6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

High-order simulation of zero mass jets for reduction of turbulent skin friction

Feng Xie[1], Jose Daniel Pérez Muñoz[2], Ning Qin[3], Pierre Ricco[4]

Department of Mechanical Engineering, The University of Sheffield, Mappin Street, Sheffield S1 3JD, UK

[1] fxie2@sheffield.ac.uk, [2] jdperezmunoz1@sheffield.ac.uk,
[3] n.qin@sheffield.ac.uk, [4] p.ricco@sheffield.ac.uk

Keywords: *Direct numerical simulation, Zero mass jets, Flow control, Turbulent drag reduction.*

A 5^{th} order MUSCL scheme is implemented in an inhouse flow solver (SHEFFlow) to investigate a unique active flow control method, using spanwise zero mass jets to manipulate the near-wall turbulence structure. Friction drag reduction has been achieved for a fully developed turbulent channel flow at $Re_b = 2800$, based on the bulk velocity and the half channel height. Direct numerical simulation (DNS) is employed to reveal the fundamental mechanisms of the drag reduction by accurately capturing the near-wall region. Statistical analysis has been used to process the data for the understanding of the flow physics. Implementing the 5^{th} order MUSCL scheme in SHEFFlow has been numerically tested against the Taylor-Green vortex case [1] and the classic turbulent channel flow case [2]. Some examples of these tests include energy dissipation rate, turbulent profile comparisons, and probability density functions. After the verification of the high order method, SHEFFlow is used to simulate the flow control method by means of DNS. Drag reduction is achieved at a jet inclination angle between $60 \sim 85°$. It is observed that with a proper jet inclination angle, the friction drag reduction comes from the fact that the mean velocity profile is dramatically twisted by the spanwise zero-mass-jets. Applying the 5^{th} order MUSCL scheme in SHEFFlow helps us to investigate the near-wall region by accurately capturing the turbulent structures.

References

[1] Zhijian J Wang, Krzysztof Fidkowski, Rémi Abgrall, Francesco Bassi, Doru Caraeni, Andrew Cary, Herman Deconinck, Ralf Hartmann, Koen Hillewaert, Hung T Huynh, et al. High-order cfd methods: current status and perspective. *International Journal for Numerical Methods in Fluids*, 72(8):811–845, 2013.

[2] John Kim, Parviz Moin, and Robert Moser. Turbulence statistics in fully developed channel flow at low Reynolds number. *J. Fluid Mech*, 177:133–166, 1987.

[3] Emile Touber and Michael A Leschziner. Near-wall streak modification by spanwise oscillatory wall motion and drag-reduction mechanisms. *Journal of Fluid Mechanics*, 693:150–200, 2012.