REFRIGERATION REVIEW

Gaining "Lost Work" for a Greener Planet

By Henry B Bonar II P.E. and Dr. John Nuszkowski

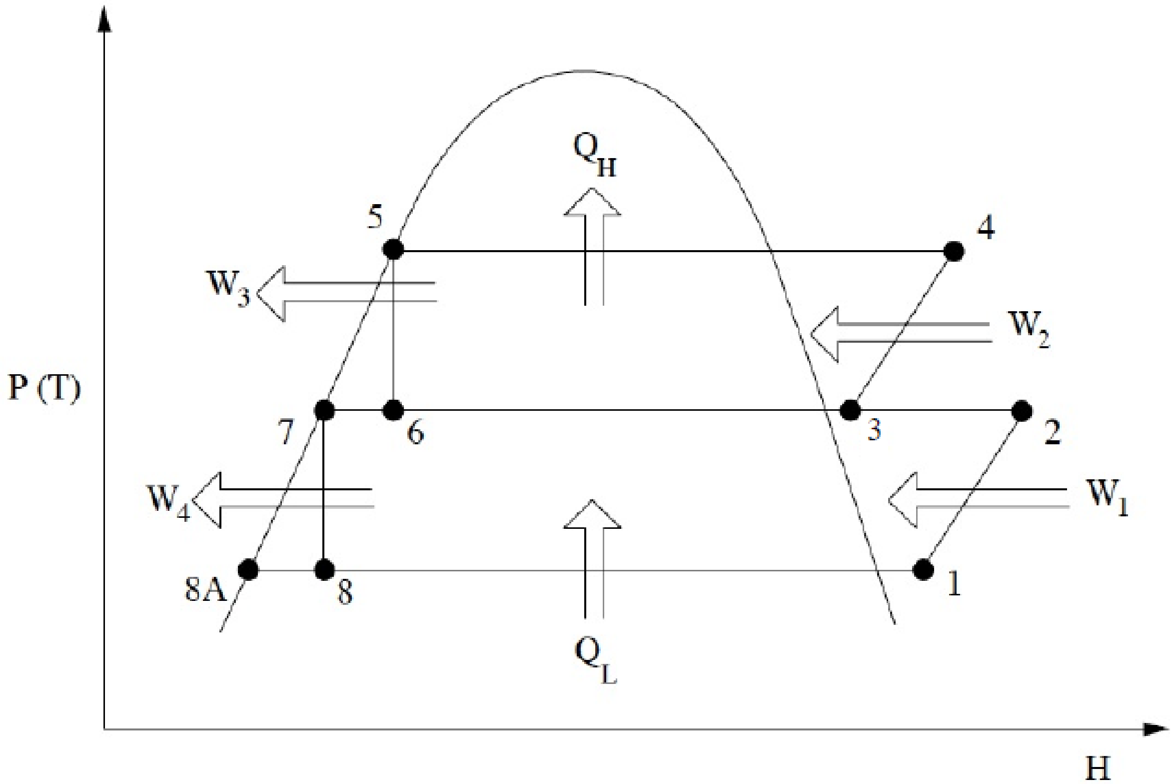
The refrigeration cycle has been used for more than 100 years to remove heat from one area and convey it to another area. The common way of expressing its efficiency is with Coefficient Of Performance, COP, which would normally be considered the heat removed divided by the work into the system that it took to accomplish the process.

Because the refrigeration cycle is the combination of compression, condensing, expansion and evaporation, the energy and equivalent heat of the work can for the most part be determined with the use of equations and a thermodynamic Mollier diagram. While industrial refrigeration systems can be complicated with such things as recirculating pumps and flooded surge drums, the cycle remains fairly straightforward and basic. The compression cycle portion of the system is quite definable in that there is compression work by the motor to accomplish the compression portion of the system. On the other hand, the expansion portion of the system, particularly the portion where liquid is "flashed" to vapor and liquid, is less understood and has always been deemed the lost work process. This process is a violent expansion, as liquid molecules temporarily go sonic when they are released in a space of lower pressure and relatively low molecular density. This results in the fluid "doing work on itself," without any energy change. Ultimately, in industrial systems, the flash gas is removed via compressors and the liquid is then docile, at its new pressure, and its new lower temperature.

The lost work process, as it is known, has energy which could be captured. The purpose of this discussion is to bring to light that it is in the refrigeration cycle, and that, hopefully, in time we would learn how to capture this energy for useful purposes. For instance, if such a device were created that would let liquid expand through a piston or some other mechanical device, whereby the change of state would no longer be at constant enthalpy. A controlled release of the energy, transmitting the energy to mechanical or fluid, could provide useful work resulting in a reduction of the fluid's enthalpy. An example would be driving a mechanical device at a direct expansion air unit that would operate the fan motors of that unit. In industrial systems, the device could be one that would provide the pump horsepower required for liquid recirculated systems.

In theory, it can readily be seen that the change in enthalpy can provide more than enough work in industrial systems for pump recirculation. By doing so, one is trying to make the process closer to isentropic in lieu of isenthalpic. The device to do this would need to consider the effects of critical flow pressure drop for the fluid, so sonic velocities are minimized. It would be difficult to use a turbine type device, because of the tremendous forces of nucleous and cavitating aspects of the expanding liquid/gas. Even 25-30% recovery of the energy would probably be a meaningful amount for pump recirculation.

The intent of this article is to bring to light what we have all known but otherwise thought very little about in our refrigeration systems, that surely we can devise devices for capturing "lost work" energy and helping make our planet a little greener, more sustainable, and less wasteful as we provide meaningful living standards for our industrial and perishable food processes.



BASIC PRESSURE-ENTHALPY DIAGRAM

Calculations –

Basic $COP_R \frac{\dot{Q}_L}{\dot{W}_1+\dot{W}_2} = \frac{\dot{m}_L(h_1-h_8)}{\dot{m}_L(h_2-h_1)+\dot{m}_U(h_4-h_3)}$

Improved $COP_R = \frac{\dot{Q}_L}{\dot{W}_1+\dot{W}_2-\dot{W}_3-\dot{W}_4} = \left(\frac{\dot{m}_L(h_1-h_{8,A})}{\dot{m}_L(h_2-h_1)+\dot{m}_U(h_4-h_3)-\dot{m}_U(h_7-h_6)-\dot{m}_L(h_{8,A}-h_7)}\right)$

References

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Biography

Henry B. Bonar, II P.E.

Henry B. Bonar, II, is CEO of Bonar Engineering & Construction Company. Mr. Bonar holds Professional Engineering licenses in 36 states and consults throughout the world on refrigerated facilities and refrigeration systems in the perishable food industry. Hank is also the author of many publications and the book *"Florida Comes of Age"*, holds patents, and is a frequent speaker at industry conferences throughout the nation.

Dr. John Nuszkowski

Dr. John Nuszkowski is an Assistant Professor at the University of North Florida (UNF). Dr. Nuszkowski's research includes engine combustion modeling, vehicle powertrain optimization, in-use vehicle emissions, advanced combustion, alternative fuels, and large bore diesel emissions reduction. Currently, he is evaluating fuels for advanced combustion in diesel engines. Dr. Nuszkowski teaches Thermodynamics and Machine Design.