On energy based vector-hysteresis models

Bachelor-Thesis presentation
Franz Scharnreitner
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JOHANNES KEPLER UNIVERSITY LINZ
Altenbergerstraße 69
4040 Linz, Austria
jku.at

Unrestrained Model

Restrained Model

For the energy density W in a magnetic material the equations

$$W = \frac{1}{2}\mu_0 h^2 + U(m) \qquad \text{and} \tag{1}$$

$$\dot{W} = \langle h, \dot{b} \rangle - \| r\dot{m} \| \tag{2}$$

hold, with $b = \mu_0(h + m)$ being the magnetic induction. Differentiating (1) and combing it with (2) yields

$$\mu_0 \langle h, \dot{h} \rangle + \langle \frac{\partial U}{\partial m}(m), \dot{m} \rangle = \mu_0 \langle h, \dot{h} + \dot{m} \rangle - \| r\dot{m} \| \Leftrightarrow \tag{3}$$

$$\langle h - \frac{1}{\mu_0} \frac{\partial U}{\partial m}(m), \dot{m} \rangle = \| \frac{r}{\mu_0} \dot{m} \| \tag{4}$$

Restrained Problem

Let $\chi = \|\frac{r}{\mu_0}\|$, $h_r = f(m)$ and $h_i = h - h_r$, then (4) can be further rewritten as

$$\langle h_i, \dot{m} \rangle = \chi \|\dot{m}\| \tag{5}$$

This holds when $\dot{m} \in \partial I_{\tilde{K}}(h_i)$, where I is the indicator function and $\tilde{K} := \{u \in \mathbb{R}^3 : \|u\| \leq \chi\}$, or alternatively if $h_r \in K(h) = \{u \in R^3 : \|h_r - h\| \leq \chi\}$ and $\langle \dot{m}, u - h_r \rangle \geq 0 \ \forall u \in K(h)$

Equivalence

Code overview