Fluid-Structure Interaction: a port-Hamiltonian systems approach.

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Abstract

The first part of this talk will be devoted to a review of classical models of fluid mechanics in 2D or 3D, such as Euler and Navier-Stokes equations. We aim at showing that port-Hamiltonian systems can encompass many physically meaningful models: compressible / incompressible, potential / rotational, linear / nonlinear, inviscid / viscous. The thermodynamical hypotheses will be recalled. The specific variables classically used in fluid mechanics, such as velocity potential, stream function or vorticity, will appear in a very natural and physically meaningful way in this formalism. We will also address simpler 1D models, such as Webster horn equation, and shallow water (also known as Saint-Venant) equation; in both cases, care will be taken to identify the appropriate boundary variables as port variables.

In the second part of the talk, we will apply the interconnection facility provided by port-Hamiltonian systems to *sloshing*, a typical Fluid-Structure Interaction problem. In airplanes, the coupled vibrations between fluid and structural dynamics can lead to structural fatigue, noise and even instability. At ISAE, we have an experimental device that consists of a cantilevered plate with a fluid tank near the free tip. This device is being used for model validation and active control studies. Port-Hamiltonian systems formulation is being used for the structured modeling of this experimental device: structural dynamics and fluid dynamics are modeled independently as infinite-dimensional systems; the plate is approximated as a Euler-Bernoulli beam, and shallow water equations are used for representing the fluid in the moving tank. The global system is finally easily coupled thanks to the interaction ports of the pHs elementary models. Finally for a numerical simulation objective, the spatial discretization of the infinite-dimensional systems using mixed finite-element method is performed, and gives rise to a finite-dimensional system that is still Hamiltonian; comparisons between experimental results and numerical simulations will be presented, and can already be found on the WEB site [2].

Collaborators: The second part of the talk is joint work with Flávio Luiz Cardoso-Ribeiro (on leave from Instituto Tecnólogico of Aeronáutica, Brazil, now at ISAE, France), Ph.D. student co-advised with Valérie Pommier-Budinger (ISAE, France), see [2].

Context: The contribution of the author has been done within the context of the French National Research Agency sponsored project HAMECMOPSYS: *Hamiltonian Methods for the Control of Multidomain Distributed Parameter Systems*.
Further information is available at `http://www.hamecmopsys.ens2m.fr/`

References

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`http://github.com/flavioluiz/port-hamiltonian`

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