December 8, 2008
San Jose State University

Mirela Radov
Malali Mohammad
Jessica Vasquez
Alan Li
Brandon Lin

Airport

Environmental

Interaction

THE ENTHALPY WHEEL

The most efficient energy recovery system

Contents

1. Executive Summary

Our team chose to tackle the category of Airport Environmental Interaction; more specifically, our report will discuss in detail a relatively untapped technology which has been recently unleashed and has provided very promising results: the enthalpy wheel. It is the most efficient energy recovery rotating mechanism that has ability to control heating, cooling and moisture. In the world today engineers and architects are facing the challenges of designing and building structures and facilities which will leave a minimal carbon footprint while meeting stringent demands for air quality as well as cost effectiveness. Today's airport HVAC building infrastructures, whether new or old, can be designed or upgraded to serve the needs of the many people who pass through them, all the while providing comfort, security, and cost efficiency for both the users (like passengers) and the operators.

Our team of San Jose State University students has recognized that increasing energy efficiency and management can be and should be extended to these airport buildings. Utilization of a new generation of fresh air units/systems (i.e. the enthalpy wheel) has remarkably addressed the needs of airport operators and has provided a sound and innovative technology which can be utilized for years to come. Our report will address this piece of technology and its many facets of innovation, analyze the cost, and close with the numerous benefits this technology's implementation will bring forth.

2. Problem Statement and Background

The rules have changed in world of engineering a cleaner, greener building. In regards to the area of HVAC systems, the demands of meeting rigid measures of indoor air quality have increased. According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE),

> ASHRAE 62-1989 IAQ STANDARD VENTILATION FOR ACCEPTABLE INDOOR AIR QUALITY: The shift of focus to address total indoor environmental quality needs of offices and workplaces to include higher ventilation and fresh air needs along with other issues like ergonomics, light, noise, decoration, and ambience has forced world bodies such as ASHRAE to relook at the prevailing standards (p. 1).

The requirements of having fresher ventilation and avoiding microbial contaminations, while also considering the cost factor, have provided quite a challenge for engineers. But these issues have also opened the door to new technologies, including the enthalpy wheel.

The challenges being faced today as far as airport buildings are concerned can be put into perspective by examining current energy usage and the associated costs for terminal and airport buildings. Take for example Mineta San Jose International Airport and its implementation of upgraded HVAC equipment. It was found that through rebates offered by Pacific Gas and Electric Company, Mineta San Jose would upgrade the old HVAC system through a major retrofit. The following quote was found on the Mineta San Jose International Airport's website:

> Mineta San José International Airport (SJC) announced on Wednesday, February 9, 2005 that it received a rebate of $29,363 from Pacific Gas and Electric (PG&E). They received the rebate for installing energy saving equipment in its heating, ventilation and air conditioning (HVAC) system at both Terminal A and the International Arrivals Facility (p. 1).

Not only did Mineta San Jose Airport benefit by receiving a rebate from the utility company, but it also benefitted as far as its annual cost savings. The Airport's HVAC system upgrade has reduced total annual costs from $135,351 to $85,818 for a net annual savings of $49,533. San Jose Mayor Ron Gonzales commended the project stating "Our operations have become more efficient, which saves money while dramatically reducing our City's energy demand. That's good for everyone” (sjc.org). The statement provides justification to the world of opportunity and innovation that is available once implemented.

3. Summary Of Literature

The resources our team used consisted of an array of individuals, websites, and other resource we found useful in understanding the technology, its application, and its efficiency. Mirela Radov and Malali Mohammad were able to contact personnel in key industry position to gather their input on the technology and its impact. More specifically, Ms. Radov was able to get in touch with Bob Swenson of Mineta San Jose International, while Ms. Mohammad was able to interview Project Engineer Christian Omphroy from AirSystems Inc. Both individuals gave quite a bit of feedback regarding this technology and its application in the real world. Jessica Vasquez, Brandon Lin, and Alan Li utilized websites as well contacted other company officials to obtain more information on the product. A vast amount of information was collected regarding the enthalpy wheel, and was incorporated into the report as deemed necessary.

4. Team Problem Solving Approach

4.1. Problem Solving Approach Overview

The Team Problem Solving approach for our group entailed a variety of discussion topics to try to address the aforementioned topic of the enthalpy wheel. Weekly meetings and discussions were held to streamline the research and to encapsulate the research behind the technology and create a clear-cut, concise proposal to address this challenge. Our group members brought forth a plethora of information from their respective backgrounds to formulate the proposal as well as shed light on challenges which would potentially be faced. It was agreed that each member would tackle different aspects of the challenge which would allow him or her to bring forth personal expertise, and specialization.

4.2. Division of Labor and Specialization of Research

Ms. Radov had considerable experience in the management and day-to-day operations of the airport. Her current internship at the Mineta San Jose International provides a firsthand glimpse of the current technology and the infrastructure of its current HVAC equipment, as well as access to cost analysis reports and key personnel who have offered their perspectives. She addressed the challenge from the cost analysis angle. Mr. Lin is currently employed in the engineering field addressing innovation in mechanical technology. He also specialized in the cost effectiveness as well as the general layout of the proposal. Ms. Mohammad has also been employed at Mineta San Jose and is currently employed by an HVAC company. Her research lies in the introductory aspect of the challenge as well as the implication of its usage. Mr. Li is an aspiring pilot who has brought forth substantial information relating to the current application of the enthalpy wheel and its overall effectiveness. Lastly, Ms. Vasquez has addressed the technical aspects of the design challenge. More specifically, she delved into the challenges facing this type of technology as well as presenting an in-depth overview of its effectiveness through charts and graphs.

4.3. Interdisciplinary and Systems Engineering Approaches

The systems engineering approach for our project dealt with the major aspects of its successful implementation and design. In a systems engineering approach, segments of the industry that traditionally work independently are united. Our teams assessed the segments as a whole structure recognizing that the design of each segment of the challenge proposal was equally significant. The team focused on the aspects of cost, design and technology, operations, performance, and implementation. Using these major segments we were able to efficiently and successfully address the design challenge as a whole.

5. Safety Risk Assessment

Although, implementing an enthalpy wheel system does not impose immediate safety issues two important factors need to be considered.

The first potential area of concern is a cross leakage in a wheel-based energy recovery system. Cross leakage means that the small amount of exhaust air is returning to the space from which it came from. This exhaust air is often considered to be contaminated even though it never left the system. To ensure continuous supply of outdoor air into the enthalpy wheel system, purge sectors would need to be installed. Purge sectors redirect a portion of the supply air into the exhaust airstream and separate exhaust from the supply air. It should be noted that purge sectors are capable of reducing the cross leakage to less than one percent (Mumma, 2003, p. 1).

The second major concern is that utilizing an enthalpy wheel system as an environmentally clean, alternate method of energy recovery will dramatically reduce the carbon footprint of airports and contribute to the prevention of catastrophic damage to the global environment.

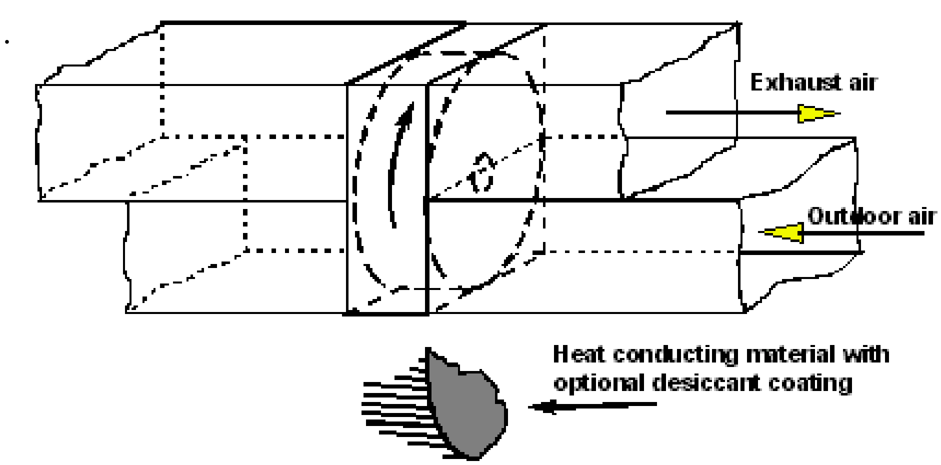
The enthalpy wheel system should not fall under the definition of a Safety Management System (SMS) for airport operators as described in FAA Advisory Circular NO: AC 150/5200-37. It should be a part of Airport Design and FAA Advisory Circular AC150-5320-10. Additional proactive Safety Management System's (SMS) measures could be provided through 14 CFR: Part 157.

6. Description of How the Technical Aspects of the Design Challenge Will Be Presented

6.1. Technical Aspects

The enthalpy wheel is a type of air-to-air rotating recovery device. Their primary use is in HVAC systems that operate on the principle of heat and moisture transfer between outside air and building's exhaust air. These devices have the ability to lower peak energy demand and total energy consumption. Their design meets current green building requirements and ASHRAE standards.

An enthalpy wheel operates between two air supplies and serves as an intermediary device. Using a rotating mechanism, it can absorb or transfer sensible and latent heat. Sensible heat is the type of heat that is easily felt and measured on a thermometer. Latent heat or moisture is transferred using desiccant coating which is applied on the wheel's surface. This ability to control humidity is equally important in heating and cooling seasons. With latent heat recovery the capacity and the unit size of the system can be significantly reduced because it allows preconditioning of the outside air.



http://cipco.apogee.net/ces/library/tdew.asp

6.2. Technology Description

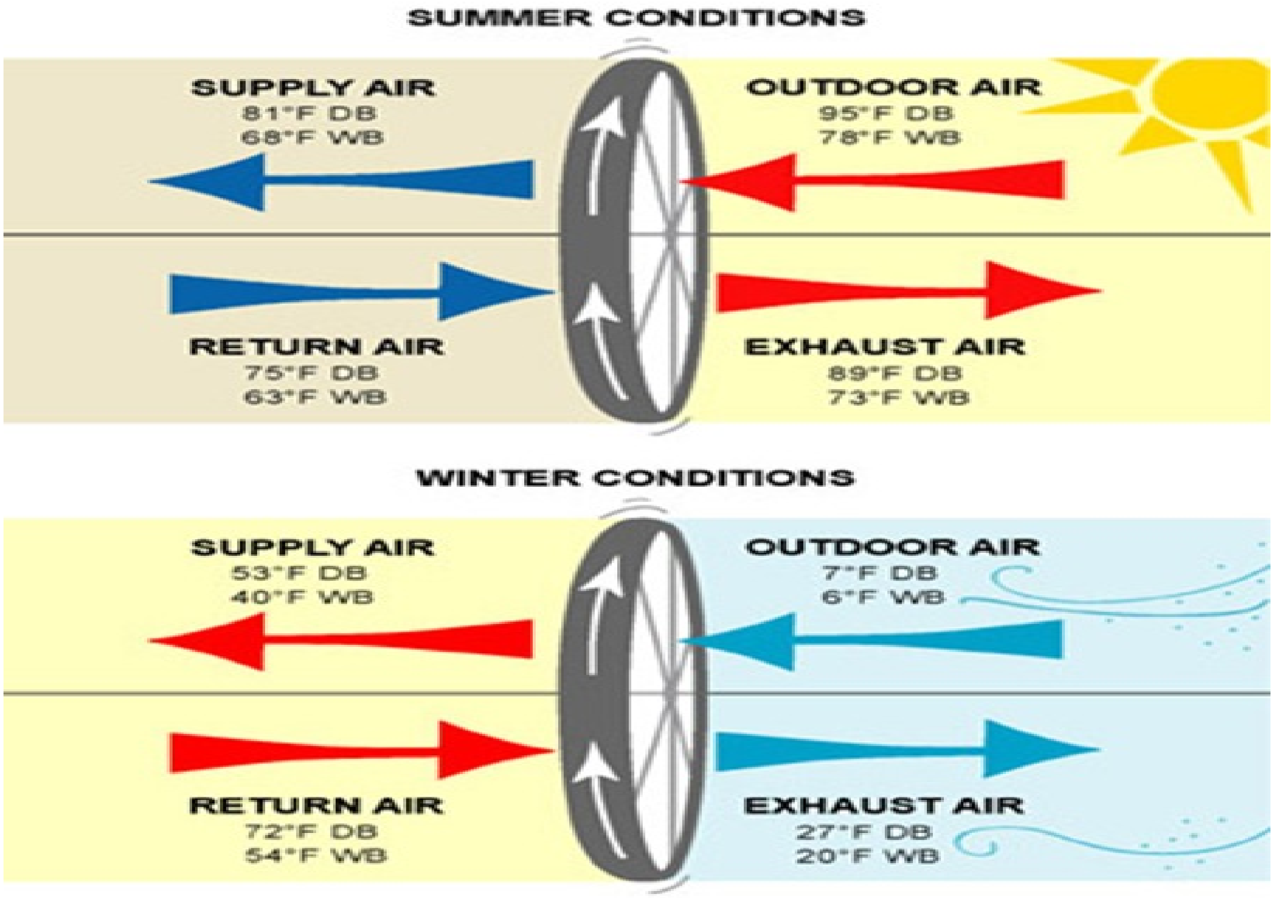
The enthalpy wheel can be described as "...a large, turning disc made out of an aluminum honeycomb material that is coated in desiccant" (QU, 2006). It contains numerous small air passages called flutes. They can have triangular or semicircular cross-section. The honeycomb structure is created with flat and high layers of a heat conductive material. The components of an enthalpy wheel are: exhaust and supply air sections, filters for sections, air blower, heat transfer section, motor section and cooling section (DRI, 2007).

The enthalpy wheel results depend highly on the type of a desiccant that is chosen. One of the most commonly used desiccants is silica gel. It has excellent water absorbance characteristics and can perform well in acidic environments. Stainless steel, aluminum, ceramic, and synthetic materials can be used, too.

Aluminum, for example, expands when it is heated, and carries that energy around with it as the wheel rotates. When it hits a cooler airstream, the aluminum contracts and the heat energy is released into the air. The enthalpy wheel's ability to exchange of humidity depends upon vapor pressure from the wheel. This vapor pressure changes because of the difference in temperature and moisture contents of the incoming and returning air. The desiccant material absorbs moisture with the flow of warm air, after the wheel enters the cold air stream the water starts to evaporate. As a result of this procedure the cooler air becomes more humid and the warmer air looses humidity.

6.3. How an Enthalpy Wheel Works

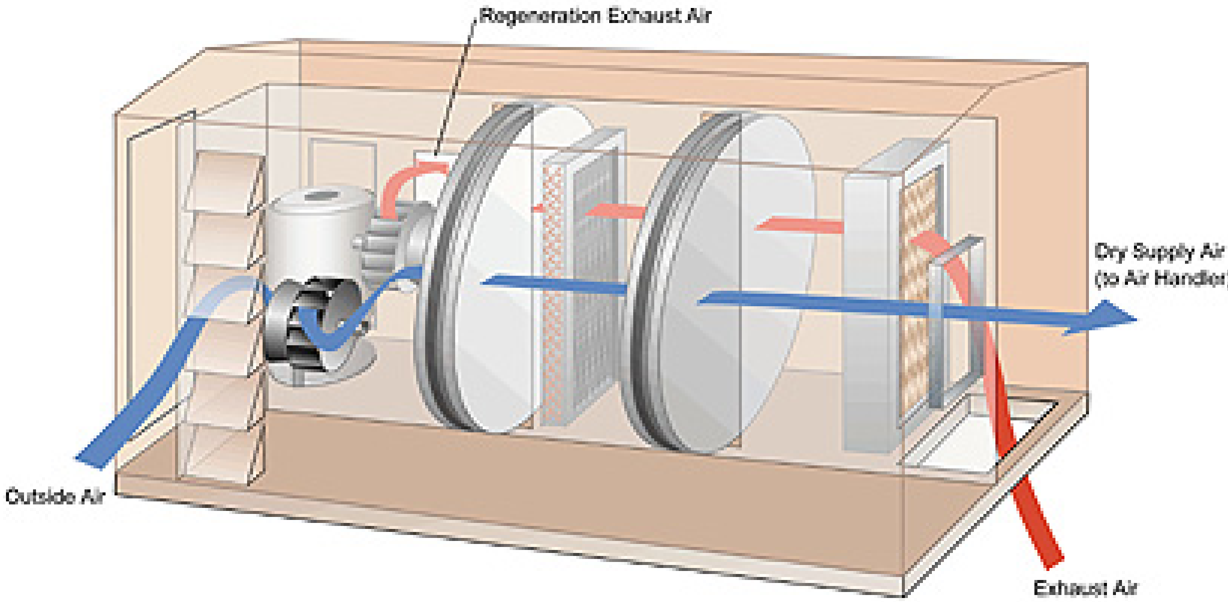
Here is what you would see in terms of performance and how the enthalpy wheel would handle summer and winter conditions:



http://greenlineblog.com/what-is-an-enthalpy-wheel/

Basically in the summer when the outdoor air is hot the enthalpy wheel will cool the supply air so that the inside of a building will be cool. The retuning cooler air will flow through the wheel and hotter exhaust air will be pushed out by the enthalpy wheel. This process is vice versa for winter time conditions. The cooler outdoor air will be heated by the heat transferred from the enthalpy wheel. The warmer air flow will be pushed into the indoor air supply for the building and once that air rises to a certain temperature, it will be pushed out as return air. The return air will then go back through the enthalpy wheel and the heat will be recaptured in the enthalpy wheel, sending cooler air back out through the exhaust air supply section.

Here is a picture of enthalpy wheels inside of a complete unit:



http://cipco.apogee.net/ces/library/tdew.asp

6.4. Advantages

There are numerous advantages when utilizing enthalpy wheels. They are quite compact and can achieve high heat-transfer effectiveness. Typically they cause a relatively low air pressure drop, between 0.4 and 0.7 in. of water (CIPCO, 2005). The cost of frost protection is minimal and is not an issue for the enthalpy wheel. In some cases the size of the cooling or heating equipment can be modified to accommodate specific needs. This type of compact equipment will allow for more free space, which is not the case for traditional HVAC equipment. Additionally, these devices have ability to lower peak energy demand and total energy consumption.

There are other very important advantages for utilizing the enthalpy wheel. For example, existing standards for outside ventilation can be met or exceeded causing minimal impact on energy costs. During cooling seasons, the incoming outside air in the enthalpy wheel is dehumidified by the desiccant that absorbs water on the wheel. As a result, it will allow the rest of the ventilation system to run dry. This ability to control humidity in the enthalpy wheel system would cause indoor humidity to stay below the level that favors microbial contamination and growth of mildew and mold. Another advantage is that it eliminates the need for cooling capacity that normally would be required to control humidity and cooling of the outside air.

6.5. Disadvantages

The main disadvantage of the enthalpy wheel is the initial capital expenditure for the product. However, the return on investment is well worth the initial cost.

It should also be noted that for optimal performance optimal performance of the overall system, the enthalpy wheel requires two air streams be adjacent to each other. The enthalpy wheel also requires that the air streams must be relatively clean so it does not clog the wheel’s small air passages and may require filtration. This is something that could easily be accommodated by the use of common filters, and the cost increase should be minimal.

Lastly, as with any HVAC equipment, maintenance is a key factor in making sure the product maintains its longevity and optimal performance. This could possibly require that the rotating mechanism be periodically inspected and maintained throughout the life of the product. Beside cleaning or changing out filters we would also have to clean the fill medium of the enthalpy wheel.

6.6. Current Applications

The heat-recovering or enthalpy wheel is a relatively new technology, and is currently being applied in some newly designed green buildings. The designers of many schools, laboratories, office buildings and some homes chose this technology because of its cost-effective operating performance. In fact, the application of heat-recovering wheels is expanding rapidly, and soon it should find its use at the airports, too.

The Carnegie Mellon University's Intelligent Workplace has implemented an enthalpy wheel energy recovery system with great success. To verify the manufacturer's data the university tested their system's operating performance. According to their findings and data, the enthalpy wheel system operated with an effectiveness of 82%; it failed to recover only 12% of system's energy (Zhai et all, 2006, p. 1). Another example of successful enthalpy wheel installation is at Johns Hopkins Ross Research Building in Baltimore, MD. The savings in energy were measured in millions of dollars and the return on investment was accomplished with the first cost savings. As a result of high performance and great cost savings, Johns Hopkins installed enthalpy wheels in new labs and the Cancer Research Building (VanGeet O., Reilly S., 2006, p. 7).

The enthalpy wheel system can best fit users that require a large percentage of outdoor air mix to refresh the indoor air and that have the exhaust air duct in close proximity to the intake. Many airports in the U.S. fall into this description and can benefit greatly from the increased air-conditioning system efficiency. New terminal buildings are often constructed with many doors where the required amount of ventilation air causes excess loads to the air-conditioning system. This situation greatly reduces the air-conditioning system's performance, and the equipment does not have sufficient latent capacity as designed. In this case, enthalpy or heat recovery wheels can also improve the latent capacity of the existing system (CIPCO, 2005).

6.7 Maintenance

To maintain high standards of indoor air quality, the enthalpy wheel system requires regular maintenance of key components. The long-term performance of the system is highly dependent on early detection and prevention of the system's degradation. Proper design and implementation is needed to provide early and continuous signs of degradation to the enthalpy wheel users. The enthalpy wheel performance can be compromised in three major areas: supply air quantity, the supply air condition and the building pressurization. Supply air motor, belts or bearings can be responsible for the system’s failure to supply the needed air quantity. Accumulated dirt on filters can seriously impact the system's ability to provide ventilation requirements. A decrease in the thermal performance of an enthalpy wheel system can be the result of air leakage due to the system’s loss of pressure. Such pressure loss can bring latent loads beyond systems capacity. Sensible and latent cooling and heating can be affected by failure of the enthalpy wheel’s drive belt or motor. Additionally, the cooling coil can lose cooling capacity or fail because of insufficient air flows (Mumma S, 2003, p. 1).

In order to prevent corrosion and other kinds of damage to the system, cleaning is required for the enthalpy wheel. The rotor surface can be cleaned by vacuuming with a soft brush attachment. Mild detergent compatible with aluminum can be used to remove grease or dirt from the rotor, and water needs to be sprayed afterward. In addition, compressed air can also be used for cleaning the rotor. It is important to recoat the brush seals with silicone oil after cleaning the rotor. (Xetex, 2001)

7. Description of the Interactions with Airport Operators and Industry Experts

The team made contacts with Mr. Robert Swenson who serves as Mineta San José International Airport’s Airside Operations Manager. Our team member, Ms. Radov, met with Mr. Swenson in person on November 15, 2008. She was able to get his personal opinion and perspective on our project. Mr. Swenson found the enthalpy wheel technology and our proposal to implement it at the airport very interesting. He acknowledged the possible benefits of such system and stated that he would be happy to present our final proposal to some airport engineers and other decision makers. The meeting was a success and as a main result we received encouragement for further studies and development of our idea.

The team also utilized a vital resource in terms of contacting Air Systems, Inc. (ASI). ASI was founded in 1973 and offers services including mechanical, architectural sheet metal, service, repair, electrical, and process piping (Air Systems Inc., 2008). ASI has a dedication for energy solutions — more specifically, improving the efficiency of existing systems — while reducing operating costs and helping the environment. Ms. Mohammad met on November 18, 2008 with Christian Omphroy, a project engineer, to discuss the strategies of utilizing an enthalpy wheel. Mr. Omphrov was a great resource in pointing out the advantages of using such technology. He also went into the details of using heat wheels in current projects the company is working on, such as the UC Berkeley Doe Library. The meeting served to be very beneficial because the technology of the enthalpy wheel is a promising venture that will ultimately be very beneficial in decreasing overall carbon footprint.

8. Description of the Projected Impact of Team's Design and Findings

8.1. Benefits for an Airport Operator

Consuming energy costs money, uses and reduces energy resources, contributes to air pollution and causes global warming. Today in commercial buildings, Heating, Ventilating and Air-Conditioning (HVAC) systems are responsible for 39% of total energy used (Graham, 2008, p.1). Implementing an enthalpy wheel system in new buildings or retrofitting it into existing ones can result in significant energy savings. Airport operators cannot ignore these facts and should consider the energy conservation and potential cost savings of an enthalpy wheel system.

8.1.1. Energy Conservation

Reduced energy consumption of an enthalpy wheel system is a result of its very high performance and efficiency. Overall energy consumption and peak energy demand can be greatly reduced with an enthalpy wheel system. This is due to the fact that they can recover sensible heat, latent heat and moisture from the air streams. The efficiency of an enthalpy wheel depends on its size relative to the volume and the difference in heat between the air streams. If the typical range for the total effectiveness is from 70% to 80% that means that the enthalpy wheel recovers approximately three quarters of the total energy and moisture (Kjelgaard, 2004, p.1).

To calculate the efficiency — which is defined as the amount of temperature or moisture transferred — we need to find effectiveness of the system. ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers, defines effectiveness of energy recovery devices as following:

$$\epsilon = \frac{Wsa(Xsa - Xoa)}{Wmin(Xra - Xoa)} = \frac{Wea(Xra - Xea)}{Wmin(Xra - Xoa)}$$

Where;

ϵ is effectiveness

Xsa is supplied air, Xoa is outside air, Xea is exhaust air, Xra is return air condition

Wsa is supply air mass flow rate; Wea is return air mass flow rate

Wmin is smaller of Wsa and Wea (Crowther, 2001, p.2).

8.1.2. Potential Energy Cost Savings

The calculation of heat recovery savings is possible to obtain through several online programs that are available. Calculations in these programs are performed using hourly weather data that are available for most cities. Also, the historical hourly data can be used for measuring heat recovery savings and for finding the performance of an existing enthalpy wheel system. According to Kjelgaard (2004), the following data are necessary for the potential energy costs savings calculations:

- Location and elevation
- Exhaust and supply airflow (cfm)
- Space or process exhaust air temperature and relative humidity (if humidified)
- Hours of operation and operating schedule
- Utility rates
- Supply and exhaust pressure drop through the heat exchanger
- Thermal effectiveness of the proposed enthalpy wheel system (p. 1).

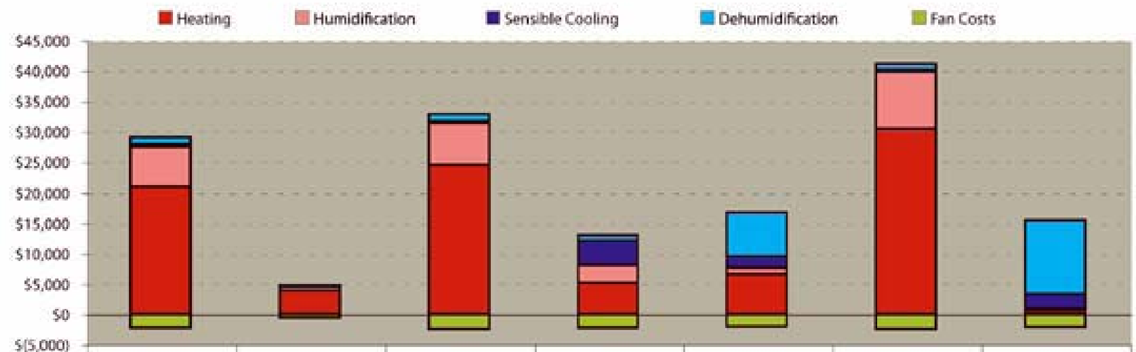
The two tables below represent results of a simulation for a 25,000 cfm enthalpy wheel heat recovery system located in different climates.

Table 1. Annual energy savings by region - 25,000 CFM enthalpy wheel

	Heating and humidification				Cooling and dehumidification				Fan
	Sensible therms	Latent therms	Total therms	Humid. gallons	Sensible ton-hrs	Latent ton-hrs	Total ton-hrs	Dehumid. gallons	Energy KWH
N.Y. City	23,851	7,523	31,374	78,343	6,039	16,767	22,806	191,632	29,219
L.A.	4,265	786	5,051	8,187	1,132	2,036	3,168	23,266	8,169
Chicago	27,959	7,803	35,762	81,264	6,398	14,922	21,320	170,541	30,954
Phoenix	5,814	3,326	9,140	34,639	56,428	12,317	68,745	140,763	29,153
Houston	7,412	1,303	8,715	13,568	24,380	101,077	125,457	1,155,168	25,055
Minneapolis	34,868	10,560	45,428	109,970	4,508	13,741	18,249	157,037	31,986
Miami	633	44	677	460	32,736	169,175	201,911	1,933,432	27,865

http://www.plantservices.com/Media/PublicationsArticle/SpentThermsGraphics.pdf

Annual cost savings by region — 25,000 CFM enthalpy wheel



	N.Y. City	L.A.	Chicago	Phoenix	Houston	Minneapolis	Miami
Fan Costs	$(2,338)	$(653)	$(2,476)	$(2,332)	$(2,044)	$(2,559)	$(2,229)
Dehumidification	$1,207	$147	$1,074	$887	$7,278	$989	$12,180
Sensible Cooling	$435	$82	$461	$4,063	$1,755	$325	$2,357
Humidification	$6,583	$688	$6,827	$2,910	$1,140	$9,239	$339
Heating	$20,869	$3,732	$24,464	$5,086	$6,485	$30,510	$554

http://www.plantservices.com/Media/PublicationsArticle/SpentThermsGraphics.pdf

According to the results from both tables we can conclude that energy savings are higher in colder climates. It appears that savings in Minneapolis were the highest mostly due to the sensible heat recovery. The results for Los Angeles are slightly inaccurate due to the fact that there was an operating limit to the system. The system was set to stop the enthalpy wheel when the outside air temperature was between 55 ºF and 75ºF. If we remove this limitation or adjust it to the higher values, the total savings for Los Angeles would be much higher (Kjelgaard, 2004, p.1)

8.2. Cost Analysis

In this section we will discuss the costs associated with our proposed enthalpy wheel system. Cost is of great importance to airport operators because today they constantly face the challenge to lower energy consumption and maximize energy savings with economically justified means. Accordingly, our proposed system should be presented in a way that emphasizes its attractive return on investment, especially during the initial introduction period. The costs for this system are divided up into two different sections: the capital cost for implementing an enthalpy wheel system and the ongoing operating costs. We will finish by discussing some cost diversion strategies that could be used to spark interest in the system and/or make it possible for the airports to afford such systems.

8.2.1. Capital Cost

In his article Crowther (2001) states that the direct expenses of implementing the enthalpy wheel systems that need to be considered in cost analysis are the following:

- The capital cost of the enthalpy wheel system
- The cost associated with upgrading the fan motors to be able to handle drops in static pressure.
- The cost associated with upgrading the return air ductwork so the system can handle required and higher volume when using enthalpy wheels.
- The cost savings that result from downsizing the humidifiers which are not needed due to ability of enthalpy wheel to control humidity.
- The cost savings associated with downsizing the cooling system due to better cooling technique that enthalpy wheels can demonstrate (p. 2).

The increased cost of the return air ductwork can be offset with downsizing the cooling system and downsizing the dehumidification equipment. This means that the cost to implement the enthalpy wheel includes the capital cost of the system and the expense for the standards associated with it.

8.2.2. Operating Cost

Estimating operating costs requires calculating effectiveness of an enthalpy wheel system. With calculated effectiveness, bin weather data, and information about indoor design conditions; it is possible to simulate how an enthalpy wheel will operate. Bin analysis is used to simplify calculations and it refers to the number of hours that the outdoor temperature is within a certain temperature range, which can be further divided to certain time periods during the day. The effectiveness of the energy recovery can be calculated using above mentioned ASHRAE Standard 84. The calculations are performed for every bin and then extended for the year by multiplying them with the number of occurrences in that bin (Crowther, 2001, p. 2).

The following table demonstrates a sample of calculations presented in Crowther's (2001) article and these are the design parameters that were used:

- Occupancy 8:00 – 17:00 hrs.
- Ventilation requirement 14 000 cfm
- Exhaust requirement 11 750 cfm
- Summer space conditions 75°F, 50% RH (humidification required)
- Winter space conditions 72°F, 30% RH (p. 3).

Ventilation Load	No Device	Enthalpy Device
Heating (Mbtu/year)	1 230 000	507 440
Cooling (Mbtu/year)	268 400	110 600
Humidification (pounds/year)	225 000	92 800

http://www.mcquay.com/eprise/main/mcquaybiz/MT_Corporate/EngNews/0701.pdf

Looking at the calculation results in the table, we can see that there is a significant reduction in a ventilation load with the enthalpy wheel device. The data shows that there is about 40% savings in heating, cooling and humidification with an enthalpy wheel system.

Taking into consideration the rising cost of energy and uncertainty about its availability, we can conclude that using an enthalpy wheel system is a wise economic decision. The immediate expenses and possible additional operating costs for implementing an enthalpy wheel system can be justified by year-over-year operating cost savings. Additionally, further cost savings may be available through rebates from the local gas or electric supplier.

9 Appendices

Appendix A

<u>Contact Information</u>

Brandon Lin
21925 Almaden Ave
Cupertino, CA 95014
(408)799 - 3872
lin71f@gmail.com

Malali Mohammad
295 Sposito Circle
San Jose, CA 95136
(408) 893 - 5667
malalim2004@yahoo.com

Mirela Radov
614 Arcadia Terrace, Unit 306
Sunnyvale, CA 94085
(650) 796 - 6448
mizemun@yahoo.com

Jessica Vasquez
P.O. Box 32369
San Jose, CA 95152
(408) 221 - 3581
jess_svb@yahoo.com

Alan Li
34525 Somerset Terrace
Fremont, CA 94555
hinchung64@hotmail.com

Appendix B

<u>Overview of San Jose State University</u>

San José State University, commonly shortened to San José State and SJSU, is the founding campus of what became the California State University system. The urban campus in San Jose, California has an enrollment of about 32,000 students and claims to have more graduates working in Silicon Valley than any other college or university (sjsu.edu).

San José State was founded as the California State Normal School by the California Legislature on May 2, 1862, and is the oldest public university in California. The California State Normal School was itself derived from the Minn's Evening Normal School, which was also known as the San Francisco Normal School. The San Francisco normal school, led by principal George W. Minns trained elementary teachers as part of that city's high school system from 1857 to 1862. Thus, the school now called "San José State" is even older than the University of California, Berkeley (the Organic Act, which established the University of California, was signed into law on March 23, 1868), but not quite as old as the College of California established in 1855, which was the predecessor of the University of California.

Mission:

To enrich the lives of its students, to transmit knowledge to its students along with the necessary skills for applying it in the service of our society, and to expand the base of knowledge through research and scholarship.

Appendix C

<u>Non-University Partners</u>

Live Building, Integrated Learning Center

The Integrated Learning "live building" concept was inspired by the Integrated Teaching and Learning program in Colorado. Their idea -- to create an online building -- was used as a basis for the construction of Queen's Integrated Learning Centre, Beamish-Munro Hall.

The building was created to serve undergraduate Applied Science students in several different ways. The IL Centre contains both laboratory and studio space, as well as being a giant lab itself. Exhibits and data are available to the public, to researchers, and to students, to help advance the understanding of engineering issues, concepts and ideas.

SEMCO Inc.

Since it's founding in 1963 as a sheet metal fabrication company with five employees, SEMCO has built a reputation as a world-wide product innovator in the science of air movement, noise abatement, and air quality, with more than 300 employees and more than 300 manufacturer's representatives.

SEMCO is a part of the Fläkt Woods Group with headquarters in Columbia, Missouri. The company operates six manufacturing facilities at the following locations:

* Morrilton, Arkansas
* Petit Jean, Arkansas
* Salisbury, Missouri
* Crossville, Tennessee
* Arlington, Texas
* Roanoke, Virginia

The facilities in Arlington, Roanoke, and Salisbury all produce high quality spiral, rolled, round, and oval duct products for commercial, architectural and industrial HVAC applications.

The Crossville facility produces acoustical panels and silencers for various markets, including HVAC, highway and cooling tower barriers, manufacturing equipment barriers, manufacturing production lines, paint facilities, acoustic barriers for sports facilities and airports, and almost any other situation where noise pollution might be a concern.

The Petit Jean and Morrilton plants fabricate packaged energy recovery equipment and desiccant-based wheel products for the commercial, industrial and institutional HVAC markets.

In addition, SEMCO also has an extensive, Columbia, Missouri based, ASHRAE 84 compliant research and development facility dedicated to the development of new products for the 21st Century and beyond.

XeteX Inc.

XeteX is intent on providing the most cost-effective air-to-air heat exchangers available today. Based on technical design and application experience on commercial HVAC equipment since 1960, XeteX was incorporated in 1984 to develop heat exchangers and systems appropriate for the expanding needs of commercial buildings for better indoor air quality.

As the need to design, fabricate and supply heat exchangers in the USA increased, XeteX established a plant in LaCrosse, Wisconsin where air-to-air heat exchangers are fabricated. XeteX has supplied aluminum and stainless steel flat plate exchangers made in the USA to a large variety of applications ranging from 100,000 CFM indirect evaporative coolers to 50 CFM residential ventilators and 12,000 CFM high temperature process to 4,000 CFM precooler/reheaters.

Appendix D

FAA Design Competition for Universities

Design Submission Form (Appendix D)

Note: This form should be included as Appendix D in the submitted PDF of the design package. The original with signatures must be sent along with the required print copy of the design.

University ____San Jose State University____

Design Developed by: Student Team

If Student Team:

Student Team Lead ____Malali Mohammad and Mirela Radov____

Permanent Mailing Address ____295 Sposito Circle, San Jose, CA 95136____

____

Permanent Phone Number (408) 893 - 5667 ____ Email ____malalim2004@yahoo.com____

Competition Design Challenge Addressed:

____Airport Environmental Interactions____

I certify that I served as the Faculty Advisor for the work presented in this Design submission and that the work was done by the student participant(s).

Signed ________________________ *Date: April 15, 2009*
Name ____Glynn Falcon____
University/College ____San Jose State University____
Department(s) ____Aviation____
Street Address ____One Washington Square____
City ____San Jose____ State ____CA____ Zip Code ____95192____
Telephone ____(408) 924 - 3203____ Fax ____________

Appendix E

FAA Design Competition Evaluation

1. Did the FAA Design Competition provide a meaningful learning experience for you? Why or why not?

Yes we were able to expand our knowledge about new energy recovery technologies which will leave a minimal carbon footprint while meeting stringent demands for air quality as well as cost effectiveness. Overall energy consumption and peak energy demand can be greatly reduced with an enthalpy wheel system. We learned about many different alternative technologies that can and should be implemented to mitigate future environmental concerns.

2. What challenges did you and/or your team encounter in undertaking the Competition? How did you overcome them?

One of the greatest challenges was getting the team together and meeting deadlines. We were able to accomplish the project by improving communication and managing out time.

3. Describe the process you or your team used for developing your hypothesis.

The team first sat down and brainstormed on what were the most important issues to be resolved within the near future for airport operations. We then conducted research as to what technologies could be best used and implemented to solve these problems. When were all agreed on what product we felt would be most beneficial to airport operations we focused on the enthalpy wheel for our submission

4. Was participation by industry in the project appropriate, meaningful and useful? Why or why not?

Industry has done much research and development on this subject which we were able to capitalize on. Many papers were written and laboratory tests were performed by different companies in industry which were referred to. Working examples of the product also gave us guidance as to how it could be implemented.

5. What did you learn? Did this project help you with skills and knowledge you need to be successful for entry in the workforce or to pursue further study? Why or why not?

We have learned how to perform in a team and successfully complete a project. This will be an invaluable experience in our future careers and education.

Exhibit E

(Advisor/Instructor Portion)

1. *Describe the value of the educational experience for your student(s) participating in this Competition submission.*

Entering this competition has proven to be an excellent Capstone experience for our graduating seniors. They have now experienced “real-world” deadlines, planning, schedules, teamwork and personal commitment, personal and group conflicts, interfacing and consulting with aviation experts, and preparing and editing a professional report. As their professor, I was able to observe their growth throughout the process, and see how they overcame problems which, in other college courses, would have left them stymied and looking to their instructor for resolution. Not here, as I was able to act merely as facilitator for access to information and expertise, and left these student competitors to find their own solutions.

2. *Was the learning experience appropriate to the course level or context in which the competition was undertaken?*

Yes, as we restricted the college-sponsored applications only to those Capstone enrolled, graduating seniors. In this way, we believe we could witness their culminating learning experience and, hopefully, successful outcomes.

This belief proved to actually be true. This year, without exception, each of our seniors demonstrated maturity and educational excellence and competence in their approach to submitting their designs to the FAA, and also in their work ethic.

3. *What challenges did the students face and overcome?*

They faced too many challenges to adequately list them all, here. But the most significant challenges seemed to be adaptability to working efficiently within the group dynamic, and in developing sufficient knowledge and expertise within their proposed design submissions to appreciate flaws or limitations with their proposals.

I also placed an additional requirement upon their work, and that was to document on video their group’s progress and setbacks, and then compile and edit the video into a 10 to 15 minute presentations to be submitted with their designs. This will be played for faculty review, and at graduation to the families of our graduates.

4. *Would you use this Competition as an educational vehicle in the future?*

Why or why not?

Yes. As a "competition," I previously commented upon some inequities and unfairness that existed under the former rules which had caused us some concern. Those comments appeared to be taken to heart by the Design Committee, and are no longer an issue. As a "learning experience," this program remains an outstanding opportunity to have our senior class demonstrate their readiness to join government and industry employment.

5. *Are there changes to the Competition that you would suggest for future years?*

Yes. Instead of having one "annual" competition, divide it into 2 (for semester programs) or 3 (for quarter programs) so that within the university, we are not competing one class against another. We believe that the Spring submissions have an advantage in the competition, as not only to they have several additional months to research and prepare, but (at least within the university) they have the advantage of witnessing the work, designs, and deficiencies of the Fall class's submissions.

Thank you for providing this excellent program to our students.

Respectfully submitted:
April 13, 2009

__________/s/_______________
Glynn Falcon
Director of Aviation
Aviation & Technology Dept.
College of Engineering
San Jose State University

Appendix F

Reference List

Air System Inc. (2008). Corporate History ASI. Retrieved Nov. 21, 2008 from http://www.airsystemsinc.com/home/management.html

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (2008). Standards & Guidelines. Retrieved Oct. 25, 2008, from http://www.ashrae.org/technology/page/548

Central Iowa Power Cooperative (CIPCO). 2005. Enthalpy & Heat Wheels. Retrieved on Nov. 24, 2008, from http://cipco.apogee.net/ces/library/tdew.asp

Crowther H. (2001). Energy Recovery: Is it the Right Choice for your Application. *Engineering System Solutions*. Retrieved Nov. 15, 2008, from http://www.mcquay.com/eprise/main/mcquaybiz/MT_Corporate/EngNews/0701.pdf

Desiccant Rotors International. (2008). EcoFresh Heat Recovery Wheel. Retrieved Nov. 24, 2008, from http://www.drirotors.com/hrw.htm

Desiccant Rotors International. (2007). Energy Conservation In Air-conditioned Space using Enthalpy Wheels. Pg 1-13. Retrieved Nov. 1, 2008, from http://www.drirotors.com/pdf/articles/iaq/enegyconserv_ac_wheels.pdf

Dressler, Rich. (2005). Mineta San José International Airport Receives Rebate for Energy Saving Efforts. Retrieved Oct. 26, 2008, from http://www.sjc.org/newsroom/press/2005/pge.htm

Graham, C.I. (2008). High-Performance HVAC. Retrieved Nov. 15, 2008, from http://www.wbdg.org/resources/hvac.php

Jonasrisen. (2007) What is an Enthalpy Wheel? *Greenline: Futurosity Magazine Theme by Upstart Blogger.* Retrieved Oct. 21, 2008, from http://greenlineblog.com/what-is-an-enthalpy-wheel/

Kjelgaard, M. (2004). Recapture Those Spent Therms. Retrieved Nov. 15, 2008, from http://www.plantservices.com/articles/2004/113.html?page=print

Mumma, S. (2003). Detecting System Degradation. Retrieved Nov. 30, 2008, from http://doas-radiant.psu.edu/IAQ9.pdf

Queen’s University. (2006) Enthalpy Wheel. Queen’s University- Faculty of Applied Science: Live Building Integrated Learning Centre. Retrieved Oct. 7, 2008, from http://livebuilding.queensu.ca/green_features/enthalpy_wheel

VanGeet, O., Reilly, T. (2006). Ventilation Heat Recovery for Laboratories [Electronic Version]. *ASHRAE Journal*, 48, 1-8.

Xetex. (2001). Enthalpy Wheels. Retrieved Nov. 24, 2008, from http://www.xetexinc.com/energy_recovery/products/heat_wheels.html

Zhai, C. et all. (2006, Nov 5-10). The Performance of an Enthalpy Recovery Wheel in Ventilation of CMU’s IW. Retrieved Nov. 30, 2008, from http://www.cmu.edu/iwess/people/zhai/performance_of_enthaly_recovery_wheel.pdf