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DEMONSTRATION OF CLEANING KINETICS USING A PILOT-SCALE TEST RIG AND IMPLICATIONS FOR DAIRY MANUFACTURERS

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ABSTRACT

A pilot-scale fouling and cleaning test rig was developed to investigate fouling and cleaning kinetics of dairy processing equipment. The test rig comprises a plate and frame heat exchanger, which includes a regenerative section and a pasteuriser section, is fully instrumented and is monitored using a data logging system.

A standard fouling protocol was established to achieve a consistent level of fouling in the test rig for cleaning trials. Raw whole milk was heated to 80°C in the test rig, at a flow rate of 110 L h^{-1}, until the pressure drop across the pasteuriser section increased by 17 kPa, corresponding to a total dry weight of fouling material of 210 g m^{-2} deposited in the pasteuriser section. The change in pressure drop across the pasteuriser section was used to calculate the fouled hydraulic diameter, which had a good correlation ($r^2 = 0.99$) with the total dry weight of fouling material deposited in the pasteuriser section.

Cleaning trials were conducted using a standard protocol in which the cleaning solution was circulated for 20 min. The rate at which the fouled hydraulic diameter across the pasteuriser section decreased during cleaning was the best online indicator of cleaning rate. A second clean, performed using a standard cleaning solution, was used to determine the amount of fouling material, measured as an increase in chemical oxygen demand (COD) and absorbance at 280 nm of the standard cleaning solution, that remained on surfaces within the test rig after the first clean.

The test rig was used to investigate the influence of caustic strength, reuse of cleaning solutions and alternatives to sodium based cleaning chemicals (*e.g.* KOH) on cleaning rate and cleaning efficiency. Our investigation demonstrated that cleaning rate improved as the concentration of NaOH in the cleaning solution increased from 0.1 to 1.0 % w/v NaOH. However, at higher concentrations of 2.0 and 3.0 % w/v NaOH, the cleaning rate was reduced. The substitution of equi-molar amounts of KOH for NaOH in cleaning solutions did not affect cleaning rates. The presence of builders (*e.g.* sequestrants and wetting agents) in cleaning solutions did not affect the cleaning rate but reduced the amount of residual fouling material in the test rig. Reuse of cleaning solution with subsequent increases in fouling matter (measured as COD) did not affect cleaning rate or effectiveness, indicating that limits on reuse should be determined by other factors.

Outcomes from the test rig applications have been demonstrated to industry personnel through the Dairy Process Engineering Centre's technology transfer activities and have promptly been implemented on more than eight dairy manufacturing sites.