# Design of Ultra-High-Power-Density Machine Optimized for Future Aircraft

The NASA Glenn Research Center's Structural Mechanics and Dynamics Branch is developing a compact, nonpolluting, bearingless electric machine with electric power supplied by fuel cells for future "more-electric" aircraft with specific power in the projected range of 50 hp/lb, whereas conventional electric machines generate usually 0.2 hp/lb. The use of such electric drives for propulsive fans or propellers depends on the successful development of ultra-high-power-density machines. One possible candidate for such ultra-high-power-density machines, a round-rotor synchronous machine with an engineering current density as high as 20,000 A/cm^2, was selected to investigate how much torque and power can be produced.

Last year we developed a code and finite element model for analyzing and optimizing the performance of ultra-high-power-density and high-specific-power machine that consists of rotor and stator windings and back-irons. This analytical code written in the MatLab language and a finite element model by AnSoft gave us the basic tools for optimal designs for synchronous round-motor machines.

Volume per unit length of disk.
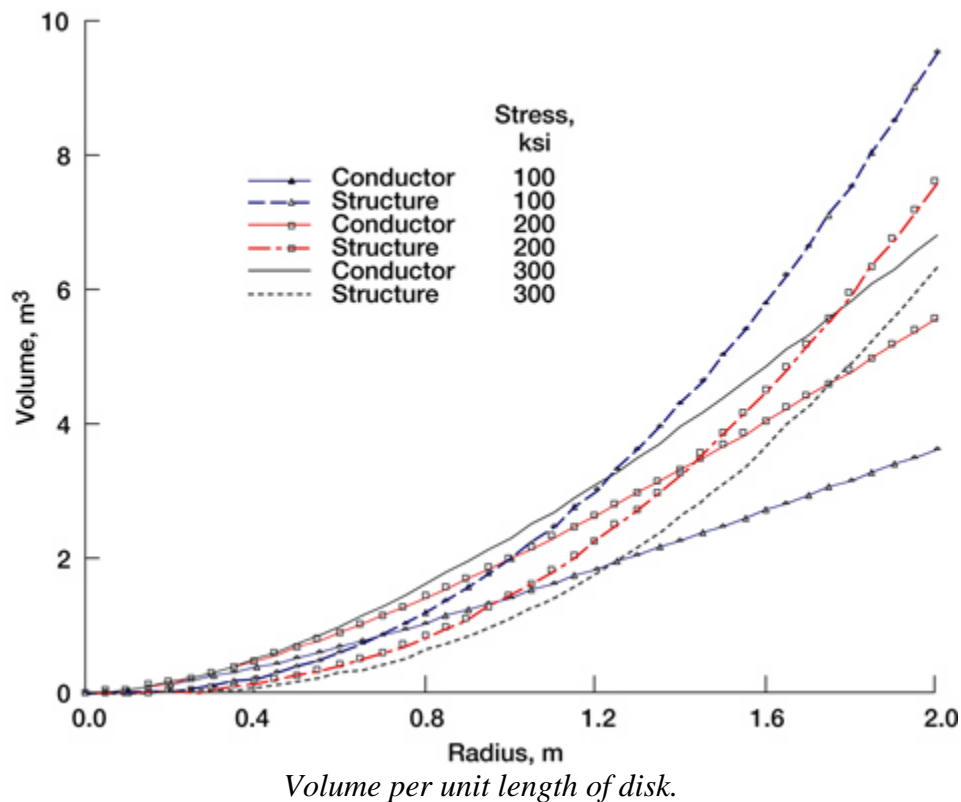
This year we derived an improved electromagnetic model with carbon fiber structure on the rotor and implemented it into the current optimization code. At first we added a filament-wound structure to the rotor in proportion to local centrifugal stress, reducing

the current density by the volume fraction occupied by the structure (see the preceding graph). Then, we optimized the results with respect to motor dimensions. At this point, the hoop stress due to electromagnetic tangential force was not considered because centripetal stress dominates in the rotor. Also the number of input and output parameters for the existing code variables for optimizing either specific power or power density was modified to provide more detailed quantitative results and to give the code the ability to determine optimal designs for synchronous round-motor machines. We also conducted a preliminary study to examine factors that influence the choice of motor length-to-diameter ratio, and we determined the optimum length-to-diameter ratio for best power density.

We enhanced our Electromagnetic Analysis of Synchronous Machine code and verified the results using an AnSoft (finite element software) model (see the following graph). This work showed the feasibility of using this technology for a future more-electric engine, making advances on the Ultra-High-Power-Density Motorproject.
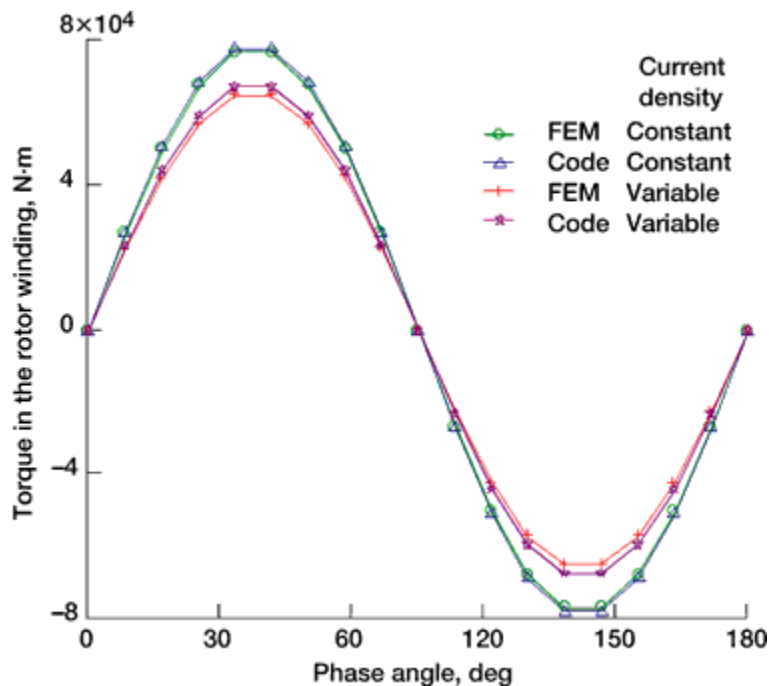
Torque in the four-pole synchronous motor with constant and variable current density.

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