Proceedings Paper:
Chen, L., Chen, X., Wang, J. orcid.org/0000-0003-4870-3744 et al. (1 more author) (2017) Computationally efficient, electro-thermally coupled model for permanent magnet machines in electric vehicle traction applications. In: UNSPECIFIED SAE Thermal Management Systems Symposium, TMSS 2017, 10-12 Oct 2017, Plymouth, MI, USA. .

Computationally efficient, electro-thermally coupled model for permanent magnet machines in electric vehicle traction applications

Liang Chen, Xiao Chen, Jiabin Wang and Antonio Griffo

University of Sheffield, UK

Permanent magnet (PM) machines are receiving prominent interest in electric vehicle (EV) traction applications due to their high torque/power density and high energy efficiency. Interior permanent magnet machines (IPM) which also benefit from reluctance torque and exhibit good field weakening capability are particularly favoured in EV traction applications which require constant power operation over a wide torque-speed range.

In order to improve the driving range of an electric vehicle in cold weather conditions, advanced thermal management architecture which recovers the waste heat from the power train components, such as traction motor and inverters, may be employed. However, the losses in traction motors are highly dependent on temperatures which, in turn, are influenced by a thermal management strategy. Thus, in order to quantify the amount of waste heat that can be recovered from an EV power train, it is essential to represent the temperature dependent loss behaviour and their interaction with the thermal management system.

This paper proposes an accurate and computationally-efficient modelling method that considers the effect of temperature variation on the electromagnetic behaviours of IPM machines. The temperature influence is accounted conveniently on a machine high-fidelity model established at a reference temperature, by employing an equivalent *d*-axis current offset which varies linearly with temperature. No extra model building calculations are required while the effect of saturation and space harmonics are represented. The proposed machine model is combined with a lumped-parameter state-space thermal model to form an electro-thermal coupled machine model. The proposed model is validated with experiments on a prototype IPM machine. The models will be integrated into thermal management architecture and their utilities are illustrated by simulation study over representative driving cycles.