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Industrial Services Factsheet

Industrial Heat Pumps for Low-Temperature Heat Recovery

Industrial heat pumps can significantly reduce fossil fuel consumption and greenhouse gas emissions in drying, washing, evaporation and distillation processes in a variety of applications. They can also be used to produce steam and to provide process water heating and cooling. Industries that can benefit from this technology include food and beverage processing, forest products, textiles, and chemicals.

Industrial heat pumps are used in heat recovery to transfer heat from a relatively low-temperature source and “upgrade” it to a higher temperature, and to recover *latent heat*¹ from high-humidity streams. Heat exchangers in contrast are used to transfer heat from a warm stream to a cooler one.

In a retrofit of fossil-fuel fired equipment, an industrial heat pump will increase electricity consumption due to the heat pump’s compressors and fans, while fossil fuel use will be reduced or eliminated. Overall

¹ Latent heat is energy associated with a phase change. In latent heat recovery, the energy released when water vapor condenses back to a liquid is recovered.



Application: Tree Top apple drying facility, Wenatchee, Washington

THE TREE TOP FOOD PROCESSING FACILITY IN WENATCHEE, Washington, plans to retrofit an industrial heat pump to a direct-fired natural gas conveyor dryer for apples. Warm water reclaimed from the heat pump will be used for freezer defrost. The existing natural gas burners will remain as auxiliary and back-up heat. Project managers estimate this measure will save 89,400 million British thermal units of natural gas per year, while increasing annual electricity use by 8,580,000 kilowatt hours.

With net energy savings of \$463,000 per year and an installed cost of \$1.25 million, this measure has an estimated payback of approximately 2.7 years. The project also will reduce net carbon dioxide emissions by more than 2.4 million pounds per year*, which represents a 10% reduction in greenhouse gas emissions associated with their drying operations. Companies that register and verify greenhouse gas emissions have the opportunity to market reductions as carbon offsets on exchanges such as the Chicago Climate Exchange, or through nonprofit organizations such as the Climate Trust.

“The natural gas savings potential with this type of project is significant, along with the opportunity for carbon dioxide emissions reduction,” says Paul Scheihing of the U.S. Department of Energy’s Industrial Technologies Program. “There are dozens of food processors throughout the Northwest that can benefit from the technology.”

* This figure takes into account emissions from electricity generation. The marginal carbon production rate of the Northwest Power System forecasted over the period 2010 through 2025 is 0.9 lbs of CO₂ per kWh. (<http://www.nwcouncil.org/Library/2008/2008-08.pdf>)



energy efficiency is improved because of latent and *sensible heat*² recovery. For best efficiency, heat exchangers and heat pumps can be applied together, as shown in Figure 1. Industrial heat pumps are most cost effective in regions with low electrical costs compared to fossil fuel costs.

Re-emergence of an existing technology

Many industrial heat pumps were installed in the 1980s. However, the federally mandated phase out of ozone-damaging chlorofluorocarbons in the 1990s necessitated the development of new refrigerants capable of operating at the higher temperatures needed for typical applications. Today, new environmentally sound refrigerants have allowed industrial heat pumps to reemerge in a range of applications.

Temperature considerations

Vapor compression heat pumps can achieve maximum temperatures of 220 degrees Fahrenheit with temperature rises of as much as 100 F. To achieve greater temperature rises, two-stage systems can be used. Each stage uses its own refrigerant designed for a specific temperature range.

Open-cycle versus closed-cycle systems

Most new heat pump systems operate in a closed cycle, returning exhaust to the dryer after it is dehumidified. Closed-loop systems have greater efficiency (*coefficient of performance*³ of 4 to 6) compared to open-loop systems, and do not have emissions. In open-cycle systems, as illustrated in Figure 1, none of the exhaust air is returned to the dryer after being cooled and dehumidified by the heat pump. An open-cycle may be necessary to, for example, exhaust impurities or to exhaust combustion gases if direct-fired auxiliary heating is used. Also, it is often difficult to convert an existing closed-loop system to open-loop as a retrofit.

Avoiding corrosion and fouling

When drying acidic products, such as apples and oak, or if caustic cleaning products are used, the exhaust heat exchanger may require stainless steel tubes with aluminum fins coated with a protective material such as ElectroFin's "e-coat." Sticky exhausts can be handled by incorporating a wash cycle to periodically clean heat exchanger surfaces. During the wash-down cycle, which might last a few minutes once a day or so, auxiliary heat can be used to maintain temperature.

² Sensible heat is energy added or subtracted that causes a change in temperature. In sensible heat recovery, energy is transferred from a hot source to a cooler one.

³ Coefficient of performance is a ratio calculated by dividing the total heating capacity provided by the heat pump by the total electrical input.



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Paul Scheihing,
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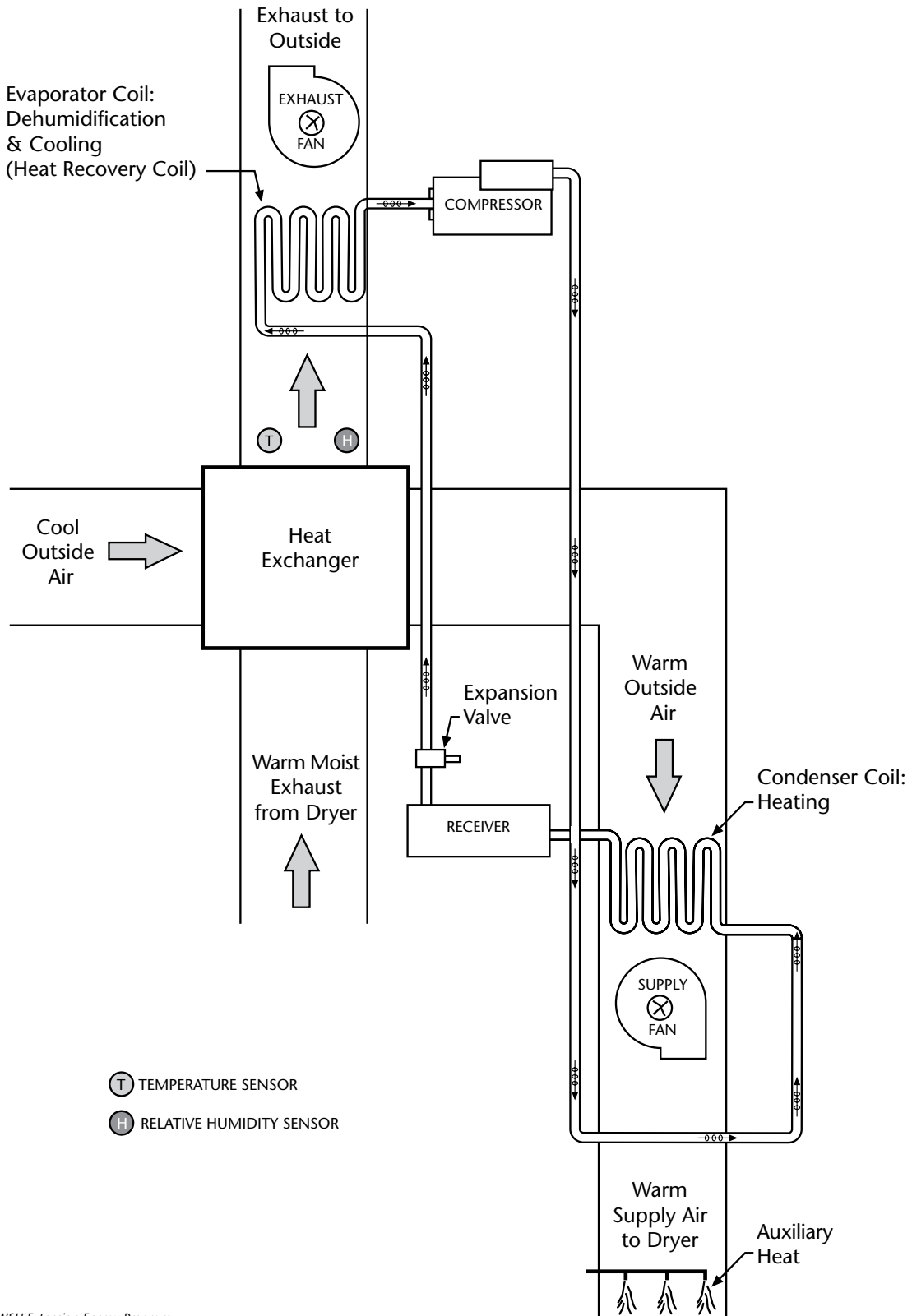


Other considerations

- Warm water that is condensed out of the exhaust can be recovered for other uses. If condensed water is not reused, its addition to the waste water stream must be accounted for.
- When installing a large unit on a roof, structural issues must be considered.
- The increased electrical demand of the compressor may increase electric demand charges and may require upgrade of the electrical service.

Figure 1.

Open-Loop Heat Pump Dehumidification System



Source: WSU Extension Energy Program

More Information

- “Heat Pumps in Industry”
www.heatpumpcentre.org/About_heat_pumps/HP_industry.asp
- “Industrial Heat Pumps for Steam and Fuel Savings”
www.eere.energy.gov/industry/bestpractices/pdfs/heatpump.pdf
- “Industrial Heat Pumps: A Means to Mitigate Global Industrial Emissions”
<http://www.heatpumpcentre.org/publ/HPCOrder/default.aspx#38>
- “Waste Heat Recovery in the Process Industries”
(Carbon Trust Report # GPG141)
www.carbontrust.co.uk
- “Learning from Experience with Industrial Heat Pumps”
www.caddet.org/public/uploads/pdfs/Report/ar_23.pdf
- The Chicago Climate Exchange
www.chicagoclimatex.com
- The Climate Trust
www.climatetrust.org
- Northwest Food Processors Association
www.nwfpa.org/eweb/Startpage.aspx?site=NWFPA

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WSU Extension Energy Program Mission Statement

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