

Analysis of washing modes of metal tin cans outer surface in jet-type washing machines

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Abstract. The main parameters of jet washing of cans are: the concentration of the alkaline solution and its temperature, the pressure of the solution at the nozzle, the shape and dimensions of the nozzle opening, the angle of the direction of the jet toward the surface being cleaned, the distance from the water jet nozzle to the surface of the washable cans. The study of these parameters was carried out on a special experimental setup equipped with instrumentation. Dependence of washing efficiency on solution pressure given to the cap with different diameters of its holes was found. Furthermore, it is established that the process efficiency decreases with increase of pressure for more than 3 kg/cm^2 , as a certain hydrodynamic mode of jet percussion action begins at the boundary with the surface being cleaned. Cleaned surface becomes larger with increase of concentration and temperature of washing solution. Increase of solution concentration for more than 3% and its temperature for more than 70÷75°C do not promote intensification of the process. Cleaned surface depends on angle of jet direction at the point of its strike with the can surface. This dependence represents the fact that the cap should be placed in relation to transported cans in such a way that the jet would be always at right angle to the dirty surface.

1. Introduction

Canned goods are one of the most consumed products in the Russian Federation. There are several reasons of this phenomenon: wide range of canned food, gain of consumers' welfare, increase in demand on ready meals due to acceleration of life pace, extended storage period of canned goods, special storage conditions are not required, ease of use, contraction of home-made canned food [1–3].

Every year, in the Russian market of tin cans appear more and more new trademarks, new manufacturers, which aspire to improve the quality of produced product and attract a buyer. In this situation, the packaging and label of the goods are powerful means of promoting the goods on the market.

Package and label are important for promotion of the product in the market. That is why it is necessary to stick the clean undamaged label on the whole surface of the tin can firmly and accurately.

According to the technical requirements, an automatic labeling machine should work with the clean dry tin cans having no grease stains on the surface and meeting the requirements of the GOST 5981-88 and GOST 11771-93. The procedure of cans degreasing with the help of jet-type washing machines was included in the technological process of canned goods production to consider all these requirements.



Quality of cans cleaning, labour capacity, industrial standards, and cost price of canned food production depend on excellence of technology and washing machines.

A large number of modern washing machines work in an irrational regime and are energy and metal consuming, so their use is unprofitable. Consequently, the development of new efficient machines and the improvement of existing washing machines in the canning industry is great reserve to reduce energy consumption, materials and cost of the whole production process of canned food.

Therefore, research aimed at improving the washing process filled cans in the production of canned food are very relevant and have great importance in the food industry.

Appliance of jet and submersible cleaning as the less energy-demanding method is more prospective according to the criteria of specific energy costs on a unit of the surface being cleaned [4–7].

2. Experimental

The main parameters of jet washing of cans are: the concentration of the alkaline solution and its temperature, the pressure of the solution at the nozzle, the shape and dimensions of the nozzle opening, the angle of the direction of the jet toward the surface being cleaned, the distance from the water jet nozzle to the surface of the washable cans. The study of these parameters was carried out on a special experimental setup equipped with instrumentation.

The time of action of the detergent solution on the cleaned surface was measured with a stopwatch.

When studying the basic parameters characterizing the washing process of cans, a method of assessing the quality of washing was applied, which consists in exposing the surface of the cans to ultraviolet irradiation. At the same time, the remnants of non-washed contaminants (mainly fats) start to luminesce, i.e., to glow. It is easy to fix it not only visually, but also by photographing.

3. Results of Researches

The results of experimental research specifying the main parameters and washing modes of the filled metal tin cans outer surface with the help of the jet-type washing machines are represented below.

Experiments allowed to determine efficiency of washing, that is dependence of the cleaned surface on solution concentration and time of exposure on this surface. From the diagram (Figure 1), it can be seen that the cleaned surface becomes larger with increase of solution concentration. The process starts intensively and then it slows down. Optimal solution concentration is 2–3%.

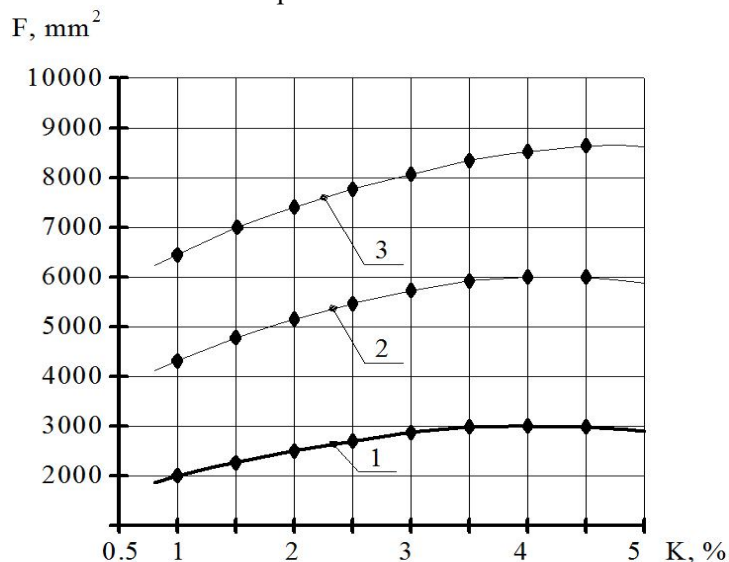


Figure 1. Dependence of the cleaned surface F on concentration of solution K of caustic soda, where 1 is time of jet exposure on the surface being washed for 15 sec; 2 is time of jet exposure on the surface being washed for 45 sec; 3 is time of jet exposure on the surface being washed for 90 sec.

Data of this experiment corresponds to the following conditions of washing: diameter of the cap's cylindrical hole is 2 mm, pressure of the spraying jet is 2.5 kg/cm^2 , temperature of the washing solution is 70°C , angle of jet direction to the can surface is 90° , distance between the cap and their surface is 200 mm. Increase in temperature of the washing solution leads to keen intensification of washing only to a certain limit that is to $70\div 75^\circ\text{C}$. Its further increase is inappropriate and leads to unnecessary heat loss

It was established that the cleaned surface becomes larger with increase in pressure of the given solution. From the diagram (Figure 2) it is seen that the cleaned surface becomes smaller due to the solution pressure over 3 kg/cm^2 . That is why it is inappropriate to increase pressure of the given solution for more than 3 kg/cm^2 for the tin cans with inconsiderable and easy-to-wash stains.

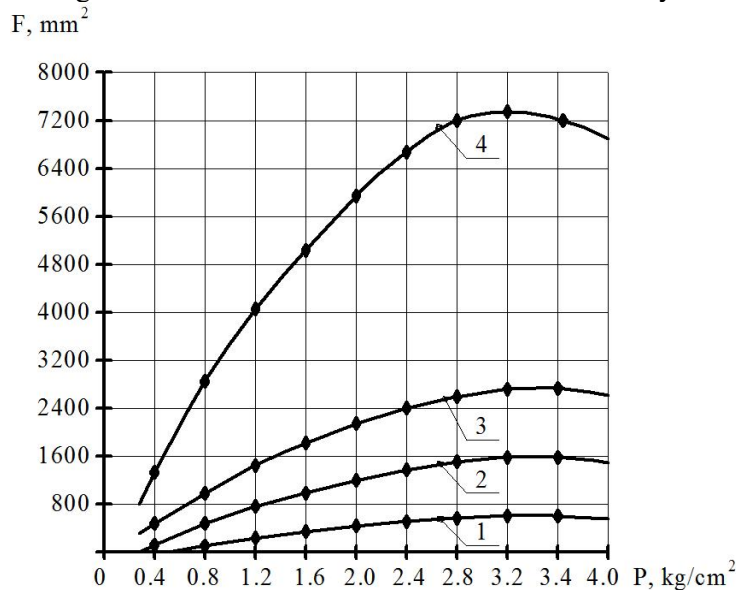


Figure 2. Dependence of the cleaned surface F on pressure P of the given solution with the diameter of the water jets: 1 mm-the 1st line; 2 mm - the 2nd line; 3 mm – the 3rd line; 5 mm - the 4th line.

Angle of jet direction from the cap to the can surface is also very important.

Efficiency of washing rises with angle increase (Figure 3) and reaches the maximum due to $\varphi=90^\circ$ and it decreases with angle decrease.

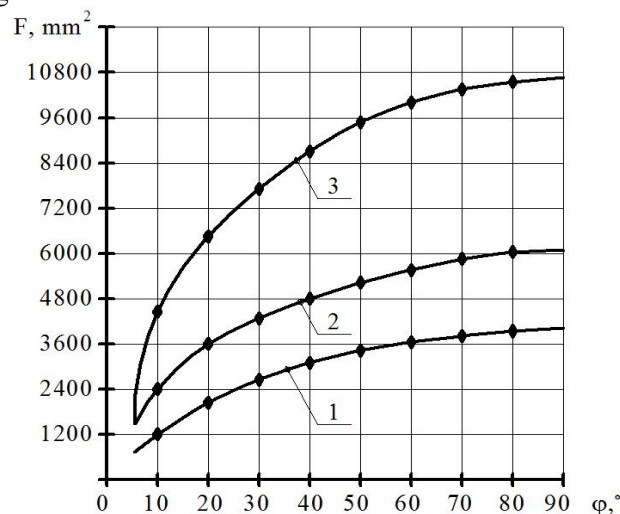


Figure 3. Dependence of cleaned surface on angle of φ - jet direction to the can surface with the diameter of cap's water jets, where the 1st line - 1 mm; the 2nd line - 2 mm; the 3rd line - 3 mm.

When distance between the cap and the can surface becomes larger (Figure 4), the cleaned surface decreases. Research shows that it is better to recommend the distance between the cap and the can surface of 90÷120 mm depending on position of collectors with caps in the washing machine to continuously moving cans and way of moving during washing and cans arrangement.

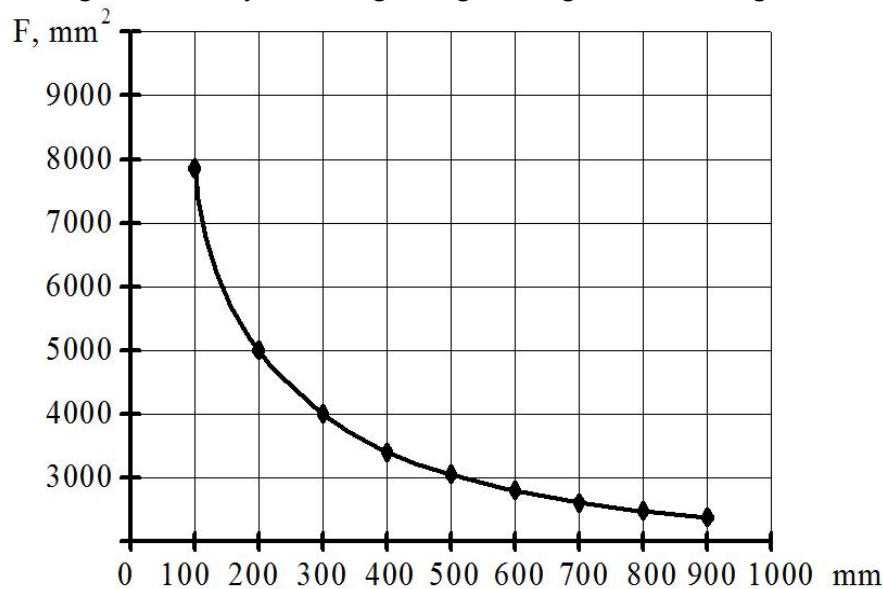


Figure 4. Dependence of cleaned surface on distance l between the cap and the can surface

4. Conclusion

Cleaned surface becomes larger with increase of concentration and temperature of washing solution.

Increase of solution concentration for more than 3% and its temperature for more than 70÷75°C do not promote intensification of the process.

Dependence of washing efficiency on solution pressure given to the cap with different diameters of its holes was found.

Furthermore, it is established that the process efficiency decreases with increase of pressure for more than 3 kg/cm², as a certain hydrodynamic mode of jet percussion action begins at the boundary with the surface being cleaned.

Cleaned surface depends on angle of jet direction at the point of its strike with the can surface. This dependence represents the fact that the cap should be placed in relation to transported cans in such a way that the jet would be always at right angle to the dirty surface.

The distance from the syringe nozzle to the can should be chosen within 90÷120 mm.

References

- [1] Rauf S *et al* 2016 *Procedia Comput Sci* **83** 902–906
- [2] Abdel-Fatah M A *et al* 2017 *Ain Shams Engineering Journal* **8(3)** 305–310
- [3] Wahad H S *et al* 2017 *IOP Conf. Ser.: Mater. Sci. Eng.* **174** 012021 doi: 10.1088/1757-899X/174/1/012021
- [4] Jain S V and Patel R N 2014 *Renew Sust Energ Rev* **30** 841–868
- [5] Akikur R K *et al* 2013 *Renew Sust Energ Rev* **27** 738–752
- [6] Plappally A K and Lienhard V J H 2012 *Renew Sustain Energy Rev* **16(7)** 4818–4848
- [7] Tadesse M G *et al* 2017 *Smart Mater Struct* **26** 065016