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Targeted use of residual stress in electrical steel to increase energy efficiency

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The magnetic flux guidance in an electric engine is achieved by introducing cutouts in the electrical steel (ES) sheets that make up its core. However, these cutouts create thin structures, reducing the mechanical strength of the ES sheets and limiting the achievable rotational speed and therefore the energy efficiency of the engine. Residual stress in ES sheets reduces the mobility of magnetic-domain walls due to the magneto-elastic effect. This effect was used to create a novel type of magnetic flux barrier relying on the local decrease in magnetic permeability introduced by embossing of the ES sheet. Such barriers show similar flux guidance as traditional barriers while the mechanical strength is comparable to unworked ES.

To prove the applicability of such magnetic flux barriers in future electric drives, the performance under different external parameters was probed using neutron grating interferometry (nGI). In nGI the dark field image (DFI) maps ultra-small-angle neutron scattering as resulting from the interaction of the magnetic moment of the neutron with the magnetic domain structure in the bulk of the sheet sample. Hence, enabling the visualization of the local distribution of magnetization.

In this presentation, we will give a comprehensive overview of the influence of operational conditions, such as tensile load and alternating magnetic fields (time-resolved), in an electric motor on embossed magnetic flux barriers.

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