Smooth sailing: Rough surfaces that can reduce drag

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From the sleek hulls of racing yachts to Michael Phelps' shaved legs, most objects that move through the water quickly are also smooth. But researchers from UCLA have found that bumpiness can sometimes be better.

"A properly designed rough surface, contrary to our intuition, can reduce skin-friction drag," said John Kim, a professor in the mechanical and aerospace engineering department at UCLA. Kim and his colleagues modeled the fluid flow between two surfaces covered with tiny ridges. They found that even in turbulent conditions the rough surface reduced the drag created by the friction of flowing water. The researchers report their findings in the journal *Physics of Fluids*.

The idea of using a rough surface for reduced drag had been explored before, but resulted in limited success. More recently scientists have begun experimenting with rough surfaces that are also extremely difficult to wet, a property called superhydrophobicity. In theory this means that the surfaces can trap air bubbles, creating a hydrodynamic cushion, but in practice they often lose their air cushions in chaotic flows.

The ULCA team chose to model a superhydrophobic surface design that another group of researchers at UCLA had already observed could keep air pockets entrapped, even in turbulent conditions. The surface was covered with small ridges aligned in the direction of flow.

The researchers modeled both laminar and turbulent flows, and unexpectedly found that the drag-reduction was larger in turbulent conditions. The irregular fluctuations and swirling vortices in turbulent flows on smooth surfaces generally increase drag, Kim explained. However, the air cushion created by the superhydrophobic ridges altered the turbulent patterns near the surface, reducing their effect, he said.

The team expects insights gleaned from their numerical simulations to help further refine the design of rough, drag-reducing surfaces. Further down the line, such surfaces might cover the undersides of cargo vessels and passenger ships. "It could lead to significant energy savings and reduction of greenhouse gas emissions," Kim said.

More information: The paper, "A numerical study of the effects of superhydrophobic surface on skin-friction drag in turbulent channel flow," authored by Hyunwook Park, Hyungmin Park, and John Kim, appears in the journal *Physics of Fluids*: dx.doi.org/10.1063/1.4819144

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