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# MODELLING AND SIMULATION FOOD PRODUCTS PRODUCTION

**Abstract**

*Modelling and simulation food product production are presented in the paper. There is some information about how to analyse continuous production systems in food industry. As the example we have got here in the paper choosen food product production simulation. There was illustrated optimum production process run. In modelling and simulation there was included food industry specifity. There was take into consideration how components expiration date and production times influence on ready made products expiration date. The problem was solved in support of ARENA module. There is some information about solving problems of machine servicing with taking into account technological changes.*

## 1. INTRODUCTION

In food industry the production process is more complex then in machine industry. To the problems which are typical for machine industry overlap questions connected with the time-limit of production components use and expiration date for final products.

The final time of using components or products consumption is defined by the shortest term of the given ingredient or ready-to serve product.

Factories work in limited demand and buyers market conditions. That makes necessity of continuous improvement firm activity. That is why the more important problem becomes production processes optimization.

In modeling and simulation the aim is to build the simulation model and define the results. In optimization the important thing is to define requisite input data to have in result demange output data. Optimization criteria are need for building mathematical models.

In food industry we have continuous production processes. In the paper there is presented simulation model of production of the chosen food product. Simulation model was created in Arena system.

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## 2. PRODUCTION PROCESS

In food industry model of production system mostly fall out from three main parts:
- supply (A),
- production (B),
- distribution (C) .

This is presented below at fig.1.

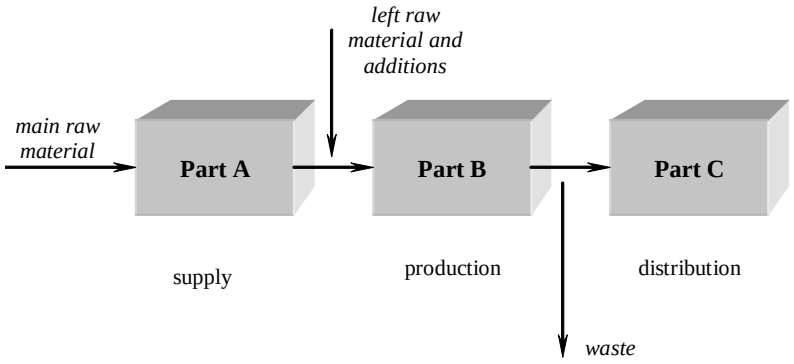


Fig. 1. Production system

For this process was made mathematical and simulation model which contains: number of operation, operation names and number of machines on each work-station**.**

At figure 2 is illustrated production and distribution time influence on consumption validity period. This data is needed to later analysis.

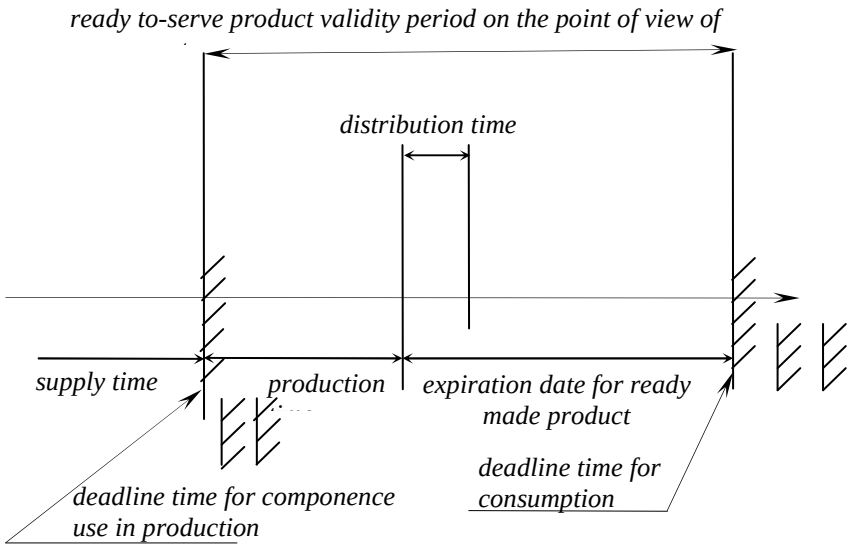


Fig. 2. Influence of production and distribution time on consumption validity period

$$Y = f(x_n) \quad (1)$$

for $n = 1 \ldots N$

$c = \text{const}$

In case of production process the parameters influence on process run, which is presented at fig. 3, and due to fulfill quality requirements the criterion production process evaluation are costs and execution time. This is connected with schedule of: production process optimum, machine rearming, machine shutdown and work station repairs.

The parameters influence on cost, time and product quality are illustrated at fig.3.

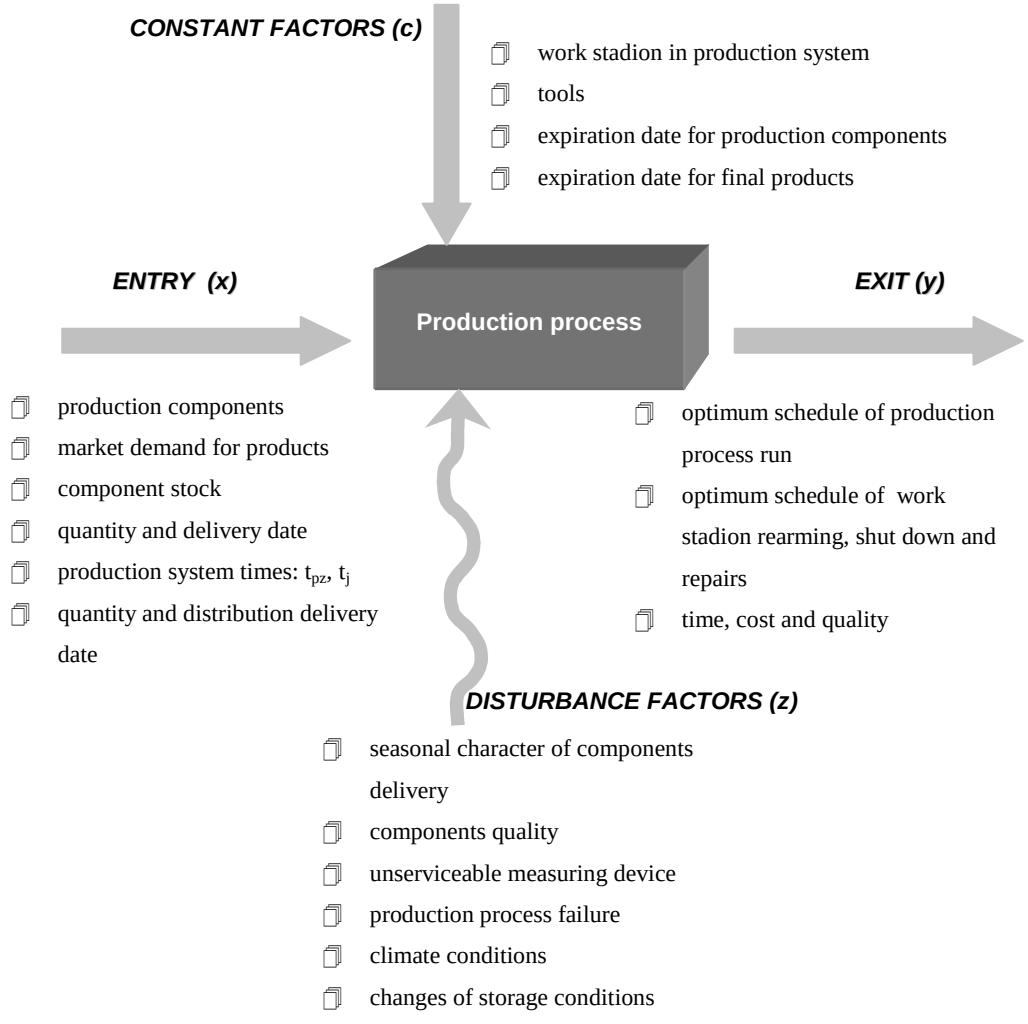


Fig. 3. Production process ingredient influence model

## 3. PRODUCTION PROCESS MANAGEMENT

During modelling and simulation is created a lot of production process solution variants. Very time-consuming are studies enclosing all possible: combinations and factors value configuration. In order to reduce numbers of simulation it is possible to apply experimental research methodology.

In production systems analysis testing factors are generally: time, cost, and quality.
The main action targets to make production process improvement are:

- shorting of the production order realization time,
- production cost minimization,
- compliance with client product quality requirements.

The simulation for production process run was made for following assumptions:

- ✓ at production line are makes different kind of products: a, b, c;
- ✓ there are some possible product sequences: a ⇨ b, a ⇨ c; b ⇨ c; the combination a ⇨b doesn't need the line to be cleaning, but if we want to produce another kind of margarine that is necessary to make line cleaning;
- ✓ after each 40 working hours it is obligatory to clean whole production line;

- production plan:
  - product fulfill time:
    - a – 3 time units
    - b – 1 time unit
    - c – 1 time unit
- production line cleaning time: 2 time units;
- production line disinfection time: 1 time unit;
- rearming time: 1 time unit.

Logistic of supply, production and distribution is presented on figure 4.

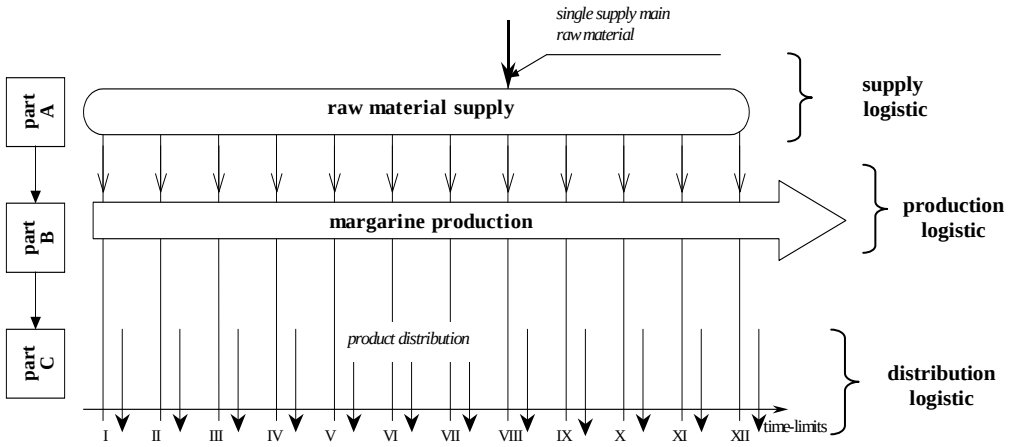


Fig. 4. Logistic of supply, production and distribution

Below at the fig. 5 is illustrated an example of production process run for chosen food product.

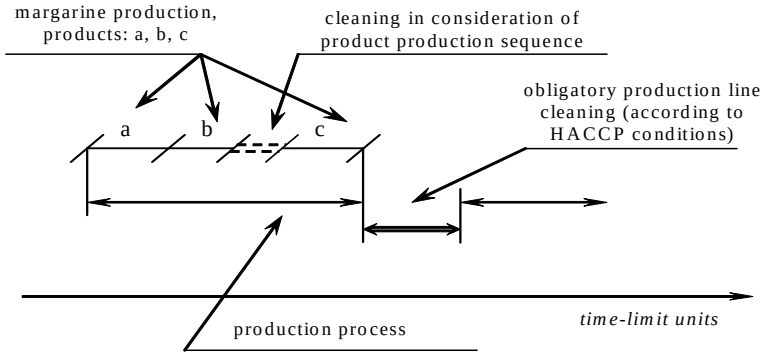


Fig. 5. Chosen food product production process run

Different variants combination of production process run is illustrated at figure 5. In time-limits unit was define production cycle length for making products: a, b, c for different production alternatives.

In addition we have got information about production cost.

## 4. MACHINES AND EQUIPMENT USING

One from factors connected with production logistic is to give definition of proper production system operating scenario.

In literature there are described different procedures of making scenario.

One from methods which enable non-detailed but complex description of function of the Maintenance Service is Business Centered Maintenance.

BCM conception is presented at fig. 6.

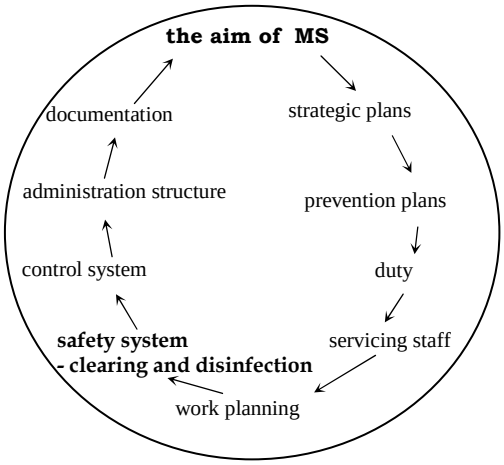


Fig. 6. Business Centered Maintenance conception (MS – Maintenance Service)

The next figure shows that in food industry technical reliability on process line work overly technological reliability. This is the difference from machine industry.

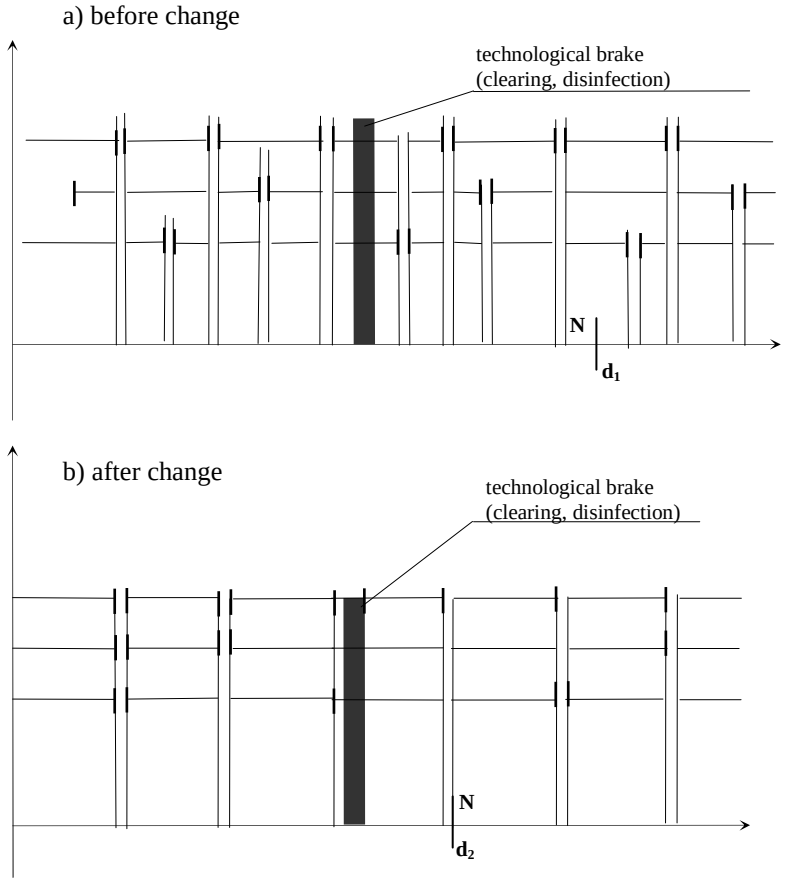


Fig. 7. Solving problems of machine servicing with taking into account technological changes (cleaning, disinfection), $d_2<d_1$

## 5. MODELLING AND SIMULATION PRODUCTION PROCESSES

As the example of using modeling and simulation method there is presented production process analysis for chosen product form fat industry - margarine.

The simulation model was made in system for modelling and simulation production processes called ARENA. One of the goal of the simulation was to check if the final results are this some or close to production reality. The next goal was to show changes which can be introduce in next stages of production process. There was take into account cost of production too.

The fig. 8 illustrated production process for margarine.

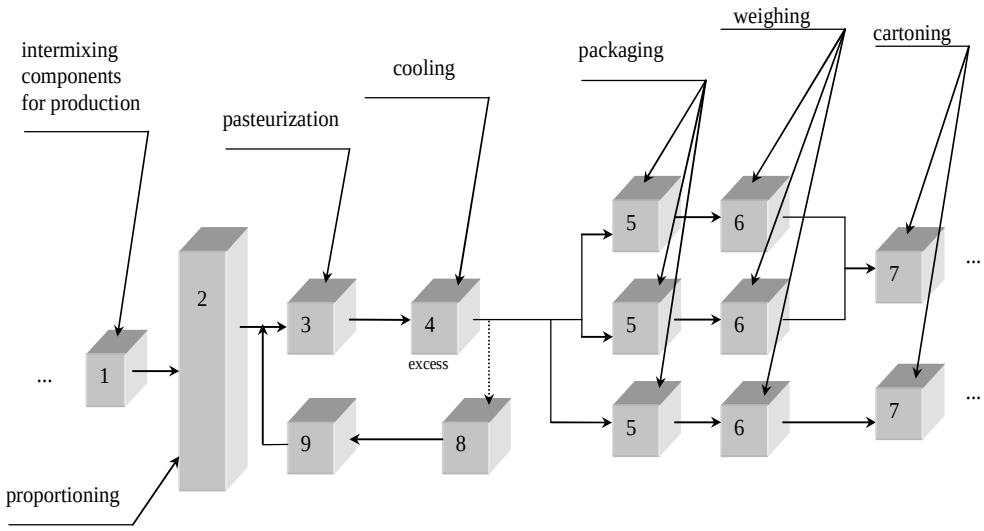


Fig. 8. Technological margarine production process scheme.
1-„emulsion tank", 2- metering pump, 3-pasteurizer, 4- combinator, 5-packing machine, 6-scales, 7-cartoning machine, 8- turn tank, 9-turn pump

For preparing production process model there was take into account following data:

- information about approachable departament resources– machine and equipment, workers, work organization, planning standstill for example machine cleaning and disinfection ,
- production plan– type of margarine, quantity unit,
- production process of margarine – operations, cycle time.

The table below shows technological production process of margarine and operations.

Tab.1. The margarine technological line – production process, machines

| **Operation number** | **Operation name** | **Work stadion (fig.2)** |
|---|---|---|
| 1. | pasteurization | Pasteurizer (3) |
| 2. | cooling | Combinator (4) |
| 3. | packaging | Packing machine (5) |
| 4. | weighing | Scales (6) |
| 5. | cartoning | Cartoning machine (7) |

The fig. 9 illustrated model which was made in ARENA system. That simulation was made for production process (part B from fig. 1).

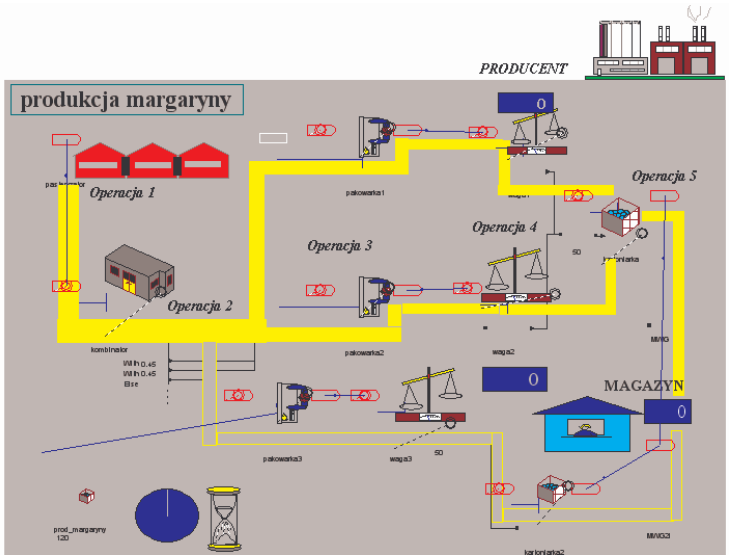


Fig. 9. Simulation model of margarine production line in ARENA system (part B)

The simulation results for different variants of production process for product a, b, c are presented at fig. 10.

Possible solution set define formula (2):

$$Z_{W_M} = \{W_m\} \tag{2}$$

where: m = 1… M

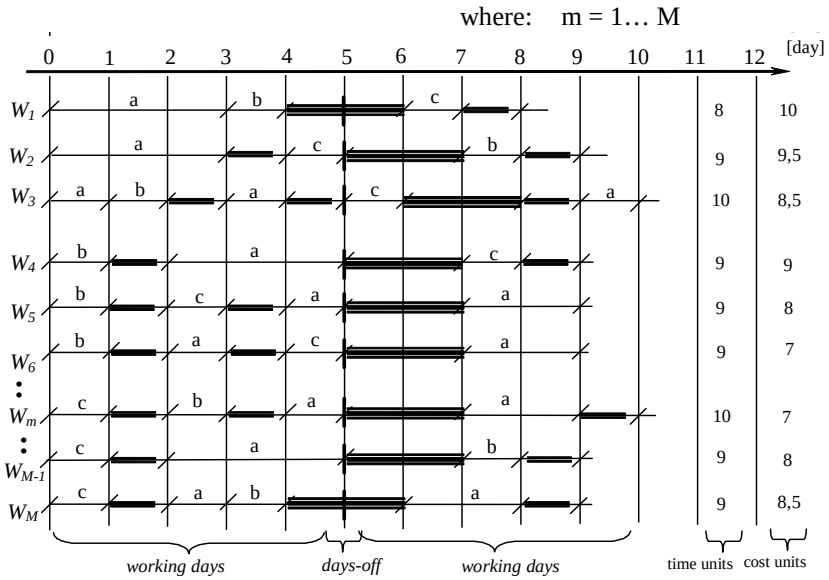


Fig. 10. Alternative variants a,b,c processes.

At figure 11 there is optimum Pareto as a result of analysis for products a, b, c, and variants $W_1$-$W_M$.

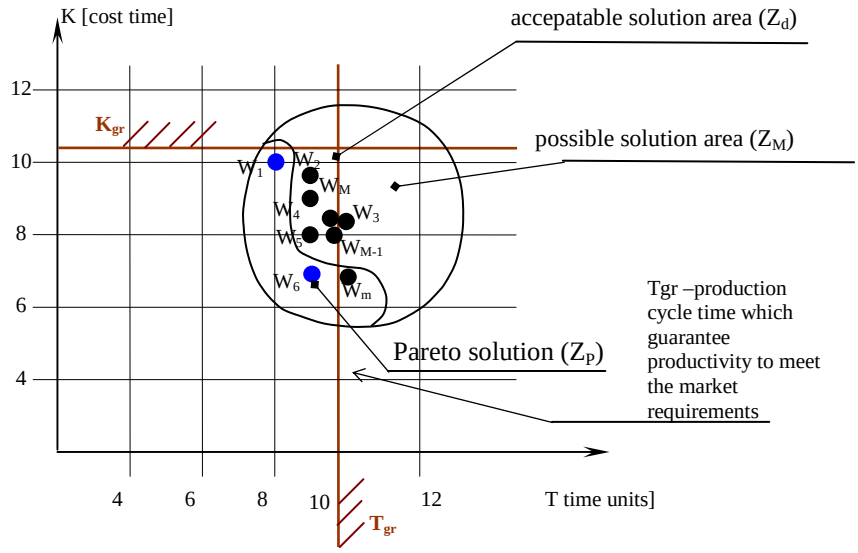


Fig. 11. Optimum Pareto

Acceptable solution set define formula (3):

$$Z_{WD} = \{W_d\} \tag{3}$$

where: d = 1…D

Pareto solution set define formula (2):

$$Z_{W_P} = \{W_p\} \tag{4}$$

where: p = 1… P

## 6. CONCLUSIONS

Food production process is a complex process. On problems, which are well-known from production process management in engineering industry, overly problems connected with expiration data for components and final products. There are specific sanitary limitations such a cleaning and disinfection machines and equipment.

Because of such specific production conditions using of the modeling and simulation method makes possible to qualify:

- optimum solution set, which is called the optimum Pareto,
- optimum process alternative in dependence from market situation,

- scenario procedure in case of machine break-down,
- stock on hand ( of components for production) and principles for final product storage and distribution procedure.

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