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M2Or3J-04: [Invited] A Double Rotor Flux Switching Machine with High-Temperature-Superconductor Field Coils for Transportation Applications

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Abstract - The increasing demand for high-power density electric motors in transportation industries opens a new research opportunity to develop motor topologies with less weight and higher efficiency. In particular, electric aircraft applications require very high power density motors. And increases of efficiency are desired for transportation, to reduce system impacts of high heat loads and reduce fuel costs; e.g. yearly savings of $4B for aviation fuel worldwide could be realized, for a 1% increase of drivetrain efficiency. Flux-switching machines are used by a large percentage of the automotive industry, since they have reasonable power and efficiency for a wide range of motor speeds from low to high. And axial flux machines are commercially available for the electric aircraft industry, e.g. by MagniX for Eviation aircraft.

This paper provides the design of a new 1 MW 20-pole/15-slot radial flux switching machine with double rotors, and using high-temperature superconductor tapes for the field coils and a cryofuel thermal management system. The proposed motor features an air-core stator. Aluminum Litz wire is chosen for the armature conductors operating at 25-50 K, and Y-Ba-Cu-O high-temperature superconducting tapes are used for the field coils operating at 20-25 K. Flux switching motors provide an interesting opportunity to incorporate superconducting tapes for the DC field coils, since the field coils are stationary which are relatively straightforward to cool. However there is some risk for the field coils, since AC and harmonic B-fields will penetrate into the field coils to some degree. However solutions to address the problems of AC penetration were discovered and will be presented.

The active part power density including rotors, armature windings and field coils obtained with the proposed design is > 100 kW/kg. The efficiency can be higher than 99% which is a significant increase from 94-96% of motors operating at ambient temperatures, to greatly reduce heat loads and reduce fuel and operating costs.

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