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<sup>1</sup>Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, Kasuga-koen 6-1, Kasuga-shi, Fukuoka 816-8580, Japan;

<sup>2</sup>Department of Agricultural Engineering, Faculty of Agricultural Sciences & Technology, Bahauddin Zakariya University, Bosan Road, Multan

60800, Pakistan; <sup>3</sup>Faculty of Engineering Sciences, Kyushu University, Kasuga-koen 6-1, Kasuga-shi, Fukuoka 816-8580, Japan; <sup>4</sup>International

Institute for Carbon-Neutral Energy Research (WPI-I2CNER), Kyushu University, 744 Motoooka, Nishi-ku, Fukuoka 819-0395, Japan

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<sup>1</sup>Chemours Fluorochemicals, Wilmington, Delaware, United States of America; <sup>2</sup>Viking Heat Engines, Kristiansand, Norway; <sup>3</sup>Viking Heat Engines, Remscheid, Germany; <sup>4</sup>Viking Development Group, Kristiansand, Norway

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<sup>1</sup>University of Illinois, United States of America; <sup>2</sup>Harbin Institute of Technology, Harbin, P R China

**Keywords:** Dynamic Contact Angle, Droplet Shape, Droplet Velocity, Textured Surface, Gradient in Wettability

ID: 2120

### CFD-Based Correlation Development for Air Side Performance of Wavy Fin Tube Heat Exchangers Using Small Diameter Tubes.....527

Daniel Bacellar, Vikrant Aute, Reinhard Radermacher

University of Maryland, United States of America

**Keywords:** Airside Heat Transfer, Airside Friction, CFD, Correlations, Wavy Fin

ID: 2363

### CFD-Based Airside Heat Transfer and Pressure Drop Correlation Development for Small Diameter (3 Mm to 5 Mm) Louver Fin Heat Exchangers.....537

Shekhar Sarpotdar<sup>1</sup>, Dennis Nasuta<sup>1</sup>, Vikrant Aute<sup>1,2</sup>

<sup>1</sup>Optimized Thermal Systems, 7040 Virginia Manor Road, Beltsville, MD, 20705; <sup>2</sup>Center for Environmental Energy Engineering Department of Mechanical Engineering, University of Maryland College Park, MD, 20742

**Keywords:** Louver Fin, CFD, Correlation

ID: 2362

### CFD Based Comparison of Slit Fin and Louver Fin Performance for Small Diameter (3mm to 5 Mm) Heat Exchangers.....547

Shekhar Sarpotdar<sup>1</sup>, Dennis Nasuta<sup>1</sup>, Vikrant Aute<sup>1,2</sup>

<sup>1</sup>Optimized Thermal Systems, 7040 Virginia Manor Road, Beltsville, MD, 20705; <sup>2</sup>Center for Environmental Energy Engineering Department of Mechanical Engineering, University of Maryland College Park, MD, 20742

**Keywords:** CFD, Fin, Slit, Louver, Optimization

ID: 2587

### Method for Determining Air Side Convective Heat Transfer Coefficient Using Infrared Thermography.....557

Scott S. Wujek<sup>1</sup>, Wayne L. Staats<sup>2</sup>, Stefan W. Elbel<sup>1</sup>, Jeffrey P. Koplow<sup>2</sup>, H. Arthur Kariya<sup>2</sup>, Predrag S. Hrnjak<sup>1</sup>

<sup>1</sup>Creative Thermal Solutions, United States of America; <sup>2</sup>Sandia National Laboratory, United States of America

**Keywords:** Heat Transfer Coefficient, Infrared, Experimental Methods, Convective Heat Transfer

ID: 2555

### Numerical Simulation (CFD) to Explore Optimal Vortex Generator Array Configurations in Air Cooled Condensers.....567

Mei Yung Wong, Gregory D Hardy, Anthony M Jacobi, Predrag Hrnjak

University of Illinois at Urbana Champaign, United States of America

**Keywords:** Air Cooled Condensers, Vortex Generator Arrays, Numerical Simulation

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*Time:* Tuesday July 12, 2016: 9:45 AM - 11:45 AM — *Location:* 278

*Session Chair:* William E. Murphy

**ID: 2454**

### **Design and Modeling of 3D-Printed Air-Cooled Heat Exchangers.....577**

**Rachel Ann Felber, Gregory Nellis, Natalie Rudolph**

University of Wisconsin-Madison, United States of America

**Keywords:** Heat Exchangers, Design, Additive Manufacturing

**ID: 2424**

### **Thermodynamic Analysis of an Electrochemically Driven Chemical Looping Heat Pump.....585**

**Nelson A James, James E Braun, Eckhard A Groll, W Travis Horton**

Ray W. Herrick Laboratories, Purdue University, United States of America

**Keywords:** Chemical Heat Pump, Electrochemical Cells

**ID: 2629**

### **Development and Evaluation of an Automated Virtual Refrigerant Charge Sensor Training Kit.....595**

**Akash Patil, Andrew L. Hjortland, James E. Braun, W. Travis Horton, Orkan Kurtulus**

Purdue University - Ray W. Herrick Laboratories, United States of America

**Keywords:** FDD, Virtual Sensors

**ID: 2569**

### **Experimental and Numerical Study of a Mobile Reversible Air Conditioning-Heat Pump System.....605**

**Lili Feng, Pega Hrnjak**

University of Illinois at Urbana-Champaign, United States of America

**Keywords:** Mobile Air Conditioning, Heat Pump, Simulation, Modeling, System

**ID: 2271**

### **Hydrodynamic Considerations for Optimal Thermal Compressor Design.....615**

**Marcel A. Staedter, Khoudor Keniar, Srinivas Garimella**

Georgia Institute of Technology, United States of America

**Keywords:** Thermally Driven Heat Pumps, Waste Heat Recovery, Distillation, Thermal Compressor, Desorption

**ID: 2420**

### **Online, Non-Intrusive Composition Measurements of Circulating Co<sub>2</sub> Based Mixtures in an Experimental Heat Pump by Means of Infra-Red Spectroscopy.....625**

**Paul Bouteiller<sup>1</sup>, Marie-France Terrier<sup>1</sup>, Maria Isabel Barba-Garrancho<sup>2</sup>, Pascal Tobaly<sup>1</sup>**

<sup>1</sup>CNAM, IFFI, case 2D3P21, 292 rue saint martin 75003 Paris, France; <sup>2</sup>CREVER, Universitat Rovira I Virgili, Avinguda Països Catalans, 26 (Campus Sescelades) - 43007 Tarragona, Spain

**Keywords:** Mixture Composition, Online-Measurements, Spectroscopy, Heat Pump

## **R-12: Advanced Equipment Controls II (IBO)**

*Time:* Tuesday July 12, 2016: 1:30 PM - 3:30 PM — *Location:* 218 A&B

*Session Chair:* John House

**ID: 2386**

### **Review of Temperature and Humidity Control Technology for Heat Pump and Air Conditioning Systems.....635**

**Xiaojie Lin, Yunho Hwang, Reinhard Radermacher, Saikee Oh**

University Of Maryland, United States of America

**Keywords:** Temperature; Humidity; Control; VRF ; Heat Pump; Air Conditioning

**ID: 2571**

### **Dynamic Charge Management for Vapor Compression Cycles.....644**

**Christopher R. Laughman, Hongtao Qiao, Daniel J. Burns, Scott A. Bortoff**

Mitsubishi Electric Research Laboratories, United States of America

**Keywords:** Dynamic Simulation, Control, Heat Pump, Modelica, Optimization

**ID: 2433**

### **Cooling Capacity Control for Multi-Evaporator Vapor Compression Systems.....654**

**Daniel J. Burns, Scott A. Bortoff**

Mitsubishi Electric Research Laboratories, United States of America

**Keywords:** Controls, Feedback Systems, Multi-Evaporator Cycle Control

**ID: 2496**

### **Optimisation of Expansion Valve Control in Refrigeration Appliances Under Cyclic Operation.....663**

**Marcel van Beek, Hans de Jong**

Re/genT, Netherlands, The

**Keywords:** Expansion Device, Control Strategy, Small Cooling Capacity, Energy Efficiency

**ID: 2365**

### **Development of an Adaptive PID Controller for Superheating Control Employing Artificial Bee Colony Algorithm.....673**

**Nathalie Martins Panoeiro<sup>1</sup>, Ricardo Nicolau Nassar Koury<sup>2</sup>, Luiz Machado<sup>2</sup>, Antonio Augusto Torres Maia<sup>2</sup>**

<sup>1</sup>M.Sc. candidate - Programa de pós-graduação em Engenharia Mecânica - Universidade Federal de Minas Gerais, Brazil; <sup>2</sup>Programa de pós-graduação em Engenharia Mecânica - Universidade Federal de Minas Gerais, Brazil

**Keywords:** Superheating Control, PID Controller, Artificial Bee Colony Algorithm

## **R-13: Expansion Devices + Two Phase Separators**

*Time:* Tuesday July 12, 2016: 1:30 PM - 3:30 PM — *Location:* 218 C&D

*Session Chair:* Ullrich Hesse

**ID: 2062**

### **Theoretical and Experimental Analysis of Expansion Devices for Meso-Scale Cooling Systems.....681**

**João Fabio Parise de Lara, Claudio Melo, Joel Boeng**

Federal University of Santa Catarina, Brazil

**Keywords:** Expansion Device, Capillary Tube, Meso-Cooling

**ID: 2009**

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**Thomas Tannert, Ullrich Hesse**

Bitzer-Stiftungsprofessur für Kälte-, Kryo- und Kompressorentchnik / Technische Universität Dresden, Germany

**Keywords:** Refrigerator, Capillary Tube, Flow Pattern, Two Phase Flow, Noise

**ID: 2426**

### **Experimental Research and Theoretical Analysis on Throttling Characteristics of Electronic Expansion Valve in Series With Capillary Tube.....701**

**Xiangfei Liang<sup>1,2</sup>, Jinsheng Fang<sup>2</sup>, Bo Zheng<sup>1,2</sup>, Youlin Zhang<sup>2</sup>**

<sup>1</sup>National Engineering Research Center of Green Refrigeration Equipment, China, People's Republic of; <sup>2</sup>Gree Electric Appliances, Inc. of Zhuhai, China, People's Republic of

**Keywords:** R-32, Electronic Expansion Valve, Capillary Tube, Throttling Model

**ID: 2276**

### **Experimental Study of Two-Phase Separators for Vapor Compression Systems in Household Appliances.....708**

**Jessica Alvarado, Brent Junge, Andrea Kelecny**

General Electric Appliances, United States of America

**Keywords:** Two-Phase, Liquid Phase, Vapor Phase, Efficiency, Separator

**ID: 2549**

### **Performance Testing of Unitary Split-System Heat Pump With an Energy Recovery Expansion Device.....718**

**Nicholas Czaplá, Harshad Inamdar, Nicholas Salts, Eckhard Groll**

Purdue University, United States of America

**Keywords:** Energy Recovery, Heat Pump, Turbine, Nozzle, R410A



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*Time:* Tuesday July 12, 2016: 1:30 PM - 3:30 PM — *Location:* 310

*Session Chair:* Lorenzo Cremaschi

**ID: 2643**

### **Computationally Efficient Modeling Approach for Evaporator Performance Under Frost Conditions.....728**

**Donghun Kim, Sugirdhalakshmi Ramaraj, James Braun**

Purdue University, United States of America

**Keywords:** Evaporator, Frost, Defrost, Refrigeration

**ID: 2195**

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**Marco Timmermann, Jader Barbosa**

Federal University of Santa Catarina, Brazil

**Keywords:** Compact Heat Exchanger, Frost Formation, Porous Medium, Peripheral Fins

**ID: 2222**

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**Ergin Bayrak<sup>1,2</sup>, Akın Çağlayan<sup>1</sup>, Alper Şevki Konukman<sup>2</sup>**

<sup>1</sup>Research and Development Department, Friterm Inc, Istanbul, 34957, TURKEY; <sup>2</sup>Energy Systems Division, Department of Mechanical Engineering, Gebze Technical University, 41400, Kocaeli, TURKEY

**Keywords:** Finned Tube Evaporators, Frosting, Air Flow Rate, Air and Refrigerant Side Maldistribution

**ID: 2294**

### **Assessing Defrosting Performance on Hydrophilic, Hydrophobic, and Micro-Patterned Heat Transfer Surfaces.....757**

**Nickolas C. Schmiesing, Andrew D. Sommers**

Miami University, Oxford, OH, United States of America

**Keywords:** Frost, Surface Wettability, Microchannels, Hydrophilic, Hydrophobic

**ID: 2016**

### **Frost Growth Investigation and Temperature Glide Refrigerants in a Fin-And-Tube Heat Exchanger.....767**

**Elie Keryakos<sup>1,2</sup>, Joseph Toubassy<sup>1</sup>, Denis Clodic<sup>1</sup>, Georges Descombes<sup>2</sup>**

<sup>1</sup>CRYOPUR, France; <sup>2</sup>Cnam (Conservatoire National des Arts et Metiers), laboratoire chimie Moléculaire, Génie des Procédés Chimiques et Energétiques (CMGPCE)-EA 7341, France

**Keywords:** Biogaz, Upgrading, Frost, Heat Exchanger, Heat Transfer

## R-15: Commercial/Industrial Refrigeration III

Time: Tuesday July 12, 2016: 4:00 PM - 6:00 PM — Location: 218 A&B

Session Chair: Brian Fricke

ID: 2556

### Conversion of Cold Beverage Dispenser's Refrigeration System to R744 Refrigerant.....777

Matej Visek<sup>1</sup>, Stefan Elbel<sup>1,2</sup>, Pega Hrnjak<sup>1,2</sup>

<sup>1</sup>Creative Thermal Solutions, United States of America; <sup>2</sup>University of Illinois at Urbana-Champaign, United States of America

Keywords: Carbon Dioxide, Light Commercial, Performance, Thermal Storage, Optimization

ID: 2220

### Challenges on Converting an Upright Ice-Cream Freezer From R404a to R290 Complying With 150g Refrigerant Charge Restriction.....787

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EMBRACO, R&D

Keywords: Variable Speed Compressor, Natural Refrigerants, Light Commercial Application, Upright Freezer, Energy Saving

ID: 2388

### Testing of HFO Refrigerant With Less Than 150 GWP in a Commercial Freezer.....796

Barbara Haviland Minor<sup>1</sup>, Sonali Shah<sup>2</sup>, Luke Simoni<sup>3</sup>

<sup>1</sup>The Chemours Company, United States of America; <sup>2</sup>The Chemours Company, United States of America; <sup>3</sup>The Chemours Company, United States of America

Keywords: Refrigerant, GWP, Refrigeration, XL20, Freezer

ID: 2561

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Michael Petersen, Gustavo Pottker, Gregory L. Smith, Samuel F. Yana Motta, Ankit Sethi

Honeywell International, United States of America

Keywords: Fractionation, Low GWP Blends, Miscibility, Solubility, Material Compatibility

ID: 2286

### Laboratory Evaluation of a Commercial CO<sub>2</sub> Booster Refrigeration System.....815

Brian Fricke<sup>1</sup>, Shitong Zha<sup>2</sup>, Vishal Sharma<sup>1</sup>, Jeff Newel<sup>2</sup>

<sup>1</sup>Oak Ridge National Laboratory, United States of America; <sup>2</sup>Hillphoenix, United States of America

Keywords: Commercial Refrigeration, Carbon Dioxide, Transcritical

ID: 2281

### Simulation Model of an Automatic Commercial Ice Machine.....825

Haithem Murgham<sup>1</sup>, David Myszka<sup>1</sup>, Vijay Bahel<sup>2</sup>, Rajan Rajendran<sup>2</sup>, Kurt Knapke<sup>2</sup>, Suresh Shivashankar<sup>2</sup>, Kyaw Wynn<sup>2</sup>

<sup>1</sup>University of Dayton, United States of America; <sup>2</sup>Emerson Climate Technologies

Keywords: Ice Maker, Transient Simulation

## R-16: Ejector/Injector Analysis and Performance

Time: Tuesday July 12, 2016: 4:00 PM - 6:00 PM — Location: 218 C&D

Session Chair: Stefan Elbel

ID: 2666

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Kamil Smierciew<sup>1</sup>, Dariusz Butrymowicz<sup>1</sup>, Jerzy Gagan<sup>1</sup>, Sławomir Pietrowicz<sup>2</sup>

<sup>1</sup>Białystok Technical University, Wiejska 45C, Białystok, 15-351, Poland; <sup>2</sup>Wrocław University of Technology, Wybrzeże Wyspińskiego 27, Wrocław, 50-370, Poland

Keywords: Gas Ejector, Isobutane, CFD

ID: 2012

### Coupled Thermodynamic and CFD Approaches Applied to a Supersonic Air Ejector.....844

Sergio Croquer, Sébastien Poncet, Nicolas Galanis

Université de Sherbrooke, Canada

Keywords: Ejectors, CFD, Thermodynamics, Air, Refrigeration

ID: 2155

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Deng Jianqiang<sup>1</sup>, Zhang Yazhou<sup>1</sup>, He Yang<sup>2</sup>, Zheng Lexing<sup>1</sup>

<sup>1</sup>School of Chemical Engineering and Technology XI'AN JIAO TONG UNIVERSITY; <sup>2</sup>State Key Laboratory of Multiphase Flow in Power Engineering, Xi'an Jiaotong University

Keywords: Visualization Measurement, Ejector, Refrigeration Cycle, Phase Transition, Flow Pattern

ID: 2671

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Roman Kwidziński<sup>1</sup>, Dariusz Butrymowicz<sup>2</sup>, Jarosław Karwacki<sup>1</sup>, Marian Trela<sup>1</sup>, Kamil Smierciew<sup>2</sup>

<sup>1</sup>Institute of Fluid-Flow Machinery Polish Academy of Sciences, ul. Gen. J. Fiszer 14, Gdańsk, 80-231, Poland; <sup>2</sup>Białystok University of Technology, Faculty of Mechanical Engineering, Wiejska 45C, Białystok, Poland

Keywords: Two-Phase Flow, Injector, Low Pressure

ID: 2664

### Investigations of Heat and Momentum Transfer in Vapor-Liquid Isobutane Injector.....873

Kamil Smierciew<sup>1</sup>, Dariusz Butrymowicz<sup>1</sup>, Tomasz Przybylinski<sup>2</sup>

<sup>1</sup>Białystok Technical University, Wiejska 45C, Białystok, 15-351, Poland; <sup>2</sup>The Szwedzki Institute of Fluid-Flow Machinery of Polish Academy of Sciences, Fiszer 14, Gdańsk, 80-231, Poland

Keywords: Two-Phase Injector, Isobutane, Heat Transfer, Mass Transfer

ID: 2076

### A New Control Mechanism for Two-Phase Ejector in Vapor Compression Cycles Using Adjustable Motive Nozzle Inlet Vortex.....883

Jingwei Zhu<sup>1</sup>, Stefan Elbel<sup>1,2</sup>

<sup>1</sup>ACRC, University of Illinois at Urbana-Champaign; <sup>2</sup>CTS – Creative Thermal Solutions, Inc. Urbana IL

Keywords: Ejector, Refrigeration, Air-Conditioning, Control, Vapor Compression

## R-17: Heat Exchanger Refrigerant Flow Distribution

*Time:* Tuesday July 12, 2016: 4:00 PM - 6:00 PM — *Location:* 310

*Session Chair:* Pega Hrnjak

**ID: 2089**

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**Karthik Panghat, Sunil S Mehendale**

Michigan Technological University, United States of America

**Keywords:** Microchannel Heat Exchangers, Two-Phase Flow, Header, Refrigerant, Maldistribution, Take-Off Ratio

**ID: 2471**

### **Effect of Channel Geometries on Flow Reversal in Microchannel Evaporators.....903**

**Huize Li, Pega Hrnjak**

University of Illinois at Urbana-Champaign, United States of America

**Keywords:** Microchannel Heat Exchanger, Reverse Flow

**ID: 2198**

### **Oil Effects on Distribution of Refrigerant in MAC Heat Exchangers.....913**

**Xuan Liu<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>**

<sup>1</sup>ACRC, the University of Illinois, United States of America; <sup>2</sup>CTS – Creative Thermal Solutions, Inc. Urbana IL

**Keywords:** Lubricant, MAC, OCR, Distribution

**ID: 2367**

### **CFD Simulation of R134a and R410A Two-Phase Flow in the Vertical Header of Microchannel Heat Exchanger.....926**

**Yang Zou<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>**

<sup>1</sup>University of Illinois at Urbana-Champaign; <sup>2</sup>Creative Thermal Solutions

**Keywords:** Microchannel Heat Exchanger, Vertical Header, Two-Phase Flow, Refrigerant Distribution, CFD

**ID: 2290**

### **Refrigerant Distribution Characteristics in Vertical Header of Flat-Tube Heat Exchanger.....936**

**Kazuhiro Endoh**

Hitachi, Ltd., Japan

**Keywords:** Refrigerant Distribution, Two-Phase Flow, Header, Flat Tube, Heat Exchanger

**ID: 2248**

### **Separation of Liquid and Vapor in Header of MCHE.....946**

**Jun Li<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>**

<sup>1</sup>ACRC, University of Illinois at Urbana-Champaign, United States of America; <sup>2</sup>Creative Thermal Solution, Inc., Urbana IL, United States of America

**Keywords:** Two-Phase Flow, Separation, Vertical Header, Microchannel Heat Exchanger, Modeling

## **R-18: Rooftop Unit Diagnostics (IBO)**

*Time:* Wednesday July 13, 2016: 9:45 AM - 12:00 PM — *Location:* 218 A&B

*Session Chair:* David Yuill

**ID: 2364**

### **A Prediction Method for Overall Economic Value of Fault Detection and Diagnostic Tools for Rooftop and Split Systems.....956**

**David Yuill<sup>1</sup>, James Braun<sup>2</sup>**

<sup>1</sup>University of Nebraska - Lincoln, United States of America; <sup>2</sup>Purdue University, United States of America

**Keywords:** FDD, Fault Detection and Diagnosis, Diagnostics, HVAC, Air-Conditioning

**ID: 2627**

### **The Effectiveness of Using Total System Power for Fault Detection in Rooftop Units.....964**

**Andrew L. Hjortland<sup>1</sup>, James E. Braun<sup>1</sup>, Mikhail Gorbounov<sup>2</sup>**

<sup>1</sup>Purdue University - Herrick Laboratory, United States of America; <sup>2</sup>United Technologies Research Center, East Hartford, CT, United States of America

**Keywords:** FDD, Fault Impacts

**ID: 2069**

### **Lab and Field Evaluation of Fault Detection and Diagnostics for Advanced Roof Top Unit.....976**

**Jinliang Wang<sup>1</sup>, Mikhail Gorbounov<sup>1</sup>, Murat Yasar<sup>1</sup>, Hayden Reeve<sup>1</sup>, Andrew L Hjortland<sup>2</sup>, James E Braun<sup>2</sup>**

<sup>1</sup>UTRC, United States of America; <sup>2</sup>School of Mechanical Engineering, Purdue University

**Keywords:** RTU, FDD, Fault, Performance, Degradation

**ID: 2074**

### **Fault Diagnosis of Refrigerant Charge Based on PCA and Decision Tree for Variable Refrigerant Flow Systems.....988**

**Jiangyan Liu<sup>1</sup>, Huanxin Chen<sup>1</sup>, Jiangyu Wang<sup>1</sup>, Guannan Li<sup>1</sup>, Haorong Li<sup>2</sup>, Wenju Hu<sup>3</sup>**

<sup>1</sup>Huazhong University of Science and Technology, Wuhan 430074, Hubei, China; <sup>2</sup>University of Nebraska-Lincoln, Lincoln, 68182, NE, USA;

<sup>3</sup>Beijing Key Lab of Heating, Gas Supply, Ventilating and Air Conditioning Engineering, Beijing University of Civil Engineering and Architecture 100044, Beijing, China

**Keywords:** Fault Diagnosis, Refrigerant Charge, Decision Tree, Principal Component Analysis, Variable Refrigerant Flow

**ID: 2379**

### **Development of an Embedded RTU FDD Using Open-Source Monitoring and Control Platform.....996**

**Andrew L. Hjortland, James E. Braun**

Purdue University - Herrick Laboratory, United States of America

**Keywords:** Fdd

**ID: 2465**

### **Generalized Effect of Condenser Fouling and Refrigerant Charge on Operating Parameters of Vapor Compression Air Conditioning Systems.....1008**

**Mehdi Mehrabi, David Yuill**

University Of Nebraska-Lincoln, Architectural Engineering, Omaha, NE, US

**Keywords:** Vapor Compression Cycle, Refrigerant Charge, Condenser Fouling, Fault Effects, Operating Parameters

## R-19: Transient System Modeling

Time: Wednesday July 13, 2016: 9:45 AM - 12:00 PM — Location: 218 C&D

Session Chair: Donghun Kim

ID: 2031

### A Modeling Study on the Operational Stability of a Variable Speed Direct Expansion Air Conditioning System.....1018

Yudong Xia, Shiming Deng

Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong S.A.R. (China)

**Keywords:** Operational Stability; Sensor Dynamics; Variable Speed; Hunting; EEV

ID: 2157

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Viren Bhanot, Jiazhen Ling, Vikrant Aute, Reinhard Radermacher

University of Maryland, College Park

**Keywords:** Transient, Modeling, Flash Tank, Vapor Injection, Simulink

ID: 2144

### Transient Modeling of a Thermosiphon Based Air Conditioner With Compact Thermal Storage: Modeling and Validation.....1037

Rohit Dhumane, Yilin Du, Jiazhen Ling, Vikrant Aute, Reinhard Radermacher

University of Maryland, United States of America

**Keywords:** Thermosiphon, Thermosyphon, Compact Storage, Air Conditioner, Heat Pump

ID: 2302

### Transient Multiphysics Modeling of a Robotic Personal Air-Conditioning Device.....1047

Rohit Dhumane<sup>1</sup>, Jiazhen Ling<sup>1</sup>, Vikrant Aute<sup>1</sup>, Reinhard Radermacher<sup>1</sup>, Aravind Mikkilineni<sup>2</sup>, Philip Bingham<sup>2</sup>

<sup>1</sup>University of Maryland, United States of America; <sup>2</sup>Oak Ridge National Laboratory, United States of America

**Keywords:** Multiphysics, LTMS, Transient, Air Conditioning

ID: 2027

### Experimentally Validated Model of Transient Heat Transfer Between a Magnetocaloric Packed Particle Bed and Stagnant Interstitial Fluid.....1057

Michael Goodman Schroeder<sup>1,2</sup>, Ellen Brehob<sup>2</sup>, Michael Benedict<sup>1,3</sup>

<sup>1</sup>General Electric, United States of America; <sup>2</sup>University of Louisville, United States of America; <sup>3</sup>University of Florida, United States of America

**Keywords:** Magnetocaloric, Transient, Regenerator, Packed Bed, Stagnant

ID: 2224

### Analysis of Dynamic Stability of Ejector Expansion Refrigeration System.....1067

Jianqiang Deng, Lixing Zheng, Fei Wang

School of Chemical Engineering and Technology, Xian Jiaotong University, China.

**Keywords:** Dynamic Stability, Lyapunov Stability Theorem, Stability Margin, Refrigeration System

ID: 2441

### A Novice Method for Calibrating the Transient Model of an Automotive HVAC System.....1076

Zhiyu Yang<sup>1</sup>, Junye Shi<sup>1</sup>, Jianmin Li<sup>2</sup>, Jiangping Chen<sup>1</sup>

<sup>1</sup>Shanghai Jiao Tong University, People's Republic of China; <sup>2</sup>Anhui Jianghuai Automobile Co. Ltd, People's Republic of China

**Keywords:** Transient Model, Optimization, Automotive HVAC, Time Series

## R-20: Evaluation of R410A Alternatives

Time: Wednesday July 13, 2016: 9:45 AM - 12:00 PM — Location: 310

Session Chair: Barbara Haviland Minor

ID: 2402

### Interim and Long-Term Low-Gwp Refrigerant Solutions for Air Conditioning.....1086

Hung M. Pham, Ken Monnier

Emerson Climate Technologies, United States of America

**Keywords:** Climate Change, Interim, Drop-In, R32, A2L HFO Blends, Discharge Temperature, Long-Term, LGWP, LCCP, System Architecture

ID: 2205

### Experimental Assessment on Performance of a Heat Pump Cycle Using R32/R1234yf and R744/R32/R1234yf.....1096

Sho Fukuda<sup>1</sup>, Hedeki Kojima<sup>1</sup>, Chieko Kondou<sup>2</sup>, Nobuo Takata<sup>1</sup>, Shigeru Koyama<sup>1</sup>

<sup>1</sup>Kyushu Univ., Japan; <sup>2</sup>Nagasaki Univ., Japan

**Keywords:** COP, Zeotropic Mixture, R1234yf, R32, R744

ID: 2459

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Toshimitsu Kamada, Tomoyuki Haikawa, Shigeharu Taira

Daikin Industries, LTD., Japan

**Keywords:** Air-Conditioner, Heat Exchanger, Refrigerant, Low-Gwp

ID: 2409

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Shigaharu Taira<sup>1</sup>, Tomoyuki Haikawa<sup>2</sup>, Tomoatsu Minamida<sup>3</sup>

<sup>1</sup>Japan; <sup>2</sup>Japan; <sup>3</sup>Japan

**Keywords:** GWP, COP, Refrigerant, Heat Pump System, R410A, R32/R1234ze, R32/R125/R1234yf, R32

ID: 2333

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Bo Shen, Omar Abdelaziz, Lane Liudahl

Oak Ridge National Laboratories, United States of America

**Keywords:** Low GWP, RTU, DR-55, IEER, Modeling

ID: 2589

### Testing of Low GWP Replacements for R-410A in Stationary Air Conditioning.....1132

Joshua Hughes, Sonali Shah

The Chemours Company, United States of America

**Keywords:** Air Conditioning, DR-55, XL55, DR-5A, XL41

ID: 2116

### Behavior of R410A Low GWP Alternative Refrigerants DR-55, DR-5A, and R32 in the Components of a 4-Rt RTU.....1142

Kenneth Schultz

Ingersoll Rand, United States of America

**Keywords:** Alternative Refrigerants, Rooftop Unit, Component Performance

## R-21: Transportation Air-Conditioning

Time: Wednesday July 13, 2016: 9:45 AM - 12:00 PM — Location: 278

Session Chair: Bernhard Vetsch

ID: 2132

### Researches on Heat Pump System Using Rotary Compressor in Electric Vehicle.....1150

Jun-ye Shi<sup>1</sup>, Tian-yuan Gao<sup>1</sup>, Bing-qing Lu<sup>1</sup>, Wan-yong Li<sup>1</sup>, Zi-qi Zhang<sup>1</sup>, Bo-wei Cai<sup>1</sup>, Jiang-ping Chen<sup>1</sup>, Le-yan Pan<sup>1,2</sup>, Tian-ying Wang<sup>2</sup>, Rui-dong Yan<sup>3</sup>

<sup>1</sup>Shanghai Jiao Tong University, Shanghai, People's Republic of China; <sup>2</sup>SAIC Motor Co., Ltd., Shanghai, People's Republic of China; <sup>3</sup>Changan Automobile (Group) Co., Ltd., Shanghai, People's Republic of China

**Keywords:** Electric Vehicles, Heat Pump, Rotary Compressor, Refrigerants, Heating Capacity

ID: 2347

### Impact of a 12-Volt Lead Acid Battery State-Of-Charge on the Performance of an Automotive Air Conditioning System.....1159

Santanu Prasad Datta<sup>1</sup>, Prasanta Kumar Das<sup>2</sup>, Siddhartha Mukhopadhyay<sup>2</sup>

<sup>1</sup>Birla Institute of Technology & Science Pilani, Hyderabad Campus, India; <sup>2</sup>Indian Institute of Technology Kharagpur, 721302, India

**Keywords:** Experiment, Lead Acid Battery, Automotive HVAC, COP.

ID: 2411

### LCCP Analysis of Energy-Saving Effect of Defaulting to Recirculated Cabin Air in EV Mobile Air Conditioning System.....1168

Ziqi Zhang, Xiaoning Chen, Cichong Liu, Wanyong Li, Junye Shi, Jiangping Chen

Shanghai Jiao Tong University, China, People's Republic of

**Keywords:** Mobile AC System, Energy Saving, LCCP, Fuel Economy, Default Cabin Air Recirculation

ID: 2407

### Simulation of a VRF System Applied in Electric Buses in Taiwan.....1176

Anne Liebold<sup>1</sup>, Po-Hsu Lin<sup>2</sup>, Bernhard Vetsch<sup>1</sup>, Cordin Arpagaus<sup>1</sup>, Stefan S. Bertsch<sup>1</sup>

<sup>1</sup>Interstate University of Applied Sciences of Technology NTB, Switzerland; <sup>2</sup>Automotive Research & Testing Center, Taiwan

**Keywords:** VRF, Electric Buses, Variable Capacity, Dynamic Simulation, Public Transportation

ID: 2172

### Modelling of an Automotive Multi-Evaporator Air-Conditioning System.....1186

Thomas Gillet<sup>1,2,3</sup>, Emmanuelle Andrès<sup>1</sup>, Amin El-Bakkali<sup>1</sup>, Gérard Olivier<sup>1</sup>, Vincent Lemort<sup>2</sup>, Romuald Rullière<sup>3</sup>, Philippe Haberschill<sup>3</sup>

<sup>1</sup>Renault SAS, 1, avenue du Golf, 78288 Guyancourt, France; <sup>2</sup>Laboratoire de Thermodynamique et Energétique de l'Université de Liège, 17, allée de la Découverte, 4000 Liège, Belgique; <sup>3</sup>CETHIL UMR5008, Université de Lyon, CNRS, INSA-Lyon, Univ. Lyon 1, F-69621, Villeurbanne, France

**Keywords:** Multi-Evaporator Air Conditioning System, Automotive, Simulation

ID: 2199

### Oil Effects on Performance of Automobile A/C System.....1195

Xuan Liu<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>

<sup>1</sup>ACRC, the University of Illinois, United States of America; <sup>2</sup>CTS – Creative Thermal Solutions, Inc. Urbana IL

**Keywords:** Lubricant, MAC, OCR, Distribution



## **R-22: Absorption/Adsorption Technology**

*Time:* Wednesday July 13, 2016: 1:00 PM - 3:00 PM — *Location:* 214 C&D

*Session Chair:* Srinivas Garimella

**ID: 2043**

### **CFD Heat and Mass Transfer Studies in a R134a-Dmf Bubble Absorber With Swirl Flow Entry of R134a Vapour.....1207**

**Santosh Kumar Panda, Annamalai Mani**

Indian Institute Of Technology Madras, India

**Keywords:** Bubble Absorber, Swirl Flow, Heat and Mass Transfer, CFD, R134a-Dmf

**ID: 2159**

### **Experimental Study on a Solar-Powered Thermochemical Sorption Refrigeration System Using Strontium Chloride/EG-ammonia Working Pair.....1217**

**Si Wu, Ting Xian Li, Ting Yan, Ru Zhu Wang**

Institute of Refrigeration and Cryogenics, Shanghai Jiao Tong University, China, People's Republic of

**Keywords:** Chemisorption, Refrigeration, Solar Energy, Strontium Chloride, Consolidated Composite

**ID: 2285**

### **Screening Criteria for ILs Used in NH<sub>3</sub> Based Absorption Heat Pump Systems.....1227**

**Meng Wang, Carlos A. Infante Ferreira**

Process and Energy Department, Delft University of Technology, The Netherlands

**Keywords:** Absorption Cycle; Heat Pump; ILs; NH<sub>3</sub>;

**ID: 2479**

### **Theoretical and Experimental Investigation on Dewatering Performance From Aqueous Lithium Bromide Solution Stream Confined by Hollow Fiber Membrane.....1236**

**Sung Joo Hong, Eiji Hihara, Chaobin Dang**

University of Tokyo, Japan

**Keywords:** Automobile Air Conditioner, Desorber, Hollow Fiber Membrane Distillation, Flat Fiber Membrane Distillation, Hydrophobic Membrane, Vacuum Membrane Distillation, Vapor Absorption Refrigeration System

**ID: 2467**

### **A Novel Model Considered Mass and Energy Conservation for Both Liquid and Vapor in Adsorption Refrigeration System.....1244**

**Tsung Yi Lin, Chien Chang Wu, Tsung Lin Chen**

Department of Mechanical Engineering, National Chiao Tung University, Hsinchu 30010, Taiwan.

**Keywords:** Modeling, Refrigeration, Adsorption, Lumped Parameter, COP

## R-23: Analysis of Systems With Ejectors

Time: Wednesday July 13, 2016: 1:00 PM - 3:00 PM — Location: 218 A&B

Session Chair: Stefan Elbel

ID: 2396

### Thermodynamic Analysis on a Novel Gas-Gas Ejector Enhanced Autocascade Refrigeration Cycle.....1253

Jiaheng Chen, Jianlin Yu, Gang Yan

Xi'an Jiaotong University, China, People's Republic of

**Keywords:** Zeotropic Mixtures, Gas-Gas Ejector, Autocascade Refrigeration Cycle, Performance Enhancement

ID: 2667

### Assesment of Refrigerant Selection for Ejection System Driven by Low-Grade Heat.....1263

Kamil Smierciew, Dariusz Butrymowicz, Jerzy Gagan

Bialystok Technical University, Wiejska 45C, Bialystok, 15-351, Poland

**Keywords:** Ejection System, Low-Grade Heat, Working Fluid

ID: 2665

### Performance Model of Co2 Two-Phase Ejector for Subcritical Conditions.....1271

Kamil Smierciew<sup>1</sup>, Dariusz Butrymowicz<sup>1</sup>, Piotr Baj<sup>2</sup>

<sup>1</sup>Bialystok Technical University, Wiejska 45C, Bialystok, 15-351, Poland; <sup>2</sup>Star Refrigeration, Wincanton Close, Ascot Drive, DE24 8NB, Derby, United Kingdom

**Keywords:** CO2, Ejector, Two-Phase Flow, Subcritical

ID: 2689

### Experimental Investigations of Low-Temperature Driven Ejector for Isobutane.....1280

Mark Bergander<sup>1</sup>, Dariusz Butrymowicz<sup>2</sup>, Kamil Smierciew<sup>2</sup>, Jerzy Gagan<sup>2</sup>, Sarken D. Kapayeva<sup>3</sup>

<sup>1</sup>Magnetic Development, Inc, Madison, CT, USA; <sup>2</sup>Bialystok University of Technology, Bialystok, 15-351, Poland; <sup>3</sup>Eastern Kazakhstan Technical University, Ust Kamenogorsk, Kazakhstan

**Keywords:** Ejector, Isobutane, Experimental Results

ID: 2045

### Experimental and Numerical Investigations of Ejector Jet Refrigeration System With Primary Stream Swirl.....1290

Jiautheen Parveen Banu, Jawali Maharudrappa Mallikarjuna, Annamalai Mani

Indian Institute of Technology Madras, India

**Keywords:** Ejector, Swirl, Entrainment Ratio, COP, VJRS

ID: 2368

### Modeling of Initially Subcooled Flashing Vortex Flow in the Nozzle for Possible Applications in the Control of Ejector Cooling Cycles.....1300

Jingwei Zhu<sup>1</sup>, Stefan Elbel<sup>1,2</sup>

<sup>1</sup>ACRC, University of Illinois at Urbana-Champaign; <sup>2</sup>CTS – Creative Thermal Solutions, Inc. Urbana IL

**Keywords:** Numerical, Flashing, Vortex, Ejector, Nozzle

## R-24: Boiling Heat Transfer Enhancements

Time: Wednesday July 13, 2016: 1:00 PM - 3:00 PM — Location: 218 C&D

Session Chair: Kenneth Schultz

ID: 2513

### Continuous vs. Pulsating Flow Boiling. Part 1: Experimental Comparison and Visualization.....1310

Martin Ryhl Kærn<sup>1</sup>, Brian Elmegaard<sup>1</sup>, Knud Erik Meyer<sup>1</sup>, Björn E Palm<sup>2</sup>

<sup>1</sup>Technical University of Denmark, Denmark; <sup>2</sup>Royal Institute of Technology, Sweden

**Keywords:** Flow Boiling, Flow Pulsations, Heat Transfer Enhancement, Visualization, Experiments

ID: 2514

### Continuous vs. Pulsating Flow Boiling. Part 2: Statistical Comparison Using Response Surface Methodology.....1319

Martin Ryhl Kærn<sup>1</sup>, Brian Elmegaard<sup>1</sup>, Knud Erik Meyer<sup>1</sup>, Björn E Palm<sup>2</sup>, Jørgen Holst<sup>3</sup>

<sup>1</sup>Technical University of Denmark, Denmark; <sup>2</sup>Royal Institute of Technology, Sweden; <sup>3</sup>Danfoss Drives A/S, Denmark

**Keywords:** Flow Boiling, Flow Pulsations, Heat Transfer Enhancement, Response Surface Methods, Experiments

ID: 2098

### Effect of Nanoparticles Aspect Ratio on the Two Phase Flow Boiling Heat Transfer Coefficient and Pressure Drop of Refrigerant and Nanolubricants Mixtures in a 9.5 Mm Micro-Fin Tube.....1328

Pratik Shashikant Deokar<sup>1</sup>, Lorenzo Cremaschi<sup>1</sup>, Thiam Wong<sup>3</sup>, Gennaro Criscuolo<sup>2</sup>

<sup>1</sup>Auburn University, Department of Mechanical Engineering, Auburn, AL, USA; <sup>2</sup>Polytechnic University of Milan, Department of Energy Engineering, Milan, Italy; <sup>3</sup>Oklahoma State University, School of Mechanical and Aerospace Engineering, Stillwater, OK, USA

**Keywords:** Micro-Fin Tube, Nanorefrigerant, Nanolubricant, Heat Transfer Enhancement, Flow Boiling

ID: 2340

### A Comparison Between Recent Experimental Results and Existing Correlations for Microfin Tubes for Refrigerant and Nanolubricants Mixtures Two Phase Flow Boiling.....1338

Andrea A. M. Bigi, Lorenzo Cremaschi

Auburn University, United States of America

**Keywords:** Nano-Fluid, Microfin, Two-Phase Flow, Flow Boiling, Modeling

ID: 2129

### Wettability Change by Pool Boiling of Nanofluids and Its Impact on Heat Transfer.....1348

Feini Zhang, Anthony Jacobi

University of Illinois at Urbana Champaign, United States of America

**Keywords:** Wettability, Nanofluid, Pool Boiling, Heat Transfer

ID: 2264

### R134a Flow Boiling Heat Transfer on an Electrically Heated Carbon/Carbon Surface.....1356

Luca Doretto<sup>1</sup>, Simone Mancin<sup>2</sup>, Claudio Zilio<sup>2</sup>, Giovanni A. Longo<sup>2</sup>

<sup>1</sup>Dept. of Civil, Architectural and Environmental Engineering, University of Padova, Italy; <sup>2</sup>Dept. of Management and Engineering, University of Padova, Italy

**Keywords:** Carbon/Carbon, Flow Boiling, R134a

## **R-25: Domestic Refrigeration I**

*Time:* Wednesday July 13, 2016: 1:00 PM - 3:00 PM — *Location:* 310

*Session Chair:* Claudio Melo

**ID: 2056**

### **An Experimental Study on the Effect of a New Defrosting Strategy on the Energy Consumption of Household Refrigerators.....1366**

**Fernando Testoni Knabben, Claudio Melo**

Federal University of Santa Catarina, Brazil

**Keywords:** Defrost Heater, Evaporator, Refrigerators, Energy Consumption

**ID: 2401**

### **Optimized On-Off Controller for Energy Saving in a Household Refrigerator.....1375**

**Ulisses Carvalho de Elían Saffar, Antônio Augusto Torres Maia**

Universidade Federal de Minas Gerais, Brazil

**Keywords:** Household Refrigerator, On-Off Control, Energy Saving

**ID: 2058**

### **A Methodology for Measuring the Air Infiltration Rates Into Refrigerated Compartments.....1385**

**Paula do Vale Pereira, André Sgrott, Lucas F. Back, Débora T. Kohara, Claudio Melo**

Federal University of Santa Catarina, Brazil

**Keywords:** Air Infiltration, Gasket, Tracer Gas, Household Refrigerator, Frost Accumulation

**ID: 2063**

### **An Experimental Study on the Use of Vaccum Insulation Panels in Household Refrigerators.....1395**

**Susan Thiessen, Fernando Testoni Knabben, Claudio Melo, Joaquim Manoel Gonçalves**

Federal University of Santa Catarina, Brazil

**Keywords:** Household Refrigerator, Vaccum Insulation Panel, Thermal Insulation

**ID: 2145**

### **Observation of R600a Flow at Subcooled Temperature Conditions in a Vapor Compression Refrigeration System.....1403**

**Joonyoung Seo, Daesig Shin, Ji Hwan Jeong**

Pusan National University, Korea, Republic of (South Korea)

**Keywords:** Phase Behavior, Refrigeration Cycle, Two Phase Flow, Non-Equilibrium, Enthalpy

## **R-26: Heat Exchanger Design, Manufacturing, and Operational Impacts**

*Time:* Wednesday July 13, 2016: 1:00 PM - 3:00 PM — *Location:* 278

*Session Chair:* Christian Bach

**ID: 2438**

### **Accelerated Fatigue Testing of Aluminum Refrigeration Press Fittings for HVAC & R Applications.....1411**

**Stefan Elbel<sup>1,2</sup>, Michael Duggan<sup>3</sup>, Tony LaGrotta<sup>3</sup>, Sharat Raj<sup>2</sup>, Pega Hrnjak<sup>1,2</sup>**

<sup>1</sup>University of Illinois at Urbana-Champaign, United States of America; <sup>2</sup>Creative Thermal Solutions, United States of America; <sup>3</sup>RLS Refrigeration Press Fittings, United States of America

**Keywords:** Press Fitting, Flame Free, Accelerated Testing, Aluminum, Copper

**ID: 2545**

### **A Study of Microchannel Heat Exchanger Performance Associated With the Manufacturing Process.....1421**

**Hui Zhao<sup>1</sup>, Sharat Raghunandan<sup>1</sup>, Stefan Elbel<sup>1,2</sup>, Pega Hrnjak<sup>1,2</sup>**

<sup>1</sup>Creative Thermal Solutions, Inc., United States of America; <sup>2</sup>University of Illinois at Urbana-Champaign, United States of America

**Keywords:** HVAC & R Heat Exchangers, Microchannel, Header, Brazing

**ID: 2289**

### **Manufacturing & Testing of Air-To-Refrigerant Heat Exchangers Based on 0.8mm Diameter Tubes.....1429**

**Yoram Shabtay<sup>1</sup>, Zhiwei Huang<sup>2</sup>, Vikrant Aute<sup>2</sup>, Vishaldeep Sharma<sup>3</sup>, Reinhard Radermacher<sup>2</sup>**

<sup>1</sup>Heat Transfer Technologies, United States of America; <sup>2</sup>University of Maryland, United States of America; <sup>3</sup>Oak Ridge National Laboratory, United States of America

**Keywords:** Small Diameter Tubes, Heat Exchanger, Microchannel, Copper Tube, Manufacturing

**ID: 2532**

### **An Evaluation of a Pressure Expansion Method for the Manufacturing of Copper Tube Heat Exchangers.....1437**

**Roger Tetzloff<sup>1</sup>, Vikrant Aute<sup>2</sup>, Song Li<sup>3</sup>, Cara Martin<sup>3</sup>**

<sup>1</sup>Burr Oak Tool, Inc., Sturgis, MI, USA; <sup>2</sup>Center for Environmental Energy Engineering, University of Maryland College Park; <sup>3</sup>Optimized Thermal Systems, Inc., United States of America

**Keywords:** Heat Exchanger, Manufacturing, Expansion Process

**ID: 2234**

### **A Literature Review on Heat Exchanger Air Side Fouling in Heating, Ventilation and Air-Conditioning (HVAC) Applications.....1447**

**Omer Sarfraz, Christian Bach**

Oklahoma State University, United States of America

**Keywords:** Air Side Fouling, Fouling Mechanism, Fin Tube Heat Exchangers, Fouling Matter, Air Pressure Drop

**ID: 2246**

### **Enhancement of R1234ze(Z) Pool Boiling Heat Transfer on Horizontal Titanium Tubes for High Temperature Heat Pumps.....1456**

**Ryuichi Nagata<sup>1</sup>, Chieko Kondou<sup>2</sup>, Nobuo Takata<sup>1</sup>, Shigeru Koyama<sup>1</sup>**

<sup>1</sup>Kyushu university, Japan; <sup>2</sup>Nagasaki university, Japan

**Keywords:** Low GWP, R1234ze(Z), Pool Boiling, Heat Transfer

## **R-27: Absorption Technology II**

*Time:* Wednesday July 13, 2016: 3:30 PM - 5:30 PM — *Location:* 214 C&D

*Session Chair:* Srinivas Garimella

**ID: 2142**

### **Investigations on Performance of an Auto-Cascade Absorption Refrigeration System Operating With Mixed Refrigerants.....1464**

**Shengjian Le, Qin Wang, Dahong Li, Xiaohong Han, Guangming Chen**

Key Laboratory of Refrigeration and Cryogenic Technology of Zhejiang Province; Institute of Refrigeration and Cryogenics, Zhejiang University, China, People's Republic of

**Keywords:** Mixed Refrigerant, Absorption Refrigeration, Auto-Cascade

**ID: 2273**

### **Experimental Evaluation of a Small-Capacity, Direct-Fired Ammonia-Water Absorption Chiller.....1473**

**Anurag Goyal, Marcel A. Staedter, Dhruv C. Hoysall, Mikko J. Ponkala, Srinivas Garimella**

Georgia Institute of Technology, United States of America

**Keywords:** Absorption Refrigeration, Waste Heat Recovery, Ammonia-Water

**ID: 2270**

### **Investigation of Air-Cooled Condensers for Ammonia-Water Absorption Chillers.....1484**

**Subhrajit Chakraborty, Victor C. Aiello, Srinivas Garimella**

Georgia Institute of Technology, United States of America

**Keywords:** Absorption Refrigeration, Air-Cooled Condenser, Zeotropic Mixture Condensation

**ID: 2603**

### **A Preliminary Study on Innovative Absorption Systems That Utilize Low-Temperature Geothermal Energy for Air-Conditioning Buildings.....1494**

**Zhiyao Yang, Xiaobing Liu, Kyle R. Gluesenkamp, Ayyoub M. Momen**

Oak Ridge National Laboratory, United States of America

**Keywords:** Low-Temperature Geothermal Energy, Energy Storage and Transportation, Absorption System, Renewable Energy, Economic Analysis

**ID: 2552**

### **Regional Climate Zone Modeling of a Commercial Absorption Heat Pump Hot Water Heater - Part 1: Southern and South Central Climate Zones.....1504**

**Patrick Geoghegan<sup>1</sup>, Bo Shen<sup>1</sup>, Christopher Keinath<sup>2</sup>, Michael Garrabrant<sup>2</sup>**

<sup>1</sup>Oak Ridge National Laboratory; <sup>2</sup>Stone Mountain Technologies, Inc.

**Keywords:** Commercial, Absorption, Heat, Pump, Water

## **R-28: Heat Exchanger Modeling and Characterization**

*Time:* Wednesday July 13, 2016: 3:30 PM - 5:30 PM — *Location:* 218 A&B

*Session Chair:* Hongtao Qiao

**ID: 2534**

### **A Review of State of the Art in Modeling of Air-To-Refrigerant Heat Exchangers for HVAC&R Applications.....1512**

**Vikrant C. Aute**

University of Maryland, United States of America

**Keywords:** Heat Exchanger, Modeling, Optimization, Tube-Fin, Microchannel

**ID: 2672**

### **Experimental Investigations of Propane Minichannel Condenser and Evaporator.....1522**

**Dariusz Butrymowicz, Jerzy Gagan, Teodor Skiepko, Adam Dudar, Michal Łukaszuk, Kamil Smierciew**

Białystok University of Technology, Wiejska 45C, Białystok, 15-351, Poland

**Keywords:** Heat Exchanger, Minichannel, Propane, Investigation

**ID: 2474**

### **Round-Tube and Microchannel Heat Exchanger Modeling at Wet Air Condition.....1532**

**Yang Zou<sup>1</sup>, Huize Li<sup>1</sup>, Ke Tang<sup>2</sup>, Pega Hrnjak<sup>1,2</sup>**

<sup>1</sup>University of Illinois at Urbana-Champaign; <sup>2</sup>Creative Thermal Solutions

**Keywords:** Round Tube Heat Exchanger, Microchannel Heat Exchanger, Model, Wet Air

**ID: 2137**

### **Development and Validation of a Minichannel Evaporator Model Under Different Dehumidifying Conditions.....1542**

**Abdelrahman Hussein Hassan<sup>1</sup>, José González-Maciá<sup>1</sup>, Santiago Martínez-Ballester<sup>1</sup>, José R. García-Cascales<sup>2</sup>**

<sup>1</sup>Institute for Energy Engineering, Universitat Politècnica de València, Spain; <sup>2</sup>DITE, ETSII, Universidad Politécnica de Cartagena, Spain

**Keywords:** Minichannel Evaporator, Numerical Modeling, Heat and Mass Transfer

**ID: 2298**

### **Modeling of Finned-Tube Heat Exchangers: A Novel Approach to the Analysis of Heat and Mass Transfer Under Cooling and Dehumidifying Conditions.....1552**

**Hongtao Qiao, Christopher R. Laughman**

Mitsubishi Electric Research Laboratories, United States of America

**Keywords:** Modeling, Evaporator, Heat and Mass Transfer, Dehumidification, Partially Wet

**ID: 2453**

### **Internal Heat Exchanger Performance Quantification and Comparison Testing Methods Including Exploration of the Effects of Location of Measurements and Oil in Circulation.....1562**

**Andrew Musser<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>, Stefan Elbel<sup>1,2</sup>**

<sup>1</sup>Creative Thermal Solutions, Inc., United States of America; <sup>2</sup>University of Illinois at Urbana-Champaign, United States of America

**Keywords:** Internal Heat Exchanger, Suction Line Heat Exchanger, Effectiveness, Test Standard, Customized Test Facility

## **R-29: Desiccant and Other Heat/Mass Transfer Studies**

*Time:* Wednesday July 13, 2016: 3:30 PM - 5:30 PM — *Location:* 218 C&D

*Session Chair:* Carlos Infante Ferreira

**ID: 2096**

### **Adsorption and Desorption Isotherms of Desiccants for Dehumidification Applications: Silica Aerogels and Silica Aerogel Coatings on Metal Foams.....1569**

**Kashif Nawaz<sup>1</sup>, Shelly J. Schmidt<sup>2</sup>, Anthony M. Jacobi<sup>3</sup>**

<sup>1</sup>Department of Aerospace and Mechanical Engineering, University of Oklahoma, Norman, OK, 73071; <sup>2</sup>Department of Food Science and Human Nutrition, University of Illinois at Urbana Champaign, Urbana, IL, 61801; <sup>3</sup>Department of Mechanical Science and Engineering, University of Illinois at Urbana Champaign, Urbana, IL, 61801

**Keywords:** Dehumidification, Silica Aerogels, Metal Foams, Adsorption, Desorption, Isotherms

**ID: 2125**

### **Parametric Evaluation of Governing Heat and Mass Transfer Resistances in Membrane Based Heat and Moisture Exchangers.....1579**

**Paul D. Armatis, Brian M. Fronk**

Oregon State University, United States of America

**Keywords:** Energy Recovery, Heat and Mass Transfer, Dehumidification, Membrane

**ID: 2670**

### **Numerical Modelling of Heat and Mass Transfer Processes in Chinese Cabbage Cold Storage Chamber.....1589**

**Mirosława Kolodziejczyk, Dariusz Butrymowicz, Kamil Smierciew, Jerzy Gagan**

Białystok University of Technology, ul. Wiejska 42A, Białystok, 15-351, Poland

**Keywords:** CFD, Cold Storage Chamber, Heat Mass Transfer, Vegetables

**ID: 2262**

### **Investigation of Hydrate Growth Rate on the Interface Between Liquid and Solid Film.....1598**

**Hongxia Zhou, Carlos Infante Ferreira**

Technology University of Delft, The Netherlands,

**Keywords:** Hydrate Slurry, Crystallization, Kinetic Model



## R-30: Domestic Refrigeration II

Time: Wednesday July 13, 2016: 3:30 PM - 5:30 PM — Location: 310

Session Chair: Joaquim Rigola

ID: 2057

### The Influence of Non-Condensable Gases on the Thermal-Acoustic Behavior of Household Refrigerators.....1608

Rodolfo da Silva Espíndola, Fernando Testoni Knabben, Claudio Melo

Federal University of Santa Catarina, Brazil

Keywords: Mon-Condensable Gases, Energy Consumption, Refrigerator

ID: 2500

### Performance Characteristics of a Refrigerator-Freezer With Parallel Evaporators Using a Linear Compressor.....1617

Byungchae Min<sup>1</sup>, Sangjin Song<sup>1</sup>, Kiyoul Noh<sup>1</sup>, Geonwoo Kim<sup>1</sup>, Teaseung Yoon<sup>1</sup>, Sangkyung Na<sup>1</sup>, Sanghoon Song<sup>2</sup>, Jangsik Yang<sup>3</sup>, Gyungmin Choi<sup>4</sup>, Duckjool Kim<sup>4</sup>

<sup>1</sup>Graduate School of Mechanical Engineering, Pusan National University, Korea, Republic of (South Korea); <sup>2</sup>Engineering Design Department, Refrigeration Division, LG Electronics, Korea, Republic of (South Korea); <sup>3</sup>Rolls-Royce University Technology Centre, Pusan National University, Korea, Republic of (South Korea); <sup>4</sup>Department of Mechanical Engineering, Pusan National University, Korea, Republic of (South Korea)

Keywords: Domestic Refrigerator, Linear Compressor, R600a, Experimental Simulation, Performance

ID: 2553

### Virtual Household Refrigerators at Steady-State and Transient Conditions. Numerical Model and Experimental Validation.....1625

Nicolas Ablanque, Carles Oliet, Joaquim Rigola, Carlos-David Pérez-Segarra

Heat and Mass Transfer Technological Center - POLYTECHNIC UNIVERSITY OF CATALONIA, Spain

Keywords: Refrigerator Model, Experimental Validation, Steady-State, Transient, Parametric Studies

ID: 2060

### A Numerical and Experimental Study on Skin Condensers Applied to Household Refrigerators.....1635

Elias Gava Colombo, Rodolfo da Silva Espíndola, Fernando Testoni Knabben, Claudio Melo

Federal University of Santa Catarina, Brazil

Keywords: Hot-Wall Condenser, Skin Condenser, Household Refrigerator, Heat Exchanger

ID: 2217

### Numerical Simulation of the 3D Transient Temperature Evolution Inside a Domestic Single Zone Wine Storage Cabinet With Forced Air Circulation.....1645

Johann Hopfgartner<sup>1</sup>, Martin Heime<sup>1</sup>, Stefan Posch<sup>1</sup>, Erwin Berger<sup>1</sup>, Raimund Almbauer<sup>1</sup>, Stephan Schlemmer<sup>2</sup>

<sup>1</sup>TU Graz, Austria; <sup>2</sup>Liebherr-Hausgeraete Lienz GmbH

Keywords: CFD, Simulation, Forced-Convection, Domestic Wine Cabinet

ID: 2280

### Calibration Strategies and Limitations of Cycle Simulations Representing Complex Domestic Cooling Devices.....1655

Martin Heime<sup>1</sup>, Erwin Berger<sup>1</sup>, Stefan Posch<sup>1</sup>, Johann Hopfgartner<sup>1</sup>, Stephan Schlemmer<sup>2</sup>, Raimund Almbauer<sup>1</sup>

<sup>1</sup>Graz University of Technology, Austria; <sup>2</sup>Liebherr-Hausgeräte Lienz GmbH

Keywords: Cycle Simulation, Experiment, Actuators, Calibration

## R-31: Property Measurements, Modeling, and Assessments I

Time: Wednesday July 13, 2016: 3:30 PM - 5:30 PM — Location: 278

Session Chair: Ian Bell

ID: 2014

### Method of Measuring the Vapor Pressure and Concentration of Fluids Using VLE and Vibrating Tube Densitometer Apparatuses.....1665

Momin Elhadi Abdalla<sup>1</sup>, Siddharth Pannir<sup>2</sup>

<sup>1</sup>University of Khartoum, Sudan; <sup>2</sup>Purdue University

Keywords: R152a, R365mfc, VTPR, Vapor Pressure, Concentration

ID: 2013

### Density of the Refrigerant Fluids of R365mfc and R152a: Measurement and Prediction.....1675

Momin Elhadi Abdalla<sup>1</sup>, Siddharth Pannir<sup>2</sup>

<sup>1</sup>University of Khartoum, Sudan; <sup>2</sup>Purdue University

Keywords: Density, VTPR, Vibrating Tube, R152a, R365mfc

ID: 2283

### Measurements of Thermodynamic Properties for R1123 and R1123+R32 Mixture.....1685

Yukihiro Higashi<sup>1</sup>, Ryo Akasaka<sup>2</sup>

<sup>1</sup>Kyushu University, I2CNER, Japan; <sup>2</sup>Kyushu Sangyo University, Japan

Keywords: Low GWP Refrigerant, R1123, R1123+R32 Mixture, Thermodynamic Properties, Critical Parameter

ID: 2448

### Hot Surface Ignition Testing of Low GWP 2L Refrigerants.....1695

Mary Koban, Barbara Minor, Patrick Coughlan, Nina Gray

Chemours Fluoroproducts, United States of America

Keywords: Low GWP Refrigerant, Class 2L Flammable, Burning Velocity

ID: 2122

### Compositional Fractionation Studies of R410A Alternative R452B or DR55 and Their Impact on Flammability Behavior and Safety Implications.....1703

Steve Kujak, Ken Schultz

Ingersoll Rand, United States of America

Keywords: DR-55, R410A Alternatives, Flammability, Safety, R-452b

ID: 2318

### Use of Nanoparticles in Refrigeration Systems: A Literature Review Paper.....1711

Amey Majgaonkar

Kirloskar Pneumatic Co. Ltd, India

Keywords: Nanoparticles, Nanofluids, Nanorefrigerants, Heat Transfer, Efficiency

## **R-32: Equipment Performance Measurements and Modeling**

*Time:* Thursday July 14, 2016: 9:45 AM - 12:00 PM — *Location:* 214 A&B

*Session Chair:* Reinhard Radermacher

**ID: 2382**

### **Harmonization of Life Cycle Climate Performance (LCCP) Methodology.....1721**

**Sarah Troch, Hoseong Lee, Yunho Hwang, Reinhard Radermacher**

University Of Maryland, United States of America

**Keywords:** LCCP; Vapor Compression Cycle; Residential Heat Pump

**ID: 2067**

### **Steady State Modeling of Advanced Vapor Compression Systems.....1729**

**Mohamed Beshr, Vikrant Aute, Reinhard Radermacher**

University of Maryland, United States of America

**Keywords:** Steady State Simulation, Advanced Vapor Compression Systems, Multiple Air and Refrigerant Loops

**ID: 2328**

### **Second-Law Analysis to Improve the Energy Efficiency of Environmental Control Unit.....1738**

**Ammar M. Bahman, Eckhard A. Groll**

Ray W. Herrick Laboratories, Purdue University, United States of America

**Keywords:** Exergy Destruction, Irreversibility, Performance, Energy, ECU

**ID: 2052**

### **Steady-State Numerical Simulation of a Vapor Compression Heat Pump System as an Effective Method to Predict Its Performance.....1748**

**Zvonimir Janković<sup>1</sup>, Jaime Sieres Atienza<sup>2</sup>, Fernando Cerdeira Pérez<sup>2</sup>, Branimir Pavković<sup>3</sup>**

<sup>1</sup>Department of Energetics, Mechanical Engineering Faculty in Slavonski Brod, University of Osijek; <sup>2</sup>University of Vigo, Spain; <sup>3</sup>Faculty of Engineering in Rijeka

**Keywords:** Simulation Model, Heat Pump, R407C, Vapor Compression System

**ID: 2109**

### **Automated Optimization of Air Conditioning Systems Using Geometry Based Simulation Models.....1758**

**Joerg Aurich, Rico Baumgart, Eric Tomoscheit**

IAV GmbH, Germany

**Keywords:** Automated Optimization, Physical Based Simulation, Household Appliance Industry, Air Conditioning, Dehumidification Unit

**ID: 2235**

### **Development of Operating Envelope Limits for Equipment Tested in a Wind Tunnel.....1768**

**Omer Sarfraz, Christian Bach**

Oklahoma State University, United States of America

**Keywords:** Wind Tunnel, Operating Envelope, Capacity Limit, Low Temperature Testing, Psychrometric Analysis

**ID: 2102**

### **Oil Return Measurements in a Unitary Split System Air Conditioner Using Different Refrigerant Mixtures.....1778**

**Gabriel A. Feichter<sup>1</sup>, Eckhard A. Groll<sup>2</sup>, Orkan Kurtulus<sup>2</sup>, Ben Meng<sup>3</sup>**

<sup>1</sup>Interstate University of Applied Sciences of Technology NTB, Switzerland; <sup>2</sup>Purdue University, United States of America; <sup>3</sup>BMP International Inc., United States of America

**Keywords:** Oil Return, R22 Replacement, Drop-In Refrigerant R438

## **R-33: Evaluation of Natural Refrigerants**

*Time:* Thursday July 14, 2016: 9:45 AM - 12:00 PM — *Location:* 214 C&D

*Session Chair:* Frank Rinne

**ID: 2615**

### **Conversion of Platelet Incubator Refrigeration System to R600a and Performance Optimization.....1787**

**Matej Visek<sup>1</sup>, Stefan Elbel<sup>1,2</sup>, Pega Hrnjak<sup>1,2</sup>, Brian Hoaglan<sup>3</sup>, Chengzhi Tang<sup>3</sup>, Dennis Smith<sup>3</sup>**

<sup>1</sup>Creative Thermal Solutions, United States of America; <sup>2</sup>University of Illinois at Urbana-Champaign, USA; <sup>3</sup>Helmer Scientific, USA

**Keywords:** Hydrocarbon, Laboratory Equipment, Performance, Optimization, Conversion

**ID: 2530**

### **Experimental Comparison of a Cascade Refrigeration System Operating With R744/R134a and R744/R404a.....1797**

**Marcus Vinicius Almeida Queiroz<sup>1</sup>, Victor Hugo Panato<sup>1</sup>, Arthur Heleno Pontes Antunes<sup>1</sup>, Jose Alberto Reis Parise<sup>2</sup>, Enio Pedone Bandarra Filho<sup>1</sup>**

<sup>1</sup>University Federal of Uberlandia, Brazil; <sup>2</sup>Pontific University Catholic of Rio de Janeiro, Brazil

**Keywords:** Cascade Refrigeration, R744, R134a, R404a

**ID: 2429**

### **A Fair Comparison of CO<sub>2</sub> and Propane Used in Light Commercial Applications Featuring Natural Refrigerants.....1807**

**Stefan Elbel<sup>1,2</sup>, Matej Visek<sup>2</sup>, Pega Hrnjak<sup>1,2</sup>**

<sup>1</sup>University of Illinois at Urbana-Champaign, United States of America; <sup>2</sup>Creative Thermal Solutions, United States of America

**Keywords:** Natural Refrigerant, Light Commercial, Efficiency, Comparison, Design

**ID: 2008**

### **Modelling of an R-290/Poe ISO 22 Variable Speed Air Conditioner System Under SEER Conditions.....1816**

**Guilherme B. Ribeiro<sup>1</sup>, Jader Riso Barbosa Jr.<sup>2</sup>**

<sup>1</sup>Aerospace Science and Technology Department, Brazil; <sup>2</sup>Federal University of Santa Catarina, Brazil

**Keywords:** Simulation, Mixture, Oil, SEER, Air Conditioner

**ID: 2049**

### **Performance Comparison of R32, R410A and R290 Refrigerant in Inverter Heat Pumps Application.....1825**

**Supharuek Konghuayrob, Kornvalee Khositkullaporn**

Siam Compressor Industry, Thailand

**Keywords:** R32, Heat Pump, DSH Control

**ID: 2105**

### **CO<sub>2</sub> as an Alternative Refrigerant for Applications Below -50°C.....1835**

**Robin Langebach, Ullrich Hesse, Yixia Xu**

TU Dresden, Germany

**Keywords:** CO<sub>2</sub>, Cycle, Sublimation Heat Transfer

**ID: 2202**

### **Development of a Refrigerant to Refrigerant Heat Exchanger for High Efficiency CO<sub>2</sub> Refrigerant Cycle.....1845**

**Ryuhei Kaji, Shun Yoshioka, Hirokazu Fujino**

Daikin Industries, LTD, Japan

**Keywords:** Refrigerant to Refrigerant Heat Exchanger, CO<sub>2</sub> Refrigerant Cycle, Evaporating Performance, Heat Transfer

## R-34: Flow Boiling

Time: Thursday July 14, 2016: 9:45 AM - 12:00 PM — Location: 218 A&B

Session Chair: Claudio Zilio

ID: 2417

### Experimental Investigation on Up-Flow Boiling of R1234yf in Aluminum Multi-Port Extruded Tubes.....1853

Jiyang Li, Chaobin Dang, Eiji Hihara

Department of Human and Engineered Environmental Studies, The University of Tokyo

Keywords: Upflow Boiling, Heat Transfer, Multi-Port Extruded Tube, Rectangular Minichannel

ID: 2371

### Flow Boiling Heat Transfer Characteristics of R32 Inside a Horizontal Small-Diameter Microfin Tube.....1861

Daisuke Jige, Kentaro Sagawa, Norihiro Inoue

Tokyo University of Marine Science and Technology, Japan

Keywords: Boiling Heat Transfer, Pressure Drop, Microfin Tube, Small-Diameter, R32

ID: 2251

### An Experimental Investigation of Convective Boiling Heat Transfer Using Alternative and Natural Refrigerants Inside Horizontal Microchannels.....1869

Nguyen-Ba Chien, Pham-Quang Vu, Kwang-II Choi, Jong-Taek Oh

Chonnam National University, Korea, Republic of (South Korea)

Keywords: Correlation, R32, R410A, R290, Boiling Heat Transfer, Microchannel

ID: 2265

### R134a Flow Boiling Inside a 4.3 Mm ID Microfin Tube.....1879

Simone Mancin<sup>1</sup>, Claudio Zilio<sup>1</sup>, Giulia Righetti<sup>1</sup>, Luca Doretto<sup>2</sup>, Giovanni A. Longo<sup>1</sup>

<sup>1</sup>Dept. of Management and Engineering, University of Padova, Italy; <sup>2</sup>Dept. of Civil, Architectural and Environmental Engineering, University of Padova, Italy

Keywords: Microfin Tube, Flow Boiling, R134a, Heat Transfer, Pressure Drop

ID: 2167

### HFO1234ze(E) and HFC134a Flow Boiling Inside a 4mm Horizontal Smooth Tube.....1889

Giovanni A. Longo, Simone Mancin, Giulia Righetti, Claudio Zilio

University of Padova, Italy

Keywords: Boiling, Tube, HFO

ID: 2166

### HFO1234ze(E) Boiling Inside a Brazed Plate Heat Exchanger.....1899

Giovanni A. Longo, Simone Mancin, Giulia Righetti, Claudio Zilio

University of Padova, Italy

Keywords: Boiling, BPHE, HFO

ID: 2244

### Comparison on Evaporation Heat Transfer Between R32/R1234yf and R32/R1234ze(E) Flowing in Horizontal Microfin Tubes.....1909

Shingo Nakamura<sup>1</sup>, Chieko Kondou<sup>2</sup>, Nobuo Takata<sup>1</sup>, Shigeru Koyama<sup>1</sup>

<sup>1</sup>Kyushu university, Japan; <sup>2</sup>Nagasaki university, Japan

Keywords: Low GWP, Refrigerant Mixtures, Evaporation, Heat Transfer

## **R-35: Residential Heat Pumps**

*Time:* Thursday July 14, 2016: 9:45 AM - 12:00 PM — *Location:* 218 C&D

*Session Chair:* Bo Shen

**ID: 2035**

### **Experimental Evaluation of Low-Cost Gas Heat Pump Prototypes for Building Space Heating.....1918**

**Michael Garrabrant<sup>1</sup>, Roger Stout<sup>1</sup>, Christopher Keinath<sup>1</sup>, Paul Glanville<sup>2</sup>**

<sup>1</sup>Stone Mountain Technologies, Inc.; <sup>2</sup>Gas Technologies Institute

**Keywords:** Heat Pump, Absorption, Ammonia-Water, Prototype, Space Heating

**ID: 2505**

### **Experimental Evaluation of High Performance Integrated Heat Pump.....1926**

**William A. Miller<sup>1</sup>, Robert Berry<sup>2</sup>, Neal Durfee<sup>1</sup>, Van D. Baxter<sup>1</sup>**

<sup>1</sup>Oak Ridge National Laboratory, United States of America; <sup>2</sup>Unico, Inc., United States of America

**Keywords:** Heat Pump, Integrated, Space Heating, Space Cooling, Water Heating

**ID: 2586**

### **Laboratory Performance Evaluation of Residential Scale Gas Engine Driven Heat Pump.....1936**

**Ahmad Abu-Heiba<sup>1</sup>, Isaac Y. Mahderekal<sup>3</sup>, Ayyoub Momen<sup>2</sup>**

<sup>1</sup>Oak Ridge Associated Universities, United States of America; <sup>2</sup>Oak Ridge National Laboratory; <sup>3</sup>IntelliChoice Energy

**Keywords:** Gas Heat Pump, GHP

**ID: 2171**

### **Techno-Economic Analysis of a Novel Solar Thermal and Air-Source Heat Pump System.....1945**

**Stefano Poppi<sup>1,2</sup>, Chris Bales<sup>1</sup>**

<sup>1</sup>Dalarna University, Falun; <sup>2</sup>KTH, Energy Technology, Stockholm

**Keywords:** Air Source Heat Pumps, Vapor Injection, Solar Thermal Combisystems.

**ID: 2442**

### **Research on the Operating Characteristics of Floor Heating System With Residential EVI Air Source Heat Pump in China.....1955**

**Xiaoning Chen, Ziqi Zhang, Junye Shi, Zhiyu Yang, Jiangping Chen**

Shanghai Jiao Tong University, China, People's Republic of

**Keywords:** Air Source Heat Pump, EVI, Floor Heating, Cold Region, HSPF

**ID: 2103**

### **Evaluation of R-410A Refrigerant Alternatives in a Residential Reversible Air to Water Heat Pump.....1964**

**Pierre Pardo, Louis Charbonnier, Michèle Mondot**

CETIAT, Centre Technique des Industries Aérauliques et Thermiques, Villeurbanne, France

**Keywords:** Residential Heat Pump, Refrigerant Alternatives, DR-5A, L41-2, Drop-In Tests

**ID: 2408**

### **Performance Evaluation of Heat Pump System Using R32 and HFO-mixed Refrigerant in High Ambient Temperature.....1970**

**Shigeharu Taira<sup>1</sup>, Tomoatsu Minamida<sup>3</sup>, Tomoyuki Haikawa<sup>2</sup>, Fumio Ota<sup>4</sup>**

<sup>1</sup>Japan; <sup>2</sup>Japan; <sup>3</sup>Japan; <sup>4</sup>Japan

**Keywords:** GWP, COP, Refrigerant, Heat Pump System, R410A, R32/R1234yf, R32, Zeotropic, High Ambient Temperature

## R-36: Property Measurements, Modeling, and Assessments II

Time: Thursday July 14, 2016: 9:45 AM - 12:00 PM — Location: 310

Session Chair: Barbara Haviland Minor

ID: 2287

### Viscosity Correlations for Refrigerants and Other Working Fluids From Residual Entropy Scaling.....1980

Ian Bell, Arno Laesecke

National Institute of Standards and Technology, United States of America

Keywords: Fluid Properties, Viscosity, Entropy Scaling

ID: 2297

### A Helmholtz Energy Equation of State for Trifluoroethylene (R-1123).....1990

Ryo Akasaka<sup>1</sup>, Masato Fukushima<sup>2</sup>, Eric W. Lemmon<sup>3</sup>

<sup>1</sup>Kyushu Sangyo University, Japan; <sup>2</sup>ASAHI GLASS CO., LTD., Japan; <sup>3</sup>National Institute of Standards and Technology, USA

Keywords: Equation of State, Low GWP Refrigerant, R-1123, Thermodynamic Property, Vapor Pressure

ID: 2176

### Comparison of Models for Calculation of the Thermodynamic Properties of NH<sub>3</sub>-CO<sub>2</sub>-H<sub>2</sub>O Mixture.....2000

Vilborg Gudjonsdottir, Carlos Infante Ferreira

Delft University of Technology, Section Engineering Thermodynamics, Netherlands

Keywords: NH<sub>3</sub>-CO<sub>2</sub>-H<sub>2</sub>O, Thermodynamic Model, Extended UNIQUAC, E-Nrtl, Aspen Plus

ID: 2288

### Psychrometric Properties of Humid Air From Multi-Fluid Helmholtz-Energy-Explicit Models.....2010

Ian Bell, Eric Lemmon, Allan Harvey

National Institute of Standards and Technology, United States of America

Keywords: Psychrometric Properties, Humid Air, Thermodynamics

ID: 2204

### The Viscosity Characteristics for the Mixed Refrigerant HFO-1234yf + HFC-152a.....2021

Zhangzhang Yang<sup>1</sup>, Xuehui Wang<sup>1</sup>, Yibo Fang<sup>1</sup>, Xiaohong Han<sup>1</sup>, Xiaogang Qiao<sup>2</sup>, Guangming Chen<sup>1</sup>

<sup>1</sup>Institute of Refrigeration and Cryogenics, State Key Laboratory of Clean Energy Utilization, Zhejiang University, Hangzhou, Zhejiang, China;

<sup>2</sup>Zhejiang College of Construction, Hangzhou, Zhejiang, China

Keywords: Liquid Viscosity, Mixed Refrigerant, HFO-1234yf, HFC-152a

ID: 2151

### Thermodynamic Properties of Low-Gwp Refrigerant for Centrifugal Chiller.....2029

Masato Fukushima, Hiroki Hayamizu, Mai Hashimoto

AGC Chemicals, ASAHI GLASS Co., Ltd, Japan

Keywords: Thermodynamic Properties, Low-Gwp, Refrigerant, HFO, Centrifugal Chiller

## R-37: Plate Heat Exchangers

Time: Thursday July 14, 2016: 9:45 AM - 12:00 PM — Location: 278

Session Chair: Vikrant C. Aute

ID: 2279

### An Improved Approach for Modeling Plate Heat Exchangers Based on Successive Substitution in Alternating Flow Directions.....2039

Radia Eldeeb, Vikrant Aute, Reinhard Radermacher

University of Maryland, United States of America

**Keywords:** Plate Heat Exchanger, Numerical Modeling, Validation

ID: 2338

### A Method to Combine Local Heat Transfer and Flow Visualization of Flow Boiling in Frame-And-Plate Heat Exchanger.....2047

Shenghan Jin<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>

<sup>1</sup>University of Illinois, United States of America; <sup>2</sup>Creative Thermal Solutions, Inc. (CTS), Urbana IL, USA

**Keywords:** Plate Heat Exchanger; Local Heat Transfer Coefficient; Flow Boiling; Visualization

ID: 2600

### Local Heat Transfer Characteristics of the R1234ze(E) Two Phase Flow Inside a Plate Heat Exchanger.....2057

Keishi Kariya, Mohammad Sultan Mahmud, Akitoshi Kawazoe, Akio Miyara

Saga university, Saga, Japan

**Keywords:** Plate Heat Exchanger, Local Heat Transfer, HFO Refrigerant, Two Phase Flow

ID: 2278

### Investigation of Thermal-Hydraulic Characteristics of Pillow Plate Heat Exchangers Using CFD.....2065

Radia Eldeeb, Vikrant Aute, Reinhard Radermacher

University of Maryland, United States of America

**Keywords:** Pillow Plate Heat Exchanger, NURBS, CFD

ID: 2337

### Effect of End Plates on Heat Transfer of Plate Heat Exchanger.....2075

Shenghan Jin<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>

<sup>1</sup>University of Illinois, United States of America; <sup>2</sup>Creative Thermal Solutions, Inc. (CTS), Urbana IL, USA

**Keywords:** Plate Heat Exchanger; End Plate Effect

ID: 2106

### Experimental Results for Hydrocarbon Refrigerant Vaporization in Brazed Plate Heat Exchangers at High Pressure.....2085

Adriano Desideri<sup>1</sup>, Torben Schmidt Ommen<sup>3</sup>, Jorrit Wronski<sup>2</sup>, Sylvain Quoilin<sup>1</sup>, Vincent Lemort<sup>1</sup>, Fredrik Haglind<sup>3</sup>

<sup>1</sup>Univerisy of Liege, Belgium; <sup>2</sup>IPU, Denmark; <sup>3</sup>Technical University of Denmark

**Keywords:** Brazed Plate Heat Exchanger, Experimental Test Rig, High Pressure Evaporation

ID: 2609

### Single Phase Pressure Drop and Flow Distribution in Brazed Plate Heat Exchangers.....2094

Wenzhe Li<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>

<sup>1</sup>Air-Conditioning and Refrigeration Center (ACRC), University of Illinois Urbana-Champaign, United States of America; <sup>2</sup>CTS – Creative Thermal Solutions, Inc. Urbana IL

**Keywords:** Single Phase, Pressure Drop, Flow Distribution, Brazed Plate Heat Exchangers (BPHE)



## R-38: HVAC Equipment Performance Enhancements

Time: Thursday July 14, 2016: 1:00 PM - 3:00 PM — Location: 214 A&B

Session Chair: Roy Crawford

ID: 2387

### Isentropic Mixtures and Their Application in Heat Pumps in Cold Climate Region.....2104

Nan Zheng<sup>1,2</sup>, Yunho Hwang<sup>1</sup>, Li Zhao<sup>2</sup>, Reinhard Radermacher<sup>1</sup>

<sup>1</sup>University Of Maryland, United States of America; <sup>2</sup>Tianjin University, China

**Keywords:** Zeotropic Mixture; Vapor Injection; Multi-Stage; Thermodynamic;

ID: 2606

### Reduction of Energy Consumption in Air-Conditioning Systems Employing Direct Evaporative Pre-Cooling of Condenser Air.....2114

Theodore Aganachi Ndukaife<sup>1,2</sup>, A.G Agwu Nnanna<sup>1,2</sup>

<sup>1</sup>Mechanical Engineering department, Purdue University NorthWest; <sup>2</sup>Purdue University Water Institute, United States of America

**Keywords:** Cellulose Pad, Evaporative Cooling, Air-Conditioning System, Condenser, Coefficient of Performance

ID: 2101

### Two-Stage Heat Pump Using Oil-Free Turbocompressors - System Design and Simulation.....2124

Cordin Arpagaus<sup>1</sup>, Stefan Bertsch<sup>1</sup>, Adeel Javed<sup>2</sup>, Jürg Schiffmann<sup>2</sup>

<sup>1</sup>NTB University of Applied Sciences of Technology Buchs, Institute for Energy Systems, Buchs, Switzerland; <sup>2</sup>Ecole Polytechnique Fédérale de Lausanne, Laboratory for Applied Mechanical Design, Neuchâtel, Switzerland

**Keywords:** Two-Stage Heat Pump, Multiple Heat Sources, Oil-Free Turbocompressors, System Design, Simulation

ID: 2528

### An Integrated Solution for Commercial AC Chillers Using Variable Speed Scroll Compressors.....2134

Stephane Bertagnolio, Eric Winandy, Dina Koepke

Emerson Climate Technologies, Aachen, Germany

**Keywords:** Chiller, Control, Variable Speed Scroll

ID: 2123

### Modelling and Simulation of a R744 Based Air Conditioning Unit.....2143

Mihir Mouchum Hazarika, Maddali Ramgopal, Souvik Bhattacharyya

IIT KHARAGPUR, India

**Keywords:** R744, Lmtd, Lmed

ID: 2140

### Cost Optimization of Thermoelectric Sub-Cooling in Air-Cooled CO<sub>2</sub> Air Conditioners.....2153

Kazuaki Yazawa<sup>1</sup>, Yefeng Liu<sup>2</sup>, Orkan Kurtulus<sup>2</sup>, Eckhard A. Groll<sup>2</sup>

<sup>1</sup>Birk Nanotechnology Center / Purdue University, United States of America; <sup>2</sup>Department of Mechanical Engineering / Purdue University, United States of America

**Keywords:** Sub-Cooler, CO<sub>2</sub>, Thermoelectric

## **R-39: Alternative Refrigerant Evaluation Methods and Results**

*Time:* Thursday July 14, 2016: 1:00 PM - 3:00 PM — *Location:* 214 C&D

*Session Chair:* Andy Pearson

**ID: 2649**

### **Low GWP Refrigerants for Air Conditioning and Chiller Applications.....2162**

**Ankit Sethi, Samuel Yana Motta**

Honeywell, United States of America

**Keywords:** Refrigerants, Low GWP, Air Conditioning, Chiller

**ID: 2064**

### **AHRI Low Global Warming Potential Alternative Refrigerants Evaluation Program (Low-Gwp AREP) – Summary of Phase II Testing Results.....2170**

**Xudong Wang, Karim Amrane**

Air-Conditioning, Heating, and Refrigeration Institute, United States of America

**Keywords:** Low GWP, Refrigerants

**ID: 2614**

### **Analysis of the Drop-In Operation of a Refrigeration System by the Response Surface Methodology.....2180**

**Victor Hugo Panato, Marcus Almeida Queiroz, Luis Manoel Paiva Souza, Arthur Heleno Pontes Antunes, Enio Pedone Bandarra Filho**

Federal University of Uberlandia, Brazil

**Keywords:** Drop-In, Response Surface Methodology, Optimization, COP, Desirability Function

**ID: 2071**

### **R-32 as an Alternative to Ammonia in Industrial Refrigeration.....2190**

**Andy Pearson**

Star Refrigeration Ltd, United Kingdom

**Keywords:** Industrial, Refrigeration, Ammonia, R-32, Hazard

**ID: 2332**

### **Novel Reduced GWP Refrigerant Compositions to Replace R-134a in Stationary Air-Conditioning and Refrigeration.....2198**

**Laurent Abbas<sup>1</sup>, Sarah Kim<sup>1</sup>, Kenneth Schultz<sup>2</sup>**

<sup>1</sup> ARKEMA Inc, United States of America; <sup>2</sup> Ingersoll Rand, United States of America

**Keywords:** R-134a, Low GWP, New Refrigerant

**ID: 2450**

### **Multi-Year Evaluation of R-449a as a Replacement for R-22 in Low Temperature and Medium Temperature Refrigeration Applications.....2206**

**Andrew Pansulla<sup>1</sup>, Charles Allgood<sup>2</sup>**

<sup>1</sup> Chemours, United States of America; <sup>2</sup> Chemours, United States of America

**Keywords:** Refrigeration, HFOs, R-22 Replacement, GWP, Retrofits

## **R-40: Refrigerant Heat Transfer and Pressure Drop I**

*Time:* Thursday July 14, 2016: 1:00 PM - 3:00 PM — *Location:* 218 A&B

*Session Chair:* Harshad Vijay Inamdar

**ID: 2077**

### **A New Flow Map and Flow Characterization of Condensation in Smooth Round Tube From Superheated Vapor.....2216**

**Jiange Xiao<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>**

<sup>1</sup>ACRC, the University of Illinois; <sup>2</sup>CTS – Creative Thermal Solutions, Inc. Urbana IL

**Keywords:** Condensation, Condensing Superheated Region, Flow Regime, Void Fraction, Film Thickness

**ID: 2078**

### **Heat Transfer of Condensation in Smooth Round Tube From Superheated Vapor.....2226**

**Jiange Xiao<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>**

<sup>1</sup>ACRC, the University of Illinois; <sup>2</sup>CTS – Creative Thermal Solutions, Inc. Urbana IL

**Keywords:** Condensation, Condensing Superheated Region, Heat Transfer

**ID: 2053**

### **Condensation of Superheated R134a Inside a Vertical Tube.....2235**

**Jaime Sieres<sup>1</sup>, José Antonio Martínez-Suárez<sup>1</sup>, Elena Martín<sup>2</sup>**

<sup>1</sup>Área de Máquinas y Motores Térmicos, Escuela de Ingeniería Industrial, University of Vigo, Spain; <sup>2</sup>Área de Mecánica de Fluidos, Escuela de Ingeniería Industrial, University of Vigo, Spain

**Keywords:** Degree of Superheat, Convection, Heat Transfer Coefficient, Vertical Tube, Measurement and Instrumentation

**ID: 2299**

### **Heat Transfer and Visualization in Large Flattened-Tube Condensers With Variable Inclination.....2245**

**William A. Davies<sup>1</sup>, Yu Kang<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>, Anthony M. Jacobi<sup>1</sup>**

<sup>1</sup>ACRC, University of Illinois, United States of America; <sup>2</sup>CTS - Creative Thermal Solutions, Inc. Urbana IL

**Keywords:** Air-Cooled Condenser, Steam Condensation, Heat Transfer

**ID: 2413**

### **Literature Review of Condensation and Evaporation of R290.....2255**

**Cichong Liu, Ziyang Sun, Ziqi Zhang, Junye Shi, Jiangping Chen**

Shanghai JiaoTong University, China, People's Republic of

**Keywords:** R290; Condensation; Evaporation; Heat Transfer; Pressure Drop

**ID: 2250**

### **Effect of Inclination on Pressure Drop in Large Flattened-Tube Steam Condensers.....2265**

**Yu Kang<sup>1</sup>, William A. Davies<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>, Anthony M. Jacobi<sup>1</sup>**

<sup>1</sup>ACRC, University of Illinois, United States of America; <sup>2</sup>CTS – Creative Thermal Solutions, Inc. Urbana, IL

**Keywords:** Pressure Drop of Steam, Air Cooled Condenser, Inclination, Flattened Tube

## R-41: Heat Pump Water Heaters

*Time:* Thursday July 14, 2016: 1:00 PM - 3:00 PM — *Location:* 218 C&D

*Session Chair:* Van D. Baxter

**ID: 2174**

### High Efficiency Heat Pump With Subcooling for Sanitary Hot Water Production Working With Propane.....2275

**Miquel Pitarch-Mocholí, Emilio Navarro-Peris, José Gonzalvez-Maciá, José Miguel Corberán**

Instituto de Ingenieria Energética, Universitat Politècnica de València, Spain

**Keywords:** Propane, Heat Pumps, Natural Refrigerants, Hot Water, Subcooling

**ID: 2469**

### Investigation, Analysis and Solution of Higher Noise of Heat Pump Water Heater.....2285

**Bo Huang, Weiyan Chu, Yinxiao Lu**

Shanghai Hitachi Electrical Appliances Co.,Ltd, China, People's Republic of

**Keywords:** Water Heaters; Compressor; Fan; Noise;

**ID: 2277**

### Heat Pump Driven by a Gas Engine for Heating and Domestic Hot Water Generation.....2292

**Amine Mekdache<sup>1,2</sup>, Assaad Zoughaib<sup>1</sup>, Denis Clodic<sup>2</sup>**

<sup>1</sup>Ecole des Mines de Paris / Centre efficacité énergétique des systèmes, France; <sup>2</sup>Engineering Research Innovation for Energy (EREIE), France

**Keywords:** Heat Pump, Gas Engine, Grey Waters, Heat Recovery, Positive Enrgy Buidings

**ID: 2633**

### Fifteen Years of Dehumidification Results From Heat Pump Water Heaters.....2301

**William E. Murphy**

Retired - University of Kentucky, United States of America

**Keywords:** Heat Pump Water Heater, Dehumidification, Field Tests

**ID: 2112**

### Modeling and Experimental Study of a Heat Pump Water Heater Cycle.....2309

**Kevin Ruben Deutz<sup>1,2</sup>, Odile Cauret<sup>1</sup>, Romuald Rullière<sup>2</sup>, Philippe Haberschill<sup>2</sup>**

<sup>1</sup>Electricité De France, EDF, France; <sup>2</sup>Institut National des Sciences Appliquées de Lyon, INSA Lyon

**Keywords:** Heat Pump Water Heater, Modeling, Simulation, Convection, Stratification

**ID: 2134**

### Experimental Investigation on the Influence of Refrigerant Charge on the Performance of Trans-Critical CO<sub>2</sub> Water-Water Heat Pump.....2319

**Ze Zhang<sup>1,2</sup>, Rong Xue<sup>2</sup>, Shuangtao Chen<sup>2</sup>, Shijie Song<sup>2</sup>, Yu Hou<sup>1,2</sup>**

<sup>1</sup>State Key Laboratory of Multiphase Flow in Power Engineering, Xi'an Jiaotong University, Xi'an 710049,China; <sup>2</sup>School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an 710049, China

**Keywords:** CO<sub>2</sub>, Heat Pump Water Heater, Refrigerant Charge, Performance

## **R-42: Thermal Storage**

*Time:* Thursday July 14, 2016: 1:00 PM - 3:00 PM — *Location:* 310

*Session Chair:* Gerhard Schmitz

**ID: 2192**

### **Integrated Thermal Energy Storage.....2327**

**William L. Kopko**

Johnson Controls, United States of America

**Keywords:** Energy Storage, Subcooling, Demand Reduction, Refrigeration Cycle, Chillers

**ID: 2141**

### **Numerical Simulation on Heat Transfer Performance of Silicon Carbide/ Nitrate Composite for Solar Power Generation.....2337**

**Ruixin Zhou, Xiaole Chen, Yang Lu, Bei Guo**

School of Energy and Power Engineering, Xi'an Jiaotong University, China

**Keywords:** Phase Change Material, Thermal Energy Storage Unit, SiC Honeycomb, Numerical Simulation, Solar Power Generation

**ID: 2018**

### **Design and Performance of Thermal Energy Storage Module Using High Thermal Conductivity Phase Change Composite Material.....2347**

**Siddique Khateeb Razack<sup>2</sup>, Yoram Shabtay<sup>1</sup>, Mukund Bhaskar<sup>1</sup>, Yoram Shabtay<sup>2</sup>, Hal Stilman<sup>1</sup>, Said Al-Hallaj<sup>1</sup>**

<sup>1</sup>Heat Transfer Technologies, United States of America; <sup>2</sup>NetEnergy, United States of America

**Keywords:** Thermal Energy Storage, Phase Change Material, Peak Load Shifting

**ID: 2221**

### **Experimental Analysis of Latent Heat Storages Integrated Into a Liquid Cooling System for the Cooling of Power Electronics.....2361**

**Thomas Bezerra Helbing, Gerhard Schmitz**

Institute of Thermo-Fluid Dynamics, Hamburg University of Technology, Germany

**Keywords:** Latent Heat Storage, Phase Change Materials, Buffer Storage, Liquid Cooling System, Peak Load

**ID: 2170**

### **Experimental Comparison of Different Composite Latent Heat Storage Devices With Spatially Non-Constant Heat Loads.....2371**

**Henrik Veelken, Gerhard Schmitz**

Institute of Thermo-Fluid Dynamics, Hamburg University of Technology, Germany

**Keywords:** Composite Latent Heat Storage, Phase Change Materials, Optimization

## **R-43: Air Conditioning Equipment Assessments**

*Time:* Thursday July 14, 2016: 3:30 PM - 5:30 PM — *Location:* 214 A&B

*Session Chair:* Kevin Mercer

**ID: 2227**

### **Conversion Factors for Comparing the Performance of Variable Refrigerant Flow Systems.....2381**

**Emi Matsui<sup>1</sup>, Shigeki Kametani<sup>1</sup>, Tatsuo Nobe<sup>2</sup>**

<sup>1</sup>Tokyo University of Marine Science and Technology, Japan; <sup>2</sup>Kogakuin University, Japan

**Keywords:** Conversion Factor, Energy Saving, Performance Evaluation Method

**ID: 2541**

### **Cooling Season Full and Part Load Performance Evaluation of Variable Refrigerant Flow (VRF) System Using an Occupancy Simulated Research Building.....2388**

**Piljae Im, Malhotra Mini, Jeffrey D Munk, Jehyeon Lee**

Oak Ridge National Laboratory, United States of America

**Keywords:** Variable Refrigerant Flow, Occupancy Emulated Building, HVAC Field Performance Evaluation

**ID: 2439**

### **Design Integration of Dedicated Outdoor Air System With Variable Refrigerant Flow System.....2398**

**Milind Vishwanath Rane, Deepa M Vedartham, Niranjana Bastakoti**

IIT Bombay, India

**Keywords:** DOAS, Air to Air Heat Recovery Unit, Indirect Evaporative Cooling, Sensible Heat Exchangers, Desiccant Dehumidification

**ID: 2138**

### **A Study of High Efficiency CO<sub>2</sub> Refrigerant VRF Air Conditioning System Adopting Multi-Stage Compression Cycle.....2408**

**Tetsuya Okamoto, Kazuhiro Furusho, Ikuhiro Iwata, Eiji Kumakura, Ryuhei Kaji**

Daikin Industries, Ltd.

**Keywords:** CO<sub>2</sub>, VRF, High Efficiency, Four-Stage Compression, New Type Compressor

**ID: 2303**

### **Simulation of a R410A Residential Air-Conditioning System With Round-Tube And/Or Microchannel Evaporators and Condensers Under Both Dry and Wet Air Conditions.....2418**

**Yang Zou<sup>1</sup>, Huize Li<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>**

<sup>1</sup>University of Illinois at Urbana-Champaign; <sup>2</sup>Creative Thermal Solutions

**Keywords:** Air-Conditioning System, Simulation, Microchannel, Wet Air

**ID: 2563**

### **Low GWP Refrigerants Modelling Study for a Room Air Conditioner Having Microchannel Heat Exchangers.....2428**

**Bo Shen<sup>1</sup>, Mahabir Bhandari<sup>1</sup>, Milind Rane<sup>2</sup>, Deep Mota<sup>2</sup>**

<sup>1</sup>Oak Ridge National Laboratories, United States of America; <sup>2</sup>Mechanical Engineering Department, Indian Institute of Technology Bombay, India

**Keywords:** Low GWP, Micro-Channel Heat Exchanger, Modelling, Room Air Conditioner

**ID: 2472**

### **Experimental Study on Microchannel and Round Tube Plate Fin Evaporators in a Residential Air Conditioning System.....2437**

**Huize Li<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>**

<sup>1</sup>University of Illinois at Urbana-Champaign, United States of America; <sup>2</sup>Creative Thermal Solutions

**Keywords:** Microchannel Evaporator, Round Tube Evaporator

## **R-44: Electronics/Thermoelectric Cooling**

*Time:* Thursday July 14, 2016: 3:30 PM - 5:30 PM — *Location:* 214 C&D

*Session Chair:* Orkan Kurtulus

**ID: 2263**

### **Loop Heat Pipes and Mini-Vapour Cycle System for Helicopter Avionics Electronic Thermal Management.....2446**

**Claudio Zilio<sup>1</sup>, Simone Mancin<sup>1</sup>, Romain Hodot<sup>2</sup>, Claude Sarno<sup>2</sup>, Vincent Pomme<sup>3</sup>, Bertrand Truffart<sup>3</sup>**

<sup>1</sup>Dept. of Management and Engineering, University of Padova, Italy; <sup>2</sup>Thales avionics, France; <sup>3</sup>Airbus Helicopter, France

**Keywords:** Electronics Thermal Management, VCS, Loop Heat Pipe, Avionic

**ID: 2196**

### **Compact Refrigeration System for Electronics Cooling Based on a Novel Two-Phase Jet Impingement Heat Sink.....2456**

**Pablo de Oliveira, Jader Barbosa**

Federal University of Santa Catarina, Brazil

**Keywords:** Compact Vapor Compression System, Enhanced Heat Transfer, Two-Phase Jet, Heat Sink, Electronics Cooling

**ID: 2473**

### **The Transient Supercooling Enhancement for a Pulsed Thermoelectric Cooler (TEC).....2466**

**Jia-ni Mao, Jun-yan Du, Shi-fei Wang, Jing-wei Zhou, Yu-gang Wang**

Department of Energy and Power Engineering, China JILiang University, Hangzhou 310018, People's Republic of China

**Keywords:** Thermoelectric Cooler (TEC), Dynamic Behaviour, Optimization, Supercooling Effect, Pulse-Excitation Voltage

**ID: 2623**

### **Thermoelectric Multi-Utility Water Heater Cum Air-Conditioner.....2477**

**Milind Vishwanath Rane<sup>1</sup>, Dinesh B Uphade<sup>1</sup>, Adittya M Rane<sup>2</sup>**

<sup>1</sup>IIT Bombay, India; <sup>2</sup>Vishwakarma Institute of Technology, Pune, INDIA

**Keywords:** Thermoelectric, Multi-Utility, Heat Pump, Water Heater

**ID: 2567**

### **Experimental Evaluation and Thermodynamic System Modeling of Thermoelectric Heat Pump Clothes Dryer.....2487**

**Viral K. Patel, Dakota Goodman, Kyle Gluesenkamp, Anthony Gehl**

ORNL, United States of America

**Keywords:** Energy-Efficient, Clothes Drying, Thermoelectric, Model, Energy Factor

## **R-45: Refrigerant Heat Transfer and Pressure Drop II**

*Time:* Thursday July 14, 2016: 3:30 PM - 5:30 PM — *Location:* 218 A&B

*Session Chair:* Pega Hrnjak

**ID: 2189**

### **Two-Phase Evaporation Pressure Drop Experimental Results for Low Refrigerant Mass Flux.....2495**

**Anna Fenko, Ellen Brehob, Andrea Kelecyc**

GE Appliances, United States of America

**Keywords:** Two-Phase, Pressure Drop, Low Mass Flux, R600A, R134A, Refrigerator Evaporator

**ID: 2394**

### **Evaporation Heat Transfer and Pressure Drop of R32 Inside Small-Diameter 4.0 Mm Tubes.....2504**

**Norihiro Inoue, Daisuke Jige, Kentaro Sagawa**

Tokyo University of Marine Science and Technology

**Keywords:** Evaporation, Heat Transfer, Pressure Drop, Helical-Grooved Tube, Small-Diameter, R32

**ID: 2133**

### **Heat Transfer and Pressure Drop During Evaporation of R134a in Microchannel Tubes.....2512**

**Houpei Li<sup>1</sup>, Pega Hrnjak<sup>1,2</sup>**

<sup>1</sup>ACRC, the University of Illinois; <sup>2</sup>Creative Thermal Solutions, Inc. Urbana IL

**Keywords:** Microchannel, Refrigerant, Heat Transfer, Pressure Drop, Experiment

**ID: 2602**

### **Experimental Study on Boiling and Condensation Heat Transfer in a Horizontal Mini Channel.....2522**

**Yasuhiro Kudo, Kyosuke Nakaiso, Keishi Kariya, Akio Miyara**

Saga university, Saga, Japan

**Keywords:** Minichannel, Boiling, Condensation

**ID: 2437**

### **Flow Boiling Pressure Drop for R410A and RL32H in Multi-Channel Tube.....2529**

**Xiu Wei Yin, Wen Wang, Vikas Patnaik, Jin Sheng Zhou, Xiang Chao Huang**

Ingersoll Rand, China, People's Republic of

**Keywords:** Flow Boiling, Pure Refrigerant, Refrigerant-Oil Mixture, Pressure Drop

**ID: 2044**

### **Falling Film Evaporation on a Thermal Spray Metal Coated Vertical Corrugated Plate Conduits.....2539**

**Jerin Robins Ebenezer, Annamalai Mani**

Indian Institute Of Technology Madras, India

**Keywords:** Falling Film Evaporation, Vertical Corrugated Plate Conduit, Numerical Simulation, Heat Transfer Enhancement, Thermal Spray Metal Coating



## **R-46: Geothermal/Ground Source Heat Pumps**

*Time:* Thursday July 14, 2016: 3:30 PM - 5:30 PM — *Location:* 218 C&D

*Session Chair:* Ron Domitrovic

**ID: 2351**

### **Improvement of Thermal Conductivity of Grout Mixture for Geothermal Heat Pump Systems.....2548**

**Chantal Maatouk**

Saint Joseph University, Lebanon (Lebanese Republic)

**Keywords:** Geothermal Heat Pump, Thermal Conductivity, Grout.

**ID: 2601**

### **Experimental Performance Estimations of Horizontal Ground Heat Exchangers for GSHP System.....2556**

**Md. Hasan Ali, Salsuwanda Bin Selamat, Keishi Kariya, Akio Miyara**

Saga university, Saga, Japan

**Keywords:** Ground Source Heat Pump, Heat Exchanger, Experiment, Numerical Simulation

**ID: 2207**

### **Heat Pumps Architecture Optimization for Enhanced Medium Temperature Geothermal Heat Use in District Heating.....2566**

**Matthildi Apostolou<sup>1,2</sup>, Sahar Salame<sup>1</sup>, Stéphanie Barrault<sup>1</sup>, Assaad Zoughaib<sup>1</sup>**

<sup>1</sup>MINES ParisTech, PSL Research University, CES - Center for energy Efficiency of Systems, France; <sup>2</sup>EDF R&D Division, EDF Lab Les Renardières, France

**Keywords:** Geothermal, District Heating, Heat Pumps

**ID: 2412**

### **Experimental Investigation on the Performance of Ground-Source Heat Pump With the Refrigerant R410A.....2576**

**Junhao Niu<sup>1</sup>, Huagen Wu<sup>1</sup>, Yunda Dong<sup>2</sup>**

<sup>1</sup>School of Energy and Power Engineering, Xi'an Jiaotong University, P.R. China; <sup>2</sup>Waterfurnace Shenglong HVACR Climate Solutions Co., Ltd

**Keywords:** Ground-Source Heat Pump, R410A, Experimental Investigation, Performance Research, Test.

**ID: 2284**

### **Characterization of Nanofluids Formed by Fumed Al<sub>2</sub>O<sub>3</sub> in Water for Geothermal Applications.....2584**

**Sergio Bobbo, Laura Colla, Antonella Barizza, Stefano Rossi, Laura Fedele**

Istituto per le Tecnologie della Costruzione – Consiglio Nazionale delle Ricerche, Italy

**Keywords:** Nanofluid, Fumed Al<sub>2</sub>O<sub>3</sub>, Secondary Fluid, Geothermal Application, Efficiency