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Improved Iron Loss Prediction in Transformers

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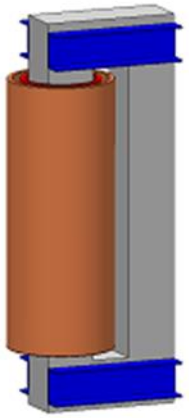
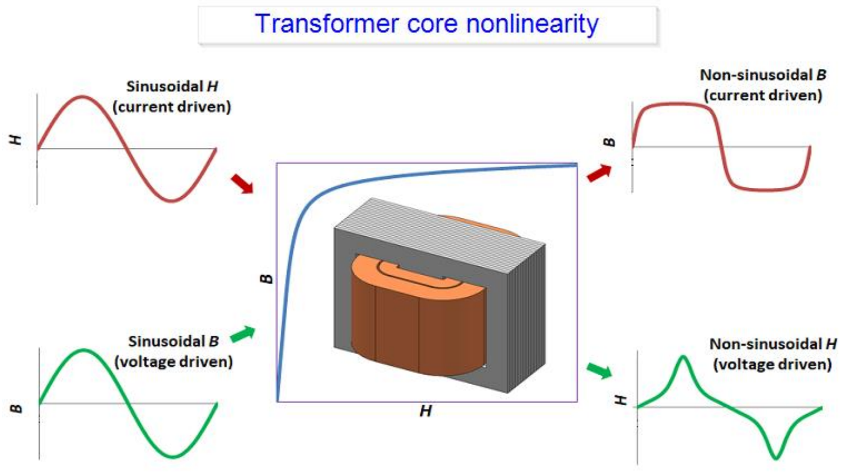
Improved Iron Loss Prediction in Transformers

Accurate iron loss prediction with minimal solution-time is desirable in power transformer design. However, it requires accurate treatment of nonlinearities, which are rigorously handled by Simcenter MAGNET's transient solvers at the cost of longer solution-times. The sheer size of these power devices and the inherent 3D analyses, further increases the solution-time significantly. This example shows that a Simcenter MAGNET time-harmonic solver can predict the same iron loss as a transient solver within a fraction of the time. A 90 % reduction in solution-time was achieved in this example of a 100 kVA single-phase distribution transformer.



The example also touches on the time-harmonic BH curve modifying parameters that also account for voltage (sinusoidal B) or current (sinusoidal H) supplies, the voltage start-up point for single-phase transformers to reduce transient time, and validation of the flux density and iron losses predicted by Simcenter MAGNET‘s time-harmonic solvers.

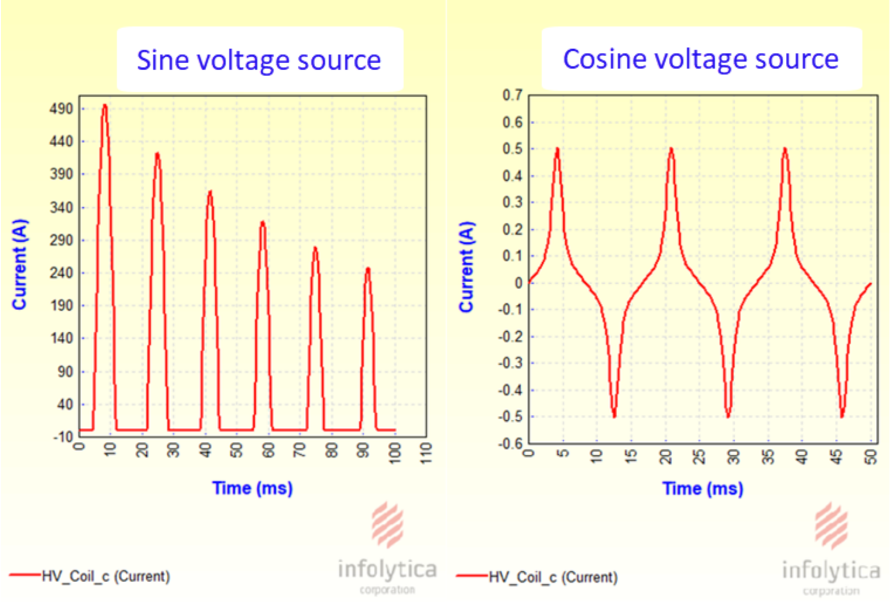
TRANSFORMING THE BH CURVE FOR NONLINEAR TIME-HARMONIC ANALYSIS



Time-harmonic analysis is usually done at a single frequency. However, as seen in the figure, when a sinusoidal H or B field is applied to a nonlinear core, the corresponding B or H waveform is non-sinusoidal, affecting the predicted iron loss.

To improve the approximation of the core nonlinearity, Simcenter MAGNET's time-harmonic solvers transform the BH curve, tuning the predicted iron losses against the transient or measured iron losses. The user can specify whether the model is voltage or current driven.

VOLTAGE SOURCE SETTINGS TO REDUCE TRANSIENT SOLUTION-TIME



The accurate prediction of iron losses in a transient solve requires the solution to reach steady-state, and the losses be averaged over one or multiples of the supply cycle. This is in addition to the time-step resolution needed to account for nonlinearities such as harmonics.

In single-phase transformers, the supply voltage should be a cosine waveform, as a sine waveform requires more time to reach steady-state. It took 16 ms (a cycle) for the current to reach steady-state for the cosine voltage source, while for the sine voltage source, it is evident that it requires a significantly long solution-time.

PEAK FLUX DENSITY DISTRIBUTION

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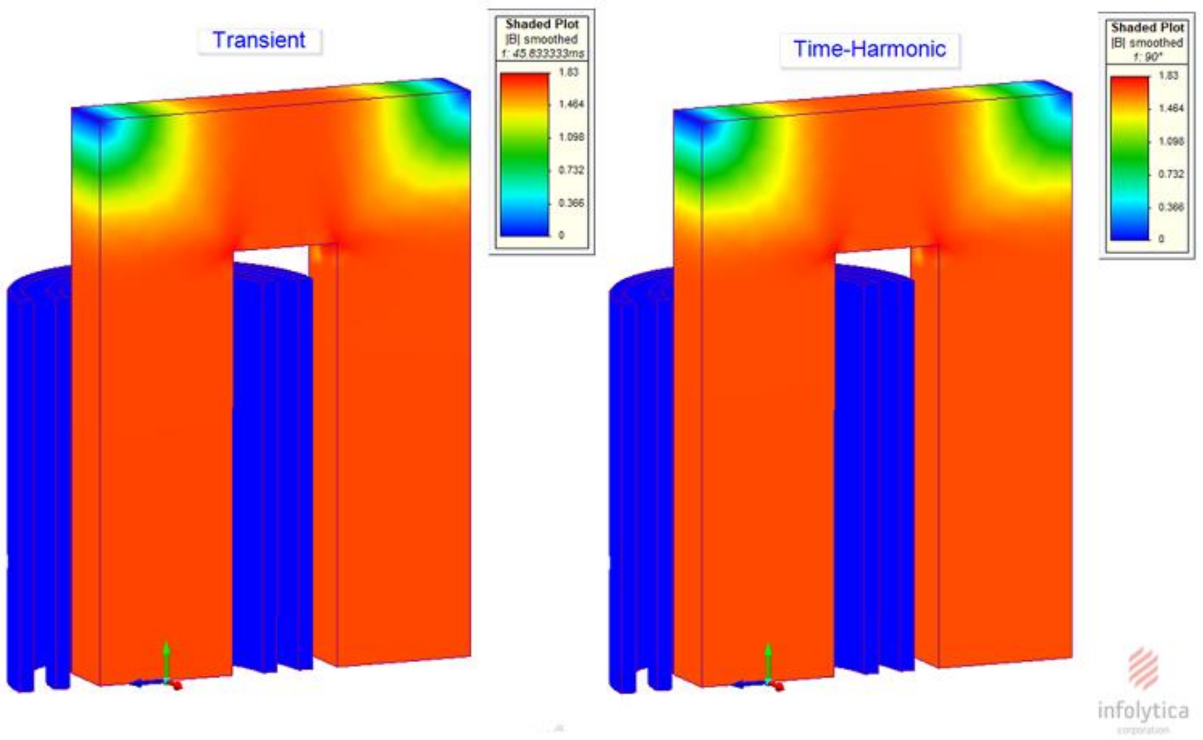

Since the transformer was voltage driven (sinusoidal B), the solver was configured so that the time-harmonic waveforms will have the same peak as the transient waveforms. The figures show that the peak flux density distribution of the time-harmonic solver matches that of the transient solver.

PREDICTED IRON LOSSES

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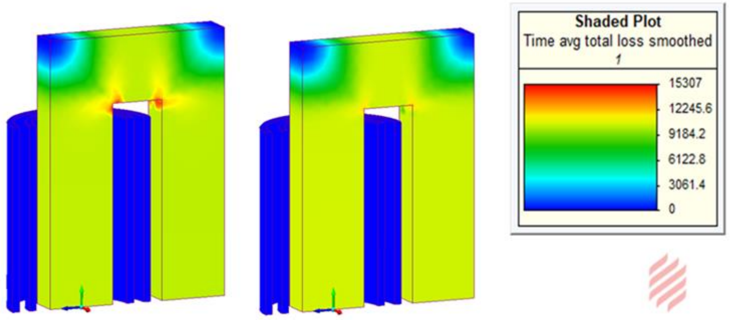
Simcenter MAGNET's treatment of nonlinear materials in time-harmonic solvers improves the accuracy of predicting iron losses to match those of a transient solve, with a great reduction in solution-time. This is validated in the table, which also shows that the user can adjust the BH curve modifying parameters to match the iron loss to the transient or measured one. The iron loss distribution as seen in the following figures, further confirms the accuracy of Simcenter MAGNET's time-harmonic solvers in predicting iron losses.

Solver	α	β	Iron Losses (W)	Solving time	Δt (%)
TH	0.5*	TransformForBestFit*	226.0	1 min 34 secs	95
TH	0.1	InterpretAsPeak	228.0	3min 12secs	90
TR	N/A	N/A	229.2	33 mins	N/A

TH - Time-Harmonic solver
TR - Transient solver
* - default case
α - MaterialBHACInterpolationFactor
β - MaterialBHACOption



Transient Solution (229.2 W, 33 minutes)

Time-Harmonic Solution (228 W, 3 minutes)

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