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Impact of large beam-induced heat loads on the transient operation of the beam screens and cryogenic plants of the Future Circular Collider (FCC)

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The Future Circular Collider (FCC) under study at CERN will produce 50-TeV high-energy proton beams. The high-energy particle beams are bent by 16-T superconducting dipole magnets operating at 1.9 K and distributed over a circumference of 80 km. The circulating beams induce 5 MW of dynamic heat loads by several processes such as synchrotron radiation, resistive dissipation of beam image currents and electron clouds. This beam-induced heat loads will be intercepted by beam screens operating between 40 and 60 K and induce challenging transients during beam injection, energy ramp-up and beam ejection on the distributed beam-screen cooling loops, the sector cryogenic plants and the dedicated circulators.

Based on the current baseline parameters, numerical simulations of the fluid flow in the cryogenic distribution system during a beam operational cycle were performed. The effects of the thermal inertia of the headers on the helium flow temperature at the cryogenic plant inlet as well as the temperature gradient experienced by the beam screens has been assessed. Additionally, it enabled a thorough exergetic analysis of different cryogenic plant configurations and laid the building-block for establishing design specifications of cold or warm circulators.

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