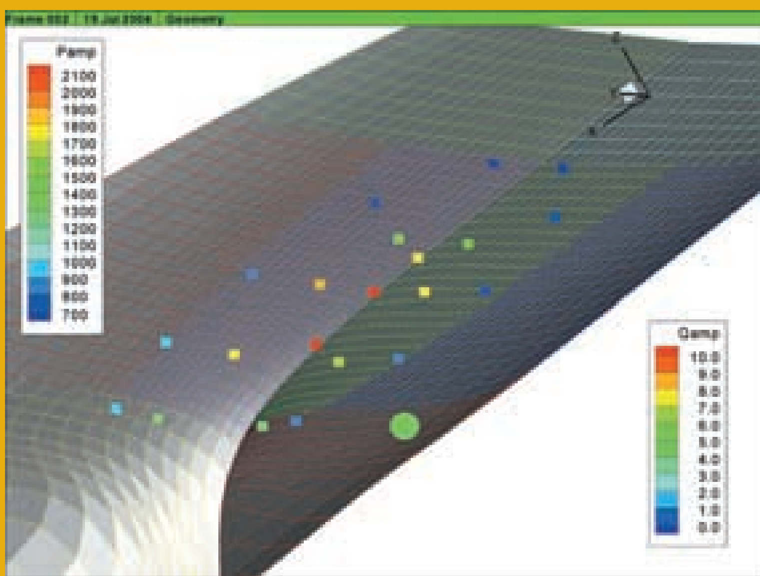

Figure 2: Example of inverse diffraction.