PROPOSITION DE STAGE – MASTER 2 / STAGE INGÉNIEUR

Institut de Mécanique des Fluides de Toulouse
UMR 5502 CNRS/INPT/UPS

Titre : A SMart Active GRid to Explore the Impact of Free-Stream Turbulence (SMARTGRID)

Responsables :
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Lieu du stage : Institut de Mécanique des Fluides de Toulouse, Allée du Professeur Camille Soula, 31400 Toulouse

Durée / période : 5 mois

Candidature [CV, lettre de motivation, références] à envoyer à : R. Mathis (romain.mathis@imft.fr)

General context

The effect of free-stream turbulence in the incoming flow, as generally encountered in nature or industrial applications, are rarely taken into account in laboratory experiments, especially in the field of aerodynamics. The wind tunnels are generally built such as the incoming flow is "as clean as possible", *i.e.* homogeneous, without distortions, and with the lowest turbulence level (*Tu*) as possible (usual $Tu << 1\%$). Paradoxically, most of fundamental research works in this context aim at studying industrial or environmental problems in which the incoming flow is far from laminar. One way to investigate free-stream turbulence is to introduce, at the inlet of the test section, a fixed (passive) grid of turbulence, that increases the turbulence level. Makita [1] suggested a novel way to produce high Reynolds number turbulence by using an active grid, as shown in figure 1(*right*). This device consists of an arrangement of vertical and horizontal winged rods actuated by independent stepper motors, which control the rotation of each rods. The rotating rods produce a blockage effect which enables to adjust the downstream turbulence parameters by varying the angular speed of the rods. The active grid is able to generate one order of magnitude higher Reynolds numbers, based on Taylor micro-scale λ , $Re_\lambda = u_{rms}\,\lambda/\nu \sim O(10^3)$ (where u_{rms} is the root-mean square of the streamwise velocity component and ν is the kinematic viscosity), than passive grids, globally limited to $Re_\lambda < O(10^2)$. With an active grid, the turbulence intensity and the integral length scale can be varied independently: the impact of the size of the turbulence eddies and of the free-stream turbulence can be explored separately. Only a few active grids of turbulence are currently employed, worldwide, but as mentioned in this detailed review [2] there is a growing interest and a recent surge in their usage.

Objectives

Previously, the active grid has been made and assembly at the laboratory (see figure 1, right), as well as the control system that drives the rods. This includes the command and synchronisation of all of the motors, and command laws capable to drive globally of independently the 20 motors that actuate the rotating rods. The aim of the present project is to integrate the active grid to the IMFT wind tunnel and then to investigate the free-stream turbulence produces downstream. The objective is to determine several scenarios of command laws depending on the desired level of turbulence in the test section. This will be performed for different flow conditions : *(i)* homogeneous turbulence in a spanwise/vertical section, sheared turbulence in *(ii)* vertical, *(iii)* spanwise, or *(iv)* both directions, and finally *(iv)* unsteady flow resulting of turbulent gusts generated by the active grid, as illustrated in figure 1(*left*). These experiments will be performed in a closed-loop wind tunnel facility at IMFT for which the active grid is mounted at the inlet of the test section. Measurements will mainly consist of hot-wire anemometry using single, multiple and/or rake mounted probes. Eventually, the active grid and the effects of the incoming turbulence will be investigated on ongoing research projects undertaken in the IMFT wind-tunnel, such as the study of vortex-induced vibrations of a finite cylinder in turbulent flow.

Skills requirement

On the scientific part of the problem, fluid mechanics, turbulence and signal processing knowledges will be necessary. The intership is mainly experimental, therefore good practical sense and organisation are required. Matlab will be use to drive the data acquisition during fluid mechanics measurements, as well as for the data post-processing. Knowledges of this software would be then a benefit.

References

[1] H. Makita. Realization of a large-scale turbulence field in a small wind tunnel. *Fluid Dynamics Research*, 8:53 – 64, 1991.

[2] L. Mydlarski. A turbulent quarter century of active grids: from makita (1991) to the present. *Fluid Dynamics Research*, 49:061401, 2017.

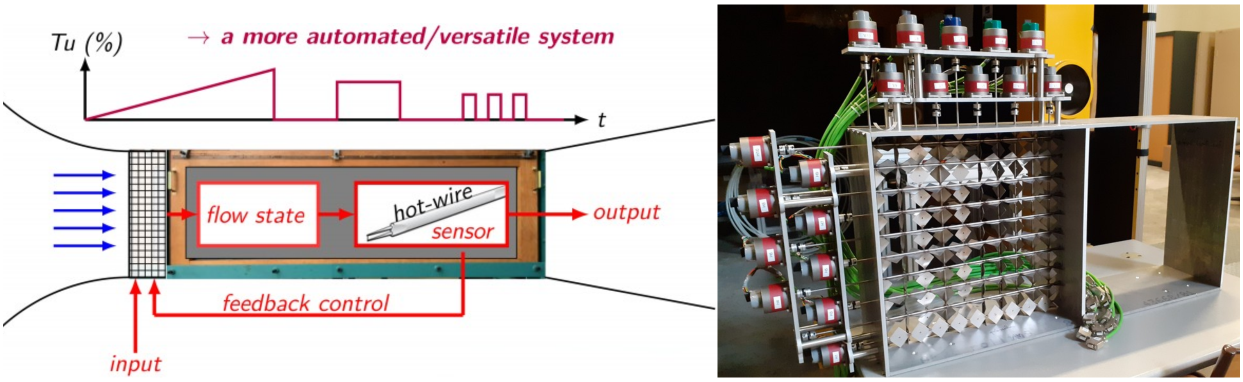

Figure 1: *(left)* schematic view of the test section of the IMFT S2 wind tunnel setup with the active grid at the inlet of the test section with a block diagram of the feedback loop; *(right)* wind tunnel active grid.