Summary of the deliverable D2.1: Flow measurements (SPIV, high-speed imaging, wall pressure) for cavitating vortex in existing test rig configuration (Vortex data)
provided by ESR16, Mr Ali Amini, under the guidance of Dr. M. Farhat, École polytechnique fédérale de Lausanne (EPFL), June 2018

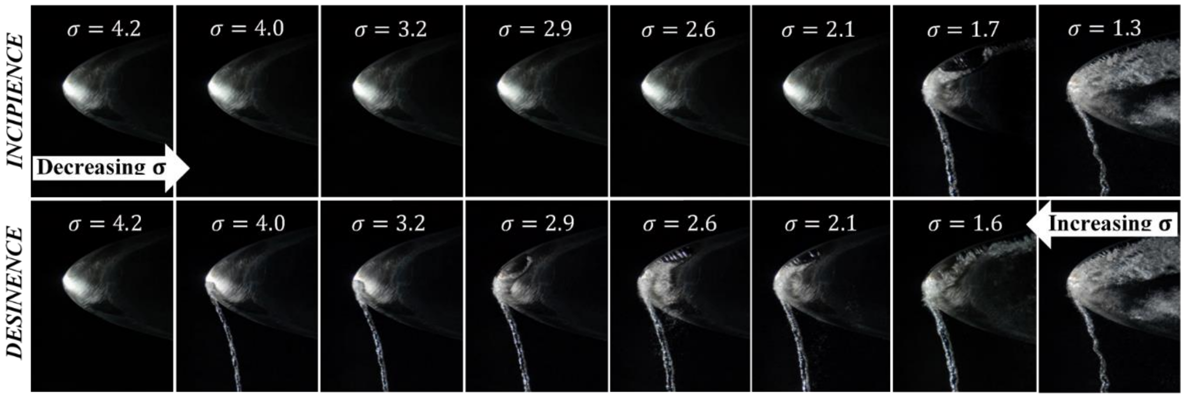

Figure 1: A typical tip vortex cavitation inception-desinence test, performed at 10 m/s and 12° of incidence angle. The large difference between the two thresholds results in the so-called hysteresis problem. For this test, water was fully saturated with air at 18° Celsius.

Tip vortex cavitation (TVC), which may occur in axial turbines, pumps and marine propellers, can lead to severe erosion of the impeller blades or discharge ring with a significant increase in the maintenance costs. In this research, we have investigated the incipience/desinence hysteresis of a TVC and the role of the gas content. The case study is made of an elliptical NACA-16020 hydrofoil, placed in the test section of the EPFL high-speed cavitation tunnel. The TVC incipience and desinence were measured experimentally for various flow conditions and gas content levels. The observations clearly reveal the existence of a hysteresis between inception and desinence of TVC, which is strongly dependent not only on the air saturation level of water, but also on the bulk flow parameters. For specific conditions, the cavitation desinence may require a static pressure within the vortex as high as atmospheric pressure. We argue that (i) the observed cavity is made of non-condensable gases without any water vapor and (ii) the cavity sustains high pressure because of gas diffusion from the super-saturated water close to the vortex axis.

We have also shown for the first time the significant role of the flow structure on the cavitation hysteresis. Owing to our high-speed flow visualizations, we believe that a laminar separation of the boundary layer in the tip area of the hydrofoil enhances the outgassing process and contributes to sustaining the gas cavity. We have also observed in the near wake of the hydrofoil that the presence of the separation bubble is responsible for a jet-like flow within the vortex core. Besides the gas content, the combination of the separation bubble and the jet-like flow contributes significantly to the cavitation hysteresis phenomenon. Further investigations are needed to validate this explanation and clarify the difference between “vapor cavitation” and “gaseous cavitation” in terms of the erosion risks, radiated noise and flow-induce vibrations. From practical viewpoint, our results pave the way for the elaboration of new guidelines for model testing of hydraulic machines with a clear distinction between these two cavitation types.