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PULSE/BATCH REFRIGERATION COOLING

TREASURY WINE ESTATES

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ABSTRACT

Pulse cooling provides a new method of controlling temperatures in wine tanks while driving electrical energy efficiency and thereby reducing our carbon footprint.

SUSTAINABLE TARGET

Reduction in energy usage and CO2 intensity..

PARTNERS

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DESCRIPTION AND STRATEGIES

Wine refrigeration and temperature control is the largest energy consumption process for winery operations, with estimates up to 75% of the winery's electrical usage (Boulton et al. 1996). Conventional temperature control systems confound the winery's refrigeration efficiency in two ways:

Returning cooling liquid at a temperature close to the original, outgoing temperature. This requires that the refrigeration system operate at a lower temperature, with correspondingly lower efficiency, which is wasteful in terms of energy and its related carbon footprint.
High coolant flows or volumes are required to meet cooling demand from continuously open control valves. This can result in a larger than necessary cooling systems or the final few tanks in a cooling loop being 'starved' of sufficiently cool liquid during peak operation.

COMPANY SUMMARY

Treasury Wine Estates (TWE) is one of the world's largest wine companies, listed on the Australian Securities Exchange. Everything we do is dedicated to realising our ambition of becoming the world's most admired premium wine company.

WEBSITE

https://www.tweglobal.com/

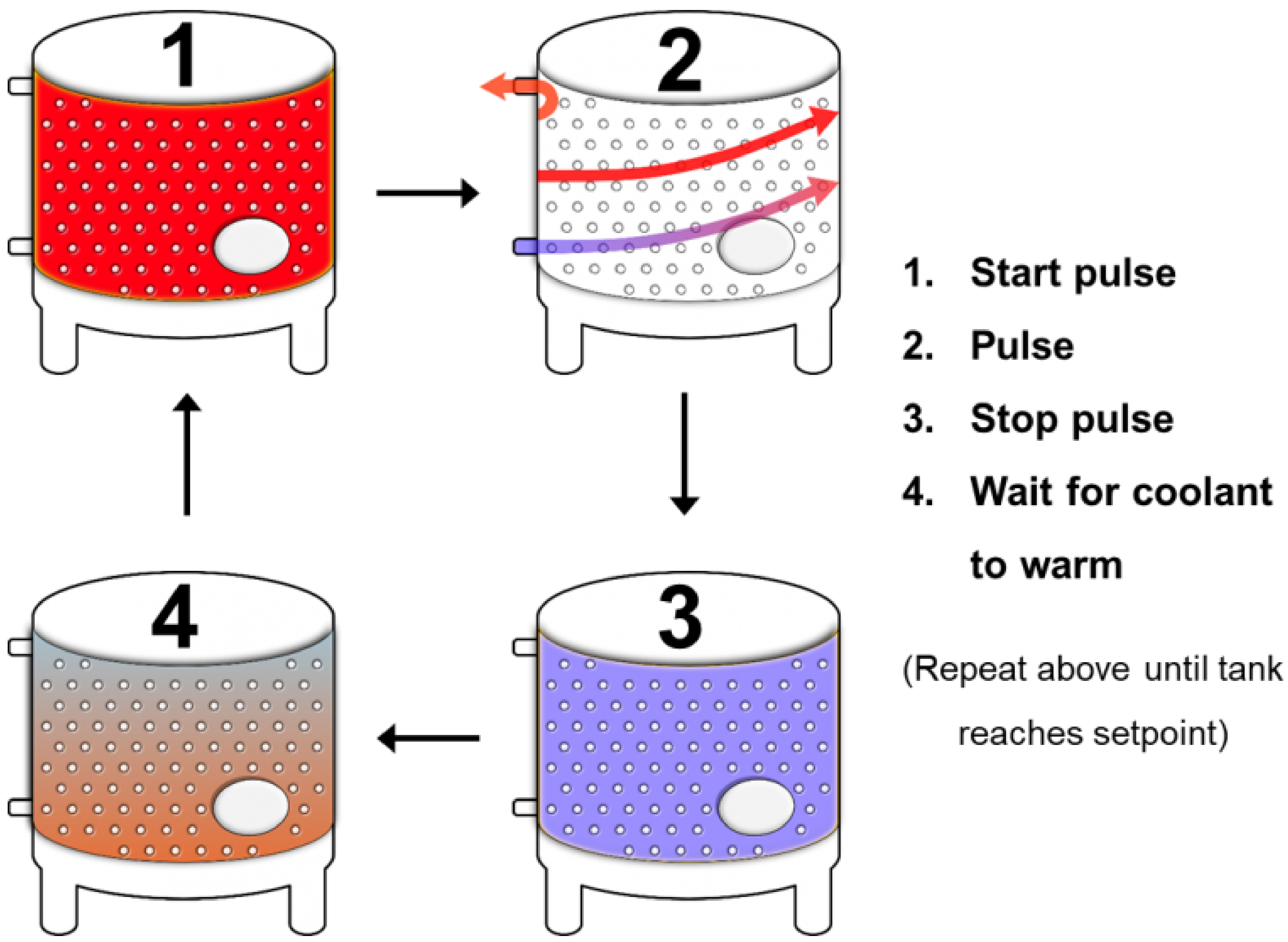
COST

LEVEL OF DIFFICULTY

DESCRIPTION & STRATEGIES

'Pulse cooling' addresses the currently wasteful control practices to reduce the overall electrical energy consumed, while maintaining proper refrigeration control for both storage and fermentation.

Pulse cooling modifies the current tank cooling program (or refrigeration valve control) by adding a 'cascade routine'. This routine changes the conventional 'continuous' flow of coolant (i.e. glycol or brine) to 'batch' flow. A batch of coolant is allowed to fill/replace the volume in a tank's refrigeration jacket or pillow, subsequently followed with a wait time for the jacket temperature to rise before the next batch or pulse. This process exploits time to improve efficiency; time for heat to pass from the tank into the coolant. This allows for a more efficient exchange of heat when it returns to the winery's main refrigeration plant (evaporator, compressor, and condenser). Greater detail on the cascade routine can be found in 'Potential for Replication' below.



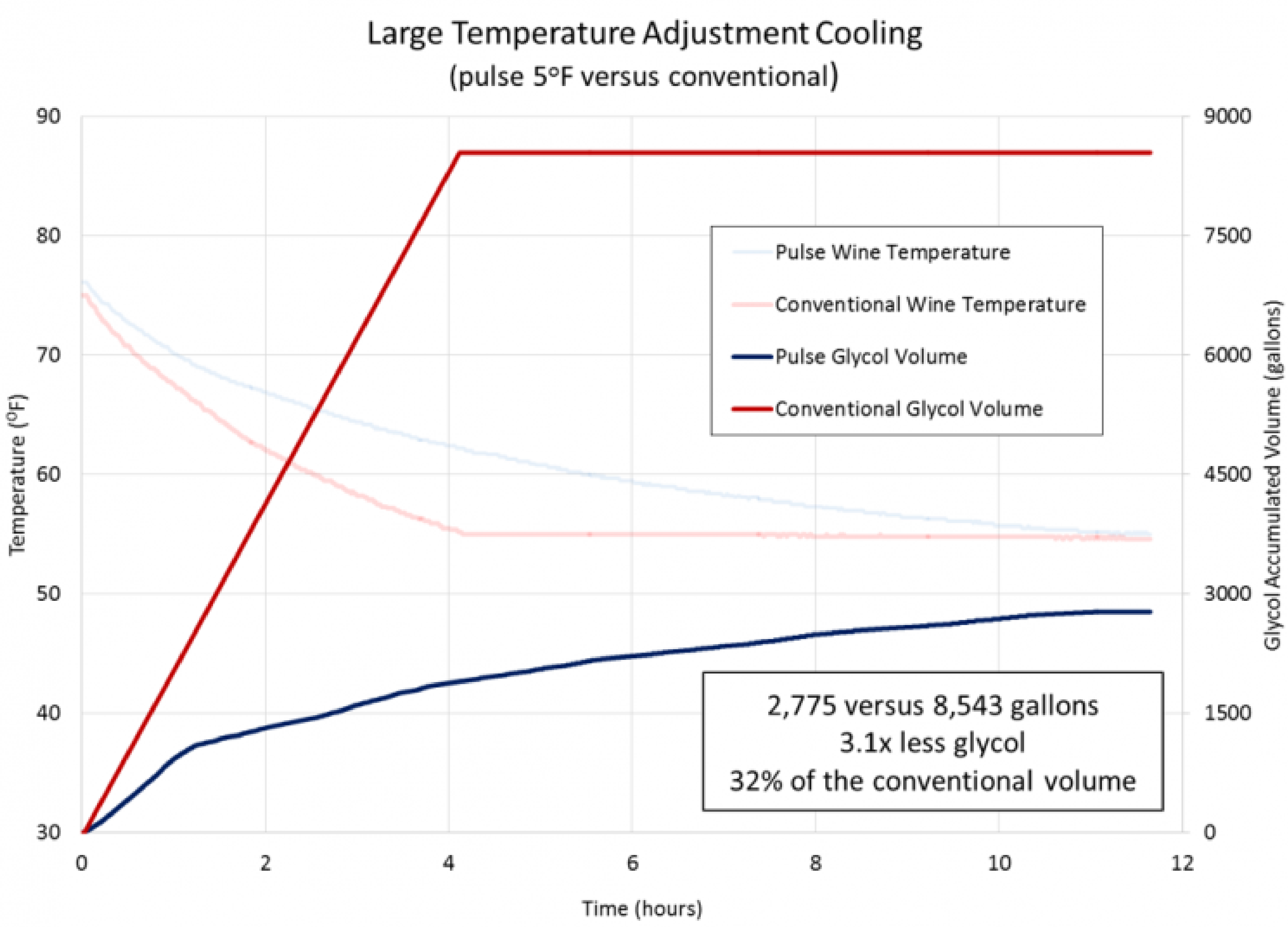
ACHIEVEMENTS SO FAR

- With the pulse control implementation at Beringer Winery, California, we have measured a 3.5 times reduction in coolant volume during normal temperature storage conditions at 55F (13C). Additionally, 3.1 times less coolant volume was used during a tank temperature reduction from 75F (24C) to 55F. This reduction in coolant volume relates to a reduction in the energy requirement on the coolant circulation pump.

ACHIEVEMENTS SO FAR (CONT.)

- The overall reduction in coolant utilization at the single tank level allows for more uniform pressure management of the total coolant loop. Uniform pressure ensures that tanks do not become ‘starved’ of coolant due to upstream neighboring tank usage. This starving of coolant by conventional controls leads to an ‘end of the line’ issues in maintaining temperature control; this becomes more apparent under heavy heat transfer loads (e.g. fermentation).

- Lastly, the coolant temperature leaving the tank under pulse control, in our trial, was on average ~6F (3.3C) warmer than conventional control – this result will change depending on how close the coolant supply temperature is to the set point temperature. The warmer return of coolant to the winery’s main refrigeration plant allows for more efficient heat exchange with the evaporating refrigerant (i.e. ammonia), allowing it to operate at a higher temperature and leading to an overall improvement in compressor and electrical energy efficiency.



LESSONS LEARNED

The benefits of pulse cooling cannot be fully realized if implemented independently of the winery’s main refrigeration plant (evaporator, compressor, and condenser). Currently, it appears that the conventional wine tank refrigeration control system limits the entire winery’s refrigeration efficiency by returning coolant at a temperature close to that at which it was cooled.

LESSONS LEARNED (CONT)

Pulse cooling improves control of the returning coolant temperature and increases this heat transfer efficiency. However, after the implementation of pulse cooling, the next most inefficient element in a winery's refrigeration plant will become more apparent. These inefficiencies may be one or more of the following: compressor/temperature feedback and control programs, evaporator surface area, and/or condenser performance. Increased real-time monitoring of the refrigeration plant components will allow for further optimization of these areas. It may be necessary to consult with your refrigeration engineer or refrigeration consultant on how to appropriately tune your refrigeration package to warmer returning glycol from pulse cooling implementation.

NEXT STEPS

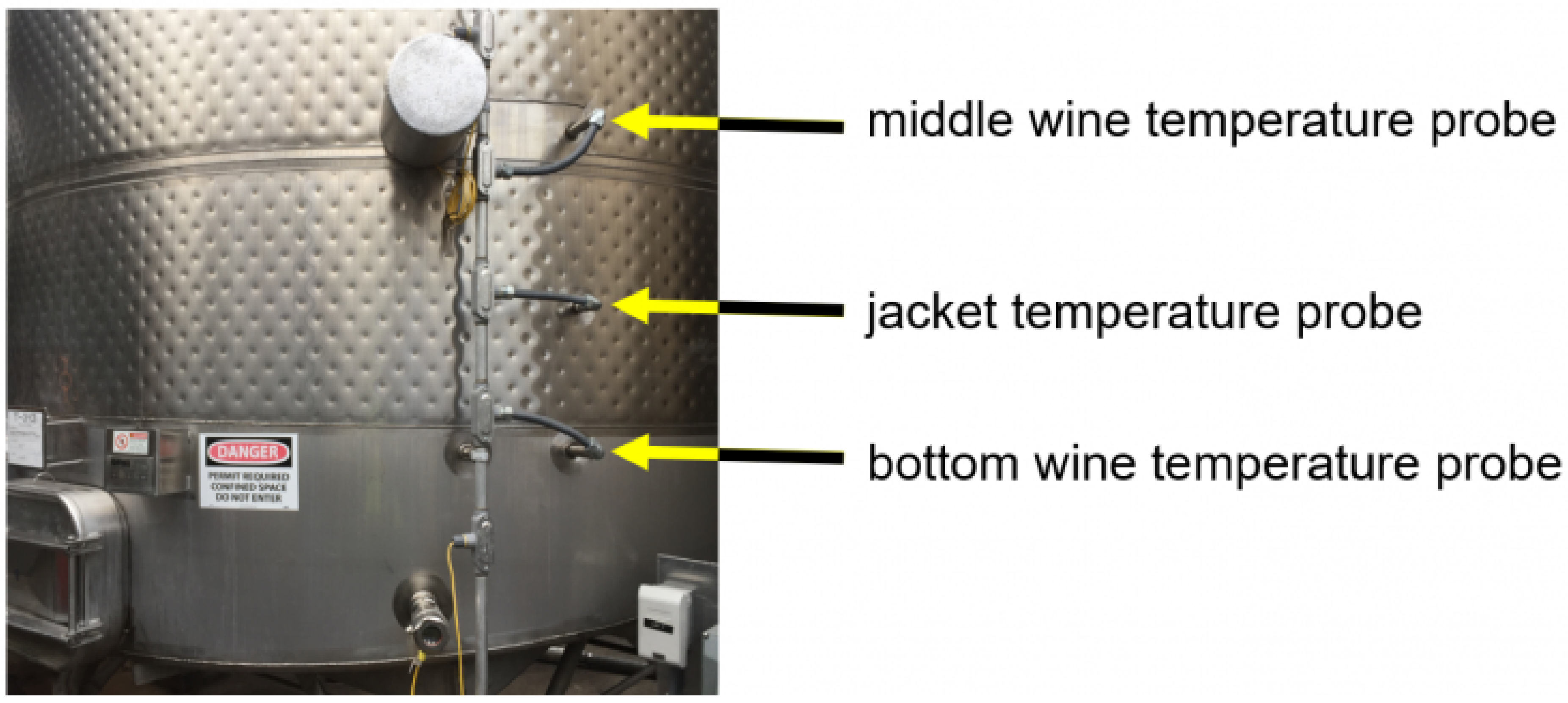
Case study of Beringer Winery (including winery refrigeration plant efficiency performance) – conducted with UC Davis
Engineering modeling and empirical testing of pulse cooling at small tank scale (50 gallon) and commercial tank scale (8,000 gallon) – conducted with UC Davis

POTENTIAL FOR REPLICATION

In the wine industry, there are at present at least 3 methods of pulse cooling, each with various levels of implementation ease and various levels of projected efficiency improvement. Below, we explore each of these methods based on ease of implementation, starting with the easiest.

- Timed pulse – the cascade routine opens and the closes the coolant valve for a static prescribed time to refresh the coolant in the tank's refrigeration jacket or pillow – this is a 'pulse'. As well, the cascade routine keeps the coolant valve off between pulses for a prescribed 'wait' time. There is no dynamic response to change the time of the pulse or the wait time between pulses. It should be noted that if the tank is at the desired temperature set point, the cascade routine is no longer running; it only runs as a subroutine under the main temperature control routine.
- Tank temperature pulse – the cascade routine modifies the wait-time between pulses based on the temperature change from the tank's primary (wine) temperature sensor (i.e. thermocouple or RTD).
- Jacket temperature pulse – perhaps the most difficult to implement but also likely the most efficient method. The cascade routine in this method modifies the 'wait' time between pulses based on the jacket coolant temperature itself. A second 'coolant' temperature sensor monitors the coolant warming in the tank's jacket.

POTENTIAL FOR REPLICATION (CONT)



This allows the cascade routine to refill (or pulse), fresh coolant into the jacket coolant when the temperature difference from coolant to content (i.e. wine) is no longer enough to cool the content effectively. This method is currently in place at Beringer Winery. Future work will benchmark this method against the other two methods described above.

The potential for replication is high across the wine industry, and various levels of entry and implementation exist. The first two methods are essentially software changes to existing control systems. The third requires the addition of an additional temperature sensor in the jacket and software changes. The first two methods are inexpensive to implement, while the third will require more capital for the addition temperature sensor and electrical infrastructure. The third method would be ideal to implement for new tank builds.

Boulton, R.B., V.L. Singleton, L.F. Bisson, and R.E. Kunkee. 1996. Principles and Practices of Winemaking. Chapman & Hall, New York. Springer, Boston, MA.

(see the presentation).