2006-2: INTERNATIONAL PARTNERSHIP FOR EVALUATING HEAT RECOVERY EQUIPMENT

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International Partnership for Evaluating Heat Recovery Equipment

Abstract

An international collaboration between the Mechanical Engineering Technology (MET) Department at Purdue University and a well-known HVAC Engineering School in Lucerne, Switzerland is helping MicroMetl Corporation of Indianapolis refine the design of its innovative wheel-type heat recovery equipment. Exchanging energy between supply and exhaust air streams is required for commercial buildings in Switzerland, but the practice is just starting to gain popularity in the United States. A team of MET students traveled to Switzerland for two weeks in the summer of 2005 and studied a heat recovery installation of European design. In the fall of 2005, Swiss students visited Purdue for two weeks to conduct heat recovery experiments using MicroMetl equipment. After the students returned to their home institutions, subsequent research was conducted using a web-based building control platform that allowed students to monitor/control equipment physically located at Purdue University. This project is one example of how educators in the U.S. and abroad can pursue projects that highlight the globalization of engineering practice. In addition, the project addresses some of the challenges for funding and completing international partnerships on a sustainable basis. MicroMetl Corporation supported the project because it provided new data and analysis about how their stand-alone energy recovery systems perform while mated to a commercial air handler.

Global Outlook is Important for Students

Purdue University is a well-established destination for international students. With more than 5,000 undergraduate and graduate international students, Purdue has one of the largest populations of foreign students for a public university in the U.S. Despite the large international presence on the West Lafayette campus, Purdue University traditionally sent relatively few students abroad compared to its peer institutions. The status quo for study abroad started changing in 2001, when a new university-wide strategic plan called for expanding the international opportunities for undergraduate students enrolled at Purdue.¹

Once Purdue began promoting global partnerships, the number of international opportunities increased dramatically. International Travel Grants encouraged faculty members to make direct contact with foreign colleagues and plan study abroad trips. In addition, Purdue waived tuition for students studying abroad during the summer semester. Purdue now maintains active educational and research collaborations with partner institutions in many parts of the world, with the heaviest concentrations in Europe and Asia.

With international collaborations being strongly encouraged, a faculty member from Mechanical Engineering Technology (MET) made contact with HTA Lucerne located in Horw, Switzerland. Figure 1 shows the campus of HTA, which is one of the Schools of Applied Science in Central Switzerland and is particularly well-known for its research and teaching in Heating, Ventilating, and Air Conditioning (HVAC). A planning meeting between the Purdue College of Technology (COT) and HTA Lucerne was held in May of 2003. At that time, strong similarities between the COT and HTA were noted. Both schools have many of the same majors and a strong applications-based technical focus.
The HVAC program was the starting point for a project-based exchange between the Purdue COT and HTA Lucerne. Rather than having students attend classes at the other institution, students work together on collaborative projects that are required for graduation. The focus on laboratory work avoids problems presented by language difference. Although HTA students have some proficiency in English, German is the standard classroom language. Laboratory work at HTA is routinely conducted in Swiss German, German and partly in English, which has become the standard medium for international technical communications.

Table 1 shows the overall schedule for collaborative HVAC projects between Purdue COT and HTA Lucerne during the calendar year. Potential projects are identified in January, when HTA students begin planning for their final diploma project. Once a particular project is selected the initial planning takes place from January through April, using email communications and an occasional teleconference.

Project work commences after the Spring semester is completed in U.S., when two-person teams of Purdue students visit Switzerland for approximately two weeks. This trip takes place in May and focuses on the design and planning necessary to complete the research project. In addition to the technical deliverables, U.S. students are required to observe and report on cultural aspects of their trip.

There is a break in the project from June to September, although this time off has been used for laboratory fabrication work. Swiss students visit the U.S. for two weeks in October to finalize the research project. The results of the project are finalized in December, when HTA students receive their diploma.
Table 1. Project-based exchanges take place during one calendar year.

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<th>Project Task</th>
<th>2005 Calendar Year</th>
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<td>J</td>
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<tr>
<td>1. Selection &amp; Planning</td>
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<td>2. Work in Switzerland</td>
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<td>3. Fabrication / Holiday</td>
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<td>4. Work in U.S.</td>
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<td>5. Project Completion</td>
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Advantages of Web-Enabled Laboratories

The controls for most HVAC systems in modern commercial buildings are web-enabled. This feature allows a small number of Facility Engineers to remotely monitor and control a large amount of real estate. The MET Department at Purdue has already exploited this commercially available feature while developing and evaluating remotely accessible energy laboratories. With funding from the U.S. National Science Foundation, the Purdue HVAC team demonstrated that remote laboratory experiments had a positive impact on student learning, particularly for distant learners who would not otherwise have had access to the equipment.¹

Web-based laboratories have already been proven to be effective for promoting international collaboration. With funding from both the Swiss and U.S. National Science Foundations, faculty from the École Polytechnique Fédérale de Lausanne in Switzerland and the University of Florida have used remotely accessible laboratory equipment to supplement traditional classroom lectures on automatic controls.² Using laboratory equipment physically located in Switzerland, faculty at both institutions conducted motion control experiments over the Internet.

Web access has also been important for pursuing the international collaboration between the Purdue MET Department and HTA Lucerne. The first collaborative HVAC project was completed in 2004, when students developed a web interface to modern HVAC laboratory equipment located at HTA Lucerne.³ This portal allowed large numbers of Purdue students to conduct experiments using heat recovery equipment that was not available in the U.S. Heat recovery systems conserve energy by exchanging energy between a building’s supply and exhaust air streams. This technology has been required for commercial buildings in Switzerland for many years, but the practice is just starting to gain popularity in the United States.

This web-enabled experiment allowed students to monitor and control the energy recovery equipment located at HTA Lucerne. Students collected data on heat recovery effectiveness at several different air flow rates. When combined with seasonal weather data for a given geographic location, students were able to compute the economic payback for installing heat recovery technology in a commercial building located in the U.S. The successful project in 2004 was the basis for the follow-on project in 2005.
Evaluating Heat Recovery Equipment

Working in conjunction with Carrier Corporation, undergraduate students in a standard Air Conditioning & Refrigeration (MET 421) class designed a new air handler for the Applied Energy Laboratory in the College of Technology at Purdue. Figure 2 shows the 39M Aero that was specified. Outdoor air enters the equipment at the lower left and is mixed with recirculated air, then passes through a filter, cooling coil, heating element and upblast fan before entering the environmental chamber at the back. A steam humidifier downstream of the fan is available as needed. Air returning from the environmental chamber is either recirculated or exhausted from the building.

![Image of the 39M Aero air handler](image)

Figure 2. Purdue students specified a Carrier air handler for the Applied Energy Laboratory.

Based on the expertise gained in 2004 with HTA Lucerne, the MET Department at Purdue began working with Micrometl Corporation of Indianapolis. Micrometl manufactures a successful line of heat recovery equipment, but was looking for additional research and development expertise while developing next generation equipment. The installation of the new Carrier air handling equipment provided a perfect opportunity for building a laboratory platform to evaluate Micrometl energy recovery equipment.

Starting in January of 2005, a team of students from Purdue and HTA started work to make the web-based test facility a reality. Early discussions were conducted over email and focused on how to integrate the heat recovery system with the air handler. The amount and type of instrumentation was also discussed.

During May of 2005, two Purdue students visited HTA Lucerne in person. In addition to face-to-face meetings to discuss details of the air handler / heat recovery design, students tested heat recovery equipment of European design to get a better feel for the technology. Figure 3 shows Purdue and HTA students working together in the laboratory at HTA Lucerne.
The students broke up the project into segments while working in Switzerland. The work assignments were based largely on the student’s proximity to the laboratory equipment. The Purdue students were responsible for managing the HVAC equipment installation, installing the sensors, creating the web-based HVAC control platform, and commissioning the new equipment. This work was started after returning to Purdue in June. The goal was to have the air handler / heat recovery test platform fully operational when the Swiss students visited Purdue in October.

When the Swiss student arrived in October, they were responsible for evaluating the performance of this new equipment. In particular, Micrometl Corporation was interested in data and analysis showing about how their stand-alone heat recovery systems perform while mated to a commercial air handler. Since these computations targeted system-level thermal performance (as opposed to proprietary design issues), this particular project avoided some of the intellectual property issues that can be problematic for university/industry collaborations.

The key parameter of interest is the Combined Efficiency, or CEF, which compares the beneficial air heating or cooling to the overall energy being consumed. This particular computation is difficult to achieve for several reasons. Complex building energy simulations, using software products like DOE-2 from the U.S. Department of Energy, typically fail to accurately account for the off-peak efficiency of air handling components when mated to a heat recovery system. The performance computation is also difficult to achieve from direct measurements for a real building. Few commercial buildings have enough instrumentation to account for all the energy being consumed.
Despite the best effort of the Purdue team, unavoidable delays in the delivery of the air handler and heat recovery system put the project behind schedule. By the time the Swiss students arrived, the basic installation was complete but the equipment was not fully commissioned. The Purdue team was still testing the hardware and software interface. Figure 4 shows the Swiss students helping commission the newly installed heat recovery equipment. Despite the delays, some preliminary experimental data was conducted during the October visit. The Swiss students conducted more heat recovery experiments after returning home.

Figure 4. HTA students evaluated new heat recovery equipment at Purdue.

The ability to conduct the energy efficiency tests remotely, using the web-based control interface, was the key to a successful project. Figures 5, 6, & 7 show some of the web interfaces used by the Swiss students. Figure 5 shows that outdoor air enters the heat recovery system on the lower left, is pre-conditioned as it passes through the rotary heat recovery wheel, and is sent to the air handler. Return air from the building enters the heat recovery wheel on the upper right, passes over the rotary heat recovery wheel, and is exhausted. Figure 5 also shows real-time temperature, pressure, flow, and humidity readings as air traverses the system. Figure 6 shows how the power consumption of the chiller, supply fan, heater, humidifier, and energy recovery system were monitored. Power data was presented as instantaneous power (W), peak power (W), energy usage by day (W-hr), and energy usage by month (W-hr). Figure 7 is an excerpt from the blog that allowed fast communications while testing from HTA Lucerne.6
Figure 5. Swiss students evaluated heat recovery using the web interface.

Figure 6. Swiss students monitored component-level energy use from the web interface.

Friday, November 18, 2005

New Air Flow Sensors

Hi,

I just installed two new Ebtron air flow sensors, which are averaged together as Kn07RF. They seem to be functioning properly.

Thanks,

David

Figure 7. A blog was used for instantaneous communication during remote testing.
The remote tests were conducted early in the morning when the laboratory was empty, coinciding with late afternoon in Switzerland. Swiss students controlled the duration and test conditions using the web-enabled control platform. When the project ended in December 2005, a successful report summarizing preliminary data on the overall performance of the combined air handler / heat recovery system was delivered to MicroMetl Corporation. It will serve as the basis for more detailed investigations, conducted by other students under varying weather conditions.

Figure 8 is one example of the heat recovery performance data included in the Swiss test report. This particular experiment was conducted when the outdoor temperature was 54 °F. The temperature inside the environmental chamber (similar to a single zone of a building) was set to 75 °F and the air flow was configured for 100% outside air (no recirculation). The horizontal scale of the graph is the duration of the test in minutes. The vertical scale of the graph is the total energy in Watt-hr for operating the supply fan, electric heating coil, and ERV wheel.

The upper line of the graph is the energy consumption with the energy recovery wheel off. Air was still passing through the wheel, but the rotary motion was turned off so its beneficial heat transfer was negligible. The lower line is the energy consumption while the heat recovery wheel was being used. The graph shows nearly 50% in energy savings (3400 W-hr versus 6500 W-hr) when the heat recovery wheel was in operation.

Figure 8. Experiments conducted by Swiss students tested demonstrated significant energy savings from using the heat recovery wheel.
Future Work

Planning is already underway for new collaborations with HTA Lucerne in 2006. Since energy efficiency is a key concern in the U.S., future HVAC projects will probably continue to focus on improving the performance of HVAC equipment. Funding for these international projects will continue to be a challenge, so corporate sponsors will be important. Recent developments from other Departments within the College of Technology at Purdue are an encouraging sign that the collaboration with HTA Lucerne will continue to prosper. The Electrical & Computer Engineering Technology Department hosted two students from HTA for the Fall 2005 semester and is sending students to Switzerland in the summer of 2006.\textsuperscript{7}

Recognizing that Purdue MET graduates will work in an increasing global business environment, the MET Department is looking for opportunities to formalize the role of study abroad in its curriculum. A white paper recently issued by the MET Department Head is challenging the faculty to develop an innovative curriculum that encourages learning experiences outside the classroom.\textsuperscript{8} New study abroad opportunities for undergraduate students is one of the expected outcomes of this curriculum reform effort.

Conclusions

This project demonstrated a creative way for educators and students to learn more about the globalization of engineering practice. A variety of international codes and standards were referenced while conducting the heat recovery research. A collaborative effort from teams of U.S. and Swiss students was needed to achieve a satisfactory result. In addition to the small number of students directly involved, larger numbers of students gained a better appreciation for globalization by interacting with the international students on and informal basis.

Acknowledgment

Partial support for this work was provided by the National Science Foundation's Office of International Science & Engineering under grant OISE-0427516.

Bibliography