Contribution ID: **142** Type: **Poster Presentation**

HTS cooling below 60 K with two-stage mixed-refrigerant cascades using low-flammability mixtures

Monday 29 June 2015 09:00 (2 hours)

High-temperature superconductors offer new perspectives for efficient transportation of electrical energy in urban and industrial power grids. The size of the components is in many cases limited by the available refrigeration technology. In the operating temperature range of 65 –70 K, cooling is presently achieved by liquid nitrogen, turbo-Brayton plants or batteries of regenerative cryocoolers. However, none of these options is practicable in applications requiring a few kilowatt of cooling power. Also a reduction of the temperature to below 60 K is desirable in order to increase the current density in the superconductors.
Two-stage mixed-refrigerant Joule-Thomson cascades can present a reliable and highly scalable refrigeration alternative in this temperature range. The first stage of the envisioned process consists of a classical mixed-refrigerant cycle for pre-cooling to 120 K. The second, low-temperature stage operates with a mixture of nitrogen, oxygen and neon at high pressure.
In order to avoid combustible hydrocarbon refrigerants in the pre-cooling stage, this work examines the use of a new mixture with low flammability consisting of nitrogen, argon, R-14, R-23 and R-1234yf. The applicability of different equations of state for the prediction of the thermophysical behavior of the mixture by is discussed.

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Session Classification: C1PoB - Intermediate Temperature Systems

Track Classification: CEC-09 - Cryogenics for Power Applications, Energy, Fuels and Transportation