Comparison of Advanced Turbulence Modeling Approaches for Fluid-Structure Interaction

A. Ali*[1], T. Reimann[1], D. C. Sternel[1] and M. Schäfer[1]

[1] Institute of Numerical Methods in Mechanical Engineering
Technische Universität Darmstadt
Dolivostraße 15, 64293 Darmstadt, Germany
e-mail: ali,reimann,sternel,schaefer@fnb.tu-darmstadt.de, web page: http://www.fnb.tu-darmstadt.de

ABSTRACT

Fluid structure interaction (FSI) phenomena arise in many engineering application areas, such as flutter analysis of aircraft wings, structural design of bridges and buildings, and blood flow analysis through arteries. Experimental methods and apparatus could lack the ability to study complex real-world systems involving FSI phenomena. On the other hand, numerical simulations can be used to gain useful insight into the complex interaction phenomena between fluids and solids. These numerical methods have to be tested against experimental benchmark cases to access efficiency and stability.

Many of the practical engineering applications involve turbulent fluid motion. This makes it important to study FSI phenomena in turbulent flows. Gomes and Lienhart [1] proposed a corresponding benchmark test case. The structural model for this test case consists of a thin flexible sheet attached to a revolvable cylinder. A rectangular end mass is attached to the other end of the sheet. The Reynolds number based on cylinder diameter is 15000. We present a numerical study of this test case, employing different turbulence modelling techniques. An implicit partitioned coupling approach is used to solve the coupled problem. The finite volume flow solver FASTEST is utilized to compute the fluid subproblem, while the finite element structural solver FEAP is used to solve the structural subproblem. Both solvers are second order accurate in time and space. MpCCI is used for data transfer and interpolation, where also non-matching grid interfaces can be handled. Force prediction based on previous time-steps is employed to accelerate FSI convergence.

A 2-d URANS approach using the elliptical relaxation (ζ-f) turbulence model[2] successfully captures the oscillation mode. Further investigations are performed using DDES with ζ-f as baseline RANS model as well as LES. Cylinder deflection angles, trailing edge coordinates and oscillation frequencies of the structural system from simulations show a reasonable agreement with the experimental data.

REFERENCES

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