THE Ames Laboratory
Creating Materials & Energy Solutions

Creating Materials & Energy Solutions

A Cool New Way to Use Magnets

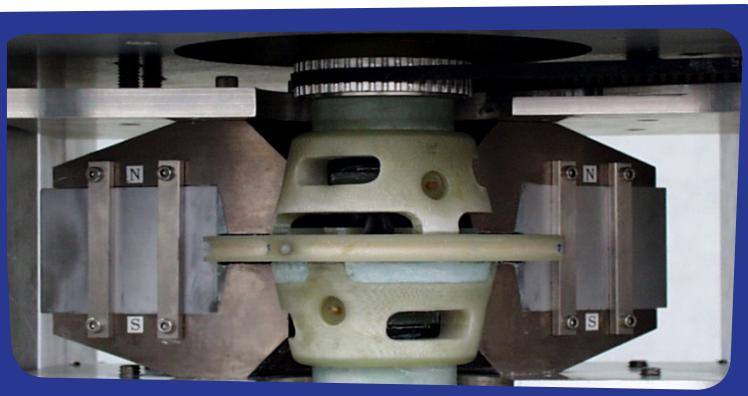
You've heard of refrigerator magnets. But did you know that some refrigerators actually use the power of magnetism to keep foods cold?

Magnetic refrigeration is just one of the many cool technologies being developed by the U.S. Department of Energy's Ames Laboratory in Iowa. Someday you may see magnetic refrigerators operating in supermarkets and perhaps even your home.

To understand how magnetic refrigeration works, it helps to first understand how common refrigerators – like the one in your kitchen – keep foods cool. Most refrigerators today use a gas of some kind as a cooling agent. An air pump, called a compressor, keeps the gas moving through long, thin pipes that travel inside and outside the refrigerator. The compressor is the motor in your refrigerator that you hear turn on and off periodically.

As the compressor pushes the gas through pipes located outside of the refrigerator, the gas becomes more and more compact or – as scientists say – pressurized. The more the gas is pressurized, the more it generates heat. Eventually, the pressure builds so much that the gas transforms into a liquid.

Soon after, this liquid gets pushed into a section of tubing that is larger, so the liquid is under less pressure. In just a moment, much of the heat energy trapped inside the liquid escapes, and the liquid transforms into a gas once again. This process makes the gas become very cold. Next, the compressor pushes this now-cold gas inside the refrigerator. Once there, it works just like ice in a cold drink, absorbing heat from the food inside. The compressor continues to move the gas back toward the outside of the refrigerator where it can be pressurized once again. This process repeats over and over for as long as your refrigerator is running.



A prototype magnetic refrigerator.

PEOPLE VS. REFRIGERATORS

Exactly how a refrigerator makes food cold might sound complicated and **STRANGE**.

BUT it's really not much different from the way human beings stay cool on hot days.

Water inside our bodies absorbs the heat we all naturally produce. The **HOTTER** we get, the more that water gets transferred through our skin in the form of perspiration.

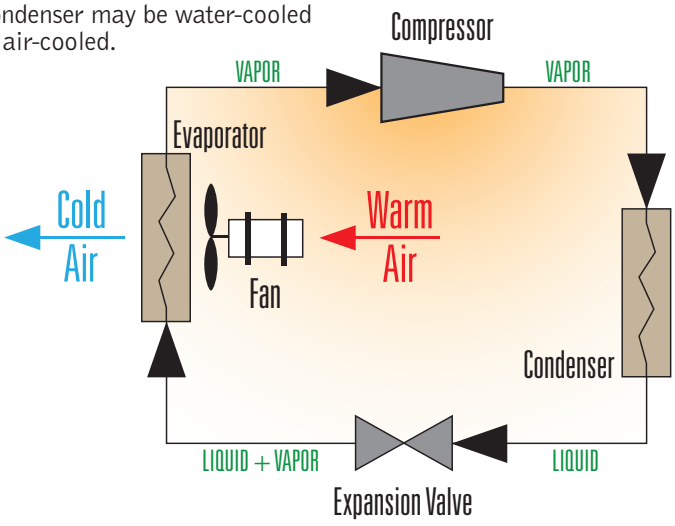
The perspiration **EVAPORATES** as it expands, taking some of our bodies' excess heat energy with it.

In the same way, gases in refrigerators remove heat when they **EXPAND**.

CONTACT INFORMATION:
Steve Karsjen
Public Affairs
karsjen@ameslab.gov
515.294.5643
111 TASF, Ames, IA 50011

Using magnets instead of gas

Magnetic refrigerators work the same way traditional refrigerators do, except in place of a gas, they cool food using magnets. They also use water, plus a very special metal containing gadolinium. The reason it's special is because whenever a magnet gets close to this gadolinium-containing metal, it quickly heats up. All magnetic metals react this way a little bit when they come in contact with a magnet but gadolinium is one of the metals that heats up the most. The term for this phenomenon is the magnetocaloric effect.



Typical Single Stage Vapor Compression Refrigeration

You're probably asking how a metal can heat up simply because a magnet comes close to it. The answer is because the magnet forces the electrons within the atoms to arrange themselves in a more orderly fashion, a little like bowling pins. When magnets force electrons into this kind of ordered arrangement, they are no longer able to move as easily. But to maintain the same energy level, something else must change, so the atoms themselves begin to vibrate faster. Faster vibrations means that the atoms become warmer. In short, the metal acts just like the pressurized gas in your home refrigerator. When you move the metal away from the magnet, the atom's vibrations relax and are able to release their heat. That makes the metal cooler in the same way the gas in a home refrigerator is pushed out of the high-pressure area so the heat trapped inside it can escape.

Cooling the gadolinium-containing metal with water

But back to our magnetic refrigerator. Now it's time for the water to do its work. Magnetic refrigerators use two separate streams of water. Each stream travels through a separate set of tubes. The first stream comes in contact with the warm metal while the magnet is still located close by. This stream cools the metal down. Then, when the magnet is removed, the gadolinium cools down even more – enough so that the metal itself is now able to cool a second stream of water. It's this second stream of water that gets pumped inside the refrigerator to keep the food inside it cool.

Did you notice that our magnetic refrigerator doesn't use a compressor? Instead, there's typically a wheel-like device with the gadolinium attached to it. As the wheel turns, the metal moves closer to and then away from the magnet. This makes the metal warm up each time the magnet draws close and then cool as the turning wheel moves the metal further away. Meanwhile, simple pumps circulate the two cooling streams of water. Pumps use a lot less energy than compressors, which makes magnetic refrigerators a lot greener than traditional refrigerators. What makes refrigerators greener still, is the water that's used as a coolant. As you may already know, water is about the safest, most earth-friendly substance known.

Some years from now, when magnetic refrigerators are in common use, remember that the ice cream and drinks they've made deliciously cool came about because of an invention at the Ames Laboratory in Iowa.