PREDICTING THE PERFORMANCE OF AN ELECTRIC MOTOR VIA A MULTIPHYSICS SIMULATION: COUPLING ELECTROMAGNETIC, FLUID, AND STRUCTURAL SIMULATIONS

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SUMMARY

To confidently predict the performance of a product in the real world, design engineers must consider all the physics involved, as well as their interactions, simultaneously.

An automotive electric engine is an excellent example of a system that requires a multiphysics approach to predict with confidence its performance. One of the most crucial aspects to consider in an automotive electric engine is the cooling mechanism. Temperature affects many components within the engine as well as its performance; materials temperature affects electromagnetic forces which in turn impacts the performance of the engine as well as heat losses, which also have an effect on the temperature of the air surrounding the engine. Then, the temperature of the surrounding air impacts the temperature of the materials. Therefore, engineers need to take a multiphysics approach to simulation and analyze the electromagnetic, structural and fluid characteristics of an electric engine to accurately predict the electric motor performance. Furthermore, while 2-dimensional simulation tools were once acceptable, predicting the performance of a complex system like an electric engine requires high fidelity 3-dimensional representations of the design.

This presentation will first analyze a multiphysics simulation of a generic and publicly available electric motor. First, a coupled electromagnetic fluid and electromagnetic simulation is performed to a) determine the temperature of the surrounding air and the temperature of the magnet, and b) the electromagnetic characteristic of the system and its heat losses. Electromagnetic characteristics must be evaluated locally because as the magnet temperature changes from one location to another, so does the electromagnetic characteristics. The material temperature is then used as an input to a structural simulation to compute the deformation of the system. The simulation results are validated using empirical data.

Because the temperature of the system is accurately predicted by the fluid/electromagnetic coupled simulation, the subsequent deformation simulation can be performed by a structural simulation tool using these accurate inputs. Lastly, a comparison of results obtained using a 2-dimensional approach will be compared to results obtained by a full 3-dimensional simulation. This comparison demonstrates that accurate prediction of the performance of the system requires a detailed 3-dimensional simulation.