Aerodynamics of a fly swatter

Ariane Gayout[1], Mickaël Bourgoin[2], Nicolas Plihon[2]

[1] Biomimetics, ESRIG, University of Groningen, Nijenborgh 7, 9747AG Groningen, Netherlands
[2] Laboratoire de Physique, ENS de Lyon, UMR CNRS 5672, 46, allée d'Italie, F-69364 Lyon
a.m.m.gayout@rug.nl

Our everyday life provides us with the perfect example of a porous object moving in a flow over a wide range of angles of attack : the fly-swatter. While its holes were originally introduced for durability and elasticity, their aerodynamic function is scarcely discussed, despite being well-known for strongly influencing aerodynamic properties. Through partially covering the holes of a square-shaped fly-swatter (Figure 1.a), we investigate experimentally the effect of the porosity pattern on the fly-swatter aerodynamics, and in particular on the development of stall in a tri-dimensional context.

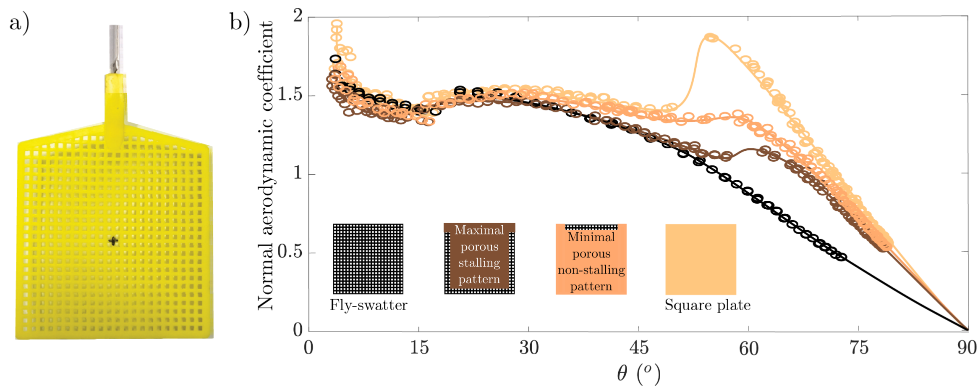

Figure 1. a) Fly-swatter used in the experiments. b) Angular evolution of the normal aerodynamic coefficient C_N for four different porous configurations. A sharp stall is observed for the square plate (beige) and the maximally porous stalling pattern (brown) while a smooth evolution is found for the fly-swatter (black) and the minimally porous non-stalling pattern (orange). Holes on the leading-edge are sufficient to hamper stall, by destabilizing the formation of the leading-edge vortex. To trigger stall, the whole leading-edge needs to be flat, especially its corners, suggesting that the trailing vortices need to find grounds to attach and interact with the leading-edge vortex for stall to occur.

By taping progressively the holes of the fly-swatter over 19 pattern configurations, we identified sufficient conditions for the absence of sharp stall and necessary conditions for its appearance. The aerodynamic coefficients of four configurations are presented in Fig. 1.b. Preliminary PIV measurements were also conducted for the fly-swatter and full plate configurations, and showed wide discrepancies in wake structure along the lift branch ($\theta > 50°$), supporting our hypotheses based on the aerodynamic coefficient.

Références

1. A. Gayout, M. Bourgoin, N. Plihon, Influence of the porosity pattern on the aerodynamics of a square-shaped fly-swatter, *Phys. Fluids*, **36**(1) :0179009, 2024.