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Thermodynamics Real World Example:

How a Kitchen Refrigerator Works

The modern refrigerator represents an everyday example that effectively displays thermodynamics concepts. In nature, heat naturally transfers from a high-temperature body to a low-temperature body. At first glance, a refrigeration cycle appears to defy laws of nature and thermodynamics by transfer of heat from a low-temperature body to a higher temperature body. However, this process is made possible through the use of a refrigerant and a cyclic device.

Most modern refrigerators are constructed the same. They consist of a condenser, evaporator, expansion valve, and a compressor. Refrigerators also use a refrigerant as the working fluid. A working fluid is a fluid that is used to transfer heat to and from the cyclic device in use.

At the beginning of the process, a work input is required to start the refrigerator system and keep it running. Electricity is used to start the system and power the compressor. Initially, the refrigerant enters the compressor as a super-heated vapor. Once the vapor reaches the compressor, electricity is used to make a piston decrease the volume of the vapor. As the volume of the vapor decreases, the temperature and the pressure dramatically increase. Some compressors will have heat coils that will expel some heat to the surroundings (the air of the room that the refrigerator is in) of the system.

This high temperature and high pressure vapor is then passed to the next step of the cycle, the condenser. This is where the majority of the heat dissipation occurs. While traveling through the coils of the condenser, the refrigerant vapor rapidly cools and approaches a liquid state. This occurs through and interaction between the working fluid, the refrigerant, and the condenser

coolant. The heat from the refrigerant vapor passes to the condenser coolant. The coolant then ejects the heat to the surroundings. As the temperature of the vapor drops, the working fluid becomes liquid.

After passing through the condenser, the working fluid is in a state of high pressure and a lower temperature than it was at the compression stage. The fluid then approaches the expansion valve. An expansion valve is a flow-restricting device that drops the pressure of a fluid. Expansion valves are usually so small that the flow through one can be considered adiabatic. Therefore, there is no theoretical heat transfer at this point. Additionally, expansion valves are able to drop the pressure of a fluid without any work input. The reason is that most expansion valves consist of capillary tubes. These tubes restrict the flow of the liquid, thus able to control the pressure. When the fluid passes through the capillary tubes, the temperature and pressure drop significantly.

The low temperature and low pressure fluid then flows to the evaporator. In this stage, the significant drop in pressure causes the working fluid to immediately boil and evaporate. In order to complete this process, the working fluid must absorb heat from the system (the refrigerated space). This is done through a gas inside the evaporator. This evaporator gas absorbs heat from the refrigerated space and then transfers the heat to the working fluid (the refrigerant). This results in a significant decrease in temperature of the evaporator coil and the refrigerated space.

Once the fluid absorbs heat from the evaporator vapor and exits the evaporator, it reenters the compressor. This step completes the overall cycle. So long as the refrigerator is plugged in to an electric outlet it will continuously run the refrigeration cycle, thus keeping the inside of the refrigerator at a low temperature.