WIND TUNNEL LABORATORY

Proposal 2019-2020

Topic #2 - The role of roughness patches on the aerodynamics of a sphere

Contacts

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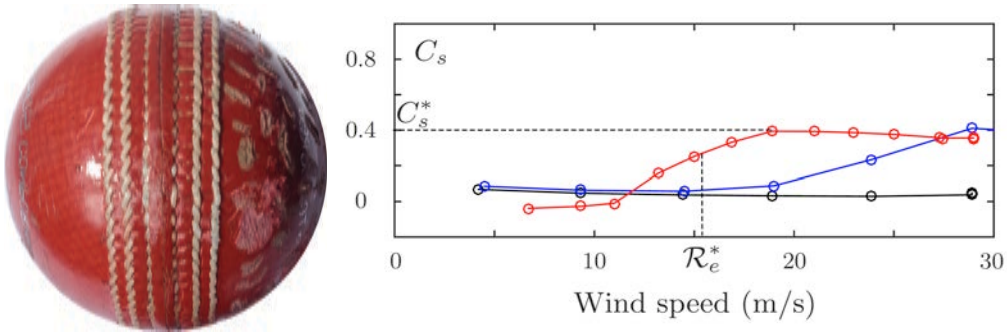
Context

The surface roughness of an object in motion in a fluid has a strong effect on the behaviour of the boundary layer that develops on its surface. In the case of bluff-bodies characterised by rounded shapes (e.g. sphere, cylinders, ellipses), it impacts the location of the separation point, which leads to important variations of the global aerodynamic loads. On the one hand, these effects are well known in the case of a uniform surface roughness distribution thanks to the works of Achenbach in the 70's [1,2]. On the other hand, little information exists on **the aerodynamic effects of localized rough patches** are present on the body surface.

Recently, the Wind Tunnel Laboratory has quantified the effect of localised roughness on the aerodynamic loads up to the flying trajectory of cricket balls [3].



This master thesis is an extension of this initial research work. The objective is to push further the fundamental understanding of the roughness effects on the flow around rounded shape bluff-bodies.

The research will start with an extensive wind tunnel test campaign on different bodies (spheres and cylinders) characterized by different roughness patterns. Measurements of the aerodynamic loads (mean and fluctuating lift and drag forces), surface pressure distributions and wake velocity will be carried out. Optionally, numerical simulation analysis (using CFD) could be considered.

[1] Influence of surface roughness on the cross-flow around a cylinder, E. Achenbach, Journal of Fluid Mechanics (1971), vol. 46, part 2, 321-335

[2] The effect of surface roughness and tunnel blockage on the flow past spheres, E. Achenbach, Journal of Fluid Mechanics (1973), vol. 65, part 1, 113-125

[3] How to obtain a curved trajectory without spinning the ball? The cricket ball reverse swing. L. Tadrist, N. Sampara and T. Andrianne, Sports Physics, Ecole Polytechnique, France, 8-10 June 2016

Tasks

The project consists in 4 main tasks:

- Literature review about roughness effects on bluff-bodies in turbulent flows (Reynolds numbers [10^3-10^5])
- Wind tunnel tests and signal processing, to obtain the steady (C_L, C_D) and unsteady (C_L', C_D', St) aerodynamic coefficients.
- Checking the potential of existing CFD codes (Ansys Fluent or OpenFOAM) to model the roughness effects on spheres and cylinders.
- Comparison of the experimental and numerical outputs.

In addition to the Master thesis manuscript, it is expected to summarize the results in a publication that could be submitted to a scientific conference or to an international journal.