VOLUME 35 A, 2010 ISSN 0379-0479

INDIAN JOURNAL OF CRYOGENICS

A quarterly journal devoted to Cryogenics, Superconductivity and Low Temperature Physics

Published by

Indian Cryogenics Council

Proceedings (Part-C) of Twenty Second National Symposium on Cryogenics (NSC-22)

held at
Indian Institute of Science. Bangalore
December (6-8), 2008

July 2010

Indian Journal of Cryogenics

A quarterly journal devoted to Cryogenics, Superconductivity and Low Temperature Phys**ics**

Guest editors for this volume

Subhash Jacob, R Karunanithi, D S Nadig

Centre for Cryogenic Technology, Indian Institute of Science
Bangalore- 560012

All the papers received for publication in Indian Journal of cryogenics are reviewed by a large no of distinguished scientists from all over india in an honorary capacity.

Communication regarding contribution of paper, subscription for the journal should be addressed to :

Amit Roy
President, Indian Cryogenics Council
Inter- University Accelerator Centre
Aruna Asaf Ali Marg. New Delhi- 110067

Tel : 0091-11-26893045, 26893955
Fax : 0091-11-26893666
Email : roy @iuac.res.in

For detail information, please visit our
website **:http://www.iuac.ernet.in/iccwebsite/icc.html**

Indian Journal of Cryogenics

A quarterly journal devoted to Cryogenics, Superconductivity and
Low Temperature Physics

General informations :

A) Paper received for publication is being reviewed independently by referees and based on the feedback editorial board takes decision whether to be published with minor correction or to be returned to author with recommendation on additional work or analysis to consider publication in next volume.

B) This is the only Indian journal where articles on cryogenic enginnering is encouraged. Editorial board encourages work on indigeneous development as an import substitution.

C) Editorial board has decided to include at leat one review article (by invitation) on each forthcoming issue in the field of Superconductivity, low temperature physics, cryogenic engineering or covering status of major cryogenic related project in India etc.

D) The manuscript format is available in the ICC website : **(www.iuac.ernet.in/iccwebsite/icc.html).** Shorly format will be revised and a new format template will be iavailable in the website.

E) The subscription rate is revised and the present rate is

1) Institutes : Annualy Rs 4000/- (For four issues)
2) Individual : Annualy Rs 800/- Single Isuue : Rs 200/-
3) For Life Members of ICC : Only postage Charge

Payment in respect of subscription may be sent by Cheque/ DD in favour of
Indian Cryogenics Council- Delhi and to be sent along with request letter to

President
Indian Cryogenics Council
Inter- University Accelerator Centre
Aruna Asaf Ali Marg
New Delhi – 110067

EDITORIAL

It gives us great pleasure to bring out these special issues of the Indian Journal of Cryogenics, Vol. 34 and Vol. 35, which is compiled with manuscripts of invited talks and peer reviewed contributory papers presented at the 22nd National Symposium on Cryogenics (NSC-22) held at Indian Institute of Science, Bangalore during 4-6 December 2008. This symposium was jointly organized by the Indian Cryogenics Council (South Zone) and Centre for Cryogenic Technology, Indian Institute of Science and was held in the centenary year of helium liquefaction by Kammerlingh Onnes, coincidentally the centenary year of founding of Indian Institute of Science by the great visionary J.N. Tata. We were fortunate to have a galaxy of eminent cryogenic stalwarts from abroad and India to deliver invited talks at the symposium and many of them did agree to give manuscripts for publication in the Indian Journal of Cryogenics. The manuscript of Helium Liquefaction Centenary talk by Prof. A.T.A.M de Waele, published in this issue of Indian journal of Cryogenics is a rare collection of the fascinating history of helium liquefaction by Kammerlingh Onnes.

The NSC-22 witnessed unprecedented number of contributed papers reflecting the significant growth of cryogenic science and technology in the country. Key areas of space cryogenics, cryogenic heat transfer, cryocoolers, large scale cryogenic systems, materials technology, superconductivity and applications, gas liquefaction and storage systems, low temperature physics and cryo- instrumentation were adequately covered at the symposium.

Publication of the papers has been through a rigorous process of peer reviewing of the papers. For us it was a Herculean task to identify a large number of experts from the small cryogenic community in India for peer review of the 99 contributory papers. The referees rejected few papers and good number of papers was asked for revision.

The process of uploading, reviewing papers and incorporating corrections for this issue was done electronically, largely through the web portal of NSC-22, probably for the first time in the history of Indian Journal of Cryogenics. We are happy that for the first time a user-friendly electronic template giving exact format for publication in the Indian Journal of Cryogenics was evolved for this special issue. Naturally, complexity of all these developments coupled with large number papers to be dealt with has caused some delay in the publication. However we are glad that the processes we have generated for this issue will be aiding faster submission and publication of refereed manuscripts in the future. We are still awaiting corrected manuscripts from 25 authors, which will be published in regular Volume 36 of Indian Journal of Cryogenics, in the near future.

We are extremely thankful to the referees who spent substantial time in correcting the manuscripts in the most professional way. There are many who have worked behind the scenes to make this volume come through and we do not have adequate words to thank them. The Editorial Board of the Indian Journal of Cryogenics deserves special appreciation for their work to print out this volume. We bring out this volume with the hope that it sets new standards in publication for Indian Journal of Cryogenics.

Centre for Cryogenic Technology
Indian Institute of Science, Bangalore

Subhash Jacob, R. Karunanithi and D.S. Nadig
(Guest Editors)

CONTENTS

(Part -C of NSC-22 Proceedings)

Vol. 35 A, 2010

CONTENTS

(Part -B of NSC-22 Proceedings)

Vol. 35 No. 1-4, 2010

Cryogenics for Space, Accelerator & Tokamak

Cryocooler

Cryogenic Instrumentation

(Part -A of NSC-22 Proceedings)

Cryogenics for Space, Accelerator & Tokamak

Cryocooler

Comparison of mixed refrigerants thermodynamic property data predicted at low temperatures using 'aspen' with experimental results

N S Walimbe[1], K G *Narayankhedkar2*, M D Atrey[1]

[1]*Indian Institute of Technology Bombay, Powai, Mumbai – 400 076.*
[2]*Veermata Jijabai Technological Institute, Matunga, Mumbai – 400 019.*

One of the most important tasks involved in the design of MR J-T cryocooler is the property evaluation of a given mixture of refrigerants at low temperatures. The property variations are significant at low temperatures and high pressures depending upon the composition of the mixture. The determination of the p-h charts, evaluation of heat exchanger design and prediction of cooling effect directly depend on the thermodynamic properties of the mixed refrigerant composition. The property determination of such mixtures could be done by various techniques. The properties could be determined using different equations of state like Peng-Robinson (P-R) equation of state and Soave-Redlich-Kwong (S-R-K) equation of state. In the present work, we have used Aspen software to determine the property data of such mixtures. The property data is obtained for a mixture of three components down to 150 K and high pressures. The predictions, based on both the equations of state, are compared with the experimental data available in the literature [1].

Key Words: Mixed refrigerants, J-T cooler, Equation of state

Indigenous development of coiled finned tube heat exchangers

Prabhat Kumar Gupta and PK Kush

CCDS, RRCAT, Indore (MP)

Coiled finned tube heat exchangers are used in small and medium capacity helium liquefiers/refrigerators.The effective heat exchange in each of heat exchanger is a vital issue for achieving high performance of the refrigerator/liquefier. These heat exchangers present the biggest challenges in terms of realizing the compact design with fairly high net effectiveness and low pressure drop in fluid streams. Moreover, the most basic engineering challenges are to design and fabricate these heat exchangers in proper sizes subject to minimum weight and space constraints. In the present paper, we report the development of coiled finned-tube heat exchangers. These heat exchangers have been developed with completely indigenous resources and are in operation with more than 95% effectiveness with acceptable pressure drops.

Key words: Cross Counter Flow Heat Exchangers, High Effectiveness

An experimental setup for thermodynamic and rotordynamic performance study of cryogenic turbo-expander

Ashok K.Dewangan and Parthasarathi Ghosh

Cryogenic Engineering Centre, Indian Institute of Technology, Kharagpur-721302, India

Turboexpander constitutes an important component of Claude cycle based cryogenic process plants. With an increasing demand for energy efficiency of industrial processes, it is now necessary to probe deeper into the functioning of each component. Cryogenic expansion turbine, a high speed dynamic device supported on gas bearings, demands confidence in rotordynamics for its reliability and understanding its aerodynamics for attaining better efficiency. In this paper, a test setup has been envisaged for studying thermal and rotordynamic performance of cryogenic turbo-expander. The paper describes the test rig and associated instrumentation for mapping the performance. The relevant parameters have been identified for characterization of the machine. Selection of instrumentation has been done on the basis of data obtained from the design of a prototype turbine. An estimation of the uncertainty of each parameter has been attempted with accuracy data for the sensors available in the open domain

Keywords: Cryogenic turboexpander, Gas bearings, Experimental Setup, Instrumentation.

Engineering studies related to fixed bed adsorber and its application for fission gas adsorption at cryogenic temperature

Puwar Dhairyapalsinh[1], Prabhat Kumar[1], V.A. Subramani[1], B. Muralidharan[2] and Bharti V. Dave[3]

[1]Bharatiya Nabhikiya Vidyut Nigam Limited, Kalpakkam - 603 102
2Indira Gandhi centre for Atomic Research, Kalpakkam – 603102
3L.D. College of Engineering, Ahmedabad – 380015
Author Email Address: dnpuwar@yahoo.co.in

A detailed literature review for comprehensive understanding of fixed bed adsorption is presented. This includes scientific and engineering aspects pertaining to (1) Compilation of adsorbent properties like adsorption capacity, internal surface area and pore structure, selectivity, regenerability, compatibility and density (2) TYPE I to TYPE VI isotherms and related theories like Henry, Freundlich, Langmuir, BET, Polanyi and Dubinin used for equilibrium adsorption (3) Interparticle heat and mass transfer and intraparticle diffusion using dimensionless numbers like Re, jD and Sc (4) Pressure drop across the bed using Ergun equation (5) Resistance for interparticle and intraparticle heat and mass transfer process using Biot number Bi (6) Application of Mass Transfer Zone(MTZ) and breakthrough curve concept (7) Application of fixed bed adsorber bed packed with activated charcoal to trap fission gases till decay and (8) Effect of temperature and moisture content on adsorption coefficient.

Experimental performance study of cryogenic turboexpander

Subrata Kr. Ghosh[1], Ranjit K. Sahoo[2], Sunil Kr. Sarangi[3]

[1]Mechanical Engineering Department, Indian School of Mines University, Dhanbad
[2, 3]Mechanical Engineering Department, National Institute of Technology, Rourkela

An indigenous programme on design and development of a cryogenic turboexpander has been taken up at NIT, Rourkela. In this paper, the performance characteristics of a turboexpander system, which contains a rigid rotor supported by aerodynamic thrust bearing have analysed. Experiment has been done with the aerodynamic thrust bearing by changing the inlet pressure of turboexpander. Attention has been paid to the study of the effect of stability and vibration of bearings. The maximum rotational speed obtained was 200,000 rpm. The outcome may help the designers, researchers and manufacturer of these components.

Keywords: Turboexpander, Aerodynamic thrust bearing, Instrumentation

A compact heat transfer solution for cryogenics

Zafar Akbar Shaikh

Larsen & Toubro Limited, Powai, Mumbai 400 072
E-mail: zafar_akbar@rediffmail.com

Originally Shell and Tube or PHE are used for the heat transfer in various heat transfer processes in the chemical, Cryogenics and Process industry from a long back. Apart from that Compact heat exchangers are unique, in feature and capabilities, and proven best in terms of space and performance criterion. One novel type is Printed Circuit Heat Exchanger (PCHE) in the Compact heat exchanger category. PCHE offers high compactness, flexibility in design and multi fluid capabilities. This paper describes the features, manufacturing aspects, design consideration and comparison of PCHE with other type of heat exchangers in the cryogenic temperature range.

Space environment thermal balance testing of insat 3D imager cryogenic radiant cooler for IR detectors cooling

Madhu Prasad*, Basavaraj S Akkimaradi, Sant Ram, Subramanya, T.Selvan, A K Shrivastava, D W Tijare, S C Rastogi, K Badarinarayana and D R Bhandari

Thermal Systems Group, ISRO Satellite Centre, Bangalore, India

INSAT-3D Imager Cryogenic Cooler is used to cool and maintain IR detectors of Imager Meteorological Payload at 95K (BOL) and at 100K (EOL). The three-stage passive radiant cooler is designed to cool IR detectors to 95K for a detector heat dissipation of 18 mW. The Mathematical Model is developed for cooler subsystem level and spacecraft level model including the cooler. The on orbit temperatures are predicted for winter solstice and equinox seasons for BOL and EOL conditions. In order to validate the thermal mathematical model, the thermal balance tests are conducted experimentally in simulated space environment of high vacuum, space temperature (100K) and incident heat loads from sun, earth and spacecraft are simulated by using on board heaters. Thermal Balance Tests were conducted for different seasons and conditions. The mathematical model was updated based on thermal balance test and on orbit temperatures were predicted.

Key words : Imager, cryogenic cooler, thermal balance test

Liquid nitrogen thermal shield for SST-1

Manoj Kumar Gupta*, Vijay Bedakihale, Ziauddin Khan, V.L. Tanna and D. Chenna Reddy

Institute for Plasma Research, Bhat, Gandhinagar – 382 428 (India)
** E-mail: jmk@ipr.res.in*

Applications at 4.5 K need to guard from external heat in-leaks (due to radiation and conduction) from the ambient temperature (300 K) surfaces. Intermediate thermal shields always have been appreciated to limit the thermal load at 4.5 K from ambient. In SST-1, the thermal shield will be maintained at 80 K using liquid nitrogen in order to reduce the heat load on superconducting magnet system at 4.5 K. In order to provide the uniform temperature distribution, vacuum and cryo compatible improved version of 80 K thermal shield design is proposed with Helium leak tightness of < 1.0 × 10-8mbar-l/s at service conditions. The design is based on Bubble panel concept. This particular design provides less pressure drop and better temperature uniformity. The thermal shield of SST-1 consists of 9 different types of LN2 panels having a total surface area of ~ 130 m2. Thermo-hydraulic design, technical specification, mechanical integrity, modularity and assembly aspects of this shield will be presented in this paper. Special attention is given for protecting direct room temperature radiation on the magnet system and electrical breaks.

Key words: NSC22, Thermal Shield, Bubble Panel, SST-1, Heat load and mass flow

Conceptual design of superconducting magnets for 28 GHz ECR ion source

G.Rodrigues, A.Chowdhury,P.S.Lakshmy,S.Kar,P.Kumar,A.Mandal, T.S.Datta & D.Kanjilal

Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi 110067, India
gerosro@gmail.com

Due to demand from the nuclear physics community for heavier ions and rare ion species for nuclear physics related experiments, heavy ion development from an ECR ion source is continuously progressing. Production of heavy ions from a typical ECR ion source is relatively more difficult as compared to that for lighter ions. In order to improve the intensity of heavier ions, the source is required to be operated at higher frequencies and higher magnetic fields to improve their confinement times. ECR ion sources like PKDELIS, HYPERNANOGAN etc, which operate at 14.5 - 18 GHz cannot deliver more than a few tens of microamperes in DC mode of operation for heavy beams like Ta,Au,Pb etc. A new, fully superconducting source capable of operation at 28 GHz is being designed keeping in mind these design goals of achieving a few hundreds of microamperes of heavy ions. The design aspects for the superconducting magnets (axial and radial) for a 28 GHz electron cyclotron resonance ion source involves more stringent conditions as compared to a hybrid type of ion source which has superconducting magnets for the axial confinement and permanent magnets for the radial confinement.

Key words: ECR ion source, superconducting magnets

Development of two stage filter wheel cooler for sounder meteorological payload on-board insat 3D spacecraft

Madhu Prasad*, Basavaraj S Akkimaradi, Sant Ram, Subramanya, T.Selvan, D W Tijare, A K Shrivastava, S C Rastogi, K Badarinarayana and D R Bhandari

Thermal Systems Group, ISRO Satellite Centre, Bangalore, India

Sounder meteorological instrument on board INSAT-3D satellite requires 18 Infrared Channel in the band of SWIR, MWIR and LWIR. The IR detectors are mounted on main sounder cooler. The filter wheel is required for the separation of spectral channels of the sounder instrument. It is housed in a filter wheel casing whose temperature is controlled at 213 K by a filter wheel radiant cooler utilizing deep cold space. It is a two stage passive cooling device consisting of radiator the second stage and vacuum housing/sun shield as a first stage. The radiator is coupled to top casing of filter wheel cooler as an integral part. The cooler assembly is subjected to space qualification tests like vibration test, thermal cycling test, thermal balance test and electrical test/insulation resistance tests. The thermal balance test is conducted to validate the thermal model and updated TMM is used to predict the on-orbit thermal performance of the cooler. The cooler is expected to meet all the specifications of the payload.

Key words : Sounder, Filter Wheel Cooling System, Thermal Balance Test, Radiant Cooler

Flow and heat transfer in lH_2-LOX cryogenic rocket engine regenerative coolant channels

Biju T. Kuzhiveli

Department of Mechanical Engineering, National Institute of Technology Calicut, India-673601,
Email: btkuzhiveli@nitc.ac.in

In an LH2-LOX cryogenic engine thrust chamber, liquid hydrogen is passed through the regenerative channels in order to take care of the high energy combustion resulting out of a reasonably high mixture ratio. However the cryogenic cooling results in wide range of temperature distribution in the cross section and along the axis of the thrust chamber with respect to time and poses serious structural strength concerns. In order to have an understanding of temperature distribution and stable structural design, an accurate prediction of heat transfer characteristics for the complete spectrum of the thrust chamber with respect to time is necessary. The objective of this paper is to present transient thermal analysis with three dimensional approaches which can provide transient temperature distribution along the axis and across the cross section during transient and steady state conditions for chill down and hot test. A computational model has been developed for the prediction of temperature distribution on the thrust chamber which could be suited for parametric studies and also for generating an optimum design for cryogenic rocket engines to recommend stable operation.

Key words: thrust chamber, cryogenic engine, computational model

Radiation effects on insulation system for superconducting fusion magnets

Rajiv sharma[1], V.L. Tanna[1], Anurag Shayam[1], Basant Das[1] and B. V. Dave[2]

[1]Institute for plasma Research, Near Indira Bridge, Bhat, Gandhinagr, Gujarat
[2]L.D. College of Engineering, Ahmedabad

The selection of insulating materials for superconducting magnet systems considering the neutron and gamma irradiation at 4 K of fusion devices are an important factor. We have developed the helium electrical breaks in which the GFRP has been used for SST-1 superconducting machine, after the charging, due to radiation effects the insulation system properties is degrading, these helium feed is to be installed in fusion machine and our future plan is to test for radiation effects on its insulation system used. Glass fiber Reinforcement Plastics (GFRP) is usually employed as insulating material for the superconducting coils of large fusion magnets e.g. The International Thermonuclear Experimental Reactor (ITER). The effect of irradiation at the room temperature and cryogenic temperature range degrade the mechanical, electrical, thermal properties of nonmetallic insulators and effect the more load on the refrigeration system, as the residual flexural and compressive strength of G-10 and G-11 (CR grade) laminates reduced to 10 to 15% of original volume after exposure to 2.4 x109 radiation by the fast neutron flux of 2.2 x 1022 n/m2. In this paper, we will present the effect of irradiation spectrum on the on the mechanical, electrical, thermal properties on the insulation systems and its behavior at room temperature and cryogenic temperature prior and after irradiation will be presented.

Key words: ITER, Fusion GFRP (G-10/G-11 CR), Irradiation

Development of compact liquid nitrogen based table top thermo vacuum system to meet special test requirements of satellite subsystems

M.C.A.Naidu, D.K.Dhodi and KM Kavani

Space Applications Centre, ISRO, Ahmedabad-380 015

Acceptance / Qualification tests of subsystems of satellite payloads under thermal vacuum conditions are essential to assess their workmanship, components quality, reliability, space worthiness etc. Temperature attainability and control with minimum gradient from top to bottom, of high heat dissipated electronic packages of compact size is critical and need of the hour. Due to miniature technology of present times, the size of the electronic packages is becoming compact with a high heat dissipation and short harness lengths, which is a challenge to make a thermal vacuum system with precise temperature control. This paper describes the specifications, special features, design values, liquid nitrogen based direct injection thermal system, precise temperature control, shroud movement mechanism, data acquisition & control system etc. The entire system is a PLC+PC based, completely auto system with auto tuned thermal profile control system. This system requires a very nominal amount of liquid nitrogen while conducting thermal vacuum tests.

Key words: Vacuum, temperature, short harness, high heat dissipation, shroud movement mechanism, liquid nitrogen

Space qualification testing of sounder cryogenic radiant cooler of IR detector on board sounder payload of insat 3D satellite

Madhu Prasad*, Basavaraj S Akkimaradi, Sant Ram, Subramanya, T.Selvan, A K Shrivastava, D W Tijare, K Badarinarayana, S C Rastogi, and D R Bhandari

Thermal Systems Group, ISRO Satellite Centre, Bangalore, India

Sounder Cooler is used to cool the IR detectors of Sounder Payload of INSAT 3D Satellite. The temperature of these IR detectors is controlled at 95K (BOL) and 100K (EOL). The three-stage radiant cooler is developed to meet the specification of IR detector cooling. The Cooler assembly was subjected to space qualification testing like insulation resistance test/electrical tests, optical alignment tests, vacuum leak test, vibration test and thermal cycling test. The space environment thermal balance test is conducted to validate the thermal mathematical model. Also, decontamination heater power verification test was conducted. The assembly was integrated with sounder instrument and IR detector bench test was conducted. The Sounder assembly has undergone vibration test, thermo vacuum performance test successfully. Based on the above tests conducted, the thermal performance of cooler is expected to meet the critical requirements of IR detector cooling.

Key words : sounder, cryogenic cooler, space qualification test

Performance validation tests on electrical isolators for SST–1

V.L. Tanna, J.C. Patel, D. Sonara, R. Patel, R. Panchal, P. Shukla, G. L. N. Srikanth and D. Chenna Reddy

Institute for Plasma Research, Bhat, Gandhinagar (India) – 382 428

The function of Helium electrical isolators is to isolate the magnet system electrically from helium distribution system at desired voltage level of 5 kV (maximum). The 360 numbers of such electrical isolators for Helium service were installed in SST-1 machine for the magnets and associated auxiliary sub-systems. The functional requirements and material used to manufacture such isolators are discussed. During the commissioning of SST-1, the performance of in-house developed isolators was not found satisfactory from the quality of materials. Although the electrical isolators gone through all the necessary functional tests under laboratory conditions, to be more precise, as a part of leak-proof validation tests at rated conditions, the test was conducted for two variants: [i] Performance test on in-house developed Electrical Isolators and [ii] Performance test on procured Electrical Isolators. The details of experimental scheme and test results will be presented in this paper.

Key Words: Electrical Isolator, Leak tightness, Supercritical Helium, Cryostat and Heat Exchanger

Effect of flow straightner on the performance of the G-M type pulse tube cryocooler

S. Desai[1], K. P. Desai[2] , H. B. Naik[2] and M. D. Atrey[3]

[1]Mechanical Engineering Department, C. K. Pithawala College of Engg. & Tech., Surat
[2]Mechanical Engineering Department, S. V. National Institute of Technology, Surat and
[3]Mechanical Engineering Department, IIT Bombay, Mumbai

The pulse tube cryocooler has no moving parts at its cold section. It is attractive in obtaining higher reliability, simpler construction, and lower vibration as compared to Stirling and G-M type cryocoolers. The pulse tube cryocooler consists of a thin-walled tube with heat exchangers at both ends, connected to a pressure oscillator via regenerator. The pressurized pulse enters the cold end of the pulse tube where the cold end heat exchanger is located. The Heat exchanger also acts as a flow straightner to minimize gas turbulence effects in the pulse tube. The axial flow channels in the flow straightner provides large surface area which increases heat exchange with the outer copper block and also performs the function of flow straightening. The present work provides experimental results on the G M type pulse tube cryocoolers using different configurations of the flow straightners at the cold end of the pulse tube. The comparison for the different configurations of the flow straightners is carried out in terms of cool down time and no load temperature.

Key words: Pulse Tube Cryocooler, Flow Straightner

Analysis of miniature crank driven cryocooler

Biju T. Kuzhiveli[1], Manmohan Singh[2]

[1]Department of Mechanical Engineering, National Institute of Technology Calicut, India-673601, Email:btkuzhiveli@nitc.ac.in
2Cryocooler Division, DRDO, SSPL, New Delhi -110 054

Over the past quarter century the cryocooler drive mechanism has undergone transition from heavy crank to linear drive and to miniature drives. While the advances in miniature linear drive is progressing steadfastly, the significance of miniature crank drive has not been completely ruled out. It has distinct niche in low cost cryocooler family and also in certain applications which demand for a positive drive mechanism, making use of a miniature crank driven compressor. The system offers advantages of low production cost, remote cooling and flexibility to mount in any direction in ground and aerial infra red devices. Because of the complexities associated with such a system a detailed computational model was necessary and has been carried out for the steady state conditions. Based on the analysis various design parameters are arrived at, which are necessary to develop miniature crank driven cryocooler.

Key words: cryocooler, compressor, regenerator

Simulation of a simple GM type double inlet pulse tube refrigerator

Y. P. Banjare[1], R. K. Sahoo[2], S.K. Sarangi[2]

[1]Deptt. of Mech. Engg., GEC Bilaspur
[2]Deptt. of Mech. Engg., NIT Rourkela

This paper performs a two-dimensional computational fluid dynamic (CFD) simulation of a GM type double inlet pulse tube refrigerator (DIPTR). A commercial Computational Fluid Dynamics (CFD) software Fluent 6.1 is used to model the oscillating flow inside a pulse tube refrigerator. The simulation represents fully coupled systems operating in steady-periodic mode. The externally imposed boundary condition is sinusoidal pressure inlet by user defined function at one end of the tube and constant temperature or heat flux boundaries at the external walls of the hot end and cold end heat exchangers. The general results, such as the cool down behaviors of the system, phase relation between mass flow rate and pressure at pulse tube section and the temperature profile along the wall of the cooler are presented for different boundary conditions of the system. The results confirm that CFD based Fluent simulations are capable of elucidating complex periodic processes in DIPTR.

Keywords: Double inlet pulse tube refrigerator; GM type cooler, Regenerator; CFD, Fluent.

A theoretical model of orifice pulse tube refrigerator

***N.K.Mohammed Sajid, K.A.Shafi, and **Arun Mohan**

**Department of Mechanical Engg. T.K.M. College of Engg, Kollam. Kerala, India*
***Department of Mechanical Engg. SNG College of Engg. Kadayirippu, Kolenchery, Kerala.*

Many numerical models for pulse tube refrigerators have been developed in the past. In this work the isothermal model developed by Zhu and Chen[10] has been modified by incorporating major refrigeration losses in the pulse tube refrigerators. This improves the accuracy of the model and can be used to predict the net refrigeration power. The present model can be used to investigate the effects of important system parameters on the performance of OPTR. It predicts cooling power as well as pressure/volume relationships of the cold and hot ends of the pulse tube and compressor, with minimal computational requirements. A comparison of the ideal and the actual cooling powers have also been performed. Quantitative analyses of the major refrigeration losses in the pulse tube refrigerator have also been conducted and a heat balance chart is prepared.

Keywords: pulse tube refrigerators; isothermal model; cryocoolers

Solar-PV stirling refrigerator

V.R.Rajesh and Biju T.Kuzhiveli

Department of Mechanical Engineering, National Institute of Technology Calicut, Calicut, Kerala, India–673 601.E-mail: rajeshvr.kld@gmail.com

The solar photovoltaic (PV) modules are best means for tapping sun's energy. A Stirling refrigerator powered with solar energy in this way would be an ideal choice in the present world of energy crisis. A small Stirling refrigerator, with well insulated cabinet, has competitiveness against small domestic vapour compression refrigeration system. The use of thermal energy storage makes the system to connect directly to PV-panel. A small cabinet of 40 litres consumes a maximum of around 100 W, inclusive of all leaks and that consumed by fan and other electronics, within the temperature limits of -25℃ and 35℃. This paper specifically addresses the design of the PV system for a small capacity linear motor driven Stirling refrigerator using helium as working gas. As the piston motion is accomplished by moving magnet type linear motor than conventional moving coil type, the problems associated with the latter, such as unreliability due to flying leads etc., are eliminated. The results of the preliminary analysis are also presented.

Key words: Photovoltaic, Stirling cycle, Linear motor

CFD study of orifice pulse tube cryo-cooler

B.S.Gawali and P. A. Mane

Mechanical Engineering Department,
Walchand Collegeof Engineering, Sangli.

A commercial computational fluid dynamics (CFD) software package is used to model theoscillating flow insidea pulse tubecryocooler. Thecryocooler comprises compressor, aftercooler,regenerator,pulse tube with coldand hot heatexchanger, orifice and a reservoir. Atwo-dimensional axis symmetric model is considered forsimulation.This simulationdemonstrates the timevarying temperature at cold heat exchanger along with computation ofthe heatfluxes atthe cold heat exchanger (CHX).Also the phase difference in pressure andmass flow rate at CHX is also predicated. The only externally imposedboundary conditionsare a cyclically moving piston wall at one end of tube and constant temperature boundaries atthe external walls of the hot and cold heat exchangers. The present work aims to analyze theCFD simulation oforifice pulse tube cryocooler and swirling phenomenon in the pulsetube.Andalso make an attempt to reducethe swirling phenomenon by using mesh.

Keywords: Orifice pulse tube cryocooler, CFD, cold heat exchanger (CHX), Regenerator.

Preliminary experimental results on moving-magnet compressor

Shreesh Mishra, S. L. Ba*p*at and M. D. Atrey

Indian Institute of Technology Bombay, Powai, Mumbai – 400 076, India.

Advantages like longevity, maintenance free and reliable operation of cryocoolers for space applications led to the development of linear motor driven compressors. Among them, the moving magnet configuration ensures lesser contamination of the working gas due to isolation of the coil from the gas. The objective is to design and fabricate a moving magnet driven compressor with dual opposed piston arrangement. A single piston and a dual-opposed piston compressor based on moving-magnet motor have been developed. Experiments are carried out to find the effect of different parameters – compression space volume, number of flexure units, charging pressure and input power. Resonance at different operating conditions is observed and is found to result in higher piston stroke and pressure ratio.

Key words: Cryocoolers, Linear Motor, Moving-Magnet, Resonance

Thermal conductivity measurements of carbon epoxy and glass epoxy composites from 300K to 80K

R S Praveen[1], S Jacob[2], C R L *Murthy3, P Balachandran4, Suresh Bhardwaj5 and A M A*wasthi[5]

[1]gsLVM3, Vikram Sarabhai Space Centre, Trivandrum, 2Centre for Cryogenic Technology, IISc, Bangalore

3Dept. of Aerospace Engineering, IISc, Bangalore, 4PRD, Liquid Propulsion Systems Centre, Trivandrum

5U.G.C.-D.A.E., Consortium for Scientific Research, Indore

This paper describes the results of measurements of the thermal conductivity of composites made from carbon and glass fibres reinforced uni-axially into an epoxy resin matrix. Steady state measurement technique is followed. The results shows that thermal conductivity decreases at a higher rate in the case of carbon epoxy laminate when compared to glass epoxy samples as the temperature is lowered from 300 to 80K.This gives confidence in use of these materials in hybrid form at various low temperatures depending on the application. The behaviour of these materials with respect to their constituents viz the matrix system and the fibres used is discussed. Liquid nitrogen is the refrigerant used for creating the desired low temperature. The experiments were conducted at Thermodynamics Lab, Consortium for Scientific Research,Indore using a custom made experimental set-up. The paper also describes about the experimental complexities with respect to testing of composite materials at low temperatures.

Key words: Thermal conductivity, carbon-epoxy, glass-epoxy

One/two step easy synthesis routes for obtaining ground state of refeaso (Re=Sm, La, Pr) superconductors

R. S. Meena, Anand Pal, Arpita Vajpayee, Monika Mudgel, V.P.S Awana and H. Kishan

National Physical Laboratory, Dr. K.S. Krishnan Marg, New Delhi-110012

In this article, we report easy and versatile one/two step synthesis routes for phase formation of the ground state of newly discovered Fe based REFeAsO1- compounds at normal atmospheric pressure instead of widely used high-pressure and high-temperature (HPHT) methods. In two-step method first the precursors of FeAs and ReAs are prepared and mixed with REO/Fe2O3 & RE/Fe in stoichiometric ratio by solid-state reaction route method and finally vacuum-sealed (10-5Torr) and heat-treated at high temperature. In single step method, the Fe, REO, RE, and As are taken in stoichiometric ratio of REFeAsO1- and finally heat treated. The resulting compounds are nearly single phase & crystallize in tetragonal P4/nmm structure. These samples show the ground state spin density wave (SWD) like metallic behavior below around 150 K. In conclusion the ground state (non-superconducting) of newly discovered Fe based superconductor is synthesized for various rare earths including Gd, Sm, La, and Pr via one-step/ two-step solid sate reaction routes.

Key words: Rare earth arsenide, spin density wave (SDW), HPHT.

Thermal characterization of MLI in the temperature range 80-4K

P. Srinivasa Rao[1], A. Prasada Rao[2], and M.B.N Murthy[3]

[1]Engineer-SE, Cryo propellant Systems, Liquid Propellant Storage & Stage Servicing Facility (LSSF), SDSC SHAR-ISRO, [2]Engineer-SF, Cryo propellant Systems, LSSF, SDSC SHAR and [3]Engineer-SG, Cryo propellant Systems, LSSF, SDSC SHAR

The experimental set up for thermal characterization of Multi layer insulation (MLI) is configured in such a way that it ensures minimum and accountable heat-in-leak. The experimental set up includes inner vessel, LIN shield and Outer vessel along with temperature, flow and vacuum sensors integrated with data acquisition system. A LIN phase separator is also configured to ensure continuous liquid feed and uniform skin temperature on the shield. Upon realizing the test set-up, experiments are conducted with Liquid Nitrogen prior to Liquid Helium to validate the LIN shield configuration parameters. Also the optimal insulation material in the temperature range of 300-80K is selected and number of insulation layers for LIN shield is finalized. Subsequent test has been conducted with Liquid Helium to study the heat insulation characteristics and layer temperatures of MLI. This test is conducted by providing 40 & 30 layers of MLI on the inner vessel and LIN shield respectively. The shield and insulation layer temperatures are observed for stable values for more than 24 hours. The steady state parameters of the experiment i.e., gas flow rate, layer temperatures and vacuum recordings have confirmed that the insulation being tested is suitable for the desired application with an Apparent mean thermal conductivity of 0.11 x 10^{-4} W/mK as against the targeted value of 0.5 x 10^{-4} W/mK as considered for LH2/LHe service by the leading manufacturers in the world.

Key words: Multi Layer Insulation (MLI), Apparent mean thermal conductivity(K), Liquid Nitrogen is refered at (LIN), Liquid Helium

Thermal conductivity measurements of carbon-glass hybrid composites from 300K to 20K

R.S. Praveen[1], Subhash Jacob[2], C.R.L. Murthy[3], P. Balachandran[4], Suresh Bhardwaj[5] and A.M. Awasthi5

[1]gsLVM3, Vikram Sarabhai Space Centre, Trivandrum, 2Centre for Cryogenic Technology, IISc, Bangalore 3Dept. of Aerospace Engineering, IISc, Bangalore, 4PRD, Liquid Propulsion Systems Centre, Trivandrum, 5U.G.C.-D.A.E., Consortium For Scientific Research, Indore

This paper describes the results of measurements of the thermal conductivity of hybrid composites made from carbon and glass unidirectional lamina layers reinforced epoxy resin matrix. Steady state measurement technique is followed. Experiments were done with thin as well as thick specimens measuring relative values and near actual values respectively. The experiments were done with liquid helium and liquid nitrogen from 80K to 20K and from 300K to 80K respectively. Comparisons have been made with a known theoretical model vis a via the experimental results. A program in MATLAB was also written for calculations using theoretical model. Comparisons are made with the thermal conductivity observed when these materials are not in hybrid state with the theoretical model.

Key words: Hybrid, Thermal Conductivity, Carbon-epoxy, Glass-epoxy