Eco-efficiency for Australian dairy processors

Fact sheet 8: Optimisation of CIP systems

What is a CIP system?

A 'clean-in-place' or CIP system is an automatically operated cleaning system that delivers a number of wash and rinse cycles to the internal surfaces of processing equipment such as cleaning tanks, piping, filling machines, pasteuriser and homogenisers. CIP systems largely eliminate human contact with cleaning agents and can save the labour costs required for manual cleaning. One of the main advantages of CIP systems is that they can recirculate the cleaning solution through a series of holding tanks and associated pumps and piping to allow the reuse of chemicals and water, thereby reducing water and chemical consumption.

Chemical recovery plant

CIP systems may be classified as single use, multi-use or full recovery. Single use (SU) systems dispose of water and spent solution to drain after one use, while multi-use (MU) systems recover final rinse water and appropriate-quality chemical solution for reuse. Full recovery systems typically use membrane technology to recover chemicals, water, and potentially product. Such systems can recover as much as 99% of cleaning solution, most often caustic.[1] The retentate, which contains highly concentrated nitrogen and fatty compounds, is treated as sludge.

Typical cleaning cycles in a CIP system for dairy processors consist of a water rinse followed by a caustic wash, a second water rinse, an acid wash, a third water rinse and often a final sanitiser rinse. Caustic washes are usually carried out at least once a day, whereas acid washes are less frequent and may be carried out once or twice a week.

Reuse of water by CIP system

Pauls in Stuart Park previously utilised a single use CIP system where all water and chemicals were used once and then discharged to waste. The system has been replaced with a multi-use CIP system that recycles final rinse water for the pre-rinse cycle. All chemicals used in the system are also returned and circulated through holding vats, where temperature and conductivity are monitored and automatically adjusted to meet specifications. The new CIP system saves Pauls $40 000/yr, with a payback period of only one year.

Detection of interfaces

To control CIP cycles, interfaces between product, chemical and wash water are usually detected using conductivity or turbidity meters, while other systems use timers. The effectiveness of conductivity and turbidity meters compared with timers is a topic of debate. Timers may not provide a consistent or repeatable quality of clean, due to factors such as varying flow rates and pump or valve wear; while meters can fail, causing operating delays or unnecessary loss of product, chemicals or water to the waste stream. In addition, over time, instrumentation can 'drift' out of calibration or timers can be adjusted (lengthened) to compensate for operational factors. Regardless of which system is used, it is important to validate and regularly review the CIP system.

'When optimising CIP systems, take one step at a time and don't try to make too many changes at once.'

Alison Dilger, National Foods, Morwell

1 G Daufin et al. 'Recent and emerging applications of membrane processes in the food and dairy industry'. *Trans IChemE*, vol. 79(C2), 2001, pp. 89–102.

Reviewing CIP effectiveness

There are numerous factors that influence the cleaning process, and many of these are interlinked. Changes should not be made without considering the overall impact on cleaning effectiveness and product quality. For further case studies demonstrating the savings that can be made by regularly reviewing CIP systems, see Fact sheet 9, 'Chemical use'.

There may be opportunities to improve the efficiency of CIP systems by reviewing:

- chemicals and blends, to ensure they are the most effective for the specific cleaning application while also minimising environmental impacts and ensuring operator safety
- chemical concentrations, to ascertain whether they can be reduced for specific applications without affecting cleaning effectiveness. Automated chemical dosing systems should also be regularly monitored
- cleaning cycle length, to ensure they have not become inefficient or excessive over time; this commonly occurs to compensate for modifications to processing equipment or to help rectify product quality issues
- in-line monitoring instrumentation, to ensure it is well maintained and regularly calibrated
- temperatures, to ensure they are not excessive (which not only increases energy consumption but also can increase the corrosive nature of chemicals) or alternately too low (which may reduce the effectiveness of cleaning)
- opportunities to recover more rinse water and spent solution
- water treatment effectiveness
- operator training and supervision, to ensure efficient and safe use of CIP systems
- equipment operation and maintenance. Equipment such as pumps, spray balls, nozzles and hose connections should be regularly monitored and promptly repaired. Equipment such as nozzles should be selected to suit the application, particularly with regard to the temperature and corrosive nature of the cleaning fluids.

Validation of CIP system

During the early stages of commissioning the National Foods Morwell plant, there were problems with product quality and cleaning times and concentrations were increased. As the quality issues were resolved it was found that many concentrations and times were above recommended levels. These were able to be reduced without compromising product quality. The costs of implementing the changes were just the time and tests required to validate the changes. There were challenges in convincing others that the changes would not affect the finished product. The savings were in the order of $100 000/yr.

Fine-tuning of CIP system

National Foods in Penrith, as part of a regular audit of CIP systems, reviewed the flush time of its pasteuriser. The plant was able to reduce the flush time by 12 minutes per day, which resulted in water savings of 15 ML per year.

Burst rinsing

Burst rinsing is commonly used for cleaning tanks and tankers to maximise product recovery before CIP. Rather than a continuous rinse, a series of bursts is used which can minimise water use, depending on the characteristics of the product being cleaned e.g. viscosity. One disadvantage is that it can add time to the cleaning cycle.

Burst rinsing in ice-cream plant

Peters and Brownes in Balcatta introduced burst rinsing into the ice-cream CIP after an audit by the factory's chemical suppliers. The initiative required some small program changes to the CIP automation system, which resulted in water savings of 15 ML/yr or $20 000.

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For further information see the *Eco-efficiency for the Dairy Processing Industry Manual*, August 2004 or contact the UNEP Working Group for Cleaner Production: phone 07 3365 1432, email p.prasad@uq.edu.au
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