Discussions for the Conference and Technical Papers from the 2020 ASHRAE Winter Conference in Orlando, Florida

This is a compilation of the written questions and comments submitted to authors by attendees at the 2020 ASHRAE Winter Conference in Orlando, Florida. All authors were given the opportunity to respond.

The questions/comments and authors' responses are published with the papers in the hardbound volume of *ASHRAE Transactions*, Vol. 126, Part 1.

OR-20-C003

Smart Control for Optimum Residential Fuel Switching between Natural-Gas and Electricity

Farzin M. Rad, PhD, PEng *Member ASHRAE*   **Nima Alibabaei, PhD**   **Tom Grochmal, PhD, PEng**

Sreenidhi Krishnamoorthy, Engineer/Scientist III, Electric Power Research Institute, Palo Alto, CA: How prevalent is this technology among residential customers in Canada?

Authors: The utility is working on providing incentives for customers to accept and adopt it.

Kevin Stuart, Instructor, Midlands Technical College, Columbia, SC: Do the GHG reductions include the impacts of electric-power-source emissions?

Farzin M. Rad: Yes, the emission calculations are based on the hourly source electricity generation (in Ontario), which is almost 95% emission-free.

OR-20-C015

Gradient Descent for Multi-Objective Optimization to Find a Cohesive Solution for Fenestration Sizes

Sara Motamedi, PhD

Baojie Mu, Research Engineer, Rheem Manufacturing Company: What is the method used to find global optimum?

Sara Motamedi: The parametric study in this research verifies that the global optimum and local optimum were the same when it comes to find optimal skylight sizes considering all the design criteria (glare, daylight and energy). The paper does not suggest any method to find global optimum for research questions with multiple local optimums. However, to find a global optimum with a gradient descent method, I recommend repeating the process with random initial inputs. The results should be compared after running a series of randomized optimization processes. The solution will be the one with the maximum performance. Further research is necessary to examine the proposed randomized method for research questions with multiple local optimums.

Holly Brink, Arup, San Francisco, CA: You presented three different types of analysis: parametric, genetic algorithm, and gradient descent. Can you confirm that gradient descent is not a type of genetic algorithm?

Sara Motamedi: Genetic algorithm is different than the gradient descent method that I proposed in this paper. Genetic algorithm is based on the evolutionary concept and starts with a descent size of initial population and applies fitness functions and mutation process on a random basis. The successive generation will be generated by applying random changes to the previous generation. However, the concept of GD is that it repeatedly but smartly moves toward the optimum by taking the steps in the direction of the negative gradient.

OR-20-C016

Cost-Optimal Sizing and Operation of a Hybrid Heat Pump System Using Numerical Simulation

Noah Rauschkolb *Student Member ASHRAE*

Vijay Modi, PhD

Patricia Culligan, PhD

Farzin Rad, Enbridge Gas, Inc., Toronto, ON, Canada: One of the slides on emissions considers the average energy generation mix across the U.S. This creates a misleading slide as the GHG savings are very sensitive to electrical generation.

Noah Rauschkolb: Using historical region-specific emissions factors provides a false sense of precision. Any large-scale change in electricity use (heat pumps, electric vehicles, etc.) will necessitate an expansion of generation capacity and result in a change to the generation mix. Rather than attempt to model these changes, we use a reasonable heuristic.

OR-20-C017

A New Model for Two-Phase Flow Boiling Heat Transfer of Refrigerant and Nanolubricant Mixtures in Smooth Tubes

Pratik S. Deokar *Student Member ASHRAE*

Lorenzo Cremaschi, PhD *Member ASHRAE*

Andrea A.M. Bigi, PhD *Member ASHRAE*

Jun Chen, Senior Engineer, CAC Group, Shanghai, China: I don't agree with the nucleate pool boiling model in this paper. In consider in a nucleate surface boiling and it is a nonhomogeneous situation, because nucleates are mainly created in the surface of the tube. Would the author please elaboration on the consideration?

Lorenzo Cremaschi: For the two-phase flow boiling of this work, the boiling is of non-homogeneous nature, where bubbles nucleate on the tube surface at the liquid-solid interface. The model does not consider evaporative phase change at the vapor-liquid interface, i.e. at the liquid film and vapor core interface, of the two-phase flow. At the tube surface, the lubricant rich fluid accumulates due to preferential boiling of the high vapor pressure refrigerant from the bulk refrigerant-lubricant mixture. As a result, the lubricant excess layer resides on the heater's surface and it affects the heat transfer performance by controlling the bubble departure diameter and the nucleate site density. If nanoparticles are present in the fluid, they interact with the growing bubbles. The pool boiling model used in this work was developed by Kedzierski (2003a, 2003b, 2011), and was used in this work because Kedzierski had used similar refrigerants and nanolubricants as the ones used in the present work.

Piotr Domanski, NIST, Gaithersburg, MD: Thank you for your presentation of this challenging research project. In your study, you used over 2% of lubricant content. How different would your results be if a lower lubricant content (~0.5%), which is more often seen in an operating system, was used?

Lorenzo Cremaschi: Thank you for your comment. The experimental data, in absence of nanoparticles, at 2.4 wt.% of POE lubricant concentration in R410A refrigerant showed enhancements in heat transfer up to 20% at low refrigerant vapor quality of 0.25 and up to 60% at high vapor quality of 0.7 (the uncertainty in the enhancement measurements were ±8%). The authors of this work believe that, because R410A-POE liquid mixture had higher surface tension than liquid R410A, the R410A-POE liquid mixture climbed up the wall of the smooth horizontal tube in stratified flow and improve wetting of tube surface, and thus helped to increase the heat transfer. The model of this work was developed using the experimental data measured at 0 wt.% and 2.4 wt. % of POE concentration in the R410A. For flow boiling in a horizontal smooth tube at lower POE lubricant content of ~0.5 wt.%, and in absence of nanoparticles, the model would predict heat transfer enhancement of 4% at low refrigerant vapor quality of 0.25 and up to 12% at high vapor quality of 0.7.

OR-20-C019

Development of Multi-Stage Two-Evaporator Transcritical Carbon Dioxide Cycle for Experimental Comparisons of Expansion Work Recovery Technologies

Riley B. Barta
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Davide Ziviani, PhD
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Eckhard A. Groll, Dr. Ing.
Fellow Member ASHRAE

Raymond Good, Global Director of Application Engineering, Danfoss Turbocor, Tallahassee, FL: How did you control the liquid level in the flash economizers in the system? Did you experience any problems with the flash economizer liquid levels?

Riley Barta: The liquid levels for both economizers are controlled via independent electronic expansion valves upstream of both tanks. In addition, the rate of vapor pulled across the evaporator bypass is metered in order to match the pressure differential seen across the evaporators fed by the liquid outlets of each respective flash tank. We have had trouble bypassing enough vapor such that some of the vapor passes through the liquid outlets and increases the quality of the flow entering our evaporators. We are addressing this by increasing the size of the bypass valves and are implementing capacitive liquid level sensors as well as a visual liquid level monitor in each flash tank for redundant liquid level monitoring. This way we can ensure that we know the liquid level and develop system control strategies to ensure that the liquid remains at a safe level.

OR-20-C026

CFD Application to Improve Infection Control in Office Rooms

Ahmed ElDegwy

Mohammed Sobhi

Essam E. Khalil
Fellow Member ASHRAE

Robert Cox, Director and Energy and Commissioning, Jacobs Engineering, Chapel Hill, NC: Please state the location of all supply and return diffusers for the six cases of the analysis.

Authors: See Figure 3.

OR-20-C028

The Effect of Boundary Conditions on Transient Airflow Patterns: A Numerical Investigation of Door Operation

Arup Bhattacharya
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Ehsan Mousavi, PhD
Associate Member ASHRAE

Jeff Franklin, Director of CFD Airflow Sciences Corporation, Livonia, MI: Did you explore different pressure boundary condition locations?

Authors: No but we are looking at this now.

OR-20-C034

A Novel Simulation Framework for Comfort-based Assessments of Window Designs

Shengbo Zhang **Jamie Fine, PhD** *Associate Member ASHRAE* **Marianne F. Touchie, PhD** *Associate Member ASHRAE* **William O'Brien, PhD** *Associate Member ASHRAE*

Lixing Gu, Florida Solar Energy Center, Cocoa, FL: The solar model developed by the author has some uncertainties. The first requirement is occupancy location related to window area. The second is solar radiation impact related to beam and diffuse. This author should include these factors and address uncertainty for the factors and provide better explanation.

Shengbo Zhang: The occupant location was considered as the simulation performed relevant calculations for

each discretized point in the space for each hour in a year. A detailed description is given in "Step 3" in the "Modeling Techniques" section. For the second comment: Beam and diffuse radiation intensities are calculated separately but then summed up into a single value for the ERF solar calculation.

OR-20-C072

Evaluation of Fixed and Variable Speed Compressor Energy Consumption in a Residential Environment Before and After Building Renovations

Jonathan P. Ore *Student Member ASHRAE* **Nicholas P. Salts** *Student Member ASHRAE* **Eckhard A. Groll, Dr. Eng.** *Fellow Member ASHRAE*

David Claridge, Professor, Texas A&M University, College Station, TX: Why did you use a base 65°F design day as the "independent" variable for your plots when better metrics are available?

Jonathan Ore: Thank you very much for your inquiry. After making modifications to the home, energy data was collected in a variety of weather conditions, so degree days were used to estimate weather severity and normalize its effect on energy data to capture the effect of modifications on energy consumption. Due to the unavailability of a better estimate of the base temperature for this house at this point as a result of limited testing data, the 65° F value as suggested by the ASHRAE Handbook of Fundamentals (2017) was selected. This value might be different from the actual base temperature, but the use of this particular base temperature was sufficient for normalizing the effect of weather conditions to study the effect of different building modifications on energy consumption. To your point, there would certainly be more accurate temperature references to use for each building modification, and as a result we are planning to study in a future work the correlation of energy consumption with weather data.

Richard Weekley, Engineering Manager, FHP Manufacturing, Fort Lauderdale, FL: Was the comparison using systems with different sized heat exchangers a good comparison?

Jonathan Ore: Thank you for addressing this point. The goal of this study was to consider different building and equipment configurations as scenarios, rather than attempt to directly evaluate a fixed-speed heat pump unit against a variable-speed unit. As a result, we consider rather the configuration of the fixed-speed heat pump unit installed in the home without insulation against the configuration of the variable-speed heat pump unit installed in the home with insulation. Ideally, we would have been able to obtain a variable-speed heat pump unit with the same sized heat exchanger, but this was not feasible within the project timeframe.

OR-20-002 (RP-1745)

The Use of Reanalysis in ASHRAE Applications

Michael Roth, PhD, PEng
Member ASHRAE

Henrique Lagoeiro, London South Bank University, London, UK: What is the reason for the high negative deviation in dew-point data throughout India?

Michael Roth: India is a monsoonal climate that can be difficult to capture completely in numerical weather models and reanalyses. Dew point, being so intimately tied to precipitation, can be particularly troublesome.

Joe Huang, White Box Technologies, Moraga, CA: Has any study been made of the accuracy of simple lapse rate connections for elevation differences between the site and the grid cell (i.e., how well do lapse rate connections correct for elevation changes)?

Michael Roth: The lapse rate is the rate at which dry-bulb temperature, for example, cools as altitude increases. Thus, one could conceivably adjust a reanalysis temperature, estimated at the elevation of the grid cell, upward or downward to a desired elevation. Note that this methodology is also possible for other variables such as pressure, dew point, or solar radiation. However, the difficulty is estimating a valid lapse rate—depending on the location, season, inversions, time-of-day, and so on, the lapse rate can change substantially. Applying an incorrect lapse rate can potentially reduce the accuracy, especially if applied over large elevation changes.

OR-20-016

Pressure Loss Measurements in Typical Flexible and Sheet Metal Light-Commercial Duct Systems

C. Kodali **A. Paruchuri** **S. Idem, PhD**

Eugene Faris, Vice President of Engineering, Nailor Industries, Houston, TX: I offer caution on inlet sizes and the ability to upsize.

Stephen Idem: The authors agree that the results presented in this paper may not be applicable to other duct system configurations. Further testing, or development of performance models based on verified loss coefficient data, is suggested.

Robert Cox, Director of Energy and Commissioning, Jacobs Engineering, Chapel Hill, NC: Are these results applicable to systems with elbows instead of just straight ductwork?

Stephen Idem: The data presented in this paper offers guidance to duct system designers concerning the use of longer lengths of flexible ducts than are currently recommended, provided they are installed correctly. However, the results reported in the paper cannot be readily extended to duct systems exhibiting a very different geometry. Please note that 90° flexible duct elbows with a dimensionless turning radius of one were installed at the collars of the diffusers and were taken into account in the analysis of the pressure loss coefficients that were reported. Otherwise no elbows were present in the steel or flexible duct runs.

OR-20-017

A Simple Airflow and Power Model of Fan-Coil Units with Permanent Split Capacitor Motors

Dennis O'Neal, PhD, PE *Fellow/Life Member ASHRAE*
Peng Yin, PhD *Associate Member ASHRAE*

Michael Sulva, Senior HVAC Acceptance Engineer, NAVFAC, Washington, DC: Where is the fan simulation software from? You'd think that it would be verified by the software manufacturer, no?

Dennis O'Neal: The software mentioned in the paper is EnergyPlus, which is a public-domain building simulation program. One of the systems it models is fan-coil units. Some of the default assumptions it uses, such as fan efficiency, are more appropriate for large air handlers, not the fractional horsepower fan used in many fan-coil units. In addition, there has been little guidance in the user's manual on what values to use. This leaves an inexperienced user estimating with very low power and energy values for the fan-coil units because they have used the defaults. EnergyPlus is in the process of having some major revisions that should make it easier to specify some realistic values of input for fan-coil units.

Eugene Faris, Vice President of Engineering, Nailor Industries, Houston TX: Are simulations coming?

Dennis O'Neal: Papers are being written that have simulations and include the thermal and air-side of fan-coil units. These were all a part of the ASHRAE Research Project RP-1741.

Steve Kavanaugh, University of Alabama, Tuscaloosa, AL: Did you notice differences in the default fan efficiencies in equipment manufacturers' simulation programs compared to values used in public-domain programs?

Dennis O'Neal: For this paper, we did not directly measure fan efficiency. However, we did quantify power/airflow, typically expressed in W/(ft^3/min) or W/(m^3/min). As shown in the paper, the biggest differences were in the rated size (expressed in airflow) of the systems. The larger airflow systems typically had higher power/airflow values. We think this was primarily caused by squeezing larger fans into similarly sized cabinets. With the higher airflows, there would be larger pressure drops in the cabinets and therefore higher power used by the fans.

OR-20-018

Laboratory Performance Measurement of Blowers with Electronically Commutated Motors in Horizontal Low-Profile Fan Coil Units

Peng Yin, PhD
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Beau Derouen

Albert McBride

Dennis O'Neal, PhD, PE
Fellow/Life Member ASHRAE

Ralph Koerber, Vice President of Manufacturing and Technical Services, ATCO/ADC, Fort Worth, TX: Good presentation. I wonder if the conclusion that actual efficiency is far below estimated (15-25 vs. 60-70) could be verified by actual whole-house modeling and/or testing.

Peng Yin: The following recent study examined the performance of fans driven by fractional horsepower motors in fan-coil units:

O'Neal, D.L., J. Cramer, and P. Yin. 2019. Field evaluation of the performance of fan coil units with permanent split capacitor fan motors. *Science and Technology for the Built Environment* June 2019.

Based on the measurements on 321 fan-coil units with permanent split capacitor motors, this study reveals that the maximum measured fan/motor overall efficiency is 18.4%. It should be noted that the above study targets fans with permanent split capacitor motors. Studies on fans with electronically commutated motors should be included in the future so that the field fan performance with different motors can be compared.