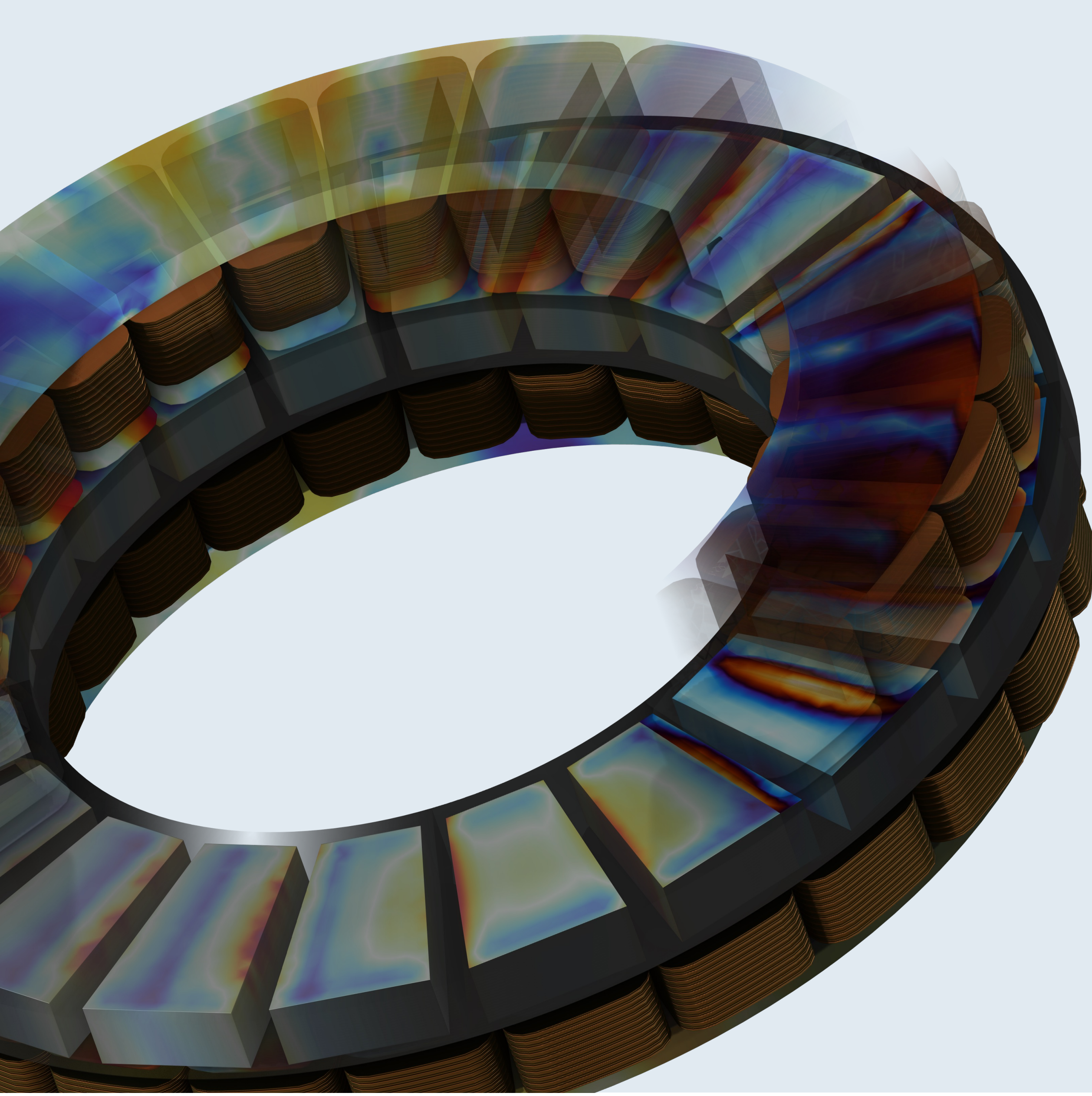




3D Axial Flux Motor: Electromagnetic Simulation & Parametric Optimization

Parametric electromagnetic model validated by physical twin. Utilized in rapid development cycles, optimizing for any customer demand.

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Abstract

The architecture of axial flux machines has gained strong popularity in recent years due to its enhanced torque density in comparison to conventional radial flux motors, but finding the best configuration for specific applications is a multiparametric optimization problem, which is difficult to solve using traditional parameter sweeps or manual trial and error. In this project, a high-fidelity

electromagnetic model of an axial flux motor was combined with parametric optimization to search for the optimal parameter configuration of the motor based on arbitrary customer demand. This process completely bypasses manual iteration, accelerating motor development cycles using tools within COMSOL Multiphysics®.

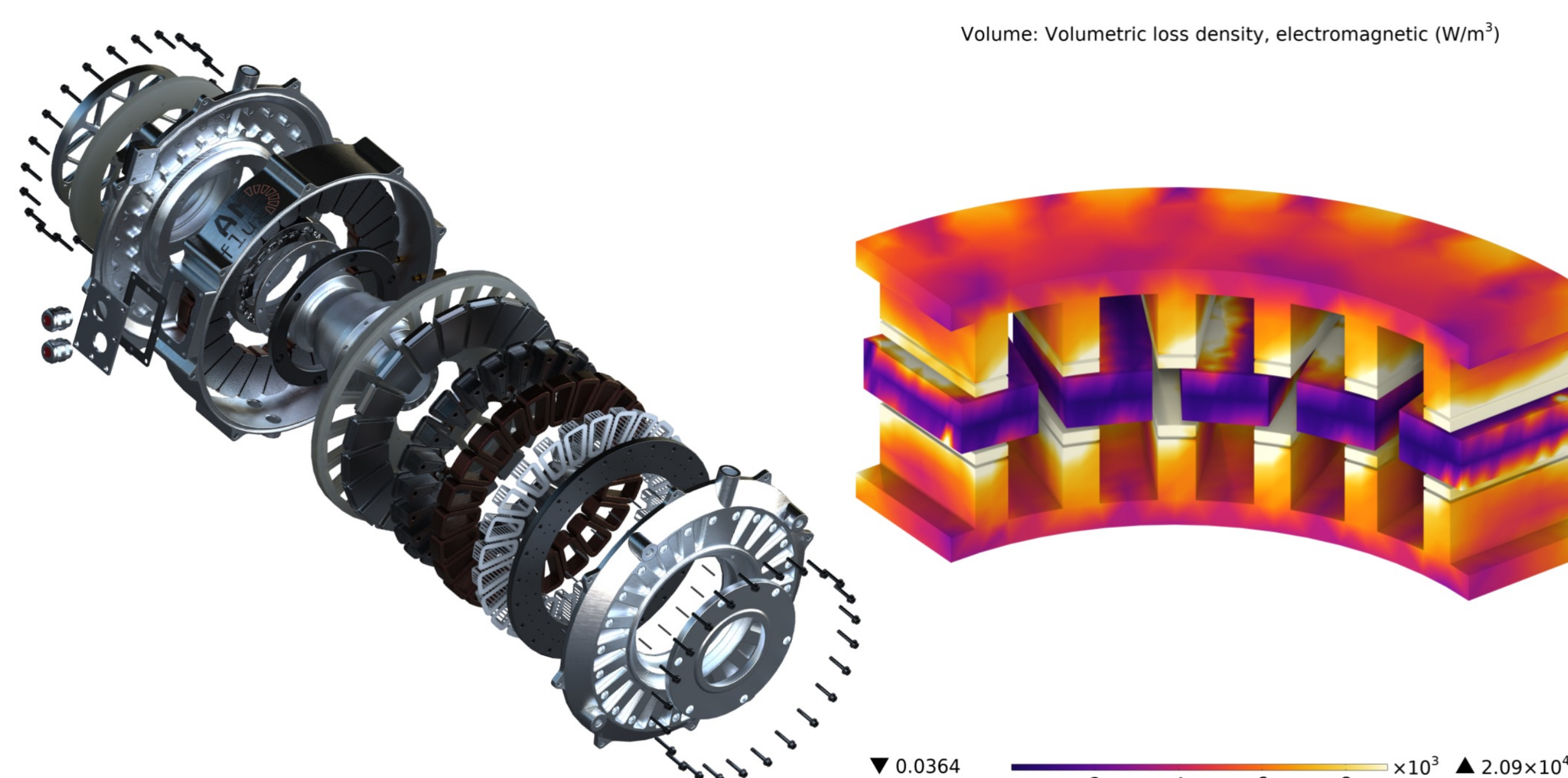


Figure 1 Left: Explosion view of AMflux Prototype B, AFIR-Configuration
Right: Frequency-dependent loss of soft magnetic compound and permanent magnet in default model

Methodology

The **Rotating Machine, Magnetic (RMM)** and **Moving Mesh** interfaces were used to set up the electromagnetic simulation. The core components of the 20-pole, 24-slot permanent magnet motor are modeled parametrically using the **Design Module**, based on initial designs of actual CAD data. The soft magnetic property of the AMflux developed additively manufactured Ferrosilicon wt. 6.5% is approximated using custom B-H curve. The resulting model outputs torque, motor related constants, energy consumption, ripple harmonics and loss calculation. (Figure 1b)

The base model is then fed into a **Parameter Optimization** study, including 11 geometric and 2 electrical control variables. Furthermore, the objective functions (e.g., torque density or motor constant) and constraints (geometric and electrical) are defined according to customer demand.

Results

The baseline model was partially validated through comparison to the testing results of the physical twin. The simulated **nominal dynamic torque** yielded an error of 1.13% in comparison to the measurements.

Moreover, the algorithm was chosen based on its performance on the nonlinear Rosenbrock function, emulating the real search space. The results show that the **BOBYQA**-algorithm converged in the fewest iterations while also exploring the largest section of the search space, compared to COBYLA and Nelder-Mead. (Figure 2b)

By utilizing the optimization pipeline in a demonstration run (Figure 2a), the motor doubled its **motor constant (K_m)** over 300 iterations, while also including max. total thickness and max. resistive losses constraints, validating the pipeline's ability to effectively improve the motor's performance according to customer's demands.

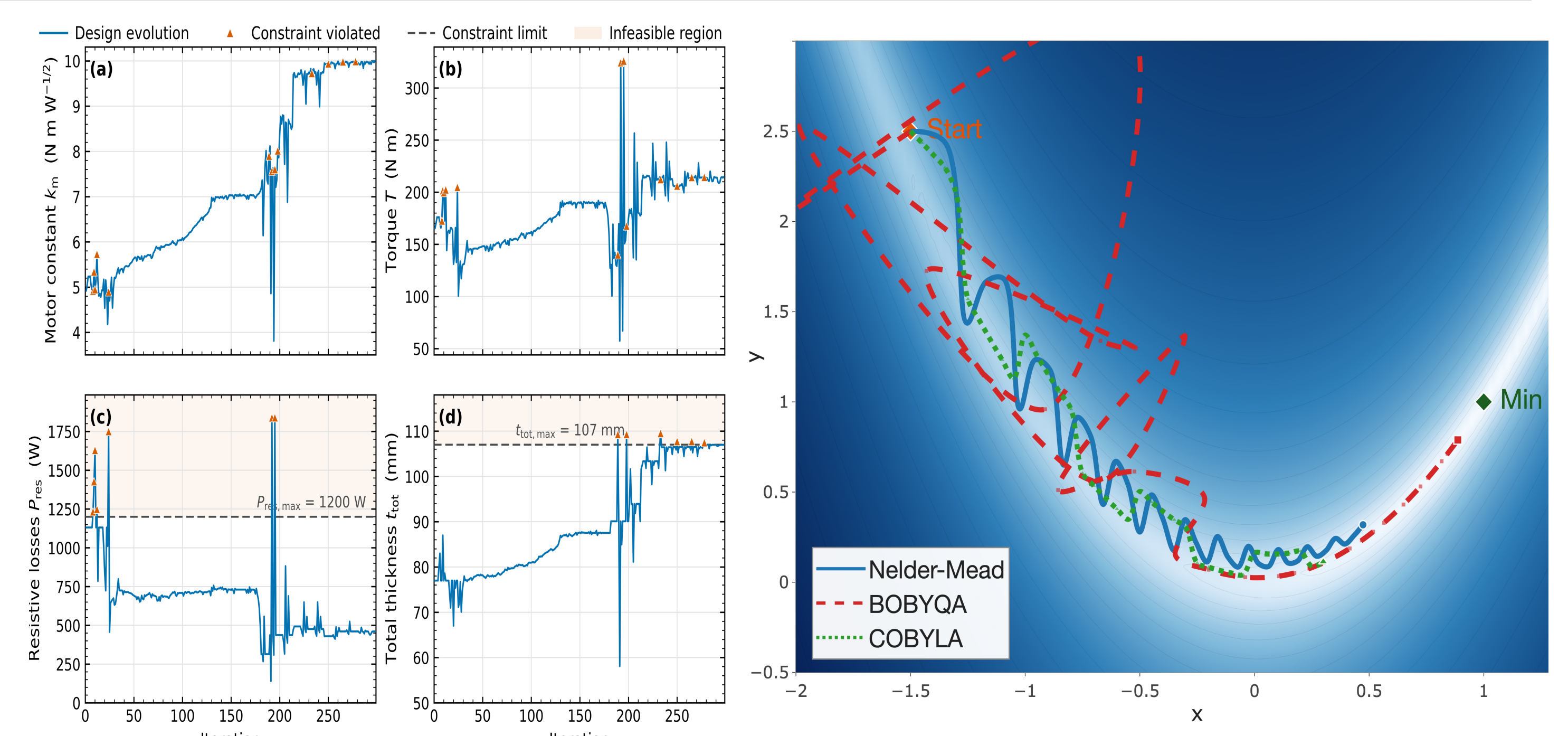
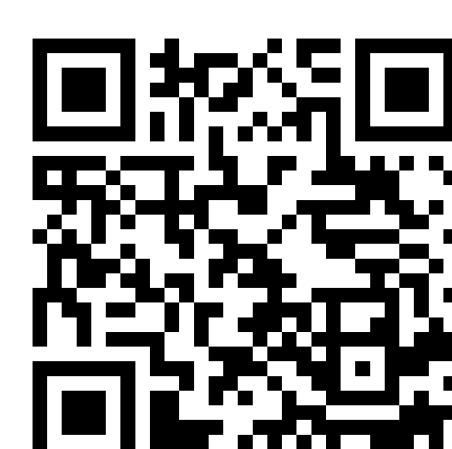


Figure 2 Left: Motor constant, torque, resistive losses and total thickness over optimization iterations
Right: Optimization algorithms on the Rosenbrock function, iteration 36/50

REFERENCES

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