Lehrstuhl für Umformtechnik und Gießereiwesen (*utg*)
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Embossed flux barriers for efficient electric motors

Motivation

The advancing climate change requires efficient and resource-saving drive systems. In the mobility sector, electric drives are a core technology in dealing with these requirements. Increasing the efficiency of electrical machines can therefore help to reduce emissions in this sector. Due to its ferromagnetic properties, iron-silicon-based electrical steel stacked in thin laminations forms the magnetic core of electrical machines and is therefore crucial to their efficiency.

Compromises in the rotor: mechanical strength and flux guidance

Modern electrical synchronous machines place high demands on the guidance of the magnetic flux in the rotor and stator laminations. These non-grain orientated electrical laminations are typically produced by shear cutting and then packaged. A strong magnetic coupling between the rotor and stator is essential for a high torque density. Particularly in permanent magnet synchronous machines (PMSM) and synchronous reluctance machines (SynRM), a high magnetic anisotropy of the rotor is necessary to generate the torque. This anisotropy is conventionally generated via shear-cut recesses, so-called flux barriers. However, these flux barriers lead to a mechanical weakening of the rotor, as the centrifugal forces of the rotor then act completely on the remaining thin webs.

Targeted use of forming induced residual stress for flux guidance

Previous studies by the consortium of the Technical University of Munich and RWTH Aachen University have already shown that the targeted introduction of residual stresses by embossing is suitable for creating flow barriers. The local reduction in permeability, i.e. the strength of the flow barrier, depends on process parameters such as the embossing geometry, embossing pattern and embossing force. The comparison of embossed and conventionally shear-cut flux barriers showed similar magnetic properties. At the same time, a considerable increase in mechanical strength was achieved by replacing cut-outs with embossed flux barriers.

From laboratory scale to application in the series rotor

The aim of this research project is to transfer the findings of the previous project phases to the application of a series rotor. This is being done together with the industrial partner Mubea. To this end, a series rotor is first replicated with a reference material and then its geometry is further developed with embossed flow bars on this basis. According to the research hypothesis, this innovative rotor will then have a comparable magnetic coupling between the rotor and stator with the same dimensions but will have increased mechanical strength and therefore a higher maximum permissible speed and consequently an increased energy density.

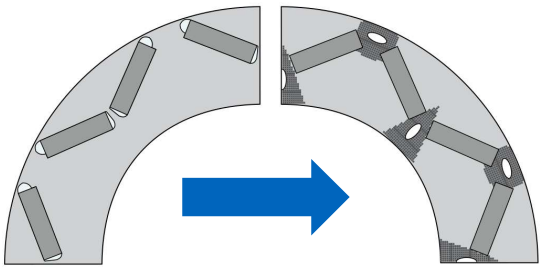

Figure 1: Schematic representation of the innovation approach. Conventional flow barriers are replaced by similar but smaller recesses with embossed flow barriers.

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