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Mathematical Modelling of Structural Health Monitoring Systems: Coupling Fluid-Structure Interaction with Wave Propagation.

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In this contribution, a novel concept of coupling Fluid-Structure Interaction (FSI) with an ultrasonic wave propagation is proposed. It is referred to as extended Fluid-Structure Interaction (eXFSI) problem. The eXFSI is a one-directional coupling of typical FSI problem with an ultrasonic wave propagation in fluid-solid and their interaction (WpFSI). While the WpFSI is a strongly coupled problem of acoustic and elastic wave equations, where FSI problem solution feeds in automatically the boundary condtions at each time step. The principal aim of this research is the exploration and development of concepts for the efficient numerical solution of the eXFSI problem. The finite element method is used for the spatial discretization. Temporal discretization is based on finite differences and is formulated as a one step-θ scheme, from which we can consider shifted Crank-Nicolson and the fractional-step-θ schemes. The nonlinear problem is solved by a Newton-like method. To demonstrate the application of the eXFSI and WpFSI models, we elaborate on the design of the on-live and off-live Structural Health Monitoring (SHM) systems for composite material and lightweight structure, respectively. The implementation is accomplished via the software library package DOpElib.

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