A novel approach to characterize the degradation of a superhydrophobic surface in turbulent channel flow

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A large amount of turbulence control techniques specifically aims to reduce the drag and therefore achieve energy conservation goals[1]. Superhydrophobic surfaces could potentially reduce drag passively via a very thin air-layer (the "plastron") formed at the liquid and solid interface, as many previous studies have shown[2]. However, these surfaces and the formed air layer are inherently fragile, and can degrade over time. The surface can easily loss its super-hydrophobicity (i.e., loss all air layer/air plastron) which can even result in a drag *increase* caused by the inherent roughness of such surfaces.

In the current study, we introduced a simple method - using reflecting pixel intensity to characterize the air plastron - to monitor *in-situ* the status of the air-layer in an on-going turbulent channel flow. With this technique, we firstly conducted a no-flow hydrostatic test and found a critical absolute pressure beyond which the surfaces would loss air plastron continuously with time. Secondly, turbulent flow tests (Reynolds numbers ranged from 1000-4000 based on channel half height and bulk velocity) over such surfaces have been conducted and a 5-10% drag reduction (calculated from pressure drop) has been achieved under the condition even though only ~14% of the area between the pressure tapings has actually been coated. The drag ratio (i.e. the friction factor ratio between superhydrophobic and smooth surfaces) increases with flow time. Meanwhile, the reflection intensity also increased with time, and it had a consistent trend with the drag ratio evolution. This indicated that the surface was degrading, and the air plastron was being lost with time. Moreover, the higher the absolute pressure/Reynolds number, the faster the degradation/loss of air plastron. Finally, a fixed wall-normal location velocity measurement has been performed using a laser doppler velocimetry (LDV) system. Results demonstrated that at a fixed y/h location, the near wall (viscous sublayer) velocity increased with time (i.e., with the degradation of the surfaces) as the shear stress *increased* (due to the loss of the air layer). A velocity measurement at the centre of the channel exhibited a decrease consummate with an overall downward shift of the velocity profile. Interestingly, RMS (root-mean-square) velocity values are constant when normalized by the local mean velocity. Consistency between the velocity, pressure drop and light reflection results demonstrates the feasibility of the *in-situ* characterization method to determine plastron stability/degradation.

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