Concept for a self-learning adaptive tank cleaning strategy

From worst case cleaning programs towards need-based cleaning

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State of the art

To ensure product safety, food processing plants have to be cleaned regularly. To clean tanks CIP is used, despite some disadvantages:

- No possibility to check cleaning result inside the tank
- Thus using worst case scenario for cleaning program

Approach: Machine learning model of cleaning process and optimization using metaheuristic algorithms

1. Collect data from the cleaning process
2. Build a correlation model of process parameters and cleaning result using machine learning
3. Find optimal parameter set using metaheuristic optimization on the previously built model

The data flow is shown in Figure 1.

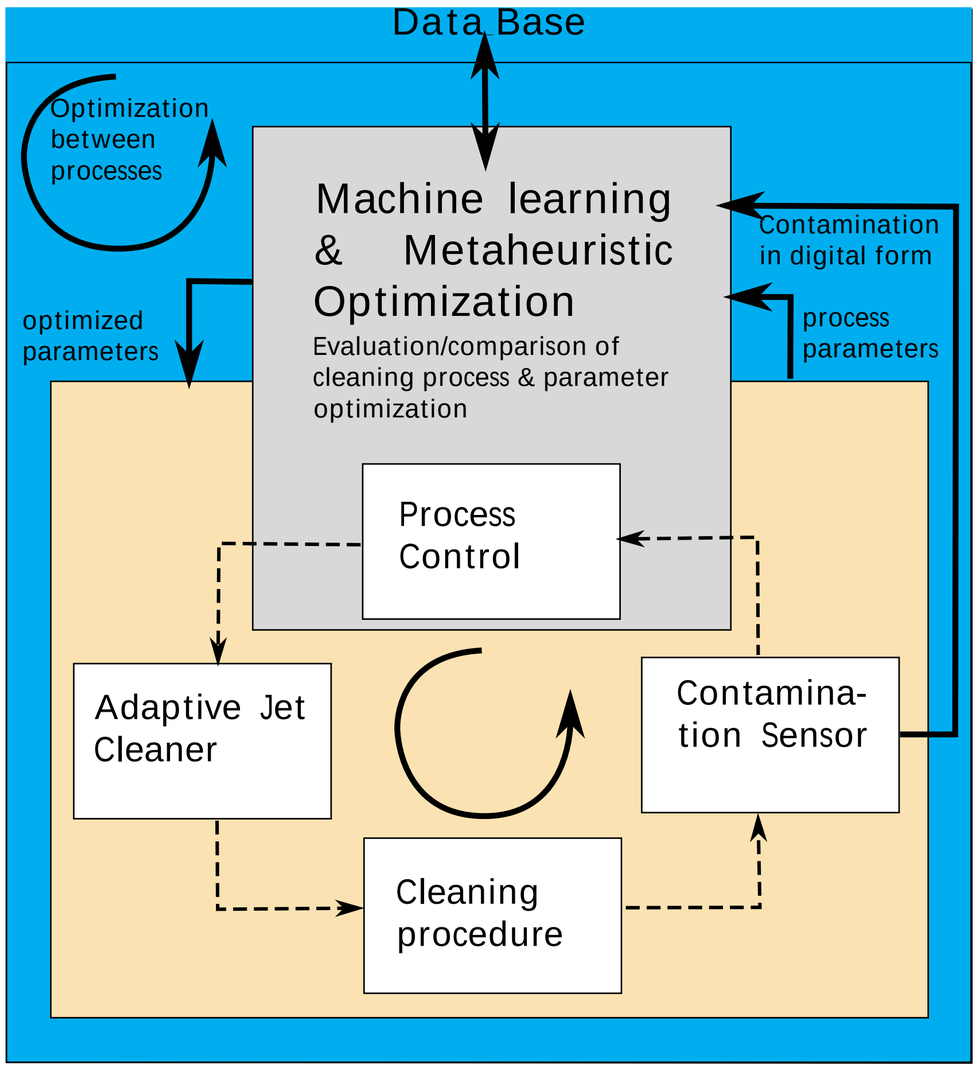

Figure 1: Procedure of whole process

1. Data acquisition using inline inspection

To inspect the contamination of the tank surface the Adaptive Jet Cleaner will be used (Figure 2). An optical sensor will be mounted to record the status inside the tank.

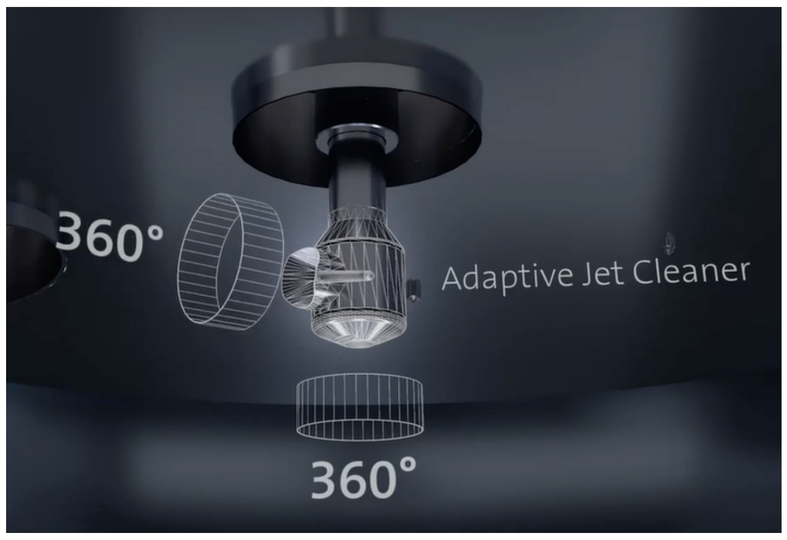

Figure 2: Adaptive Jet Cleaner allows free movement

2. Building a regression model

According to the Sinner Circle, four main factors are influencing the cleaning process as shown in Figure 3. But fixed factors like product properties will be fed into this model as well.

Figure 3: Sinner Circle

Being aware of data needed, we can collect it experimentally. With carefully designed experiments we can control the explanatory variables and to find out the correlation.

The aim is to reach all parameters with enough randomization to not simply overfit the machine learning model but also to avoid spurious correlations in the data.

3. Finding the optimum

After the regression model is fitted, a cost/fitness function is introduced to calculate the complete cost of the process based on variable set and fixed parameters. To formulate the fitness function the constraints of physics and production environment must be taken into consideration.

Considering, that the regression model may be like an Ackley function (Figure 4). It has planty of local extrema and only one global extremum. In comparison to derivation based algorithms, the main aim of applying metaheuristic algorithm is, that it can deal with such functions even if the function is not derivable at some places.

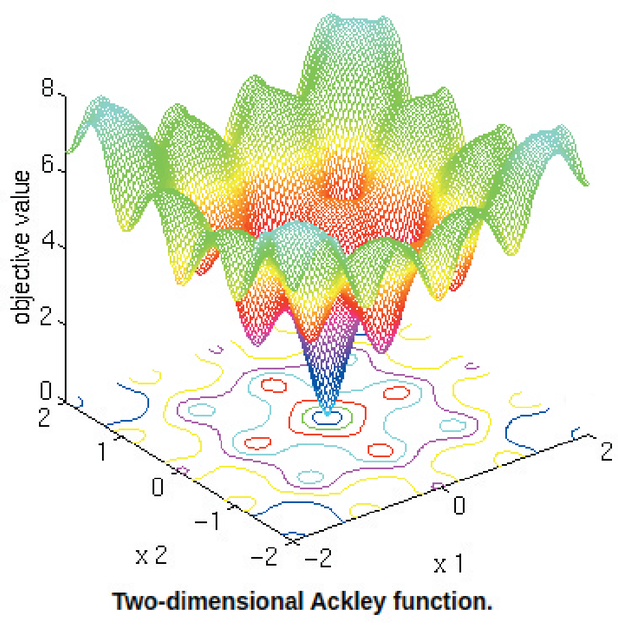

Figure 4: Ackley function

Gefördert durch:

Bundesministerium für Ernährung und Landwirtschaft

aufgrund eines Beschlusses des Deutschen Bundestages

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