Proceedings of the Canadian Society for Mechanical Engineering International Congress 2021
CSME Congress 2021
June 27-30, 2021, Charlottetown, PE, Canada

Interfacial cavitation over longer-length interfaces: why elastomers may not be scalable anti-fouling surfaces

Kevin Golovin[1*]
[1]Department of Mechanical & Industrial Engineering, University of Toronto, Toronto, Canada
*kevin.golovin@utoronto.ca

ABSTRACT

Fouling is a ubiquitous issue worldwide, including the accretion of ice on turbine blades, the build-up of scale within pipes, the adhesion of marine organisms to boat hulls, and the accumulation of particles and debris in the processing of pulp and paper. Elastomers have been championed over the last decade as a promising class of materials that could curtail fouling. The fracture mechanism by which elastomers derive their low solid adhesion is a surface buckling instability known as interfacial cavitation. Although elastomers have exhibited excellent low-adhesion properties when evaluated using small interfaces on the order of 1 cm^2, larger interfaces have not been explored. In this work we demonstrate that elastomers may not be suitable for anti-fouling applications over large areas, due to strain energy dissipation caused by the cavitation. We've uncovered a new regime of interfacial fracture whereby a foulant remains partially adhered to an elastomeric surface during shear, and cavitation bubbles initiate and propagate from this 'initial detachment'. A model interface was formed by silicones of three different moduli and an optically transparent polyurethane hard foulant cured directly on the silicones. This enabled the real-time imaging of interfacial cavitation or fracture *in situ*, along with tracking of the applied load. Similar results were observed with ice, wax, and epoxy adhesion although the polyurethane was studied in detail for ease of visualization purposes. Overall, we found that an increasing bending moment was needed with increasing interfacial length, in order to fully de-bond the foulant from the elastomer, but this of course is limited by the thickness of the foulant itself. In the absence of sufficient tension, caused by the bending moment, the foulant will slide along the interface without fully detaching; the input shear strain energy is fully dissipated by cavitation bubble formation and propagation. We present design criteria for the correct fabrication of elastomers suitable for large-scale anti-fouling applications, and comment on other low-adhesion strategies that are suitable for larger, industrially relevant interfacial areas.

Word count: 326