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Editorial

Fluid/Structure Interactions

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This Special Issue contains 12 papers devoted to fluid/structure interaction (FSI) problems. This is a fundamental subject of fluid dynamics, in which a lot has already been done in the theory, experiments, and computational techniques. However, every day further developments in marine engineering, bioengineering, and renewable energy call for addressing new problems and arising phenomena. That is why it would be helpful to explain in this preface basic motivations for publishing this issue.

FSI can be defined as a joint motion of a deformable structure with an internal or surrounding fluid flow. The structure and the fluid the governing equations are different, which calls for introducing an interface on which consistent boundary conditions for both the liquid and the solid regions are formulated. This is the main feature of FSI problems. In some cases, the liquid causes such a small deformation of the structure that it does not affect the motion of the liquid. These fluid–structure interaction systems are called weakly coupled systems, or one-way interaction, i.e., the liquid deforms the structure shape, but the deformation is so small that it does not affect the flow significantly. In contrast to this, a strong interaction, or two-way interaction, occurs when the deformation of the structure is great enough to change the flow characteristics, which, in its turn, may affect the structure deformation. Two-way interaction problems are complicated due to nonlinearity since the shape of the interface is unknown in advance and has to be determined as part of the solution of the problem using boundary conditions at the interface, which come from joining the solutions for the solid and the liquid parts.

The interest in FSI problems is very great due to their practical importance. Recent developments in engineering have led to advanced formulations of FSI problems. Some of them could not be formulated several years ago. These problems require progress in both numerical algorithms and mathematical apparatus and advanced computational techniques, such as parallel computations.

In this issue, we have tried to collect different FSI problems, new mathematical and numerical approaches, new numerical techniques and, of course, new results, which can provide an insight into FSI processes.

The issue opens with the paper by Ren et al. [1] on vortex induced vibration (VIV) of risers in oil/gas offshore production systems. Caused by ocean currents, vortices are periodically generated on the sides of the riser and manifest themselves as a periodic excitation force. When the frequency of the periodic force approaches one of the natural frequencies of the riser, an increase in the vibration amplitude can be expected.

The second paper by Qiu, Ren and Li [2] presents a study on FSI during the water impact of a lifeboat in free-fall from a ship into a rough see. The paper not only reviews recent developments in the water-entry theory, but also presents a way to account for the boat elasticity and friction forces. The computational results are verified by experiment.

The paper by Ni et al. [3] on ice–ship interaction is very remarkable. Activities in the Arctic Regions have rapidly increased in the last decade due to ice melting caused by the climate change and opening new routes for transportation. This paper presents a numerical simulation of a ship moving in level ice with a crack propagation process including radial and circular cracks. The computations are based on a one-way CFD-DEM coupling method.

A two-way fluid–structure interaction (FSI) approach is presented in the paper by Malazi et al. [4] considering three-dimensional FSI in the case of an elastic beam. They developed a two-way FSI coupling method and demonstrated its high efficiency. The method may be employed in various engineering fields, such as mechanical, civil, and ocean engineering. Chie and Wahab [5] investigated the flow field around an intake structure and derived engineering design criteria to mitigate the seawater intake operation impact on marine life.

Typically, pumps and turbines work with high loads on the impeller. In the case of flow unsteadiness, this may cause a response of the pump structure, which leads to vibration and even dangerous resonance phenomena. Mao et al. [6] investigated another type of instability of reversible pump/turbines caused by a transition from the turbine to the pump mode of operation. They studied the axial hydraulic force and determined the deformation of the support bracket and the main shaft, which contribute to the resultant force on the crown and the band.

The interesting study Liu et al. [7] related to the fish industry deals with the design parameters of a trawl net and its effect on the hydrodynamic characteristics. Based on the experiments conducted, it was found that the codend drag force oscillation mainly included a high-frequency and a low-frequency oscillation. The low-frequency oscillation of the drag force included a strong wave oscillation and a weak wave oscillation set up alternately.

A study on the vibration characteristics of a marine centrifugal pump unit and different excitation sources is presented by Dai et al. [8]. They developed a computational code coupling the fluid and the structural dynamics of the pump unit and studied the vibration characteristics caused by fluid excitation and electromagnetic excitation. The agreement between the calculated and the test results is quite impressive.

A two-way FSI coupling approach for the vp1304 marine propeller is presented by Masoomi and Mosavi [9]. They developed a code that predicts the pressure and stress distributions with a low-cost and high-precision approach. They pointed out that an important factor for the coupling approach is the rotational rate interrelated between two solution domains. The propeller strength was assessed by considering the blades' stress and strain for different load conditions.

The paper Liu et al. [10] deals with a numerical modal analysis of a prototype Francis pump turbine runner. They employed an acoustic–structure coupling method. The effect of the energy loss on the chamber wall on the natural modes of the runner was studied by the absorption boundary. The results show that the constraint condition (especially the rotating shaft) has significant impacts on various modes of the runner.

The case of one way fluid/structure interaction is presented by Marty et al. [11]. They studied the interaction of a coastal current with submerged components of floating wind turbines, risers and mooring lines for floating units taking into account surface roughness caused by mussel's colonies. The authors found two realistic shapes caused by mussel's colonization and presented tests of those shapes in a hydrodynamic tank.

Flow detachment conditions in the presence of surface tension are discussed in Savchenko et al. [12] for a case study of cavity flow past a wedge with rounded edges. The authors analyze the Brillouin–Villat criterion of flow detachment and its applicability to flows with surface tension. It was found that the Brillouin–Villat criterion has a limited applicability, especially for small Froude numbers and small edge radii. For moderate Weber numbers, surface tension slightly decreases the cavity size and the drag force. As the Weber number decreases further, the velocity at the point of cavity detachment increases, and the angle of flow detachment changes in such a manner that the wetting part of the edge becomes larger. The tendency seems to be towards wetting the whole of the edge and making the flow attached to the wedge.

We expect that this Special Issue will be helpful to researchers in different fields of hydrodynamics and will contribute to the study of fluid/structure interaction problems.

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