Scaling law of efficient drag reduction due to Lorenz actuators[1]

JOHN M. CASTANO, PROMODE R. BANDYOPADHYAY, Naval Undersea Warfare Center, Newport, RI — Drag reduction due to Lorenz pulsing in seawater turbulent boundary layers is considered focusing simultaneously on efficiency which is generally low in this technique. Experimental and numerical data from two- and three-dimensional pulsing actuators are examined in the context of vorticity reorientation hypothesis of Stokes' drag reduction (Bandyopadhyay, Jou. App. Mech., V73, 483-489, 2006). Drag reduction is compared between actuators based on their efficiencies rather than the level of their drag reduction alone. This leads to an effective interaction parameter of inertia and Lorenz forces based on the effective value of Lorenz force rather than on the applied levels. Viscous sublayer thickness is taken as the length scale that is appropriate for drag reduction due to both two- and three-dimensional actuators rather than any large scale boundary layer integral parameter or actuator geometric scale. A universal relationship of drag reduction with effective interaction parameter is obtained.

Promode Bandyopadhyay
Naval Undersea Warfare Center, Newport, RI

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