Innovative approach makes for a smoother ride

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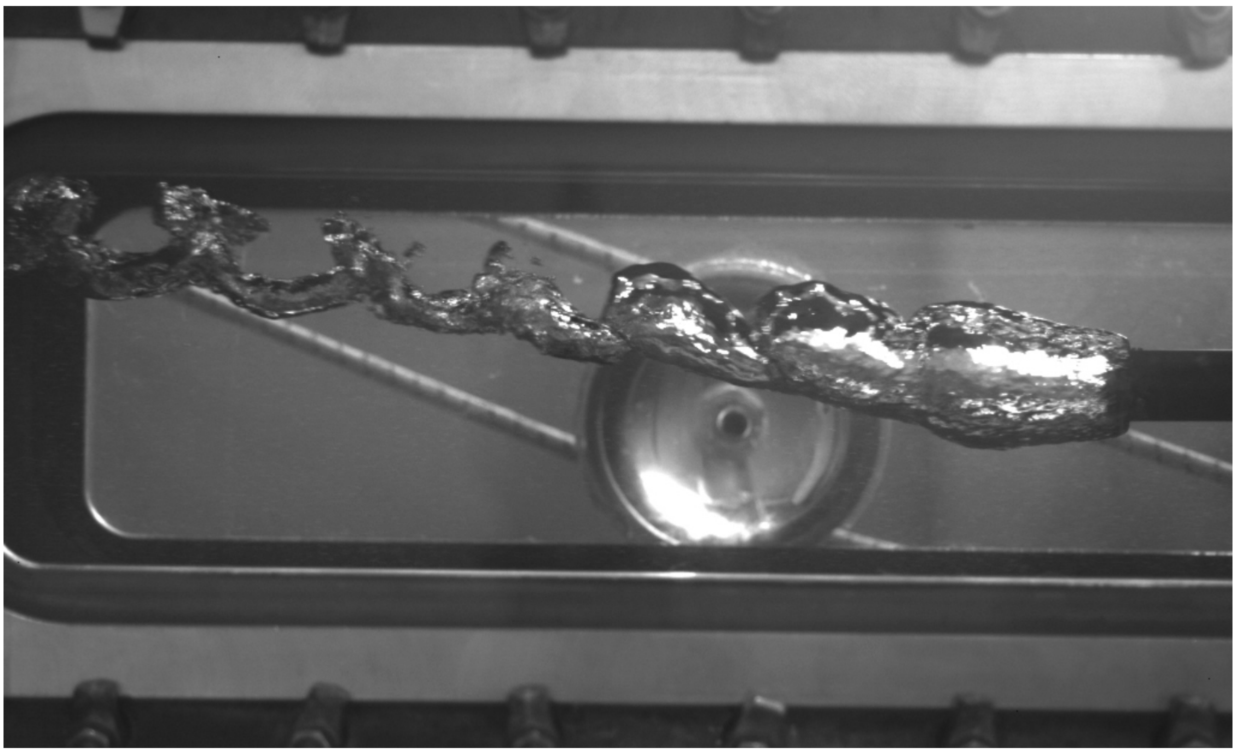

A photograph of a second order pulsating supercavity in the Penn State ARL Garfield Thomas Water Tunnel facility's 12-inch diameter water tunnel. The circular object is a window mounted hydrophone. Credit: Penn State Applied Research Laboratory

Moving through water can be a drag, but the use of supercavitation bubbles can reduce that drag and increase the speed of underwater vehicles. Sometimes these bubbles produce a bumpy ride, but now a team of engineers from Penn State's Applied Research Laboratory have an approach that smooths out the ride and stabilizes the bubble.

In supercavitation, a bubble of gas encompasses an underwater vehicle reducing friction drag and allowing high rates of speed through the water.

"Basically supercavitation is used to significantly reduce drag and increase the speed of bodies in water," said Grant M. Skidmore, recent Penn State Ph.D. recipient in aerospace engineering. "However, sometimes these bodies can get locked into a pulsating mode, causing a problem with stability and noise."

To create the bubble around a vehicle, air is introduced in the front and expands back to encase the entire object. However, sometimes the bubble will contract, allowing part of the vehicle to get wet. The periodic expansion and contraction of the bubble is known as pulsation and is the source of the instability and noise.

"Shrinking and expanding is not good," said Timothy A. Brungart, senior research associate at ARL and associate professor of acoustics. "We looked at the problem on paper first and then experimentally."

The researchers first explored the problem analytically, which suggested a solution, but then verifying with an experiment was not simple. The ideal outcome for supercavitation is that the gas bubble forms, encompasses the entire vehicle and exits behind, dissipating the bubble in twin vortices. Another acceptable gas exit scheme is a re-entrant jet where some of the discharged gas reverses and re-enters the cavity, but pulsation is to be avoided. The researchers report the results of their analytic analysis and experimentation online in the *International Journal of Multiphase Flow*.

"It is easier to study this problem in the lab than in open water," said Michael J. Moeny, senior research engineer at ARL. "There are tow basins where you can pull models along, but it is harder to observe what is happening than in a water tunnel and the experimental runs are short because of the basin sizes."

The ARL researchers decided to use the Garfield Thomas Water Tunnel facility's 12-inch diameter water tunnel to test their numerical calculations.

"The water tunnel was the easiest way to observe the experiment," said Brungart. "But not the easiest place to create the pulsation."

Creating a supercavitation bubble and getting it to pulsate in order to stop the pulsations inside a rigid-walled water tunnel tube had not been done.

"Eventually we ramped up the gas really high and then way down to get pulsation," said Jules W. Lindau, senior research associate at ARL and associate professor of aerospace engineering. "It was a challenge because the walls of the tunnel are really close. Others couldn't get pulsation in a closed tunnel. That's what we did."

Once they could predictably create the phenomena in the water tunnel, they then had to apply their numerical solution to the experimental model. They found that once they had supercavitation with pulsation, they could alternate increasing the air flow and decreasing the air flow in a sinusoidal manner and, in many cases, the pulsation would stop. The amount and rate of air flow variation did not correlate to just one pulsation frequency, but could calm a range of pulsation states.

The researchers reported that "despite the fact that modulation of the ventilation rate was effective at suppressing pulsation over a wide range of frequencies, not all modulation frequencies resulted in a transition to the twin vortex closure regime." Up and down air flow rate modulations that did not result in the desired twin vortex, did alter the frequency of the pulsation.

The researchers note that successful supercavitation can reduce the drag on underwater vehicles enough to increase the speed about 10 times.

"Supercavitation technology might eventually allow high speed underwater supersonic transportation," said Moeny. "It may be the only way to get the speed. Without the technology there is no way to control the cavitation that results from those speeds."

Provided by Pennsylvania State University

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