OPTIMIZATION OF THE DUST COLLECTION PROCESS OF ELECTRIC-FILTER IN A BIRD CAGE BREEDING POULTRY FARM

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Abstract: *Optimization of the dust collection process of tube-typed electric-filter in a cage-breeding poultry farm has been made. The influence of the air-flow velocity and the discharging voltage on the dust collection process has been researched. A model has been constructed, which allows the optimization of the electrical filter parameters.*

Keywords: *electric filter, dust, mathematical model, optimization*

1. INTRODUCTION

The electrical filters have many advantages in comparison to the other types of dust collectors – universality, high productivity, high percentage of dust collection, low electrical consumption, possibility to work with high temperature gases. This is the reason for them to become main equipment for air- and gas-emissions from solid and liquid particles. The optimization of the dust collection process is very important part of their usage. It provides maximum efficiency during the exploitation, right choice and maintenance of these installations. There are lots of scientific papers concerning different types of electrical filters, working mostly in the industry [5, 2], but there are no results about their use in poultry farms. On the other hand, there are specific conditions for their exploitation at the farms and this is the reason for the current research about optimization of electrical filter, working at such place.

The purpose of this research is optimization of the dust-collection process in cage-breeding poultry farm, depending on the air-flow velocity and the discharging voltage. This process is influenced from other factors like temperature and humidity of the air, the gas composition, the size of the dust particles, etc. But these parameters are more or less constant and are not considered in this research work.

2. METHODS

The experiments are conducted in a cage-breeding poultry farm with capacity of 18,000 layers. The equipment used is typical – three cage battery BKN-3. The electrical filter has been placed in the middle of the farm, near the long walls at the height of the birds. The measurements have been carried out during winter months, when the ventilation system doesn't work, e.g. when the dust concentration is maximum.

The scheme is shown in Fig. 1 The determination of the dust concentration and the rate of dust collection of the electrical filter is via the measurement of the weight of the dust, deposited on the filters 6, which are placed in the testers 7. The first tester sucks in the air before the electrical filter and the other - after it. The experiments are carried out with an equal amount of air, passed through the testers, which is controlled by the air-flow meters, mounted in the two channels. The dust concentration, in mg/m^3, is determined by the weight method [1]:

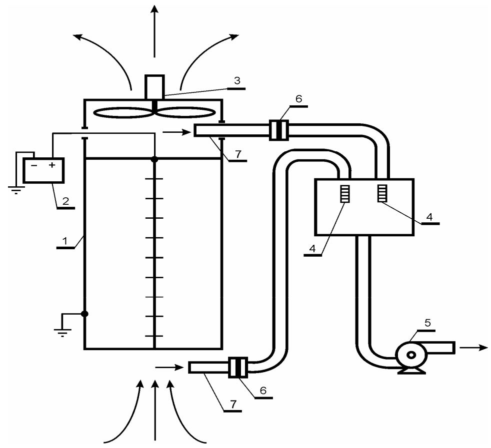

Fig. 1. Technological scheme of the experiment:
1-tube-type electrical filter; 2-high-voltage source; 3–ventilator with adjustable air-flow; 4-air-flow meter; 5–ventilator; 6–filters; 7–testers

$$k=(m_2-m_1)/V_0 \qquad (1)$$

where m_1 is the mass of the filter before the experiment, mg;
m_2 - the mass of the filter after the experiment, mg;
V_o - the volume of the air passed through the filter, m^3.

The measurement are carried out with a volume Vo = 500 dm^3. The rate of dust collection of the filter is computed with the equation:

$$\eta=(k_1-k_2)/\kappa_1, \qquad (2)$$

where k_1 is the dust concentration in the air before the electrical filters, mg/m^3;
k_2 – the dust concentration in the air after the electrical filters, mg/m^3.

The dust mass (mg) caught in the electrical filter is defined from the expression:

$$G=(k_1-k_2).V, \qquad (3)$$

where V is the volume of the air passed through the electrical filter, m3.

For the measurement of the dust mass an analythical balance is used. The pre-research work shows that the variation area of the factors Uk = (10-16) kV and v= (1÷5) m/s [3], does not have an clear extreme. This is the reason to increase the interval of the variation of the v keeping the same interval of Uk. If the crown discharge voltage is increased, the parameter η increases insignificantly, but at the same time the generated O_3, increases rapidly [6].

This violates the acceptable levels. A full factoral experiment is conducted. The number of the factors is 2 and the plan of the experiment is shown in Table 1. The process of optimization is made with the random search method [7]. The software product Statgraf is used.

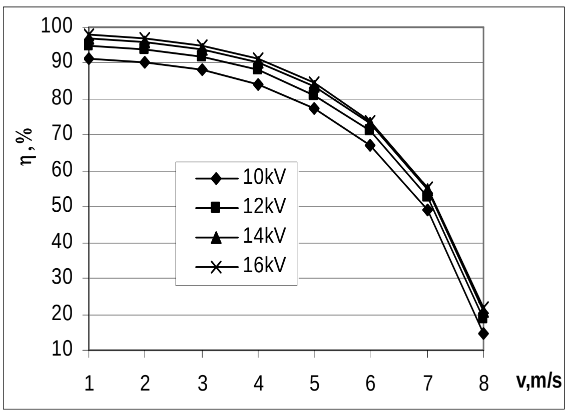

Fig. 2. Dependence of the dust collection rate of the electrical filter from the air-flow

Plan of the experiment - Table 1.

№	$\dot{X}_0$	$\dot{X}_1$	$\dot{X}_2$	X_1	X_2	G′	G′′	G′′′
-	-	-	-	m/s	kV	mg/s	mg/s	mg/s
1	+1	+1	+1	8	16	1,7801	1,7219	1,706
2	+1	-1	+1	4	16	3,6032	3,6420	3,700
3	+1	+1	-1	8	10	1,1358	1,2290	1,1080
4	+1	-1	-1	4	10	3,3221	3,349	3,4389
5	+1	+1	0	8	13	1,5733	1,5894	1,5701
6	+1	-1	0	4	13	3,5663	3,5782	3,5691
7	+1	0	+1	6	16	4,4318	4,4398	4,4466
8	+1	0	-1	6	10	4,0398	4,0345	4,0253
9	+1	0	0	6	13	4,3312	4,3362	4,3520

3. RESULTS AND DISCUSSION

Dependence of the dust collection rate η of the electrical filter from the air-flow velocity v, which varies in the new interval (1-8) m/s at the same interval of Uk = (10-16) kV , is given on the Fig. 2. After the statistical processing of the experimental data a mathematical model is built (4, 5, 6, 7). Here the test of Fisher is [4, 7] $F_{0.05;3;4} = 6{,}59$.

$$\eta_{10} = 99{,}13 - 10{,}11v + 3{,}32v^2 - 0{,}42v^3 \qquad F = 568{,}08 \tag{4}$$

$$\eta_{12} = 102{,}65 - 9{,}92v + 3{,}26v^2 - 0{,}41v^3 \qquad F = 644{,}50 \tag{5}$$

$$\eta_{14} = 104{,}82 - 9{,}77v + 3{,}22v^2 - 0{,}41v^3 \qquad F = 666{,}97 \tag{6}$$

$$\eta_{16} = 105{,}53 - 9{,}45v + 3{,}12v^2 - 0{,}40v^3 \qquad F = 752{,}93 \tag{7}$$

$$\hat{y} = 4.3365 - 1.0046\dot{x}_1 + 0.20535\dot{x}_2 + 0.0709995\dot{x}_1\dot{x}_2 - 1.76292\dot{x}_1^2 - 0.099123\dot{x}_2^2, \quad F=2{,}546 \tag{8}$$

The higher velocity of the air-flow does not permit the electrical charge of the particles. This decreases the rate of dust collection. After the full experiment a second rate mathematical model (8) is built. As the condition $F=2{,}546 < F_{0.05;3;18} = 3{,}16$ the hypothesis for the adequacy of the model is accepted. The spatial surface gives the extremum. After the process of optimization, the following values have been received: $y_{max.} = 4{,}76165$ mg upon working parameters $x_1 = -0{,}224023$ (5,5519 m/s), $x_2 = 1$ (16 kV). For this point the dust collection rate of the filter is $\eta = 79{,}71\%$ (see Fig. 2).

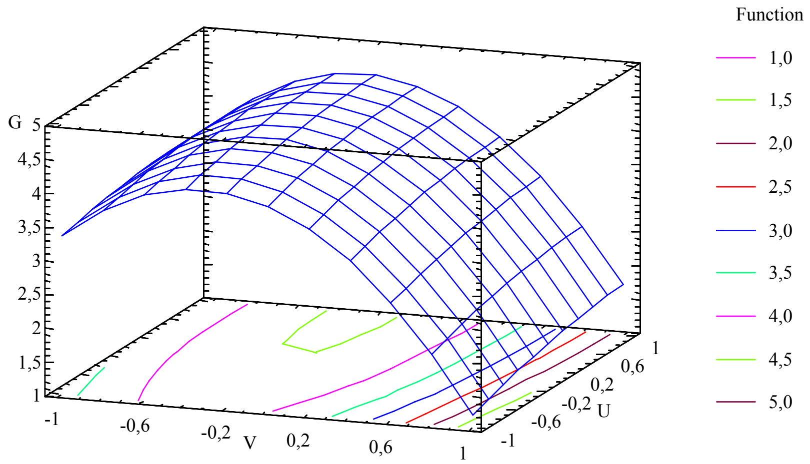

Fig. 3 Dependence of the collected dust mass from the air-flow velocity and the crown discharge voltage

4. CONCLUSIONS

The results of the experiment allow making the following conclusions:

1. The mathematical model allows to choose a suitable work range for the parameters air-flow velocity v and crown discharge voltage Uk, which provide maximum dust collection G. For the tested electric filter appropriate parameters are: v = 5,55 m/s, U=16 kV.
2. The used electrical filter decreases the rate of dustiness by 80%, which significantly decreases its influence over the health, mortality, expenses and productivity of the bird.
3. These results allow to determine the location of the electrical filters in the farm and the necessary electrical power.

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