Advanced Thermal management of Electric Machines

Prof. Satish Kumar, G. W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA; satish.kumar@me.gatech.edu

Micro Nano Devices and Systems Lab (MiNDS); https://sites.gatech.edu/minds/

Abstract: Stringent greenhouse gas emission legislations have accelerated the need for electrification of ground and air transportation. Since electric motors are one of the core components of the electric drivetrain, improvement of their performance is a key enabler of better performance metrics of the electric drivetrain. High heat generation in electric motors, especially at high power density, as a consequence of electromagnetic losses, limits motor efficiency and longevity by ultimate aging of the winding wire insulation and premature demagnetization of the magnets. Therefore, enhanced cooling technology is essential to increase motor power and torque density, by pushing up the current density, while keeping the peak winding temperature below the winding insulation temperature threshold. In this presentation, liquid cooling concepts to extract heat directly from the winding of electric motors will be discussed, which dramatically reduces the thermal resistances between the winding and the coolant and hence enables significantly higher current density while operating within the thermal limit of materials employed in electric motors. Tradeoffs involving the copper fill factor, power losses, shaft torque, peak temperature, and overall efficiency of electric motors for different liquid cooling solutions will be presented.

Bio: Dr. Satish Kumar is currently a Professor at George W. Woodruff School of Mechanical Engineering at Georgia Tech. Prior to joining Georgia Tech in 2009 as an Assistant Professor, he worked at IBM Corporation, where he was responsible for the thermal management of electronic devices. Kumar received his Ph.D. in Mechanical Engineering and M.S. degree in Electrical and Computer Engineering from Purdue University, West Lafayette in 2007; and B.Tech. degree in Mechanical Engineering from the Indian Institute of Technology, Guwahati in 2001. His research interests include electro-thermal transport study in electronic devices and materials, e.g., wide band-gap devices, electric motors, etc. He is the author or co-author of over 150 journal or conference publications. Dr. Kumar is an ASME Fellow and recipient of the 2005 Purdue Research Foundation Fellowship, 2012 Summer Faculty Fellow from Air Force Research Lab, 2014 Sigma Xi Young Faculty Award, 2014 DARPA Young Faculty Award, 2017 Woodruff Faculty Fellow, and 2020 ASME K-16 Clock Award.