Calculation of the heat exchanger for the cryostat system of the superconducting electrical cable

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In the 1900s, the Danish scientist Kamerlingh Onnes discovered that with a significant drop in temperature, mercury actually loses its electrical resistance. This discovery laid the foundation for the study of superconductivity.

For a long time, scientists believed that superconductivity means only the absence of electrical resistance in a substance. If you apply a magnetic field to any conductor, then part of it will be conducted through this conductor. But in 1933, scientists V. Meisner, R. Oxenfeld and F. Heidenreich proved that a conductor completely replaces the magnetic flux, when it passes into the superconducting state, even if it is immersed completely in a magnetic field.

The use of the phenomenon of superconductivity in the power industry would have made a revolution, as it gives the opportunity to get rid of losses in the transmission of electricity through the cable. But, due to the fact that this physical phenomenon manifested itself only at the helium liquefaction temperature (4.2 K), the practical application of superconductivity developed relatively slowly. This continued until, in 1986, IBM employees Karl Muller and Georg Bednorz discovered high-temperature superconductors (HTSC). Since then, superconductivity and its application has become a promising area of research.

Nowadays, HTS systems are used in various fields: from magnetic resonance tomography to high energy physics. The most common systems of high-temperature superconductivity are used to make superconducting magnetic systems (localized superconducting systems) and superconducting cables (and the like distributed superconducting systems in which the current-carrying lines are stretched in space). Superconducting magnets have one great advantage, due to which their development was at high speed, - stationarity. Such systems can be cooled using stationary sources of cooling capacity.

And for distributed systems, things are different, since they were drawn into the cable, which means that the surface area of thermal insulation per unit length of cable is incomparably greater than that of local systems. The distribution of heat from the OS distributed along the cable length only creates an increased thermal load, but also does not allow local sources of cooling capacity to be used for cryostatting HTSCs.

For cooling distributed JV systems, we need autonomous refrigerators with high reliability and uptime. These requirements are best met by turbo-pressure refrigerators running on neon. The main problem of manufacturing of refrigerating machines of this type is the design of heat exchange equipment, the size and thermal inertia of which has a decisive influence on the compactness and energy efficiency of the refrigerator as a whole. To select rational design solutions, it is necessary to create a mathematical model of the heat exchanging device and, in the mode of a numerical experiment, select the best combinations of design parameters.