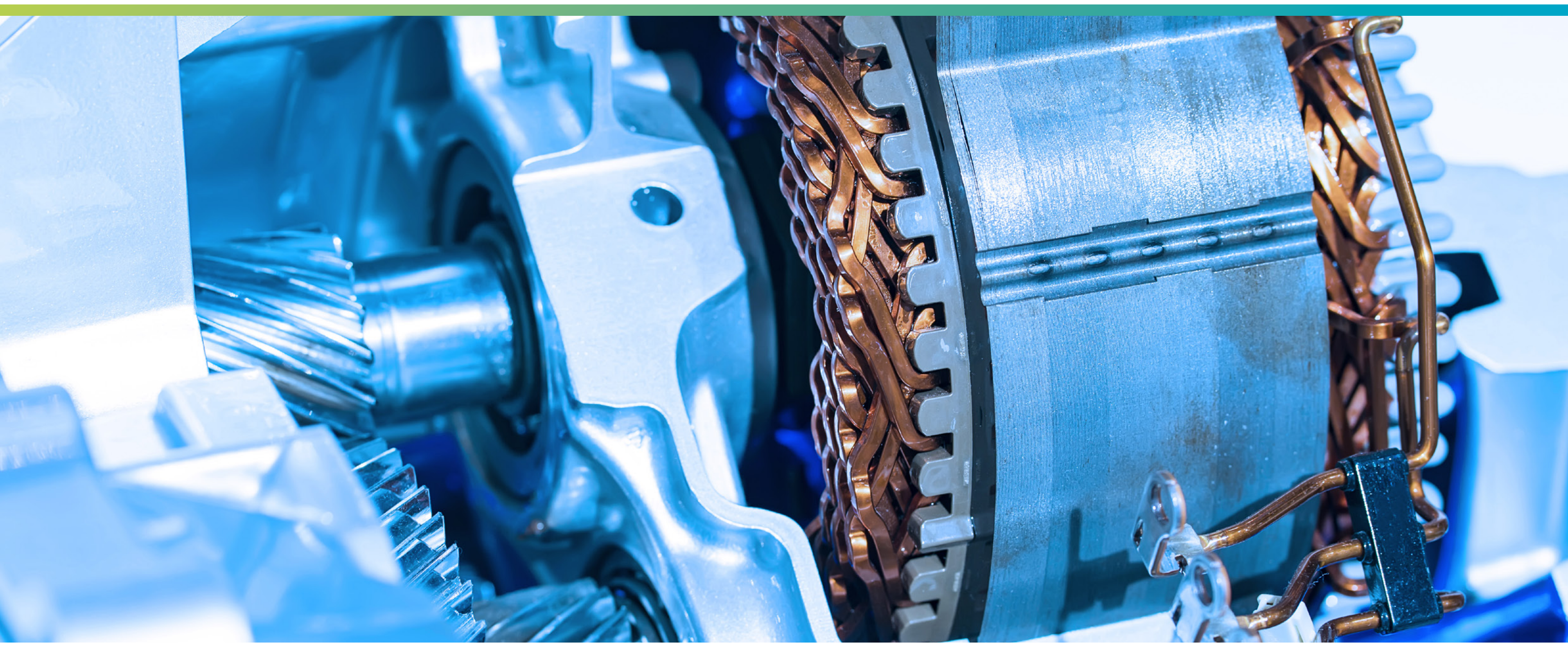
Case study

Smart motor designing with ODYSSEE CAE

Nagaoka University of Technology – Nagaoka, Japan



ODYSSEE CAE reduces modeling time by 87%.

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Nagaoka University of Technology establishes itself as an indispensable member of the global society by producing engineers with practical and creative capabilities. The multiple research centers inside Nagaoka University of Technology lead with cutting-edge technology. Companies have formed many partnerships due to Nagaoka University of Technology's focus and passion for technology and engineering.

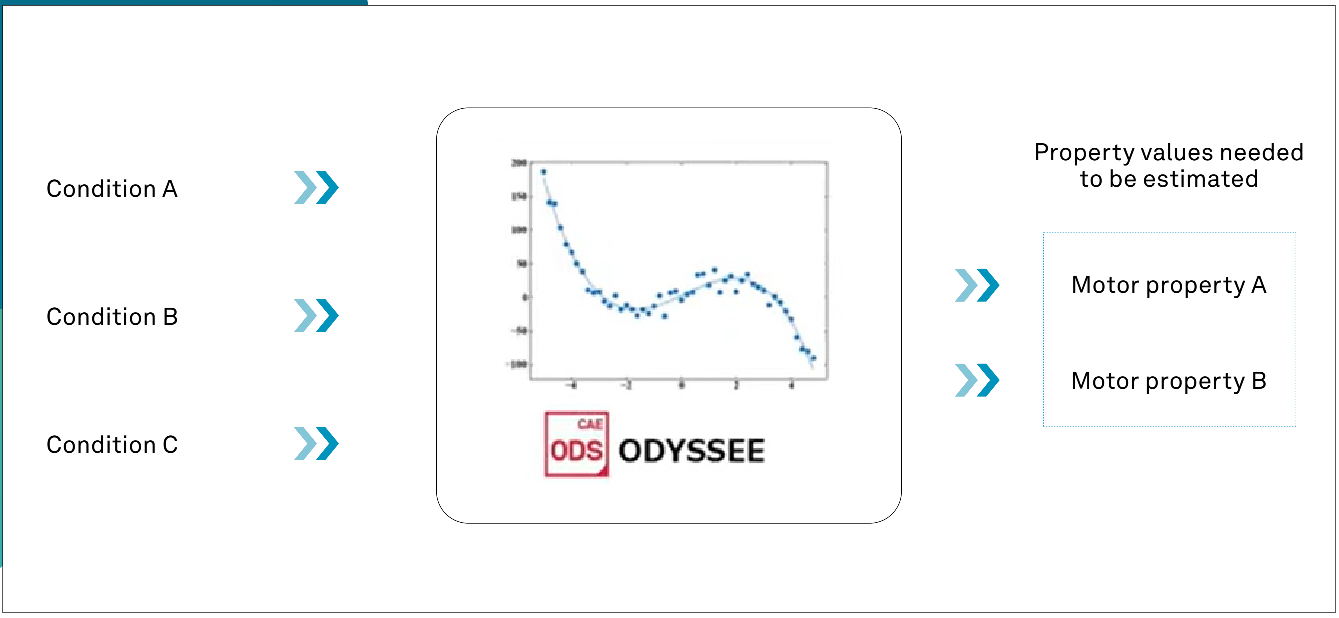

Fig 1: Simplified view of ODYSSEE CAE. The conditions A-C represent different current conditions supplied by the inverter, and the motor properties represent the accelerating power (torque) and vehicle speed (rotational speed).

Challenge

Electric vehicles are gaining popularity with consumers, and the market share expects to grow to over 2 million electric vehicles by 2035. The increasing variety of electric vehicles requires higher performance electric motors to meet the vehicle requirements. Achieving these requirements is getting more difficult for electric motor design engineers. Each new electric motor design needs to be analysed and simulated before being produced into a high-performance motor.

Establishing higher performances in electric motors is difficult. One challenge in achieving this is to optimise the motor parameters geometrically. This optimisation requires a large amount of computation power to model the non-linear electromagnetic dynamics in the motor. The second challenge for high-performance motors is predicting and optimising the properties for a wide range of load conditions. There is a sizeable computational need to simulate all these analyses to find the optimal current conditions, which takes a significant amount of time. This amount of time and simulations increases the time needed to go from the concept to production in newer electric vehicles.

Solution

The two challenges of optimising the motor shape parameters and the current load for a wide range of conditions were separated and worked on independently.

The target of motor shape optimisation was maximising the average torque while minimising the torque ripple. The optimisation uses a genetic algorithm. The genetic algorithm initially used only FEM simulations.
Using ODYSSEE CAE machine learning to replace the 1200 FEM simulations with an accurate model reduces the time needed for the genetic algorithm to converge. The reduced order model was trained to saturation with 387 FEM simulations.

Determining the optimal current load for the multiple load cases leads to improving the driving efficiency of an automotive motor. The modified parameters are the stator coil, magnet, and rotor coil. The entire current load trade-space was initially simulated with over 1800 FEM analyses. ODYSSEE CAE was then used to model the same trade-space with only 240 FEM analyses. The machine learning functions effectively model the motor properties based on the parameters.

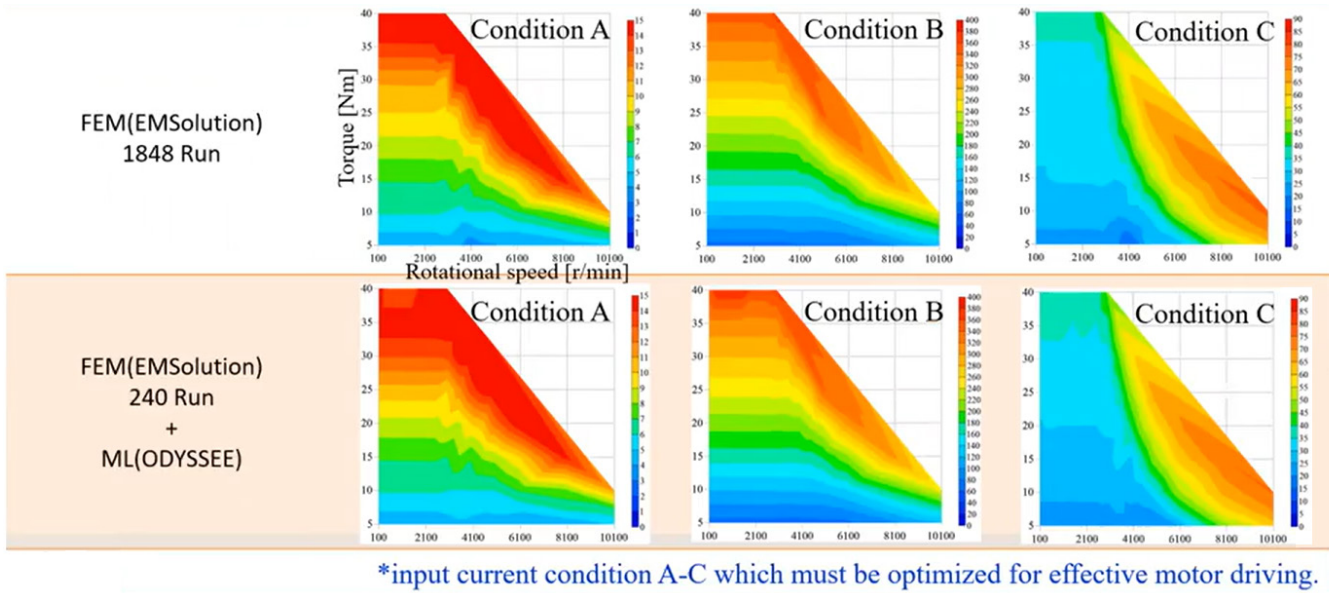

Fig 2: The comparison between using only FEM simulations and using machine learning with ODYSSEE CAE.

Results

ODYSSEE CAE reduced the time needed for optimising the motor parameters in both challenging cases. ODYSSEE CAE used a fraction of the time required by the FEM-only approach with similar accuracy.

For the initial shape optimisation challenge, ODYSSEE CAE reduced the time from 10.3hrs to 3.2hrs (68.9% total calculation time reduction). The results were accurate to the FEM simulations with only slight deviations based on the non-linear properties.

The optimisation of the motor's parameters for the load current in multiple load cases was achieved with ODYSSEE CAE machine learning. The initial run with 1848 FEM simulations was reduced to 240 analyses to train the reduced order model. This corresponds to the time reduction of 87%, 30.8hrs to 4.0hrs. The predicted results from the reduced model were highly accurate, matching the FEM values.

By using the ML (ODYSSEE), we can reduce the number of FEM about 87.0% with high estimation accuracy."

Prof. Yuki Hidaka
Associate Professor

Key highlights
Product: ODYSSEE CAE
Industry: Automotive
Benefits: • ODYSSEE CAE reduces modeling time by 87%

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