Innovations on Heat Exchange in Thermorefrigeration

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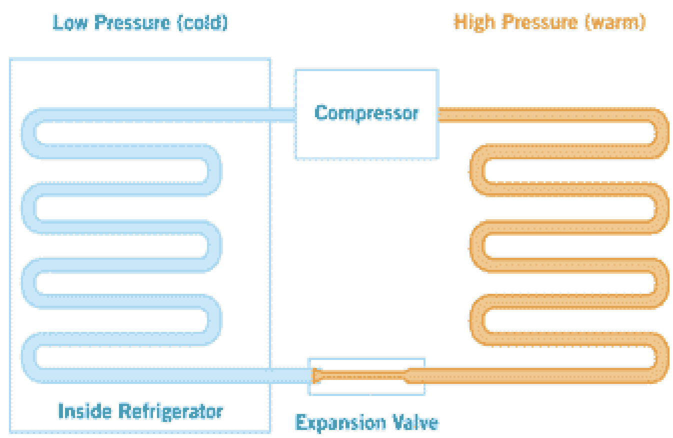
Introduction to Refrigeration:

In a refrigerator, heat is pumped from the cool inside to the warm outside. Because this is against the normal flow of heat, energy input (work) is required to pump the heat out. This comes in the form of electricity. The more efficient the heat exchange, the less energy is necessary to power the heat flow. To take heat out of the compartment of a refrigerator, a cyclic flow of refrigerant fluid is used.



Refrigerant liquid at a low pressure absorbs heat from the inside of the refrigerator. With this added heat, the liquid is boiled to a gas. This gas passes through a compressor making it high pressure. At this higher pressure, the gas gives off heat to the surroundings. At a lower temperature, this high pressure gas condenses into a liquid. The "condenser" of the refrigerator is long and winding so as to maximize surface area across which to give off heat. Having given off heat, the high pressure liquid passes through an expansion valve to be converted to a low pressure liquid, ready to absorb more heat from the inside of the refrigerator. Thus, by decreasing the pressure of a refrigerant fluid, it can be boiled at a low temperature, carrying heat out of the refrigerator. Then, it can be condensed at a high pressure, allowing heat to be given off to the surroundings. By manipulating the pressure of the liquid, heat can be carried from areas of low temperature to high. Energy input is required to manipulate the pressure as such.

Abstract Goals:

We would like to redesign refrigerators to be more energy efficient, whether by using an entirely different system of refrigeration or streamlining its current system. To begin with, we will identify where the inefficiency in current refrigerator models derives from to see what aspects of the unit hold the most potential for improvement.

We will experiment with different refrigerant liquids and methods of insulation for the refrigerant to see if the most effective ones are currently employed.

We will try placing the condenser in tubs of water of varying sizes and temperatures and with the condenser in different positions to see if we can improve heat exchange. We will try burying the condenser beneath cold soil to see whether the improved heat exchange outweighs the extra energy that may be needed to pump the refrigerant back up to the refrigerator. We will measure the amount of energy used long-term to keep the refrigerator cold to see whether possible real-world applications of the buried condenser are practical.

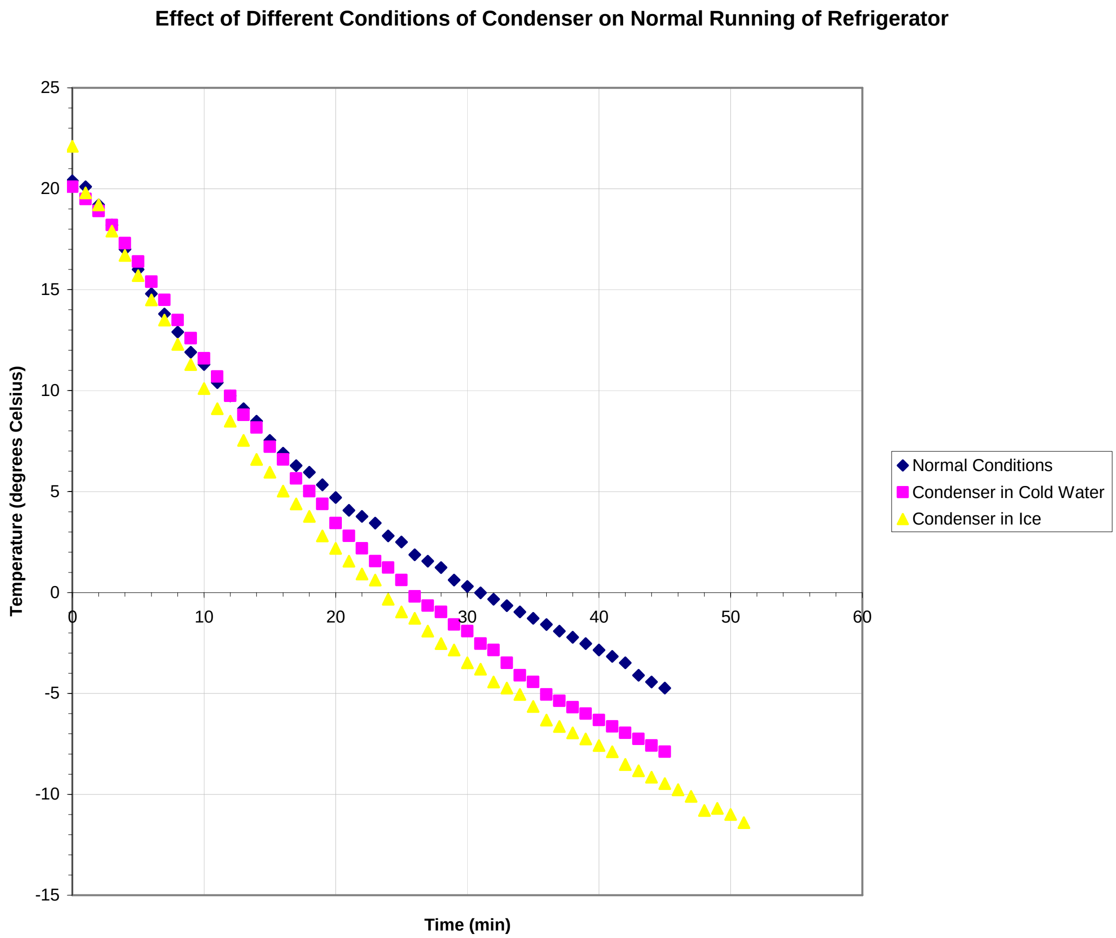
Further, we will consider different manners of improving convection of air around the condenser to ensure it is surrounded by the coolest air possible. Refrigerators often are encased on all sides but the front. As such, the heat given off by the condenser remains there. As the refrigerator tries to give off more heat, it becomes more difficult with a smaller temperature gradient. We will let the refrigerator run in hot and cold environments as well as in an environment where it is mostly surrounded to see how profound an effect this has on efficiency. Following this, we will consider different designs to improve air convection and carry heat away from the condenser. To this end, we may employ fans to circulate air or may reposition the condenser on the unit. We will also try repositioning the condenser to change the way gravity acts on it to have improve the way pressure drives the flow of refrigerant.

We will try to recycle the energy given off as heat back to the system to add to its efficiency. We may use thermal metal couples to turn the heat energy into electricity and we have considered employing capacitors to use this electricity to run lights inside the refrigerator.

Finally, we will consider manners of entirely redesigning the methods of refrigeration. This may include employing a water pump system to carry heat from the refrigerator or finding a way to make acoustic refrigeration practical for regular refrigerators.

Work Thus Far:

The refrigerator was tested in varying conditions starting at room temperature. The temperature was measured every minute inside the refrigerator to observe the rate at which heat was carried out of the refrigerator compartment and at what temperature the refrigerator seemed to settle. The following shows the temperature inside the refrigerator versus time under normal conditions and with the condenser in water of 10 degrees Celsius, and in ice.



As can be seen, the colder the surroundings of the condenser, the more easily it was able to dissipate heat. Being that these all started at room temperature, the differences in efficiency became more exaggerated over time. Thus, if a refrigerator is allowed to run, over time this improved energy flow could mean a significant amount of energy saved. The key is to find practical real-life situations in which this phenomenon observed with the condenser can be exaggerated.