Turbulent Drag Reduction/Enhancement in a 304 Stainless Steel Rectangular Channel Functionalized with a Femtosecond Laser

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ABSTRACT

In this paper, we present methods for enhancing or reducing drag experienced by metallic surfaces (304 stainless steel) functionalized with a femtosecond laser. Experiments were conducted with purified water (0.2 μm filtration). Femtosecond laser surface processing (FLSP) was performed on 304 stainless steel plates to create angled microstructures, which mimic those of shark skin. Data were collected at different Reynolds numbers by varying the mass flow rate. Data were recorded after steady state was reached. The processed plates were superhydrophilic and were used to obtain the friction factor in a rectangular channel test section over Reynolds numbers ranging from 8,000 to 13,000. For a superhydrophilic rectangular channel with angled structures, drag enhancement was measured with respect to smooth (unprocessed) surfaces over the total range of Reynolds numbers tested. After superhydrophilic testing was completed, the surfaces were coated with fluorinated silane using evaporative deposition that made the plates hydrophobic. The hydrophobic plates were then tested in the rectangular channel setup to obtain the friction factor. With the addition of an acrylic viewport, the presence of an air layer (plastron) was observed that sheds light to the friction factor data obtained for hydrophobic plates. Drag reduction was shown for Reynolds numbers that were accompanied with a thin plastron. When the plastron fully degraded, the surface was fully wetted, and the friction factor value shifted towards just below the superhydrophilic value.

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