Perturbed Partial Cavity Drag Reduction at High Reynolds Numbers

SIMO MAKIHARJU, University of Michigan, BRIAN ELBING, ANDREW WIGGINS, DAVID DOWLING, MARC PERLIN, STEVEN CECCIO, University of Michigan — Ventilated partial cavities were investigated at Reynolds numbers to 80 million. These cavities could be suitable for friction drag reduction on ocean-going vessels and thereby lead to environmental and economical benefits. The test model was a 3.05 m wide by 12.9 m long flat plate, with a 0.18 m backward-facing step and a cavity-terminating beach, which had an adjustable slope, tilt and height. The step and beach trapped a ventilated partial cavity over the longitudinal mid-section of the model. Large-scale flow perturbations, mimicking the effect of ambient ocean waves were investigated. For the conditions tested a cavity could be maintained under perturbed flow conditions when the gas flux supplied was greater than the minimum required to maintain a cavity under steady conditions, with larger perturbations requiring more excess gas flux to maintain the cavity. High-speed video was used to observe the unsteady three-dimensional cavity closure, the overall cavity shape, and the cavity oscillations. Cavities with friction drag reduction exceeding 95% were attained at optimal conditions. A simplified energy cost-benefit analysis of partial cavity drag reduction was also performed. The results suggest that PCDR could potentially lead to energy savings.

Simo Makiharju

Date submitted: 05 Aug 2010