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NEW TEST METHOD FOR ROTATING SPRAY HEAD PERFORMANCE IN TANK CLEANING

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Abstract

The purpose was to develop a new, easy and fast, test method for evaluation of rotating spray heads (RSHs) performance in tank cleaning, which does not require advanced training.

A visual cleaning test was chosen, in which a visible soiling medium is spread on a plate and the cleaning time is recorded. Choosing a suitable soiling medium was important. Amongst others the following criteria should be met: Readily available, water soluble, adequate removal pattern. The removal pattern is important, as the test medium should be removed by water droplets and not, as seen with some soils, in flakes.

The chosen medium was a mixture of commercially available toothpaste and tap water. This mixture meets the needed criteria. One issue with the mixture was a tendency to foam formation, however an anti-foam agent was successfully used.

Final test method: Preparation of test medium; even spreading on a standardised stainless steel plate; positioning the steel plate in tank; record total cleaning time. The method was tested on four different RSHs from Alfa Laval. Cleaning times were recorded at different distances and flow rates.

Using the new method, it is possible to distinguish between RSHs based on the cleaning time at the same distances and flow rates. A new method for testing and comparing the performance of RSHs, is found and will help in development of a standardised method for objective evaluation of different RSHs.

Key words: *Test method, spray head, tank cleaning.*

1. Introduction

In the food industry tank systems are often used as processing equipment, e.g. for fermentation or storage. Tank cleaning is often carried out using cleaning in place systems and by the use of rotating spray heads (RSH). When water is pumped through the RSH they rotate as water is pressed through narrow slits in the sides and bottoms, which creates a fan-like water pattern. The cleaning is then a combination of the direct droplet impact and their footprints, and the movement of the created falling water film along the tank wall.

Today there is no standardized method for assessing the efficiency or perform comparisons for different RSHs. This work is a first step towards developing such a test method. A test set-up and a soiling material have been tested for a number of RSHs; different combinations of water pressure and distances to the test soil have been used. The tested set-up must be capable of both distinguishing between different, as well as similar RSHs, and have a good overall robustness and reproducibility. In the following, different test methods are briefly described along with the chosen type of test method and some of the considerations for choice of soiling material.

2. Materials and Methods

2.1 The Test Method

The set-up for the test method is a soil-and-clean test. A stainless steel plate is covered in the selected soiling material, cleaned, and then the cleaning is evaluated. A number of existing methods for validation of cleaning efficiency can be used with this type of set-up. The four main groups are gravimetric methods (Graßhoff [1]), chemical-analytical methods (Graßhoff [1] and Lelieveld *et al*. [2]), microbiological methods (Graßhoff [1], Holah *et al*. [3], Galesloot *et al*. [4], Bénézech *et al*. [5], Mardigan *et al*. [6]), and visual inspection methods (Salo and Wirtanen [7]). Gravimetric methods are very simple. The weight of the tested equipment or unit is measured before cleaning and after cleaning. The difference indicates the efficiency of the cleaning procedure. Due to the time needed before the stainless steel plate would be completely dry, and thus not contain any cleaning water, this method was deemed unsuitable. The most widely described methods are microbiological tests. While these are versatile, and can be used both for quantitative and qualitative tests, the incubation time and the recirculation of cleaning water in the tank set-up, excluded this type of test. Using a chemical-analytical method was considered. As the cleaning water was reused between tests and because the detection methods should be simple, this method was not used. Visual inspection methods can be carried out both directly by the operator or by the use of image analysis.

A direct visual inspection by the operator was chosen. This method is fast, easy, and does not require significant measuring equipment. The measured quality is the total time needed for complete cleaning of a stainless steel plate.

2.2 The Soiling Material

After choosing the test method a suitable soiling material was to be found. The desired properties for this were visibility on stainless steel, water solubility, suitable removal pattern, readily available, and easy and safe to handle. The reasons for selecting these properties were: The visual evaluation is performed at normal light; use of detergent should be avoided if possible to keep the procedure simple as possible; the soil must be removed by droplet impact and falling film action and not e.g. in flakes. As the test is to be performed ad hoc and with no major preparations the soiling material must be readily available. Furthermore, it has to be easy and safe for the operator to handle.

Besides being fast and easy visual inspection allows for a wide range of soiling materials fulfilling the listed properties. Often dairy based materials have been used in cleaning tests and for visual evaluation (Graßhoff [1], Lelieveld *et al*. [2], Holah *et al*. [3], Galesloot *et al*. [4], Bénézech *et al*. [5], Mardigan *et al*. [6], Salo and Wirtanen [7] and Konrad and Scheybal [8]) In the initial set-up tests, when designing this specific method, yoghurt was used. The water used in the tanks was not changed on a daily basis. Therefore it was decided not to use dairy products, but to find a more odor-stable material. A number of alternatives were considered, and the final choice fell upon toothpaste. The used brand of toothpaste was chosen based on high availability and a lower tendency to foam formation than alternative brands. The spreadability and removal pattern of the toothpaste as provided directly from the manufacturer was not optimal. This was solved by adding a controlled amount of water, giving a lower yield stress and viscosity.

2.3 The Tested Procedure

During the initial cleaning tests it was observed that even though the toothpaste was of a low-foam kind it still caused too much foam in the cleaning water. The foam bubbles resulted in decreased cleaning times. The solution to this was addition of an anti-foam agent to the cleaning water prior to the cleaning tests.

The test protocol:

1. Preparation of the test material: 100mL of the toothpaste is mixed with 20 mL of tap water.
2. Spreading on test surface: An even layer consisting of 1/3 of the total prepared test material is spread on a pre-wetted stainless steel plate (316L, 300 mm x 210 mm, with a surface roughness of 2B). Elastic bands are used to keep an even soil height as it is spread using a suitable straight plastic or metal bar (Figure 1).
3. Positioning of the plate: The plate is mounted on a rod and placed in the tank at the desired distance to the RSH. The set-up can be seen in Figure 2.
4. Cleaning step: The cleaning and timer are started using the desired water pressure and type of RSH. The timer is stopped when the plate is completely free of soiling material. Cleaning can be seen in Figure 3.

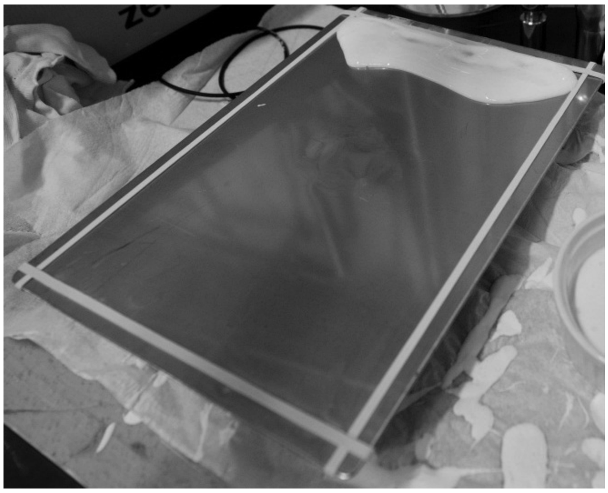

Figure 1. Preparation of the test plate

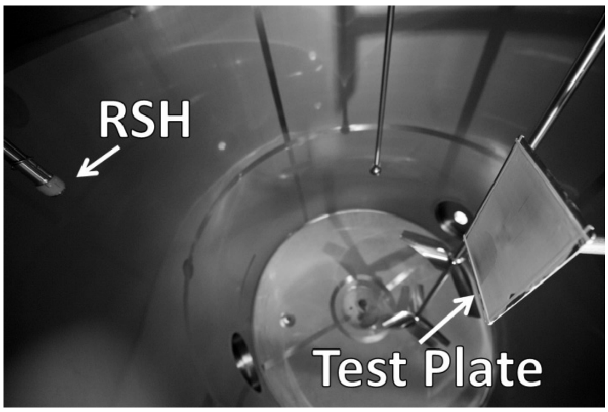

Figure 2. The set-up used for the cleaning test. To the far left the used RSH is seen and to the right the stainless steel plate covered in the test material

Figure 3. During cleaning the removal of the soiling material from the stainless steel plate (right) is followed visually

3. Results and Discussion

Four different RSHs were tested at four different distances to the plate using three different water pressures. The test set-up is shown in Table 1. It is seen that not all of the four RSHs were tested at all distances and water pressure conditions. This was due to their different design, working conditions, and throwing lengths. The RSHs are named in the order of increasing flow capacity. Type A is designed for cleaning of the smallest equipment, B and C are working in the same range and D is the largest RSH. The repeatability of the cleaning tests was determined by performing all cleaning tests in triplicate. Results for the two distances with most measurements with different RSH are shown in Figure 4 and Figure 5.

Table 1. The table shows the combination of experiments carried out

	Distance to the plate (m)			
Pressure (bar)	**0.75**	**0.95**	**1.5**	**2.1**
1	A	B, C	B, C	
2	A	A, B, C	B, C, D	B, D
3	A	A, B, C	B, C, D	B, D

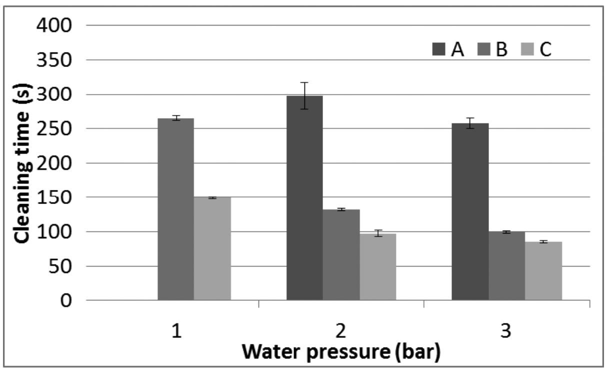

Figure 4. Average cleaning times for different RSHs are shown with one standard deviation at different water pressures. The cleaning distance is 0.95 m

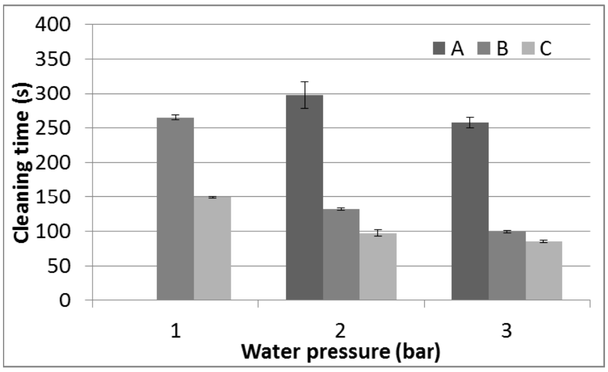

Figure 5. Average cleaning times for different RSHs are shown with one standard deviation at different water pressures. The cleaning distance is 1.5 m

At a cleaning distance of 0.95 m it is seen that the results for B and C are very similar. When the pressure is increased the difference between the two RSHs is seen to decrease. This is observed both at a distance of 0.95 and 1.5 m. At 3 bar it is not possible to statistically distinguish between any of the three tested RSHs. The test is seen to give low standard deviations, which indicates good repeatability. This is important as the test method is to some extend subjective, depending on the operator's judgment of "total cleaning". However it has to be noted that each combination of RSH-distance-pressure were performed on the same day, and all by the same operator. In order to investigate the repeatability from day to day a number of tests runs were carried out. The tests, each consisting of three repetitions, were performed over three different days using the same settings. The results are shown in Table 2. It is seen that the variation on one day is smaller than the standard deviation on the average values. This indicates that there might be a higher degree of variation than what is seen in Figure 4 and Figure 5. Besides this increased uncertainty it should be investigated what the effect of changing operators will have on the reproducibility of the test.

Table 2. Test of the reproducibility of the cleaning test using RSH B, (pressure = 2 bar, distance = 1.5 m)

Day	Average cleaning time (s)	SD (three repetitions)
1	230	3.7
2	225	2.7
3	216	1.5
Average cleaning time and standard deviation between the three tests: 224 (6.9)		

Another variable to be investigated was the cleaning water temperature. It was not possible to influence the water temperature much, but it was seen to increase over time and depending on the room temperature. The rheological impact on the soiling medium at different temperatures had been investigated in laboratory scale using a rheometer, but only at 10 and 20 °C. The temperature when running the experiments was seen to increase as high as 30°C therefore a comparison was made for cleaning around 20 °C and 30 °C. The results are shown in Table 3. Even with a possibly increased variation, if the day and operator are varied, the increased water temperature seems to decrease the cleaning time. The remaining experiments were therefore carried out as close to 20 °C as possible (average 18.6 °C).

Table 3. The effect of the cleaning water temperature on the average cleaning time

Temperature (°C)	Average cleaning time (s)	SD (three repetitions)
19	216	1.5
33	200	2.1

4. Conclusions

A method for testing the efficiency and perform comparisons of rotating spray heads has been presented. The method was found to be applicable and showed good results for differentiating between various RSH models working at the same water pressure and distance to the soiling material. The method could be improved by employing a soiling material less prone to foam formation. In order to validate the overall robustness of the method future studies should include an investigation of the influence of varying operators. Overall, the tested method is shown to be a useful way to handle assessment and comparison of the cleaning efficiency of different types of rotating spray heads.

Acknowledgement

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