Master thesis proposals 2022-2023

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1 Build a better model of a pitching wing by fusing numerical (CFD) and experimental data

The FLOW research group is active in wind tunnel testing of unsteady flow problems, such as pitching wings, oscillating cylinders, helicopter rotors, and vertical-axis wind turbine (VAWT) scale models. This thesis will focus on available measurements and simulations of a pitching NACA 0018 wing (though extra measurements could be envisaged if appropriate). The objective is to build a model of the pitching wing from the experiments and the CFD simulations by fusing these data. Recent work has succeeded in a preliminary step: fusing model output prediction with experimental observation through an *extended kalman filtering* technique. That will be the starting point of the thesis. Here, the construction of a data-driven state-space model from fused experimental and numerical data is sought.

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2 Sensitivity analysis of wind measurements using a ground- or nacelle-based LiDAR

This master thesis proposal will be in collaboration with Engie Laborelec.

The verification of a wind turbine power curve (i.e., how much power a wind turbine produces for wind speeds between cut-in and cut-out) is regulated by the IEC 61400-12-1 standard. In previous versions of this standard, the wind speed was supposed to be measured by anemometers on a meteorological mast some distance away from the turbine. However, the use of nacelle- and ground-based LiDARs are becoming common-practice for power performance measurement. In this master thesis, the objective is develop insights on the sensitivity of LiDAR measurements to the environment (temperature, humidity, the presence of wakes, turbulence,…). The aim is to create an understanding of the impact of uncertainties of LiDAR measurements on the uncertainties of a measured power curve. The ideal candidate for this thesis likes to analyse data using Python and has an affinity for research.

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3 Experimental study of forced-vibration vortex shedding behind a circular cylinder

In our research group, we have developped a vibrating-cylinder setup in our large low-speed wind tunnel. The current cylinder is equipped with 60 pressure taps to measure the (unsteady) pressure distribution around the cylinder at high sampling speed. In this master thesis project, the student will study vortex-induced vibration of a cylinder oscillating transversely in a fluid flow. The focus is on the execution of wind tunnel tests, data analysis, and comparison with the literature.

1. First, the student will study the existing literature to acquire a deep understanding of the vortex-induced vibration and its study in the wind tunnel using forced-motion experiments. The student

will further collaborate with other FLOW researchers in performing wind tunnel experiments using this setup.

2. The experimental data will be processed to study intricate flow features such as variation of the pressure distribution for different vortex shedding regimes, or the movement of the point of separation and its dependence on vibration amplitude and frequency.

3. Furthermore, the student will compare results with literature, an collaborate with other researchers to investigate a limited number of simplified models to represent the transversal (lift) force.

Throughout the project, the wind tunnel will be available for dedicated testing periods.
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4 Design and manufacturing of a pressure calibration device

The FLOW research group has been performing wind tunnel tests of pitching wings and oscillating cylinders. In both setups, the device under test (wing, cylinder) is equipped with a row of pressure taps that are connected to a high-speed pressure scanner. For ease of calibration, the flexible tubes connecting the pressure taps and the scanner all have equal length. To minimize the distortion, the tubes are as short as possible. According to theoretical models, the distortion we expect is negligible. However, we are blind for the true distortion taking place, which might be negatively affected by small imperfections (bent tubes, changing inner diameter, micro-obstacles, …).

In this master thesis project, the goal is to design and manufacture a calibration system to chart the level of distortion taking place in our setup. The system will need to produce a controlled pressure jump at the pressure tap that can be simultaneously measured by a the pressure tap itself and by a reference port without distortion (at the pressure scanner).

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5 Network-based analysis of fluid flows: sense or nonsense for unsteady aerodynamics

Machine learning is a new, powerful tool for the study of many (dynamic) phenomena, including from fluid mechanics. As an alternative, albeit not completely independent, network-based analysis of fluids can be considered. In this master thesis, the goal is to become familiar with basic network theory, and then apply some of these tools on the experimental data available within the group:

- pitching aerofoil (pressure + wake)
- oscillating cylinder (pressure + wake)
- vertical-axis wind turbine pair (pressure + wake)
- empty tunnel at high turbulence intensity (wake)

The goal is to select a few cases to demonstrate the usefulness of the approach when compared to other data-driven techniques.

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