

Measurement of exploitation parameters of the hen feeding line

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Abstract: The paper deals with the analysis of the operation of a hen feeding line in the reproduction breeding hall at the floor stabling type combined with the deep bedding on grates. We have measured the hen feeding line operation time in accordance with STN 47 0120, the losses of the fodder spilled by hens during a single feeding and the consumption of electricity of the observed line. As a result of the failure to carry out regular technical maintenance of the line as a preventive measure against the origin of defects, a relatively low value of the productive time use coefficient (0.77) was detected. Based on the analysis of the consumption of electric power, the electric engines driving individual segments of the line were found to be correctly dimensioned. Using the monitored technology, we managed to record excessive losses of the spilled feed mixture from the chain trough. For the whole farm it represents up to 702.8 kg of feedstuff per a day. The detected losses are very negatively projected into the economy of the production of one-day chickens. A negative and statistically highly conclusive correlation coefficient ($r = -0.9230^{**}$) was recorded between the chickens age and the losses of feed.

Keywords: feed losses; economy of chicken production; technical maintenance; consumption of electricity

Requirements for technology in poultry breeding are different, based on individual kinds of poultry and their age categories. The investment into reconstructions and use of new technologies for hen breeding is a basic condition for the achievement of such financial costs [an elimination of a high percentage of broken eggs with outdated technologies (10÷12%)] which would allow effectively carrying out the final production at domestic and foreign markets. New technologies must meet the welfare requirements. The increasing consumer demands and solvency will result in gradual increase in demands for the so-called bio-eggs (GÁLIK *et al.* 2001). MATOUŠEK (1997) maintains that to feed poultry on deep bedding and on grate floors, the chain rack is used. It is of a unit construction type, consisting of the feeder, one or two transport circuits, gearbox driven by an electromotor and a driving gear wheel. The feeding line is made up of channels in which a flat chain moves. Recently there has been an increased use of bowl racks equipped with a feed level regulator. A large offer of racks for individual

poultry types is available. The operation of feeding lines is fully automated. The whole transport system is hung on the hall ceiling, capable of being elevated by means of a capstan, which allows the used bedding to be removed in a mechanised way after the laying cycle, without a need to dismantle the system. These technological equipments put minimum requirements on control. The aim of our work was to analyse the operation of the hen feeding line in the reproduction breeding hall from the aspect of both the performance and energy consumption. There is not enough works treating the problem either in Slovak or foreign literature.

MATERIAL AND METHODS

The set tasks were analysed based on the following methodological procedure:

(1) Measuring the time of the operation of a hen breeding line (based on STN 47 0120). The line operation time was measured by means of a stopwatch. 10 measurements were carried out. The average

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time value from these measurements was in further assessment considered to be the time of one work cycle. The arrived at values of time were calculated for one hen. We drew on the following relations:

– operative time (s)

$$t_{02} = t_1 + t_2 \quad (1)$$

where: t_1 – operation time of chain conveyor (s),

t_2 – operation time of spiral conveyor (s),

– time for maintenance and preparation of technological equipment (s)

$$t_3 = t_{31} + t_{32} + t_{33} \quad (2)$$

where: t_{31} – time for shift maintenance (s),

t_{32} – time for a redesign of the equipment from the transport to the operation position (s),

t_{33} – time for the first setup of the equipment (s),

– time for the removal of defects (s)

$$t_4 = t_{41} + t_{42} \quad (3)$$

where: t_{41} – time for the removal of functional defects (s),

t_{42} – time for the removal of technical defects (s),

– productive time (s)

$$t_{04} = t_{02} + t_3 + t_4 \quad (4)$$

where: t_{02} – operative time (s),

t_3 – time for the maintenance and preparation of technological equipment (s),

t_4 – time for the removal of defects (s),

– total time (s)

$$t_{07} = t_{04} \quad (5)$$

From the measured operation values of the feeding line the following indicators were determined:

– unit operative time necessary to take care of one hen at one feeding (s/pcs)

$$t'_{02} = \frac{t_{02}}{n} \quad (6)$$

where: n – number of hens fed by chain conveyor (pcs),

– unit productive time necessary to take care of one hen at one feeding (s/pcs)

$$t'_{04} = \frac{t_{04}}{n} \quad (7)$$

– unit total time necessary to take care of one hen at one feeding (s/pcs)

$$t'_{07} = \frac{t_{07}}{n} \quad (8)$$

– coefficient of use of operative time (1)

$$K_{02} = \frac{t_1}{t_{02}} \quad (9)$$

– coefficient of use of productive time (1)

$$K_{04} = \frac{t_1}{t_{04}} \quad (10)$$

– line efficiency in main time (pcs/s)

$$Q_1 = \frac{n}{t_1} \quad (11)$$

– line efficiency in operative time (pcs/s)

$$Q_{02} = \frac{n}{t_{02}} \quad (12)$$

– line efficiency in productive time (pcs/s)

$$Q_{07} = \frac{n}{t_{07}} \quad (13)$$

(2) Determining losses of feed that hens spill out from the feed trough during one feeding. For this purpose, the catchers consisting of wooden frame of $1000 \times 500 \times 50$ mm and a bottom were prepared. On the top of the frame we put the sieve to prevent the burrowing out of the caught feed. The catchers were distributed to four places of the feed trough (3rd, 30th, 59th, and 76th grate). The measurements were done ten times during the second feeding (from 9:00 a.m. to 1:00 p.m.). The active length of the feed trough determined the loss quantity per one feeding. The results of the experiment were evaluated by the following mathematical-statistical methods: calculation of coefficients of correlation between the monitored indicators and the method of a simple nonlinear regression using the parabolic function ($y = a + bx + cx^2$), assessing its suitability through the determination index (R^2).

(3) Determining the unit consumption of electricity during the operation of the hen feeding line, specifically by the drive of the spiral conveyor and the drive of the chain conveyor. The consumption of electricity was measured through the following procedure:

– By measuring the currents used by the electro-motor through a grip voltmeter of the PK 210 type.

– By recording of voltage between the outer conductors and the values of the power factor $\cos \phi$ given on the engine label.

– By performing ten measurements of which calculated average values will serve as a basis for the calculation of exploitation parameters based on the following relations (HAJACH *et al.* 1969):

– performance of the asynchronous electromotor (kW):

$$P = \frac{\sqrt{3} \times U_s \times I \times \cos \phi}{1000} \quad (14)$$

where: U_s – voltage between outer conductors (V),
 I – electric current (A),
 $\cos\phi$ – engine power factor (1),

– electric work taken by asynchronous electromotor (kWh)

$$A = P \times t \quad (15)$$

where: P – electromotor performance (kW),
 t – time of operation of chain or spiral conveyor (h),

– consumption of electric power (kWh/pcs)

$$A_m = \frac{A}{M} \quad (16)$$

where: A – electric work (kWh),
 M – average daily lay of eggs in the reproduction breeding hall (pcs).

RESULTS

In the selected company's lay hall the trough chain rack is used for the feeding of hens. It has a wholly metallic construction and a storage bin with two branches of feed troughs. As a drive serves an electromotor (550 W) with a gearbox. The feed line consists of the following equipments:

- a feed mixture storage bin,
- spiral conveyor,
- an intermediate storage bin,
- a trough chain rack.

Exploitation indicators of the feed line

The operation time of the feeding line was measured in the hall. 10 measurements were carried out. In the further considerations average time values were taken into account. The measured values were put down into the relations given in the part "Material and methods". The calculated values are recorded in Table 1.

Determining feed losses

During the second feeding the feed catchers were put to the four places of the chain rack. Before the

Table 1. Calculated values of exploitation indicators of the feeding line

Indicator	Calculated values			
	s	s/pcs	–	pcs/s
t_{02}	2185	–	–	–
t_{04}	2725	–	–	–
t_{07}	2725	–	–	–
t'_{02}	–	0.38	–	–
t'_{04}	–	0.47	–	–
t'_{07}	–	0.47	–	–
K_{04}	–	–	0.96	–
K_{07}	–	–	0.77	–
Q_1	–	–	–	2.71
Q_{02}	–	–	–	2.60
Q_{07}	–	–	–	2.08

beginning of the third feeding the catchers were removed from the hall and the caught feed was weighed by means of laboratory scales. Average loss values at one meter of the chain rack, obtained from ten measurements, are given in Table 2.

Between the hen age and feed losses the negative correlation coefficient (-0.9230) with high statistical evidence was recorded ($P < 0.01$). The regression relation of the given indicators, theoretically expressed by the parabolic equation

$$y = 0.0396x^2 - 5.3998x + 211.47 \quad (R^2 = 0.9213)$$

is presented in Figure 1. In accordance with the expression of the given relation by this equation, feed losses are influenced by hen age up to 92.13 %.

The active length of the two circuits of a chain rack is 258 m. Average losses per the length of 1 m reached, during the laying period, 48.68 g. Average losses for one feeding were:

$$Q_{s1} = 48.68 \times 258 = 12\,559.4 \text{ g} = 12.55 \text{ kg} \quad (17)$$

At 4 times-daily feeding, total feed losses per one day reached:

Table 2. Average volume of feed losses for 1 m of feed trough's length

Age of hens (weeks)	29	33	37	42	47	52	56	61	65	69
Feed losses (g)	92.7	65.7	65.7	66.5	47.0	29.6	30.7	32.6	28.4	27.6

Table 3. Measured values of electric quantities

Measured equipment	Electric current I (A)	Voltage between outer conductors U_s (V)	Power factor $\cos\phi$ (1)
Chain rack	1.0	380	0.70
Spiral conveyor	2.4	380	0.72

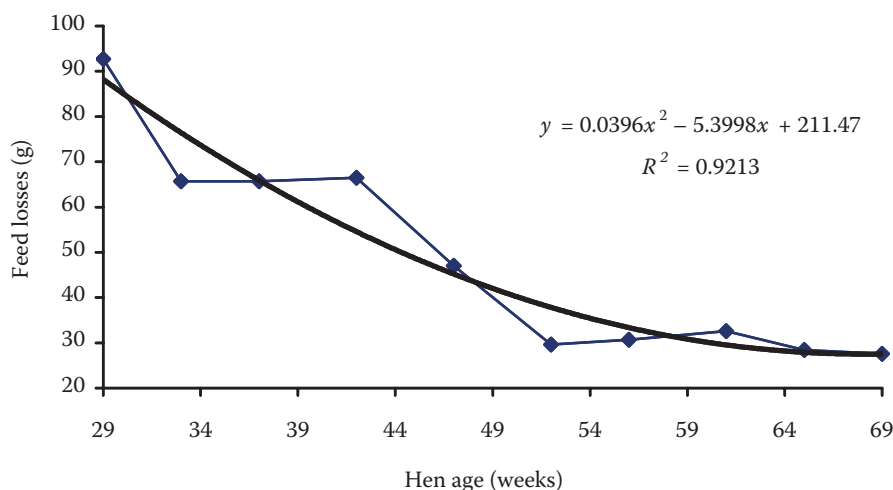


Figure 1. Regression relation between feed losses and hen age

$$Q_{sc} = 12.55 \times 4 = 50.2 \text{ kg} \quad (18)$$

Determining the consumption of electric power of the hen feeding line

As a result of the procedure given in the work's methodology, we have obtained the values of electric quantities necessary for the calculation of outputs and consumption of electric energy of the asynchronous motors of the hen feeding line. The measured values are given in Table 3.

From the measured quantities we have calculated exploitation parameters given in the methodological procedure. In the case of the application of a chain conveyor according to the relation (14), the output of the asynchronous electromotor was 0.46 kW.

The electric work used by the asynchronous electromotor for time t_1 in accordance with the relation (15) was 0.26 kWh. Since there are four feedings a day, the total electric work consumed by the asynchronous electromotor was 1.04 kWh.

The asynchronous electromotor consumption of electric power calculated for one laid egg during one day according to the relation (16) reached 0.0002 kWh/piece.

In the case of a spiral conveyor according to the relation (14) the output of the asynchronous electromotor was 1.13 kW.

The electric work used by the asynchronous motor according to the relation (15) was 0.022 kWh. The total consumption of electric work for one day reached 0.088 kWh.

According to the relation (16) the consumption of electric power of the asynchronous electromotor calculated for one laid egg during one day was 0.00001 kWh/pcs. The consumption of electric energy for per a feeding calculated for one laid egg for one day reached 0.00021 kWh/pcs.

DISCUSSION

Feeding of hens by means of a trough chain rack results in great damages caused by feed losses. Average losses per one meter of the rack's length during the laying period that we have determined reached the weight of 45.68 g. Per one feeding, at the active length of the trough rack being 258 m, it reaches 12.55 kg, and for one day with four feedings, as much as 50.2 kg of feed mixture in one hall (with 6106 of stored hens). Since the selected company has as many as 14 identical parental breed halls, total losses at full operation reach 702.8 kg of feed mixture per one day. According to MATOUŠEK (1997), the minimum daily consumption of feed mixture for the meat type hens in the sixtieth week of age is 150 kg per 1000 pieces. If, for example, in the monitored hall were 5400 hens in the 60th week of age, the maximum daily consumption of feed mixture would make 810 kg. This means that the 50.2 kg losses of feed

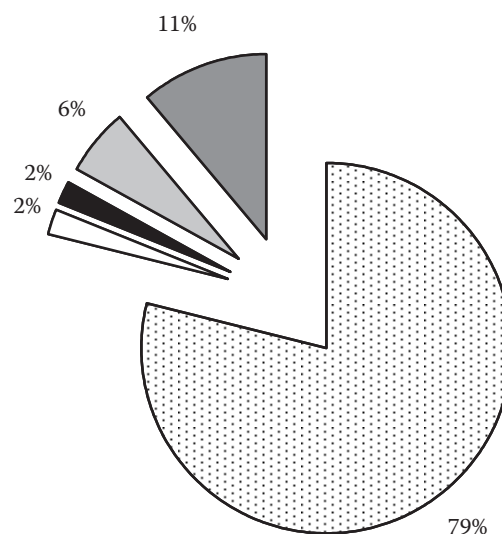


Figure 2. Structure of costs for one sexed hen

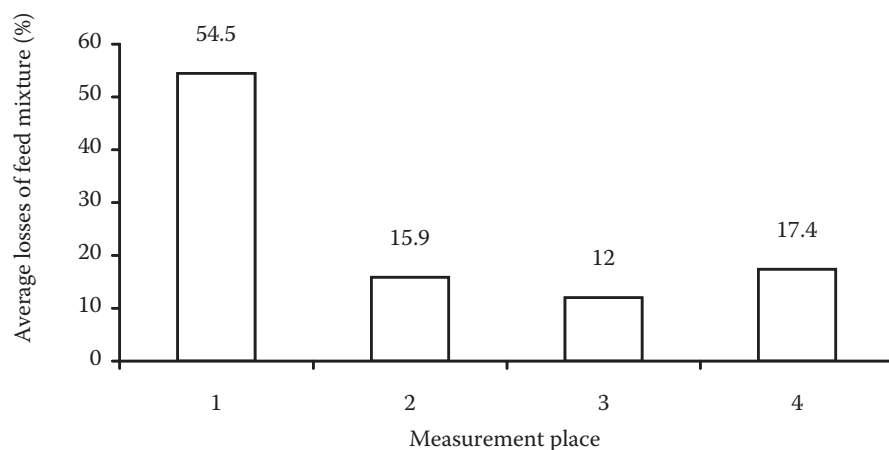


Figure 3. Share of measurement places in average losses of feed mixture

mixture in one hall make up 6.1% of the maximum daily consumption of feed mixture.

In the structure of costs for the production of one sexed chicken are, based on the data from the selected company (Figure 2), feed mixture costs included into the consumption of material, which makes up the largest portion of total costs, which is as much as 79%. From the possibilities of rationalisation of the production of one day chickens follows that the production economy may be improved by decreasing the disproportionately high feed losses through the application of a modern feeding system. The price of complete feed mixture for hens taken by the company from the producer is 6870 SK/t. The price of the devalued feed in the farm's 14 halls during a day is 4828.2 SK.

These losses are disproportionately high, and they result in a need to apply measures aimed at their decrease. Between the hens' age and the feed losses a negative correlation coefficient with a high statistical evidence ($P < 0.01$) was recorded. Based on the results of the applied regression analysis method, the variable (feed mixture losses) is dependently influenced by hens' age up to 92.13%. With regard to the impact of individual measurement places on the losses of feed mixture caused by spilling out, it is evident (Figure 3) that markedly highest losses were recorded in the catcher placed at the measurement place No. 1 (3 grate of the hall). From this follows that the distribution of hens along the whole length of the hall during the breeding is not regular either. After setting the chain rack into operation, a major part of hens moves to the front part of the hall. HALAJ (1999) claims that this may result in the shortage of space at the rack, which has a stressful effect and decreases the laying rate. Evaluating the consumption of electric power in the monitored line, it is possible to state that the dimensioning of electromotors driving the individual lines, which takes into account also

the sufficient backup of the electromotors' output, was right. The total consumption of electric power for the breeding, calculated for one laid egg during a day, was 0.00021 kWh/pcs.

From the measured values of the operation of feeding line, the exploitation indicators (use coefficients) were calculated. The coefficient of the use of productive time (K_{04}) reached the value of 0.77. This relatively low value is influenced by a frequent occurrence of some defects on the line and by the long time to remove them ($t_{04} = 540$ s). The most frequent defects include: a broken chain, a rubbed in or worn out guiding block, and a broken spiral. Our measurements then show that in the monitored hall no technical maintenance of the hen feeding line was done ($t_3 = 0$). HRUBEC (1989) claims that the technical maintenance, taken also as a preventive measure to prevent defects or to lower their intensity, can be carried out through many measures during the operation, e. g. through cleaning, greasing, protecting against corrosion, setup, tightening of screw connections, setting the clearance, and through other specific operations. Technical maintenance, together with observing all rules of correct operation of the equipment, may significantly prolong the technical life of machinery elements, lower the number of their defects per an operation time unit, and thus generally lower costs needed to remove defects and carry out the repairs. We believe that the regular line maintenance would lower the time needed to remove systematic as well as accidental defects (e.g. a burn out engine) and the coefficient of the use of productive time would reach a higher level. The defects of the feed line break the regularity of feeding, which is, according to HALAJ (1999), significant for the maintaining of the breeding condition of hens to the end of the laying cycle. If hens do not get feed regularly, they draw necessary nutrients from their own reserves. The delayed feeding does not entirely

make up for such losses and the hens' organism thus gets excessively exhausted.

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Abstrakt

GÁLIK R., KARAS I., TKÁČ Z., ORSÁG J. (2006): **Meranie exploatačných parametrov linky na kŕmenie sliepok.** Res. Agr. Eng., 52: 55–60.

V príspevku sme sa zamerali na meranie exploatačných parametrov linky kŕmenia sliepok v hale rozmnožovacieho chovu pri podlahovom spôsobe ustajnenia v kombinácii hlbkej podstielky s roštami. Na tento účel sme uskutočnili merania času činnosti linky kŕmenia sliepok podľa STN 47 0120, merania strát krmiva vytrúseného sliepkami počas jedného kŕmenia a merania spotreby elektrickej energie sledovanej linky. V dôsledku nevykonávania pravidelnej technickej údržby linky ako preventívneho opatrenia zabraňujúceho vzniku porúch sme zistili pomerne nízku hodnotu koeficienta využitia produktívneho času (0,77). Podľa analýzy spotreby elektrickej energie konštatujeme správne dimenzovanie elektromotorov na pohon jednotlivých článkov linky. Použitím sledovanej technológie sme zaznamenali neúmerne vysoké straty vytrúsenej kŕmnej zmesi zo žlabového reťazového kŕmidla. Pre celú farmu to predstavuje až 702,8 kg krmiva za deň. Zistené straty sa výrazne nepriaznivo premietajú do ekonomiky výroby jednodňových kurčiat. Medzi vekom sliepok a stratami krmiva sa zistil záporný a štatisticky vysoko preukazný korelačný koeficient ($r = -0,9230^{**}$).

Kľúčové slová: straty krmiva; ekonomika výroby kurčiat; technická údržba; spotreba elektrickej energie

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