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Fuzzy model of temperature control in the bread-baking chamber

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Abstract
In this paper, we discuss the solution of the actual problem that is connected with development of fuzzy decision-making model by the temperature control in the bread-baking chamber under uncertainty. We offer the method of the designing of the fuzzy model. This method can be generalized for the control of other technological processes especially for the class of the thermal facilities. Distinguish of the described method together with fuzzy control model consists in possibility of correction of the expert knowledge that fulfills in the results of the statistical processing of control objects outputs. The sequence of actions by the development of the fuzzy control model is determined. The structure of the fuzzy control model is offered. The example of inputs and outputs setting of the model of temperature control in the bread-baking chamber, rule base and fuzzy inference algorithm is considered. The estimation of fuzzy control model adequacy is shown and conclusion is made about efficiency of its application.

Keywords: bread-baking chamber; temperature control; uncertainty; expert knowledge; decision making.

Introduction

The application of the fuzzy methods for control of the production facilities by the example of temperature control in the bread-baking chamber is actual problem nowadays [1-3]. In order to get the adequate work of fuzzy control system of the bread-baking chamber it needs to set control model of bread-baking chamber parameters correctly, choose the decision-making mechanism, estimate the accuracy (adequacy) of the application of fuzzy model results and if necessary to update the model parameters [4, 5].

In the process of design of the fuzzy decision-making model the expert assessments are used for taking into account of a prior uncertainty and determination of the qualitative characteristics of the control object. The subjective data of experts are required the check. The check can be conducted by the results of accuracy (adequacy) assessment of getting application of fuzzy model results. Therefore, the necessity of increasing of fuzzy model accuracy parameters appears [6].

The method of designing of fuzzy control model of production facilities by the example of control of the bread-baking chamber is offered. This method differs by the following features, such as after developing and simulation of fuzzy model the assessment of decision-making results are fulfilled and if necessary the updating of model parameters are carried out. The sequence of actions by the development of the fuzzy control model consists in three stages:

- stage 1 – the design of the fuzzy control model of production facilities;
- stage 2 – the analysis of accuracy (adequacy) of the fuzzy control model of production facilities results;
- stage 3 – the updating of the fuzzy control model of production facilities parameters.

On the first stage of the design of the fuzzy control model the type of the fuzzy inference algorithm is chosen.

On the second stage the experimental investigation of the fuzzy control model of production facilities is conducted. After fulfilment of experimental researches the assessment of received results of control by the production facilities is carried out. Then the conclusion is made about accuracy of received results of control, i.e. about adequacy of all the designed fuzzy control model. The decision is made about necessary fulfillment of updating of fuzzy control model of production facilities parameters.

On the third stage the updating of fuzzy control model parameters is conducted. The updating of the fuzzy control model parameters allows us to decrease the error, correct the outputs meanings and approximate them to given values.

Design of the fuzzy decision-making model

Fulfillment of the described approach leads to the expanded structure of the fuzzy control model of production facilities that consists in the unit of fuzzy inference and unit of the updating of fuzzy control model parameters. The structure of the fuzzy control model of production facilities under uncertainty is shown in Figure 1.

The object is worked by the control of fuzzy controller. The work of the fuzzy controller is determined by the unit of fuzzy inference (decision-making). The sensors measure the current values of control object parameters and transmit information to the unit of fuzzy inference. The updating algorithm of fuzzy model parameters bases on the analysis of the base of getting values and the choice of criterion updating.

We observe the implementations of fuzzy inference that represent the well-used solutions [7,°8]. The fuzzy inference algorithm is a sequence of actions where on the basis of conditions the conclusions are taken out:

- step 1 – the setting of fuzzy control model of production facility parameters;
- step 2 – the determination of the rule base;
- step 3 – fuzzification of inputs;
- step 4 – aggregation of conditions;
- step 5 – activation of conclusions;
- step 6 – accumulation of conclusions;
- step 7 – defuzzification.

The most popular fuzzy inference algorithms are Mamdani and Sugeno algorithms [7 – 10].

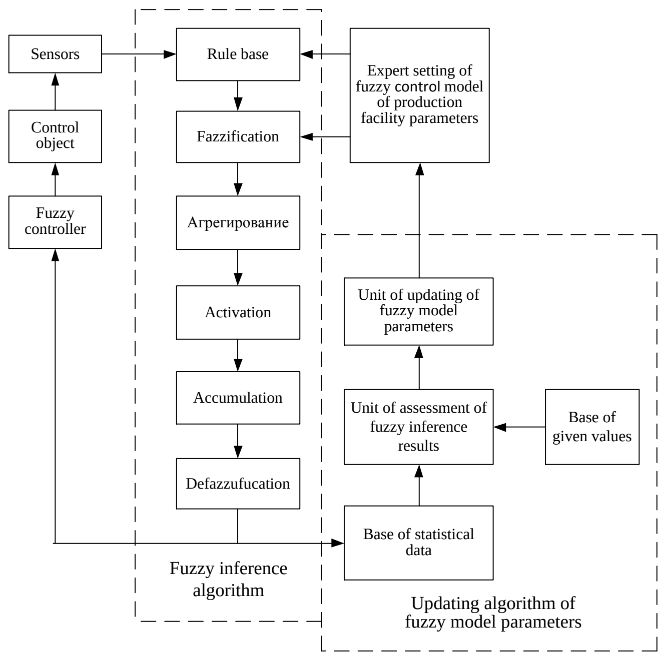

Fig. 1. The structure of fuzzy control model of production facilities

The set of input variables $X=\{x_{ij}\}$ and the set of output variables $Y=\{y_{kv}\}$ are determined. The term set of input variables $A=\{a_{ns}\}$ and the term set of output variables $B=\{b_{ue}\}$ are defined.

In the Mamdani fuzzy inference algorithm the fuzzy production rules are applied that have the following view:

- **Rule 1**: P_1 «IF x_{11} IS a_{11} AND (OR) x_{12} IS a_{12}… AND (OR) x_{1j} IS a_{1s}, THEN y_1 IS b_1»;
- **Rule 2**: P_2 «IF x_{21} IS x_{21} AND (OR) x_{22} IS a_{22}… AND (OR) x_{2j} IS a_{2s}, THEN y_2 IS b_2»;

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- **Rule z**: P_z «IF x_{i1} IS a_{n1} AND (OR) x_{i2} IS a_{n2}… AND (OR) x_{ij} IS a_{ns}, THEN y_k IS b_u».

During the work the rules can be updated and the rule base can be decreased or increased if necessary.

On the stage of fuzzification the inputs are associated with values of membership functions (MF), the numerical values of the production facility parameters are replaced by the terms of the linguistic variables. The MF of input variable $\mu_s(X_i)$ by the range $[a_i; b_i]$ and the output variable $\mu_f(Y_k)$ by the range $[c_k; d_k]$ are set.

The state of aggregation is represented as procedure of identification of the truth degree of conditions from each rule of the designed fuzzy model.

On the stage of activation of conclusions the truth degree of each fuzzy rules conclusion is identified. In the case of few output variables the truth degree of conclusion is determined as production of all the conclusions for described rule.

The accumulation in the fuzzy inference systems is represented as procedure of finding of MF for each output linguistic variable.

The goal of the defuzzification consists in the usage of accumulation results and getting the numerical values of outputs from the fuzzy variables. The centroid method is applied on the stage of defuzzification in order to get the crisp numerical values [8].

The distinction of Sugeno algorithm from Mamdani algorithm consists in the form of production rule. The rules of Sugeno algorithm keep the structure of the production rule but the distinctive feature is the form of conclusion. The conclusion is set no the linguistic term but the linear function from input signal [9]:

- **Rule 1**: P_1 «IF x_{11} IS a_{11} AND (OR) x_{12} IS a_{12}… AND (OR) x_{1j} IS a_{1s}, THEN $y_1 = b_{10} + b_{11}x_{11} + b_{12}x_{12} + \ldots + b_{1j}x_{1j}$»;
- **Rule 2**: P_2 « IF x_{21} IS x_{21} AND (OR) x_{22} IS a_{22}… AND (OR) x_{2j} IS a_{2s}, THEN $y_2 = b_{10}+b_{21}x_{21}+ b_{22}x_{22}+\ldots+b_{2j}x_{2j}$»;

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- **Rule z**: P_z « IF x_{i1} IS a_{n1} AND (OR) x_{i2} IS a_{n2}… AND (OR) x_{ij} IS a_{ns}, THEN $y_k = b_{i0}+b_{i1}x_{i1}+ b_{i2}x_{i2}+\ldots+b_{ij}x_{ij}$»,

where b_{ij} – weighting coefficients; y_k – conclusions that are represented as real numbers.

The production rules of Mamdani fuzzy inference algorithm more describe the human reasoning and don't require the knowledge of accurate values and numerical dependences. The Mamdani algorithm is chosen on the basis of implementation simplicity of expert information for designing of fuzzy control model of production facility. The setting of rules has the subjective character therefore the accuracy of the control solution depends on competence and quantity of asked experts.

Mamdani-type fuzzy model is designed for temperature control in the bread-baking chamber. At first, we observe the development of the model without updating of fuzzy model parameters.

The fuzzy control model of bread-baking chamber parameters are set [11,°12]. The set of input fuzzy variables with range of values is identified for the process of temperature control in the bread-baking chamber: T – current value of temperature in the bread-baking chamber with the range [100 - 300°C]; Z – the oven load (quantity of baked goods) with the range [450; 500] kg; P – steam consumption that is computed on the 500 kg baked production with the range [90; 160] kg. Also the set of output fuzzy variables is identified: G – fuel consumption with the range [13,5; 17,5] m^3/h; V – air consumption with the range [157,3; 161,2] m^3/h.

The functional diagram of fuzzy model of temperature control in the bread-baking chamber is shown in Figure 2 [13].

Identification of the linguistic variables. Three input linguistic variables are set.

The first input linguistic variable T "temperature in the bread-baking chamber" has the term-set $T = <T_1; T_2; T_3; T_4; T_5>$ where T_1 – low temperature; T_2 – below average temperature; T_3 – average temperature; T_4 – above average temperature; T_5 – high temperature.

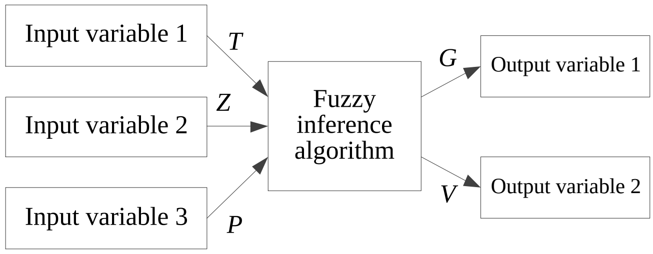

Fig. 2. The functional diagram of fuzzy model of temperature control in the bread-baking chamber

The second input linguistic variable Z "oven load" has the term-set $Z= <Z_1; Z_2; Z_3>$ where Z_1 – not full oven load; Z_2 – below normal oven load; Z_3 – normal oven load.

The third input linguistic variable P "steam consumption" has the term-set $P=<P_1; P_2; P_3; P_4; P_5>$ where P_1 – steam consumption practically is absent; P_2 – low stem consumption; P_3 – average steam consumption; P_4 – above average steam consumption; P_5 – high steam consumption.

Two output linguistic variables are set.

The first output linguistic variable G "fuel consumption" has the term-set $G=<G_1; G_2; G_3; G_4; G_5>$ where G_1 – low fuel consumption; G_2 – below average fuel consumption; G_3 – average fuel consumption; G_4 – above average fuel consumption; G_5 – high fuel consumption.

The second output linguistic variable V "air consumption" has the term-set $V=<V_1; V_2; V_3; V_4; V_5>$ where V_1 – low air consumption; V_2 – below average air consumption; V_3 – average air consumption; V_4 – above average air consumption; V_5 – high air consumption.

Set of the rule base.

On the basis of these observations and experience the experts identify the rule base $P_z =<P_1, P_2,...,P_z>$ where z – the number of rules in the rule base. In the fuzzy inference systems the production rules are used that are represented as interconnection between conditions and conclusions. The number of rules in the rule base is determined as product between the terms of all the input variables set: $z =T*Z*P$. For described problem the number of rules in the rule base is $z = 75$.

The verbal definition of the first rule is the following:

Rule 1: If *the temperature in the bread-baking chamber* is *high* and *the oven load* is *normal* and *steam consumption* is *high* then the *fuel consumption* is *high* and *air consumption* is *high*.

Formally the rules are determined in the following view.

Rule 1: If T is T_1 and Z is Z_1 and P is P_1 then G is G_3 and V is V_3;

Rule 2: If T is T_1 and Z is Z_1 and P is P_2 then G is G_3 and V is V_3;

Rule 3: If T is T_1 and Z is Z_1 and P is P_3 then G is G_3 and V is V_3;

Rule 4: If T is T_1 and Z is Z_1 and P is P_4 then G is G_4 and V is V_4;

Rule 5: If T is T_1 and Z is Z_1 and P is P_5 then G is G_4 and V is V_4;

Rule 6: If T is T_1 and Z is Z_2 and P is P_1 then G is G_3 and V is V_3;

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Rule 71: If T is T_5 and Z is Z_3 and P is P_1 then G is G_1 and V is V_1;

Rule 72: If T is T_5 and Z is Z_3 and P is P_2 then G is G_1 and V is V_1;

Rule 73: If T is T_5 and Z is Z_3 and P is P_3 then G is G_2 and V is V_2;

Rule 74: If T is T_5 and Z is Z_3 and P is P_4 then G is G_2 and V is V_2;

Rule 75: If T is T_5 and Z is Z_3 and P is P_5 then G is G_2 and V is V_2;

Only the logical conjunction "AND" is used in the conditions and conclusions of the rules. The identified expert rule base is checked by non-contradiction, redundancy and conformity

Set of MF and decision-making.

The grade of membership to the fuzzy set is determined for each term of the fuzzy variable. In this research the expert assignment method of MF is used. If we suppose that the expert answers are represented as implementation of the unified stochastic mechanism then such assignment method corresponds to the probabilistic treatment of MF [9, 14 – 16].

In the Table 1 the example of the set of MF is described where the set of MF for the fuzzy variable T_1 "low temperature" of the linguistic variable T "temperature in the bread-baking chamber" is fulfilled on the basic set of temperature variation. In the survey the 10 experts take part. The basic set is divided into 10 intervals.

The similar actions is fulfilled by the experts for the fuzzy variable Z_1 "not full oven load" of the linguistic variable Z "oven load", for the fuzzy variable P_1 "steam consumption practically is absent" of the linguistic variable P, for the fuzzy variable G_1 "low fuel consumption" of the linguistic variable G and for the fuzzy variable V_1 "low air consumption" of the linguistic variable V.

For the design of MF the triangle type is selected because of popularity and simplicity of such kind of MF [7, 8, 10].

After answering of experts the MF are determined for all the terms: T_1, T_2, T_3, T_4, T_5; Z_1, Z_2, Z_3; P_1, P_2, P_3, P_4, P_5; G_1, G_2, G_3, G_4, G_5; V_1, V_2, V_3, V_4, V_5 and the MF are built for all the fuzzy variables of the designed fuzzy model of temperature control in the bread-baking chamber [13, 16]. The results of MF design are shown in **Figure-3**.

The received values, among which, the set of the input, output fuzzy variables, their ranges and MF are represented as the fuzzy model of temperature control in the bread-baking chamber parameters. These parameters are combined in the Table 2.

In order to conduct the temperature control in the bread-baking chamber the expert set the required values for the output parameters. The given values of the outputs are determined as correspondence: $X=\{x_{ij}\}\rightarrow Y=\{y_{kv}\}$, i. e. the set of the inputs should correspond to the set of the outputs. Complication consists in the following fact that the described production control objects are represented as multidimensional fuzzy models. It needs to take into account the influence of the set of inputs. For implementation of such mechanism the rule base is offered to use where the set of the inputs is a condition of the production rule and gives an appointed conclusion. The implementation of the base of given values is described by the example of the designed fuzzy model of temperature control in the bread-baking chamber by which the rule base is identified.

The state of the described production object is determined by the three input linguistic variables.

The considered fuzzy control model has two output linguistic variables: G "fuel consumption", V "air consumption". One output linguistic variable is changed relatively to another variable therefore the values can be set only for the first of them. Some rules have the same conclusions thereby all the rules can be grouped to the five units relatively to their conclusions as shown in the Table 3. The required values of outputs are set for these five units.

Tab. 1.Values of MF T_1 of the linguistic variable T $\mu_{T_1}(x)$

l	T									
	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9	I_{10}
	100^0-120^0C	120^0-140^0C	140^0-160^0C	160^0-180^0C	180^0-200^0C	200^0-220^0C	220^0-240^0C	240^0-260^0C	260^0-280^0C	280^0-300^0C
1	1	1	0	0	0	0	0	0	0	0
2	1	1	0	0	0	0	0	0	0	0
3	1	1	0	0	0	0	0	0	0	0
4	1	1	0	0	0	0	0	0	0	0
5	1	1	0	0	0	0	0	0	0	0
6	1	0	0	0	0	0	0	0	0	0
7	1	0	0	0	0	0	0	0	0	0
8	1	0	0	0	0	0	0	0	0	0
9	1	0	0	0	0	0	0	0	0	0
10	1	0	0	0	0	0	0	0	0	0
$\mu_{T_1}(x)$	1	0,5	0	0	0	0	0	0	0	0

Tab. 2. The fuzzy model of temperature control parameters

The input linguistic variables and their terms				
T – temperature in the bread-baking chamber: [100; 300]^{0}C				
$\mu(T_1)$ low temperature	$\mu(T_2)$ below average temperature	$\mu(T_3)$ average temperature	$\mu(T_4)$ above average temperature	$\mu(T_5)$ high temperature
[90 120 150]	[140 160 190]	[180 200 230]	[220 240 270]	[260 300 310]
Z – oven load: [450; 500]kg				
$\mu(Z_1)$ not full oven load		$\mu(Z_2)$ below normal oven load		$\mu(Z_3)$ normal oven load
[440 450 500]		[465 475485]		[480 500 510]
P – steam consumption: [90; 160]кг				
$\mu(P_1)$ steam consumption practically is absent	$\mu(P_2)$ low stem consumption	$\mu(P_3)$ average stem consumption	$\mu(P_4)$ above average steam consumption	$\mu(P_5)$ high steam consumption
[80 90 110]	[105 115 125]	[120 130 140]	[135 145 155]	[150 160 155]
The output linguistic variables and their terms				
G – fuel consumption in the bread-baking chamber: [13,5; 17,5]m^3/h				
$\mu(G_1)$ low fuel consumption	$\mu(G_2)$ below average fuel consumption	$\mu(G_3)$ average fuel consumption	$\mu(G_4)$ above average fuel consumption	$\mu(G_5)$ high fuel consumption
[13 13,5 14,5]	[14,3 14,815,3]	[15 15,5 16]	[15,8 16,2 16,6]	[16,5 17,5 18]
V – the air consumption in the bread-baking chamber: [157,3; 161,2] m^3/h				
$\mu(V_1)$ low air consumption	$\mu(V_2)$ below average air consumption	$\mu(V_3)$ average air consumption	$\mu(V_4)$ above average air consumption	$\mu(V_5)$ high air consumption
[157 157,3 158,4]	[158,2 158,8 159,2]	[159,0 159,5 159,9]	[159,7 160,2 160,6]	[160,4 161,2 161,5]

Tab. 3.Combination of the rules by their conclusions for the fuzzy model of the temperature control in the bread-baking chamber

Used rule	Used conclusion of the output variable G "fuel consumption"
Rules: 46, 47, 51, 52, 61, 62, 66, 67, 71, 72	G_1
Rules: 31, 32, 33, 36, 37, 41, 42, 48, 49, 53, 54,56, 57, 63, 64,65,68,69,70, 73, 74, 75	G_2
Rules: 1, 2,3,6, 16, 17, 18, 21, 22, 26, 27, 34, 35, 38,39, 43,44, 45,50, 55, 58, 59, 60	G_3
Rules: 4, 5, 7, 8, 9,10, 11, 12, 19, 20, 23, 24, 25, 28, 29, 30, 40	G_4
Rules: 13, 14, 15	G_5

The experts determine the required values of outputs on the basis of the conditions of the described production control object, as shown in the Table 4.

The results of the work of the fuzzy model of temperature control in the bread baking chamber should lead to the given values of the output variable. Therefore the expert setting of the base of given value allows us to estimate the work of the fuzzy control model of production facility and accuracy of received results.

After receipt of MF values it can begin the process of the decision-making. On the stage of aggregation the MF with nonzero values are kept, i. e. $\mu_x(T)>0$; $\mu_y(Z)>0$; $\mu_e(P)>0$; $\mu_w(G)>0$; $\mu_l(V)>0$. In the described rules the condition consists in some under-conditions that are connected with the logical conjunction "AND". Therefore, on the stage of aggregation the minimum operation is used.

On the stage of activation the truth degree of each under-conclusion of fuzzy rules is determined. The selected early rules are limited on the basis of the active conclusions. The formula for min-composition is used. On the stage of accumulation the MF with the maximum value is chosen, the join of MF is applied.

On the stage of defuzzification the numerical value for each active fuzzy variable is founded. The goal of the defuzzification consists in the usage of accumulation results in order to get the numerical value of each output variable. The centroid method is applied.

Then the experimental investigation of the fuzzy control model of production facility is fulfilled by the results of which the statistical data of input-output parameters are collected:

$$X=\{x_{ij}\}\rightarrow Y=\{y_{kv}\}.$$

The values put on the input, they characterize the current state of the control object, on the output the control actions are put out. The collected statistical data allow us to determine the influence character of inputs on the outputs and to assess the accuracy of the fuzzy model of control of production facility work.

Tab. 4. The given values of the output linguistic variable *G*

Used rule	The given value of the output linguistic variable *G* "fuel consumption"
Rules: 61, 62	G_{1giv}
Rules: 46, 47, 51, 52, 66, 67, 71, 72	G_{23giv}
Rules: 31, 32, 33, 36, 37, 41, 42, 48, 53, 56, 57, 63, 64, 68, 70, 73, 74	G_{3giv}
Rules: 49, 54, 65, 69, 75	G_{43giv}
Rules: 1, 2, 6, 16, 17, 18, 21, 22, 26, 27, 34, 35, 38, 39, 43, 50, 55, 58, 59	G_{5giv}
Rules: 3, 44, 45, 60	G_{6giv}
Rules: 4, 5, 7, 8, 9, 10, 11, 12, 19, 20, 23, 24, 25, 28, 29, 30, 40	G_{7giv}
Rules: 13, 14, 15	G_{8giv}

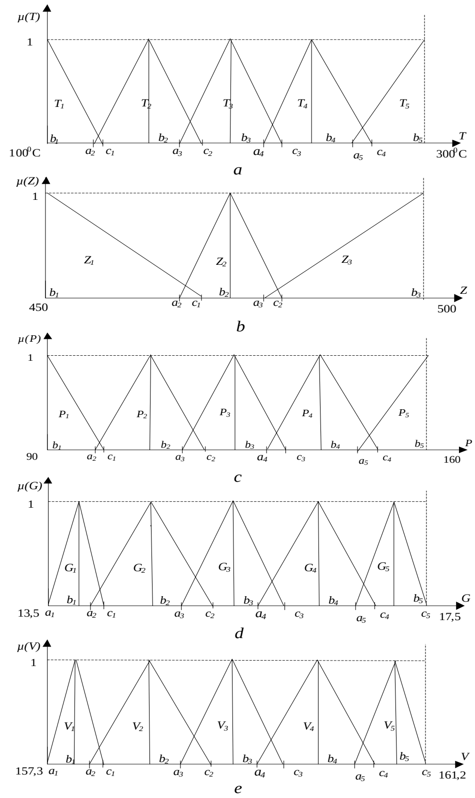

Fig. 3. The MF of the fuzzy model of temperature control in the bread-baking chamber. *a* – the MF of fuzzy variable *T*; *b* – the MF of fuzzy variable *Z*; *c* – the MF of fuzzy variable *P*; *d* – the MF of fuzzy variable *G*; *e* – the MF of fuzzy variable – *V*

The assessment of adequacy of the fuzzy model of temperature control in the bread-baking chamber without updating unit.

The analysis of the experimental investigation is fulfilled. The efficiency of the designed fuzzy model and accuracy of its results without updating of fuzzy model parameters are determined. These researches direct to the confirmation of hypothesis of application suitability of the fuzzy methods for the control of production facilities under uncertainty.

For the assessment is selected the root mean square deviation (RMSD) by the fuel consumption [7, 16 – 20]:

$$RMSD_{cur}=\sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_{cur}-y_{giv})^2},\ CKO_{cur}\le CKO_{giv}\le 5\%, \qquad (1)$$

where N – the number of modeling; $RMSD_{cur}$ – the current value of deviation; $RMSD_{giv}$ – the given value of deviation; y_{cur} – the received value of output variable; y_{giv} – the given value of output variable.

The 1000 simulations are conducted in the process of fulfillment of the experimental investigation of the fuzzy model of temperature control in the bread-baking chamber. Every time the new values of parameters correspond to the given ranges of variables randomly put on the input of the fuzzy model of temperature control. The results of fuzzy model work for the 1000 simulations are put in the **Table-5**.

In the described rules the condition consists in some under-conditions that are connected with the logical conjunction "AND". Therefore on the stage of aggregation the minimum operation is used.
It can make a conclusion after analysis of received values of fuzzy model parameters that average value of *RMSD* in one simulation mode satisfies the formulated condition (1) and doesn't exceed 1,25 %. However the values of *RMSD* in some simulations exceeds 5 % (1), for example the maximum value is 46,42 %.

Tab. 5. The assessment of adequacy of the fuzzy model of temperature control in the bread-baking chamber without updating of its parameters

Number of simulations	Parameters of fuzzy model				
	Input parameters			Output parameters	
	$T, ^0C$	Z, kg	P, kg	G, m^3/h	V, m^3/h
1000	[106; 294]	[453; 500]	[91; 160]	[14,0099; 16,9949]	[157,849; 160,7852]
	The assessment parameter of fuzzy model				
	$RMSD_{average}$		$RMSD_{min}$		$RMSD_{max}$
	1,25%		0,22%%		46,42%

The work of the fuzzy model of temperature control in the bread-baking chamber without updating of its parameters gives the satisfactory results of process control. For the improvement of fuzzy model work it is necessary to update its parameters.

The algorithm of fuzzy control model work
The algorithm of the development of the fuzzy control model of production facilities under uncertainty is gotten by the example of the designed fuzzy model of temperature control in the bread-baking chamber. The algorithm of the fuzzy control model of production facilities without updating of its parameters is shown in the Fig. 4.
This algorithm allows us to fulfill the design, simulation and assessment of adequacy of the fuzzy control model of production facilities. According to the research of the algorithm of the designed fuzzy model it makes a conclusion about necessity of updating of fuzzy model parameters in spite of satisfactory results of fuzzy methods usage for control of production facilities under uncertainty. The updating of fuzzy model parameters allows us to lead the optimal values of control factors.

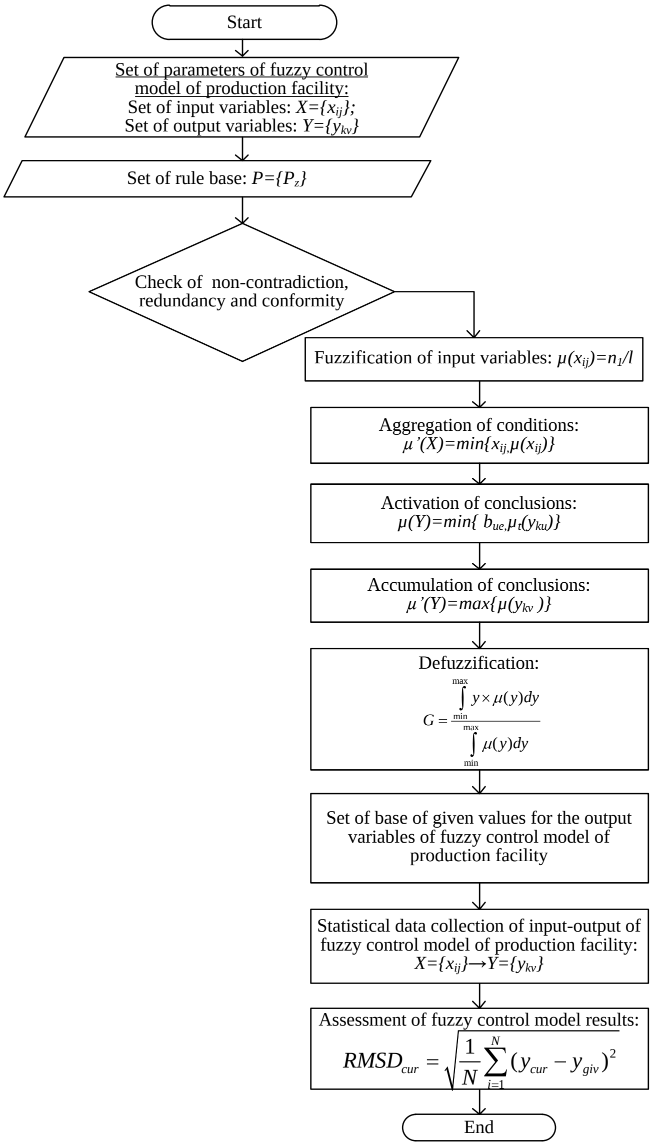

Fig.4. The algorithm of the fuzzy control model of production facilities without updating of its parameters

Discussions
In this paper, the fuzzy model is designed on the example of the temperature control in the bread-baking chamber. This fuzzy model can be applied for control of other production facilities. The developed fuzzy model distinguishes by the structure on which the unit of statistical data collection, unit of assessment of simulation results, base of given values is added.
The application of the fuzzy model allows us to fulfill the full research of control problem of production facilities under uncertainty from design and simulation to assessment of the model parameters.
The analysis of the experimental investigation of the designed fuzzy model of temperature control in the bread-baking chamber is fulfilled. This research is conducted without updating parameters of the fuzzy model. The received results of the fuzzy model not fully correspond to the given values of assessment parameters. In order to improve the fuzzy model

work it is necessary to use the updating algorithm of the fuzzy model parameters.
The offered structure of fuzzy model intends for the solution of control problems of production facilities under uncertainty. This approach allows us to assess the work and results of fuzzy control model of production facilities and if necessary to use the updating algorithm of model parameters.

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