Experimental settings description

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Most of the experimental settings are detailed in the paper [1]. However, additional informations are given in this document in order to better understand all the provided files.

I. Experimental cases

The flow velocity imposed in the tank is always the same for all the tests: $U_\infty = 0.8m/s$. Two turbulent intensity rates have been tested: $I_\infty \simeq 3\%$ and $I_\infty \simeq 15\%$, corresponding to the cases $C1$ and $C2$ in the paper, respectively. These different turbulent intensity rates are obtained with or without a flow straightener, in the upstream part of the tank test area.

The turbine is equipped with a torquemeter located between the rotor and the motor, on the rotation axis. In addition, a six components load-cell is used at the top of the shaft (see figures 1 and 2) measuring the 3 forces and 3 moments applied on the turbine and mast. The motor of the turbine is equipped with an encoder enables the rotation speed to be measured. The rotation speed is normalized with the classical Tip Speed Ratio number:

$$TSR = \frac{\omega R}{U_\infty} \quad (1)$$

with ω the rotation speed and $R = D/2 = 0.35m$ the turbine radius. For most of the tested cases TSR is chosen at the maximum of the turbine power extraction: $TSR = 4$. But some tests have been carried out with $TSR = 2.5$ as well. All the data coming from the turbine are collected with a sampling frequency of $f_s = 100Hz$.

For measuring the flow velocity, a bi-dimensional Laser Doppler Velocimeter (LDV) is used. This system records the particles velocity where the laser beams cross. Thus, the velocity acquisition is performed with an irregular sampling rate. The measurement volume is an ellipsoid with a $0.12mm$ diameter and $2.51mm$ high. The settings are chosen in order to obtain a quite high data rate, between 800 and 900 particles per second. The in-line distance (e_x) between the laser and the turbine is $x = \pm 4D$, for every case (figures 1 and 2). That means the laser measures the velocity at an upstream position of the turbine for some of the cases and in the wake of the turbine for others cases. The traverse distance (e_y) is null, $y = 0$, for most of the cases, excepted for some of the cases, when the laser is in the wake of the turbine, where some tests have been performed at $y = -0.5D$. Concerning the vertical dimension (e_z), the velocity measurement point is always at mid-depth of the tank, $z = 0$, *i.e.* at the turbine rotor depth.

The acquisition time is 3 hours for all the cases, excepted one case for $I_\infty = 3\%$ and $TSR = 4$, where the laser was at the upstream position, for which the acquisition time is reduced at $1h$. This last case has been repeated for a $3h$ long acquisition as well, but a shorter acquisition time may be interesting because of the reduced size of the files. All turbine parameters are acquired in synchronisation with the LDV measurements, both starting with the same trigger event.

II. Informations on the files

The provided files are organized in two different folders corresponding to the LDV positions regarding the turbine: upstream or downstream. There are two files per tested case: one for the turbine parameters and another one for the laser measurements. All the tested parameters are summed up in the table I.

Table I
TESTED PARAMETERS DEPENDING ON THE LASER POSITION REGARDING THE TURBINE. T_{acq} STANDS FOR THE ACQUISITION TIME.

	laser position	
tested parameters	upstream	downstream
TSR	2.5 & 4	4
I_∞ [%]	3 & 15	3 & 15
y/D	0	0 & -0.5
T_{acq} $[h]$	1 & 3	3

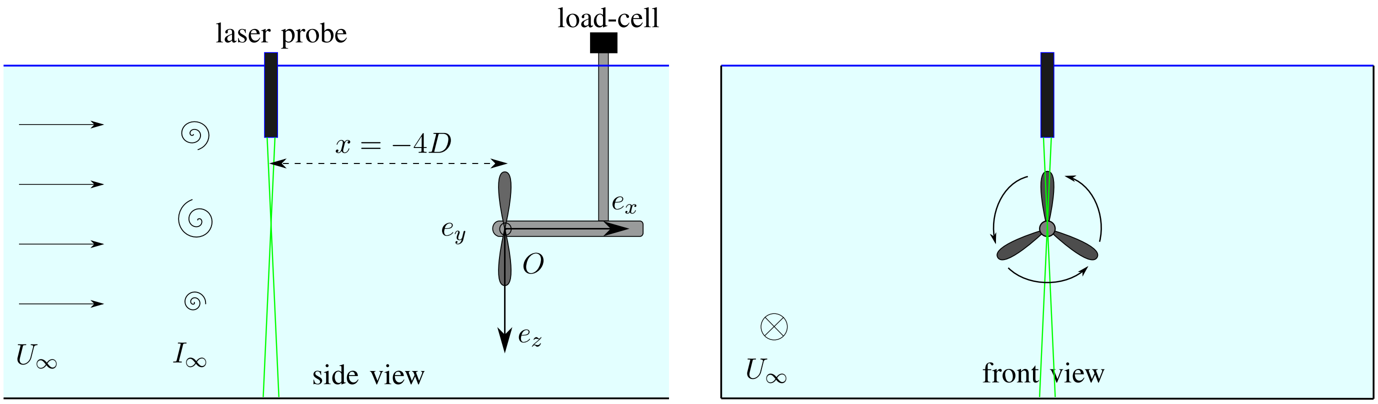

Figure 1. Experimental set-up with LDV at the upstream position

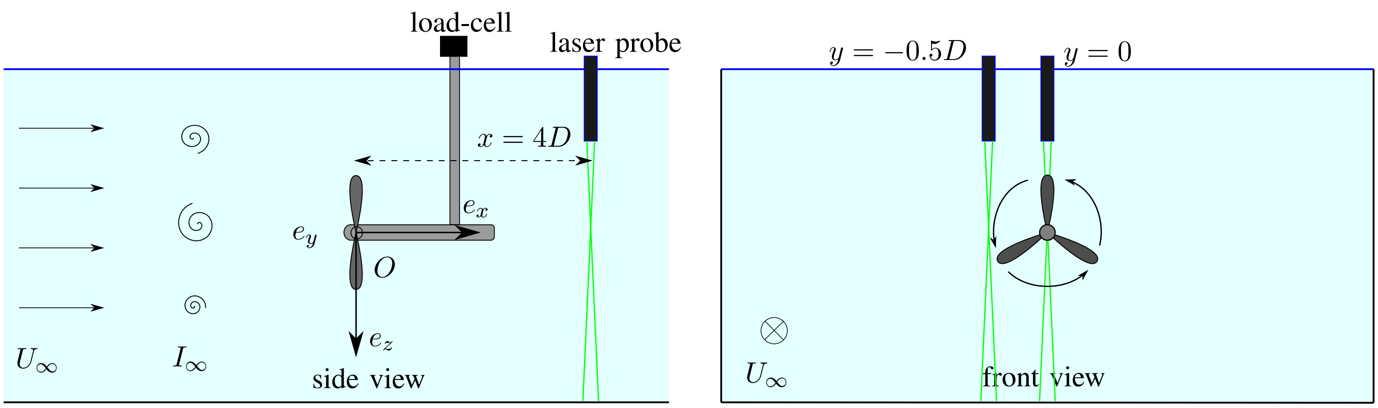

Figure 2. Experimental set-up with LDV at the downstream position

The name of the files are formatted in order to easily understand the measured case. *E.g.* `U=0.8_TSR=2.5_TI=3_3H_turbine.txt` means this file concerns the turbine parameters when its rotation speed was $TSR = 2.5$ and it was acquired during $3h$ in a flow velocity with $U_\infty = 0.8m/s$ and $I_\infty = 3\%$.

The content of the turbine files are constituted of 10 columns including:

- the 6 components of the load-cell: F_x, F_y, F_z, M_x, M_y and M_z, expressed in N for forces and $N.m$ for moments
- the torquemeter expressed in $N.m$. The orientation of the torquemeter requires to multiply it by -1 in order to get positive values.
- the demand current and the motor current recorded for internal control, but not useful for this study, both expressed in V
- the RPM expressed in V. The transfer function is the following: $RPM[RPM] = RPM[V] \times 26.54810 + 0.02461$

The content of the laser (LDV) files are constituted of 7 columns including:

- the row number
- the Arrival Time (AT) in ms, the Transit Time (TT) in μs and the value of the particle velocity in m/s for the first component of the velocity: $u.e_x$
- the Arrival Time (AT) in ms, the Transit Time (TT) in μs and the value of the particle velocity in m/s for the second component of the velocity: $v.e_y$

The Arrival Time is the time at which the particle has been seen by the laser. The Transit Time is the time during which the particle stays in the measurement volume.

Because the laser is in non-coincident mode, the number of particles perceived by each component is different. A particular attention has to be made for the second component of the velocity which has usually a lower number of values: its corresponding columns are filled-in with zeros in order to have the same length than the other component.

References

[1] O. Durán Medina, F. G. Schmitt, R. Calif, G. Germain, and B. Gaurier, "Turbulence analysis and multiscale correlations between synchronized flow velocity and marine turbine power production," *Renewable Energy*, vol. 112, pp. 314 – 327, 2017. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0960148117304093