

Scenarios of intellectual fuzzy automated control of bread production

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Abstract

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Introduction. The research of the scenario approach in the automation of the control of the processes of baking bakery products [3, 4] has been carried out in order to increase the efficiency of production and improve the quality of products.

Research methods. Are analysis of the characteristics and criteria of the chosen problem, compilation of qualitative assessments and previous scenarios of process management, estimation of the realistic solutions (expert, cross-influence, Saati method [1]), rules and sequence of their application in the writing of generalized scenarios.

Result and discussion. The article deals with the main components of the stages and operations of bread production and various possible schemes for their regulation. The disadvantage of the typical scheme of automatic humidity control on dough machines of continuous action is its orientation to the stable quality of flour. To regulate the duration of fermentation, the mass of the semifinished product in the fermentation vessel fixes the weighing mechanism, and the consumption takes into account the flow meter, these data are processed according to the corresponding formula. At the stage of mechanical treatment of the dough, it is necessary to control the mass of the dough and its degree of readiness for baking. The controlled parameters are the temperature and humidity of the air in the cabinet, as well as the durability of the stand.

It is proposed to develop an automated multi-purpose control system based on a scenario approach and intelligent technologies [5, 8, 10] in order to increase productivity, reduce specific losses and cost of resources while improving product quality. The essence of the situational approach to the management of technological processes of baking bread is outlined. The abstract (A-) and structural (C-) scenarios of bread production are offered, which can be used in the quotient-purpose analysis of bread production. C-scenario details the A-script based on the evolution of the object when performing operations and transferring objects from one operation to another [6, 7]. Each class C- scenario runs autonomously and interacts with other classes and the environment to make new objects in the input queues and to remove from the output queues "worked out".

Conclusions. The analysis of the state of the problem of control of technological processes of bread production and the examples of control scenarios are given.

Introduction

As a result of the study and analysis of baking processes as objects of control, it was found that, firstly, dynamic models of objects of control are characterized by considerable dimensionality, lag, uncertainty and parametric instability; and secondly, with a limited number of regulated parameters and adjusting actions [3,4], the requirements for stabilization of regulated parameters increase with the transition to more complex control; thirdly, the set of functional management tasks is limited, but the requirements for the effectiveness of their solution are increasing; and fourth, the analysis of production, which is characterized by multi-stage, allows to allocate a technological subsystem of a number of subsystems. All this allows you to move from estimates to the ratio to the estimates of the situation. In this case, first of all, two guiding approaches are used: program-target and network (scenario).

The program-oriented approach in control is oriented towards the achievement of the final result: the formation of a goal tree, the development of an executive program and its implementation. The scenario approach is associated with prediction. There are not only one, but several possible strategies, respectively, which builds the system of mathematical models and does not set rigid goals. The main elements in the scenario approach lie not in linear, but in network logic. The scenario approach is not necessarily focused on solving a global problem and it is a continuation of simulation without the use of formal methods of analysis [9].

Studies have been conducted on the creation of automated systems for managing baking production processes based on a scenario (network) forecasting approach, and not only on the achievement of the final result according to the logic of phased actions, as in the program-target approach, in order to increase the efficiency of production and quality products. The purpose of the article is to increase the technical and economic indicators of baking production by creating an automated system of multi – purpose management using scenarios of production situations and intellectual mechanisms.

Materials and methods

Modern methods, means and forms of organization of information management processes (materials), which should include and automate the processes of production of bread [3, 4, 5], do not allow to effectively solve the tasks of automated control. There are problems of a fundamental nature, connected with the absence, firstly, of theoretical studies of production processes (the theory of the development of information-logical models of subject areas), and secondly, the structure and functioning of the corresponding automated system [4, 5]. The combination of the processes of modernization of equipment and production technologies will provide the theoretical basis for implementation in the process of production management of methods and means of information technology.

Research methods in the complex of technological prediction implementation in the control scenarios were used at different stages of the different:

- preliminary study of the problem – analyzed its characteristic features, determined directions of research, formed important criteria for the chosen problem;
- qualitative analysis of the problem – qualitative assessments or previous scenarios were prepared for the next stage of the prediction, which summarized the scenarios, analyzed and evaluated their realism for final decisions (Delphi method – expert assessments, cross-impact, Saati method [1]);
- Writing scenarios – for a set of rules and their sequential use in writing generalized scenarios.

Result and discussion

Considering the main problems hampering further effective development of the baking industry, we can say that one of the most important problems is yearly reduction in of bread consumption of in Ukraine. Reduction caused by as decreasing of production as well as by the needs of the internal market. In recent years the population has decreased by millions of people, also blur has decreased purchasing power, increased prices for bread products. In the Table 1 is presented production dynamics and consumption of bread in Ukraine over recent years [2].

Table 1

Indicator	2003	2004	2005	2006	2007	2008	2009	2010	2011	Jan.- Dec. 2012
Production of bread and bakery products, thousand tons	2335	2307	2264	2160	2032	1978	1828	1808	1769	1607
Consumption of bakery, kg/person	125	125	123,5	120	115,9	115,4	111,7	111,3	110,4	-

Recently, the situation has only intensified. To ensure production efficiency is possible only by improving the quality of products under these conditions.

In the baking industry the main raw material may be different by its quality characteristics. A wide range of changes in raw material quality significantly influences the course of technological processes and carries out the constant disturbing influences which complicate the production process control of quality products.

To prevent shortages of products and receipt of satisfactory quality of bakery products from flour with low baking properties can be regulated the run of technological processes with help of using different technological methods. Parameters of technological process as the storage of raw materials, the duration of kneading, the dough temperature, temperature, humidity and length of proofing, baking temperature and duration also have influence upon the quality of the finished product (Figure 1).

Making bread sponge method has several advantages over spongeless method: reducing of yeast costs and significant technological flexibility to select the most efficient regime for processing flour depending on its technological features. However, the sponge method also has disadvantages: during the preparation of dough is necessary twice dosing and mixing of raw sponge and dough more overall duration of fermentation. Therefore, the loses of dry matter of raw materials to fermentation increases, and the output of bread decreases by 0.5% compared to spongeless method.

It is believed that products made by the sponge method have better flavor and aroma, porosity, physical properties of the crumb, due to the degree of swelling and peptization of flour colloids. Sponge method also gives better result in the processing of weak and defective flour with low-quality grain.

In order to develop an effective system of automation there is conducted a detailed analysis of technological process of bread production. So, let's consider the main the stages and operations, highlighting tasks problems and problems of each stage [3, 4].

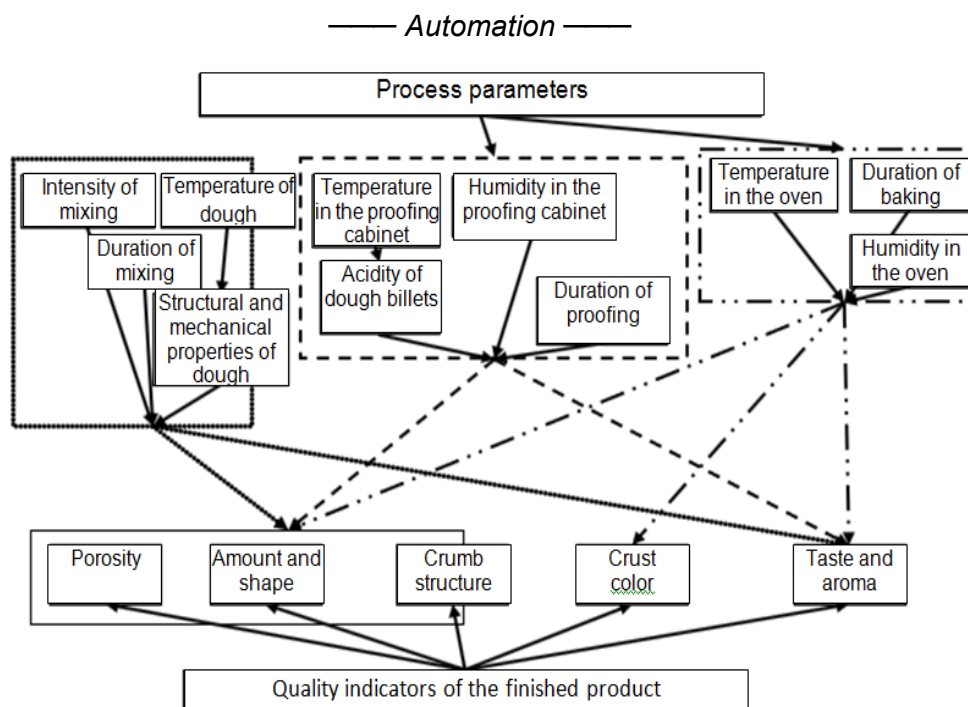


Figure 1. Indicators of baking quality finished product

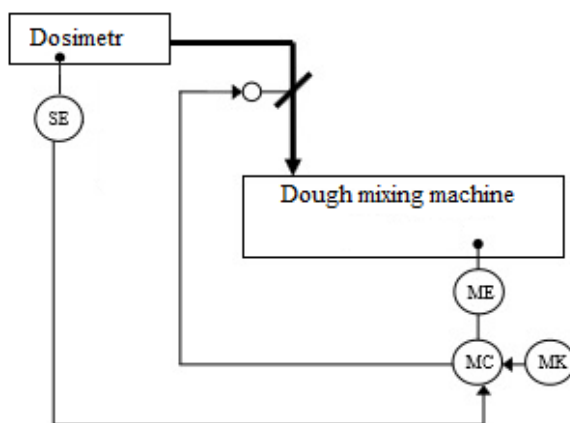


Figure 2. The typical scheme of automatic control and regulation of humidity of semi-finished products and dough

A typical scheme of automatic control of humidity on dough mixing machines of continuous action is shown in Figure2. The disadvantage of this scheme is that it is designed for consistent quality of flour. Therefore rational will be add a decision support system, will be rational approach and using of it will contribute to the effective recycling of different flour quality. Duration of semi fermentation is a basic parameters of dough [3]. For the weighting mechanism fixes the mass of semifinished product in the fermentation tank for its regulation and the consumption is taken into account by flowmeter, these data is processed by the corresponding formula (Figure 3).

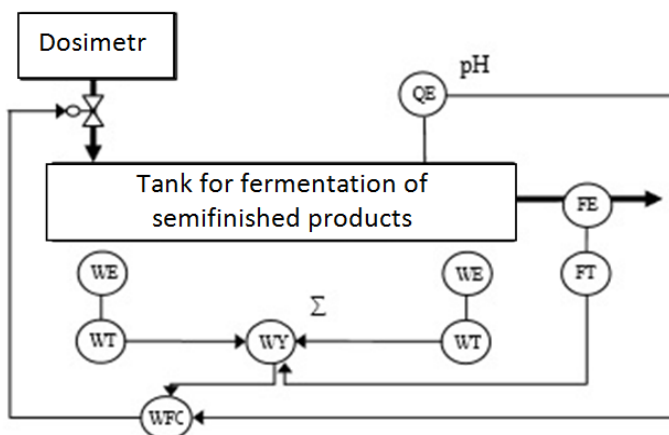


Figure 3. The typical scheme of regulation the duration of fermentation.

If you change the duration of fermentation (due to malfunction of batcher dosimeter or when you change the performance of the aggregate unit (WFC) gives a command to change the performance for batcher dosimeter calculating device to establish a new weight.

The degree of mechanical processing of dough during mixing is characterized by the expended energy. Following the scheme in Figure 4 torque by sensor that sends a signal to the control device, which according to the rheological properties of dough for this type of flour controls the frequency rotation, slope of mixing blades or kneading duration.

At this stage it is necessary to control the mass of dough billets and degree of readiness for baking. Controlled parameters are temperature and humidity in the proofing cabinet and the duration of proofing. Typical scheme of the section of processing dough, with contours of regulation is shown in Figure 4.

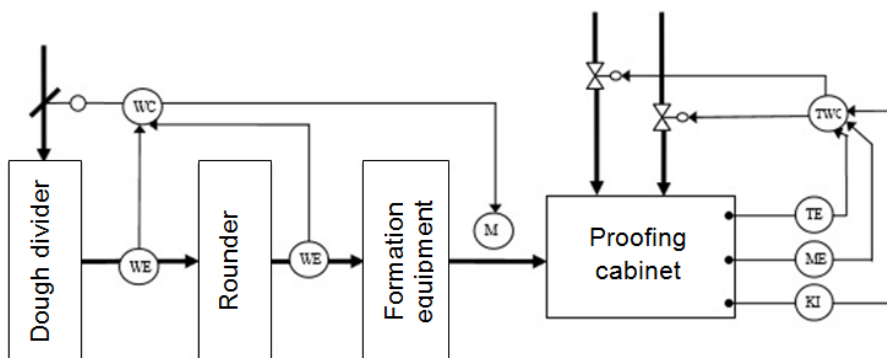


Figure 4. A typical scheme of automatic control processing dough

The regulation the weight of the dough billet by stabilizing the level of the dough above divider with level sensors doesn't give the required accuracy, so it is advisable to stabilize the temperature and humidity in the proofing cabinet and regulate only the duration proofing.

Formed dough proofing billet has porous less structure. So for, the stress relaxation, for loosening dough billets, and providing her forms of bread the future it is used to conduct a final proofing process. To proceeding this process in quite rapidly and without drying the surface of the dough blanks, the parameters of air in proofing cabinet must comply with certain values of temperature and relative humidity (35–45 °C, 75–85%). During the proofing biochemical, microbiological, physical and colloid processes are occurred. Then bread baking starts.

Baked bread is placed in trays that are placed on trolleys and then happens the selecting of products that do not comply with standard documentation. Quality of finished products is evaluated according to the analysis of overage samples taken from the batch bakery products, according to state Standard.

Bakery industry is characterized by a high degree of uncertainty, for which you can eliminate some of the controls at various stages of the process. For example, intensive dough reduces the duration of fermentation. Insufficient degree of fermentation dough can be compensated by increasing the duration of proofing and baking under appropriate modes, they are: increasing the relative humidity in the proofing cabinet and the environment in the baking chamber, and increasing the temperature of proofing and decreasing the temperature of baking [4]. Thus, the same end results of functioning of technological process are available in various different operational parameters and different structure of the technological scheme that provides a wide range of control.

Action at designing of the technological scheme and attached to its analysis, in order to improve control systems. But enumerate all possible structures and choose the best of them is almost impossible.

To improve the situation may be through the use of scenarios of bakery production management (control) that based on cognitive – scenario models of technological processes and control algorithms using intellectual mechanisms. That why, the development of systems for multipurpose control (management) of technological processes of bakery production, based on scenario approach and intellectual technologies will increase productivity, decreasing losses of resources and raw materials, improving product quality [4,5].

Methodology of approaches to control of complex organizational and technical (technological) systems contain goals, laws, principles, methods, features, technology and practice in management of decisions. There are allocated different approaches of controlling organizational and technical (technological) systems, they are: system, process, situational.

The situational approach concentrates on situational differences, it determines which changeable situant and how they influence on the effectiveness of controls. The situational approach to management explores which of models and algorithms are effective and on the basis of this analysis is offered the decision to build control systems for specific conditions.

The technological situation $S(t)$ as the image is described by feature vectors that characterize the corresponding object, and determined by some relation on the set of parameters $\{Y\}$, which is characterized by multiple classes of situations $\{Ks\}$, which are reflected in the control scenario, by multiple classification algorithms $\{K_A\}$ and rules of selection of classification algorithms $\{P_K\}$:

$$\{Y\} = \{KS, KA, P_K\}.$$

The sequence of specific actions in the scenario has a property of causality and provides connection preliminary steps with the following. Implementation of scenarios of process control carried on fuzzy model of knowledge representation. This method is quite flexible and convenient to represent logical connections between elements of scenarios [6,7].

For effective production quality management model it is necessary to have models of quality, that are based on expert surveys and qualimetry.

Quality rating by methods of multidimensional scaling allows to analyze initial data of any type and receive final models with a minimum value that confirms the possibility of their using for making decision on management (control) [6].

The scenario approach allows a multivariate situational analysis of simulated system. Scenario is a way of achieving goals, considering factors affecting the environment in which the system is, which is characterized by objectives, factors of influence, operations, interoperation connections. Operation as a step of scenario is determined differently as in the abstract A- and structural C-scenarios. In case A- scenario the operation ignores the internal structure of the object while transformation input values into output ("black box"). C- scenario details the internal structure of objects that are described by a set of properties attributes. Attributes take on values in some areas. These values may vary according to the specified rules. Operation C- scenario is a block, which contains objects with the same set of attributes. The scenario has the following components: objectives, factors of influence operations, interoperable connections.

C-scenario details A-scenario considering the evolution of the object while performing operations and transfer of object from one operation to another. Evolution of the objects appears in the change attribute values, during transition "mutations" occurs – the appearance of new signs and the loss of signs that became unnecessary. Each class C-scenario operates autonomously and interacts with other classes and with environment to bring input queue in new objects and remove output queue from "worked out " objects.

The sequence of control actions defined on the set of input and output variables represented as fuzzy value [7]. Each scenario connects changes in external conditions of the resulting output. C-scenario determines, as noted, the internal structure of the object and its set of properties describing attributes. Operation is a unit which contains objects with the same set of attributes and is treated as a class, whose elements belong to some space [8].

Lets form graphical representation of A – scenario system (Figure5). Object flows A – scenarios of a process of making bread is presented in Table 2.

Table 2

Designation of object data streams

Designation	Content
P1	Flour feeding
P2	Water feeding
P3	Salt feeding
P4	Feeding yeast grout
P5	Feeding supplementary raw materials
P6	Output of finished goods to distribution network
P7	Feeding of prepared flour
P8	Water feeding
P9	Spouge feeding
P10	Feeding supplementary raw materials (by the recipe)
P11	Dough feeding
P12	Dough pieces feeding
P13	Feeding dough pieces after proofing
P14	Output of finished goods (products)

We will differentiate between modeling the functioning of the existing system and the simulation system development. The scenario approach is more effective applying to the development of the system.

The scenario should include the prediction of development of a system at different chosen strategies, choosing (based on the results of prediction) the best strategy, and operation to implement the chosen strategy.

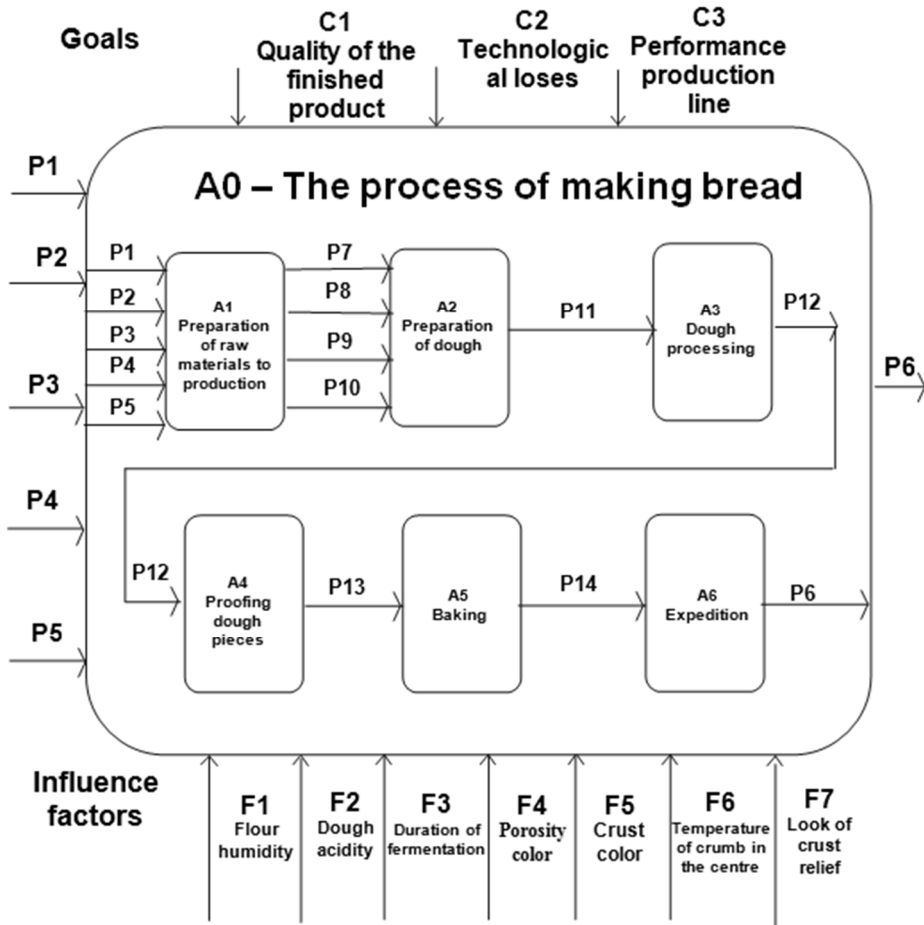


Figure 5. Graphical representation A-scenario system.

Attributes objects listed in Table 3.

A – scenario turns into a the C- scenario in such way [9]:

- structuring of objects;
- object classes and transitions between them are described of life cycles within each class is forming;
- tet of integrated indicators of system's functioning is determined(values of these parameters are established during the simulation modeling of C-scenario);
- then the expression of dependency of level of goal achieving from integrated indicators and factors of impacts is requested.

Table 3

Attributes objects C-scenario

Designation	Marking an attribute	The content attribute
A1	a 1.1	Flour power
	a 1.2	Flour Color
	a 1.3	Content of random impurities
	a 1.4	The ability to form gas
	a 1.5	Flour humidity
	a 1.6	Size of flour
	a 1.7	Flour acidity
	a 1.8	Water color
	a 1.9	Turbidity of water
	a 1.10	% Content of insoluble substances in brine
	a 1.11	Rising speed of dough
A2	a 2.1	Humidity of flour
	a 2.2	Acidity of flour
	a 2.3	Spange humidity
	a 2.4	Spange temperature
	a 2.5	Time of the ripening
	a 2.6	Maturation of dough
	a 2.7	Dough humidity
	a 2.8	Dough temperature
A3	a 3.1	Dough density
	a 3.2	Humidity of dough billets
	a 3.3	Duration of proofing
A4	a 4.1	The temperature in the proofing cabinet
	a 4.2	Relative air humidity
	a 4.3	Duration of proofing
A5	a 5.1	crumb temperature
	a 5.2	Crust color
	a 5.3	Crumb stickiness
	a 5.4	The mass of dough billets
	a 5.5	The temperature of the oven (furnace)
	a 5.6	Baking duration
	a 5.7	Humidity in the baking chamber
	a 5.8	Amount of dough billets
A6	a 6.1	Organoleptic indicators
	a 6.2	Weight of production

An important step of predictions is evaluating of realism of developed scenarios according to the previous definition of conditional probabilities of events that shape these scenarios. The main feature of conditional probabilities is that in this case they actually acts as psychological assessment of the probability of this or that event.

Figure6 shows a fragment of C- scenario based on scenario A1-preparation of raw materials to production.

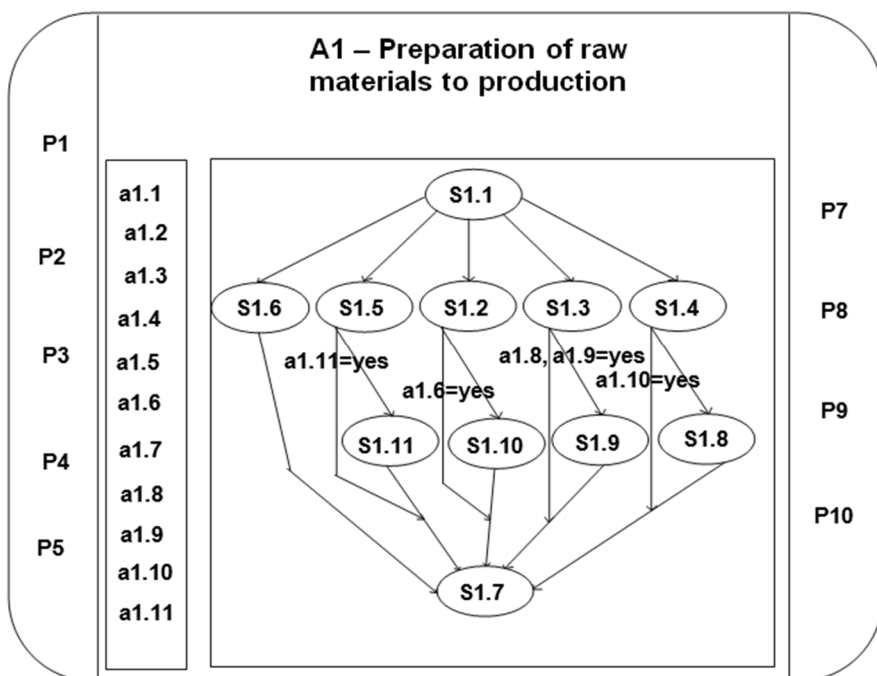


Figure 6. Fragment C scenario, class A1.

Conclusions

The use of scenarios and control algorithms using intellectual mechanisms will increase productivity, reduce specific costs and losses of resources and raw materials, improve product quality. These are presented contents and sample scenarios of abstract (A-) and structural (C-) controls and their implementation. Carried out representing the input and output variables of processes in the form of fuzzy variables. These is formed graphic representation of A- and C-management (control) scenarios.

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