ASHRAE Ottawa Valley Chapter

Chapter Meeting #6 – 15 March 2016

Meeting Date:	15 March, 2016					
Location:	Restaurant International, Algonquin College					
Attendance:	Total:	64				
	Members:	53	Guests:	8	Students:	3
Theme:	Student Activities/CTTC					
Tour:	None					
Tech Session:	None					
Table Top:	TRANE Total HVAC					
Program:	Variable Primary Flow Chilled Water Systems					
Speakers:	William P. Bahnfleth, Ph.D., P.E. , Professor, Pennsylvania State University					
Prepared by:	Daniel Redmond					

Social (17:30 – 18:30)

Business Session (18:30 –18:52)

- President Georges Maamari introduced the Board of Governors and the Executive
- Daniel Redmond introduced the guests for the evening
- Celine Baribeau introduced the new members
- President Georges Maamari discussed the upcoming seminar to be held on Thursday presented by Judy Jeske regarding the NBC. At the current time the event is sold out, but if people are still interested they are to connect with President Georges Maamari
- Adam Graham talked about the recent curling bonspiel. 8 sheets full, 16 teams. Longhill won. Money was raised for the ASHRAE scholarship and for a local charity. Chris Healey, Christine Kemp and Stan Millross were very helpful in presenting a fantastic event.
- President Georges Maamari talked about the cancelled February meeting. Algonquin closed the campus and it was very difficult to reschedule on such short notice however the speaker will be brought back next year. As the February meeting was cancelled, the theme for the March meeting was shared between Student Activities and CTTC.
- Andrew Klassen discussed the CTTC Technology Awards. The awards are currently underway and the deadline for chapter submission has been extended a couple of weeks until the end of March.
- President Georges Maamari introduced Adrianne Mitani and Robin Ellis (RVC SA) to discuss SA. Adrianne discussed the student event held at Carleton March 14. Bill Bahnfleth IAQ. Career fair is being held next week, sponsorship available. SA also looking for old ASHRAE handbooks for the Student Chapters. Liam O'Brien from Carleton University has won a grant from ASHRAE for research and Ami presented Liam with a certificate for his award.
- Robin Ellis talked about networking and the importance of students in ASHRAE. Robin

networked as a student in ASHRAE many years ago at the Toronto chapter. ASHRAE networking was very important to her success. ASHRAE benefits by providing encouragement and providing opportunities for students. Students are the key to ASHRAE succession planning and to the industry development. AMI's work was commended and the OVC was thanked for the support it provides to student members.

- Liam O'Brien discussed the award that he won. He has now won the award five years in a row. Liam expressed his appreciation for the assistance that ASHRAE has provided. Liam uses Carleton University as a living lab and has built building information models for many of the buildings. Some of the rooms are "off the grid" and the students have access to adjust and test the BAS in different configurations. This year's grant funds research in energy and mass balance at the office level using existing sensor technology. The research has also been incorporated at the campus level to help understand where energy expenditures are stemming from. Last year, the grant funded development of a heliodon to assess daylighting and solar studies and to enable study into different solar shading devices. ASHRAE has been very instrumental in the success of Liam and his team
- President Georges Maamari introduced the tabletops
    - Jeremy Strong from TRANE discussed the chiller products that TRANE has to offer
    - Steve Moons from Total HVAC discussed the chiller products that Total HVAC represents along with chilled beams
- Bob Kilpatrick spoke about the upcoming nominations. It is time to think about the longevity of the chapter and the succession plan. Bob discussed that the executive team is a progression arrangement. Bob is looking for nominations for the position of Secretary for the next year. The restrictions are that the nominee must agree and be a member in good standing. There could also be positions available on the BOG. The executive and the nominations committee are currently reviewing the positions available. The nominations committee aims to make an announcement of the proposed board at the April meeting and then installation of the new board will occur in May.
- President Georges Maamari announced that the RP campaign is underway and support is much appreciated. President Georges Maamari announced that the RP campaign is raffling tickets for an upcoming Sens game next week.

Dinner (18:52 – 19:45)

- Four tickets were raffled off for the upcoming hockey game between the Ottawa Senators and the Washington Islanders. The tickets were donated by Trane and raised $750 for ASHRAE RP and were won by Michel Arial.

Evening Program (19:45 – 21:05)

- President Georges Maamari introduced the program speaker, Mr. Bill Bahnfleth to discuss Variable Primary Flow Chilled Water Systems:
    1. Evolution of CHW systems, issues (low delta T syndrome), design considerations, and results of research to estimate performance of VPF vs other potential solutions
    2. Primary flow refers to the water that flows through the chillers evaporators. Secondary flow is the water that flows from the chilled water system to the end

uses. Primary can also be secondary.

3. On the primary side pf a primary/secondary system, the chillers are normally in parallel and configured with either headered pumps or individual pumps. The idea is that the chiller should have a constant flow rate through the evaporator. On the secondary side, the flow is continuously variable. Under most conditions there will be a difference in flow between the primary and secondary systems. What separates the flows is a bypass or a decoupler to account for the differences in flow. This is a point of hydraulic decoupling. The idea is to send out the supply temperature to the system at a match to that that is provided by the chiller system. It is important to remember that there is only one specific flow rate per evaporator
4. An alternative approach is to have a variable primary flow (primary only) chilled water system. Instead of constant flow primary pumps, the primary flow is controlled by the same signal that was used to control the secondary pumps in the primary/secondary system. In this manner we have variable flow through the chillers. In this situation, the bypass is a minimum flow bypass. This is needed to maintain stable operation of the chiller.
5. Pseudo-VPF: retrofit-P/S system with bypass check valve
    a. The check valve ensures that you are always circulating from supply to return. When valve is closed, the primary and secondary pumps will be operating in series (and will then provide greater than design flow). Articles have been written specific to this case and this can be an effective solution.
6. P/S has been the standard for many years, however over the past 10-15 years there has been a change towards VPF
    a. Reduce initial system cost and space requirement by eliminating secondary pumps
    b. Reduce pump energy use associated with excess primary flow
    c. Solve delta T related problems that afflict some P/S system
    d. Permit maximum capacity of chillers to e utilized under favourable lift conditions
    e. By reducing the condensing temperature we have the potential to get the maximum capacity out of the machine
7. How much auxiliary and pump energy is there to be saved
    a. Some reports claim 30-40% savings however many more indicate lower savings
8. History of chilled water systems (Durkin, T)
    a. Installed cost reduces
    b. Operating cost also reduces (however by 5%, not the 40% that some other reports claim)
9. Low Delta T Syndrome
    a. Chilled water supply-return temperature difference to be smaller than design
        i. Occurs continuously in some systems
        ii. Correlated with low load conditions in other systems
        iii. In some cases this is seasonal
    b. Consequences
    c. VPF is a way of accommodating low delta T better

i. If delta T is too low, the primary flow can be increased to meet the load with the same machine

d. Data was shown for two buildings that are connected to the same district primary/secondary system
    i. Two buildings on the same system – in one the delta T gets better and in the other it gets worse
        1. Is delta T really the problem?

e. Causes
    i. Controls
        1. Set points
        2. Calibration
        3. Interlocks that don't
        4. Chilled water reset
    ii. control valves
        1. three-way valves
        2. oversized two-way valves
        3. valves that don't close against system head
    iii. coil issues
        1. air or water side fouling
        2. oversizing
        3. selected for delta T less than system delta T
        4. OA economizer / 100% OA
    iv. Other things
        1. Persistent reverse flow in bypass

f. How oversized coils cause low delta T
    i. From the ASHRAE handbook
    ii. Importance of proper coil selection

10. Design Issues with VPF

a. Chiller performance
    i. Effect of variable flow on energy use
    ii. Range of evaporator flow
    iii. Rate of change of evaporator flow

b. Controls and instrumentation
    i. Bypass location and control
    ii. Pump staging
    iii. Chiller staging

c. VPF has little impact on chiller performance
    i. Because there is no change on the approach temps on the refrigerant side

d. Evaporator flow rate range – determined by tube velocity limits
    i. Velocity constraints
        1. Too high – tube damage
        2. Too low – loss of heat transfer coefficient
    ii. Typical range for flooded evaporators
        1. Minimum : 1.5 to 2 ft/s, max 11-12 ft/s
        2. Max turndown 5.5 :1 to 8 :1
        3. More likely to select toward high end of range, but not at maximum velocity

e. Rate of change of flow is closely connected to the kinds of controls that are in place for freeze detection
    i. 25 years ago chillers were likely not suitable as they could generate a fault when the flow was varied too rapidly (stability
f. Rate of change of evaporator flow effect of turnover time
    i. Turnover time – time required for one system volume to circulate
    ii. Shorter turnover time makes system less stable
g. Typical flow rate change limits were reviewed
h. Low-flow bypass
    i. To prevent extended operation of chillers below minimum flow
    ii. Sometimes omitted in plants with significant base load
i. Pump staging
    i. Perhaps the most important difference between vpf and p/s is that the wire to water efficiency can be assessed independently of the chiller operation
j. Chiller staging
    i. How rapidly should the state of the system be changed?
    ii. Potential problems include sudden loss of flow to fully loaded chillers when adding a chiller, flow changes and sudden drop in flow that could cause a safety trip
    iii. Article by Steve Taylor
    iv. An alternative approach is to use series chillers (or dual compressor assemblies)
        1. Flow does not change when second compressor starts
        2. Drawback is the pressure drop through series evaporators and condensers
k. Instrumentation
    i. Accurate flow measurement for each evaporator is important
    ii. Reliable proof of flow on each evaporator

11. Best applications
    a. Better for VPF
        i. Plants with more than 3 chillers
        ii. Plants with significant base load
        iii. System tolerant of CHW T fluctuations
        iv. Operations staff able and willing to maintain controls
    b. Better for P/S
        i. Reliability a high priority
        ii. Limited on-site operations expertise
12. VPF Performance
    a. Review of some case studies with operating data
    b. Simulation based studies
    c. How much energy (cost) should be saved if there was a fair baseline for comparison
    d. Parametric simulation study was undertaken
    e. Baseline was a P/S plant that works properly at design
    f. Four types were analyzed
    g. Three load types and three climates were analyzed
    h. Energy use results

i. VPF reduced total plant energy use by approximately 5%
ii. Check valve modification of P/S had little effect
iii. More chillers -> lower savings
iv. Sources of savings
    1. Most due to pump energy reductions (20-40%)
    2. Chiller and auxiliary use ~equal
v. Load versus delta T scenario
    1. Differences in savings with delta T trend were small
    2. Somewhat larger when « favourable »
    3. Outcome could be different for systems that always fall short of design delta T
vi. Effect of load type and climate
    1. More load -> more savings
vii. Economic analysis
    1. Capital costs validated by a mechanical contractor
    2. Regressions to give continuous functions of size
    3. 4-6% capital cost savings for VPF relative to P/S
    4. Life-cycle cost – 20 year life
    5. 3-5% of life cycle cost savings
viii. Caveats
    1. More scenarios could have been evaluated
    2. Larger savings could be available if better able to model poorly performing systems
ix. Survey
    1. Were there early adopters?
    2. Who has tried this and what were the results?
    3. Summary
        a. Manufacturers attitudes toward vpf are increasingly supportive
        b. Guidance on vpf is improving but more credible documentation of performance is needed
        c. Most designers and owners with actual experience consider vpf successful in appropriate applications
        d. Problems generally relate to setup of more complex controls (and increased Cx needs)

i. Moses
j. Taylor = P/s may be a better option when fail safe required or less expertise
k. Eppelheimer
l. Schwedler and Bradley

13. Conclusions
    a. We know how to design vpf systems that work
    b. Economics are positive – first cost savings and some operating savings – still arguing about the size of the benefit
    c. Greatest savings should be realised in plants with small number of chillers, but they are the most difficult to operate
    d. High loads (climate, occupancy) increase savings
    e. Detailed data from the field is needed in part to validate analysis

14. Questions
    a. Contemplating VPF as a result of an energy study. It seems rational however nervous about the implementation and controls configuration. Need a good controls contractor.
    b. Durkin, T. evolving design of chiller plants, ASHRAE Journal, Nov 2005
    c. Impacts when also using VFD on the chiller
15. Slides will be posted

- President Georges Maamari then thanked the speaker and reminded all attendees of the survey
- Next meeting April

Meeting adjourned 21:25