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Hydrofoil flow induced vibration mitigation by passive resonant piezoelectric shunt

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Context

Hydrofoils are subjected to flow induced vibrations

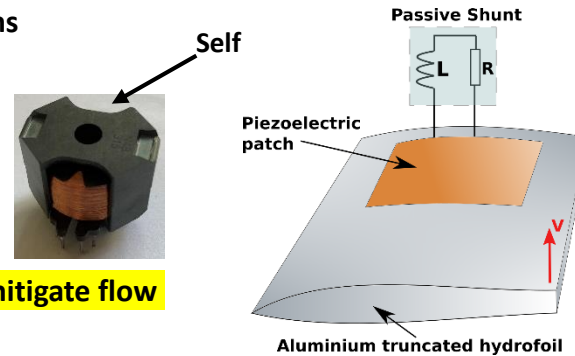
⇒ Structural fatigue + acoustic noise

If vortex shedding frequency = natural frequency

⇒ Resonance

⇒ High amplitude vibrations

Objective: Use a resonant piezoelectric shunt to mitigate flow induced vibration at resonance



Methodology

Hydrodynamic tunnel:

$U_0 = 3.0$ to 5.5 m/s

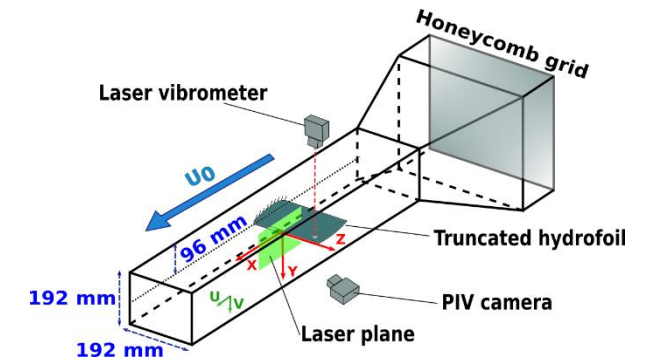
$Re = 2.40 \times 10^5$ to 4.40×10^5

Incidence = 0°

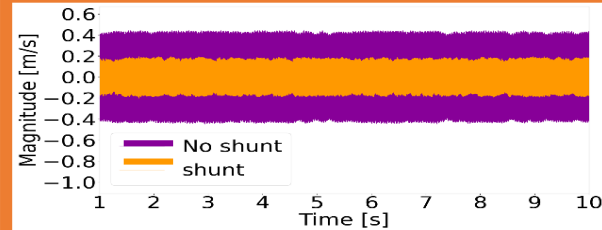
Laser Vibrometry + TR-PIV

Shunt tuning:

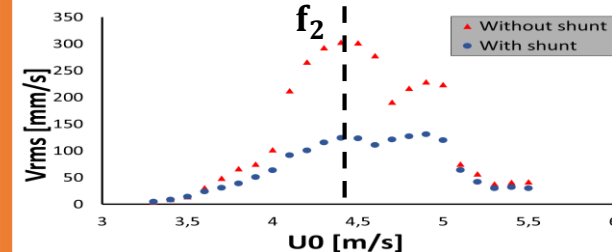
At the twisting mode frequency ($f_2 = 282$ Hz)



Vibration mitigation



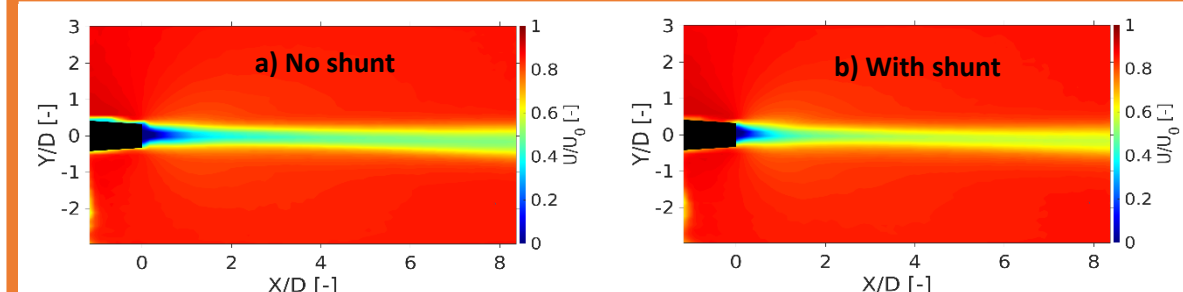
Vibration velocity signal at $U_0 = 4.4$ m/s



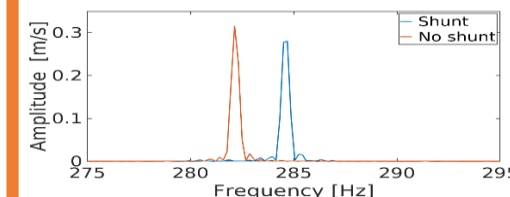
Vrms of vibration signal at various flow velocities.

- ⇒ 16 dB vibration reduction at zero flow velocity
- ⇒ High vibration level reduction at resonance (50 % on Vrms)
- ⇒ Twisting mode resonance observed at $U_0 = 4.4$ m/s
- ⇒ Impact of the shunt from 4.0 to 5.0 m/s

Impact on the wake at twisting resonance, $U_0 = 4.4$ m/s



(x,y) distribution of averaged U velocity component with (b) and without (a) shunt.



Spectrum of fluctuating v velocity downstream the trailing edge

- ⇒ Decrease of the thickness of the wake
- ⇒ Decrease of velocity fluctuation magnitude
- ⇒ Slight modification of the vortex shedding frequency

Further work

- ⇒ Study in detail the impact of vibration mitigation on the wake dynamics.
- ⇒ Optimise de shunt design for optimal mitigation.

References

- L. Pernod, B. Lossouarn, J.-A. Astolfi, J.-F. Deü, Vibration damping of marine lifting surfaces with resonant piezoelectric shunts, JSV, 2021
- Y. Watine, C. Gabillet, J.-A. Astolfi, L. Pernod, B. Lossouarn, J.-F. Deü. Vortex Induced Vibrations Analysis of a Cantilevered Blunt Plate by Proper Orthogonal Decomposition of TR-PIV and Structural Modal Analysis. Proc. ASME-FEDSM 2020