Curtailing open grocery refrigerators' energy loss

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In the experimental setup, the air curtain exits out of the top of the case, flows down in front of the wooden shelving units, and then circulates through the ducts at the bottom of the case. Credit: Mazyar Amin

Open refrigerated display cases holding eggs, cheese, drinks and more are a favorite of supermarket chains. Despite the easy access they offer customers, the inefficient energy-guzzlers cost retailers a huge amount of money.

Engineers at the University of Washington in Seattle and Kettering University in Flint, Mich. have developed an all-new way of designing

this type of refrigerated case. Mazyar Amin and his team created a method to make these cases between 10-15 percent more energy efficient, by analyzing the physics of how warm air sneaks in. In most open refrigerators, an invisible curtain of cold air blows from the top of the case to ducts at the bottom, deflecting incoming warm air. These air curtains are not impermeable: Up to 80 percent of the devices' energy consumption goes to cooling down warm air that leaks in.

The research team identified six major design variables, such as the dimensions of the case, the turbulence of the air curtains and the speed of blowing air. They said that although these refrigerators come in countless different styles and designs, improved design can dramatically reduce the amount of warm air that seeps in.

"What we are interested in is this problem is to reduce the amount of outside air that infiltrates into the system," Amin said.

To test out their model, the team built their own display case where they could easily change the dimensions, air flow and other variables.

Part of their experiment, Amin said, was to inject a tracer gas into the system to identify the way warm air infiltrated the curtain of cold air. The team blew carbon dioxide gas through their mockup instead of cool air. Using gas analyzers, they sampled the air inside and outside of the refrigerator case to measure how much outside air penetrated.

The tests showed that the systems were complex and difficult to predict; a small change that dramatically improved energy efficiency in one design could have the opposite effect in a different setup. They found many examples of unexpected outcomes, like shrinking the size of the display's opening, improves efficiency up to a point but starts making the cases less efficient if it gets too small.

The computer model that the researchers devised compiles the effects of all of the different design variables interacting with each other, and then produces a number that indicates how much warm air is leaking into the case.

According to the research team's paper, published in the October issue of Applied Thermal Engineering, the model enabled the research team to reduce energy use by 10-15 percent after using their model to design a case. They project that if all designs incorporated their insights that it would save the $562 billion grocery industry an estimated $100 million in annual energy costs.

Amin said that he thought that that savings listed in the paper were likely just the beginning, and felt that energy savings up to 25 percent was possible.

"I believe [manufacturers] would be very interested in making use of this info and applying it to their designs," said Brian Fricke, a building equipment researcher at Oak Ridge National Laboratory in Tenn., who works on the energy efficiency of refrigeration systems. "If manufacturers can reduce the infiltration 10-15 percent that will have a tremendous impact."

Amin and his team have already been in contact with several manufacturers of refrigeration units. He said that one company from New Zealand called Skope was interested in using their research to help design future models.

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