Isogeometric Analysis of the Navier-Stokes equations on Multipatch Geometries

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ABSTRACT

The Navier–Stokes equations are the basis for computational modeling of the flow of an incompressible Newtonian fluid such as air or water. The main purpose of this contribution is a fluid flow simulation in the water turbines and related subsequent shape optimization.

Finding effective approximation methods for this problem is crucial for engineering applications. Isogeometric analysis (IgA) is a recently developed computational approach modifying the well known finite element method based on B-spline/NURBS objects. It allows to avoid the time–consuming step of generating triangular/tetrahedral mesh. Moreover, computational domain is considered to be composed of more conforming or non–conforming NURBS patches, the so called multipatch domains. Thus, continuous IgA–Galerkin method is considered on different NURBS patches and discontinuous IgA–Galerkin method on interfaces between non–conforming NURBS patches. Whereas in case of conforming NURBS patches, the same degrees of freedom are required on interfaces.

Operator splitting method (also known as projection method or pressure correction) is considered as numerical solution approach for the implicite Navier–Stokes equations. The original system of Navier–Stokes equations are split into several simpler problems for which more efficient numerical method can be applied. Since the stationary problem is solved, the steady–state solution is obtained by pseudo–time method until convergence is achieved.

Due to the high Reynolds number simulation in the water turbines, resolution of the boundary layers requires application of turbulence modeling. Although LES (Large Eddy Simulation) affords higher accuracy, it still requires significantly greater computational resources and thus RANS (Reynolds–Averaged Navier–Stokes) modeling still plays a dominant role in the practical application.

Because the simulation of turbulent flow requires extreme number of grid points in spatial discretization, the PSO (Particle Swarm Optimization) algorithm is applied as more effective optimization method.

Considering the wide range of the given problem above, the contribution is focused on numerical solving of Navier–Stokes equations using isogeometric analysis together with the multipatch domains including conforming and non–conforming patches. The application of projection methods to these cases and related problems are also discussed.

REFERENCES

[1] T.J.R. Hughes, J.A. Cottrell, Y. Bazilevs, *Isogeometric analysis: CAD, finite elements, NURBS, exact geometry and mesh refinement*. Computer Methods in Applied Mechanics and Engineering 194 (3941) 4135 - 4195, 2005.

[2] U. Langer, A. Mantzaflaris, S. E. Moore. I. Toulopoulos, *Multipatch Discontinuous Galerkin Isogeometric Analysis*, NFN Technical Report 18, 2014.