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Aerodynamic properties of a succulent inspired cylinder

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Abstract

Saguaro cacti are known to have superior aerodynamic properties compared to the smooth circular cylinder that help them to cope with aerodynamic loads in their natural environment.[1] Their main feature is the presence of up to 30 ribs that, among other functions, modify the flow field, thus reducing drag and fluctuating aerodynamic forces. In the process of convergent evolution, succulents have developed a similar plant structure to cacti including ribs. Despite the lower number of ribs that is normally present in succulents they are also expected to perform the same functions as in cacti, including the attenuation of aerodynamic loads. This presumption was confirmed in a preliminary URANS investigation at a Reynolds number of 20,000.[2]

In the current study, the aerodynamic properties of a cactus-shaped cylinder with four ribs inspired by a number of succulents were investigated in two-dimensional configuration. The experiments were conducted for Reynolds numbers ranging from 50,000 to 150,000 in the de Havilland wind tunnel in the University of Glasgow. The angle of attack dependence of the aerodynamic forces, Strouhal number and mean surface pressure distribution was investigated. Hot-wire measurements were also conducted in the wake to provide additional insights into the vortex-shedding frequencies. Experimental results show that all measured quantities exhibit strong angle of attack dependence while Reynolds number dependence was not observed within the tested range. Overall, it was found that succulents with four ribs retain some of the aerodynamic benefits that have been observed for cactus-shaped cylinders with many ribs, albeit over a limited range of angles of attack.

References

[1] Talley, S and Iaccarino, G and Mungal, G and Mansour, N (2001). *An experimental and computational investigation of flow past cacti*. Annual Research Briefs, Center for Turbulence Research, NASA Ames/Stanford University pp 51-63

[2] Zhdanov, O and Busse, A (2019). *Angle of attack dependence of flow past cactus-inspired cylinders with a low number of ribs*. Eur. J. Mech. B/Fluids, 75:244-257.