TRANSIENT RADIATION BY A SYSTEM OF TWO CYLINDRICAL SHELLS

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1. INTRODUCTION

Although a system of two co-axial cylindrical shells has been considered before in both shock and acoustic loading contexts [1, 2], there is very limited information available in the existing literature regarding the structure of the acoustic field radiated by such a system in cases when the loading is transient in nature. Therefore, our goal is to offer insights into the dynamics and composition of the field for a transient external acoustic loading.

2 MATHEMATICAL FORMULATION AND SOLUTION METHODOLOGY

We employ the semi-analytical methodology that we have developed in recent years [3-7] while accounting for the fact that now there are two structures, one interacting with both external and inter-shell fluids, and one interacting only with the inter-shell fluid.

More specifically, the fluids are modelled using the wave equation, and the shells are modelled using the Kirchhoff-Love linear theory of thin shells. The analytical part of the solution employs the separation of variables and Laplace transform with respect to the spatial and temporal coordinates, respectively, and the fluid and structural parts are then coupled using a 1D finite-difference approach.

The resulting solution possesses the advantages of being very computationally efficient and robust, while its main limitation is the restriction on the complexity of system's geometry in that it can only handle cylindrical structures.

3 RESULTS AND DISCUSSION

We considered a system of two steel shells with the radius of the outer shell of 1 m, the radius of the inner shell 0.5 m, and the thickness-to-radius ratios of the shells being 0.01 and 0.02, respectively. Both the outer and the inter-shell fluids are assumed to be water. The incident acoustic load is assumed to be a single point-source pulse originated at the stand-off distance of four radii of the outer shell and with the exponential decay of the pressure behind the front, the decay constant being 0.0001314 s.

We first address the acoustic patterns observed in the system, and Figure 1 shows two representative snapshots of the acoustic field induced by the load in question. One of the immediately apparent features is the dramatic effect that the inner shell has on the overall acoustic pattern radiated by the system - the external load, upon its transition into the

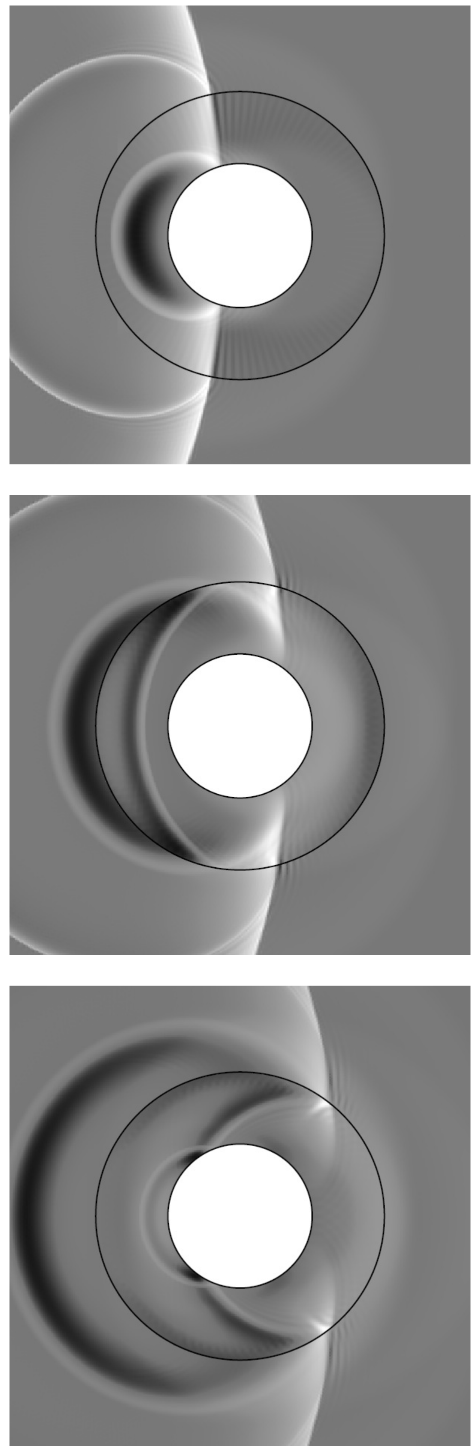

Figure 1. Representative snapshots of the acoustic field.

inter-shell fluid, reflects off the inner shell and then propagates upstream, reaching the outer shell and reflecting off it again, with the reflected wave propagating downstream, and with another wave originated in the external fluid that still propagates upstream, thus constituting an effect that might be referred to as the "leaking" of the waves propagating in the inter-shell volume into the external fluid domain.

We further remark that as the reflected wave propagates downstream, the just described process of reflection from the inner shell is repeated, thus demonstrating that multiple reflections of the waves in the inter-shell volume are important contributors not only to the internal but also to the external acoustic field observed during the interaction.

4 CONCLUSIONS

We have employed a semi-analytical model of non-stationary fluid-structure interaction that was developed with the main goal of simulating the acoustic field radiated by a submerged system of two cylindrical shells. The model allowed us to address a typical two-shell configuration, and both shells were seen to have a significant effect on the overall structure of the field radiated by the system.

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