

## TC 08.05 RESEARCH REPORT – JAN 2009 / CHICAGO

### ACTIVE PROJECTS

**1316-RP: Experimental Evaluation of the Heat Transfer Impacts of Tube Pitch on a Highly Enhanced Surface Tube Bundle.** PI: Steve Eckels, Kansas State Univ. PMS: Petur Thors (chair), Ben Dingel, Satheesh Kulankara, Axel Kriegsmann. Status: active (start date: Jan-2006. original target completion date: Jul-2008. current projected completion date: Jul-2009.)

The original PI, Bruce Babin, has resigned from KSU. Steve Eckels has taken on the role of PI. Evraam Gorgy is the student working on this project as a PhD candidate.

As noted at the previous meeting, all pool boiling work has been completed. Re-construction of the bundle test chamber is now complete. The new design worked well with regard to access to welds, etc. The refrigerant circuit plumbing is also complete, as are the hot water systems to drive the tests. The test section and pre-boiler water circuits are now under construction. This, along with final leak checking and installation of insulation, is projected to be completed by spring 2009.

Two journal papers describing the tube-average and local single-tube pool boiling results are in preparation. Drafts will be circulated to the PMS for review.

**1345-TRP: Waterside Fouling Performance of Brazed-Plate Type Condensers in Cooling Tower Applications.** PI: Lorenzo Cremaschi, Oklahoma State Univ. PMS: Jim Bogart (chair), Art Fovargue, Axel Kriegsmann, Ken Schultz, Xudong Wang (ARTI cofunding). Status: active (start date: May-2008. original target completion date: Oct-2010).

A review of the test matrix by the PMS following the Jun08 meeting revealed that the operating conditions proposed for the “high heat flux” case were outside the range of reasonable application. In PI/PMS exchanges during Sep08 and Oct08, it was decided to set the water flow rate (3 gpm/ton), cooling water inlet temperature (85°F), and refrigerant saturation temperature (105°C) at a nominal ARI operating condition for the each heat exchanger. The heat flux and outlet water temperature become dependent variables. Recognizing that fouling is expected to be significantly influenced by the plate surface temperature, a second “harder-driven” condition will be run by increasing the saturation temperature to 120°F (representing a high-head application) while holding the water flow rate (velocity) and cooling water inlet temperature fixed. In each case, entering refrigerant superheat will be maintained at 65°F.

The analysis run on the revised operating conditions indicates that the uncertainty in the fouling factor could be only 38% at the ARI operating point and 19% at the harder-driven condition assuming a nominal fouling factor of .00025 is reached. It is suspected that, although the uncertain in the absolute value of the fouling factor could be this high, the relative uncertainty between operating conditions will be smaller than this. The thinking is that random errors will be averaged out and changes in bias errors between tests will be small.

All of the heat exchangers have been delivered. The test facility is assembled. The threaded fittings on the BPHE's proved to be difficult to seal; leaks were finally plugged by using a commercial sealant paste. With a dummy heat exchanger installed, instrumentation and energy balance checks have been run. RTD's were said to be okay. Additional insulation will be installed.

The project is tracking a bit behind schedule. However, with lower capacities needed for the first test condition, it should be possible to run with two heat exchangers in parallel. This will help make some time. The PMS and the PI met to discuss the project just prior to the formal Sunday meeting.

**1394-RFP: Study of Carbon Dioxide Condensation in a Chevron Angle Plate Geometry Exchanger.** PI: Amir Jokar, Washington State University – Vancouver. PMS: Zahid Ayub (chair), Joe Huber, Jim Bogart. Status: active (start date: Sep-2007. original target completion date: Aug-2009).

Single-phase heat transfer coefficients have been determined using a Wilson plot technique with both water/water and water/Dynalene. A paper describing this work has been submitted and accepted for publication in HVAC&R Journal. Curiously, the  $Nu/Pr^{1/3}$  vs Re correlations for the different fluids do not match up. This suggests that the Prandtl number exponent might not be correct. An implication of this is that extrapolation of the correlations obtained under calibration conditions to the actual test conditions might not be accurate.

It appears that the Dynalene HC being used, said to be a mixture of potassium formate and potassium acetate, might be causing some corrosion in the copper-brazed plate heat exchanger and possibly the auxiliary chiller. This problem will continue to be traced. An option might be to switch to a potassium formate only fluid or to a hydrocarbon based fluid (eg, Dynalene MV).

## INACTIVE PROJECTS

**1324-TRP: Study of Single and Two-Phase Flow-Induced Tube Vibration in Shell and Tube Heat Exchangers.** WS author: Mahesh Valiya Naduvath

The research liaison has been asked to remove this project from the research implementation plan.

## FUTURE RESEARCH TOPICS

**1556-RTAR: Characterization of Liquid Refrigerant Flow Emerging from a Flooded Evaporator Tube Bundle.** RTAR author: Jon Hartfield

This RTAR was approved by TC 1.3 in Aug08 and accepted by RAC during the Oct08 meeting. Jon has since circulated a draft WS for review by TC 1.3 members. Discussion occurred and comments were received at the Sunday research meeting and the TC 8.5 and 1.3 committee meetings. TC 8.5 voted unanimously to consider co-sponsorship of this project (subject to review of the final work statement, of course). In general, the comments were directed at having the WS describe the desired information to be collected and allowing the bidders to propose how to do this, ie, the WS shouldn't specify what the test rig should look like and how the work should be done.

### **Fouling of Tube-in-Tube Type Condensers**

This is the only remaining topic on TC 8.5's research priority list. HTRI has expressed interest in doing this project. AHRI has indicated cofunding might also be available for this project. Need RTAR and then WS. Continues to be on the shelf until 1354-RP shows prospects for satisfactory results.

### **Research Project Ideas**

Resubmission of the fouling in enhanced tubes WS remains a possible project because 1205-RP was not successful. As above, we are waiting until good/useful data starts coming from 1345-RP (fouling in BPHE condensers) before submitting RTAR/WS for fouling in enhanced tubes again along with the fouling in tube-in-tube heat exchangers. A new WS should account for the fact that low fouling potential water did not produce any measurable fouling effect. Also consider adding a modeling aspect – how should fouling be described (ie, is " $\beta_2$ -FF" the correct/best description)?

Jamal Yagoobi submitted an idea titled "Enhancement of Internal Flow Heat Transfer Coefficient with Micro-Encapsulated Phase Change Material". A PhD student recently completed a project in this area.

Dr Yagoobi was asked to send a copy of the thesis abstract and literature review to the research chair. This will be circulated to the committee for further review. There was some discussion on whether this work might be of a more fundamental level that would better be done under TC 1.3, at least initially. This topic will be brought to TC 1.3 for discussion.

With the recent development of new refrigerants with low direct GWP, Samuel Yana-Motta offered the idea that determination of the characteristics of these new refrigerants in heat transfer equipment would be of benefit to the ASHRAE community. Again, there was some discussion about the level of this work and whether it best fell under the purview of TC 1.3 (fundamental) or TC 8.5 (application). At the TC 1.3 meeting, Samuel volunteered to begin drafting an RTAR for review.

## **SUMMARY OF RESEARCH CHAIR BREAKFAST**

The business section of the research breakfast was shortened to allow time for a presentation on the status of the next Research Strategic Plan 2010-2015. RAC is holding a meeting on Feb 23<sup>rd</sup>; the deadline for submitting new RTAR's and WS's for consideration at this meeting is Feb 9<sup>th</sup>. WS's approved at the Feb meeting could go out for bid this spring as there is money available in the research budget. The next opportunity/deadline for submitting RTAR's and WS's is May 15<sup>th</sup>.

RAC is encouraging that WS's should call out intermediate goals and objectives that can be monitored and used to ensure projects stay on track. How to do this was left quite open.

PMS chairs were asked to make sure the "Disposition of ASHRAE Research" form is filled out and submitted to MORTS following the completion of projects.

### ***Research Strategic Plan (RSP) 2010-2015***

Reviewing the previous plan is a key element of developing the next plan. While research projects that address goals can be identified, goals that will be met by 2010 can't. Many of the current plan's goals are so broad or far-reaching that they can only represent aspirations. Is another format needed?

RAP recognizes the value of and need for two types of research: tactical and strategic. Tactical research is analogous to battle field activities – actions taken to get done the work that is needed. The TC's have been very good in doing the tactical research that drives ASHRAE. On the other hand, ASHRAE has not done so well with strategic research – the high level view that gives purpose to the organization.

With development of the new plan, RAP is taking this opportunity to look at things from a broader perspective and to look for strategic opportunities. The desire is to achieve a balance between tactical and strategic research. The strategic side is to provide guidance, motivation, and prioritization for the tactical work and open opportunities for broader scope, larger dollar, multi-TC projects.

To help provide guidance during development of the plan, RAP conducted a survey of members. 388 were received comprising 187 TC/TG/TRG members representing 100 of the 103 committees. The full report of the survey can be found at <http://www.ashrae.org/RSPsurveyresults>. The top issues among respondents were energy efficiency, energy conservation, and indoor air quality.

A list of 11 goal topics has been drafted to capture the results from the survey and other input. Each goal topic will have a champion assigned to it. The topics are still generic and TC's will be asked to provide input to frame them further. The 11 topics are:

1. Maximize actual operational energy performance of buildings and facilities.
2. Progress toward cost-effective net-zero energy buildings.
3. Residential retrofit energy efficiency.
4. Quantification of IEQ benefits.
5. Energy standards development, compliance, and enforcement.
6. Building information modeling (BIM) of energy efficient, high performing buildings.

7. Load calculation methods, energy calculation methods, and design procedures suitable for low energy and net-zero energy buildings.
8. Natural refrigerants and refrigerant charge reduction.
9. Improve specific components of HVAC&R systems.
10. Support Advanced Energy Design Guides.
11. Transform engineering and architectural education.

At this point, TC 8.5 has been identified as a contributor to goal topics #8 (natural refrigerants ...) and #9 (improve specific components). These seem quite clear and logical. The champion for “natural refrigerants ...” is Zahid Ayub. The champion for “components” is Wayne Reedy.

Ultimately, the RSP is expected to be divided into two categories: work to be done within the existing funding stream and goals for which additional funding will be sought. The thought is that roughly half of the research budget (currently \$2.5M) will be directed toward tactical projects and the other half allocated to the larger strategic projects. Outside agencies have said that it would be easier to support a bigger, broader “strategic plan” than tracking 100’s of tactical projects.

The schedule is tentatively laid out as follows... Jan-May 2009: Goal champions hold discussions with TC members and others to quantify scope, benefits, costs, etc. The RSP draft with goals, but not prioritized, will be written. In Jun09, RAP will prioritize goals. Jul09-Mar10 will be used to review and revise the document that will be submitted to RAC and Tech Council in April 2010. Approval is targeted for Jun 2010.

Slides from the breakfast presentation are attached to the pdf version of these notes.