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Investigation of Spark Discharge in Water as a Source of Mechanical Actuation

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Spark discharge in water generates shockwaves which have been utilized to generate mechanical actuation for potential use in pumping application. Discharge pulses of several microseconds generate shockwaves and vapor bubbles which subsequently displace the water for a period of milliseconds. Through the use of a sealed discharge chamber and metal bellow spring, the fluid motion can be used create an oscillating linear actuator. Continuous actuation of the bellow has been demonstrated through the use of high frequency spark discharge. Discharge in water forms a region of high electric field around the electrode tip which leads to the creation of a thermal plasma channel. This process produces fast thermal expansion, vapor and bubble generation, and a subsequent shockwave in the water which creates physical displacement of the water [1]. Previous work was been conducted to utilize the shockwave effect of spark discharge in water for the inactivation of bacteria, removal of mineral fouling, and the formation of sheet metal [2-4]. Pulses ranging from 25 to 40 kV and 600 to 900 A are generated inside of the chamber and the bellow motion is captured using a slow motion video camera. The maximum displacements measured are from 0.7 to 1.2 mm and show that there is a correlation between discharge energy input to the water and the displacement that is generated. Subsequent oscillations of the bellow are created by the spring force of the bellow and vapor in the chamber. Using microsecond shutter speed ICCD imaging, the development of the discharge bubble and spark can be observed and measured.

References

[1] Yang, Y., Y.I. Cho, and A. Fridman, Plasma Discharge in Liquid: Water Treatment and Applications. 2012, Boca Raton, FL: CRC Press.
[2] Gilliland, S.E. and M.L. Speck, Inactivation of Microorganisms by Electrohydraulic Shock. Applied Microbiology, 1967. 15(5): p. 1031-1037.
[3] Melander, A., et al., Modelling of electro hydraulic free and die forming of sheet steels. International Journal of Material Forming, 2013. 6(2): p. 223-231.
[4] Yang, Y., et al., Removal of CaCO3 scales on a filter membrane using plasma discharge in water. International Journal of Heat and Mass Transfer, 2009. 52(21-22): p. 4901-4906.

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