Pressure drag reduction via imposition of spanwise wall oscillations on a rod-roughened wall

Rahul Deshpande*, Aman G. Kidanemariam* and Ivan Marusic*

Turbulent boundary layers over ship hulls and submarines correspond to the transitionally rough regime when these vehicles are freshly painted; over time, however, they move into the fully rough regime owing to biofouling. This increases the net drag experienced by the vehicle, with contributions from the pressure drag component becoming more significant with increasing roughness, while the viscous contributions reduce. With this motivation, the present study aims to investigate the efficacy of a popular drag reduction strategy[1] in reducing the pressure and viscous drag contributions to transitional and fully rough wall flows. To this end, direct numerical simulations are conducted in an open channel flow at low Reynolds numbers using an open-source spectral element solver[2]. Transitional and fully rough wall boundary layers are modeled based on previous studies[3] by considering transverse semi-circular rods positioned at various streamwise offsets. The drag reduction strategy[1] considered involves imposition of time-periodic spanwise oscillations on the rod-roughened wall. As depicted in figure 1(b), the actuation is successful in reducing the surface pressure fluctuations upstream of the roughness and also influences the near-wall flow, when compared to the non-actuated rough wall case in figure 1(a). Drag reduction statistics and detailed plow physics observed from these simulations will be presented.

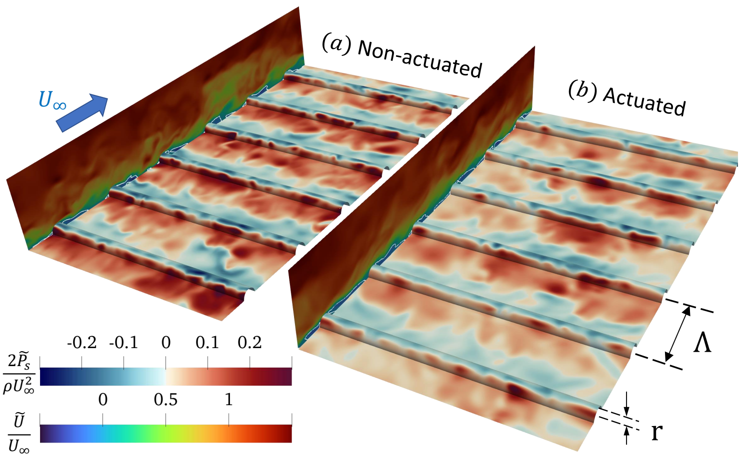

Figure 1: Instantaneous surface pressure ($\tilde{P}_s$) and streamwise velocity ($\tilde{U}$) plotted in an open channel flow with semi-circular rods (radius r) positioned on the wall at various streamwise offsets, Λ. Flow in (a) corresponds to a non-actuated wall while that in (b) is after imposition of time-periodic spanwise oscillations[1] on the wall. U_∞ and ρ are bulk velocity and density.

*Dept. of Mechanical Engineering, University of Melbourne, Parkville, VIC 3010, Australia

[1] Jung et al., *Phys. Fluids* **4**(8), 1605–1607 (1992)
[2] Cantwell et al., *Comput. Phys. Commun.* **192**, 205–219 (2015)
[3] Leonardi et al., *J. Fluid Mech.* **491**, 229–238 (2003)