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M4Or1B-04: [Invited] Effects of arc faults in HTS cables on the cryostat

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High Temperature Superconducting (HTS) cable systems are being developed for future electric ships and aircraft to support the power distribution networks capable of multi kA ampacities. HTS devices offer a high power density solution for high ampacity cables. There is increased interest in superconducting technologies because of the cryogenic cooling power of liquid hydrogen to be used as fuel for electric generators and/or fuel cells. Notional power systems consisting of HTS power devices are being developed for electric ships and aircraft. The expected power levels of electric ships and aircraft are in the ranges of 20-50 MW and 80-100 MW, respectively. Power system designs need the stability, resiliency, and redundancy of the system in the event of a fault. A failure of a component or a section of the power system should not lead to the loss of power for the vehicle. We have initiated a study to understand the electrical fault propagation in HTS cables carrying 5-10 kA current and the effects of a fault resulting in an arc. One scenario investigated is a parallel electrical fault between the HTS conductor and the inner wall of the cable cryostat at ground potential. The plasma of the arc during a parallel fault will introduce a significant heat load in the cryogenic envelope causing a thermal runaway. The occurrence of the plasma arc may also result in damage to the HTS cable cryostat which could cause a vacuum breach also leading to a thermal runaway. The high ampacity of normal operation means that the fault currents will be even higher. In our investigations, a simplified physical model of the HTS cable with polypropylene laminated paper (PPLP) as electrical insulation was designed and fabricated. A high-current unit with a current capacity of up to 100 kA was used to generate high fault current levels on the model HTS power cables. The fault currents are sustained for periods equivalent to the time required for a protection system to identify and mitigate the occurrence of a parallel fault in the power system. Measurements were performed at up to 10 kA at a voltage level of 1 kV with a capacitance of 330 mF. A high-speed camera was used to film the arc events for visual evaluation of the initiation and propagation of the fault. These measurements were performed at room temperature and 77 K in a liquid nitrogen bath. The data generated in the measurements are used to estimate the energy required to pierce the inner wall of the cryostat that would lead to a vacuum breach. The paper discusses the experimental details, the data generated, and a set of recommendations on the limits of operating and fault currents of HTS cables in the power systems of the electric transport platforms.

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