
Cryogenic supply system for high-temperature superconductivity devices (SCR 001)

© V.V. Kostyuk¹, B.I. Katorgin¹, V.P. Firsov², K.L. Kovalev²,
Yu.A. Ravikovich², I.V. Antyukhov², S.F. Timushev²,
M.M. Vereschagin⁴, D.P. Kholobtsev², Yu.I. Ermilov²,
N.G. Balaboshko², Yu.A. Gapeev², A.S. Lesovnikov²,
A.S. Sychkov³, K.A. Modestov²

¹Russian Academy of Sciences, Moscow, 117334, Russia

²Moscow Aviation Institute (National Research University), Moscow, 125993, Russia

³GROUP EKSPLOTEKX Ltd, Moscow, 125130, Russia

⁴VelisHolod Ltd, Moscow, 125130, Russia

Creation of an autonomous and efficient cryogenic supply system with a resource of continuous operation of at least 30,000 hours for use in high-current devices (cables, electric motors, generators, transformers, etc.) using high-temperature superconductivity is a key task for the widespread introduction of promising technologies in industry.

The study gives the results of the work on creation of a cryogenic supply system for SCR 001 with a cooling capacity of 1,5 ... 2,5 kW at a temperature of 65K for local and distributed cryogenic systems. SCR 001 circulates liquid nitrogen at a temperature of 65... 75K in a closed circuit of cooling superconductors and ensures the operation of electric motors, generators, etc. The refrigerator KR 001 has been built with a cooling capacity of 1...2,5 kW at 65 K. The refrigerator operates by the gas refrigerating inverted Brighton cycle with radial turbomachines. The design features of the cryorefrigerator are as follows: neon is the working fluid in the gas circuit; turbochargers and turboexpander have gas-dynamic bearings; cooling of the working fluid (neon) after compression occurs in compact plate-finned end heat exchangers with the help of antifreeze, and cooling of antifreeze is due to the air in the heat exchanger by means of fans.

Keywords: *high-temperature superconductivity, cryogenic system, cryorefrigerator, refrigerating inverted Brighton cycle, radial turbomachines*

REFERENCES

- [1] Antyukhov I.V., Volkov E.P., Karpyshev A.V., Kostyuk V.V., Firsov V.P. Teploobmen i gidrodinamika v sistemakh kriobespecheniya silovykh VTSP kabeley [Heat transfer and hydrodynamics in cryogenic HTS power cable systems]. *Innovatsionnye tekhnologii v energetike, RAN* [Innovative technologies in the energetics, RAS]. Moscow, Nauka Publ., 2010, pp. 99–130.
 - [2] Hirari H.B. et al. *Advances in Cryogenic Engineering*, 2010, vol. 55, pp. 895–902.
 - [3] Mikulin E.I., Marfenina I.V., Arkharov A.M., eds. *Tekhnika nizkikh temperatur* [Low temperature technique]. Moscow, Energiya Publ., 1975.
 - [4] Yepifanova V.I. *Nizkoterperaturnye radialnye turbodetandery* [Low temperature radial turbine expanders]. Moscow, Mashinostroenie Publ., 1974.
 - [5] Hellström F. Numerical computations of the unsteady flow in a radial turbine. *Technical Reports from Royal Institute of Technology KTH Mechanics*. March 2008, SE-100 44, Stockholm, Sweden.
 - [6] *Software package for gas and fluid flow simulation FlowVision*. Version 2.5.0. *Manual CAPVIDIA*, 1999–2007, Leuven, Belgium.
-

-
- [7] Wilcox D.C. *Turbulence modeling for CFD*. 1994, DCW Industries, Inc. 460 p.
- [8] Ravikovich Yu.A., Ermilov Yu.I., Kholobtsev D.P., Napalkov A.A. Opyt MAI po sozdaniyu malorazmernykh turboagregatov s gazodinamicheskimi podshipnikami skolzheniya dvigatelnykh i energeticheskikh ustanovok [MAI experience in creating small-sized turbo-aggregates with gas-dynamic bearings of sliding motors and power plants]. *Novye tekhnologicheskie protsessy i nadezhnost GTD. Iss. 9. Podshipniki i uplotneniya. Nauchno-tekhnicheskiy sbornik statey* [New technological processes and reliability of GTE. Bearings and seals. Scientific and technical collection of articles]. Moscow, CIAM Publ., 2013.
- [9] Ravikovich Yu.A., Ermilov Yu.I., Pugachev A.O., Matushkin A.A., Kholobtsev D.P. *Mechanisms and Machine Science*, 2015, vol. 12, pp. 1277–1288.
- [10] Ravikovitch Yu.A., Ermilov Yu.I., Kholobtsev D.P., Sukhomlinov I.Ya., Golovin M.V. *Khimicheskoe i neftegazovoe mashinostroenie — Chemical and Petroleum Engineering*, 2015, iss. 12, pp. 26–29.

Kostyuk V.V., Academician of the Russian Academy of Sciences, Vice-President of the Russian Academy of Sciences. e-mail: kostyuk@pran.ru

Katorgin B.I., Academician of the Russian Academy of Sciences, coordinator of the Program of Fundamental Research of RAS Actual Problems of Energy and Creation of New Power Plants. e-mail: bikator@mail.ru

Firsov V.P., Head of the Department of Cryogenic Systems, Research Center of New Technologies, Moscow Aviation Institute (National Research University). e-mail: firsovval@mail.ru

Kovalev K.L., Dr. Sc. (Eng.), Head of the Department 310, Moscow Aviation Institute (National Research University). e-mail: krlink@mail.ru

Ravikovich Yu.A., Vice-Rector for Research, Head of the Department of Engine Construction and Design, Moscow Aviation Institute (National Research University). e-mail: yurav@mai.ru

Antyukhov I.V., Research Scientist, Department of Aviation and Space Heat Engineering, Moscow Aviation Institute (National Research University). e-mail: cryogen204@mail.ru

Timushev S.F., Dr. Sc. (Eng.), Head of the Department of Rocket Engines, Moscow Aviation Institute (National Research University). e-mail: irico@gmail.com

Vereschagin M.M., General Director of LLC VelisHolod. e-mail: horizont-r@yandex.ru

Kholobtsev D.P., Head of the division at the Department of Engine Construction and Design, Moscow Aviation Institute (National Research University). e-mail: nio203@mai.ru

Ermilov Yu.I., Leading Research Scientist of the Department of Engine Construction and Design, Moscow Aviation Institute (National Research University). e-mail: yurer@yandex.ru

Balaboshko N.G., Head of the Laboratory of the Regional Computing Center, Faculty of Control Systems, Automation and Power Engineering, Moscow Aviation Institute (National Research University). e-mail: balng@mail.ru

Gapeev Yu.A., programmer of the Regional Computing Center, Faculty of Control Systems, Automation and Power Engineering, Moscow Aviation Institute (National Research University). e-mail: gapeevyura@mail.ru

Lesovnikov A.S., Senior Lecturer of the Department 202, Moscow Aviation Institute (National Research University). e-mail: mai202asl@mail.ru

Sychkov A.E., General Director of LLC GROUP EKSPLOTEKX.
e-mail: 4371166@mail.ru

Modestov K.A., Cand. Sc. (Eng.), Assoc. Professor of Department 310, Moscow Aviation Institute (National Research University). e-mail: kmodestov@yandex.ru