

TC 08.05 RESEARCH REPORT – JAN 2008 / NEW YORK

1316-RP: Experimental Evaluation of the Heat Transfer Impacts of Tube Pitch on a Highly Enhanced Surface Tube Bundle. PI: Bruce Babin & Steve Eckels, Kansas State Univ. PMS: Petur Thors (chair), Ben Dingel, Satheesh Kulankara, Axel Kriegsmann. Status: active (start date: Jan-06. original target completion date: Jul-08)

Report was presented by Bruce Babin. The pool boiling rig is now operational. The effect of water-side pressure drop on enthalpy change is now taken into account. Absolute pressure transducers have been installed at the inlet and outlet connections. 1000- Ω RTD's have replaced the 100- Ω RTD's used initially to improve accuracies and reduce uncertainties. To reduce water-side pressure drop, the in-tube RTD insert was reduced from 3/8" OD to 1/4". The insert is also wrapped with an insulated tinned copper wire to promote good mixing in the annulus and provide accurate core water temperatures.

Wilson plot data has been obtained for the 3/4" OD Turbo-BIIHP tube in R134a. Adding the water-side pressure measurements allows determination of the friction factor. This data is then used in the Gnielinski equation and a multiplier determined from the heat transfer data; a value of $C = 1.928$ was obtained. Heat flux and refrigerant saturation temperature were held within very narrow ranges.

The shell-side pool boiling data determined from the 3/4" OD Turbo-BIIHP tube in R134a testing appears to agree reasonably well with other published results. "Tube average" data compares very well with "local" values obtained from the in-tube RTD's. Heat flux range: $7 < q'' < 135$ kW/m². As q'' increases, h_o increases rapidly, peaks at around 45-40 kW/m², decreases slightly and levels off around 75-80 kW/m², and finally appears to begin increasing again for $q'' > 110$ kW/m².

Wilson plot and pool boiling data collection is underway on the 3/4" OD Turbo-BIILP tube in R123. Non-condensable gases have been somewhat of a problem.

Bundle facility is being pressure / leaked checked. Tubesheets for the first tube pitch ($P/D = 1.67$, 7/8" triangular pitch with 3/4" tubes). A question was asked about the thickness of the tubesheet (didn't look thick enough in the photo – looks to be ~3/4" on closer inspection). Joe Huber has provided tube rolling information to KSU. Expectation is to have bundle data by the summer meeting in Salt Lake City.

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

No activity. Still on the list, but don't know if any time will be devoted to pursuing it. (See previous notes.)

1345-TRP: Waterside Fouling Performance of Brazed-Plate Type Condensers in Cooling Tower Applications. WS author: Jim Bogart

Six prospective bidders were identified and contacted to ensure interest. Because no useful data came from 1205-RP, the requirement to test a tube along with the BPHE's was removed from the WS. With this, the updated WS was resubmitted to MORTS with RL approval and the RFP was re-released in Oct07. Five bids were received (two from the prospective bidders list and three "out of the blue"); see list below.

Bids were reviewed by the PES (Jim Bogart, Art Fovargue, Axel Kriegsmann, and Ken Schultz) along with Xudong Wang (AHRI/ARTI, contributing co-funding) and Ron Bailey (section 8 research liaison). Proposals were received from the University of Central Florida, Zhejiang University, Washington State University – Vancouver, Danish Technological Institute, and Oklahoma State University.

The Oklahoma State University (OSU) proposal was judged to be the most thorough and well thought out. They provided the most detail about the experimental method. They offered the lowest cost to ASHRAE. The PES had some questions about certain aspects of the test plan, one being inconsistent description of temperature measurement methods and their plan to test only one heat exchanger at a time. However, the PES consensus was that these issues could be addressed satisfactorily by PMS interaction with the PI as the project ramped up. As such, the OSU proposal was recommended by the PES, and the full TC voted to recommend the OSU proposal to TAC. Mike Vaughn's 31-Jan-2008 "Research & Technical Activities Report" indicates that 1345-TRP was approved for award to OSU

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-07. original target completion date: Aug-09).

Contract was signed with Washington State University in Sep07. No (public) publications of CO₂ condensation in plate heat exchangers was found. Several recent references to CO₂ based refrigeration systems were found, however. Test facility layout has been designed. A low-temperature chiller has been received as gift from Chiller Solutions. Flat Plate is contributing the heat exchangers and will consist of 1 central channel for CO₂ condensation and 2 neighboring channels for the cooling fluid. Because of the very low operating temperatures, a Dynalene heat transfer fluid is being used (which one?).

The PI has been unable to find a CO₂ pump with small enough capacity to accommodate the operating conditions specified in the WS. The smallest pump available has been purchased. One possibility is to run the pump with a parallel recirculation loop. However, the PI is suggesting that the heat flux range be increased based on the available pump and his review of the typical operating conditions (he thinks q'' s are higher than stated in the WS). The PMS will review this and discuss further with the PI.

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. ARI has indicated cofunding might also be available for this project. Need RTAR and then WS. Continues to be on the shelf until PHE fouling project gets off the ground.

1444-RP: Experimental Evaluation of Two-Phase Pressure Drops and Flow Patterns in U-Bends for R-134a, R-410A, and Ammonia. *PI: John Thome, EPFL. PMS: belongs to TC 1.3.*

Recommendation to award the contract to EPFL was accepted by RAC at the Long Beach meeting. Contract has been signed and work initiated. Monitoring/reporting of this work will be handled by TC 1.3.

Future Research Projects

Time was allotted after the Sunday evening project review session for discussion of future research project ideas. One idea is to re-submit the fouling in enhanced tubes WS because 1205-RP was not successful. Discussion centered on waiting until good/useful data starts coming from 1345-RP (fouling in BPHE condensers) before submitting WS's for fouling in enhanced tubes again along with the fouling in tube-in-tube heat exchangers. New 1205-WS should account for fact that low fouling potential water did not produce any measurable fouling effect. Also maybe consider adding a modeling aspect – how should fouling be described (ie, is " β_2 -FF" the correct/best description?).

Jon Hartfield circulated a draft RTAR on determining the characteristics of refrigerant droplets exiting flooded evaporator bundles. Generally positive encouragement was received. More specific feedback received at the TC 8.5 and TC 1.3 main meetings suggested paying attention to project scope (keeping scope limited and manageable) and more clearly identifying the objective. It was recommended to focus on the technical objective and allow bidders to propose the appropriate experimental techniques. This

project is targeted as going through TC 1.3 with TC 8.5 co-sponsorship. Beyond this, no new ideas were raised.

Repeating from last time (x2)... Based on recent experience, several strategies were discussed to improve the prospects of receiving responsive bids to RFPs. These include managing the scope of proposed work and estimating resources and costs more accurately. Identifying prospective bidders by direct contact early in the work statement process is allowed and encouraged. Thorough and careful evaluation of proposals/bids is encouraged. A PES can go back to bidders for more information if there are questions that need to be addressed. Proposals can be rescored based on this new information.

Next Meetings

None of the projects reviewed this time have become completed – all are expected to be reviewed again at the next meeting. In addition, it is expected that 1345-RP will be started and need a review slot. This means 7 projects for the next review meeting in Jun08 at Salt Lake City. The consensus seemed to be that each project should be allocated at least 30 minutes to allow thorough review and discussion. Joe Huber (TC 1.3 research chair) will send an email reminder to Satheesh Kulankara (TC 1.3 chair) to extend the research meeting time an extra hour (3:00pm-7:00pm) to accommodate all the projects. Joe will also look into having ASHRAE supply a projector because of the volume of projects we need to cover.

Schedule for the Chicago meeting in Jan09 shouldn't be as long as 1270-RP (microchannel condensation) and 1280-RP (transition flow) should be completed by the next meeting. We might keep the extended length of the meeting to ensure we have adequate time without someone bumping us.

Summary of Research Chair Breakfast

- Research budget for 07-08 is \$2.4M and \$2.3M for 08-09. \$1.2M is already obligated from previously awarded contracts. \$1.2M is therefore available for new projects. \$715K in new projects have been already been awarded leaving \$485K available for awards this spring.
- There are currently 71 active projects underway. The numbers of RTARs, WSs, and projects awarded are up from last year. This is encouraging.
- The new Research Manual is almost complete. It should be posted to the ASHRAE website by 31-Jan-08. The new Research Manual will contain all the forms and procedures needed – use it.
- Work statement authors are not prevented from bidding. Checks and balances have been established to ensure fair competition. If a work statement author submits a bid, bids will be reviewed by the PES (3 members minimum) and two members of RAC, one of whom will be an *ex officio* PES member and participate in all meetings and correspondence.
- PES meetings should not be held in public spaces; preferably, a room should be scheduled. PMS meetings are open to “the public” and should be scheduled (we've always complied with this).
- RTARs and WS due dates are March 3rd (for RAC spring meeting), May 15th, Aug 15th, and Dec 15th.
- ASHRAE focus continues to be SUSTAINABILITY. The next Research Advisory Panel has been set up with the objective to update the Research Strategic Plan by 2010 (to be done every 5 years). Jeff Spittler is the chair. Zahid Ayub is a member.
- USGBC Research has committed \$1M for green building research work with ASHRAE. Request for pre-proposals is expected to come out late January. TC's are encouraged to review the request. If TC has an idea that appears to fit, they are encouraged to work with RAC. It was said that WS should be well developed in order to meet USGBC timetable. Other co-funders are ARTI, CEC, and CIBSE.

- Each TC is encouraged to have a Research Plan. This should be done for good planning and execution. It is suggested that the Plan be listed on the TC website as a way to attract potential collaborating TCs. However, this plan no longer needs to be filed with MORTS. The “Research Plan Priority” number on the RTAR and WS forms will be dropped.
- See slides for more information.