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M2Or3J-01: [Invited] Rotating Machines for the Cryo-Electric Planes –Status and Development Issues

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Cryo-Electric planes are being envisaged for the 2030's. A key technological hurdle for realizing this is the availability of flight-weight motors, generators, and power distribution systems. Historically superconducting industrial and marine machines have been demonstrated –but not at the required flight power and volume densities. Developments for compact lightweight highly efficient rotating machines for aircraft applications are now being conducted worldwide using both government and private resources. NASA has identified the need for motors rated 3 MW @4500 rpm and generators 22 MW @6500 rpm [1]. Both conventional and superconducting options are under consideration. NASA and ARPA-E are funding several programs in the USA. Likewise, Europe, New Zealand, Japan, Korea, and other countries are funding similar programs.
This talk provides an overview of the key historic cryogenic machine demonstrations and show the missing performance space to meet aerospace application. A motor rated 3 MW, 4500 RPM is used here for reviewing various technologies. Both conventional coils cooled to cryogenic temperature and superconducting coils are included in the review. The status of some of the programs is presented. To achieve machines with > TRL-6 in the next 5-6 years will require concentrated focus in areas such as AC loss estimates for superconductor and high- conductivity aluminum windings, on-shaft high-speed coolers for cooling the rotating mass, power sources for energizing coils on rotor wirelessly, compact lightweight refrigerators, and high voltage (~1000 V) electric drives. Irrespective of selected thermal sinks, it would be essential to employ a link gas (such as GHe) for cooling the coils, and any discussion of the efficiency per say becomes irrelevant. Also, cooling with GHe has limitations imposed by its working temperature, pressure, mass flow, etc. The size of the coils will, therefore, be determined by these limitations. For example, if LH2 is used as a thermal sink, it would be necessary to condition the GHe to temperatures suitable for coils. Likewise, if LNG is assumed as the thermal sink, it would be necessary to employ refrigerators for lowering temperature of the link GHe to suit the superconducting coils.
To achieve the goal of TRL-6 or higher for motors and generators soon, government support commitments are necessary, like those of Air New Zealand's Mission Next Gen Aircraft -2030.

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