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RESONANCE-LIKE PHENOMENA IN SUBMERGED CYLINDRICAL SHELL SYSTEMS SUBJECTED TO MULTIPLE SHOCK LOADS

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We consider the interaction between a sequence of two shock waves and a cylindrical shell submerged into and filled with fluid. The focus of our study is on determining the effect such two-front loading has on the extremities of the stress state and the peak hydrodynamic pressure observed in the system, with the ultimate goal of providing the practitioner with the information that could be used at the pre-design stage in determining the most and least dangerous loading conditions for fluid-contacting industrial structures subjected to shock loading.

The mathematical model we employ is based on the semi-analytical approach that has been developed in our earlier work [1-3], and that has proven to result in numerical simulation methodologies of high computational efficiency and reliability in the context of shell-shock interaction. We then simulate the interaction for several typical incident loads, and discuss both the fluid and structural dynamics of the process.

We first address the fluid dynamics of the interaction, and demonstrate that when there are two incident waves, all the shock wave propagation, reflection, and focusing phenomena in the internal fluid are occurring twice, with the delay between the occurrences determined by the delay between the two incident wavefronts, Figure 1. Such a phenomenologically complex pattern of the internal interaction, aside from resulting in a number of interesting fluid dynamic effects, is, of course, expected to have a dramatic effect on the stress state of the structure.

In particular, when some of the hydrodynamic phenomena associated with the secondary wave of the incident sequence occur in the regions that are already experiencing sufficiently high pressure due to the hydrodynamic effects associated with the primary incident wave, the resulting pressure is expected to be particularly high. Investigating this matter certainly is of practical interest, and is best accomplished by carrying out relatively extensive parametric studies which are a subject of our current efforts.

We then consider the structural dynamics of the system, Figure 2. Here, each incident wave was seen to result in a compressive stress wave circumnavigating the shell, and when these two waves constructively superpose at certain points, a very high resulting stress is observed, thus constituting the existence of resonance-like effects in the system. However, due to the presence of the internal fluid, the shell is also experiencing a high tensile stress, and this tensile stress wave is also affected by the multiple wave phenomena in the system, a phenomenon that sometimes results in a very high peak tensile stress. Investigating these matters is, again, of considerably practical interest, and such an investigation requires extensive parametric studies which are research in progress.

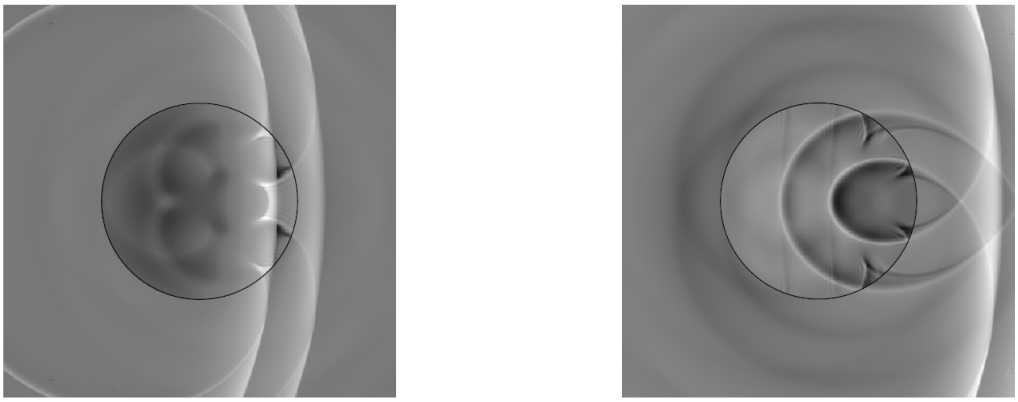

Figure 1: Representative snapshots of the hydrodynamic field observed during the interaction.

Figure 2: Representative snapshots illustrating the dynamics of the stress state of the system.

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