SHOWCASE PROJECT: LINEAGE LOGISTICS: BLAST FREEZING PROCESS AND DESIGN OPTIMIZATION

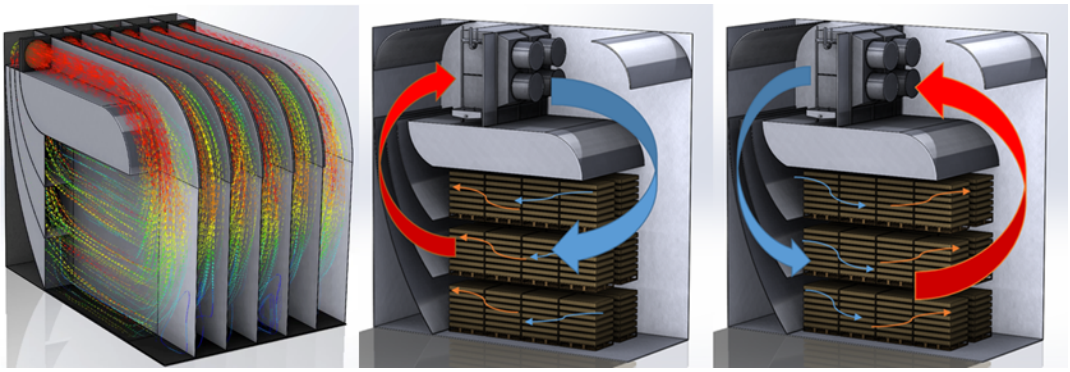
SOLUTION OVERVIEW

BETTER PROJECT WINNER 2020 Lineage Logistics is a warehousing and logistics company specializing in cold storage of temperature-sensitive goods. At their flagship facility in Oxnard, California, concerns were raised over lengthy blast freezing times that were driving up energy costs and increasing processing times for cases of perishable food products. Blast freezing is one of the more energy intensive processes in the cold chain process and is critical to compliance with food quality and safety standards. Once fresh product is received, pallets are placed in big rooms called blast freezers, where very cold air (between -35F and -25F) is “blasted” through the product, effecting the freezing process and allowing for safe storage and transport. High water content and heat properties of the products drives up energy use for blast freezing and can lead to process delays. To address these challenges, Lineage Logistics partnered with customers to redesign both the blast freezer and product case packaging, which reduced freeze times by up to 50% and increased blast-freezing capacity to more than 5 million pounds of product per day at a single facility.

A group of employees at Lineage identified inefficiencies in both the design of the blast freezers and the configuration of food product cases. The team used various mathematical and scientific techniques including data science analysis, finite element analysis (FEA) heat transfer simulations, computational fluid dynamics (CFD) airflow modeling, and wireless temperature probe experiments to analyze the freezer and opportunities to improve its energy efficiency. After determining that the blast cells could be redesigned, Lineage worked firstly with a strawberry distributor to redesign their pallets to include high-flow spacers between case layers, resulting in improved intra-pallet freezing quality and reduced blast-freezing time.

Lineage also engineered a new blast cell design to address common deficiencies found in industry standard models. The multi-tunnel blast cell redesign integrated wind tunnels and actuated louvers within the blast cell racking area. This allows for direct airflow through pallets in the blast cell. Realizing there were still untapped gains in efficiency, further improvements were made to the multi-tunnel blast cell redesign by utilizing shaped vanes in place of louvers and a more robust control system. Lineage refers to the latest design version as the guided airflow blast redesign (ZFD).

Figure 1: Guided airflow blast redesign with directional vanes



SECTOR TYPE
Industrial

LOCATION
Oxnard, California

FINANCIAL OVERVIEW
Project Cost $1,800,000

SOLUTIONS

The blast freezing process and design optimization started as a joint effort with a strawberry company to redesign food cases and incorporate high-flow spacers between case layers. To complement the case redesign, Lineage's Applied Sciences team developed a new multi-tunnel blast cell design that controls airflow via actuated louvers. This addressed an airflow distribution problem that was diagnosed using data science and simulation modeling. The study used airflow and heat transfer simulations and wireless temperature experiments to reveal inefficiencies in industry standard blast cell designs—specifically around poor airflow distribution and uneven freezing quality of products within the blast cells. This led to the eventual solution of a standardized design and practice for improved blast freezing that has been patented and applied across Lineage's portfolio of more than 50 facilities that offer blast freezing services.

Through the multi-tunnel blast cell redesign initiative, Lineage fixed inefficiencies in industry standard blast cell design. The high-flow case and spacer redesign reduced freeze time from 175 hours to 31 hours, an 82% decrease. Additional benefits included improved product quality, increased freezer throughput, and a 20% decrease in freezer energy cost per pallet. With a project cost of $180,000 per cell, the company retrofitted 10 existing blast cells with plywood panels, electrical wiring and sensors, and a controls system that equalizes airflow across all blast tunnels by shifting louver positions.

The upgrades were a retrofit and not a complete removal of old equipment, so implementation was completed within a month after design approval. Compared to industry standard blast cells,

retrofitting of the multi-tunnel blast cells resulted in a 38% reduction in freeze times, from 80 hours to 50 hours. Evaluation of the completed multi-tunnel blast cells after a month of standard operation revealed a 31% increase in the rate of heat removal along with thermal energy throughput improving from 0.415 MMBtu/hour to 0.528 MMBtu/hour. Annual power consumption was reduced by 143,000 kWh in a single cell.

OTHER BENEFITS

The re-design of food cases and blast cells led to the standardization of high-flow spacers and multi-tunnel blast cells throughout Lineage Logistics' portfolio of cold storage facilities. Seeking further process and efficiency gains, Lineage used their findings from the multi-tunnel blast cell redesign initiative to develop a second blast cell redesign, referred to as the new guided airflow blast redesign (ZFD). The ZFD achieved the same airflow performance as the multi-tunnel redesign by replacing the tunnels and louvers with curved vanes designed to guide airflow. The new ZFD design was finalized in July 2019 and approved to be built in a Midwestern beef-freezing facility the same month. Implementation of the ZFD design is not a retrofit and involves the demolition of old machinery before building new blast cells. Compared to the multi-tunnel blast cell redesign approach, the ZFD requires a higher upfront cost of $730,000 ($350,000 for construction and $380,000 for refrigeration equipment).

Lineage recorded ZFD blast performance and compared the system against previous industry standard blast cells at the facility and found that the ZFD blast cell is 20% more energy efficient per pound and 50% faster at blast freezing. Average freeze times in ZFD blast cells were 35 hours while previous blast cells used at the facility performed at an average of 72 hours. One important productivity benefit comes from the fact that the ZFD blast cell can freeze 3,086 pounds per hour of product relative to the previous blast cell's 1,500 pounds per hour.

In terms of energy performance, the benefits can be summarized with the blast efficiency metric—defined as the thermal kWh removed per electrical kWh consumed. The ZFD has a blast efficiency of 1.28, a 20% improvement over the previous blast cell value of 1.07. Based on the proven performance benefits, Lineage is currently implementing the ZFD design at all new construction cold storage facilities and plans to retrofit existing facilities where economically feasible. They are also open to licensing the technology to other companies.

Annual Energy Use

Baseline- 10 blast cells(2016)

2,094,240 kWh

Actual- 10 blast cells(2017)

661,440 kWh

Energy Savings

68%

Annual Energy Cost

(Source does not include additional annual operational savings of $425,000)

Baseline- 10 blast cells(2016)

$236,650

Actual- 10 blast cells(2017)

$74,742

Cost Savings

$161,907