The apparatus for sterilization or pasteurization control in canned meat

WOJCIECHOWSKI, J., ŻELAZNY, R.[x]
Institut of Animal Products Technology Agriculture University, Wojska Polskiego 31, 60-624 Poznań, Poland
[x] Research and Development Centre for Scientific Instruments and Teaching Aids, Czerwonej Armii 69, 61-808 Poznań, Poland

Introduction

The control of sterilization procedure in canned food is based most frequently on the regulation of temperature and water or steam pressure in the retort. The principles of semi-automatic and fully-automatic retort control systems were reported by Hughes (1971 a, b, 1972), and they have been widely used in the commercial practice. However, the variable conditions being found in the canneries at times may result in non-uniform heating and sterilization during the successive retorting cycles (Wojciechowski et al., 1974; Wojciechowski, 1975). Among the variables are e.g.: differences in temperature of the canned food prior to sterilization; various raw material composition (but within acceptable limits); fluctuation of energy supplied to the retort and uneven temperature distribution inside the static retort.
Taking into account these variables, the control of retorting procedure through the critical area of the canned food is necessary to ensure reproducible conditions for the sterilization of canned food. Such control is best based on an objective heating criterion, i.e. on the pasteurizing or sterilizing value (Ball and Olson, 1957; Stumbo, 1973). There is a number of references on that subject in the literature (Wirth et al., 1971; Reichert, 1976, 1977, 1980; Stumbo et al., 1975). Additionally, Teixeira et al. (1969) and Flambert and Deltour (1972) reported in which part of the can those values should be measured. The investigations on that topic have been continued (Naveh et al., 1984; Peterson and Adams, 1985).
The selection of an appropriate method of the F value determination is of great importance in the design and construction work of an instrument for the control of the retorting procedure by the use of the F value.
The selected method should make the current control of the sterilization process feasible, and the instrument concerned should be cheap, reliable and simple in operation and maintenance. These requirements can be met by the nomographic method for sterilizing value determination (Harabasz and Wojciechowski, 1978).

Basic concept of the instrument

The nomographic method for sterilizing value determination is different from the graphic (Ball and Olson, 1957), approximate integration (Patashnik, 1953) and Gauss numerical integration methods (Hayakawa, 1968) since it requires no calculations, and no computer is needed to obtain the results. The nomographic method is based on the tabular method prepared earlier by Wojciechowski and Harabasz (1976). In the tabular method the sterilizing value is determined by two components, called complete values.

$$F = F_h + F_d \qquad (1)$$

In the determination of the F_h value in canned food heated by thermal conduction it has been assumed that temperature increment in the critical area of the canned product is proportional to temperature difference between the heating medium and the centre of the canned product (Carslaw and Jaeger, 1959):

$$\frac{dT_h}{dt} = a\ \left(T_r - T_h(t)\right) \qquad (2)$$

On the basis of the equation 2, the F_h value can be determined as follows:

$$F_h = t_1 \frac{10^{-\frac{121{,}1-T_1}{z}}}{-\ln[2(T_1-T_0)]}\left[\ln\frac{T_1-T_0}{2} + \sum_{k=1}^{\infty}\frac{1}{2k\cdot k!}\left(\frac{-\ln 10}{z}\right)^k\left(2\,(T_1-T_0)^k+1\right)\right] \qquad (3)$$

The F_h value may also be presented briefly by the equation given below:

$$F_h = t_1 \cdot F_1(z, T_0, T_1) \qquad (4)$$

Nomographs of the iso-F_h value as a function of temperature T_1 time t_1 and z = 10°C (Fig.1) were calculated and plotted by using the quotation No.3.
If the temperature curve in the critical area of the canned product drawn into the coordinate system will intersect with the given iso-F_h curve, it is an indication that the canned product has been heated to the required sterilizing value.
The shares of the F_h value and of the F_d value within the total F value are nearly constant in the canned products heated by thermal conduction. If the shares of the F_h and F_d values with be determined than the estimation of the F_d value is not necessary. The F_d value increases during the cooling phase and will be known, since the temperature of water used in cooling of the canned products is one of the most constant parameters in the sterilization procedure. Once the product has reached the required F_h value, a pulse is generated to stop heating and initiate cooling (Fig. 2). Concequently, the intersection point of temperature curve in the critical area with the iso-F_h curve, i.e. the C point should be an indication to start cooling of the canned food.
The technical and mathematical data contained in the tabular and nomographic methods served as a basis for designing an instrument for fully automatic control of the retorting procedure.
The following requirements were estimated prior to desinging that instrument:
- temperature in the critical area of a canned product is to be measured by at least two sensors and a discriminator is to select a pulse of the lowest value;
- the required value of the iso-F_h curve is to be estimated automatically in a continuous way;
- the selected kind (type) of curve is to be understandable and well visible to the operator of the retort;
- a system is to be employed to compare the pulse of product temperature with the pulse of the temperature of iso-F_h curve. At the point those two temperatures will be identical a pulse is to be sent to stop heating and to start cooling automatically;
- current comparisons between the pulse of product temperature and the pulse of temperature of the selected iso-F_h curve are to be carried out by using a pulse difference meter to make a precise manual control also feasible;
- the pulses of the product temperature, of the selected iso-F_h curve and the heating medium temperature are to be permanently recorded to give documented proof of the retorting procedure;
- the instrument is to operate in a continuous way;

- the connections between sensor and can, and between can and instrument are to be made hermetic;
- the sensors and the instrument itself are to be corrosion-resistant.

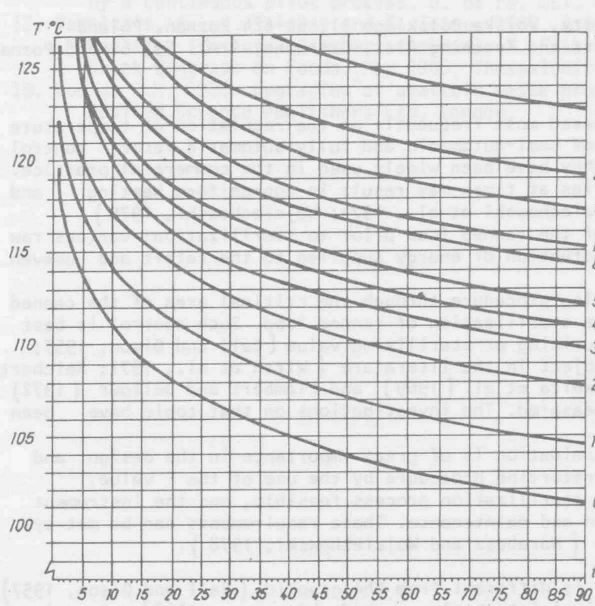

Fig. 1. Iso-F_h nomograph values

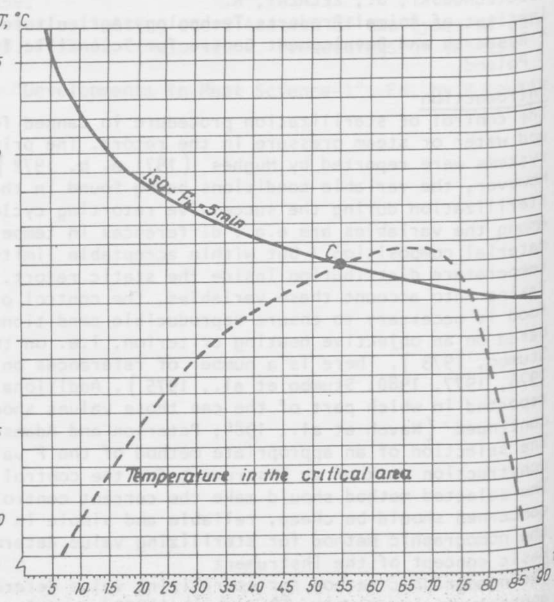

Fig. 2. Critical area temperature change curve and selected iso-F_h curve

Presentation of the instrument

The instrument for fully-automatic control of retorting procedure, designed and constructed by the authors of this paper consists of:
- a set of temperature sensors I
- a presetter-analyser-controller system II
- a recording system III.

The accompanying simplified block diagram on Figure 3 illustrates the basic construction of the instrument for fully-automatic retort control.

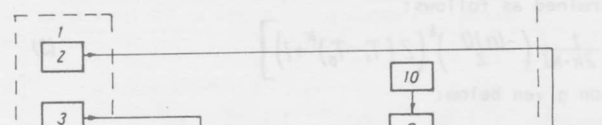

Fig. 3 Block diagram of apparatus

The signals from temperature sensors in the critical area of the canned product 3 are sent to the inputs of the lowest temperature discriminator 4. The signal of the lowest temperature of the canned product is then transmitted to comparator 5, to comparator 9, and to the device measuring difference between the temperature of the canned product and the pre-setter temperatures 14, and finally reaches the recorder 15. The signal from the pre-setter of the iso-F_h curve course 6 is sent to the second input of the comparator 5. That signal is also sent to the device which measures the difference between the temperature of the canned product and the pre-setter temperatures 14 and then to the recorder 15. The pre-setter of the iso-F_h curve course 6 makes the selection of one of the four iso-F_h curves feasible, which are equal to 2, 4, 5 or 6. That pre-setter is actuated by a signal coming from comparator 9 through the system of holding-up the pre-setter 8 in the switched-on position from the moment when the signal of the lowest temperature of the product is equal to the signal from the actuating threshold system of pre-setter 10. The latter signal is sent when the temperature is 90°C.

The system of holding-up pre-setter 8 is properly blocked by a automatic nulling system of pre-setter 7. At the moment when the signal of the lowest temperature of the product becomes equal to the signal of the pre-setter of the iso-F_h curve course 6, the comparator 5 generates a signal which is sent through operating mode change-over switch: automatic or manual 11, and through amplifier 12. Then the signal comes to the valve system of the retort 13, interrupts heating and initiates cooling of the processed canned products.

By the use of the manual control system 16, the operator of the retort 1 can carry out the sterilization procedure on the basis of the readings from the temperature difference meter which indicates the difference between the product temperature and the pre-setter temperatures 14. The recording device 15 records the signal from the temperature sensor of the heating medium 2, too.

A system of the visual and accoustic signalling 17 is actuated after heating had been stopped and cooling of the canned foods was commenced.

The apparatus when used in the commercial practice makes an objective control of the sterilization or pasteurization of the canned food feasible. In that way it can contribute to better quality of the finished product as well as to the conservation of raw materials, energy and water.

Designations:

1 - the retort
2 - the heating medium temperature sensor
3 - temperature sensor in the critical area of canned-food
4 - discriminator of the lowest temperature in canned-food
5 - the comparator
6 - pre-setter of the iso-F_h curve course
7 - automatic nulling system of the pre-setter
8 - actuating holding-up system of the pre-setter
9 - the comparator
10 - actuating threshold system of the pre-setter
11 - operating mode change-over switch: automatic or manual
12 - the amplifier
13 - valve system of the retort
14 - device measuring difference between canned-food and pre-setter temperatures
15 - recorder
16 - manual control system
17 - visual and accoustic signalling system to stop heating

Nomenclature

a - integration constant
F - sterilizing value
F_d - sterilizing value during cooling
F_h - sterilizing value during heating
F_1 - sterilizing value for t_1 = 1 min.
k - integer number
t - time
t_1 - time during temperature increase from T_o to T_1
T_h - temperature during the heating phase
T_r - water temperature in the retort
T_o - temperature of 90°C
T_1 - highest temperature of the canned-food
z - slope index for thermal death time curve of vulnerable factor

References

Ball, C.O., Olson, F.C.W. (1957). Sterilization in Food Technology. Mc Graw-Hill Book Company, New York, Toronto, London. pp.302-303.

Carslaw, H.S., Jaegger, J.C. (1959). Conduction of Heat in Solids. Oxford at the Clarendon Press, London. pp. 18-19.

Flambert, F., Deltour, J. (1972). Exact lethality calculation for sterilizing process. I. Principless of the method. Lebems. - Wiss. u. Technol., 5, 72-74.

Harabasz, J., Wojciechowski, J. (1978). Bestimmung des Sterilisationswertes von Fleischkonserven mit Hilfe von Nomogrammen. Fleischwirtsch., 58, 1996-1998.

Hayakawa, Kan-ichi. (1968). A procedure for calculating sterilizing value of a thermal process. Food Technol., 22, 905-908.

Hughes, P. (1971 a). Retorting procedures. Food Manufacture, 46, 23-26.

Hughes, P. (1971 b). Semi-automatic retort control systems. Food Manufacture, 46, 32-33, 35-47.

Hughes, P. (1972). Fully automatic retort control systems. Food Manufacture, 47, 27-33.

Naveh, D., Pflug, I.J., Kopelman, I.J. (1984). Sterilization of food in containers with on end flat experimental measurements. J. Food Sci., 49, 461-467.

Patashnik, M. (1953). A simplified procedure for thermal process evaluation. Food Technol, 7, 1-6.

Peterson, W.R., Adams, J.P. (1985). Temperature sensor placement errors in institutional size retort pouches. J.Food Sci, 50, 192-196.

Reichert, J.E. (1976). Die Stufenkochung als Mittel zur Qualitätsverbesserung von Fleischprodukten. Fleischwirtsch., 55, 611-614.

Reichert, J.E. (1977). Optimierung der Qualität von Wurstkonserven am Beispiel von Leberwurst durch Anwendung der Stufenkochung und wärmtechnisch günstiger Behälterauswahl. Fleischwirtsch., 57, 900-908.

Reichert, J.E. (1980). Zur Ermittlung des Erhitzungseffektes für Kochschinken (F-Wert). Fleischerei, 8,624-633.

Stumbo, C.R. (1973). Thermobacteriology in Food Processing. Academic Press. New York and London. pp. 107-108, 117-118.

Stumbo, C.R., Purohit, K.S., Ramakrishman, T.V. (1973). Thermal process lethality quide for low-acid foods in metal containers. J. Food Sci. 40, 1316-23.

Teixeira, A.A., Dixon, J.R., Zahradnik, J.W., Zinsmeister, G.E. (1969). Computer determination of spore surrival distributions in thermally processed conduction-heated foods. Food Technol., 23, 352-354.

Wirth, F., Takacs, J.,Leistner, L. (1971). Hitzebehandlung und F-Werte für langfristig lagerfähige Fleischkonserven. Fleischwirtsch., 51, 923-935.

Wojciechowski, J., Popławska, M., Panowicz, Zb., Pazacki, W.,(1974). Evaluation of usefullness autoclav working in meat industry. Gosp. mięsna, 2, 20-23. (in polish).

Wojciechowski, J. (1978). The current problems of canned meat products sterilization. Gosp. mięsna, 2, 24-26 (in polish).

Wojciechowski, J., Harabasz, J. (1976). Tabelarische Methode zur Bestimmung des Sterilizationswertes für Fleischkonserven. Fleischwirtsch. 56, 255-258.