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The Scalar Potential Approach in Nonlinear Magnetostatics

Electromagnetic phenomena are present in many situations of everyday life and act as the major force behind various applications (e.g. electric motors, magnetic valves, transformers, etc.). Hence the simulation of such effects is heavily studied to improve performance and cut costs. In this thesis, we study the scalar potential approach in the magnetostatic setting using energy-based nonlinear constitutive equations. First, the physical model is introduced and the material equations are motivated. We derive a nonlinear variational problem and show the existence of a unique solution using the theory of Zarantonello. For the discretization a finite element method with standard Courant elements is considered and the use of numerical integration is justified by a nonlinear variation of the Strang lemma. Lagrangian multipliers are introduced for handling a constraint appearing in the problem formulation and the resulting nonlinear system is solved using iterative algorithms. We show the global convergence of these methods using linesearch algorithms and derive convergence rates. At last, numerical results for the simulation of a magnetic valve in a two-dimensional setting are presented.