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Preface

This Special Issue contains 10 papers devoted to water impact problems and associated phenomena. The subject is not new and a lot has been done already in this field. This is why it would be helpful to explain in the introduction basic motivations for publishing this issue.

Investigation of water impact was started from the papers by von Kármán (1929) and Wagner (1932). These two papers are still the foundation of modern impact theories. Water-impact problems are of great interest up to now from two points of view – practical and theoretical. From a mathematical point of view these problems represent several important features common for many other problems of unsteady flows with free surfaces. The flow topology changes during impact – new parts of the liquid boundaries appear, when a body starts to enter the liquid domain, and the topology changes, when a cavity collapses. The position of the free surface is unknown during the impact and has to be determined together with the flow. The part of the body which is in contact with liquid, is also unknown. Impact problems are essentially nonlinear. The flow patterns are very different in the main flow region and close to the periphery of the wetted part of the body, where jet flow and separation effects are usually observed. The latter feature makes impact problems difficult to solve numerically. Specific numerical algorithms have to be developed to deal with such flows. Both theoretical and numerical difficulties are still rather severe and have not been resolved in full yet. Similar difficulties can be found in other problems of hydrodynamics: dynamics of floating bodies, breaking-wave flows, water-exit problems and so on. If these difficulties would be resolved in the water-impact theory, many other fields of hydrodynamics will greatly benefit from this. In water-impact problems the difficulties are well recognized and clearly associated with physical effects, which is helpful for theoretical analysis. Particular problems are well formulated, but they are so complicated that the majority of them is still awaiting proper analysis.

The interest in impact problems is very great also because of their practical importance. In some fields impact effects received special names, like *slamming* in ship hydrodynamics. Progress in engineering, which is well visible at present, leads to new formulations of impact problems. Some of these new problems could not have been formulated several years ago. These problems require development of both new mathematical tools and new numerical algorithms, which should be much more sophisticated than the existing ones.

In the present issue we have tried to collect new formulations of different kinds of impact problems, new mathematical and numerical models, new methods and techniques developed recently and new results, which make impact processes more clear and more understandable. The issue is tailored to give to readers a clear idea about the present state-of-the-art of the impact theory and its applications. Unfortunately, there is no paper in this issue on drop impact and breaking-wave impact. We recommend the papers and reviews on these subjects published recently by M. Lesser, M. Rein, D.H. Peregrine and A. Prosperetii.

The issue opens with the paper by Faltinsen, Landrini and Greco on slamming problems in marine applications. This paper not only gives an excellent review of the main developments and applications of impact problems in marine science but also is full of new ideas and results that will be of great interest to researchers in any field of hydrodynamics. The paper also presents future challenges for water-entry problems, which is important to establish research priorities.

The second paper by Fraenkel and Keady is very remarkable. The authors represent a group of researchers who study impact problems by means of pure mathematics. This research is extremely important but, on the other hand, extremely difficult. The authors show that not everything is so bad in this field and important results can be obtained on a rigorous mathematical basis. We expect that this paper will initiate more activity in this field with more researchers involved.

The paper by Vorus is devoted to further development of his theory, which was published for the first time seven years ago. The theory may be considered as a non-trivial generalization of the original Wagner theory. The theory by Vorus has already received considerable attention from both theoretical and practical fields. However, the theory is not trivial at all and the reader is recommended to study this paper together with previous papers by the author. An important point of this theory is that it takes into account both the separation and the nonlinear effects, which come from the nonlinear terms in the boundary conditions.

The paper by Judge, Troesch and Perlin is based to some extend on the Vorus theory. The authors develop this theory further, in order to apply it to problems of asymmetric wedge impact onto the water surface and symmetric wedge entry with non-zero horizontal velocity. Due to the flow asymmetry, the water may separate from the wedge vertex and the presented model well describes this effect. Experiments performed by the authors confirm the theoretical predictions and demonstrate the validity of the developed model.

Cointe, Fontaine, Molin and Scolan also study the asymmetric wedge impact but with the help of the asymptotic Wagner theory. They do not account for possible separation of water from the wedge vertex but resolve the pressure distribution close to the periphery of the wetted part of the entering wedge. The predictions they obtained are in good agreement with the experimental results. However, their model of impact is quite different from the model of the previous paper. We expect that the different existing models of impact will be compared to each other in the future and a conclusion about their validity will be reached. This paper also gives a solution to the important problem of energy distribution during impact; the presented analysis is the most comprehensive to date.

Water-entry problems with non-zero body velocity tangential to the free surface are presented in the paper by Howison, Ockendon and Oliver. The analysis has been performed for both deep-water and shallow-water cases. The mathematical models are developed for both two-dimensional and three-dimensional problems. This paper shows the links between the impact theory and the theories of planing and skimming. Note that asymmetric impact problems in three dimensions are extremely complicated; even so, the authors managed to solve some of them and to formulate recommendations for future research in this field.

The numerical algorithm to solve three-dimensional water-impact problems within the Wagner theory is presented by Takagi. He solved the linear boundary-value problem with mixed boundary conditions for the displacement potential with additional nonlinear restriction, which implies that liquid particles cannot penetrate the surface of a three-dimensional entering body. The trapped-air effect was taken into account. The developed algorithm is studied in detail and the numerical predictions are compared to available analytical solutions of this problem. The paper is very clearly written with full description of both the strong and the weak aspects of the algorithm.

A numerical model of water impact, which is able to describe the flow in both the main flow region and in the spray-jet region, is presented in the paper by Battistin and Iafrati. The authors are not satisfied with the common modern practice of cutting the jet region from the flow domain and imposing a boundary condition on the cut. The thickness of the jet region is small, which is why they use different numerical models in different parts of the flow domain and match the solutions at the common line. The idea is very promising and should be developed further to cover different situations. Just note that this is the jet region, where the separation of the flow from the surface of the entering body occurs. This observation provides a motivation for more careful study of the flow in the jet region.

Liquid–liquid impact is studied numerically by Szymczak, Means and Rogers. They presented a generalized formulation of the liquid–liquid impact problem together with the developed numerical code. This approach can simulate violent long-time free-surface phenomena. In particular, it can simulate liquid–cylinder impact onto a still water surface, formation of the air-entrained bubble after the impact and the subsequent pulsations of this bubble. A weak side of this approach is connected with the fact that the free surface is calculated only with first-order accuracy. However, it is hard to believe that this weakness may be a serious obstacle to future application, due to a strong potential of this approach and its remarkable stability.

The paper by Pearson, Blake and Otto is devoted to the collapse of bubbles in liquid, jet formation in the bubbles and transition from simply connected to multiply connected bubbles. This problem has several features in common with water-impact problems, such as strong jetting, change of the flow topology with time, impact of the jet onto the free surface of the cavity. An advanced boundary-integral technique is used to study both the pre-toroidal (simply connected bubble) and toroidal phases of a single-bubble behavior close to a rigid boundary. The developed numerical algorithm is able to describe high-speed liquid jets and their impact on the cavity surface. The code was validated against recent experimental data by Lindau and Lauterborn. Important physical quantities associated with the bubble and the fluid are distinguished and analyzed in depth.

We expect that this Special Issue will be helpful to researchers in different fields of hydrodynamics and will stimulate greater activity in the study of water-impact problems.

It is very sad that one of the authors of this issue, Doctor Maurizio Landrini from the INSEAN, left us this summer. He was a brilliant and talented scientist and a very nice person. He was in contact and closely collaborated with many researchers throughout the world in many different fields. He was a person of great energy, full of ideas and plans for the future. He was distinguished in theoretical and computational work but he also strongly appreciated experimental research. He provided an outstanding contribution to this issue, which can be considered as a memorial to him and to his short but bright life in science.

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