CryoBlend™

Injection System for Protein Blending

Red Meat and Poultry

Cryogen Injection to Enhance Meat Mixing Operations

Temperature Control Methods in Meat Mixing and Processing

Temperature control in meat processing and mixing is important for flavor, texture and appearance. With the modernization of large scale processing plants and the potential cost of bacterial outbreaks, product recalls, and diminished consumer experience, temperature control is even more critical than ever before. While early food processing plants relied on water ice and a sharp eye, today's food processors benefit from automated, cutting edge technology. While the transformation hasn't been overnight – the industry generally moved from water ice, tested glycol based chilling, and then selected dry ice pellets. Each approach brought some benefits albeit with some lingering limitations.

Today's meat processor has pushed past those limitations using a highly efficient automated CO_2 snow system for temperature control during mixing. By metering a fine dust of cold "snow" particles (-109°F) temperature control became easy and precise. When this approach became limited due to industry wide CO_2 shortages (and hence cost), engineers continued to innovate, using readily available liquid nitrogen (-320°F) to achieve efficiency and performance on par with CO_2 snow systems. Now, processing plants have options to achieve the highest food safety, product conformity and quality standards while minimizing operational costs.

Both fresh and raw-cooked meat products benefit from temperature control in processing. If uniform cooling is not achieved during the mixing and forming process, fresh meat products such as sausage are susceptible to degradation including fat smearing and bacterial growth. Raw-cooked meat products (i.e. products that are processed raw by grinding and mixing and then subsequently cooked) have an additional concern of negatively impacting water holding capacity with uncontrolled processing temperatures. Additionally, processors who are forming product after the mixing process often require lower average product temperatures and lower temperature variability to ensure product shape reproducibility and consistency.

Today's meat processor is under mounting pressure to produce high quality, consistent product at minimal costs while avoiding unscheduled downtime, waste and spoilage. As successful brands are nationalized, there is additional expectation that product made in one plant will have a consistent shape, texture, flavor and color as the product made in a sister plant hundreds of miles away.

Traditional Carbon Dioxide Uses

There are two main CO_2 applications for temperature control in the meat mixing process. The first approach is the use of CO_2 dry ice pellets that are mixed into the batch during the mixing process. This approach, however, is a potential vector for bacterial contamination, typically requires significant manual labor to shovel the ice, and may result in batch inconsistency (i.e. cold spots) and batch to batch temperature variations.

The second approach is a more modern, automated approach that involves the injection of CO_2 snow into a mixer to achieve optimal performance and temperature control. These CO_2 snow systems are relatively straight forward relying on a liquid CO_2 supply tank, a distribution system (hose) and delivery manifolds installed inside the meat mixer. As liquid CO_2 transitions through highly engineered delivery nozzles into the mixer, it experiences a drop in pressure and is turned into a fine CO_2 snow. This snow has direct contact with the meat mixture. As heat transfers from the meat mixture to the CO_2 snow, the snow sublimes (i.e. turns from solid to gas) efficiently removing process heat. Plants appreciate the operational ease and finished product consistency afforded with CO_2 meat mixing.

Industrial demand for CO_2 has increased in recent years. Besides being used in food/beverage applications, CO_2 is used in oil and gas recovery, pharmaceutical production, and waste water treatment applications– to name a few. CO_2 is typically a by-product of an industrial process such as fermentation, refining, or chemical manufacturing. Industrial gas suppliers will further process the raw CO_2 stream to produce liquid CO_2 suitable for food/beverage applications.

In contrast, liquid nitrogen is typically produced at an air separation plant with air being the primary raw material. Hence, liquid nitrogen supply tends to be less susceptible to supply disruptions. Many food processors have experienced disrupted CO_2 supply in the past few years. To cope, processors have had to rearrange production schedules, change product mix, or in some cases curtail operations.

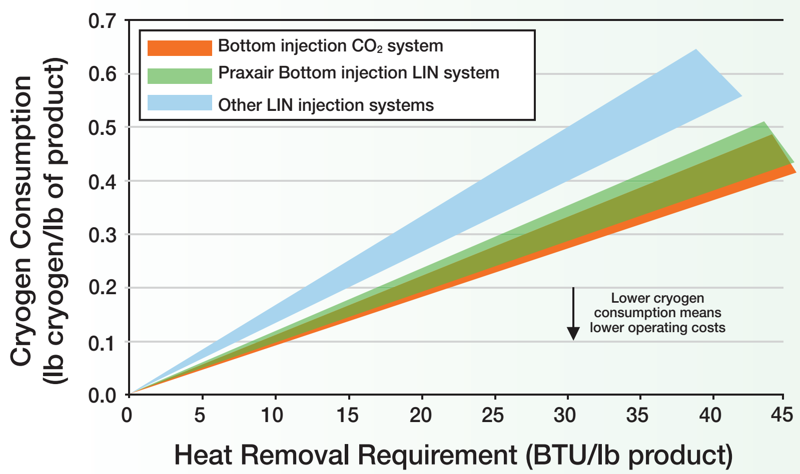
A New, Efficient, and Reliable Option

Liquid nitrogen (LIN) is an alternative cryogen used in the food processing (typically in food freezers). Historically, liquid nitrogen's use for meat mixing has been limited due to inferior efficiencies and excessive costs. Previously liquid nitrogen injection was 30% less efficient than CO_2 snow, or in other terms, a processor could expect to extract about 100 BTU/lb liquid CO_2 (LCO_2) but less than 70 BTU/lb of liquid nitrogen. The two major differences between use of LCO_2 and LIN for mixer cooling are

a) For LIN, a large portion of the refrigeration capacity is in the vapor phase (~50%), compared to LCO_2 for which the majority of the refrigeration capacity (~90%) is in the solid phase (CO_2 snow). In a mixer, where there is no means for recirculating the vapor phase, it is difficult to recover the vapor phase refrigeration capacity. Thus traditionally, LIN efficiency for mixer cooling has been significantly lower than LCO_2 efficiency.

b) Heat transfer rates are much faster with LIN than with LCO_2. This is because (i) temperature of LIN is much colder than that of dry ice and (ii) the vaporization of LIN into nitrogen gas is significantly faster than the sublimation of dry ice. Due to these two reasons LIN tends to cool the food product much faster than LCO_2. Due to its lower heat transfer rates, even if a large amount of LCO_2 is injected into the mixer at once, there will be significant time to allow the mixer to uniformly distribute the resulting CO_2 snow evenly throughout the mixer before it all sublimes and cools the product. In other words, the characteristic time for dry ice sublimation in mixers is of the same order or slower than the characteristic time for mixing. This allows fairly uniform cooling with LCO_2 even if a large amount is injected through a smaller number of nozzles. However, due to the faster LIN vaporization rates, the characteristic time for LIN vaporization is significantly faster than the characteristic time for mixing. Thus, when a large amount of LIN is injected through a nozzle, the LIN tends to quickly freeze the product closest to the point of injection. In addition to being inefficient, early efforts to cool with LIN resulted in non-uniform cooling, nozzle plugging and overall unsatisfactory product quality.

N_2 Efficiency



Recent advancements in liquid nitrogen meat mixing technology now provide processors with an attractive, cost-efficient alternative to CO_2 snow. Praxair has developed a proprietary liquid nitrogen injection technology that is on par with CO_2 meat mixing technology in every aspect including cryogen efficiency. Praxair's new *CryoBlend*™ Injection System for meat mixing allows the use of liquid nitrogen in place of liquid carbon dioxide without an increase in operating costs. Engineers have also overcome ice plugging, non-uniform cooling, inferior product quality and other technical challenges previously associated with liquid nitrogen injection.

Meat processors conducting mixing at their plants now have more options. With a highly efficient nitrogen injection system on the market, processors facing supply disruptions with CO_2 can choose to add nitrogen supply to their mixing operations to avoid production downtime. Mixers with CO_2 injection systems can be retrofitted with a new LIN injection system. If processors have existing nitrogen supply at the plant, and prefer to use a single cryogen in their operations, liquid nitrogen injection is now an option.

While today's modern meat processor still faces operational challenges, temperature control for meat mixing is not one of them. Given advances in technology, either cryogenic CO_2 or liquid nitrogen offer attractive options for meat processing operations, product safety and enhanced consumer experience.

Benefits of Temperature Control with Cryogen (CO_2 or LIN)

Criteria	Benefit
Fat Smearing	• Melting/degradation of fat is avoided at lower temperature
Product Consistency	• Precise temperature control from batch to batch • Improved product formability
Bacteria Inhibition	• CO_2 or N_2 environment limit growth of aerobic bacteria • Sub-optimal temperature for some kinds of bacterial growth
Appearance	• By mixing in CO_2 or N_2 environment, exposure to excessive oxygen is avoided • Oxidation of oxymyoglobin to metmyoglobin is reduced
Protein Extraction	• Optimized at low temperature

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