Challenges for bulk hard and soft magnetic materials in high performance electromechanical devices

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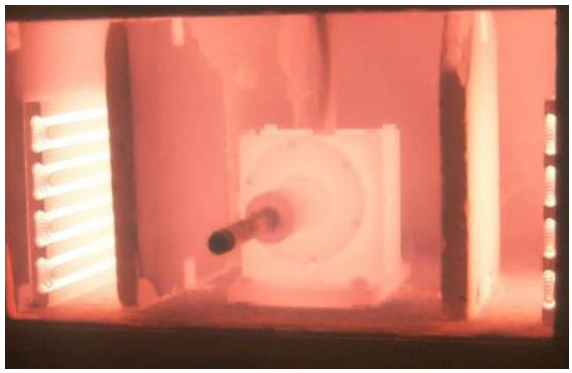
Abstract

This lecture will discuss the many properties of bulk hard and soft magnetic materials which determine their suitability for the most demanding future applications for electrical machines and actuators. The range of properties offered by commercially produced and latest state-of-the-art development grades of hard and soft magnetic materials will be reviewed within the context of their practical deployment in electrical machines and drives for applications ranging from high power density drives for aerospace through to multi-MW scale offshore wind generators. Many of the key properties used as figures of merit in magnetic material development to will be discussed in terms of their impact on the ultimate performance of the electromechanical devices into which they will be incorporated. This will include discussion of some often overlooked properties such as electrical conductivity, thermal conductivity and the coefficient of thermal expansion.

A particular focus of the lecture will be the challenges in terms of material requirements, characterisation and modelling for applications in which the magnetic components are exposed to temperatures in excess of 300^{o}C, as might encountered for example in aircraft engines, process equipment, nuclear power generation and bore-hole drilling. In many such applications, some of the magnetic components may also be subjected to high levels of mechanical stress and extreme level of internally generated losses. Within the context of high temperature applications, on-going research on the performance of Cobalt-Iron alloys at elevated temperatures will be discussed in detail, including the effects of extended ageing (e.g. 1000s of hours at 400^{o}C) on core loss and means by which such ageing effects can be accommodated into the device design process, including extensive material characterisation. The trade-offs which must be made between enhancing mechanical and magnetic properties of Cobalt-Iron alloys will be illustrated by a case studies on a high-performance switched reluctance machine and a high temperature linear actuator.

The lecture will conclude by drawing together a ‘wish-list’ of improvements in properties of both hard and soft magnetic materials which would have significant impact on the performance of electrical machines.



Cobalt Iron linear actuator operating at 800^{o}C

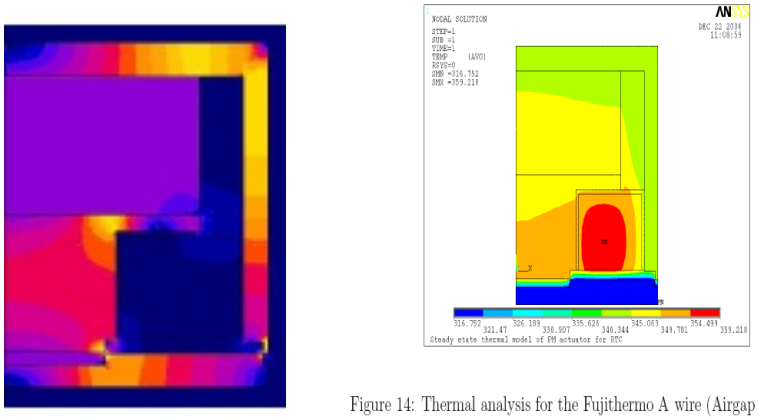


Figure 14: Thermal analysis for the Fujithermo A wire (Airgap = 2 mm)

Electromagnetic and thermal modelling of a high temperature linear permanent magnet actuator

Useful References

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