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Title

Riblet surface effect on laminar to turbulent transition by Direct Numerical Simulation

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Abstract

In recent years, the reduction of CO_2 emissions has become a more urgent technical issue than ever before, and airplane manufacturers around the world are sharply competing against each other. Viscous friction drag accounts for approximately half of the aerodynamic drag, reducing viscous drag is one of the last bastion ways.
Riblet surface, which consists of a series of micron-sized longitudinal grooves, has been one of the possible schemes to reduce viscous friction drag in the fully-developed turbulence flow [1][2]. Walsh et al. conducted extensive experiments and found that the drag reduction effect of the riblet surface is observed in the viscous sublayer where viscous effects dominate, and the crests protrude into the buffer layer [3][4]. Choi et al. [5] and Lee et al. [6] investigated flow around the riblet surface in the turbulent boundary layer too. The riblet surface was also discussed to reduce the viscous drag in the laminar flow state [7]. However, the effect of riblets on turbulent transitions has not yet been clarified though understanding how riblets affect turbulent transitions is also important for the practical application of riblets to aircraft. Therefore, in this study, we investigated the riblet surface effect on the laminar to turbulence transition numerically, by using the in-house solver for the direct numerical simulation of the compressible Navier Stokes equations. As the preliminary result for a laminar flow, our computation showed that the riblet surface increased the friction drag because of an increase in its surface area. Interestingly, the riblet surface modified the outer-scaled velocity profile, that dominated the laminar-turbulent transition via the flow instability. This suggests that could change the growth of the unstable mode, the location, and the pattern of the transition. In the presentation, the effects of the riblet surface on the laminar-turbulent transition will be discussed more in detail.

References

[1] M. J. Walsh, "Passive turbulent drag reduction; Riblets", *Prog. in Astro. and Aero*., Vol. 123, 1990, pp. 203-262.
[2] Douglas C. Chu et al., "A direct numerical simulation of laminar and turbulent flow over riblet-mounted surfaces", *J. Fluid Mech.*, Vol. 250, 1993, pp.1-42.
[3] Walsh, M.J., "Turbulent boundary layer drag reduction using riblets", *20th aerospace science meeting*, 1982, p. 169.
[4] Walsh, M. J. and Lindemann, A. M., "Optimization and application of riblets for turbulent drag reduction", *22nd Aerospace Science Meeting*, 1984, p. 347.
[5] Haecheon Choi et al., "Direct numerical simulation of turbulent flow over riblets", *J. Fluid Mech.*, Vol. 255, 1993, pp.503-539.
[6] S. –J. Lee and S. –H. Lee, "Flow field analysis of a turbulent boundary layer over a riblet surface", *Experiments in Fluids*, Vol. 30, 2001, pp.153-166.
[7] Shabnam Raayai-Ardakani and Gareth H. McKinley, "Drag reduction using wrinkled surfaces in high Reynolds number laminar boundary layer flows", *Physics of Fluids*, Vol. 29, 2017.