Core Loss by the Steinmetz Equation with Eddy Current Part

Hysteresis loss by the Steinmetz equation and classical eddy current loss of a laminated core, per kilogram and for the whole core, at a frequency and flux density.

Method: Steinmetz hysteresis law and classical eddy current loss

Input parameters

Unit system: SI

Parameter	Value	Unit
Frequency	50.000	Hz
Peak flux density	1.5000	T
Hysteresis coefficient (W/kg at 1 Hz, 1 T)	0.012000	
Steinmetz exponent	1.8000	
Lamination thickness	0.27000	mm
Steel resistivity	48.000	μΩ·cm
Steel density	7,650.0	kg/m³
Core mass	450.00	kg

Calculated results

Parameter	Value	Unit
Hysteresis loss (W/kg)	1.2448	
Classical eddy current loss (W/kg)	0.18369	
Total specific core loss (W/kg)	1.4285	
Core loss of the whole core	642.84	W

Notes for this case

• Steinmetz found hysteresis loss per cycle grows as B̂ⁿ with n ≈ 1.6–2, so the loss per kilogram is k_h·f·B̂ⁿ. Eddy currents in a thin lamination with sinusoidal flux give the classical loss π²d²f²B̂²/(6ρ_eρ_m) per kilogram. Measured loss exceeds the sum by an 'excess' (anomalous) part from domain wall motion, so fit k_h and n to the steel's published loss curve; thinner laminations and higher-silicon steels cut the eddy part.

Formula and method

$$p_h = k_h \widehat{f B^n}, \quad p_e = \frac{\pi^2 d^2 \widehat{f^2 B^2}}{6 \rho_e \rho_m}$$

Variables

f	Frequency	1/s
$\widehat{B}$	Peak flux density	T
k_h	Hysteresis coefficient (W/kg at 1 Hz, 1 T)	-
n	Steinmetz exponent	-
d	Lamination thickness	m
ρ_e	Steel resistivity	Ω·m
ρ_m	Steel density	kg/m³
m	Core mass	kg
p_h	Hysteresis loss (W/kg)	-
p_e	Classical eddy current loss (W/kg)	-
p	Total specific core loss (W/kg)	-

P_{core}	Core loss of the whole core	W

Method and standards

Core loss.

Assumptions and limits

- Sinusoidal flux; lamination thin compared with the skin depth.

References

Steinmetz hysteresis law and classical eddy current loss

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/transformers/steinmetz-core-loss

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.