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M1Or3E-05: [Invited] Design, fabrication and test of high temperature superconducting magnet for heat flux and radio blackout mitigation experiments in plasma wind tunnels

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Entering the atmosphere of a planet at high velocity poses major challenges for spacecraft. High heat fluxes caused by the compressed and partially ionized gas at the front of the spacecraft can heat the surface to temperatures, which can exceed the operational temperatures of the structure materials significantly. A thermal protection system (TPS), e.g. with ablative heat shields as in the Mercury, Apollo and Gemini missions or with radiatively-cooled heat shields as used on the Space Shuttle, is necessary to protect the spacecraft from high heat fluxes, but these systems are often heavy and fragile. Another problem that is well known since the early days of space flight is the radio-blackout phenomenon. The ionized gas in the plasma can block radio waves and lead to a loss of GPS data telemetry or communication with ground stations.

In the framework of the European project MEESST (MagnetoHydroDynamic Enhanced Entry System for Space Transportation) we have developed a high temperature superconducting (HTS) magnet for ground experiments in plasma wind tunnels to demonstrate that both heat flux mitigation and radio blackout mitigation can be achieved by magnetohydrodynamic (MHD) effects. The magnet and its cryogenic system have been designed to fit in a probe that will be installed in plasma wind tunnels at the Institute of Space Systems (IRS) of the University of Stuttgart, Germany, for heat flux mitigation experiments, and at the von Karman Institute (VKI) for Fluid Dynamics in Brussels, Belgium, for radio blackout mitigation experiments. A cryocooler and a closed gaseous helium loop will be used to cool the HTS magnet to a temperature of approximately 30 K. The HTS magnet was designed to produce a magnetic field in the range of 1-2 Tesla at the front surface of the probe, which has a warm bore to accommodate measurement equipment. The non-insulated magnet with inner and outer winding diameters of 66 mm and 143 mm, respectively, consists of 5 single pancakes wound with a total length of 700 m REBCO (Rare Earth-Barium-Copper-Oxide) coated conductor tape.

In this paper we will give a short introduction to the scientific background and the consortium of the MEESST project. We will present the boundary conditions for the design of the magnet, calculations of field distributions and show how the pancake coils were wound with a robotic winding system.

A preliminary test of the conduction-cooled magnet was carried out at the Karlsruhe Institute of Technology (KIT). Results will be presented and an outlook to further work in the project and necessary steps for future flight applications of plasma shielding magnets will be given.

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