Heat Recovery Units

Introduction

Heat recovery is a method of salvaging a portion of the energy wasted by inefficient Heating, Venting, and Air Conditioning (HVAC) systems. HVAC systems have a limited efficiency due to the laws of thermodynamics and inherent inefficiencies with real applications. Energy that would be used for work is instead dissipated in the form of heat. Heat recovery units (HRUs) harness some of this energy and redirect it for a more practical use. HRUs are typically found in applications that require both heating and cooling.

Background

There are various forms of HVAC systems, however they all operate based off the same thermodynamic principles. The vapor compression cycle is the basic design of a HVAC system. There are obvious mechanical flaws associated with imperfect designs, for example a vapor compression cycle can never exceed 75% efficiency[1]. The Carnot vapor compression cycle is used to calculate the maximum efficiency of a given HVAC system. The Carnot cycle assumes ideal conditions for heat transfer. No conditions have ever produced results better than 75%. Since heat in inevitably generated, heat recovery units were conveniently designed to conserve wasted energy.

There are numerous applications that have a substantial demand for HVAC. Whether used for product preservation or personal comfort, the refrigeration cycles in these facilities work similarly, just on varying scales. They all utilize a compressor(s), condenser, evaporator, and expansion valve as shown below in Figure 1.

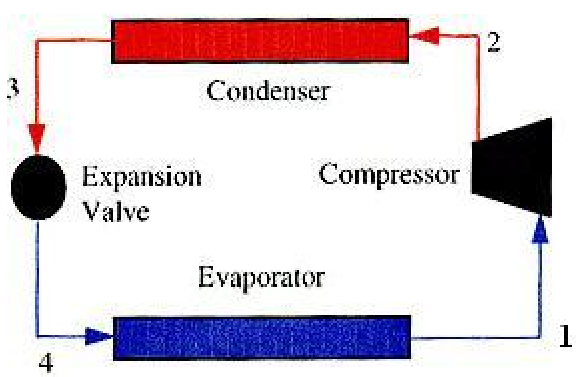

Figure 1: Vapor Compression Refrigeration Cycle

Stream 1 is vapor refrigerant leaving the evaporator. Once the vapor leaves the compressor, it becomes super-heated (Stream 2). Normally, most HVAC systems expel the heat away from the system with condensers and expansion valves. However, there is an opportunity to utilize the excess generated heat. Heat Recovery Units can be positioned in between the compressor and the condenser. This strategic placement allows them to recycle the energy that would typically be wasted.

Current Applications

The energy being released during the vapor compression cycle can be utilized to heat water or offices spaces. The proceeding Figure 2 provides a visual representation of heat recovery in a water-heating application.

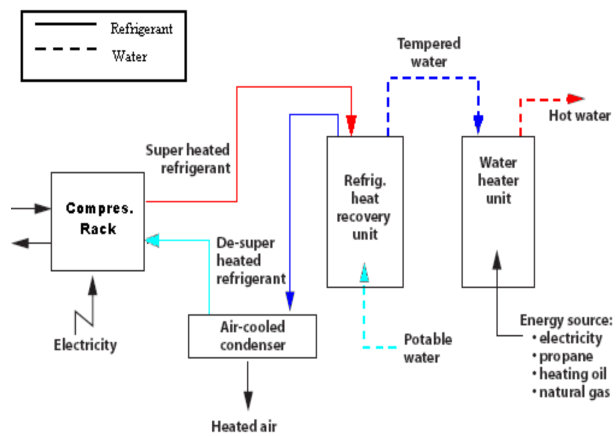

Figure 2: Heat Recovery in Hot Water Application

The heat recovery process channels the refrigerant to a heat exchanger. Inside the heat exchanger, the heat from the refrigerant is transferred to the stream that feeds the water heater. The heat recovery unit effectively preheats the water. The process conserves energy because less work (i.e. electricity) is required to heat the water to the desired temperature[2]. Therefore, the hot water heater does not have to operate as extraneously or as frequently. Similar operations are utilized for heating applications pertaining to ventilation. Once again, a heat exchanger is used to transfer heat to the air in the ventilation ducts. Since the heat can be used to warm either air or water, there are unique heat exchangers for different applications. There are multiple companies that specialize in heat recovery. The predominant manufacture of heat recovery units for hot water applications is Therma-Stor™, while Fantech™ dominates the market for heat recovery in ventilation systems. Thema-Stor™ and Fantech™ provide cost estimates for their respective units on their websites [3-4].

There is a significant potential for dairy farms to save energy with heat recovery units. Tiestall dairy farms use around-the-barn pipelines for milking, and could use the waste heat from milk cooling to preheat water for cleansing the milking system. Case studies, like the one presented, draw attention to the profit available to appropriate candidates.

Case Studies

As mentioned earlier, there are numerous applications that benefit from employing heat recovery technology. Case studies have justified the initial investment given a proper application. Benefits are frequently observed in corporate America, but agriculture also has much to gain. The New York State Energy Research and Development Authority compiled data on two Tiestall dairy farms that retrofitted their operations to include heat recovery units[5]. The water heating savings can be viewed below in Figure 3.

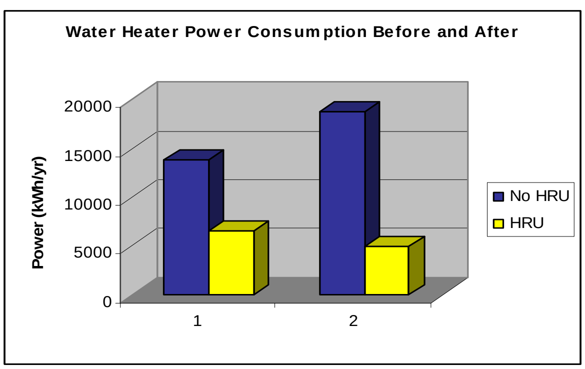

Figure 3: Water Heating Savings for Two Farms

The research was based off two Tiestall dairy farms located in northern New York. Both farms had relatively small scale facilities which employed electric water heaters. Farm 1 and Farm 2 milked 67 and 42 bovine respectively. As seen in Figure 3, Farm 1 reduced their water heater's power consumption from 13,887 kWh/yr to 6,562 kWh/yr once they installed a HRU. This translates to a power savings of 53%. Overall, Farm 2 exhibited better energy conservation because the water heater's power consumption was reduced from 18,780 kWh/yr to 5,000 kWh/yr (~73%). Even though Farm 2 saved more energy, Farm 1 was able to recover their investment quicker. The primary reason being Farm 1 was 60% larger and operated more frequently than Farm 2, and extended operation times provide ample opportunity to save energy and money.

Economic Summary

The report concluded that the average unit had a payback period of five years. After that time, the mean initial investment ($2,861) was reimbursed and facilities began to save money and energy. An economic summary of the averaged results can be referenced in Table 1 below.

Table 1: Economic Summary of Average Benefits from Retrofitting Water Heaters with HRUs [5]

	Power Demand (kWh/yr)	Annual Savings	Installation Cost	Payback (Years)
No HRU	16,333	-	-	-
HRU	5,781	$579	2,861	5.0

References

[1] J.R. Elliott, C.T. Lira, Introductory Chemical Engineering Thermodynamics. NJ: Prenetice-Hall Inc. 1999.

[2] S. Sanford, Energy Conservation on the Farm: Refrigeration Systems. WI: University of Wisconsin Extension. 2004 Jan 2.

[3] Therma-Store LLC. Madison, WI. [cited 2006 Nov 28] Available HTTP: http://www.thermastor.com/prod_heatrecovery.htm

[4] Fantech. Sarasota, FL. [cited 2006 Nov 28] Available HTTP: http://www.fantech.net/hrv_erv.htm

[5] D. Ludington, E.L. Johnson, "Dairy Farm Energy Audit Summary" [Online Document] 2003 Jun [cited 2006 Nov 17]. Available HTTP: http://www.nyserda.org/publications/dairyfarmenergysummary.pdf