Smart CIP

From fundamental understanding to optimized processes through digital tools

CIP is a commonly used process that requires significant resources in terms of time, water, and energy. With the current focus in sustainability there is an increasing interest in optimizing CIP, especially the reduced use of water and energy. In addition, there is still the question on how to ensure efficacy of CIP processes. There is a substantial risk to product quality and safety associated with reducing the intensity and duration of CIP processes, a fact that makes optimization challenging. CIP processes are designed largely empirical and to avoid risks, current practices are excessive leading to over-cleaning.

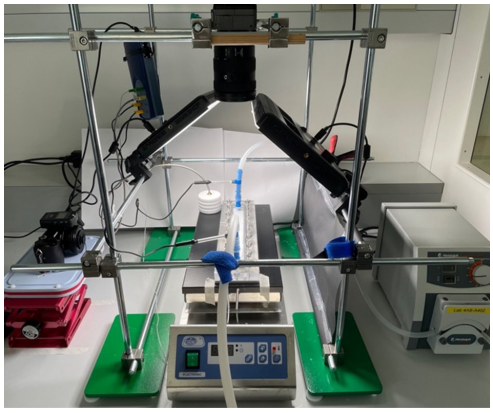
The aim of the project *SmartClean* is to develop data-validated models that will enable optimization of CIP processes in the dairy industry. The questions that *SmartClean* will address are: (1) What is a clean surface and (2) what are the kinetics to reach a clean surface?

Abstract

Cleaning in Place (CIP) is an absolute requirement to ensure hygiene. However, it consumes 20% of the total energy in manufacturing, is responsible for 30% of the effluent water, and between 15 to 30% of production downtime. Monitoring tools and advanced data analytics at industrial scale CIP provide an opportunity for optimization. An experimental setup has been developed to obtain kinetics of cleaning for different conditions, including data used to start development of models that will support cleaning optimisation.

To achieve this goal, *SmartClean* has established experimental methods to obtain kinetics for different CIP conditions, e.g. different temperatures, and pH-values. The rig consists of a flow chamber to be able to reproduce CIP flow conditions and heating as well as industrial relevant fouling. The fouling material on the surface is quantified through ima-

Experimental setup



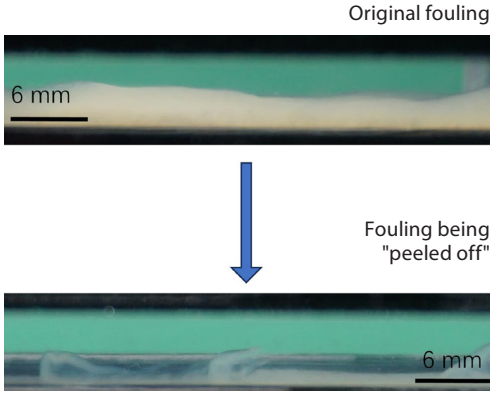


Fig. 1: Experimental set up and typical images obtained characterizing a CIP process





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ging (from a side and top view) while the effluent is monitored using UV-VIS spectroscopy (Figure 1). Typical cleaning dynamics are shown in Figure 2. One can observe that there are multiple stages during CIP: a relatively slow cleaning first phase and a much faster second phase. A mathematical model, shown as the solid line in Figure 2, indicates a good prediction of cleaning dynamics. We will expand this potential of sensor signals combined with data models in *SmartClean* to better understand kinetics of cleaning at low levels of fouling, i.e. the end stage of cleaning cycles.

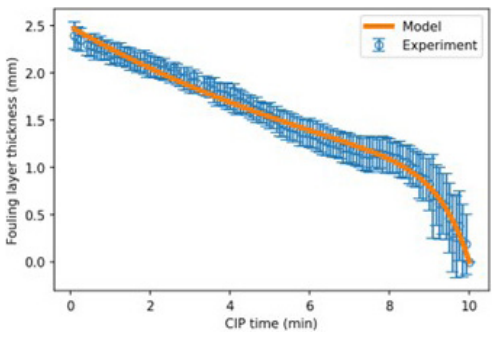

Fig. 2 Kinetics of cleaning obtained from images showing different stages of the process and a proposed model.

How can the industry benefit from this research: *SmartClean* is establishing a set of models that will be applicable to data that can be obtained in industrial production. These models will support optimization of process conditions to reduce environmental impact.

Project Info

Title: SmartClean: Minimering af miljø-påvirkning ved in-situ rengøring (Cleaning in Place)
Project Manager: *Prof. Serafim Bakalis*
Participants: Arla Foods Ingredients
Project period: 2023-2026
Objective: Optimise Cleaning in Place processes through validated models and fundamental understanding

Projects related to the Danish Dairy Research Foundation