Errata

Publication I

In (2) the powers $i+1$ are missing from I_5 and I_6 terms. The parameter values in Table 1 were erroneous and units were missing. The corrected values are given below.

Table 5.1. Parameter values used in the model.

Param.	Value	Param.	Value
α_0	$23.873\ \mathrm{J/m^3T^2}$	β_0	$-22.368 \cdot 10^4\ \mathrm{J/m^3T^2}$
α_1	$29.375\ \mathrm{J/m^3T^4}$	β_1	$-14.434 \cdot 10^6\ \mathrm{J/m^3T^4}$
α_2	$-16.011\ \mathrm{J/m^3T^6}$	β_2	$-41.678 \cdot 10^9\ \mathrm{J/m^3T^6}$
α_3	$57.938\ \mathrm{J/m^3T^8}$	β_3	$-10.131 \cdot 10^{14}\ \mathrm{J/m^3T^8}$
α_4	$-84.946\ \mathrm{J/m^3T^{10}}$	γ_0	$91.594 \cdot 10^7\ \mathrm{J/m^3T^2}$
α_5	$61.450\ \mathrm{J/m^3T^{12}}$	γ_1	$11.444 \cdot 10^{14}\ \mathrm{J/m^3T^4}$
α_6	$-20.916\ \mathrm{J/m^3T^{14}}$	γ_2	$44.708 \cdot 10^{21}\ \mathrm{J/m^3T^6}$
α_7	$2.770\ \mathrm{J/m^3T^{16}}$		

Publication IV, V and Page 53: A_s should be

$$A_\mathrm{s} = \frac{3\chi_0}{\mu_0 M_\mathrm{s}^2}.$$

Publication V

The value of parameter α_7 was erronous. The correct value is $\alpha_7 = 36.504$ $\mathrm{\mu J/m^3}$.

Page 57: At line 4, (3.30) should be (3.28).

Page 61: Equation (3.49) should be

$$\begin{bmatrix} \int_\Omega \boldsymbol{D}_\mathrm{m}^\mathrm{T} \frac{\partial \boldsymbol{H}}{\partial \boldsymbol{B}} \boldsymbol{D}_\mathrm{m} \mathrm{d}\Omega & \int_\Omega \boldsymbol{D}_\mathrm{m}^\mathrm{T} \frac{\partial \boldsymbol{H}}{\partial \boldsymbol{\varepsilon}} \boldsymbol{D}_\mathrm{s} \mathrm{d}\Omega \\ \int_\Omega \boldsymbol{D}_\mathrm{s}^\mathrm{T} \frac{\partial \boldsymbol{\sigma}}{\partial \boldsymbol{B}} \boldsymbol{D}_\mathrm{m} \mathrm{d}\Omega & \int_\Omega \boldsymbol{D}_\mathrm{s}^\mathrm{T} \frac{\partial \boldsymbol{\sigma}}{\partial \boldsymbol{\varepsilon}} \boldsymbol{D}_\mathrm{s} \mathrm{d}\Omega \end{bmatrix}.$$

Page 77: In the legend of Figure 4.12 (c), "Pure Shear" should be "Shear-I".

List of Symbols and Abbreviations

Latin Symbols

$\boldsymbol{a}$	Vector of nodal values of vector potential
$\boldsymbol{A}$	Magnetic vector potential
$\boldsymbol{A}_1$	Integral coefficient of the waveform controller
$\boldsymbol{A}_2$	Proportional coefficient of the waveform controller
$\boldsymbol{A}_\phi$	Gain of the phase angle controller
A_s	Simplified multiscale model parameter
$\boldsymbol{B}$	Magnetic flux density vector
$\boldsymbol{b}$	Direction vector of magnetic flux density
$\boldsymbol{B}_\mathrm{an}$	Anhysteretic flux density vector
$\boldsymbol{B}^i(t)$	Measured flux density waveform vector at i-th iteration
$\boldsymbol{B}_n$	Flux density vector of the n-th harmonic
B_p	Peak flux density
$\boldsymbol{B}^i_\mathrm{ref}(t)$	Reference flux density waveform vector at i-th iteration
$B_\mathrm{x}(t)$, $B_\mathrm{y}(t)$	Measured magnetic flux density waveforms along rolling and transverse directions
$B_\mathrm{x,ref}(t)$, $B_\mathrm{y,ref}(t)$	Reference magnetic flux density waveforms along rolling and transverse directions
c	Jiles-Atherton hysteresis model parameter
$c_\mathrm{0,ex}$	Stress free excess loss coefficient

$c_{0,\mathrm{hy}}$	Stress free hysteresis loss coefficient
c_{cl}	Classical eddy current loss coefficient
c_{ex}	Excess loss coefficient
c_{hy}	Hysteresis loss coefficient
$\mathrm{C_n}$	Domains for negative side of primary winding
$\mathrm{C_p}$	Domains for positive side of primary winding
c_{r}	Hauser hysteresis model parameter
d	Lamination thickness
$\boldsymbol{D}_{\mathrm{m}}$, $\boldsymbol{D}_{\mathrm{s}}$	Discrete derivative operators
$\boldsymbol{f}$	Body force vector
f	Frequency
f_k	Volume fraction
f_n	Frequency of the n-th harmonic
$\boldsymbol{h}$	Magnetic field direction vector
$\boldsymbol{H}$	Magnetic field strength vector
$\boldsymbol{H}_{\mathrm{conf}}$	Configuration field vector
$\boldsymbol{H}_{\mathrm{eff}}$	Effective field vector
$\boldsymbol{H}_{\mathrm{irr}}$	Irreversible field
$\boldsymbol{H}_{\mathrm{rev}}$	Reversible effective field
$\boldsymbol{I}$	Second order identity tensor
I_1, I_2, ..., I_6	Scalar invariants used in Helmholtz energy based model
$I_5{}'$, $I_6{}'$	Scalar invariants used in stress dependent iron loss model
I_{p}	Transformer primary winding current
$\boldsymbol{J}$	Current density vector
$\boldsymbol{k}$	Jiles-Atherton hysteresis model pinning parameter
k_{a}	Hauser hysteresis model parameter

k_r	Function to include stress dependency to coercive field in Hauser hysteresis model
k_r^0	Hauser hysteresis model parameter
l	Transformer axial length
$\boldsymbol{M}$	Magnetization vector
$\boldsymbol{M}_\mathrm{an}$	Anhysteretic magnetization vector
$\boldsymbol{M}_\mathrm{inv}$	Magnetization vector at the previous inversion of the magnetic loading direction
$\boldsymbol{M}_k$	Local magnetization vector
M_s	Saturation magnetization
N	Number of finite element shape functions
N_1	Number of turns in transformer primary winding
N_i, $i = 1, ..., N$	Finite element shape function
$p\left(\sigma_\mathrm{xx}, \sigma_\mathrm{yy}, \tau_\mathrm{xy}\right)$	Stress dependent iron loss density
p_cl	Classical eddy current loss density
p_ex	Excess loss density
p_Fe	Total iron loss density
p_hy	Hysteresis loss density
R	Transformer primary winding resistance
S_c	Transformer cross section area
t	Time
T	Period
$\boldsymbol{T}$	Clarke transformation matrix
$\boldsymbol{t}_\mathrm{amp}$	Tolerance vector for amplitude controller
$\boldsymbol{t}_\phi$	Tolerance vector for phase angle controller
$\boldsymbol{u}$	Vector of nodal values of displacements
$\boldsymbol{U}$	Displacement vector

U_1	Transformer primary winding voltage
$U_\alpha(t)$, $U_\beta(t)$	Voltage waveforms in $\alpha\beta$ coordinate system, α and β components
$\boldsymbol{U}^i_{\alpha\beta}(t)$	Voltage waveform vector in $\alpha\beta$ coordinate system at i-th iteration
$\boldsymbol{U}^0_{\mathrm{abc}}(t)$	Initial 3-phase magnetizing voltage waveform vector
$\boldsymbol{u}_k$	Magnetization orientation direction vector in a domain
W_k	Local free energy
W_k^{mag}	Magnetostatic energy
W_k^{me}	Magneto-elastic energy

Greek Symbols

α_i, β_i, γ_i	i-th Helmholtz energy based model parameters. Numbers of α_i, β_i, γ_i are material.
α_{ja}	Jiles-Atherton hysteresis model parameter
β_{e}, β_{h}, γ_{e}, γ_{h}	Stress dependent iron loss model fitting parameters
δ	Constant for defining the inversion of the magnetic field direction
Δp	Iron loss density variation
$\boldsymbol{\varepsilon}$	Mechanical strain tensor
$\tilde{\varepsilon}$	Deviatoric part of the mechanical strain tensor
$\boldsymbol{\epsilon}^i_{\mathrm{amp}}$	Amplitude ratio vector at i-th iteration
$\boldsymbol{\varepsilon}^{\mu}$	Magnetostriction strain tensor
ε^{μ}_k	Local magnetostriction strain tensor
$\boldsymbol{\epsilon}^i_{\mathrm{wav}}$	Waveform error vector at i-th iteration
$\epsilon^i_{\mathrm{x,wav}}$, $\epsilon^i_{\mathrm{y,wav}}$	Waveform error i-th iteration, rolling and tranverse direction components

$\boldsymbol{\epsilon}_{\phi}^{i}$	Phase angle error vector at i-th iteration
ζ	Hauser hysteresis model parameter
η	Simplified multiscale model parameter
θ	Angle between saturation magnetization and the applied stress
κ	Hauser hysteresis model parameter
κ_0	Value of the parameter κ previous inversion of the magnetic loading direction
κ_{ini}	Initial value of the parameter κ
λ, G	Lamé constants
λ_{s}	Saturation magnetostriction
μ_0	Permeability of free space
ν_0	Reluctivity of free space
ρ	Resistivity
$\boldsymbol{\sigma}$	Mechanical stress tensor
σ, τ	Mechanical stress amplitudes along principal and shear directions
$\tilde{\boldsymbol{\sigma}}$	Deviatoric part of the stress tensor
$\boldsymbol{\sigma_0}$	Initial stress tensor
σ_{eq}	Equivalent stress
σ_{xx}, σ_{yy}, τ_{xy}	In-plane mechanical stress components in cartesian coordinate system
$\boldsymbol{\phi}_{\boldsymbol{B}}^{i}$	Phase angle vector of flux density $\boldsymbol{B}^{i}(t)$ at i-th iteration
$\boldsymbol{\phi}_{\boldsymbol{B}_{\text{ref}}}^{i}$	Phase angle vector of reference flux density $\boldsymbol{B}_{\text{ref}}^{i}(t)$ at i-th iteration
$\boldsymbol{\phi}_{\boldsymbol{U}_{\alpha\beta}}^{i}$	Phase angle vector of voltage $\boldsymbol{U}_{\alpha\beta}^{i}(t)$ at i-th iteration
χ_0	Stress free initial susceptibility

ψ	Helmholtz free energy density

Abbreviations

2D	Two dimensional
3D	Three dimensional
B-H	Magnetic flux density versus magnetic field strength curve or loop
DDS	Density domain switching (model)
FE	Finite element
FEA	Finite element analysis
FEM	Finite element method
GO	Grain oriented
HE	Helmholtz energy based (model)
NO	Non oriented
RSD	Relative standard deviation
RSST	Rotational single sheet tester
Si-Fe	Silicon iron (alloy)
SM	Simplified multiscale (model)
SS	Standard square (model)