Opportunity for Enhanced Energy Efficiency Amid New Regulatory Challenges

Polyurethanes remain the desired material for energy efficiency in appliances.

by melissa rose and vanni parenti

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Polyurethane chemistry has helped the world adapt to change and elevated our society to a better place, especially relative to our appliances. There are endless ways to adapt polyurethane basic chemistry to work in a wide variety of processes that produce an immense range of properties—including being one of the best insulators on our planet.

We've come a long way from chilling our food in a box of ice. Today, polyurethane chemistry protects and insulates, holding up under extreme temperatures. It continues to be the "go-to" product for most appliance manufacturers, helping keep foods fresh and cold while improving energy ratings.

However, the need for energy efficiency goes beyond the home refrigerator. Convenience stores, grocery stores, and the trucks that transport fresh food from

farm to market all depend on this unique chemistry to help protect goods during transportation and storage. Polyurethane foam is one of the best insulation technologies available and helps elevate energy efficiency in these applications, including:

- Superior insulation properties to help protect and preserve goods
- Robust strength due to the rigidity of foam and adhesion characteristics
- Light weight to help reduce transportation costs
- Cost efficiency in manufacturing processes
- Energy efficiency savings

Types of Foam Application

Whether in the home or business, you expect refrigerators and freezers to keep foods and beverages fresh. A poorly insulated appliance can cause products to spoil early, resulting in higher grocery bills.

Many refrigerators and freezers are made with an outer shell of metal sheet and a plastic inner liner with a layer of rigid polyurethane foam insulation poured in between. The natural adhesive properties of polyurethanes help create a strong bond between the appliance's walls giving structural strength to the refrigerator. Its thermal properties help control the heat exchange while allowing a more streamlined manufacturing process. During product manufacturing, the foam is cured prior to the appliance being finally assembled and then shipped. Additionally, pour-in-place polyurethane foam can be used to manufacture refrigerated trailers for food transportation. Many commercial units found at retail stores also rely on this application.

Blowing Agents

A blowing agent is a substance capable of producing a cellular structure by a foaming process typically applied when the material is in liquid state. This cellular structure helps reduce density thus increasing thermal insulation while increasing stiffness of the material. During manufacturing, a blowing agent is used to expand the foam allowing foam flow into any cavity and providing excellent physical properties. Blowing agents contribute to the superior insulation performance of closed cell polyurethane foam as a result of insulating gas retention in the cells of the foam. Blowing agents must also satisfy the needs of the application and need to take multiple requirements into consideration including cost, flammability, safe and economic manufacturing, load bearing, cushioning and compatibility of materials. Therefore, each foam application has its own specifications as the density of the foam is determined by the amount of blowing.

Regulatory Impact

For decades, there have been growing concerns that some types of blowing agents could damage the stratospheric Earth's ozone layer and more recently global warming potential (GWP) concerns. There have been a number of regulatory changes that have impacted the refrigeration industry in the past years. Global agreements have been introduced to phase out less environmental friendly blowing agents, such as the Montreal Protocol, the Kyoto Protocol and, for the U.S., a new proposed rule under the Environmental Protection Agency's (EPA) Significant New

Alternatives Policy (SNAP) program. The proposed U.S. SNAP rule would prohibit certain high-GWP blowing agents and mandate the transition to lower GWP blowing agents. This would be done by expanding the list of acceptable alternatives and prohibiting use of high-GWP hydro-fluorocarbons (HFCs) for foam blowing where lower risk alternatives are available.

Historically, a number of substances have been used as blowing agents for appliance insulation over the years. At first, chlorofluorocarbons, or CFCs, were used as blowing agents due to their excellent thermal insulation. These were phased out in the late 1980s and early 1990s due to their significant ozone depleting potential. CFCs were replaced with hydro-chlorofluorocarbons, or HCFCs. Technically, HCFCs performed similarly to CFCs but having reduced ozone depletion potential, however, were an interim solution as the material also had some potential for ozone layer depletion. HCFCs were replaced by HFCs and hydrocarbons, which are still predominately used today.

Next-Generation HFOs

Much research has been undertaken in the industry to maintain and improve the insulation properties of polyurethane foams using low-GWP blowing agents that don't deplete the earth's ozone layer while reducing the global warming impact. U.S. industry is helping to lead efforts to develop and deploy the next generation of insulation products. Companies like ours have conducted research on alternative blowing agents for a decade. Now Hydro-fluoro-olefin (HFO) blowing agents with low GWP are replacing traditional HFC blowing agents to meet the proposed regulations.

Recent development work has focused in combining best-in-class insulation performance with a more sustainable profile. These new polyurethane-based solutions address the blowing agent challenge. By controlling the foaming process, uniform cell structure is achieved providing consistent physical properties and high insulation value. Performance benefits for appliances using these new foam systems include improved insulation efficiency, balanced process-ability, remarkable durability, lightweight and structural strength. Additionally, the polyurethane foams enable customization so can be tailor made to meet customer specification requirements.

Helping the Environment

Today's consumers are concerned about the environment and are more educated about the products and processes used to manufacture products, including appliances. Across these numerous applications, polyurethane rigid foam is one of the best insulation materials available to help achieve energy efficiency targets, reduce cost and mitigate greenhouse gas emissions. These features impact consumer purchases for Energy Efficiency standards, like Energy Star for domestic appliances and water heaters. Energy Star status is the trusted, government-backed label for energy efficiency that helps consumers save money and protect the environment through energy-efficient products and practices.

The Energy Star label was established to reduce greenhouse gas emissions and other pollutants caused by the inefficient use of energy. The label makes it easy for consumers to identify and purchase energy-efficient products that offer savings on energy bills without sacrificing performance, features and comfort. Products can earn the Energy Star label by meeting the energy efficiency requirements set forth in Energy Star product specifications.

Additionally, the U.S. Department of Energy (DOE) imposed regulations for household refrigerators and freezers, and walk-in coolers, which became effective in the fall of 2014. The new standards are expressed as the maximum annual energy consumption for a product of a given category. Technology to achieve these new standards includes optimized polyurethane foam systems, along with improved compressor efficiency, fan motors and the use of vacuum insulated panels, which could lead to cost effective energy savings improvements. The DOE estimates that the updated national standards would save approximately 4.8 quads of primary energy cumulatively by 2043, which equates to $36 billion in net present value savings for consumers.

Moving Forward

The EPA's proposed blowing agent rule brings a unique set of technical issues to the industry. With greater global focus on the reduction of emissions of global warming gases, the new blowing agent technologies available and in development significantly change product availability to the foam formulator and appliance manufacturer. There are challenges associated with switching from one blowing agent to another. Considerations need to be taken to ensure there isn't a decrease in performance, as well as ensuring the system works with specific manufacturing equipment. Safe handling is also critical for employee safety. It's critical to work with industry partners who are committed to developing low GWP and zero Ozone Depletion Potential solutions while also ensuring a smooth and seamless transition. ■

Sources:
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Enhanced Dow PASCAL™ Foam Technology: A More Sustainable and Energy Efficient Future for the Domestic Appliance Industry Authors: Vanni Parenti- The Dow Chemical Company, Hans Kramer – The Dow Chemical Company, Rossella Riccio – The Dow Chemical Company, Melissa Rose – The Dow Chemical Company