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A multi-scale finite element method with discontinuity capturing for reaction dominated flow regimes in unsteady turbomachinery computations

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ABSTRACT

Recent advances in turbomachinery CFD led industries to an increasing demand of computations, focusing on the prediction of overall performance and fluid dynamics of more and more sophisticated machine configurations. In this respect FEM can fully express its potential, due to the rigorous mathematical approach and the extreme variety of numerical approaches able to cope with the difficulties related to advanced turbulence closures. The questions to be tackled stem from three different aspects, namely: i. the numerical instabilities due to the partial differential operator by means of its advection and reaction terms [1], ii. the presence of shock and sharp layers in the solution [2], and iii. the computation on unsteady flows [3].

In this work a recently developed FEM formulation [2, 4] is presented, called V-SGS + DRDJ, that addresses all these three levels of numerical issues. The method is based on the VMS – Variational MultiScale approach, and is able to include in a unique operator a residual based formulation capable of working in all the most cumbersome flow cores, such as stagnation zones and high curvature geometries. The method has demonstrated a good fit with turbulence modelling [2], being able to reduce the level of numerical diffusion with respect to classical stabilized formulation, i.e. SUPG.

Results for scalar test problems and fully unsteady turbulent flows are presented, with a particular emphasis on advanced turbulence closures, in order to show the reliability of the V-SGS+DRDJ for the computation of industrial turbomachinery flows.

REFERENCES

[1] T.E. Tezduyar and Y.J. Park, "Discontinuity capturing finite element formulations for nonlinear convection–diffusion–reaction equations", *Computer Methods in Applied Mechanics and Engineering*, Vol. **59**, pp. 307–325, (1986).

[2] A. Corsini, F. Rispoli, A. Santoriello, T.E. Tezduyar, "Improved discontinuity-

capturing finite element techniques for reaction effects in turbulence computation", *Computational Mechanics*, Vol. **38**, pp. 356–364, (2006).

[3] V. Gravemeier, and W. A. Wall, "A 'divide-and-conquer' spatial and temporal multiscale method for transient convection–diffusion–reaction equations", *Int. J. Numer. Meth. Fluids*, Vol. **54**, pp. 779–804, (2007).

[4] A. Corsini, F. Rispoli, and A. Santoriello, "A variational multiscale high-order finite element formulation for turbomachinery flow computations", *Computer Methods in Applied Mechanics and Engineering*, Vol. **194**, pp. 4797–4823, (2005).