TASMANIA'S BIG CHEESE

Despite the clouds hanging over Australia's local manufacturing industry, our dairy industry is undergoing a rebirth of sorts, with millions invested in meeting growing international demand. Sean McGowan reports on refrigeration's role in the transformation of an iconic facility in Tasmania's north.

Growing international demand, industry consolidation and manufacturing expansion have created a market environment not seen for many years in Australia's dairy industry.

That's the view of Andrew Buckley, national leader for food and beverage at multi-specialist infrastructure consultancy, pitt&sherry.

He says this stems from the growing demand for dairy products in developing Asian nations. In particular, infant nutrition is a boom category.

"Led by a developing Chinese middle class and growing worldwide food security issues," Buckley says, "a mix of industry consolidation and rationalisation, coupled with expansion, has created a buzz not seen in the industry for some time."

For example, a Dairy Australia report from September 2013 revealed that Australian dairy exports to China grew by 17 per cent in 2012 compared to the previous year. This was said to be on the back of growing demand for milk powder, liquid milk, cheese and butter.

Australia's dairy expansion has gathered so much momentum that pitt&sherry is in the unique position of being involved in the past four major facility developments.

The largest was the $120 million redevelopment of the Lion-owned Burnie cheese manufacturing facility, located on Tasmania's north coast.

REDEVELOPING AN ICON

Burnie has had a long association with the dairy industry, harking back to the late 1800s when Captain William Jones established a butter factory on the banks of nearby Cooee Creek.

The Burnie cheese factory was originally built by Czech migrant Milan Vynhalek in 1955 when he established Lactos Cheese to cater for the tastes of Australia's growing migrant population.

Over the ensuing decades and under numerous changes of ownership, the factory expanded organically, with additional buildings and services feeding into the site's specialty cheese-manufacturing processes.

However, in 2012, the forecast increase in cheese volumes and a desire to consolidate all of Lion's specialty cheese manufacturing in Burnie meant the existing infrastructure required renewal.

"The site had finally outgrown itself," says Buckley.

Lion's decision to invest $120 million in the site's redevelopment aimed to double the factory's production capacity from 11,000 tonnes of cheese per annum to 22,000 tonnes per annum.

"While somewhat simplistic," Buckley says, "this also meant a doubling of the building and processing footprint, and a doubling of most of the associated services requirements."

In seeking to develop a world-class facility, Lion sought to lead the way in applying a rigorous quality control and hygiene system. This flowed through to atmospheric conditions for every room of the new facility.

To meet such specifications, the site's existing refrigeration plant required significant upgrade.

Comprising of three reciprocating compressors, and two water-cooled evaporative condensers, some of the plant was at least 40 years old.

The secondary cooling mediums being used included liquid ammonia and two chilled-water systems.

The total rated refrigeration capacity available was 25 per cent of the predicted refrigeration load for the new facility.

Taking into account the new capacity requirements, as well as the age of the plant and a desire to move away from ammonia as a secondary cooling medium, pitt&sherry set about specifying a new refrigeration system.

CRITICAL COMPONENT

HVAC&R is obviously a critical component of modern cheese-making processes.

Refrigeration is required for production processing; it's used in milk pre-cooling, milk storage and pasteurisation.

Refrigeration is also needed for cheese making, including soft-ripened cheese coagulation, pressed cheese brine bath cooling, cool rooms, maturing rooms and climate control.

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Given such a reliance on refrigeration, energy-efficiency and system redundancy requirements were considered key drivers in the system design at Burnie.

"The initial specification was for a traditional central plant layout," says John Wylie, one of pitt&sherry's senior mechanical engineers, in charge of the specification development for this aspect of the project.

This was to comprise of an engine room, evaporative condensers, flooded receiver, compressors, high- (chilled water) and low-temperature (glycol) accumulators, and chilled-water storage tank.

The secondary cooling medium for process cooling and HVAC was specified as 2°C chilled water, and -7°C glycol for the cool rooms.

"The specification gave the tenderer the option of using the existing compressors as swing compressors between the high and low-temperature accumulators," Wylie says. "The intention of this option was to provide redundancy and part-load operation."

Trigeneration tempts

According to pitt&sherry's Andrew Buckley, the consultancy encourages clients to look for the most climate-friendly solutions for projects. The redevelopment of the Lion cheese-making facility in Burnie was no exception.

As such, a thorough feasibility study of trigeneration was included in pitt&sherry's scope, the outcomes of which indicated an economic rate of return.

However, two factors apparently played against a decision to adopt this emerging technology.

The first was the difficulty found in matching existing refrigeration plant to the function of the absorption chillers.

"While both may be based on ammonia refrigerant, the quality of the circulating ammonia differed considerably, meaning the two could not be combined at the refrigerant level," says Buckley.

"This then required a stand-alone absorption chiller for sub-zero temperatures, which is not as commonly used and was possibly perceived as an unacceptable commercial risk."

The remaining cogeneration option was sidelined in favour of work on the moderation of peak heat demands through scheduling of plant operating times.

"This meant that the original perceived need for considerable additional heat capacity reduced, and the needs were able to be supplied by the existing boilers on site," Buckley says. "This reduced the capital investment significantly and was obviously an attractive option."

Despite this outcome, Buckley says the review proved to be an excellent opportunity to bring site staff up-to-date on the benefits and concerns of trigeneration technology.

Initially, a decision was made to use R717 refrigerant (ammonia). It was selected due to its widespread use in modern refrigeration plants and because it's an effective replacement of older HFC ozone-depleting refrigerants.

Chilled water and glycol were specified for the secondary refrigerant in order to minimise ammonia leaks, associated OH&S risks to personnel, and the risk of contamination of product. Because some of the cool room temperatures were required to be as low as 4°C, glycol was also specified for the cool rooms.

"However, during the tender process, some tenderers offered a packaged chiller system as an alternative to the central plant system," says Wylie.

Although the energy-efficiency penalties associated with this option were well understood, there were a number of advantages that demanded closer consideration.

Further analysis and comparison of both options confirmed the advantages of the packaged chiller system. The initial central plant specification was revised.

Tenderers were subsequently asked to submit proposals for packaged chiller options.

PACKAGED SOLUTION

Wylie says that in general terms, the packaged chiller solution adopted for the Burnie redevelopment offered a number of advantages.

Perhaps the most important was that ammonia leakage is contained and scrubbed within each package unit, as opposed to possibly contaminating an engine room or escaping into the general plant.

A lower ammonia charge compared to that of the central plant solution was also considered desirable.

Other advantages included noise emissions being contained in each unit, a lower capital cost, smaller footprint, and fewer infrastructure requirements, such as an engine room building.

PROJECT SPECS

WHO

Client: Lion

Consulting engineer: pitt&sherry

HVAC consultant:
Tazenco (Stage 1) and pitt&sherry (Stage 2)

HVAC contractor: Degree C

Refrigeration contractor:
Tritech Refrigeration

WHAT

Chiller packages: Envirochiller

Compressors: Bitzer + Mycom

Cooling towers: BAC

Fan-coil units: Cabrero

Heat exchangers: GEA

PLC: Siemens

VF drives: Danfoss

"The packaged chiller solution also allows ease of future plant upgrades," says Wylie. "For example, an additional packaged chiller can simply be bolted into place with minimal disruption to the remainder of the plant."

According to Wylie, the packaged chiller solution was chosen due to a number of important factors. These included the lack of available space onsite to install a central plant, and the extensive building modifications required (and associated costs) – as well as disruption to the existing engine room such a solution would have entailed..

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"The trade-off," Wylie says, "was a slight energy penalty."

This penalty is associated with a number of factors, including the higher cooling water flows from the ammonia condenser to the cooling tower, due to the smaller condenser area within the package system enclosure. Increased fan air flow for the cooling tower is also a contributing factor to higher energy use.

Additionally, a central plant offers a larger effective refrigerant heat exchanger area than a packaged solution, due to less restriction on space leading to improved part-load performance.

Wylie says that traditionally, the coefficient of performance (COP) of a refrigeration plant has been determined purely in terms of compressor efficiency.

"While compressor COPs do not vary between each option, to provide a complete assessment condenser/cooling tower fans, cooling water pumps and primary/secondary chilled water pumps need to be considered," he says.

The tender for the Burnie project was eventually awarded to Tritech Refrigeration, whose package solution included two 1,400kW chiller packages, each containing two 7,00kW screw compressors, as well as one 110kW chiller package containing two screw compressors.

Two 1,750kW cooling towers would provide heat rejection.

REFINING EFFICIENCY

Despite the energy penalty associated with this solution, both Lion and pitt&sherry were determined to ensure the most energy-efficient outcome was achieved without compromising redundancy in the event of a compressor failure.

"In terms of part-load performance, an oversized compressor will suffer an energy penalty at low loads, as COP varies with refrigeration demand, and drops off considerably at very low loads," says Wylie.

"This required optimisation of the number of compressors."

To assist in this decision-making process, an hourly analysis of HVAC loads over a full year was carried out using TMY (typical meteorological data year) weather data. This was added to a timing chart developed for process chilled-water loads.

From this analysis, the number of hours per year at particular demand points could be evaluated, and the compressor selection was optimised.

To meet the design demand of 2.6MW, three options were considered.

The first option was four 700kW compressors, while a second option was to run with two 1,400kW compressors. A third option included three 1,400kW compressors.

The first option became the preferred selection, as analysis revealed that four compressors were needed to service loads above the 95th percentile load – predicted to be about 50 hours per year.

"Hence, if a compressor was lost due to breakdown or maintenance, there would be negligible impact on the operations of the plant," Wylie says.

Part-load performance for this option was also considered to be good, as the compressors would progressively shut down to meet lowered demand.

Demand loads also matched the optimal COPs of each compressor.

"The analysis also showed that for 1,500 hours per year, the refrigeration load would be around 100kW – suited to one 700kW compressor," Wylie says. "And for 2,000 hours per year, the load would be around 1,000kW – suited to two 700kW compressors."

Other energy-efficiency measures adopted included the use of variable-speed-drives (VSDs) on the secondary chilled water pumps, as well as on the cooling tower fans and all compressors.

STAGED COMPLETION

The first stage of Lion's Burnie redevelopment, including commissioning of the soft ripened cheese lines, cool store and associated dispatch, was completed late in 2013.

Stage Two of the project, including work on the hard cheese manufacturing line, maturing and packaging processes, was completed late last year. Final commissioning and acceptance testing was set to commence at the time of publication.

Wylie says the plant operation – from a process services point of view – has been reliable and trouble-free to date.

However, he says the estimates of refrigeration loads provided by the process equipment suppliers tendered have been found to be conservative, based on the plant's operation to date.

"During the planning stage of the project, the refrigeration plant could only be sized on the available data at the time," he says.

"However, the Burnie project has emphasised the importance of compressor selection in terms of part-load performance."

The Lion redevelopment of the Burnie cheese-making facility represents a new chapter in the area's 120-year-old dairy industry, and is a positive sign that not all of Australia's manufacturing base is being eroded.

"It is certainly a fascinating time to be part of the changing food and beverage landscape in Australia," Buckley says. "And we are proud to be contributing to this transition with economical and sustainable solutions." ▲