Seat Motor Design Optimization

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INTRODUCTION: Presented in this work is a COMSOL multi-physics based design optimization of a head restraint motor module, which contains a BLDC motor and controller. The electronically controlled motor provides better human machine interface performance for the head restraint in a car seat.

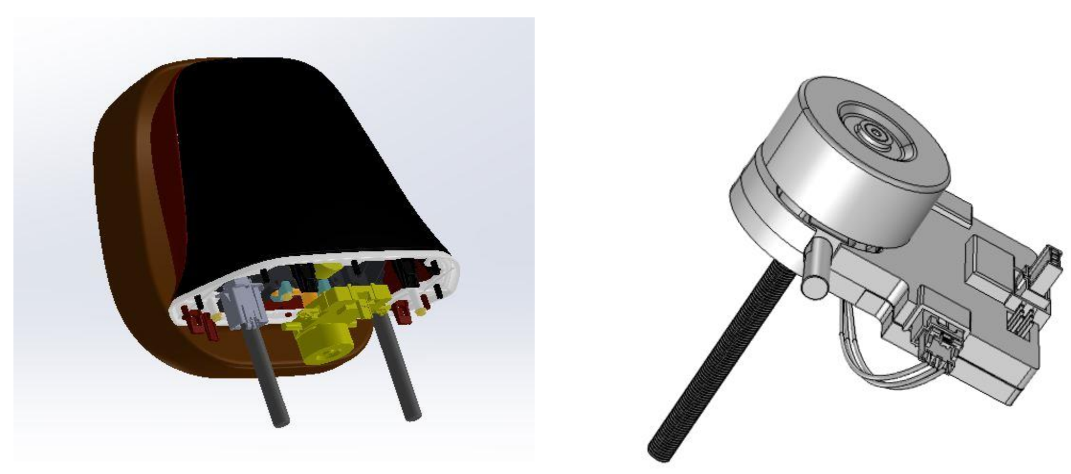

Figure 1. Head restrain module and the motor with controller

COMPUTATIONAL METHODS: Within our virtual product development environment frame work, multi-scale models are first developed and then electromagnetic, thermal, mechanical and other analysis were performed to obtain result to correlate physics and test result. These result is used to guide product design development for the next level. The prototype design first done by reduced order models and benchmark parts. Then parameterized COMSOL models are used to find optimized design. As an example, magnets parameters, including remnant flux density, ring thickness, fillet angle, etc., were optimized based on overall product targets. The optimized magnets then were implemented in the motor assembly EM analysis for torque, winding and current load analysis. Iron, copper, coil and magnet losses were obtained from the final confirmed EM model and used in the thermal analysis. The COMSOL governing equation for EM and thermal analysis are :

$$\sigma\frac{\partial A}{\partial t} + \nabla \times \left(\frac{1}{\mu}\nabla \times A\right) = 0; \nabla \times E = -\frac{\partial B}{t}; B = \mu^{*}\mathrm{H}$$

$$\rho C_p u \cdot \nabla T + \nabla \cdot q = Q + Q_{ted}; q = -k\nabla T$$

RESULTS:

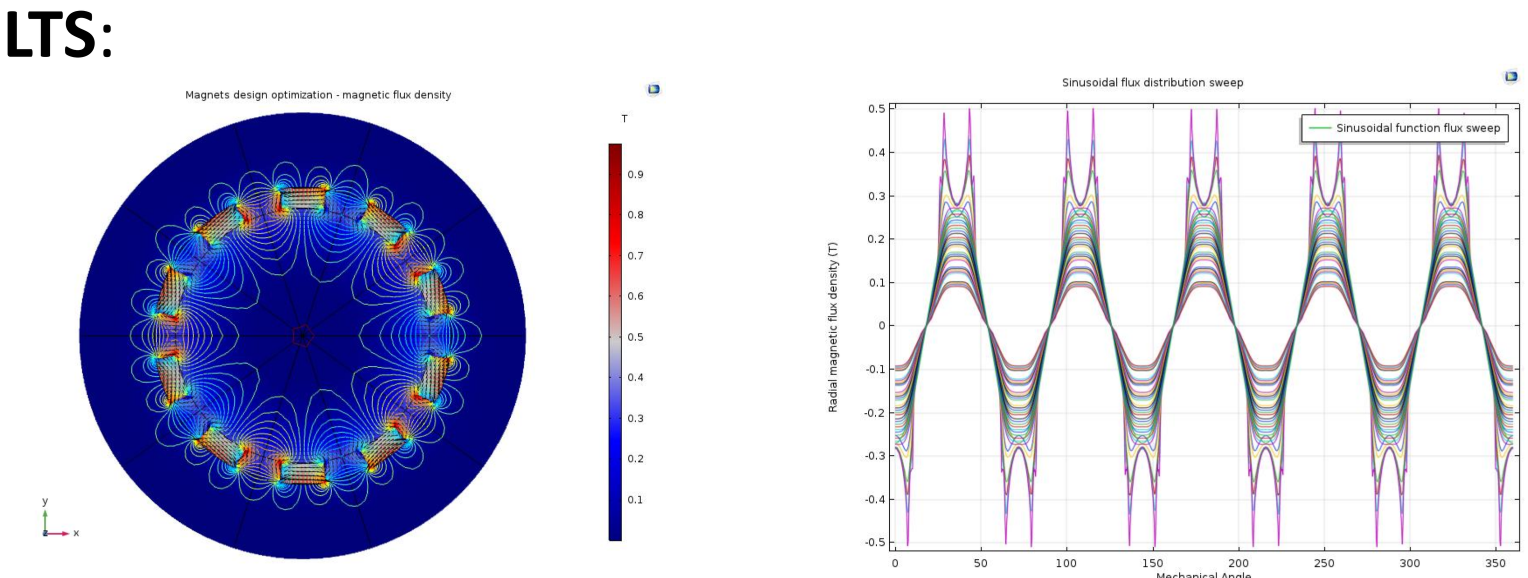

Figure 2. Parameter based permanent magnets design

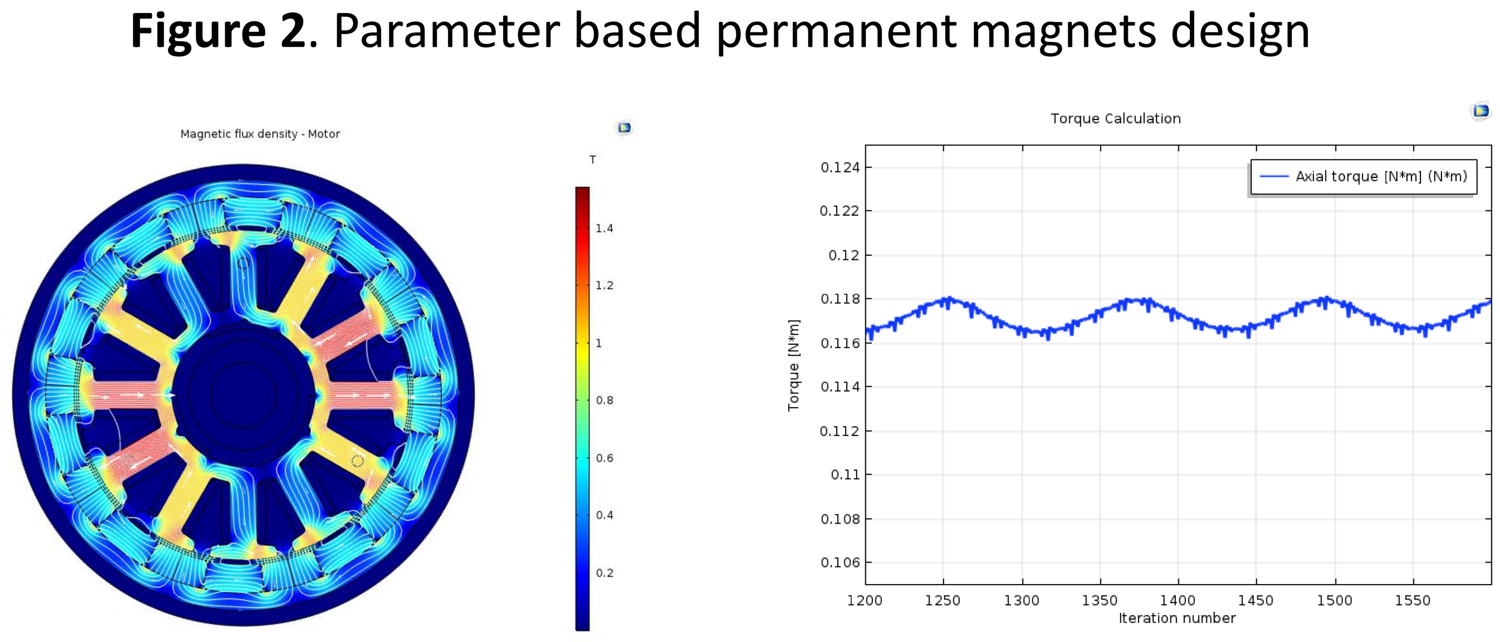

Figure 3. Motor flux density and torque at rated RPM

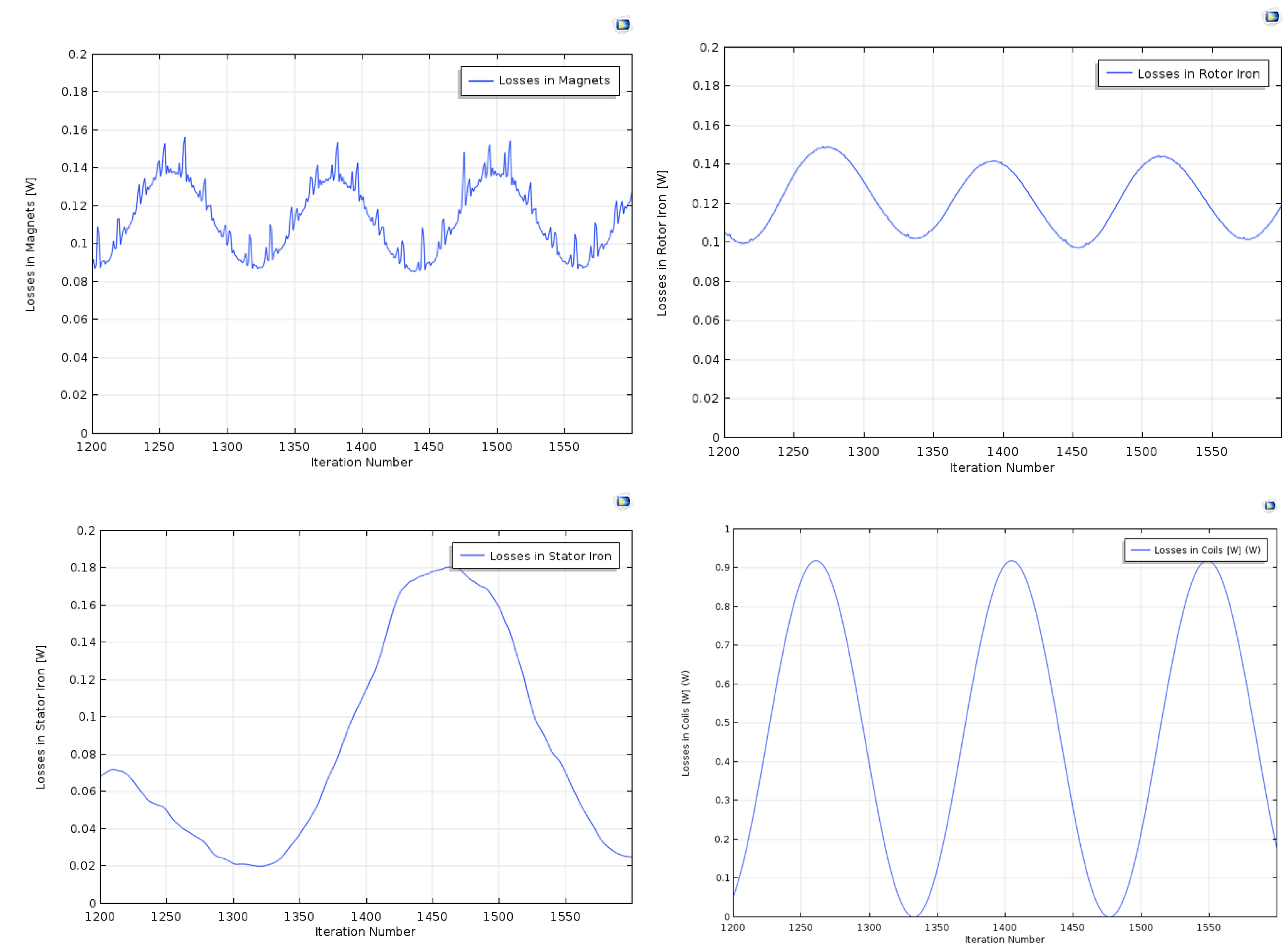

Figure 4. Magnet, rotor iron, stator iron, and coil losses from EM analysis

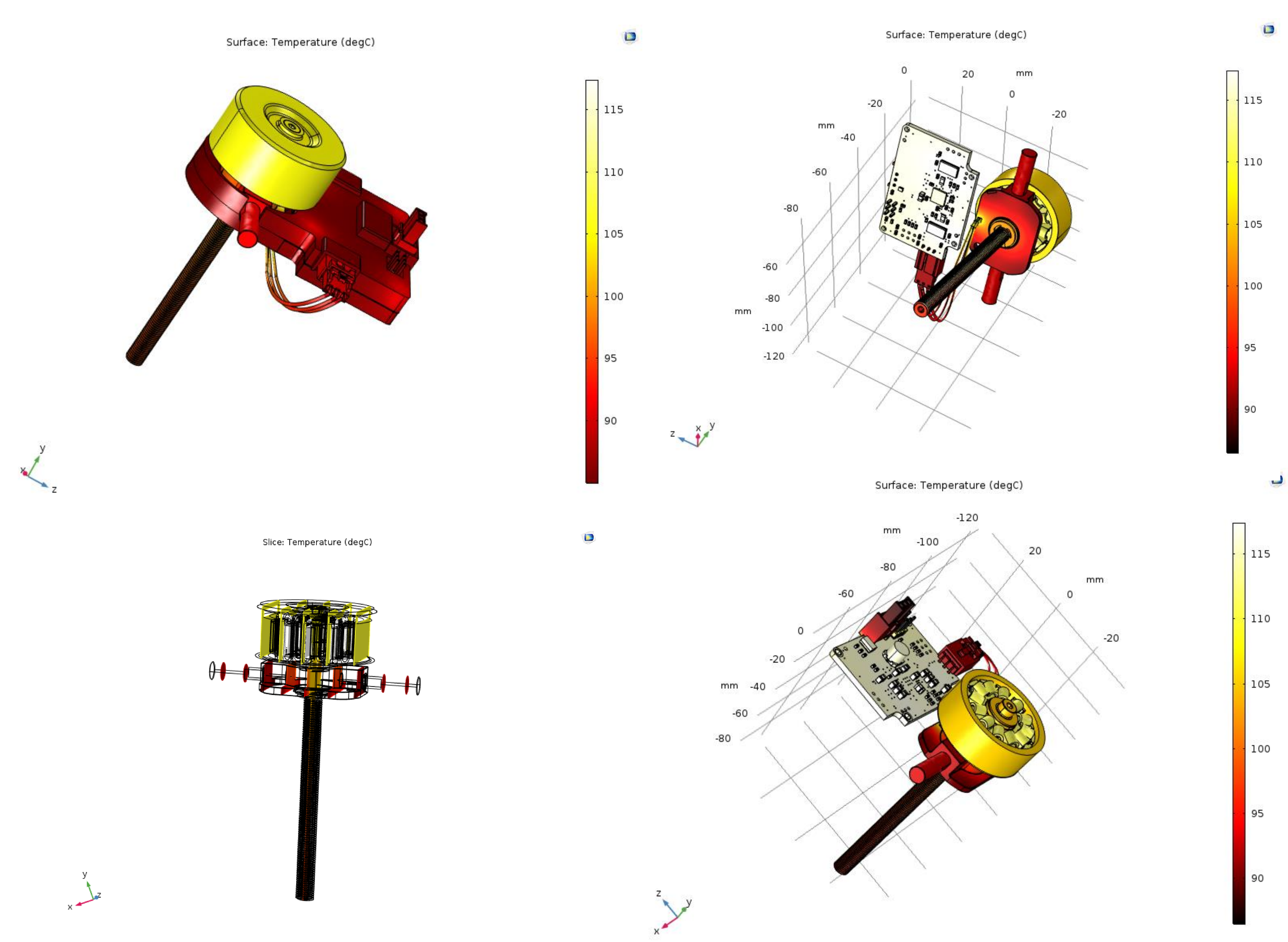

Figure 5. Head restraint motor thermal analysis result

CONCLUSIONS: Our COMSOL based virtual product development environment is used to optimize the EM design of a car seat head restraint motor module. With multi-physics modeling, the link between the EM and thermal performance of the product was thoroughly studied through parametrized simulations. This virtual prototype based method can be used on a broad range of electric controlled motor products for automotive industry. This virtual prototype will be further developed with App features for acoustic, durability and other attributes of product to gain insight knowledge of design parameters to improve product quality.

REFERENCES:

1. F. Qi *et al*, A CFD Study of an Electronic Hydraulic Power Steering Helical External Gear Pump: Model Development, Validation and Application, SAE International Journal of Passenger Cars – Mechanical Systems, April 2016 vol. 9, no. 1 346 -352 (2016)
2. Lexi Carver, Revving up Electrohydraulic Power Steering with Virtual Prototyping, COMSOL News 2017, 2017, 25-27