Liquid Jet Impingement Cooling with Spent Flow Management for Power Electronics Cooling

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Abstract: The high levels of heat generated by power electronics, on board electric and hybrid-electric vehicles, require the use of aggressive liquid cooling techniques. Incorporating the electronics cooling into the radiator flow loop is an attractive option, from a manufacturing and cost perspective, because it makes use of the existing infrastructure already on the vehicle. Therefore, it is advantageous to have a liquid cooling solution that can use a water based ethylene glycol mixture. Many of the power electronic components used in vehicles come packaged in modules which spread the heat to a large surface area. Impinging liquid jets provide the highest single-phase heat transfer coefficient at the stagnation point of currently available cooling techniques, which makes them an excellent method for removing the heat from the module surface. Since the rate of heat transfer deceases with distance from the stagnation point, it is necessary to utilize multiple jets in an array to cool large surface areas. However, it is common for the spent fluid from upstream jets to become entrained in downstream jets, successively degrading the performance of each subsequent downstream jet. In order to counteract this effect, an inclined confining wall was used to allow the spent fluid from upstream jets to be diverted around the downstream jets, thus avoiding entrainment and reducing degradation in the heat transfer coefficients of the downstream jets. A measurement technique was developed that allows the local thermal properties to be measured at the impingement surface. This technique was used to measure the effects of jet Reynolds number, confining wall angle, nozzle to plate spacing, and nozzle pitch for single-phase, normal, circular jets. The angled confining wall was found to be an effective method of spent flow management, allowing the nozzles to be placed closer to each other and closer to the surface without interfering with the performance of neighboring jets.

Biography: Dr. John F. Maddox is an Assistant Professor of Mechanical Engineering at the University of Kentucky. He received his Ph.D. in mechanical engineering from Auburn University in 2015. His primary research area is thermal management of high power and harsh environment electronics. Through his involvement with the NSF Industry and University Cooperative Research Center (I/UCRC), Center for Advanced Vehicle and Extreme Environment Electronics (CAVE3), he performed thermal characterization of various electronic packaging materials and generalized a method to measure the thermal conductivity of stacked materials. He is currently working on liquid jet impingement cooling of power converters in hybrid-electric vehicles. He was selected as the 2014-2015 outstanding Ph.D. student of the year by the Auburn University Department of Mechanical Engineering.

Date: February 5, 2015
Time: 3:00 to 4:00p
Place: CB 106
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