THE STABLE MICROCLIMATE REGULATION BY UTILIZATION OF VARIABLE CONTROL SYSTEM*

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Energetical systems in agriculture are still often being used without superior control systems or with control systems not suitable from both constructional and algorithm points of view. For research purposes, an experimental plant was built and equipped with a system for microclimate adaptation in broiler rearing house as well as a variable control system allowing for research of various control algorithms for optimization of the control system parameters. A part of that system is the monitoring system for scanning and processing the stable microclimate parameters. Algorithms have been developed for the climatization system control in temperature regulation variant and in both temperature and relative air humidity variant regulation. Both these variants are described below in this paper. These control algorithms were tested under breeding operational conditions and compared mutually and with the manually controlled climatization system variant. Based on the measured microclimate parameters evaluation, average daily temperatures, deviations of inner air as well as average daily relative humidity deviations of inner air in dependence upon the chickens age have been determined. From their assessment and mutual comparison of tested variants a suitability of practical usage of the algorithm for the air temperature and humidity control and their applicability by the local microprocessors regulators resulted.

climatization; control system; energetics; broilers breeding; recuperation heat exchanger; control algorithm

INTRODUCTION

Energetical agricultural systems, fastidious about input energy are often realized with insufficient control survey system resulting in redundant energy

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distribution. The second extreme is the effect of the technology suppliers to automate entirely certain process by means of the comfort electronic system regulators providing all functions within given productive process including linkage of all regulated technologies with the control centre. It corresponds with the complexity and a high price of that system.

Local regulators have limited these properties, i.e. they are easy to be linked and served, they are highly reliable and available for a relatively low price. The regulating process provides only selected functions, but requirements for the regulation quality are the same as in the case of complicated control systems.

At the microclimate control in the livestock production objects most of the firms offer very complex control systems providing besides the climate regulation all other functions requested, including recording of values with possibility of their later evaluation (EMI Agro, 1994; FANCOM, 1994; SKAND-CHICK, 1995; SKOV, 1990). The program equipment of the control systems is based upon various algorithms controlling temperature, or temperature plus air humidity. Both enthalpy and absolute air humidity (B u c h m a n n, 1988) may also be taken into account during the breeding cycle. For example, in the first week of the piglets fattening, the air enthalpy dropped at the thermal depended regulation from 88 to 64 $kJ.kg^{-1}$. Typical for these systems is their complexity including software and a high price. In contrast to these systems there are simple analogue regulators, however, they are only used for partial regulation, e. g. ventilators revolutions dependence upon internal temperature in a stable (SCHAUER, 1992). For the more complicated climatization systems, however, that solution is not suitable.

It may be considered as optimum that the local microprocessor's regulators enable logical functions of complicated algorithms. They are mostly involved in the USA companies (CHORE TIME EQUIPMENT, 1991; SAND LIVESTOCK SYSTEMS, 1988). These regulators have to meet the high-reliability requirements to ensure the requested functions and low price. The principal aim of their utilization is to create an optimal control process algorithm. Their detailed description is being mostly unavailable, because they are products of commercial companies. Attempts at optimization of the complicated climatization system with utilization of the plate recuperation heat exchangers were published by H a š (1987). In that case, the domestic production regulator (JZD Chotoviny, 1989) was used without any frequency exchangers for ventilators power supply. Utilization of frequency exchangers is the only solution, particularly in poultry rearing, in order to reach the high-quality stage of the regulation. Its advantages have been proved in comparison with the voltage regulation and engine pole number changing (N i e t h a m m e r, 1988).

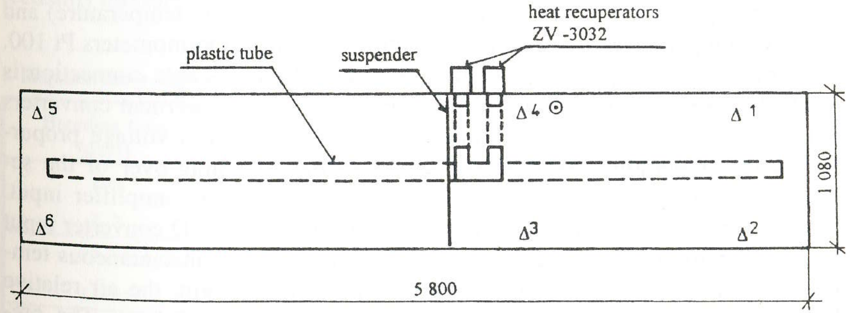
The aim of the project is to demonstrate the proposed control algorithms feasibility and realized control automation usage for agricultural objects microclimate regulation.

MATERIAL AND METHODS

For the research purposes a testing centre was established and equipped with a system for the microclimate adaptation, in this case extremely fastidious about regulating implementation enabling variant testing of the control algorithms and consequent measuring of the regulated system. It concerns a facility designed for poultry broilers rearing built by reconstruction of original cowshed K96.

The ventilating system is assembled by the recuperation exchangers from the gravitational heat tubes with by-pass unit and nine additional ventilators. The breeding space ground dimensions are 10.8 x 58 m, height is 3.2 m. Initially the chickens are kept only in part of the space (45% of the ground area), separated from the rest of an area by suspender. It results in substantial reduction of the heat losses of the young chickens. For that space two recuperators are suggested – situated as shown in Fig. 1 – both to be applicable during the start of the rearing when the space area is decreased. The air is distributed from the recuperators by perforated sleeves, initially only by one, after the suspender is removed also by other parts of the air distributing system.

Relevant calculation has been provided for 13 000 chickens at the outer air temperature t_e = –12 °C. The calculating air parameters in the stable are derived from recommended figures of the Ross Breeders Ltd. and Xaverov,

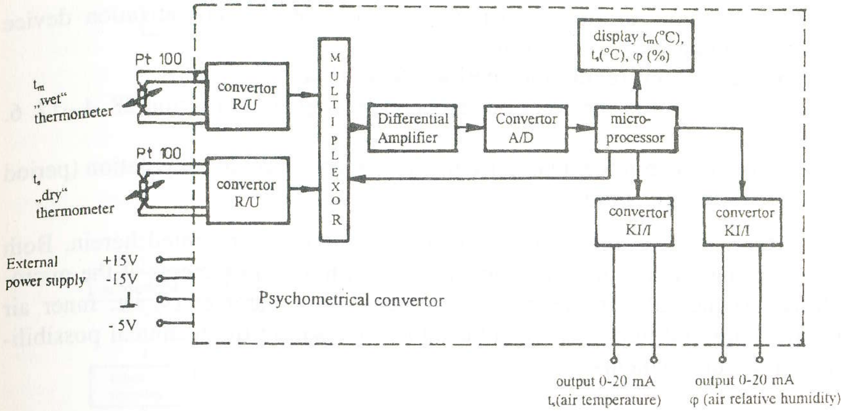


1. Ground plan of the heat recuperators installation in space for broiler breeding
△ – location of thermometers for inner air temperature measurement
⊙ – location of psychrometer for inner air humidity measurement

joint stock company, Prague. Both recuperators and additional ventilators are operated by two frequency changers, one of them being for all ventilators of the recuperators, the second one for additional ventilators Simovert P-6SE 2113 producer Siemens, whose input is a current signal 4–20 mA. The recuperator's by-pass unit flap is controlled by servomotor.

For the regulation the Procontic CS 31 system producer ABB was used to enable normal programming of the regulation functions. That system consists of proper microprocessor unit, discrete inputs and outputs unit and analogue inputs and outputs unit. The analogue inputs used for the regulation process control are of the current signals 0–20 mA for inner air temperature, inner air relative humidity and outer air temperature. The discrete input signals are represented by outputs of recuperator exchangers terminal switches by-pass flaps signalling their neither closed or opened status. Further, the discrete inputs are used for back information of the controlled power machines and devices status and for signalization of their breakdown. The analogue outputs are being used for both frequency exchangers revolution control. The contractors for frequency exchangers feeding, the servomotors contractors for the recuperation exchangers by-pass flaps control, as well as contractors for the recuperation exchangers supply ventilators disconnection and contractors for part of additional ventilators disconnection are controlled by discrete outputs.

Air relative humidity and temperature scanning is provided by the psychrometer with converter 9206 producer InterNet constructed in the Research Institute of Agricultural Engineering, Prague-Řepy. The psychrometer utilizes the vertical air flow in two air channels with an exhaustion ventilator. In both channels, there are installed resistive thermometers, one of them is wetted by means of wick. Thermal information of both thermometers, from which the air relative humidity is derived, is processed in measuring converter. Its block diagram is presented in Fig. 2. Input temperature t_m ("wet" temperature) and t_s ("dry" temperature) are scanned by platinum resistive thermometers Pt 100. To suppress the supply cables length influence the four-cable connection is used. Both resistive thermometers are connected to the congruent converters R/U (resistance/voltage). The output of these converters is voltage proportioned to temperature. Multiplexor serves to the switching-over of the selected converter R/U output into the differential operative amplifier input. The output of that operative amplifier is connected to the AD converter input of an integration type of 12 bites resolvability. After the instantaneous temperature values t_m and t_s transformation into a digital form, the air relative humidity calculation follows according to known physical laws. The presented values are consequently displayed in an alpha-numeric display (16 signs x 2 rows). At the same time there are in relevant outputs of microcomputer signals of variable keying interval type, transformed in the convert-



2. Block diagram of psychrometrical conventor

ers keying interval/I (variable keying interval/current) into current ranging from 0 to 20 mA.

In the facility the breeding of the poultry broilers Ross Breeders, supplied by Xaverov, joint-stock company, Prague, is performed. The required inner air temperature setting-up is provided manually every day. The values required are presented in Tab. I.

In the hall, electrical incubators with individual temperature regulation are installed as additional heat resource. Tab. I presents the values of illuminance in breeding space, used during experiments. For chicken feeding the standard feedstuff mixtures are used according to the Xaverov, j.s.c., recommendation.

I. Required inner microclimate parameters values in object for poultry broiler breeding

Breeding time (days)	Required t_i (°C)	Illuminance (lx)	Breeding space size
1–2	26	20	40 % of area
3–7	25		
7–10	25	20	
11–21	24	to reduce to 3	
22–27	23	3	100 % of area
28–31	22		
32–42	21		

The substance of the experiment is three variants climatization device running comparison. It concerns:

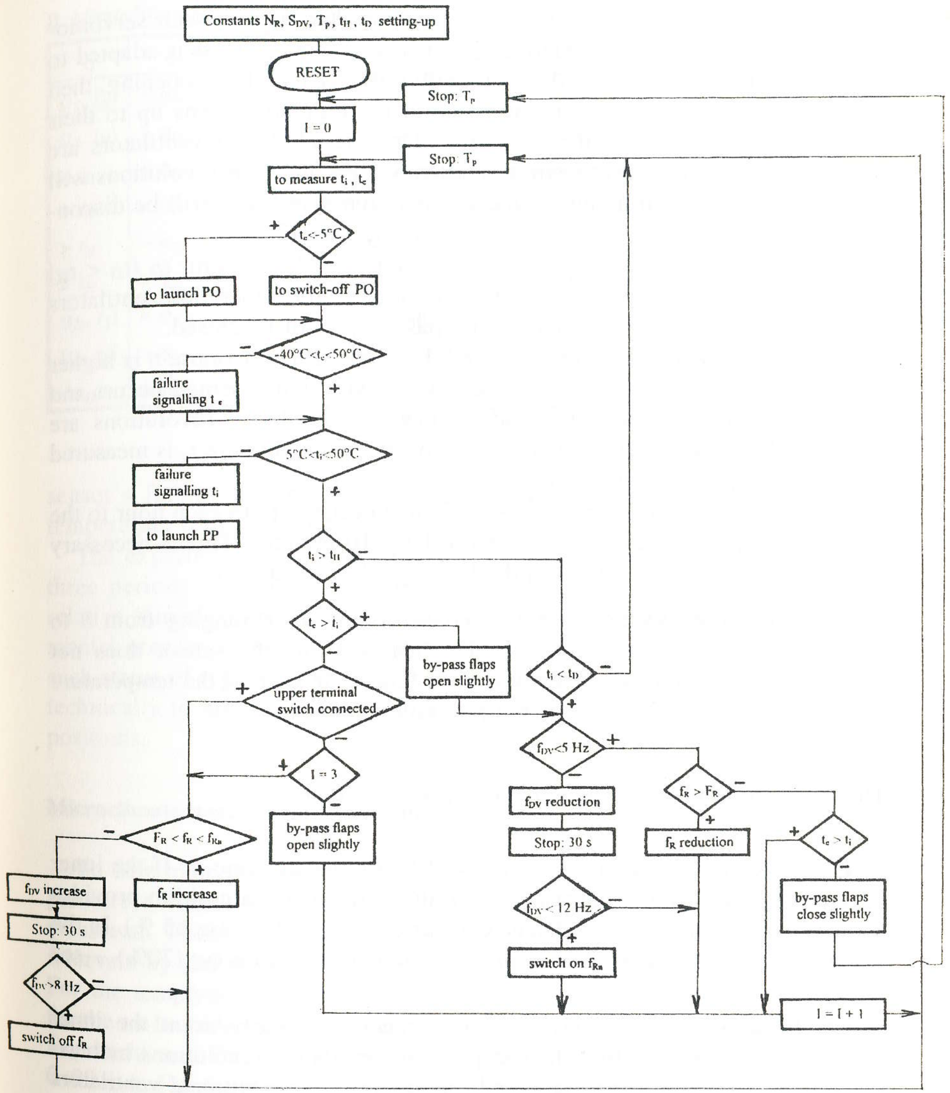
1) running without regulation (period 25. 2.–9. 4. 1995);
2) control algorithm for inner air temperature regulation (period 28. 4.–12. 6. 1995);
3) control algorithm for inner air temperature and humidity regulation (period 13. 10.–30. 11. 1995).

Further, descriptions of the control algorithm are presented herein. Both cases are based on minimum energy consumption requirements at the micro-climate requested parameters achievement. Both parameters, i.e. inner air temperature and humidity are adjustable only within the technical possibilities of action elements.

The inner air temperature regulation

The control algorithm diagram is presented in Fig. 3.

- Dependent on the chicken weight, the minimum object ventilation is determined. This is ensured by necessary air exchange to withdraw the harmful substances, i.e. ammonia, carbon dioxide and hydrogen sulphide. Technical workmanship is based on the minimum revolutions setting up of the recuperation ventilators. If this minimum is higher than the air volume delivered by recuperators at the nominal revolutions, they are switched on in cyclic manner the additional ventilators at the lowest revolutions (5 Hz). Their keying interval depends on the chicken weight. In this case it presents value of this keying interval about 50% in the end of breeding period.
- If the inner air temperature is higher than the adjusted upper thermal limit t_H, then occurs the recuperators by-pass unit flaps opening in the 3 stages. The pause length between the action impacts is adjustable and was determined to be 3 minutes. If three times over the following signals to open



3. Controlling algorithm diagram to inner air temperature regulations

Legend:

F_R – the lowest feeding frequency of recuperation ventilators
S_{DV} – additional ventilators keying interval for basic ventilation
T_P – idle time between action interferences
f_R – recuperation ventilators feeding frequency
f_{Rn} – recuperation ventilators nominal feeding frequency
f_{DV} – additional ventilators feeding frequency
t_i – inner air temperature
t_D – bottom limit of the controlled inner air temperature interval
t_H – upper limit of the controlled inner air temperature interval
t_e – outer air temperature
PO – sub-program of the heat pipes defreezing
PP – sub-program of the failure rate climatization

the flaps the terminal switch does not operate, the flaps or their servomotors failure is being presumed and further regulating process is adapted to that situation. If there is still $t_i > t_H$ within the by-pass flaps opening, then the recuperators revolutions increased in the regulating steps up to their the recuperators revolutions increased in the regulating steps up to their nominal value. Within the following steps the additional ventilators are switched on at the basic feeding frequency 5 Hz and their revolutions will increase as well. In doing so, the recuperation ventilators will be disconnected in an interval of the feeding frequency (8, 12) Hz.

- At the inner air temperature decreased under the lower limit t_D ($t_D < t_H$) a reverse regulating process, i.e. the additional and recuperation ventilators revolutions are decreased and the by-pass flaps will be closed.
- If the outer air temperature $t_e > t_i$ and the inner air temperature t_i is higher than the upper thermal limit t_H, then the by-pass flaps opening occurs and consequently the additional and recuperator ventilators revolutions are reduced in given regulating steps. The outer air temperature t_e is measured in the recuperator's input air channel.
- If the outer air temperature $t_e < -5$ °C, then occurs within each hour to the input recuperator ventilators switch off for 10 minutes. This is necessary to reduce the ice accretion on the heating tubes surface.

If the measured values do not meet the conditions t_i ranging from 5 to 50 °C, t_e ranging from –40 to 50 °C, then probably the sensor does not operate correctly and the system signals a failure. In case of the temperature t_i measuring the failure, the reserve program is launched.

The inner air temperature and air humidity regulation

The thermal interval (t_D, t_H) is divided by the mean value t_S. If the inner air temperature is in the interval (t_S, t_H), then the control algorithm provides the air relative humidity maintenance under the φ_H (in this case 65 %). In the interval (t_D, t_S,) the humidity is provided under the value φ_K (70%) – see Tab. II.

The ventilators revolutions increasing means, similarly as at the inner temperature regulation, first the recuperation ventilators revolutions increasing and consequently connection and increasing of the additional ventilators revolutions. The similar process is at the revolutions decreasing.

If the outer air temperature $t_e < -5$ °C then occurs, similarly as in previous case, during each hour to the input recuperator ventilators switching-off for 10 minutes. If measured values do not correspond with conditions $\varphi_i < 97\%$, t_i in interval from 5 to 50 °C, t_e in interval from –40 to 50 °C, it means the

II. Microclimate parameters control

t_i	φ_i	t_e	Operations
(t_S, t_H)	$< \varphi_H$	arbitrary	revolutions decreasing
(t_S, t_H)	$> \varphi_H$	arbitrary	flaps half-closing + revolution increasing
$> t_H$	$< \varphi_H$	$< t_i - 2$	flaps opening, consequently revolution increasing
$> t_H$	$< \varphi_H$	$> t_i - 2$	flaps opening + revolutions decreasing
$> t_H$	$> \varphi_H$	$< t_i - 2$	flaps half-closing + revolution increasing
$> t_H$	$> \varphi_H$	$> t_i - 2$	flaps half-closing + revolutions decreasing
(t_D, t_S)	$< \varphi_K$		revolutions decreasing, consequently the flaps half-closing
(t_D, t_S)	$> \varphi_K$		flaps half-closing + revolutions increasing
$< t_D$	arbitrary		flaps half-closing + revolutions decreasing

sensor's failure and the system is signalling a breakdown. In case of the temperature t_i measuring a failure, the reserve program is launched.

The experiment is performed in a consequential time process, i.e. in the three periods of various outdoor conditions, i.e. outer air temperature and relative humidity values. These outdoor conditions could affect the experimental process within manual controlling of the climatization system, or in such status of regulated running, when action elements are not able any more technically to assure further regulation steps, i.e. when these are in extreme positions.

Microclimate parameters measuring

To determine the inner microclimate values in the hall, the outer air temperature t_e, inner air temperature t_i and inner air relative humidity φ_i are measured. These quantities have been recorded continually in 15 minutes intervals by the measuring central station Therm 3280-8M producer AMR. For the temperature scanning the resistive thermometers Pt 100 were used, for the air humidity was used the psychrometer type 3010.0 producer Theodor Friedrichs and Co. with converter type 9209 producer InterNet with output 0–20 mA. For the inner air temperature six resistive thermometers were used, regularly arranged in horizontal level of animal motion, 0.2 m above the bedding. Their arrangement on the stable ground together with measuring psychrometer location is in Fig. 1.

The achieved thermal coefficients assessment in single measuring points of stable is based on daily average temperatures in these points. Value of the specified optimal temperature for the growth of animals is subtracted from the daily average temperatures and by this way obtained deviations in absolute value create starting values to maintain level of inner air temperature in the stable. Absolute deviations of the daily average temperatures in single measuring points represent a base for the absolute deviation calculation of a certain day as an average value of all measured points. The assessment used to be provided partly by calculation of the linear regressive dependence of the absolute temperature deviations on time within rearing period, partly by an assessment of the highest deviations within the period, because these are critical, or changeable for successful breeding process.

To assess the specified thermal regime quality kept during the period, a statistical method of dispersion analysis for single classification enabling verification of the temperature received values in individual measuring points was used. By evaluation it may be found out, if there are, within any given period of time at any given stage of a statistical importance, the temperatures in individual points are equal or different. In case they are different, it must be found out by the method of multiple comparison the points of equal temperatures. The dispersion analysis for single classification allows to observe the given factor influence upon tested quantitative sign, i.e. in this case measuring point influence upon measured temperature value. Realization of single dispersion analysis is conditioned by accordance of the dispersion extension in individual selective complexes. That condition may be verified by the Bartlett's and Cochran's test. In case the zero hypothesis is being refused, i.e. the dispersions differ mutually, it is possible to assess in detail prospective deviations by multiple comparison by means of Scheffé's method. Usage of that method is conditioned by sufficient compared complexes. For testing of scatterings agreement and analysis it is possible to use program of statistical data processing STATGRAPHICS and tabular processor EXCEL 5.0.

Air relative humidity value is besides temperature the second most important factor affecting the health condition of the poultry. The recommended value of relative humidity for chicken fattening is 65%. To assess the recorded air relative humidity values, average deviations from specified value in single days of the period were determined. The assessment is provided by the calculation of linear regressive deviations dependence values of air relative humidity on time in the course of rearing period.

RESULTS AND DISCUSSION

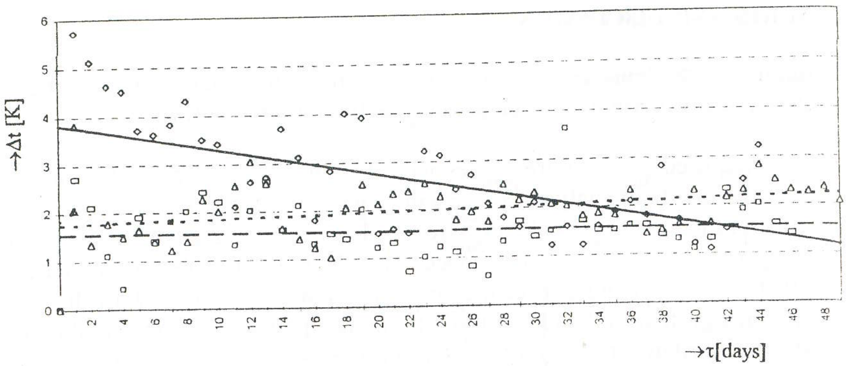
Evaluation of the inner air temperature requested values maintenance in the broilers rearing house within the poultry horizontal level motion

The measured temperature values were first used for shape and homogeneity of thermal field analysis. These values were divided into 3-days' periods for the initial breeding cycle in a reduced space and 2-days' periods for breeding cycle within the entire space. The Cochrane test results indicated, that in first and second period the set dispersions correspond with the test criteria on significance level $\alpha = 0.05$. In the last period the tested set did not satisfy the Bartlett's test condition. During this period the regulation breakdown occurred. It was found out within following average dispersion analysis, that the zero hypothesis of average temperature sets equity has not been satisfactory in horizontal stable level at selected significance level $\alpha = 0.05$.

Furthermore detailed assessment of differential measured temperatures values, an analysis was performed by means of Scheffé's method of multiple comparison of average temperature values. Based on results some common signs were discovered. At breeding start temperatures increase in measuring points 1 and 4 (Fig. 1) was indicated. This situation may be explained by using auxiliary heat resource. Its effect was presented in the mentioned way. In last weeks before period conclusion the interior was intensively ventilated by additional fans. The heat recuperator located in the opposite side wall is equipped by the by-pass flaps. These are open during the mentioned ventilating process. It results in intensive vacuum stable ventilation in such situation, that through that by-pass flaps the outer air, cooling the thermometer ambient space located in measuring point 4 and partially in point 5, is drawn in. Similarly, the temperatures decrease occurred in measuring points 5 and 6 in second measured period, when the outer air was drawn in through unproofed side gate.

It was in complex found out from statistic assessment results, that temperatures differences in second and third period when control algorithms were used, are substantially lower than in the first case.

Absolute daily average temperatures deviations were evaluated for all three measured periods of chicken fattening. Their results are presented in Fig. 4. In that figure the values of average deviations in dependence on the animal age, except extreme values in the third period, i.e. in days when regulation system failure occurred, are represented. The linear regressive straight lines for individual measured periods were interpolated by these values. The minimum deviations from the inner air temperature requested value were achieved in the second period of measurements, where the average deviation value



4. Dependence of absolute deviations of average daily inner air temperatures from specified value during breeding batch

◇ period 1, □ period 2, △ period 3

from the requested one was about 1.6 K. This value corresponds also with the regressive straight line equation presented in Fig. 4. For the second period the equation is:

$$\Delta t = + 0.0002 \,.\, \tau + 1.5564 \quad \text{(K; day)} \tag{1}$$

In this second measured period the inner stable air temperature regulation was used.

The average absolute temperature deviations values in both first and last measured period are similar, 2.5 and 2.0 K. On the first sight they differ slightly, but it is evident from Fig. 4, that the linear regressive straight lines differ markedly. In the first period the regressive equation is

$$\Delta t = -0.054 \,.\, \tau + 3.8618 \quad \text{(K; day)} \tag{2}$$

This equation gives evidence, that in the first phase of the fattening the biggest deviation was achieved (3.9 K), i.e. the time, when the chickens incline extremely to be undercooled and with the rising-up τ value (time) the deviation decreases up to 1.2 K at the end of the period.

Within the third period the regressive equation is

$$\Delta t = 0.01 \,.\, \tau + 1.7357 \quad \text{(K; day)} \tag{3}$$

In the first phase of the chicken fattening the temperature deviation from the optimum value was 1.7 K. This smallest deviation is caused by the positive sign of the τ item coefficient of the regressive equation and increases

III. Inner air temperatures deviations

Period	Average temperature deviation	Average temperature deviation in 1st week of breeding	Max. average daily deviations	Max. average daily deviations in 1st week of breeding
	K	K	K	K
1st (25. 2.–9. 4.)	2.5	4.4	5.7	5.7
2nd (28. 4.–12. 6.)	1.6	1.6	3.6	2.7
3rd (13. 10.–30. 11.)	2.2	1.5	3.0	1.7

with the animal's age up to 2.2 K at the end of the period. Results obtained from experiment are presented in Tab. III.

Tab. III gives daily temperature deviations in the first week of breeding. Within this period the bred chickens have not developed sufficient thermoregulation abilities and their tendencies to change and deviate from optimal temperature caused a heat stress. Comparison with Tab. III indicates evidently the suitability of the regulation system used together with some of both control algorithms. Compared with manual control of climatization this enables average deviation of daily temperatures decreasing and particularly reduction of this parameter at the beginning of the breeding process. Also maximum values of average daily deviations are substantially lower in both cases of the control algorithm application.

Regressive straight lines course can be explained by a real running situation. In the first period the temperature deviations are high at the start of the breeding. This is probably caused by the fact, that servicemen do not switch on the ventilators to save energy but particularly due to undercooling. Negative side-effects are also serious harmful element of concentrations in the facility. At the end of breeding when chickens are relatively resistant, the additional ventilators are in permanent running. Therefore, due to considerable biological heat development in the facility, no danger of critical undercooling occurred, however, extreme deviation increases were found.

In both periods with control algorithms application the regressive straight lines slightly increased. This is positive because of the critical state at the beginning of the periods. The straight lines increase could be explained by a higher amount of comming-in unadapted air into the facility, realized technically by additional ventilators.

Assessment of the experiments conditions, i.e. particularly outdoor air parameters, confirmed the assumption that from this point of view the experiments at regulated running are not affected. When some control algorithm was applied the outdoor air is used in the range determined by this algorithm.

Evaluation of the requested air relative humidity values observance in the broilers rearing house

As to the inner air temperature, the inner air relative humidity was measured for all three rearing periods. The deviations of values from specifical values in dependence upon chicken's age are presented in graph in Fig. 5. Evaluation of the requested air relative humidity values observance in the object starts by average deviations during the all measured periods. The highest average deviation was found out from the first period, i.e. from 25. 2. to 9. 4. 1995. By using the regressive linear straight line the equation is

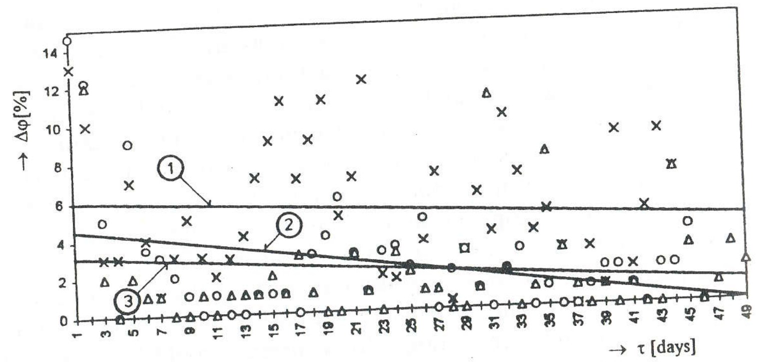
$$\Delta\varphi = -0.0321 \ . \ \tau + 6.0359 \quad (\%; \text{day}) \tag{4}$$

The highest deviation was achieved at the beginning of the periods (6.1 %) and slowly decreased up to about 5%.

The average deviation within the second period, i.e. from 28. 4. to 12. 6. 1995 was 2.5%. The regressive straight line for this period is

$$\Delta\varphi = -0.093 \ \tau + 4.5914 \quad (\%; \text{day}) \tag{5}$$

The straight line has relatively steep inclination, at the beginning of the period the deviation was 4.6%, at the end it approached the zero value.



5. Dependence of average daily inner air relative humidity deviations from specified value during breeding batch

x; 1 – period 1, ○; 2 – period 2, △; 3 – period 3

In the third period, when the air relative humidity regulation was used, the lowest average deviation of the air relative humidity 2.1% was achieved. The regressive straight line equation has the most convenient form with the slow deviation decrease from 3.2 to 1.2%.

$$\Delta\varphi = -0.0415 \ \tau + 3.1679 \quad (\%; \text{day}) \tag{6}$$

Founded deviations in course of breeding are presented in Tab. IV.

It is also evident from the dispersion assessment in the graph of presented values, that in the first period extreme deviations occurred. It confirmed again the apparent presumption of the climatization system operation inconvenience without operational super-system. In the second period the extreme deviations occurred as well, because the humidity parameter is not a part of the operational algorithm. In the third period the extreme deviations values appear in periods, when the action elements do not enable needed microclimate adaptation by outdoor air, i.e. extreme weather, e. g. when it rains. Typical for all cases is the decrease of all deviations during the breeding. It is clearly caused by the increased volume of comming-in outdoor unadapted air needed for the biological heat ventilation in the stable. Compared variants according to Tab. IV indicated evident improvement of all parameters at algorithms application to temperature and humidity control against variant when only temperature is controlled.

The total assessment of the experiment indicated that variants with control algorithms utilization reached much better operation parameters compared with manual control of the climatization system. The best running results was reached at algorithms application for inner air temperature and air relative humidity control.

A variant solution could be the timely continued regulation, or regulation of constant temperature, when smaller regulated deviations values will be achieved, but merely in terms of the climatization systems possibilities. But thermal fields course of the inner air in horizontal level of animals is not

IV. Inner air relative humidity deviations within chickens breeding

Period	Average deviation of air relative humidity	Average deviation of air relative humidity in 1st week of breeding	Maximum average daily deviations	Maximum average daily deviations in 1st week of breeding
	%	%	%	%
1st (25. 2.–9. 4.)	5.3	4.5	12.5	10.4
2nd (28. 4.–12. 6.)	2.5	5.2	12.5	12.5
3rd (13. 10.–30. 11.)	2.1	1.9	7.0	5.0

homogenous in practice and differences in various stable points exceed the temperature deviations in the breeding period course at high-quality regulation. The timely incontinous operational process indicated considerable operational advantages, i.e. lower energy consumption and better active elements utilization of the regulation system.

CONCLUSION

Used variants of control algorithms applied in a single microprocessor regulator meet completely requirements of climatization system control. This was indicated in a relatively complicated climatization system in poultry broilers housing. This knowledge could basically affect the decision about the complex conception of the hardware equipment for any agricultural facility. It is evident that the initial requirements, i.e. short-time automated operation with perfect control algorithm, high reliability and anti-failure insurance are absolutely rightful and enable installations of the relative low costs.

During the control system evaluation a necessity of the control units utilization was demonstrated at the complicated climatization systems from the point of view of the microclimate parameters quality. The inner air relative humidity is not critical when compared with air temperature and has a considerable influence upon the breeding effectiveness. It is evident that this value may be operated by usage of local microprocessor regulators. These regulators may be of simple and inexpensive construction but equipped by special program. For the ventilators control a frequency regulation of revolutions is necessary. It is possible to use simple cyclo-convertors, but it is not clear so far, if the step change of the revolutions would be applicable for complicated systems, e. g. for the mentioned poultry rearing objects.

Symbols

t_e – outer air temperature (°C)
t_j – inner air temperature (°C)
φ_i – inner air relative humidity (%)
t_H – upper limit of the controlled inner air temperature interval (°C)
t_D – bottom limit of the controlled inner air temperature (C)
t_S – middle point of the controlled inner air temperature (°C)
φ_H – upper limit of the controlled inner air relative humidity (%)
φ_K – critical value of the inner air relative humidity (%)
$\Delta\tau$ – inner air temperature deviation from required value (K)
$\Delta\varphi$ – inner air relative humidity deviation from required value (%)
τ – time (days)

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Regulace stájového mikroklimatu s využitím variabilního řídícího systému.

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V zemědělství jsou často provozovány energeticky náročné systémy, které nemají vhodný řídící nadsystém. Řízení těchto systémů může pak být nedostatečné, neboť řídící nadsystém nemá odpovídající technické parametry. Druhým extrémem je instalace složitých počítačových struktur s cílem zcela zautomatizovat chovný či pěstební proces, tedy vedle regulačních funkcí jsou zajištěny i různé vedlejší funkce, včetně záznamů hodnot, zapojení do počítačových sítí apod. Tím dochází k neúměrné technické složitosti i finanční náročnosti takovéto instalace.

Cílem práce bylo ověření řídících funkcí lokálního mikroprocesorového regulátoru v aplikaci řízení klimatizačního systému v odchovně kuřecích brojlerů a prokázání vhodnosti navržených řídících algoritmů.

Pro výzkumné účely bylo použito ověřovací pracoviště se systémem pro úpravu mikroklimatu ve stáji pro výkrm 13 000 kuřecích brojlerů typu Ross Breeders. Požadované parametry mikroklimatu jsou uvedeny v tab. I. Řízení systému je maximálně

náročné na regulační zabezpečení, a tedy dovoluje variantní zkoušení řídících algoritmů a následné měření regulovaného systému. Stáj je vytvořena rekonstrukcí kravína K96. Větrací systém tvoří rekuperační výměníky z gravitačních tepelných trubic s obtokem a doplňkové ventilátory. Půdorysná situace včetně instalovaných rekuperátorů a rozvodu vzduchu plastovými rukávci je uvedena na obr. 1.

Snímání relativní vlhkosti vzduchu ve vnitřním prostoru stáje bylo zajištěno psychrometrem originální konstrukce v kombinaci s elektrickým převodníkem, jehož blokové schéma je uvedeno na obr. 2.

Podstatou experimentu je srovnání účinků tří variant provozu klimatizačního zařízení. Jedná se o provoz bez regulace, provoz s regulací vnitřní teploty vzduchu (obr. 3) a provoz s regulací vnitřní teploty a relativní vlhkosti vzduchu (tab. II). Tyto řídící algoritmy jsou použity ve dvou chovných turnusech následujících po turnusech s manuálním řízením systému. Parametry mikroklimatu byly u všech variant měřeny měřicí ústřednou v intervalech 15 min a následně byly vypočteny průměrné denní odchylky teploty a relativní vlhkosti vzduchu v závislosti na čase. Vyhodnocení bylo prováděno jednak výpočtem lineárních regresních závislostí absolutních odchylek, jednak posouzením nejvyšších odchylek v průběhu turnusu. Dále byly statisticky vyhodnoceny hodnoty teplot v jednotlivých místech prostoru stáje a statistickým programem STATGRAPHICS byla zjišťována jejich shodnost.

Při vyhodnocení naměřených teplot vnitřního vzduchu byly zjištěny výrazně nejmenší odchylky od požadované úrovně ve druhém turnuse a srovnatelně i ve třetím turnuse, tj. při regulaci teploty a teploty i relativní vlhkosti vzduchu. V obou případech regulačních algoritmů byly zjištěny stoupající časové závislosti teplotních odchylek a malé odchylky teplot v prvním týdnu chovu, ve srovnání s prvním turnusem, tedy s manuálním řízením systému, jak je zřejmé z obr. 4 a tab. III.

Při vyhodnocení naměřených relativních vlhkostí vnitřního vzduchu byly zjištěny nejmenší odchylky od požadované hodnoty při použití řídícího algoritmu pro regulaci teploty a vlhkosti vzduchu. V celkovém vyhodnocení parametrů mikroklimatu byla v této variantě dosaženo nejlepších výsledků, jak vyplývá z obr. 5 a tab. IV.

Na základě zjištěných hodnot lze odvodit závěr, že použité varianty řídících algoritmů aplikované v jednoduchém mikroprocesorovém regulátoru zcela splňují požadavky na řízení klimatizačních systémů, což je prokázáno na poměrně složitém systému klimatizace v odchovně kuřecích brojlerů.

klimatizace; řídící systém; energetika; odchov brojlerů; rekuperační výměník tepla; řídící algoritmus

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