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HIGHER PRODUCT SAFETY IN THE PRODUCTION OF CANNED FOOD WITH SOFTWARE DEVELOPMENT

***Zoltán Fabulya, György Hampel, Piroska Muhi Joóné, Magdolna Kiss**

*University of Szeged Faculty of Engineering, 7 Mars tér, Szeged, Hungary, fabulya@mk.u-szeged.hu

Abstract

The primary aspect in food industrial researches is to increase safety. The most important aim is to lessen the degree of conservation in food processing, otherwise the food cannot preserve its original qualities, consuming and nutritional values. Furthermore, consumers claim the possibility to prepare their food more quickly, the safe and hygienic application, longer shelf-life, the constant and checked quality, the usability on wider scale and the solution of unexpected situations. These could be utilized by preserved food-makers, but for this they have to employ modern work organization which follows the expectations of our time.

The safety, quality and rentability of preserved food (besides the quality of the basic materials, the good recipe and the features of the production belts) are determined by their heat-treatment and its organization. The production process which was not planned carefully can imply safety and quality problems and can lead to considerable increase of expenses.

Key words: safety, heat treatment, optimization, production programming

INTRODUCTION

Heat-treatment of canned food, mainly in case of meat conserves, is a process which needs a lot of energy, since it involves sterilization and a long period of heat effect at around 120°C. The necessity to reduce utilization of natural energy resources also appears as an important aspect.

It is worth involving engineering calculations, modelling, computer simulation in the research of this field, for the sake of the quality of products and expense-efficient production. A work organization should be formed which guarantees manufacture of products which are safe from microbiological aspect; which keeps the regulations more precisely in the interest of higher quality and lower expenses. To do this there should be an information technology background which can provide the necessary assistance, on the basis of research results, to elaborate the suitable work organization. For this aim, the IT provides the user-friendly operation surfaces, which fulfil the claims of our time, the simulating and optimizing technique, the predicting and problem solving services and the flexible enlargement possibilities.

The literature in the 1970s addressed the question of overall heat loss (Rao et al., 1976; Rao et al., 1978; Singh, 1978). In the 1980s publications about heat utilization and heat recovery were published (Sielaff et al., 1982; Bhowmik et al., 1985; Singh, 1986). Recent researches aimed at increasing the intensity of heat penetration which can be achieved by rotating a suitable autoclave at the appropriate speed during heat treatment in case of viscous food (Yang and Rao, 1998; Akterian, 1995; Alonso et al., 1997; Meng and Ramaswamy, 2005, 2007a, 2007b). Simulation of optimization scheduling was also used with the aim to apply heat treatment of different products in the case of the same sterile formula, thus requiring less waiting period until the treatment (Simpson, 2004; Simpson and Abakarov, 2009).

The researches, however, did not address production management issues – besides product safety –, affecting positively the quality and the direct cost of the heat treatment. They also did not address the coordinated operation of autoclave groups (Fig. 1), where starting the heat treatment processes with the appropriate scheduling ensures balanced production by balanced resource (steam, water) consumption.

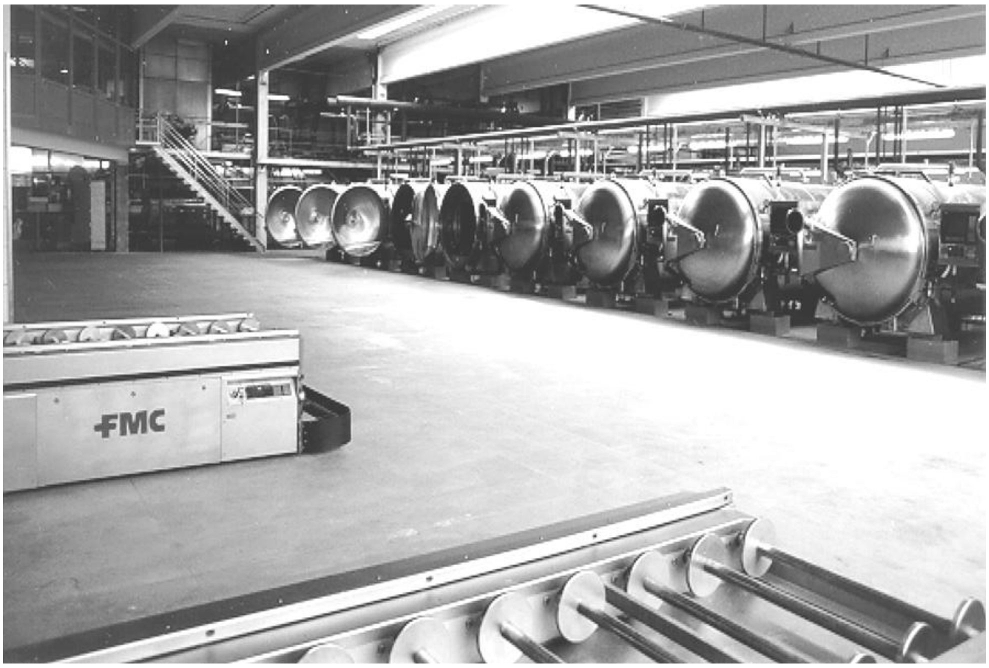

Fig. 1 Heat treatment plant with group of autoclaves (Simpson et al., 2007)

Companies set up production plans with some regularity for the coming period. The company providing ground for the research compiled the production plan for the next week on a weekly basis, where the most important element was to decide which product to be manufactured in a particular shift. There were several production lines, and the product determined what production line was suitable to manufacture the product. The details of the plan and the data of the resulting processes were not supervised by a computer, so problems could easily arise because of human carelessness.

MATERIAL AND METHOD

What basically determined the research and appeared in almost each element of the work was computer modelling. For this reason, primarily the applied methods and techniques of this field were utilized from observation and data collection through details of modelling, programming, which often needed considerable creativity, up to the statistical methods of verification and validation of the model and finally, to the statistic processing of results coming from the experiments (simulation) carried out on the model.

Data utilized in the research consisted of two groups. Chronologically the first one came from the former Meat Industrial Company of Szekszárd (Szekszárdi Húsipari Vállalat) where we carried out measurements to improve the product quality of meat conserves subjected to heat treatment. A data collecting software was developed to achieve this goal. Thus, for this present research we had the necessary data in archive files to elaborate and verify the model, to develop the test simulating and optimizing programme and finally, to find and test the scheduling algorithm, consequently, to elaborate the examination methods. We needed the other data group, which was provided by another company, for further examinations and research directions (optimization of costs and work organization).

For the modelling and the optimization with simulation we used Microsoft Excel and Microsoft Access programmes both for the development of the mentioned programme with the built-in Visual Basic for Applications (VBA) service and for the function fitting and statistical operations of Solver and Data Analysis functions available as an Excel add-in.

RESULTS AND DISSCUSIONS

In our earlier research, an overall view was given about the cost-cutting role of balancing the boiler load (Fabulya, 2011), as well as the development of the software (Fabulya and Hampel, 2010). Now, in possession of the complete programme, we can show the numerical results of the cost reduction with the use of the software.

With the simulator of the programme one can get the data series of the steam consumption for heat treatment of a week for each autoclave even in a resolution of five minutes. These data provide the steam demand of each shifts and the boiler load in percentage. Based on our previous results there is a given efficiency for each load. Table 1 summarizes the simulation data of the original and the balanced load of shifts in a week.

Table 1

Boiler load balance of shifts

Day	Shift	Unbalanced		Balanced	
		Boiler load	Efficiency	Boiler load	Efficiency
15.06	1	45%	76%	45%	76%
15.06	2	37%	73%	47%	77%
15.06	3	49%	78%	49%	78%
16.06	1	33%	71%	53%	79%
16.06	2	22%	65%	47%	77%
16.06	3	41%	75%	51%	78%
17.06	1	27%	68%	47%	77%
17.06	2	20%	63%	60%	81%
17.06	3	38%	73%	53%	79%
18.06	1	82%	87%	52%	79%
18.06	2	46%	77%	46%	77%
18.06	3	75%	86%	55%	80%
19.06	1	92%	89%	52%	79%
19.06	2	46%	77%	46%	77%
19.06	3	75%	86%	55%	80%
Averages		49%	75,8%	49%	78,2%

The averages in the last row of the table should be used hereinafter. The 49% boiler load has not changed as the result of the balancing of course, since the same products in the same amounts were there to get heat-treatment, but in a different distribution among the shifts. However, more balanced boiler load provides better efficiency.

The thermal energy of the steam (E), which indicates the load of the boiler, can be calculated from the volume of gas used for heating the boiler during a week (G), the calorific value (F) and efficiency (η):

$$E = G \cdot F \cdot \eta \qquad (1)$$

From the above, the volume of power-gas required for the heat treatment can be computed:

$$G = \frac{E}{F \cdot \eta} \qquad (2)$$

In case of invariable heat requirement (E), the lower efficiency means greater quantities of gas. The higher gas demand can be expressed as a percentage:

$$\frac{G_1}{G_2} = \frac{\frac{E}{F \cdot \eta_1}}{\frac{E}{F \cdot \eta_2}} = \frac{\eta_2}{\eta_1} = \frac{78,2\%}{75,8\%} = 1,032 \qquad (3)$$

Where:

E – steam energy (MJ)

F – calorific value of the gas (MJ/m3)

G_1 – volume of the gas without balancing boiler load (m3)

η_1 – efficiency of the boiler without balancing boiler load

G_2 – volume of the gas by balanced boiler load (m3)

η_2 – efficiency of the boiler by balanced boiler load

So, 3.2% more gas is needed without balancing the boiler load in the shifts. Performing the simulation and the load balancing on other weeks, results between 3% and 5% were found. This means an annual 3-5 million HUF in case of a base of 100 million HUF annual gas fee.

Similarly to those presented in the previous section, the time balancing of the boiler load is done here as well, but this time with scheduling within a shift, coordinating the process by putting the start of heat treatments on hold. Table 2 shows the series of 5-minute resolution data of boiler loads in a shift with and without scheduling.

Table 2

The impact of scheduling on boiler load

Day	Shift	Time	Without scheduling		With scheduling	
			Boiler load	Efficiency	Boiler load	Efficiency
15.06	1	6:00	45%	76%	38%	73%
15.06	1	6:05	43%	75%	37%	73%
15.06	1	6:10	42%	75%	61%	82%
15.06	1	6:15	75%	85%	59%	81%
15.06	1	6:20	74%	85%	58%	81%
15.06	1	6:25	74%	85%	57%	80%
15.06	1	6:30	73%	85%	50%	78%
15.06	1	6:35	65%	83%	50%	78%
15.06	1	6:40	60%	81%	49%	78%
		.				
		.				
		.				

15.06	1	13:45	17%	61%	41%	75%
15.06	1	13:50	16%	60%	40%	74%
15.06	1	13:55	16%	60%	40%	74%
Averages			45%	74,9%	45%	78,4%

Studying table 2 there can be a small misunderstanding, because there are greater efficiencies on the top of the table in the case of no scheduling. This can be explained by the fact that, in case of higher loads the efficiency is improved, but to a lesser extent than the appearing decrease of efficiency while lower load. The scheduling is aimed at the balancing of the load. Thus the better efficiency at higher loads develop to a lesser extent, but much worse efficiency also do not occur at lower loads as well. It can be seen in the last line that as the result of the scheduling, steam can be produced with better average efficiency. Equation 4 can be used to determine the higher gas demand of the unscheduled state in percentage:

$$\frac{G_1}{G_2} = \frac{\eta_2}{\eta_1} = \frac{78{,}4\%}{74{,}9\%} = 1{,}047 \qquad (4)$$

Where:
G_1 – volume of gas without scheduling (m3)
η_1 – efficiency of boiler without scheduling
G_2 – volume of gas in case of scheduling (m3)
η_2 – efficiency of boiler in case of scheduling

So, 4.7% more gas is needed during the shift without a schedule. Performing the simulation and the scheduling in several shifts, results between 3-5% percent were found, which also means an annual 3-5 million HUF savings in case of a base of 100 million HUF annual gas fee.

CONCLUSIONS

Synchronizing the starting points of parallel heat-treatment processes in the autoclaves, the automation could guarantee that regulations described in the sterile formula are kept and thus products of better quality are made. The automatic control, very properly, regards the security aspects as of major priority. That is why time spans determined in the sterile formula (heating up, keeping on temperature, cooling) cannot be shorter than what is prescribed, the speed of heating up cannot exceed the measure determined by the regulation, and keeping on temperature can be started only when the prescribed temperature has been reached. The temporary insufficient steam supply can be avoided this way, so the time span of the process will not grow which, with its groundless heat load, results in the over-cooked product of lower quality. All in all, the applied method of scheduling has a positive effect on the quality of the product.

For the software developed for simulation, optimization and scheduling, Excel can be applied in a user-friendly way, to store, process the data and to represent them in diagrams, to fulfil programming tasks, while Access can be used to feed data into the computer with forms and to create queries and reports. The developed computer system guarantees an easy possibility for data input and modification, to check product piling on the production belt, to avoid the long waiting lines for the heat-treatment by checking the autoclave capacity, to balance the gas consumption of the shifts and to prevent the gas consumption peaks. All in all, it can guarantee the manufacture of higher safety and better quality products with lower direct costs.

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