EDITORIAL

Computational Methods for Gas Dynamics and Compressible Multiphase Flows

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Introduction

Computational Fluid Dynamics (CFD) has emerged in the past few decades as a powerful tool in many fields of basic and applied sciences. Together with ever-growing development of technologies in computer hardware, there is rapid evolution of CFD techniques and models in recent years. CFD simulation is helping researchers to become more efficient, and providing the capability to obtain accurate supplemented information which are typically challenging to get from experimental measurements. The primary objective of this thematic issue has been to provide a significant coverage on recent advances and application of CFD in the field of gas dynamics and compressible multi-phase fluid flows. Given the broad nature of CFD research, papers presented in this issue are perhaps not an exhaustive representation in the selected topics. Nonetheless, this thematic issue brings together a broad spectrum of researchers from different corners and represents a good panel addressing different aspects of CFD modeling and application, from the formulation of new higher-order numerical methods for gas dynamics to the simulations of multi-physics problems involving compressible fluid flows.

Manuscripts in this thematic issue were solicited through a general call and by invitation. It also contains selected papers that were presented at the 11th International Symposium on Numerical Analysis of Fluid Flows, Heat and Mass Transfer - Numerical Fluids 2016 held in Rhodes, Greece 19-25 September 2016. Submissions were undergone a rigorous peer review process following the established standards and policies of the Shock Waves Journal. Each paper was peer-reviewed by at least two internationally recognized experts in the field. Twenty-three manuscripts were received in response to the thematic issue announcement, of which two were withdrawn by the authors following a "major revision" decision and eight papers were rejected after an initial peer review. The remaining 13 papers were eventually accepted upon one or more revisions, after a consensus was reached by the referees and the editors.

Overview of papers in thematic issue

This thematic issue includes twelve papers which can be grouped into three categories. The first group includes five excellent contributions on the discussion and development of contemporary numerical techniques. Zhu & Shu [1] introduce a new class of fifth-order finite volume weighted essentially non-oscillatory (WENO) scheme on unstructured meshes and demonstrate its convergence in steady state calculations which is often difficult to achieve with high-order WENO scheme. The paper by Margolin [2] gives an interesting fundamental interpretation of the notion of artificial viscosity from the conservation equations of finite scale. This contribution also provides relevant insights to finite-volume method formulations. Soni et al. [3] introduce a promising adaptive multiresolution methodology with a time-varying tolerance strategy by combining a wavelet based adaptive multiresolution scheme in conjunction with an immersed boundary method for capturing fine-scale features of a class of shock-bluff body interactions simulations. Compressible flows typically contains shocks and interfaces. To capture these features correctly and overcome difficulties encountered by more classical finite volume approaches such as spurious oscillations and nonphysical front blurring, a new front tracking method for 1D flow is introduced by Cao et al. [4] based on the Lagrangian method and a simplified Kamm's exact Riemann solver. The work by Re & Guardone [5] assess for the first time the application of mesh adaptation techniques within the

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Arbitrary Lagrangian Eulerian framework in the Non-Ideal Compressible Fluid Dynamic (NICFD) regime.

The second set of papers concern with the application of contemporary numerical methods to supersonic flows and shock waves related phenomena. Using an entropy generation based artificial viscosity and a high-order explicit Discontinuous Spectral Element Method (DSEM), Chaudhuri & Jacobs [6] examine in greater depth the shock wave diffraction over sharp splitter geometry and reveal new features via a detailed transient flow analysis in terms of issues such as dissipation an d dilatation. In another important area of shock wave research, Pérez Arroyo et al. [7] analyze results obtained using Large-Eddy Simulation (LES) focusing on the near-field of a non-screeching supersonic under-expanded jet. This detailed work investigate the mechanism of generation of broadband shock-associated noise (BBSAN) by combining different techniques of signal processing such as wavenumber-frequency Fourier analysis, wavelet transform, and conditional averaging. The work by Soni et al. [8] analyze a Mach three supersonic cavity flow simulated using Large Eddy Simulation (LES). Contemporary data-processing techniques of Proper Orthogonal Decomposition (POD) and Dynamic Mode Decomposition (DMD) are used to study the spatial and temporal evolution of supersonic cavity flow field.

The last part of this thematic issue is devoted to the computation of multi-phase flows. Three papers deal with the numerical modeling of condensed phase detonation. Using their recently developed multiphase models, Michael & Nikiforakis [9] examine in their first paper the shock-induced cavity collapse in inert, liquid nitromethane, particularly focusing on the evolution of the temperature field in the vicinity of the cavity. The second paper by Michael & Nikiforakis [10] turns into cavity collapse in reacting liquid nitromethane, focusing on the reacting activities and flow evolution in hot spots. The contribution by Schwendeman et al. [11] investigates the numerical results using a modified multi-scale model to advance the current understanding of detonation initiation in heterogeneous condensed phase explosives by transient piston-induced compaction. This issue is concluded with two papers on multiphase flows, one by Goncalves et al. [12] presenting the development of a four-equation model for the classical shock-induced bubble collapse and one by Kim et al. [13] exploiting the robustness and accuracy of selected numerical methods for simulating multiphase real fluid flows at all speeds, and their suitability to a broad range of engineering applications.

We believe this thematic issue highlights recent growing importance of CFD and this special compilation will make a significant contribution to the community by identifying and discussing several interesting problems in the numerical analysis of gas dynamics and compressible multiphase flows. We wish to thank the authors who submitted their works to this issue and revised according their manuscripts to insure the high quality standard of the journal. We also like to acknowledge the efforts by all referees on reviewing these papers and making it possible to publish this special issue.

References

1. Zhu, J., Shu, C.W.: Numerical study on the convergence to steady state solutions of a new class of finite volume WENO schemes: triangular meshes. Shock Waves (2018). doi:10.1007/s00193-018-0833-1
2. Margolin, L.G.: The reality of artificial viscosity. Shock Waves (2018). doi:10.1007/s00193-018-0810-8
3. Soni, V., Hadjadj, A., Roussel, O.: On the use of adaptive multiresolution method with time-varying tolerance for compressible fluid flows. Shock Waves (2018). doi:10.1007/s00193-017-0777-x
4. Cao, Y., Wang, Z., Hong, T.: A front tracking method capturing field features accurately for one-dimensional flows. Shock Waves (2018). doi:10.1007/s00193-018-0845-x
5. Re, B., Guardone, A.: An adaptive ALE scheme for non-ideal compressible fluid dynamics over dynamic unstructured meshes. Shock Waves (2018). doi:10.1007/s00193-018-0840-2
6. Chaudhuri, A., Jacobs, G.B.: Dynamics of shock wave diffraction over sharp splitter geometry using entropy-based artificial viscosity method. Shock Waves (2018). doi:10.1007/s00193-017-0767-z
7. Pérez Arroyo, C., Daviller, G.,Puigt, G., Airiau, C., Moreau, S.: Identification of temporal and spatial signatures of broadband shock-associated noise. Shock Waves (2018). doi:10.1007/s00193-018-0806-4
8. Soni, R.K., Arya, N., De, A.: Modal decomposition of turbulent supersonic cavity. Shock Waves (2018). doi:10.1007/s00193-018-0836-y
9. Michael, L., Nikiforakis, N.: The evolution of the temperature field during cavity collapse in liquid nitromethane. Part I: inert case. Shock Waves (2018). doi:10.1007/s00193-018-0802-8
10. Michael, L., Nikiforakis, N.: The evolution of the temperature field during cavity collapse in liquid nitromethane. Part II: reactive case. Shock Waves (2018). doi:10.1007/s00193-018-0803-7
11. Gambino, J.R., Schwendeman, D.W., Kapila, A.K.: Numerical study of multiscale compaction-initiated detonation. Shock Waves (2018). doi:10.1007/s00193-018-0805-5
12. Goncalves, E., Hoarau, Y., Zeidan, D.: Simulation of shock-induced bubble collapse using a four-equation model. Shock Waves (2018). doi:10.1007/s00193-018-0809-1
13. Kim, H., Choe, Y., Kim, H., Min, D., Kim, C.: Methods for compressible multiphase flows and their applications. Shock Waves (2018). doi:10.1007/s00193-018-0829-x