SMU Department of Mechanical Engineering

Propulsive Efficiency of a Biomorphic Pulsed-Jet Underwater Vehicle

Ph.D. Dissertation in Mechanical Engineering

Presented by Ali A. Moslemi

Advisor: Dr. Paul S. Krueger

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Abstract: Propulsion for small scale vehicles (cm to mm scale or smaller) can have potential applications in exploration, surveillance, or even intravenous drug delivery (not unlike the movie "Fantastic Voyage"). Pulse jet propulsion holds promise for such small scale propulsion applications due to its higher thrust compared to steady jets, which results from the formation of a vortex ring with each jet pulse. The mechanical simplicity of the thrust generation mechanism is an additional advantage of pulsed jets over more complex unsteady propulsion mechanisms. To investigate the propulsive efficiency of pulsed jet propulsion at different scales, a small pulsed-jet underwater vehicle, dubbed Robosquid due to similarity of its propulsion system to squid, was designed and built. The objective of this research was twofold. Firstly, to investigate whether pulsed-jet propulsion is more efficient than steady jets in terms of propulsive efficiency. Secondly, to determine how pulsed-jet propulsive efficiency changes during miniaturization. To address these questions, Digital Particle Image Velocietery (DPIV) was used to measure the flow field behind Robosquid and determine its propulsive efficiency. To study the effect of scale on propulsive efficiency, a mixture of glycerin and water was used to reduce the average Reynolds number (*Re*) from 2000 to 50. The results show that Robosquid can outperform its equivalent steady jet system in terms of propulsive efficiency at small jet slug length-to-diameter (*L/D*) ratios and high duty cycle. This better propulsive performance at smaller *L/D* is linked to generation of isolated vortex rings in which pulsed jets generate higher thrust at the expense of relatively lesser excess kinetic energy. Also, pulsed-jet propulsive efficiency decreases as *Re* or vehicle size decreases. However, the ratio of pulsed-jet to steady jet efficiency improves as *Re* decreases suggesting that pulsed-jets can be an efficient alternative for micropropulsion applications

Bio: Ali Moslemi received his B.S. degree in Thermo-fluids engineering from Amir Kabir University of Technology, Tehran, Iran in 2000 and earned his M.S. degree in mechanical engineering from Sharif University of Technology in 2003. He started working at KIA MOTORS (Iran branch) simultaneously with his M.S. studies where he developed a computer code to predict the temperature in a disc brake system under different braking conditions. Also, he developed a troubleshooting method for a 1300cc engine newly converted from carburetion to fuel injection while he was working in the quality assurance department. In 2005, he joined the Experimental Fluid Dynamics Lab at SMU as a research assistant to conduct research in propulsive efficiency of pulsed-jet propulsion. His current research was recently highlighted in the journal of Bioinspiration & Biomimetics. Also, he has received an outstanding graduate student award from the ASME North Texas section in 2009.