HSLU Hochschule Luzern

Technik & Architektur
Structural Mechanics
Master of Science - Mechanical Engineering

Master Thesis - Mechanical Engineering

Predictive Structural FEA & Validation on MV-Drive-Systems

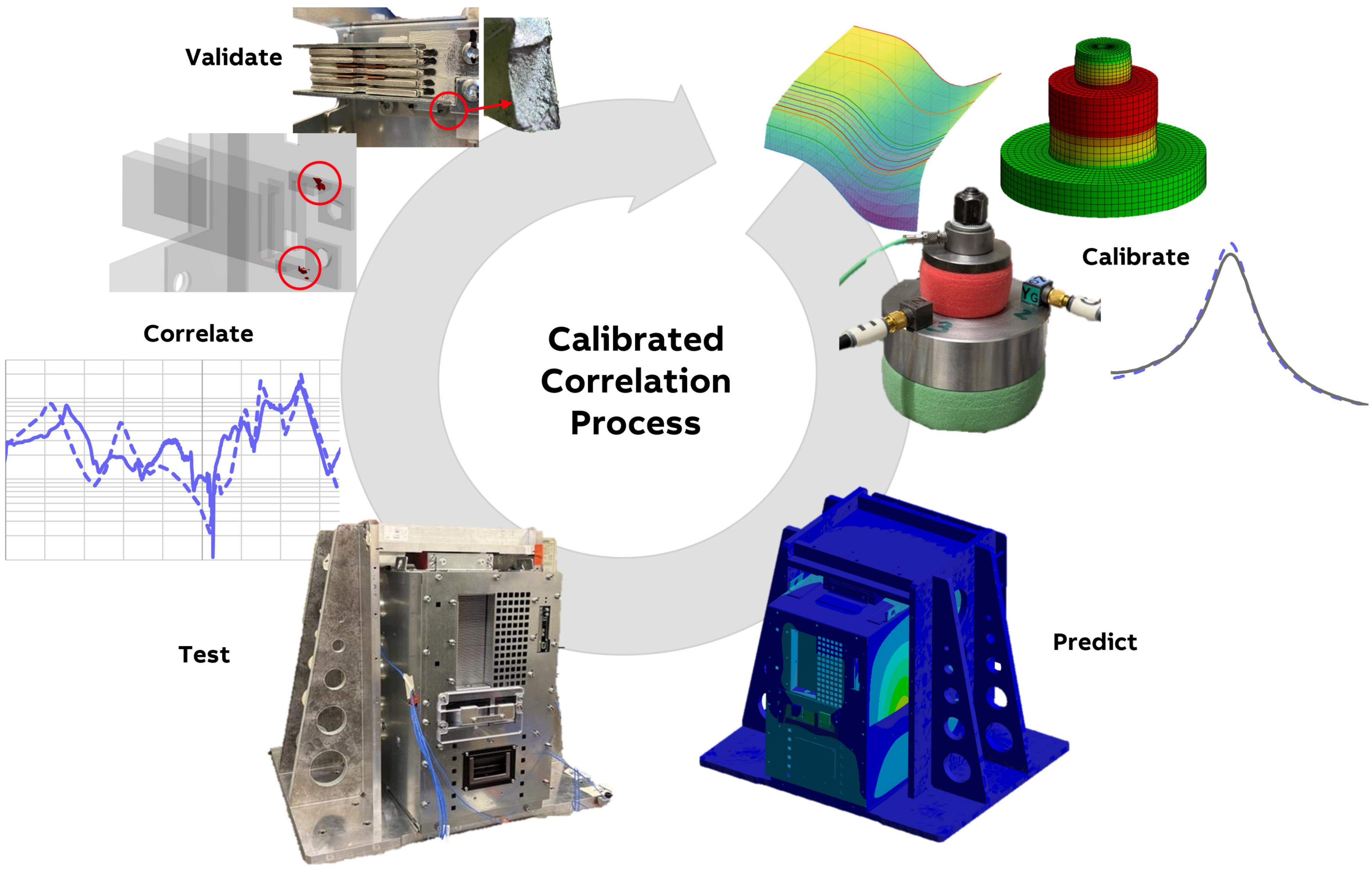

Figure: Calibrated correlation process for high-fidelity, predictive simulation

Motivation & Objective

Structural dynamic simulations shall be applied to enable first time right testing of medium-voltage drive systems.
Correlation of qualification tests was established.
While accurate frequency response correlation represents a necessary validation criterion, stress- & fatigue-envelope prediction is of most tangible benefit during the design process.
A "good enough" methodology was established, where failure hotspots were accurately predicted. Gaps in frequency response prediction were identified, due to uncertainties related to material data, connection modeling, damping representation, and boundary conditions.

Simulation-supported lean design approach has been proposed enabling first-time-right testing campaigns.

Methods

A bottom-up finite element modelling methodology is applied to understand the effect of different assumptions for establishing physically consistent and transferable models.
Characteristic structures are identified using a Design-of-Experiments approach and calibrated through combined numerical simulation and experimental vibration testing.
Material data, contact and joint representations, bolted connection simplifications, and spring–damper modeling are systematically assessed.
Calibrated assumptions are transferred to higher structural levels using modal, harmonic, and spectral fatigue analyses.

Results

Accurate stress- envelopes were predicted successfully for different models. Modelling assumptions were documented and tuned for better system reaction understanding physical integrity.
Frequency correlation is confirmed as a necessary validation criterion, but only meaningful for fatigue assessment when achieved through physically consistent modeling.
Fatigue-relevant stresses were dominated by low-frequency, high deformation modes. Fatigue-critical locations were identified prior to physical testing and experimentally confirmed.
Early detection of design-induced nonlinear boundary conditions enabled assessment of their influence on dynamic response and test scatter.

The methodology provides a robust foundation for simulation-driven design and is transferable to a wide range of modular industrial medium-voltage systems.

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