Cooling System for a Superconducting DC-Rail

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DC-rails are used in a wide field of industrial applications, for example in aluminum smelters and chlorine electrolysis plants. Up to now usually large sized DC-rails made out of copper or aluminum transport currents up to a few hundred kA. The development of compact, efficient and innovative superconductor components is forced mainly due to the high density of energy flux and requires a suitable cooling system. Replacing conventional high power rails to superconducting DC-rails allows a reduction in size, installation area and prize. Last but not least it will increase the electrical efficiency of the whole process.

Within the framework of the government founded research project "3S-SupraStromSchiene", project no. 03ET129C, a superconducting DC-rail was designed and is currently under construction. The ILK Dresden is responsible for the cooling system of this superconducting DC-rail. This novel cooling system that consists amongst others of a high power cryocooler and a special "cold" cryogenic pump will be presented for the use of a superconducting DC-rail system for a chloralkali process. The presentation describes the concept, design and experimental results of these key components.

The high power cryocooler is based on the principle of a pulse tube cooler and provides a cooling power of 400 W at a temperature of 65 K. In ordinary pulse tube coolers the acoustic power at the warm end of the pulse tube is transformed to useless heat. Using two commercial reciprocating compressors, where one is acting as a compressor and the other one as expander, it is possible to recover a certain part of these acoustic power. In this way the theoretical efficiency exceeds 11% at 65 K. The cold cryogenic pump works fully submerged inside the subcooled liquid nitrogen reservoir and consists of a double acting piston pump which is powered by a linear drive. It provides a mass flow up to 0.5 kg/s at a pressure difference of up to 2 bar. Other parameters are possible depending on the design requirements.