Contribution ID: **1102** Type: **Invited Oral Presentation**

M2Or4A-02 [Invited]: Homopolar Superconducting AC Machines, with HTS Dynamo Driven Field Coils, for Aerospace Applications

Tuesday, July 23, 2019 5:45 PM (30 minutes)

There is worldwide interest for high-speed motors and generators with characteristics of compactness, lightweight and high efficiency for aerospace applications. Several options are under consideration. However, machines employing High Temperature Superconductor (HTS) look promising for enabling machines with the desired characteristics. The machines employing excitation field windings on the rotor are constrained by the stress limit of rotor teeth and mechanism for holding the winding at very high speed. Homopolar AC synchronous machines characteristically employ both DC field excitation winding and AC armature windings in the stator. The rotor is merely a magnetic iron forging with salient pole lumps. This rotor could be rotated at very high speed up to the stress limit of the rotor materials. Rotational speeds of 50,000 RPM and higher are achievable. The high rotational speed enables more compact lightweight machines.
This paper describes 2 MW, 25000 RPM concept designs for machines employing HTS field excitation windings. We examine the use of an HTS dynamo to supply current to the HTS field windings; this enables minimization of cryogenic heat-leak, the use of very high current coil design methodology and quasi-persistent operation. Analysis will be performed to determine impact of cryogenic and operational issues relating to the HTS dynamos in this application. The AC armature winding is made of actively cooled copper Litz conductor. The field winding consists of a small turn-count HTS coil that could be ramped up or down with a contactless HTS dynamo with no physical contact with the HTS coil. This eliminates current leads which are major source for thermal conduction into the cryogenic region and thereby increase thermal load to be removed with refrigerators. Estimates of size, weight and efficiency are provided for the machine.

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Session Classification: M2Or4A - Transportation Symposium: Transportation Motors III: with Cryo