MESSER
Gases for Life

Whitepaper.

Bottoms up: How technology advances in mixer chilling can improve your food process.

Summary.

When it comes to cryogenic chilling, processors may be better starting at the bottom. The bottom of their mixer, that is. Strategically injecting cryogens such as liquid nitrogen (N_2) or carbon dioxide (CO_2) directly into the bottom of a mixture chills food faster, more effectively and at a lower cost than other cooling methods.

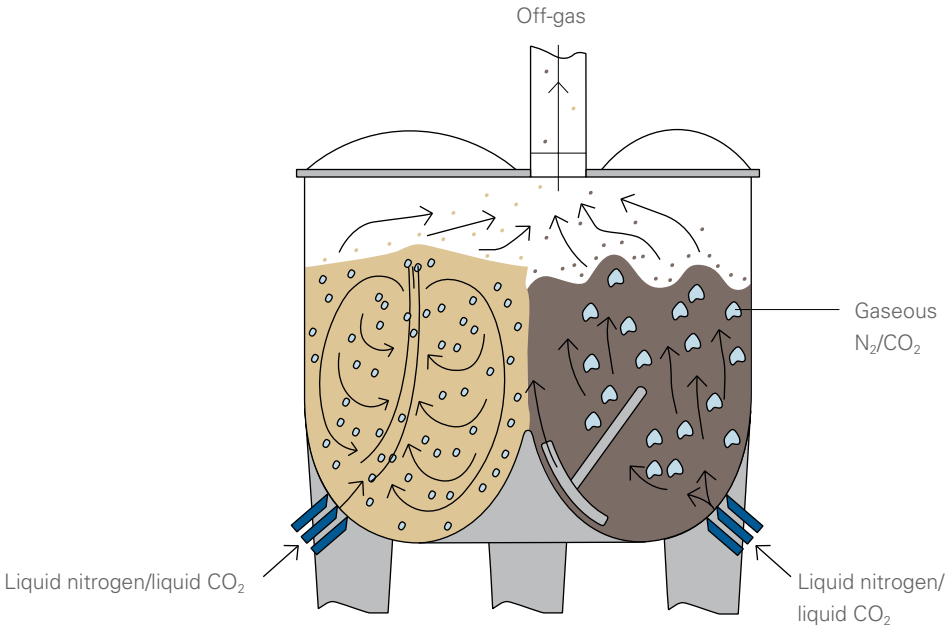
Compared with other methods, such as adding CO_2 snow, water ice or dry ice from the top of an open mixer, bottom-injection cryogenic systems using CO_2 – and more recently liquid nitrogen – rapidly remove heat from foods with a high level of control and process repeatability.

These systems may deliver between 20 and 40 percent more chilling efficiency than alternate chilling approaches, as well as help processors improve production, appearance and yield. Advanced injection systems offer hygienic design for easier cleaning and improved food safety. Equally important, advanced cryogenic control systems may deliver much higher process repeatability than just a few years ago.

Besides mixers and blenders, these cryogenic chilling systems also can be used on kettles and applied across a range of categories and food items, even including traditionally difficult products, such as dense, high-moisture and high-protein mixes.

Contents.

Faster and more efficient cooling



Fast, reliable, and highly efficient: bottom injection chilling.

Injecting cryogens into the bottom of a mixer, blender or kettle is far more efficient than other chilling methods, such as tempering and mixing frozen meat blocks, adding water ice or dry ice, or spraying a cryogen from the top. That's because injecting liquid nitrogen or CO_2 into the bottom of a mixer better leverages the thermodynamic properties of liquid N_2 (minus 320 °F) or CO_2 (minus 109.6 °F).

The cryogens start chilling the moment they are injected – and continue chilling as they disperse and blend with the food product. Bottom injection uses most of the chilling BTUs of the cryogen as it immediately contacts the food product.

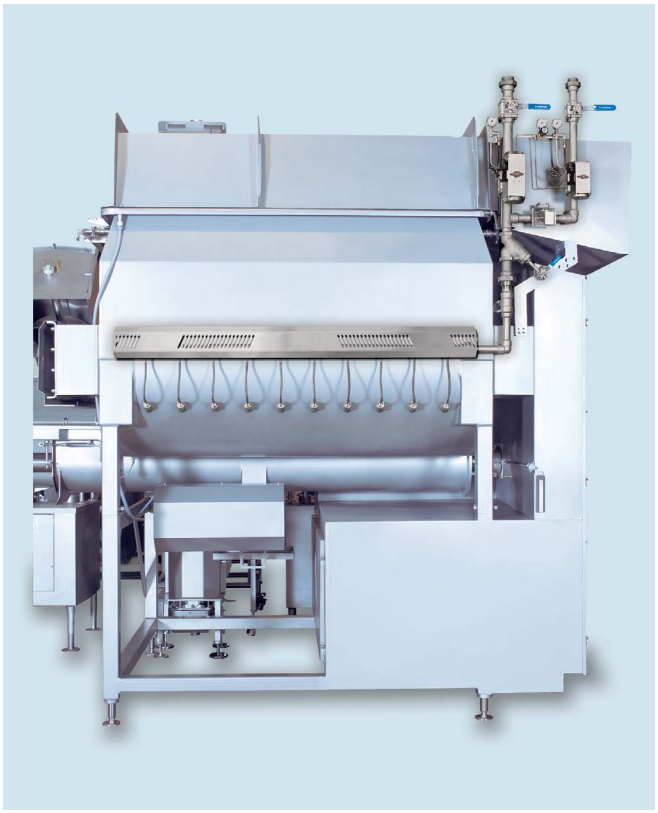
In contrast, top injection methods lose refrigeration capacity while traveling through the air medium prior to contacting the food product and dry ice pellets start to sublimate the moment they are made – usually offsite and transported to the customer – and in-mixer or blender chilling, inconsistent product temperatures can result in variations in cycle times, overworked product, product build-up on walls, fat plating out or smearing, and other problems downstream.

Cryogenic bottom-injection mixer chilling systems are not all the same, however, and advanced systems offer many advantages. See page 05 for tips on selecting the right system.

Which food products benefit most?

Red meat, poultry, and seafood	Including poultry and hamburger patties, sausages, chicken nuggets, ground products, meatball or ethnic recipes such as gyro meat or burrito meat filling, shrimp products, seafood mixes, and other formed items.
Prepared foods, ethnic foods, beans and mixes	Including pizza toppings such as sausage crumble; meat, bean or cheese mixes for burritos or tacos; sauces, gelatins, puddings and pie filings; fruits and vegetables; soups, spices, sugar mixes, etc.
Bakery products and dough	Including bread, pizza and cookie dough, batter, cake and waffle mixes.
Dairy	Including ice cream, yogurt, frozen desserts, and cheese blends.
Pet food	Including both wet protein mixes as well as mixes that may be later dried.

How to pick the right chilling system for your process



The goal of advanced bottom-injection cryogenic chilling systems is to improve temperature control while minimizing operating costs. At the same time, food safety and hygiene are important factors for consideration.

Key system design elements

- Cryogenic injectors should be designed to avoid food entrapment.
- Cryogenic control systems should be designed for consistent flow, and to avoid variations due to batch weight, line fluctuations and other factors.

Precise flow of cryogen at every injection point ensures consistent temperatures throughout the batch -- and that consistency must extend across every batch. Advanced systems are more efficient on both counts.

At the plant, the design of an effective cryogenic bottom-injection chilling system begins with a detailed understanding of process parameters, including food type(s), production volumes, incoming food temperatures, equilibration targets, chill times, and other equipment and process details. Raw proteins, bean products and wet mixes may warrant special attention. Every plant and food production process is different, so engineering expertise is crucial to matching the system to the process and maximizing value.

New mixers/blenders are often available with integral bottom-injection chilling systems. However, advanced cryogenic chilling systems that incorporates proprietary technology and controls are available and can be customized to existing mixing/blending equipment within the existing line. Upgrading with this advanced technology, coupled with engineering and process experience, can benefit even systems installed just a few years ago.

Of course, hygienically-designed injectors alone can contribute to plant hygiene and food safety efforts, but in combination with precision control, advanced cryogenic systems can greatly improve process repeatability.

Flexibility for a range of processing equipment

Chicken nuggets

Baby food

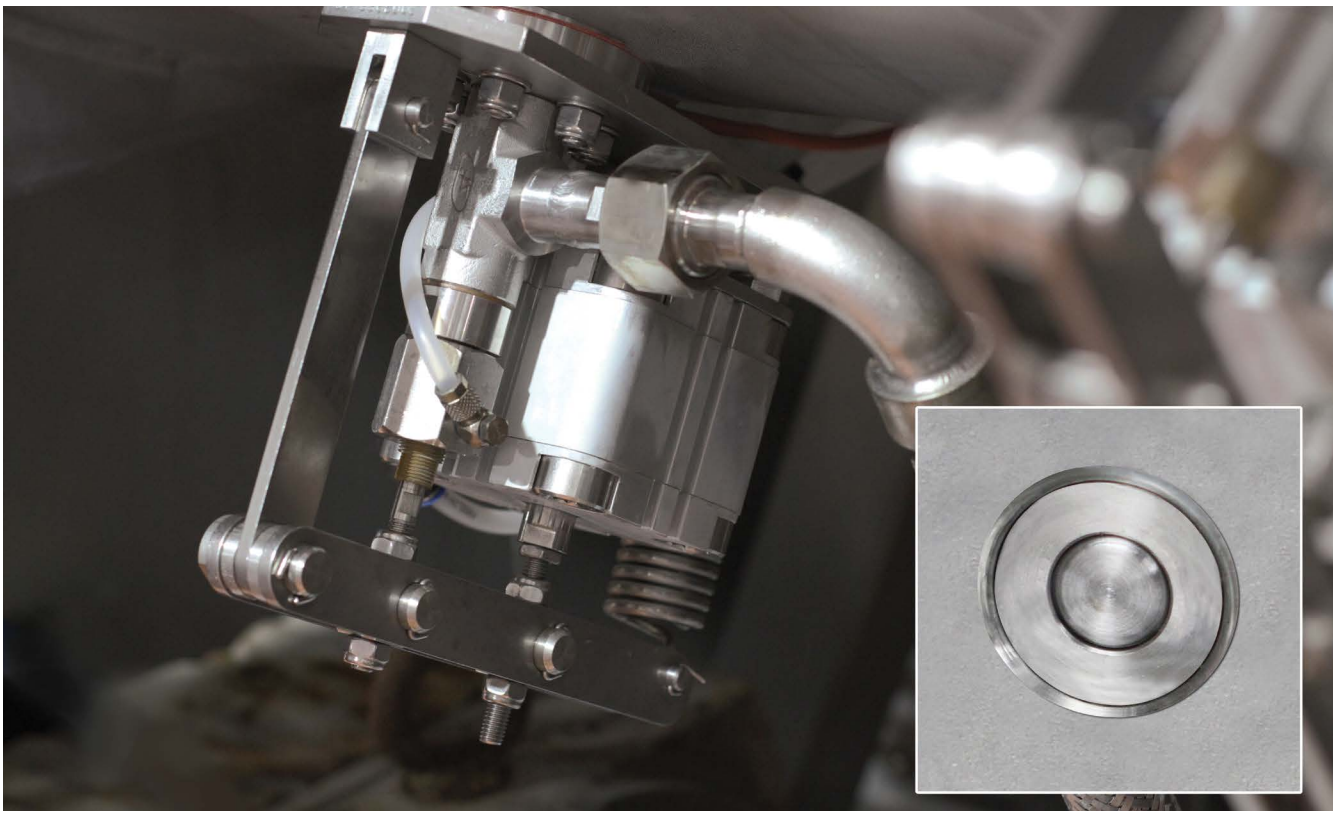
The array of equipment which can directly benefit from an advanced bottom-injection chilling system is diverse – and emphasizes the need for custom engineering. The number, type, position and design of nozzles and injection system are critical to high performance and repeatability. In addition, the same mixer/blender might be used for different products or recipes. Advanced bottom-injection chilling systems can store parameters for each recipe, and offer easy-to-use operator control interfaces.

Advanced bottom-injection systems can be installed on new mixers or retrofitted to a range of existing equipment. They can also be equipped for kettles, tumblers, grinders and other processing equipment as well as continuous mixing and blending operations. Any of these may then feed forming, packaging equipment or other processing equipment downstream.

Most foodborne pathogens reproduce quickly at warmer temperatures, so rapid chilling after cooking or during mixing can be important to food safety efforts. Advanced bottom-injection chilling systems can begin chilling almost immediately after cooking. Cryogenic bottom injectors are installed at strategic points to maximize chilling efficiency. Cryogenic systems are also significantly faster than glycol or brine-based jacketed cooling systems.

Finally, because new precision injection systems can produce highly consistent product temperatures from batch-to-batch, they also can improve the repeatability of forming equipment. The result is smoother release, more precise and consistent product weight and shape and more consistent production rates.

Evaluating hygienic design



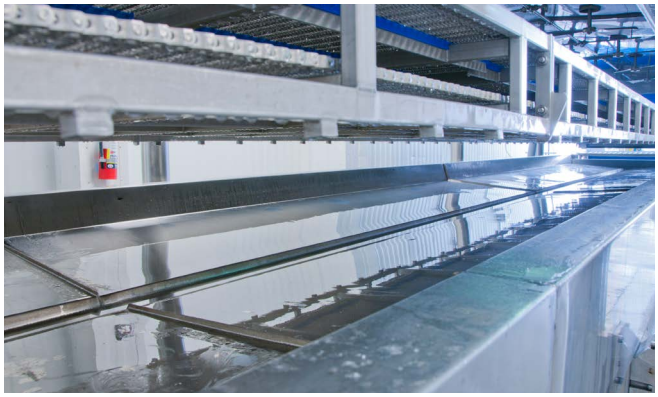
Unlike other cryogenic BI nozzles, this self-sealing injector is designed to prevent food product from penetrating injector orifices.

Maintaining sanitary operations is integral to mitigating food safety risks in mixer chilling operations. The meat and poultry industry, in particular, is sensitive to food recalls, and processors are quick to adopt new equipment and methods that can reduce potential pathways of contamination.

The hygienic design principles on the opposite page were developed by the North American Meat Institute (NAMI) as general guidelines for food equipment.

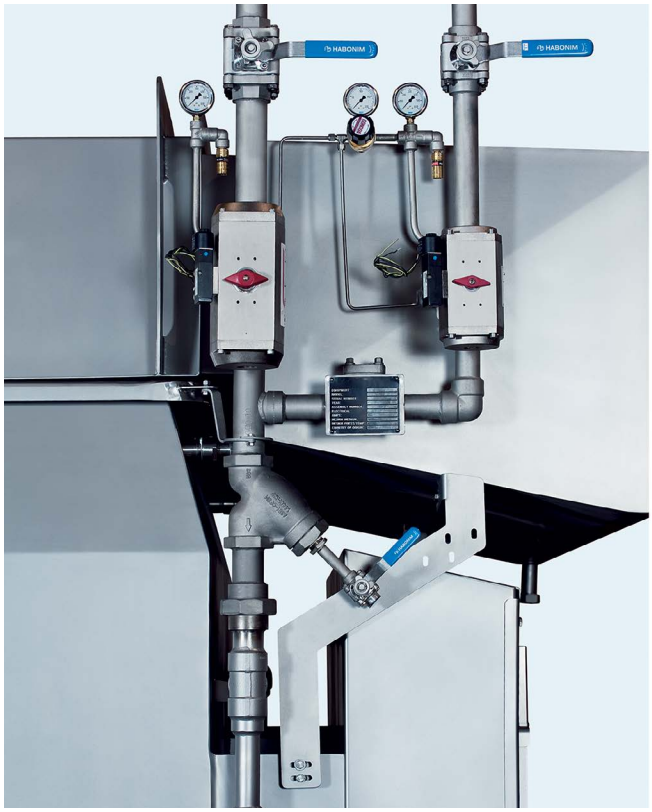
For cryogenic bottom-injection mixer chilling systems, cleanability and minimizing moisture or accidental food debris accumulation are key factors. Injectors should be inspected periodically, and old or worn injectors replaced. New hygienically-designed injectors mount flush with the inside surface and are self-sealing. This mitigates the risk of water-soluble protein or protein particles from entering the nozzle orifice and impeding the cryogen flow.

Sanitary equipment design principles



1. **Cleanable to a microbiological level.** Designed for effective and efficient cleaning to prevent bacterial ingress, survival, growth and reproduction on product and equipment contact surfaces.
2. **Made of compatible materials.** Equipment should be completely compatible with the product, the environment, cleaning and sanitizing chemicals and methods.
3. **Accessible for inspection, maintenance, cleaning and sanitation without the use of tools.**
4. **No product or liquid collection.** Equipment should be self-draining to assure liquids do not accumulate, pool or condense.
5. **Hollow areas must be eliminated or hermetically sealed.** In addition, mounting plates, brackets, must be continuously welded to surfaces, not attached with drilled and tapped holes.
6. **No niches.** Parts should be free of pits, cracks, corrosion, recesses, open seams, gaps, lap seams, protruding ledges, inside threads, bolt rivets and dead ends.
7. **Sanitary operational performance.** During normal operations, equipment must not contribute to unsanitary conditions or the harboring and growth of bacteria.
8. **Hygienic design of maintenance enclosures and operator controls.** Design should ensure that product residue or water do not penetrate or accumulate in, on or around.
9. **Hygienic compatibility with other plant systems.** Consider sanitary design risks that may be associated with the normal operation of sub systems such as exhaust, drainage and automated cleaning systems
10. **Validated cleaning and sanitizing protocols.** Procedures must be clearly written, designed and proven effective and efficient; chemicals must be compatible with the equipment and manufacturing environment.

Installation



Some cryogenic system suppliers offer turnkey services through start up and on-site testing, as well as training, technical support, and, if needed, food laboratory testing. Suppliers also must ensure that the quality of their gases – food-grade CO_2 or N_2, which are considered food ingredients under the Food Safety Modernization Act – meet the FSMA standards.

An advanced bottom-injection chilling system can be installed or retrofitted to many types of equipment, often in a matter of days. In addition to the bottom injectors and control system, installations include delivery of the cryogen from an on-site storage tank through insulated or vacuum jacketed piping to the plant processing area.

To ensure a safe work environment, properly-engineered exhaust systems are required. Proper ventilation is critical since CO_2 or N_2 gases can both be asphyxiants in high concentrations, and ambient CO_2 levels must be managed within OSHA limits.

Bottom-line advantages

Rapid and accurate control of ingredients and food temperature within each batch and batch-to-batch is one of the most important factors inplant productivity and food safety. Advanced cryogenic bottom-injection chilling systems take process and product temperature control to a higher level by improving temperature control and repeatability at the mixer or grinder, which can also improve downstream forming and packaging operations – and reduce downtime.

And with a bottom-injection chilling system, the cryogen is used only as needed which helps keep operating costs low. Chilling on demand also eliminates the need for employees to move and shovel water ice or dry ice around the plant, along with the associated risk of motion injuries. It also reduces the risk of batch contamination by microorganisms from the manual ice shoveling or chopping and tempering of frozen meat.

The design of injector nozzles is critical since moist food particles trapped inside can not only plug nozzles but pose a food safety risk. Conventional injectors need to be removed, disassembled, thoroughly sanitized and reinstalled daily. In contrast, new cryogenic injectors with advanced hygienic design mount flush with the inside wall of the blender and provide a positive seal so there is no backflow – and no need to dissemble them. Except for the face of the injectors, daily cleaning is unnecessary. This greatly reduces the time and labor required for maintenance and sanitation.

Advantages of bottom injection cryogenic chilling

- Lower operating costs
- Precise temperature control
- More uniform batches
- Faster processing
- Reduction in labor
- Improved worker safety
- Increased food safety
- Quality control / process repeatability
- Optimal texture for forming
- Smoother release
- Better appearance

Messer LLC (formerly Linde) supports the Global Food Safety Initiative (GFSI) and the advancement of food safety. Messer has a Food Safety Management System in place for all bulk carbon dioxide (CO_2) plants and air separation facilities supplying the food & beverage industry in North America. In June 2012, Messer became the first supplier to certify all of its CO_2 plants to a benchmarked GFSI scheme, FSSC 22000 (Food Safety System Certification).

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