Effect of Heat Treatment on Quality Canned Food Products

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Abstract. The article presents the results of an experimental study of the hydrodynamic features of moving sterilized cans of canned fish of various sizes under the action of a gas-liquid heat-transfer fluid circulating in a special setup. To conduct such study authors suggested an apparatus in that there were organized downward and upward flows of a gas-liquid heat-transfer fluid. In the food industry heat treatment of food products provides, both the microbiological safety of the raw materials used, and the long shelf life of finished products. Such processing is used in the chain of the technological process itself and in a great number of finishing stages. One of the main operations in the technological chain of canned fish production is the operation of sterilization of canned food. In properly chosen modes of such an operation allow to obtain high quality canned food. Based on the analysis of the research results, there are proposed the empirical dependencies for calculating the drag coefficients of different forms and sizes of packaging. There was established the necessity of using a refinement factor for calculating the real drag coefficient based on the results of the experiment.

1. Introduction

For producing of canned fish, the most common practice is the sterilization by heat treatment of canned hermetically packed fish. All existing sterilizers, both periodic and continuous, have a significant number of disadvantages. These include, in particular, the uneven temperature field of the coolant throughout the volume of the working chamber of the installation, which leads to a decrease in the temperature in some cans by the end of sterilization is lower than in ones that are in more favorable conditions. There is a risk of off-limits temperature reduction that can lead to activate some types of pathogenic microorganisms. As a result, to ensure the safety of canned fish is necessary to increase in the duration of heating, which in turn leads to an increase in labor costs and, as a rule, to a decrease in economic indicators of production.

One of the solutions of this problem became the creation of rotary sterilizers, in which the cans with canned fish move around in the heated environment inside the all volume of the machinery.

In contrast to batch sterilizers, the advantage of continuous sterilizers is to ensure that the containers are in the same temperature conditions throughout the sterilization process. The use of continuous sterilizers allows to create high-performance automated production lines, which in turn reduces labor costs.
2. Introduction
Experimental determination of the speed of movement of cans were performed by using of a can – water – air system for the entire range of densities and can forms under investigation, both for real and for model cans on the experimental setup shown below (see Ошибка! Источник ссылки не найден.-3) [1-3].

![Figure 1. Vertical section of experimental setup.](image-url)

Experimenal setup for sterilization of canned fish products includes a housing 1 with a conical lower part 2, hollow partitions to ensure circulation of the heating environment 3 and partitions 4, for downward 5 and upward 6 canals. At the bottom 7, in each section, a corrugation is made under the downward channel, heaters 8 are also installed here, and inclined guides 9 with perforation are mounted on partitions to provide circulation 3. Cans 10 are fed into the housing of setup through the loading device 13, and the exhausted steam is returned to the hollow circulation partitions by connecting with a gas supercharger installed above the surface of the liquid 11.

The montage space 12 serves to fasten the heater sections, and the shutter located in the discharge device 14 controls the flow rate.

There was studied hydromechanical behavior of cans during the sterilization of canned fish in objects № 1, 3, 6, 19 experimentally [4-6].

3. The results and discussion
The results of the experiments are presented in Fig. 2, 3 and 4 for the movement of cans № 1, 3, 6, 19 in the downward and upward flows. As can be seen from the figures, the character of the change in the velocities of cans in the downward flow $U_d$ with the change in velocities of fluid $W_g$ is approximately the same, but in all cases an effect was observed on the value of the velocities by density of cans $\rho_c$. 
The experiments were performed in the range of reduced gas velocities corresponding to the stable operation of the apparatus, i.e., in the range from 0.03 m/s to 0.15 m/s [7].

The geometry of the can also has a definite effect on the speed of movement of cans in the channels. So, when $\rho_c=1025$ kg/cm$^3$, the highest value of of cans in the downward flow $U_d$ is possessed by can № 19, and the smallest − by can № 3.

In the upstream $U_u$, we have approximately the same values for cans with density $\rho_c=1025$ kg/cm$^3$.

However, the influence of the density of $\rho_c$ and $U_c$ is more pronounced for the can №19, which is explained by the greatest deviation of its shape from the spherical one and large deviations of the can from the vertical trajectory [8-14].

Considering the fact that the velocities in the downward $U_d$ and upward $U_u$ flows differ significantly from each other (as for model of can № 1, with $\rho_c = 1300$ g/cm$^3$ and $W_g = 0.031$ m/s: $U_d = 0.36$ m/s, and $U_u = 0.12$ m/s), when calculating is necessary to take the average velocity of the can in a pair of upward and downward channels.

### Figure 2. Dependence of the speed of different cans in the downward and upward flow of the reduced gas velocity: a) can № 3; b) can № 19.

In this regard, the velocity was determined, which we called the circulation velocity of the can $U_{cir}$. The influence of the geometric shape on $U_{cir}$, where it can be seen that there is some difference in $U_{cir}$, however this difference is very slight, and with the greatest error of about 11% the circulation rate can be calculated by the equation [11, 15, 16]:

$$U_{cir} = 0.6 \cdot W_g^{0.27}$$  \hspace{1cm} (1)

Determination of the deposition rate of the cans was performed on a special experimental setup [12].

### Figure 3. The dependence of $U_u$ from the reduced speed.
Figure 4. Dependence of the circulation rate of cans on the velocity of fluid $W_f$ for cans a) №1 and b) №3.

The obtained experimental data were compared with the values calculated by the equation proposed by Smoldyrev [1] for the deposition velocity of solid particles $U_{dp}$ with particles of size greater than $2 \cdot 10^{-3}$ m.

$$U_{dp} = \frac{\frac{\pi}{6} \cdot \rho_{sp} \cdot \rho_f}{\rho_w} \cdot q \cdot d_{eqv} \cdot \frac{1}{\psi}$$

where $\psi$ - the drag coefficient depending on the shape of the solid and the surface roughness of it [17-21].

Moreover, the interpretation of the choice of form is vague. Totally, the coefficient $\psi$ should be understood in the chosen interpretation, as the fact that the drag coefficient depends, in addition to the shape of the body, on the viscosity of the medium, and $\psi$ is determined only by the shape of the streamlined body, which does not allow extending equation (2) to environments having viscosity distinctive from water. The maximum deviation of the calculated $U_{dp}$ values from the experimental ones is no more than 12%.

4. Conclusion
In experimental studies with one can, there are strong oscillations of cans from side to side, which inevitably increases the value of CR, and the presence of a gas-liquid mixture leaves a certain imprint on these values. It is not possible to estimate the magnitude of this deviation at the present time, so it is advisable to introduce a correction factor $k$ in front of CR in the corresponding equations.

5. References
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