Researchers helping connect fluid dynamics research to brain trauma

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Photo illustration of football player suffering concussion. Credit: BYU

As many YouTube videos show, striking the top of a liquid-filled bottle can shatter the bottom. Now researchers are hoping to use new knowledge of that party trick to help fill a gap in something much more

serious: brain research.

A study by engineering professors from Brigham Young University, Utah State University and the Tokyo University of Agriculture and Technology details exactly what happens when a liquid at rest—like the water in a bottle—is suddenly put into motion. Using high-speed photography, the team shows how the swift acceleration causes small bubbles to form in the liquid and then rapidly collapse, releasing a destructive shockwave.

The proper term for the phenomenon is called cavitation, a process well known to engineers for causing damage in pipes and marine propellers. The new study, published in the *Proceedings of the National Academy of Sciences*, details an alternative formula that more accurately predicts when cavitation will happen.

While the finding has immediate implications for many industrial processes interrupted by cavitation-induced damage, there's also growing evidence linking cavitation to brain trauma.

"The brain is surrounded by fluid, and when you have impact, it's possible you are experiencing cavitation within that fluid," said study co-author Scott Thomson, associate professor of mechanical engineering at BYU.

Fluid dynamics experts know how to predict when cavitation will occur in a fluid already in motion, but their formula doesn't work so well when a resting fluid is rapidly accelerated. The new study fixes that problem by finalizing a new equation that considers a fluid's depth and acceleration.

For the brain, knowing this alternative cavitation formula could be used to better predict brain injuries caused by high-velocity impact. "And

once we're able to predict when that will happen, we can better design safety devices to help prevent serious brain damage," Thomson said.

Those safety devices could be for athletic applications, such as football helmets, or even military applications.

"If a blast wave is above a certain magnitude, there may not be much we can do to prevent brain injury for a soldier," said study author Tadd Truscott, associate professor of mechanical engineering at Utah State University. "But maybe a helmet can be developed to detect when that trauma has happened so a soldier can be removed from the front line and be saved from repeat exposure to blasts."

More information: Zhao Pan et al, Cavitation onset caused by acceleration, *Proceedings of the National Academy of Sciences* (2017). DOI: 10.1073/pnas.1702502114

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