Large-eddy simulation of cavitating tip leakage vortex

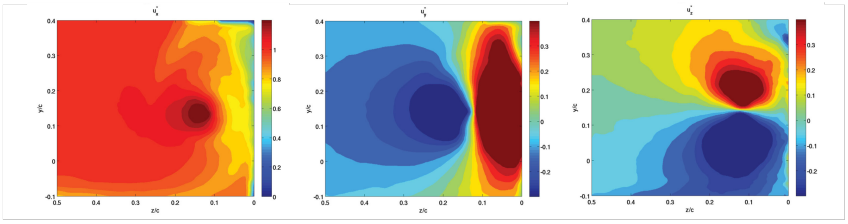
Mohammad Hossein Arabnejad*
Chalmers University of Technology

Håkan Nilsson
Chalmers University of Technology

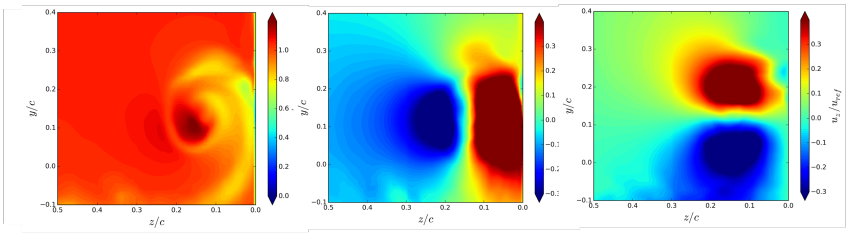
Rickard E. Bensow
Chalmers University of Technology

Tip Leakage Vortices (TLV) are very common in axial turbomachines. This type of vortex forms as the result of an interaction between the leakage flow, a flow from the pressure side of a blade to its suction side, and the upstream flow. In hydraulic machines, the high rotation in TLVs can cause a significant pressure drop at the core of the vortex leading to formation of cavitating structures. Previous experimental studies have shown that the formation of these cavitating structures is responsible for many adverse effects such as cavitation breakdown and a high level of noise and vibration [1, 2, 3]. To avoid such adverse effects, a better understanding of the flow dynamics in TLVs is needed. Numerical simulations can be a useful tool for this purpose as they provide a complete access to the flow field, especially near the cavitating regions where it is difficult to get optical access in the experiments.

In this study, we numerically investigate non-cavitating and cavitating TLVs around a NACA0009 foil using a large-eddy simulation approach. The results of the non-cavitating simulation are validated against the experimental data provided in Dreyer et al. [4]. This comparison, shown in Fig. 1, indicates that the simulation can capture the main features of the flow field. Furthermore, a cavitating condition is simulated and the effect of cavitation on the structure of the TLV is discussed in detail.



(a) Exp.



(b) Num.

Figure 1: Comparison between the velocity field in the TLV in the simulation and the experiment, a) Experimental data by [4] and b) numerical simulation results.

References

[1] D. Tan, Y. Li, I. Wilkes, E. Vagnoni, R. Miorini, and J. Katz. *Journal of Fluids Engineering*, 137 (11):111301, 2015.

[2] R. Laborde, P. Chantrel, and M. Mory. *Journal of Fluids Engineering*, 119(3):680–685, 1997.

[3] F. Avellan. In *The 6th International Conference on Hydraulic Machinery and Hydrodynamics, Timisoara, Romania*, pages 21–22, 2004.

[4] M. Dreyer, J. Decaix, C. Münch-Alligné, and M. Farhat. *Experiments in fluids*, 55(11):1–13, 2014.

*Email: mohammad.h.arabnejad@chalmers.se