

Fuzzy control of the production environment process parameters

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Abstract. The fuzzy control process for support of given microclimatic production environment process parameters with loss of one from values, regulating regime of process was shown. The structural schematic decisions with algorithm of functioning and oriented to existing apparatus (means of realization) was presented.

1. Introduction

In according with the set of the normative documents [1–3] microclimatic parameters of production environment (temperature –T, humidity – Φ , air velocity) have to are supported with the tolerance limits.

These limits propose certain spread of the parameters (interval).

There are the set of productions (for example, medicine, production of superfine substances, crystals and others) where microclimatic parameters of production environment have to are supported with high accuracy that allow achieve high quality of the final product. This task is solved with help of programming devises for conditioning of production environment parameters. They provide the given parameters and their control is realized either individual sensors or combined control devices with information transfer to regulating devices and support of production environment parameters constantly.

2. The structural scheme of settings

The structural scheme similar setting may be illustrated Figure1.

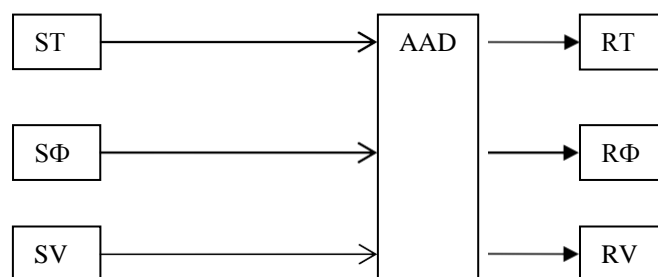


Figure 1. Structural scheme of setting: ST – sensor T; S Φ – sensor Φ ; SV– sensor V; AAD – arrangement of assumption decision; RT – regulator T; R Φ – regulator Φ ; RV – regulator V.

In common case the work regime of conditioner depends from informational parameters, that is

$$R_k = f(T, \Phi, V).$$

Possibly we have situation, when one from sensors is put out of action, that lead to distortion of information about production environment parameters, violation of given state and disparity of final quality product with regard of established requirements.

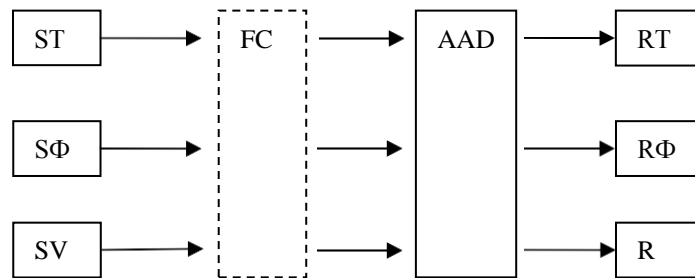


Figure 2. Structural scheme of setting: ST – sensor T ; $S\Phi$ – sensor Φ ; SV – sensor V ; FC – fuzzy control; AAD – arrangement of assumption decision; RT – regulator T ; $R\Phi$ – regulator Φ ; RV – regulator V .

For registration loss of information from one of sensors (sensor T , sensor Φ , sensor V) that is support technical process framed given parameters, one may using in structural scheme by Figure 1 fuzzy controller (Figure 2).

3. Principal of fuzzy control action

Principal of action FC is founded on fuzzy logic conception [4,5]. There are basic fuzzy logic conceptions:

- linguistic variable (LV) (any physical value, which has more than only «YES» or «NO»);
- term (great number of LV);
- membership function (describe a degree of fulfilment LV by term);
- fuzzy base of knowledge (aggregate fuzzy rules determining interrelation between input and output values of researched objects).

The realization of fuzzy process consists of from following stages [5]:

- fuzzification (determination of confidence degree that output LV accepts – concrete term);

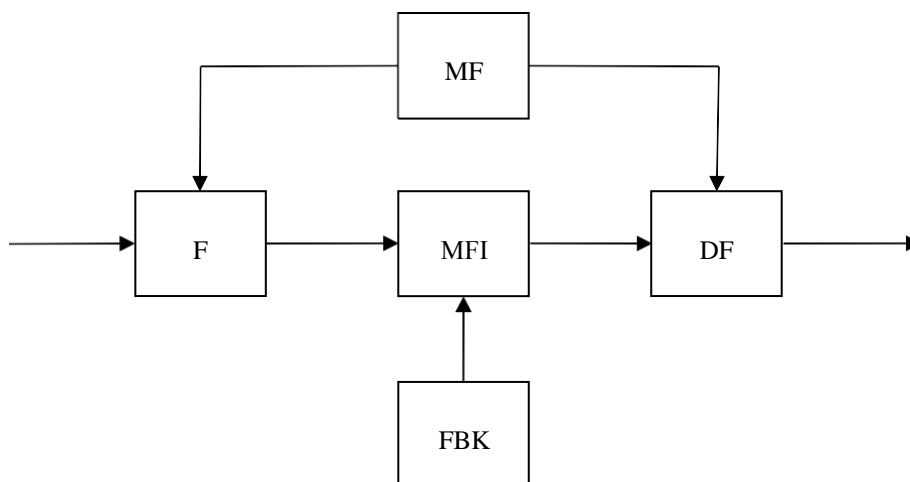


Figure 3. Fuzzy inference: F – fuzzificator; MF – membership functions; MFI – machine of fuzzy inference; FBK – fuzzy base of knowledge; DF – defuzzificator.

- fuzzy logic inference (calculation of true membership meaning LV by term on base of rules set, that is fuzzy base of knowledge);
- defuzzification (transformation of fuzzy meanings set LV to exact meanings).

The functional scheme of process is presented on Figure 3.

If we have given values LV and their ranges with chosen membership functions, fuzzy base of knowledge FC with given parameters for case of loss information (when one from sensors either T, Φ or V is put out of action) may be realized.

Today there are many series FC microchips, realizing the scheme Figure 2. The proposed fuzzy control model of production environment parameters constancy allow compensate loss of information, that is provide supporting given parameters of production environment and adequate production quality.

For illustrating mentioned reasoning discuss the concrete example of device realizing by the scheme Figure 2.

We have meanings of production environment parameters with given accuracy of supporting

$$T = (22 \pm 1) ^\circ\text{C}; \Phi = (60 \pm 2) \%; V = (0,2 \pm 0,05) \text{ m/s}.$$

All rates measurable with well known multitude of meanings. From work experience with system the set rules of interrelation between parameters are known. Even if we have situation when one from sensors of parameters measuring is put out of action (for example sensor of V), that is information about V was loss. In this case we have task about appraisal of nearly meaning V if meanings E, Φ and their interrelations are known by following rules:

- IF Temperature (T) low END Humidity (Φ) low THAT Air velocity (V) low;
- IF Temperature (T) middle THAT Air velocity (V) middle;
- IF Temperature (T) high OR Humidity (Φ) high THAT Air velocity (V) high.

In this case T, Φ , V are linguistic variables. Describe theirs with help of universes (multitude of possibly meanings) and membership functions. For this we use the standard membership functions Z, P, L, S - types [4,5,7].

Temperature. Univers – piece [(21 - 23) $^\circ\text{C}$].

Initial multitude of terms – {High, Middle, Low}.

Membership functions (Figure 4):

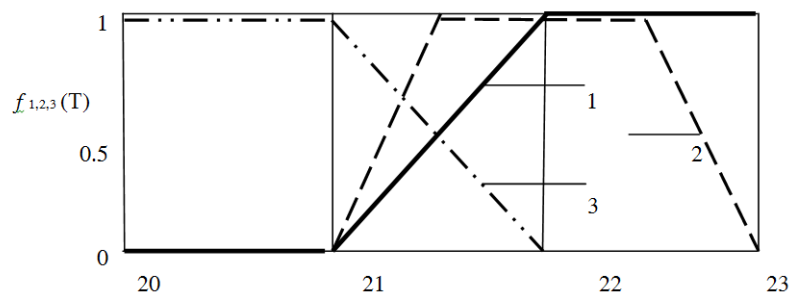


Figure 4. Membership functions of terms. 1 – T high; 2 – T middle; 3 – T low.

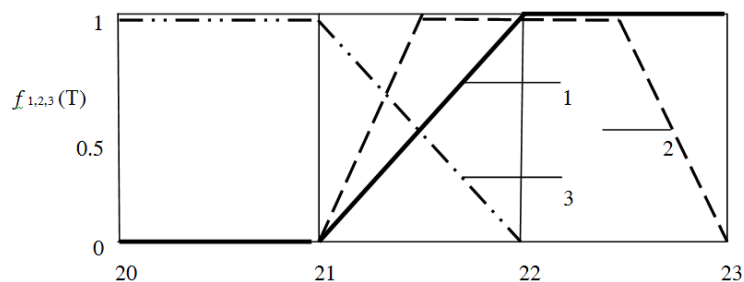


Figure 5. Membership functions of terms. 1 – Φ high; 2 – Φ middle; 3 – Φ low.

Humidity. Univers - piece [(58 - 62) %].

Initial multitude of terms - {*High, Middle, Low*}.

Membership functions: Figure 5.

Air velocity. Univers - piece [(0.15 - 0.25) m/s].

Initial multitude of terms - {*High, Middle, Low*}.

Membership functions (Figure 6):

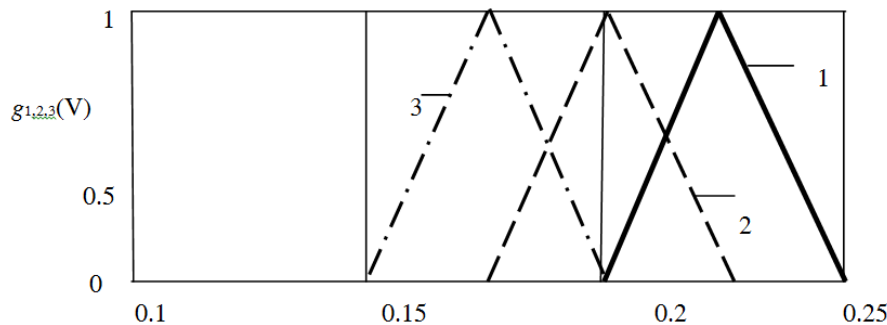


Figure 6. Membership functions of terms. 1 – V high; 2 – V middle; 3 – V low.

Fuzzification stage.

Measured meanings T and Φ are known ($T = 21,5$ °C; $\Phi = 60$ %). Conduct the appraisal of necessary meaning V . According to input meanings T and Φ we find the degree of confidence affirmations by view "linguistic variable A is term of linguistic variable A " (conversion from given precise meanings to degree of confidences). In according to measured meanings and membership functions following degree of confidences may are founded.

- Temperature (T) High - 0.7;
- Temperature (T) Middle - 1.0;
- Temperature (T) Low - 0.3;
- Humidity (Φ) High - 0.7;
- Humidity (Φ) Middle - 1.0;
- Humidity (Φ) Low - 0.3.

Fuzzy inference stage.

We find degree of confidences of antecedents [4]:

- Temperature (T_l) Low AND Humidity (Φ_l) Low,
 $\min(T_l, \Phi_l) = \min(0.3; 0.3) = 0.3$;
- Temperature (T_m) Middle = 1.0;
- Temperature (T_h) High OR Humidity (Φ_h) High,
 $\max(T_h, \Phi_h) = \max(0.7; 0.7) = 0.7$.

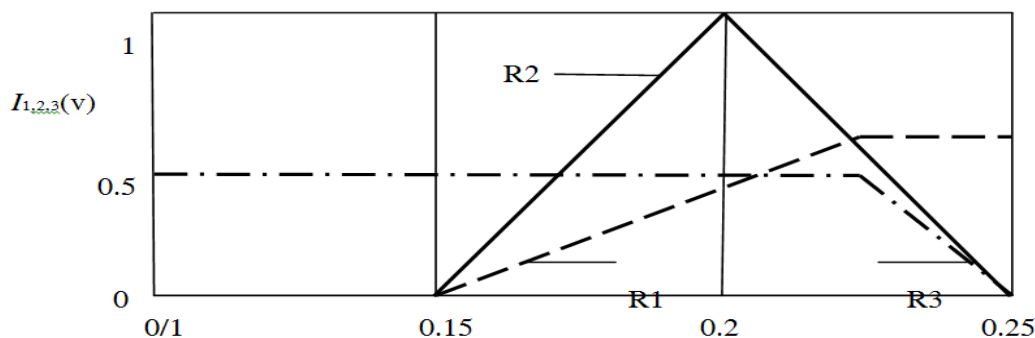


Figure 7. Functions of antecedent confidence: $R1$ – rule 1; $R2$ – rule 2; $R3$ – rule 3.

Each from rules is a fuzzy implication [7]. We have degree of confidences of antecedents but degree of confidences of conclusion is given membership functions of adequate term [5]. Using one from means of fuzzy implication construction (minimum left and right parts) the new fuzzy variable may be obtained (in our case - implication to V) (Figure 7).

Composition (accumulation) stage.

On this stage it is necessary to combine all rules. There are several means of accumulation [5].

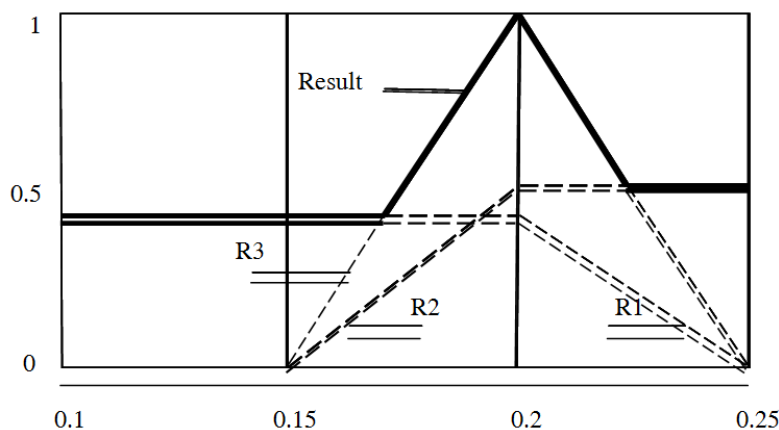


Figure 8. Membership function of output variable V.

One from the basic mean is construction of membership functions by rules numbers 1 – 3. In the result of construction following membership functions is obtained (Figure 8).

It is a new term of output variable V. Its membership function give degree of confidence for meanings input parameters and their rules of interrelations with output variable.

Defuzzification stage.

This stage is a stage of concrete meaning obtaining of from univers by given membership function. There are many methods of defuzzification but in our case sufficiently the method of the first maximum [8]. It's using to obtained membership function give the meaning of $V = 0,2$ m/s.

5. Conclusion

With the aid of obtained results fuzzy controller with given parameters for case of information loss (sensors are put out of action) about meaning either T, Φ or V may be realized.

Today there are many serial microchip complete sets fuzzy controllers for realization the scheme Figure 2 (for example, look at table 1). Their using in aggregate with the programme's resources of fuzzy systems projecting (for example, CAD - system fuzzy TECH 3.0) allow are designed the set of fuzzy control and regulation devises.

Table 1. Microchip complete sets fuzzy controllers

Platform	20 rules	20 FAM-rules	80 rules
	2 in. and 1 out.	2 in. and 1 out.	3 in. and 1 out.
MCS-96, 16 bit, 80C196KD, integrated ROM, 20 MHz	0.28 ms 0.84 Kbyte ROM 63 byte RAM	0.29 ms 0.87 Kbyte ROM 63 byte RAM	0.43 ms 1.27 Kbyte ROM 69 byte RAM
MCS-51, 8 bit, 80C51, integrated ROM, 12 MHz	1.4 ms 0.54 Kbyte ROM 25 byte RAM	1.5 ms 0.58 Kbyte ROM 25 byte RAM	4.4 ms 1.0 Kbyte ROM 29 byte RAM

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