INNOVATIVE CLEANING TECHNOLOGIE IN THE MECHANICAL WASHING OF CONTAINERS IN THE FOOD INDUSTRIE

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Abstract

The processing hygiene is the fundamental of the safe food production. It is known as well that the majority of losses from quality deteoration is derived from the neglecting the hygiene. The cost of the cleaning is significant but the theorem is valid, that the "hygiene costs a lot but this causes significant financial loss beyond the public health hazard in case of negligence of it". But the ratio of the hygiene cost in the direct production cost is not a neutral question respecting to the economic production cost ratio. The raw and processed products are transported in containers with very changeable size and type and transporting devices inside and outside of the firms for very different distances. Significant physical-, chemical- and microbiological contamination can be found on these devices causing food safety risks. Their sources are in the scenes of the food chain and the contamination adhering to it in the course of the delivery between the food chain points. One of the important element of the sustaining the processing hygiene is the cleaning and disinfection of the holding and transportation devices. Two fundamental deficiencies are arisen in the course of the use of cleaning machines. One side is that not the most suitable cleaning material and technology parameters are applied for removing the type of the contamination and other sides the equipments operating with the modern high pressure nozzles are not able to remove the contamination from the parts shaded from the fluid sprays (break through, corrugations). But there are possibilities to equip the given cleaning technology by using the ultrasound applied for cleaning and defatting the objects with complicated surface in other industries branches successfully The efficiency is very important in case of high cleaning demands and high number of objects. Fundamental expectations against the high capacity crate and box washing machines in the course of the operation that the proper cleanness is provided along with the lowest specific cost. The fundamental condition of the efficient cleaning is the optimal technology related with the quality of cleaning and expenditures directly.

Keywords: hygiene, cleaning technology, milky contaminations, efficiency

INTRODUCTIONS

The quality of the cleaning is influenced by operational parameters directly affecting the separation of the contamination in case of a selected cleaning method is influenced these are the followings:

- Operational time (t),
- Temperature of the cleaning solution (ϑ),
- Pressure of the solution streaming out of nozzles (p),
- Type and concentration of the cleaning agents (D, K).

The operational parameters closely related with the material and energy used in the course of the cleaning process.

If the amount of them is known then their costs can be calculated as well.

The quality of cleaning is characterised by the efficiency of the cleaning in the course of the investigation. The measures of the expenditures are mirrored in the specific cleaning cost.

The efficiency of cleaning (η)

A measure has to be introduced for the determination of the cleaning quality, the measures of the removal of the contamination, showing the amount of removed contamination in the course of the cleaning clearly. It has to be measured as well.

IN case of a cleaning process prolonging for a time (t):

If m_o = the original amount of contamination

And m = the amount of contamination remaining after the cleaning process

Then the amount of separated contamination after time (t) is: m_o-m

If it is compared to the original value (m_o), the efficiency of cleaning is given by (1):

$$\eta = \frac{m_0 - m}{m_0} \le 1$$

The investigation has to be directed in such a way how the cleaning process parameters affect the contamination separation and cleaning efficiency for a given contamination type and cleaning method

The investigations were carried out with crates and boxes having same 395 x 595 mm base and different height and with milky of contamination. Quickly deteriorating, strong adhering to the surface, dried on. It can be contained soil, dust and mud.

MATERIALS AND METHODS

Changing and constant parameters during the investigations

- D The type of the cleaning agent
- K Concentration of the cleaning solution (volume %)
- t cleaning time (s)
- ϑ Temperature of cleaning fluid (°C)
- p Pressure of the cleaning fluid at the nozzles (MPa; N/cm^2)
- q Volume stream of cleaning fluid (dm^3/min)
- φ Spraying angle of the fluids streaming out from the nozzle (°)

Constant parameters:

- Distance between the nozzles and the objects to be cleaned,
- Distance between the ultrasound radiating element and objects to be cleaned.

Equipments used in laboratory investigation

Experimental equipment for investigation of high pressure nozzles

Laboratory equipment was created for determination of geometry measures and measurement of the operational parameters for the type of nozzles. The equipment are shown on fig 1 (process flow) and fig 2.

Legends for process flow:

1. Water container (V = 0.15 m^3),
2. Cleaning solution,
3. Suction - basket,
4. Vacuum manometer (type: TGL, measuring region: 0–1 · 10^5 Pa),
5. Pump BMS 12/36 n= 2880 rev/min, H = 110 m),
6. Manometer (Type OHM 1/1-80, MSZ 584, measuring region: $0-12 \cdot 10^5$ Pa),
7. By-pass control (ball valve 1 1/4"),
8. Plastic crate,
9. Manometer (Type OHM 1/1-80, MSZ 584, measuring region: $0-12 \cdot 10^5$ Pa),
10. Flexible connection,
11. Nozzle,
12. Plastic tube (∅ 1”).

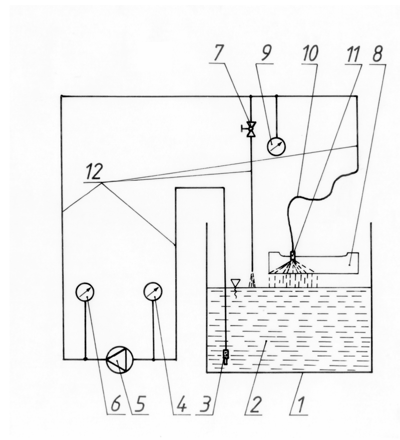

Fig. 1 Process flow of the laboratory equipment

Equipment used for ultrasound investigations

A laboratory ultrasound unit (TESLA UG 160/320 TA, Czechoslovakia) was used for the measuring the ultrasound operational parameters. The equipment consisted of a container with a net volume of 12 dm^3 and high frequency ultrasound generator, which actuated piezo-electric radiators with 25 kHz at 160 or 320 W power. Taking into account the efficiency of transformation 1.3 and 2.8 Watt/dm^3 net power density can be attained in the vicinity of the object to be cleaned.

RESULTS AND DISCUSSIONS

MODEL EXPERIMENTS FOR INVESTIGATION OF THE OPERATION PARAMETERS OF ULTRASOUND CLEANING.

We determined the highest cleaning efficiency for the operation time and cleaning agent temperature range. We applied test contamination and cleaning agents with and without ultrasound for comparison. Beyond these the combinations of them were studied as well.

Efficiency of cleaning in dependence on time

The experiments were carried out in ultrasound laboratory equipment under the following conditions:

- Operational time region: 5-60 sec.

- Cleaning solution: 1% NaOH
- Solution temperature: 65 °C
- Test contamination: dried on, milky
- Investigated surface: plastic crate
- Ultrasound generator power: 320 Watt
- Ultrasound frequency: 25 kHz

The efficiency values belonging to the given treatment time are shown on Figure 2 with (η_{UH}) and without ultrasound.

The latter one corresponds to the soaking with cleaning agent (η_A). An asymptotic function can be fitted on the measurements results according to the eq. 4.

Where:

$\eta_{UH} = 0.93 \times (1 - e^{-0.14\,t})$

$r^2 = 0.95$

$\eta_A = 0.72 \times (1 - e^{-0.05\,t})$

$r^2 = 0.93.$

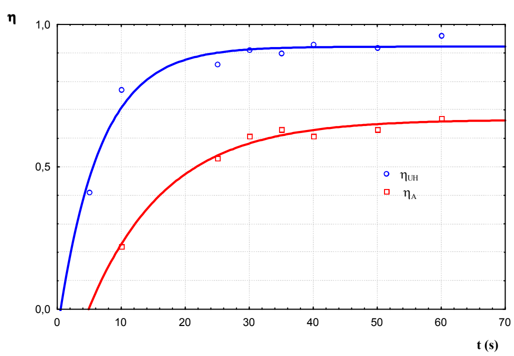

Figure 2 Development of the cleaning efficiency vs. treatment time

Cleaning efficiency in dependence on temperature

- Cleaning solution temperature region: $\Delta\vartheta = 20 - 65°C$
- Operational time: t = 60 sec, constant.

The results of the investigations are shown on Figure 3:

$\eta_{UH} = 0.607 + 0.005\,\vartheta$

$r^2 = 0.9265$

$\eta_A = 0.63 + 0.007\,\vartheta$

$r^2 = 0.9563.$

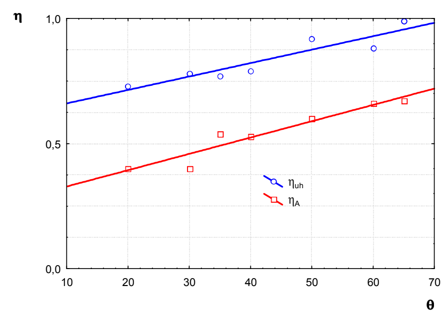

Figure 3. Development of the cleaning efficiency vs. tem ϑ (°C)

Summarising the investigation results we can state, that the time and the temperature, between certain limits, taking the cleaning agent property and its concentration as constant, and the cleaning efficiency function is increasing and approximates a maximum value.

A strong adhering contamination, such as dried milk on the surface, can be removed with the use of low concentration of cleaning agent (1%NaOH) and ultrasound treatment within 50-60 sec.

The efficient cleaning agent temperature is 55-65°C, as for the optimum temperature range of cavitations.

FLUID STREAM (NOZZLE) CLEANING OF FOOD CONTAMINATED CRATES

Fluid stream (nozzle) cleaning methods were planned in the stages of pre-washing, soaking, rinsing I. and rinsing II among the cleaning technology operation. Because the rinsing I. and rinsing II stages have no cleaning effect, therefore the experiments were focused on the determination of the operation parameters of the pre-washing and soaking stages. The water, cleaning agent and heating energy consumption are the highest in this stage. Holding on the cleaning parameters on the optimal values is the most important for the economic operation. The crates and boxes were investigated separately because of their different surface. The investigations were carried out according to combined treatment at constant (55°C) cleaning solution temperature and at constant 30 sec half treating time.

Development of the cleaning efficiency in dependence on the cleaning solution pressure and concentration for milky contamination

The investigations were carried out in fluid stream (nozzle) laboratory equipment under the following conditions:

- Type of the contamination: Milky,
- Investigated surface: inner and outside of the plastic crate, box,
- Type of the cleaning agent: MAVEBIT P35,
- Solute concentration: variable, 0; 0,5; 1; 1,5; 2 vol. %,
- Solution temperature: constant: 55°C,
- Operational time: constant: 30 sec,
- Nozzle distance: 200 mm,
- Fluid pressure: variable 2 ; 3 x 10^5 Pa,
- Nozzle type: E-2.8/1.5.

The results of the investigations are shown on Figure 4, 5, 6, 7, 8

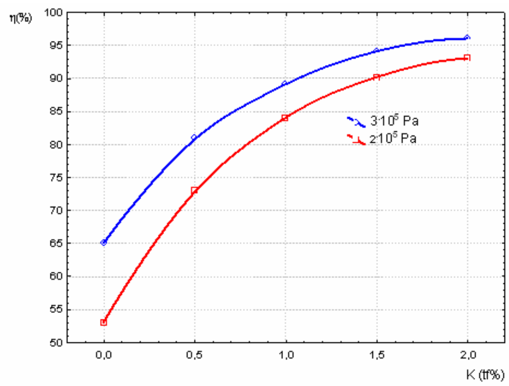

Figure 4. Development of the cleaning efficiency vs. cleaning solution pressure and concentration at the inner side of the box

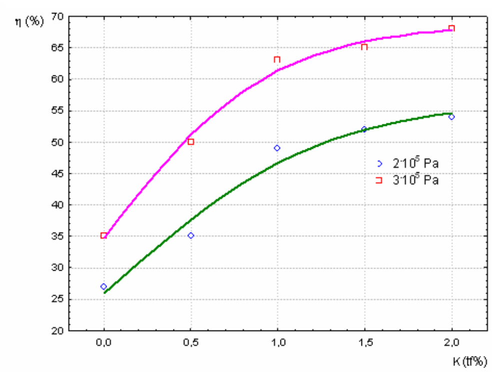

Figure 5. Development of the cleaning efficiency vs. cleaning solution pressure and concentration at the outer side of the box

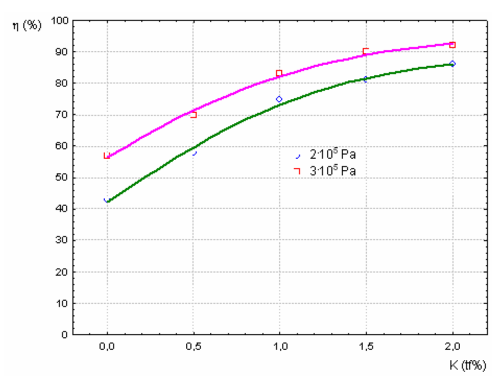

Figure 6. Development of the cleaning efficiency vs. cleaning solution pressure and concentration at the inner side of the crate

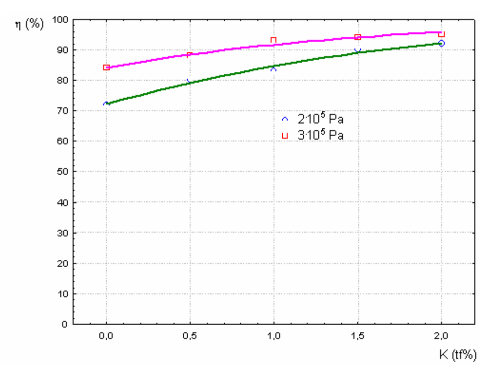

Figure 7. Development of the cleaning efficiency vs. cleaning solution pressure and concentration at the outer side of the crate

The characteristic parameters of the pre-washing operation can be given for the following limits and MAVEBIT P-35 cleaning agent on the base of the experiments carried out with nozzles (diameter of 2,8 mm) and nozzle distance of 200 mm-:

- Temperature of the solution: 50-60°C
- Solute concentration: 1-2 vol. %
- Pressure of the fluid streaming out: $2-3\cdot10^5$ Pa
- Operational time: 30-40 sec

Evaluation of the fluid stream (nozzle) investigations

The experiments showed that the significant part of the contamination can be removed without cleaning agents at pressure of $2-3\cdot10^5$ Pa. The intensive washing operation is well prepared by the nozzle cleaning at pressure of $2\cdot10^5$ Pa and at the lower level of the proposed cleaning agent concentration. Contaminations remained only in scraped outer parts of the crates and corrugations shaded from the nozzle fluid stream. It has to be removed by the cavitations fluid space.

The nozzle distance was 200 mm. From the higher cleaning efficiency values can be concluded that most of the contamination can be removed and the loosening of the contamination remaining on the surface has been occurred for any size of crates or boxes in the washing frame.

A good cleaning efficiency could be achieved by the ultrasonic cleaning and nozzle pre-washing experiments within the applied parameter region. A really effective cleaning can be expected by the combination of them in real industrial conditions as well.

Table 1.

Optimised operational parameters of cleaning technologies proposed for transport devices contaminated in the milk industry

Operation	**Fluid temperature (°C)**	**MAVEBIT P35 solution concentration (vol. %)**	**Operation time (sec)**	**Fluid pressure on the nozzle (p x 10^5 Pa)**
Pre-rinsing soaking part	$\vartheta_{I\,max}=45$	$K_{I\,max}=1$	$t_I=40$	$p_{I\,max}=2$
Intensive washing part (UH 2 kW, 25 kHz)	$\vartheta_{II\,max}=55$	$K_{II\,max}=1$	$t_{II}=30$	-
Rinsing I.	$\vartheta_{III\,max}=80$	-	$t_{III}=10$	$p_{III\,max}=1{,}5$
Rinsing II	$\vartheta_{IV\,víz}=$ Drinking water temp.	-	$t_{IV}=2$	$p_{IV}=$ network pressure

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