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ULTRASOUND APPLICATION FOR REMOVAL OF PROTEIN IMPURITIES FROM PIPING ELEMENTS[1]

Sylwia Mierzejewska*, Joanna Piepiórka-Stepuk, Sandra Masłowska

Department of Food Industry Processes and Facilities, Koszalin University of Technology

Contact details: ul. Racławicka 15-17, 75-620 Koszalin, e-mail: sylwia.mierzejewska@tu.koszalin.pl

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ABSTRACT

The paper presents results of the studies on the removal of protein impurities from the system components of a transmission installation in an ultrasonic cleaner. Contamination was removed from the places susceptible to insufficient washing in Clean In Place instalations, namely, from elbows, flap and ball valves and tees. The objective of this study was to evaluate the effectiveness of the cleaning process in an ultrasonic cleaner depending on the power of ultrasound, chemical agent (NaOH), temperature, and duration of the process. To evaluate the effectiveness of the method of cleaning Clean-Trace™ Surface Protein Plus visual tests were applied, which were based on the color reaction of copper and the protein complexes in the 5-point scale. Application of ultrasound and clean water does not completely remove protein contaminants from the cleaned surfaces. Application of chemical and high temperature improves the efficiency of the process. The fastest maximum cleaning efficiency was achieved in an ultrasonic cleaner at a full load and 40°C of ultrasound.

Introduction

Ultrasounds have been widely used in many industries such as mechanical engineering, printing, optics, jewelry, electronics and medicine and cosmetology. In the food industry by means of ultrasound, impurities are removed from the surface with complex structure and places difficult to reach. Due to their properties, the ultrasonic waves penetrate everywhere, removing impurities and destroying microorganisms. Ultrasonic waves are most commonly used in the cleaning devices called ultrasound washers. Another non-standard option is to include ultrasound generators near the measuring elements, which is intended to prevent deposition of mineral impurities. The use of such solutions in the system elements which are susceptible to insufficient cleaning could bring satisfactory results. Recent studies have shown that ultrasound can also be used for improving such processes as filtration, cutting, emulsification, drying or freezing (Chandrapala et al., 2012; Gallego-Juarez et al., 2007).

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Ultrasonic waves passing through liquid (cleaning solution), contribute to the phenomenon which removes sediment and contaminants. The most important phenomenon is cavitation, which consists in formation of gas bubbles in the lowest pressure and disappearance of the higher pressure zone. This phenomenon is very fast, and has an implosive nature and institutes detachment of pollutants from each, even the most complex element. The second phenomenon is the acoustic wind resulting from absorption of ultrasonic wave energy by liquid. The third important phenomenon in the ultrasonic cleaning process is the radiation pressure generated due to absorption of ultrasonic wave when meeting the obstacles (Sliwinski, 2001).

The effectiveness of ultrasonic cleaning in affected by:

– resistance of material of which cleaned items are made to cavitation;
– cleaning liquid, which determines the ability to create cavitation bubbles;
– cleaning temperature - is the most intense is cavitation for the temperature within 40-50ºC. A higher temperature is useful for distribution of impurities, but temperatures in the range of 70-80ºC will have a negative impact on the phenomenon of cavitation; The maximum temperature of the washing liquid should be approximately 10ºC lower than the boiling point of the washing liquid (Reidenbach, 1994);
– cleaning time - better cleaning results are achieved with a longer cleaning time, but its excessive extension can lead to corrosion and tarnishing of cleaning items.

Cleaning and disinfection of machinery and equipment for the food industry is a very important aspect of production of safe food for consumers. Well chosen parameters of the cleaning process and chemical agents should ensure that the cleaned items, piping instalations are properly cleaned and disinfected. Cleaning tests carried out in a closed circuit CIP in a laboratory, showed that not all elements of transmission pipelines are cleaned with the same efficiency. A simple design of a pipeline with a fixed cross section is relatively easy to clean, wheares all kinds of narrowings, arcs and structural components affecting the flow of the cleaning agent are problematic. Most dirt remains on elbows, small flap valves and tees with a blind end (Mierzejewska, 2013). Unsatisfactory cleaning results in the flow make it necessary to look for new solutions in the area of cleaning techniques. It was decided, therefore, to carry out preliminary studies on the possible use of ultrasound for the removal of protein impurities from the selected elements of the pipelines. The studies evaluated the efficacy of washing elbows, valves and blind ends of ultrasonic washers and analyzed the effect of ultrasound power, temperature, time, and addition of sodium hydroxide on the effectiveness of removing protein impurities.

Test stand, research material and test plan

The cleaning process was conducted in an ultrasonic washer by Intersonic IS-40S type (Fig. 1) with power of 1 kW. The washer is composed of a bath with a capacity of 40 liters, in which cleaned items were immersed in a special basket, and it has temperature control option of the cleaning liquid within 10ºC to 80ºC and the ultrasound power controller (0-(0 -100%). Two piezoceramic plates are a working element of the ultrasonic genererator. The transmitter is attached to the bottom of a bath and causes vibrations which are transferred to the cleaning liquid located in the bath. Washing is done by dipping the component in the respective cleaning solutions.

Figure 1. Ultrasound washer by InterSonic IS-40S

The research material included piping components that are uncleaned during CIP cleaning, as demonstrated in the paper by Mierzejewska et al. (2013). The test were carried out on: a butterfly and ball valve, tee with a blind ending and an elbow (fig. 2). Elements were contaminated with of milk three times thermally fixed at the temperature of 80ºC.

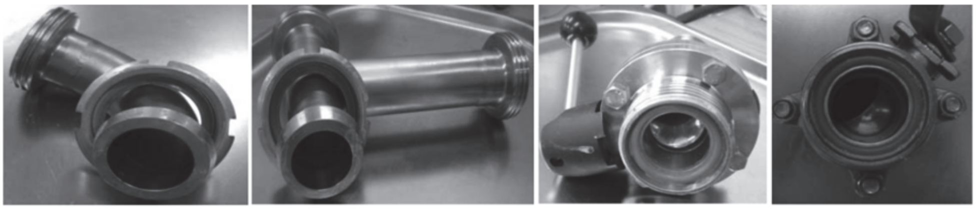

Figure 2. Elements of transmission system subjected to contamination and cleaning process

Tests were carried out on the ultrasonic washer under variable process parameters:

1. temperature of liquid (10; 30; 40ºC);
2. cleaning time (10; 20; 30 minutes);
3. ultrasound power (10; 50; 100%);
4. cleaning agent (water, soda lye).

Constant factors are: water with fixed parameters and dirty method.

Efficiency of removing protein impurities assessed visually and with Protect tests constitute Output parameters of the process. As part of the work performed 12 cycles of the tyree replicates for three different times according to the program presented in table 1.

Table 1
Plan of research

Lp.	Ultrasound power (%)	Time (min)	Temperature (ºC)	Cleaning agent
1.	10	10, 20, 30	10	H_2O
2.	10	10, 20, 30	40	H_2O
3.	50	10, 20, 30	10	H_2O
4.	50	10, 20, 30	40	H_2O
5.	100	10, 20, 30	10	H_2O
6.	100	10, 20, 30	40	H_2O
7.	10	10, 20, 30	10	NaOH 1%
8.	10	10, 20, 30	40	NaOH 1%
9.	50	10, 20, 30	10	NaOH 1%
10.	50	10, 20, 30	40	NaOH 1%
11.	100	10, 20, 30	10	NaOH 1%
12.	100	10, 20, 30	40	NaOH 1%

Evaluation method of protein impurities removal effectiveness

After the process of contamination and cleaning pipe elements, their purity and effectiveness of removing protein deposits was assessed. The assessment was carried out with the use of two methods: visual and rapid tests Clean-Trace ™ Surface Protein Plus. As a part of the tests points were awarded according to PN- EN 50242-2004 (PN-EN 50242-2004; Diakun, 2011; Diakun, 2013). Visual evaluation result may sometimes be unreliable, however it is the fastest way to assess purity. The second method, much more accurate, was based on the detection of protein and sugar residues, the presence of which caused color change of indicators, giving information about the state of purity of the surface. It is based on the color reaction of copper and protein complexes. Cleaning effectiveness in both methods was expressed in the scale of 0-5 where 0 is the initial state of dirt, and 5 completely clean surface (table 2).

Table 2
Digital scale of assessment of surface cleanness

Visual evaluation	Clean-Trace™		
Area contamination by PN-EN 50242-2004	Protein residue	Color of the reagent	Scoring
Absence	0-30 μg/μl	green	5
Number of small particles of contamination point 1 to 4 and the area completely contaminated ≤ 4mm²	30-60 μg/μl	green-gray	4
Number of small particles of contamination point 5 to 10 and the area completely contaminated ≤ 4mm²	60-80 μg/μl	gray	3
Number of small particles of contamination point >10 the area ≤ 4mm² or the area completely contaminated ≤50mm²	80-120 μg/μl	gray- violet	2
50 mm²< the area completely contaminated ≤ 200 mm²	120-300 μg/μl	violet	1
The area completely contaminated >200 mm²	300-500 μg/μl	intense purple	0

Research results

The research results of the mean from three iterations were presented in table 3. Since, protein impurities were equally removed of the tested elements, group results were presented.

The tests, which were carried out indicate that the impact of ultrasounds and the clean water environment, is not able to remove protein impurities from the washed items.For the the programs 1 to 6 within 10 minutes, the effectiveness of cleaning was at the level of 0 points. The longer the cleaning time, the higher temperature and higher ultrasound power efficiency of removing protein impurities. The highest efficiency level of 4 points without the chemical agent was achieved in the 6th program, using 100% power of ultrasounds at the temperature of 40 ° C and with the washing time of 30 minutes. The use of a chemical agent in the form of soda lye improved the efficiency of the process. Standard concentration of NaOH in industrial cleaning processes vary depending on the type and the amount of impurities at the level of 3-5%.

As a part of the study 1% solution of soda lye was applied, which was much lower than that the one used in the cleaning processes in food factories. In all programs where soda lye was the washing agent the purity level of 5 points was obtained after 30 minutes of the process. In the 10th program, with the raised temperature cleaning all protein impurities were removed after 20 minutes of washing and tested items obtained 5 points. The 12th program at the process parameters: power 100%, temperature 40ºC, total purity was obtained after 10 minutes of the process.

Table 3
Research results

Number of research program	The removal efficiency contamination protein of tested elements					
	time test 10 minutes		time test 20minutes		time test 30 minutes	
	valuation Clean- Trace™	visual valuation	valuation Clean-Trace™	visual valuation	valuation Clean-Trace™	visual valuation
1	0	0	0	2	2	2
2	0	0	1	1	2	3
3	0	0	0	2	2	2
4	0	0	2	2	2	4
5	0	0	1	2	3	3
6	0	0	3	3	4	4
7	1	1	2	3	5	5
8	2	2	3	3	5	5
9	1	1	3	4	5	5
10	3	4	5	5	5	5
11	3	2	4	4	5	5
12	5	5	5	5	5	5

Summary and conclusions

It can be concluded that:

1. The impact of ultrasound and clean water on the washed elements does not remove all protein impurities.
2. The use of 1% soda lye solution and raised temperatures improves the efficiency of washing in an ultrasonic washer.
3. Regardless of the applied temperature and ultrasonic power when using 1% soda lye solution after 30 minutes, the end result of the process was assessed at 5 points in both tests.
4. Surface cleanliness at 5 points was quickly obtained at full power ultrasound and 40ºC.

The use of ultrasounds to remove contaminants from the installation components susceptible to insufficient cleaning required their demounting. It is a laborious process and may cause secondary pollution of the washed items. Satisfactory results obtained at the use of 1% sod alye solution, and thus a lower concentration than the one used in industrial washing installation prompts reflection on the possibility of using stationary ultrasonic generators in places vulnerable to insufficient washing. However, this would require a far-reaching modernization of transmission pipelines and installation of multiple ultrasonic generators on the production line. Therefore, the opinion provided by Leighton et al. that the best solution would be to create an ultrasonic generator moving along with the cleaning liquid in the washed installation seems to be right (Leighton et al., 2013).

References

Chandrapala, J.; Oliver, C.; Kentish, S.; Ashokkumar, M. (2012). Ultrasonics in food processing. *Ultrasonics Sonochemistry, 19*, 975-983.

Diakun, J. (2011). Metody i kryteria oceny stopnia umycia powierzchni urządzeń przetwórstwa spożywczego. *Inżynieria i Aparatura Chemiczna*, *3*, 20-21.

Diakun, J. (2013). Przegląd, systematyka i analiza metod mycia. *Inżynieria Przetwórstwa Spożywczego*, *1/4*, 5-10.

Gallego-Juarez, J.A.; Riera, E.; Fuento Blanco, S.D.L.; Rodriguez, C.G.; Acosta, A.V.M.; Blanco, A.(2007). Application of high-power ultrasound for dehydration of vegetables: Process and devices. *Drying Technology*, *25*, 1893-1901,

Leighton, T.; Birkin, P.; Offin, D. (2013). A new approach to ultrasonic cleaning. *The Journal of the Acoustical Society of America*, *133*, 3314-3314.

Mierzejewska, S.; Diakun, J.; Piepiórka-Stepuk J.; Zając M. (2013). Skuteczność mycia w systemie CIP wybranych elementów instalacji przesyłowych. *Nauki Inżynierskie i Technologie, 3*, 70-79.

PN-EN 50242-2004. (2004). *Elektryczne zmywarki do użytku domowego. Metody badań cech funkcjonalnych*.

Reidenbach, F. (1994). *ASM Handbook Volume 5: Surface Engineering*. ASM International, ISBN: 978-0871703842.

Śliwiński, A. (2001). *Ultradźwięki i ich zastosowanie*. Wydawnictwo Naukowo-Techniczne, Warszawa 2001, ISBN 83-204-2567-0.

ZASTOSOWANIE ULTRADŹWIĘKÓW DO USUWANIA ZANIECZYSZCZEŃ BIAŁKOWYCH Z ELEMENTÓW INSTALACJI RUROWYCH

Streszczenie. W pracy przedstawiono wyniki badań dotyczących usuwania zanieczyszczeń białkowych z elementów instalacji przesyłowych w myjce ultradźwiękowej. Zanieczyszczenia usuwano z miejsc podatnych na niedomycie w instalacjach Clean In Place, a więc z kolanek, zaworów klapowych i kulowych oraz z trójników. Celem pracy była ocena skuteczności procesu mycia w myjce ultradźwiękowej w/w elementów w zależności od mocy ultradźwięków, środka chemicznego (NaOH), temperatury i czasu trwania procesu. Do oceny skuteczności mycia zastosowano metodę wizualną i testy Clean-Trace™ Surface Protein Plus, opierające się na reakcji barwnej miedzi z kompleksami białkowymi w skali 5 punktowej. Wyniki badań wskazują, że zastosowanie ultradźwięków i czystej wody nie zapewniają całkowitego usunięcia zanieczyszczeń białkowych z mytych powierzchni. Dopiero zastosowanie środka chemicznego i podwyższenie temperatury wpływa na poprawę skuteczności mycia. Najlepszą skuteczność mycia w myjce ultradźwiękowej, w najkrótszym czasie uzyskano przy pełnej mocy ultradźwięków i temperaturze 40ºC.

Słowa kluczowe: higiena, mycie ultradźwiękowe, zanieczyszczenia białkowe, skuteczność usuwania zanieczyszczeń