Food processing

Part 2: Increasing dry ice yield in food chilling and freezing

Tim Neeser introduces the ChillZilla® CO_2, Chart's new liquid carbon dioxide supply management system.

Over the years liquid carbon dioxide has become more abundant and readily available thanks to the increase in the production of ethanol and other chemical processes where CO_2 is a by-product. Capturing the CO_2 and processing it for applications like food chilling and food freezing is now an everyday global occurrence.

With much of the CO_2-related food processing sector considered very mature, including individually quick frozen (IQF) freezers and dry ice production equipment, a fundamental goal in the food business (aside from identifying and catering for new possible applications for these products) is to maximise on developing greater efficiency.

In fact, another author this issue notes that developing trends and potential applications for CO_2 in the food sector include taking another look at the basics surrounding CO_2 refrigeration and storage capabilities.

A good example of utilising liquid CO_2 in food chilling was implemented around 18 months ago in meat processing. For years the standard process for chilling meat at a sausage factory was to create a mixture of fresh meat and auger in mechanically frozen meat to get the right consistency for the sausage making process. A financial analysis proved that it was more cost-effective to use liquid CO_2 and inject it into the fresh meat to lower the meat temperature as the liquid flashed to dry ice.

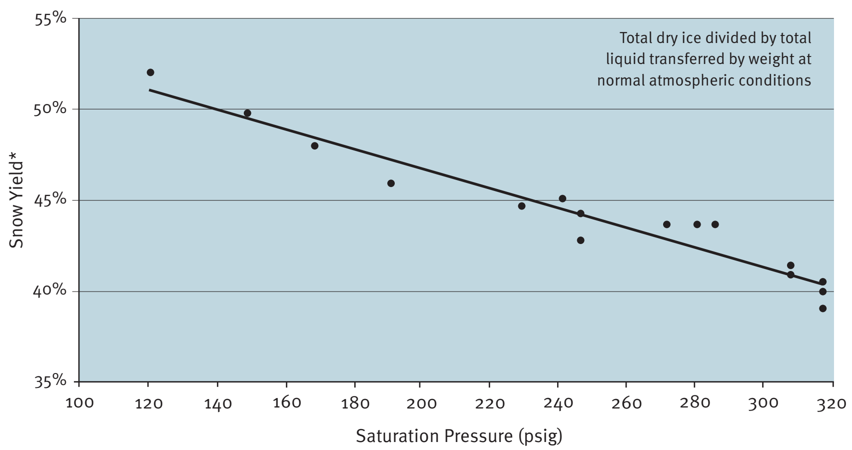
As a result, the sausage company could now use 100% fresh meat, which streamlined the process, increasing production. The additional cost of the liquid CO_2 was offset by the energy savings and the material handling of the mechanically frozen meat.

The liquid CO_2 equipment specified for the sausage factory upgrade has historically been a foam or vacuum-insulated bulk tank with a high-grade carbon steel inner material. For example, SA-612 inner pressure vessel material is used for liquid CO_2 storage under the provisions of ASME Section VIII, Division 1, Part UCS, and safe management of a depressurised tank is achieved using the guidelines described in CGA Pamphlet G-6.7.

Along with the storage tank, an installation like this should include high pressure vacuum insulated pipe to deliver the liquid to the application. In this typical set up, the dry ice yield is about 18.6 kg per 45.4 kg of liquid when dispensed at 300 psig (20.7 barg, 0°F/-18°C) to atmosphere.

It is a thermodynamic fact that if the liquid CO_2 is cooled to a lower pressure and temperature, then the dry ice yield increases. For example, at a saturation pressure of 120 psig (8.3 barg, -44°F/-42°C), the amount of dry ice produced when flashed to atmosphere increases to 23.1 kg per 45.4 kg of liquid.

CO_2 Snow Yield



Dry ice snow yield at atmospheric conditions as a function of saturation pressure for liquid CO_2.

Creating a competitive advantage

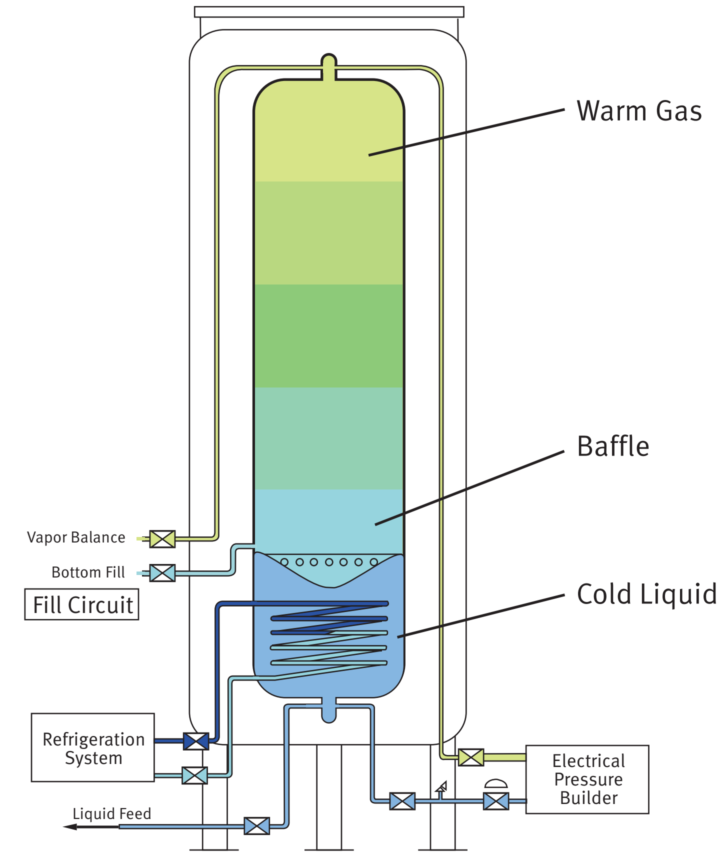
A new product is now being introduced by Chart Industries that represents a much improved system for liquid CO_2 supply management in dry ice applications – the ChillZilla CO_2 storage system.

The ChillZilla incorporates key features to sub-cool the liquid to 120 psig (8.3 barg) before it is dispensed to atmosphere while maintaining the tank top head pressure at 300 psig (20.7 barg) so the downstream equipment does not need flow rate adjustments. By chilling the liquid in the tank bottom with an internal heat exchanger and an external high-performance refrigeration system, the ChillZilla system effectively yields up to 24% more dry ice than older, traditional storage equipment.

One key feature of the ChillZilla storage system is the internal liquid temperature sensor that controls the chiller functions to maintain the liquid at a lower sub-cooled pressure.

Another key feature of the ChillZilla is the internal baffle, located above the heat exchanger, but below the bottom fill line. This design keeps the CO_2 truckload refill (typically hot at 250 psig/17.2 barg) from mixing with the chilled liquid that is staged for use to the application. Other features are a Python® VIP liquid feed line and a stainless steel electric pressure builder designed for low temperature input, making the ChillZilla system installation ready. Finally, because the inner vessel will see low temperatures beyond the traditional carbon steel material limits, the ChillZilla is built with a pressure-strengthened T304 stainless steel inner pressure vessel. The corrosion resistant stainless inner vessel offers purity advantages over the life of the tank in food applications.

ChillZilla CO_2 principle operating schematic



A case in point

So how would the sausage company have financially faired if they had installed a ChillZilla system instead of traditional storage equipment? Let's take a look:

- At a usage rate of one truckload of liquid CO_2 per day (21 US tons/19 metric tons)
- A liquid CO_2 cost of $75/US ton (€61/metric ton)
- $.10 per kWh (€.07/kWh) for electricity to run the chiller and pressure builder
- Plus a few extra dollars/euros for chiller maintenance.

The sausage company could have a net savings $5,000 (€3,700) per month, today. The reduction of up to 24% in CO_2 usage from installing a ChillZilla system can easily be calculated, and after 18 months, the equipment upgrade from traditional storage tanks to a ChillZilla system would have been paid for.

The ChillZilla CO_2 has many benefits beyond just the financials such as reducing the CO_2 emissions per unit of food processed. As the utilisation of liquid carbon dioxide increases in dry ice applications around the world, advancements in technology like ChillZilla can play an important role in production improvements as well as environmental benefits. gw

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