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COMPUTATION OF THE EFFECTIVE LAMINATION STACK'S BEHAVIOR CONSIDERING THE CONTACT SIMULATION WITH A MULTI-SCALE HOMOGENIZATION

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The influence of the lamination stack onto the mechanical behavior of an electrical machine is significant, especially for lightweight constructions. Information about the behavior of the stack is relevant for a proper calculation of the whole motor. This behavior is dependent on the contact between the single sheets.
The roughness and the existence of a coreplate varnish is relevant for this contact behavior. The roughness peaks cause a progressive stiffness, and the varnish causes a viscous behavior. The simulations are based on certain simplifications and assumptions. For example, the single peaks are deformed, based on the theory of Hertz [2] and the assumption that contact between two rough surfaces can be considered as contact between a surface with superposed roughness and a flat rigid surface. The measured sheet roughness curvatures are described by the normal distribution for the plastic model [6] and the autocorrelative structure function for the elastic one [3]. Based on this, the elasto-plastic contact behavior can be described, using the elastic model of Bush, Gibson, and Thomas [2] and the plastic model of Bowden and Tabor [1]. The simulation of the time dependence is implemented with an exponential velocity law for the creeping strain [5], which enables simulation of creeping and relaxation of the stack. In addition to this normal contact behavior, the tangential behavior is also of high interest. This is mainly characterized by the friction coefficient and the adhesion force [3].
Knowledge of the normal and the tangential contact behavior, in combination with the known material behavior of the sheets, allows a computational calculation of the lamination stack to be performed. A simulation of the whole stack is computationally very expensive. Hence, a multi-scale framework is applied to calculate the macroscopic parameters through a representative model. The RVE must be representative for the structure, the material, and the contact. To identify the macroscopic parameters, the macroscopic deformation gradient is applied to the boundary of the RVE via periodic boundary condi-

tions. The macroscopic stresses can be calculated by a homogenization over the RVE [4]. Finally, it is possible to identify a phenomenological material model from the multi-scale calculations. This is achieved by calculating the stress-strain behavior for different deformations. The result is a material model for the entire lamination stack, allowing a proper and inexpensive calculation of the electric motor.

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