Helium cryogenics pdf

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R. Tilley and J. Tilley, Superfluidity and Superconductivity, Adan Hilger, Boston, 1986. Google Scholar J. Wilks, Liquid and Solid Helium, Clarendon Press, Oxford, 1967. Google Scholar Access through your institutionVolume 37, 2001, Pages 239-276 00)80007-1Get rights and contentView full text Twenty five years have elapsed since the original publication of Helium Cryogenics. During this time, a considerable amount of research and development involving helium fluids has been carried out culminating in several large-scale projects. Furthermore, the field has matured through these efforts so that there is now a broad engineering base to assist the development of future projects.Helium Cryogenics, 2nd edition brings these advances in helium cryogenics together in an updated form. As in the original edition, the author's approach is to survey the field of cryogenics with emphasis on helium fluids. This approach is more specialized and fundamental than that contained in other cryogenics books, which treat the associated range of cryogenic fluids. As a result, the level of treatment is more advanced and assumes a certain knowledge of fundamental engineering and physics principles, including some quantum mechanics.The goal throughout the work is to bridge the gap between the physics and engineering aspects of helium fluids to provide a source for engineers and scientists to enhance their usefulness in low-temperature systems.Dr. Van Sciver is a Distinguished Research Professor and John H. Gorrie Professor of Mechanical Engineering at Florida State University. He is also a Program Director at the National High Magnetic Field Laboratory (NHMFL). Dr. Van Sciver joined the FAMU-FSU College of Engineering and the NHMFL in 1991, initiating and teaching a graduate program in magnet and materials engineering and in cryogenic thermal sciences and heat transfer. He also led the NHMFL development efforts of the cryogenic systems for the NHMFL Hybrid and 900 MHz NMR superconducting magnets. Between 1997 and 2003, he served as Director of Magnet Science and Technology at the NHMFL. Dr. Van Sciver is a Fellow of the ASME and the Cryogenic Society of America and American Editor for the journal Cryogenics. He is the 2010 recipient of the Kurt Mendelssohn Award.Prior to joining Florida State University, Dr. Van Sciver was Research Scientist and then Professor of Nuclear Engineering, Engineering Physics and Mechanical Engineering at the University of Wisconsin-Madison from 1976 to 1991. During that time he also served as the Associate Director of the Applied Superconductivity Center. Dr. Van Sciver received his PhD in Low Temperature Physics from the University of Washington-Seattle in 1976. He received his BS degree in Engineering Physics from Lehigh University in 1970. Dr. Van Sciver is author of over 200 publications and patents in low temperature physics, liquid helium technology, cryogenic engineering and magnet technology. The first edition of Helium Cryogenics was published by Plenum Press (1986). The present work is an update and expansion of that original project. Access through your institution 05)80003-7Get rights and contentH. Danielsson et al.J.C. Brunet et al.B. Rousset et al.G. Claudet et al.G. Claudet et al.G. Claudet et al.B. Rousset, G. Claudet, A. Gauthier, P. Seyfert, A. Martinez, Ph. Lebrun, M. Marquet,R. van Weelderen, Pressure Drop…J. Casas-Cubilios et al.A. Bézaguet et al.Ph. Lebrun, Th. Wahlström, R. van Weelderen and L.R. Williams, Investigation of Quench Pressure Transients in the LHC…L. Rossi, V. Sergo, B. Szeless, L. Tavian, B. Vullierme, R. van Weelderen and L.R. Williams,Thermal Behaviour and…L. BrueM. Blin et al.Ph. Lebrun et al.In the large-scale superfluid helium cryogenic refrigeration system, the helium cold compressor faces the complex operating conditions of low temperature, high speed and sub-atmospheric pressure. The radial type high temperature superconducting (HTS) bearing of inner rotor and outer superconducting stator has the advantages and characteristics that they are suitable for being used in the helium cold compressor. Combining with the structure and operating parameters of a successful application of centrifugal active magnetic bearings in helium cold compressor, the design of radial HTS magnetic bearings considering bearing levitation performance and rotor dynamic performance was carried out. In order to ensure the accurate measurement of the rotor load and the rotor offset displacement, a performance measurement platform for the HTS magnetic bearing is built, and accurately weighed load rings and differential measurement method are used. The measured axial levitation force is 77 N when the offset displacement is 0.1 mm. And the axial stiffness is 771 N/mm and radial stiffness is about 385.5 N/mm in the measuring range. The first bending mode critical speed of the rotor system can reach 74,108 rpm. The designed HTS magnetic bearing system can provide sufficient levitation force and support stiffness for the practical application of helium cold compressor system. The research work provides a guiding for the application of HTS magnetic bearings in helium cold compressor.This paper describes a superfluid 4He (He II) production system with a G-M cryocooler developed to supply continuous cooling capacity for cryogenic devices working below 2 K, such as the sealed-cell lambda-point devices and the photon detectors. Unlike the existing cooling method that injecting and pumping liquid 4He (He I) to cool the devices, high purity 4He gas stored in gas cylinder is firstly liquefied by a G-M cryocooler in the condenser, and then cooled down under 2.17 K at the He II pot through a Joule-Thomson valve along with a dry vacuum pump. This design allows a continuous supplement of He II below 2.17 K by using 4He at ambient temperature, which avoids the temperature oscillation to the devices being cooled when refilling He I. Due to the removing of cryogen injection, no additional cryogenic apparatus and professional operation are required. In this system, the He II pot can reach a temperature below 1.8 K for continuous operation.The calibration principle of the cryogenic void fraction RF-sensors of a round cross-section for a wide temperature range is proposed and described in detail. It is shown that the simplest and reliable method of the calibration procedure requires finding a dependence of the resonant frequency, f, of the empty sensor on its temperature and only two f-values when it is filled with saturated liquid and vapor at the given temperature T0. The calibration test-bench is described. The errors of the calibration are estimated, and the experimental data for helium, hydrogen and nitrogen are presented.A new variant of the void fraction RF-sensor of the round cross-section with ID = 38 mm is presented. Its sensitive part is made of the ceramic pipe with a meander line on the outer surface. This technique does not disturb the flow moving in the metal pipe of the same diameter. The technical solutions to provide rather high uniformity of the electric field within the sensitive volume and excellent stability of the readings are described. Irregular steps of the meander line are chosen after computer calculations and experimental checking. Some disadvantages of the previous modifications are shown as well. A new calibration procedure is discussed: it takes into account the dependence of the resonant frequency of the empty RF-sensor on the temperature of the sensor body. The method to find a mass flow rate of the two-phase helium and hydrogen flows in the range of void fractions from 0% to 100% is demonstrated with the new RF-sensor.The report presents the experience in the field of designing, manufacturing and testing the void fraction sensors of round and annular cross-sections for research purposes and practical applications. These sensors are of radio frequency type with a uniform electric field within the measuring volume, and their readings depend on the dielectric permittivity of the media filling the sensitive part. The measuring system and method to calibrate these sensors are described. The temperature sensors used to measure the temperatures of the void fraction sensor body and the cryogenic flows are also presented. The operational characteristics of the radio frequency (RF)-systems for TESLA Test Facility cooled with two-phase superfluid helium at 1.8 K, Nuclotron and UNK cooled with two-phase helium at 4.5 K, the installation to separate isotopes of hydrogen at 22 K, etc. are reported.This paper presents two different applications for two-phase visualization at low temperature. In the first application, a CCD video camera located inside vacuum is directly supported by the Pyrex pipe containing a two-phase superfluid flow. In the case of slightly positive slopes in which the flow is co-current but ascending, two different flow patterns have been seen, stratified and intermittent, depending on the vapor mass flow. Experimental investigations from stratified to intermittent flow have been made visually and compared to a code derived from the Taitler/Dukler model. The second application concerns phase transition of hydrogen near critical point (33 K) in zero gravity. The experiments have been performed in a cryostat equipped with a 10 T superconducting coil allowing the gravity compensation for hydrogen. Images of the condensation cell are shifted to the top of the cryostat with a specific cryogenic endoscope because CCD cameras do not work in high magnetic fields. The sample was enlightened with diffuse or parallel (coherent) light using a second endoscope. Images obtained in this apparatus are similar with those obtained in space.View all citing articles on ScopusCable-in-conduit conductors will be extensively implemented in the large superconducting magnet coils foreseen to confine the plasma in the ITER experiment. The design of the various magnet systems imposes the use of electrical joints to connect unit lengths of superconducting coils by inter-pancake coupling. These twin-box lap type joints, produced by compacting each cable end in into a copper - stainless steel bimetallic box, are required to be highly performing in terms of electrical and mechanical prop- erties. To ascertain the suitability of the first copper-clad plates, recently produced, the performance of several plates is studied. Validation of the bonded interface is carried out by determining microstructural, tensile and shear characteristics. These measure- ments confirm the suitability of explosion bonded copper-clad plates for an overall joint application. Additionally, an extensive study is conducted on the suitability of certain copper purity grades for the various joint types.The Hadron-Electron-Ring-Accelerator (HERA) at the German Electron Synchrotron (DESY) in Hamburg, Germany, was in operation between 1990 and 2007. The required cooling capacity for the superconducting magnets was provided by a cryogenic system consisting of three identical helium refrigeration plants. Due to the implementation of the X-ray free electron laser European XFEL, two of the existing HERA refrigeration plants have been adapted to the new heat load requirements of the XFEL-linac. A 2 K cooling loop of approximately 2.6 kW comprising a string of four cold compressors has been included into the existing refrigerator system. Efficient operation for 17.5 GeV beam load, for future up-grade options, and high turn down ability during partial load operation are key features of this modified cryoplant. A stepwise commissioning concept has been applied in order to compensate any changes in the overall XFEL project schedule. Another challenge was to revamp, install and commission the XFEL cryoplant under continuous operation of the third cryoplant, which is still providing refrigeration power forthe FLASH-linac and other consumers.Bare bulk tube superconducting current leads (CLs) of (Bi, Pb)2 Sr2 Ca2 Cu3 O10+x: 10 wt% Ag (Length = 410 mm, outer diameter = 45 mm, and inner diameter = 42 mm) have been found to show a degradation in the normal state affecting the superconducting properties due to ageing of the material. These reference samples (named as RF) have been studied over a period of five and ten years. A decomposition of the Bi-2223 phase has been observed after testing several times during the period affecting normal state and superconducting properties considerably. An attempt has been made in order to obtain reusable product using two recycling methods. In one of the methods, these degraded samples were re-sintered (named as RS) and in the second one, they were reprocessed (named as RP). Those is, in the second method, the steps of crushing, mixing, calcining, cold isostatically pressing into tubes, making silver current contacts at both end portions of this tube and finally of sintering were followed to make reprocessed bare bulk tube current leads. Both these RS and RP samples were sintered under identical conditions as those of the conditions used for the RF samples. Comparative analyses of the two recycling (RS and RP) methods with respect to normal state and superconducting state properties are also presented.This paper aimed to develop an augmented onset model for a looped-branched, thermoacoustically-driven, pulse tube cryocooler based on the transfer matrix model, introducing a reliable, uncomplicated prediction of the onset features compared to a full transient simulation of the thermoacoustic field. Disciplined successive multiplication of the element's matrices extracted from the linear thermoacoustic equations along with the joint, boundary and periodic conditions establish an eigenvalue onset problem. The corresponding problem solutions are in line with the earlier experimental results for a looped-branched thermoacoustic system. Investigating multiple layouts with specific startup characteristics indicated the ability of a four-stage cryocooler driven by two engines at each stage to reach an onset temperature difference of 45 K at liquid nitrogen temperature. Furthermore, the Morris screening method was adopted to rank the uncertain input factors, followed by the Sobol sensitivity analysis to quantify the uncertainty of model outcomes. The sensitivity quantification highlights that the uncertainty in the gas equation-of-state, specific heat capacity, and the cold regenerator mesh number predominantly affect the onset features. Other influential factors include the dimensions of the hot and cold segments of the unit that respectively affect the onset temperature and the frequency.The numerical geometrical configuration and cooling performances of parallel wire geometry have been investigated in one-dimensional active magnetic regenerator. Based on the actual regenerator, the wires in geometries were primarily arranged in square and triangular array, and worked in cross and parallel flow patterns. Regenerators containing wire bundles with three geometries were evaluated by varying utilization at fixed temperature spans between hot and cold reservoirs. The effects of geometrical parameters on heat transfer performance and friction factor of regenerator were firstly discussed here. Two materials, gadolinium and La(Fe,Mn,Si)13Hy, have been used for simulating the cooling performance of wire geometry. The numerical results showed that the arrangement of wires did not have influence on the cooling power greatly and the wire geometry could provide a higher coefficient of performance in parallel flow. After optimization, the desirable parallel wire geometry had a porosity of 0.40 and wire diameter of 0.15 mm. When the frequency was 2 Hz and temperature span was 10 K, the maximum cooling power could reach 158.40 W and 100.3 W for Gd and La(Fe,Mn,Si)13Hy wire geometries, whose coefficients of performance were as high as 13.46 and 14.96 respectively. Comparatively, the cooling powers of commonly used Gd and La(Fe,Mn,Si)13Hy packed bed were one third lower than those of optimized wire geometriesand the coefficients of performance were lower half.High cooling capacity free-piston Stirling cryocooler (FPSC) has been considered a promising candidate for high temperature superconducting and gas liquefaction applications, which require a cost effective and highly reliable cryocooler capable of providing large cooling power (several hundred watts to several kW) at liquid nitrogen temperature. This paper introduced an advance in a FPSC capable of providing 350 W cooling power at liquid nitrogen temperature. To reveal the relationship between operating parameters and cooling performance, the integrated impact of mean pressure and working frequency on acoustic impedance, acoustic field as well as exergy loss of cooler is studied numerically. The numerical results indicate that for the current design, by tuning the mean pressure and working frequency, an optimal operating scenario of the refurbished FPSC could be obtained, which leads to a higher thermal efficiency. Based on the optimization, a series of experiments were carried out on the improved experimental setup. A cooling power of 350 W at 80 K was obtained with an input electric power of 3.57 kW and the corresponding overall relative Carnot efficiency reached up to 26.8%. Compared with previous reports, the performance has been greatly improved by 25.2%. In addition, a special attention is paid to the heat transfer at the ambient heat exchanger due to the large detected local solid-gas temperature difference in the previous work. Comparisons of two different types of ambient heat exchanger in calculations and experiments indicate that an even better performance could further be expected by employing a shell-tube type heat exchanger with 1 mm inner diameter and a porosity around 0.16.View full text