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ENGINEERING SCHEME FOR RECONSTRUCTION OF PANEL-TYPE LIVESTOCK BUILDING

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ABSTRACT

A model for reconstruction of typical panel type livestock building is suggested. The reconstruction scheme ensures controlled natural ventilation and smooth regulation of air exchange in the building. The board fence (walls and roof) is turned into recuperative heat exchanger, forming feeding and sucking canals. A business plan for carrying out the reconstruction without any break in production process is suggested too, which leads to decrease in investment volume.
Key words: livestock production / panel type buildings / reconstruction / models

MODEL REKONSTRUKCIJE MONTAŽNEGA ŽIVINOREJSKEGA OBJEKTA

IZVLEČEK

Predstavljamo model rekonstrukcije montažnega živinorejskega objekta. Rekonstrukcija zagotavlja uvajanje krmiljenega naravnega prezračevanja in postopno uravnavanje kroženja zraka v objektu. Površina, ki ograjuje prostor (stene, streha), smo spremenili v okrepljen toplotni izmenjevalnik, pri čemer smo oblikovali kanale za dotok in izsesavanje zraka. Tak podjetniški načrt za izvajanje rekonsrukcije brez prekinitve proizvodnega procesa predlagamo zato, da bi zmanjšali višino naložbe.
Ključne besede: živinoreja / montažne zgradbe / rekonstrukcija / modeli

INTRODUCTION

Panel-type livestock buildings are very widespread in animal farms in Bulgaria. They have simple, long-lasting construction, but cannot provide good microclimate for animal breeding. During the summer these buildings are overheated and during the winter they are cold and humid. So, there is strong necessity of reconstruction and modernization in order to improve microclimate and thermal characteristics of the buildings. Systematical research on this subject is carried out in University of Rousse (Daskalov, 1977; Andonov, 1995b). A scheme of livestock building with controlled natural ventilation (aeration) is suggested (Andonov *et al*, 1993; Andonov, 1995b). High utilization of heat is achieved (up to 38% of the energy of the outgoing polluted air (Andonov, 1995a)), which leads to both increase in birth rate and decrease in death rate (Andonov, 1995b). A disadvantage of this scheme is the presence of movable side panels (Andonov and Qian Ruzhu, 1995), that complicate both building construction and the microclimate control (Andonov, 1995b). The desire to escape the disadvantages mentioned above, keeping the quality of the aeration, led to suggestion of new improved scheme (Daskalov, 1977). The movable side panels are eliminated and the sidewalls are included as elements in buildings heat and mass exchange scheme. Thus a thermos-building is created in which the aeration can be controlled smoothly during the whole year, using only one valve mounted in the roof openings (vents) and with no necessity of other movable elements (Enimanev, 1999a). This conception is applied to the existing panel-type livestock buildings, providing at the same time an effective business plan for the reconstruction process.

PRINCIPLE SCHEME

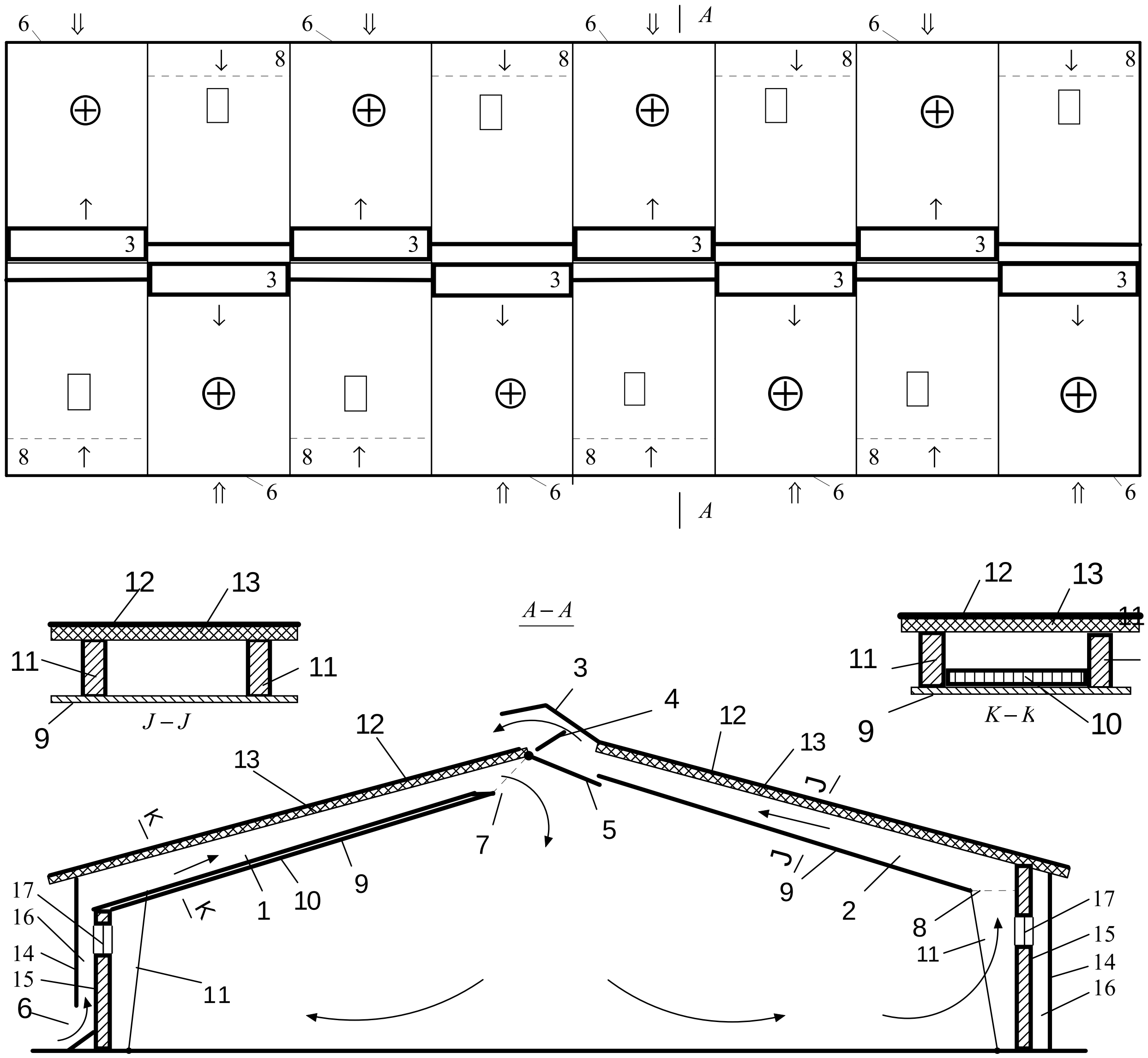

Figure 1. Principle scheme for reconstruction of panel-type livestock building. 1 = feeding canal (+); 2 = sucking canal (-); 3 = vents; 4 = regulators; 5 = valve; 6 = incoming opening; 7 = incoming air outlet; 8 = sucking outlet; 9 = bottom of the air canals; 10 = insulation layer of the feeding canals; 11 = caring frame; 12 = insulation layer of the roof panels; 13 = roof panels; 14 = planes; 15 = sidewall panels; 16 = canal for the incoming air; 17 = windows;

Principle scheme of the reconstruction of the building is presented in Figure 1. At the beginning (before the reconstruction), the existing elements are panel-type sidewalls 15, caring frames 11, windows 17, roof panels 13 and the roof insulation 12. The space between caring frames is L = 3, 4.5 or 6 m. During the reconstruction, feeding canal 1 (+) and sucking canal 2 (-) are formed in the building construction, without damaging the caring frame. The width of the canals is determinate by the space between caring frames L, and the height depends on the size of the frame 11. Thus one common ceiling surface is formed at the level of the inside parts of the caring frame 11. Outside, planes 14 are mounted parallel to panels 15. The feeding canal 1 (+) and sucking canal 2 (-) are distributed in chessboard order. Their outside openings (vents) 3 are opposite one to another, thus eliminating the effect of the wind direction. The feeding canal 1 (+) includes incoming opening 6 and canal 16, formed between side panel 15 and plane 14. The bottom of the feeding canal 1 (+) includes elements 9 (armed polyethylene or odutis) and 10 (an insulation material – mineral wool, Styrofoam or expanded polyurethane), which prevent condensation process. All those materials are light and resistant and do not load the caring frame.

PRINCIPLE ACTION OF THE SCHEME

The building remains closed during the whole year. By exclusion windows 17 or valves 5 it can be open. The air circulates through the following route: opening 6 – canal 16 – canal 1 (+) – opening 7 – room (animal zone) – sucking outlet 8 – sucking canal 2 (-) – vent 3 – atmosphere. The regulation of the airflow is realized through regulators 4. The utilization of heat occurs in canal 17 and canal 1; animal body temperature warms the air during its movement from incoming air outlet 7 through the room and from the canal 2 walls toward the room. The more animals are bred in the building, the greater amount of heat is available, and more heat is used, and air exchange rate e.g. the process is auto intensifying.

BUSINESS SCHEME FOR EFFECTIVE RECONSTRUCTION

Meat production is carried out for certain periods, (technological cycles). Poultry breeding, for instance takes approximately 60 days, pig breeding – up to 220 days, calves in different ages – up to 3, 6 and 18 months. The suggested scheme allows reconstruction process in accordance with breeding technological cycles without interruption of production process. This way, the incomes from production cycles accelerate credit reimbursement. The investment for the reconstruction should be split to three general parts (transactions) (Table 1): K1 – investment for making and mounting the vents 3; K2 – investment for making and mounting feeding canal 1 (+) and sucking canal 2 (-); K3 – investment for sidewall insulation. Each of this three parts can be divided to smaller parts – K11…K1p; K21…K2l; K31…K3d (Table 1).

Table 1. The investment matrix

Transactions	Stages
K1 – making and mounting the vents	K11, K12, … , K1p
K2 – making and mounting feeding and sucking canals	K21, K22, … , K2l
K3 – mounting the sidewall insulation	K31, K32, … , K3d

Table 2. Results of business scheme test

Transactions, BGL (DM)	$1T_{ZP}$	$2T_{ZP}$	$3T_{ZP}$	$4T_{ZP}$
Reconstruction of the livestock building with break in the production process				
K_1 = 4 475	S_0 = 37 734	S_{01} = 38 857	S_{02} = 36 493	S_{03} = 34 216
K_2 = 15 300		U_{01} = 3 413	U_{02} = 3 261	U_{03} = 4 833
K_3 = 17 404		D_{01} = 35 444	D_{02} = 33 232	D_{03} = 29 383
Reconstruction of the livestock building without break in the production process				
K_1 = 4 475	S_1 = 3 298	S_2 = 16 442	S_3 = 30 393	S_4 = 26 899
K_2 = 15 300	U_1 = 1 751	U_2 = 4 036	U_3 = 4 247	U_4 = 4 833
K_3 = 17 404	D_1 = 3 547	D_2 = 12 406	D_3 = 26 126	D_4 = 22 066
Availability, DM	ΔD_1 = 34 187	ΔD_2 = 23 038	ΔD_3 = 7 106	ΔD_4 = 7 316

The general business plan can be seen on Figure 2. At the end of each technological cycle the accumulated sums is calculated as follows:

$$(1)\quad S_1 = K_{11}\left[1+y\left(T_Z+n_0\right)\right]+K_{12}\left[1+y\left(\sum_{2}^{p} n_{1i}+n_0\right)\right]+\ldots+K_{1p}\left[1+y\left(n_{1p}+n_0\right)\right].$$

$$(2)\quad D_1 = S_1 - U_1.$$

$$(3)\quad S_2 = (D_1+K_{21})\left(1+y\left(T_Z+n_0\right)\right)+K_{22}\left[1+y\left(\sum_{2}^{l} n_{2i}+n_0\right)\right]+\ldots+K_{2l}\left[1+y\left(n_{2l}+n_0\right)\right].$$

$$(4)\quad D_2 = S_2 - U_2.$$

$$(5)\quad S_3 = \left(D_2+K_{31}\right)\left[1+y\left(T_Z+n_0\right)\right]+K_{32}\left[1+y\left(\sum_{2}^{d} n_{3i}+n_0\right)\right]+\ldots+K_{3d}\left[1+y\left(n_{3d}+n_0\right)\right].$$

$$(6)\quad D_3 = S_3 - U_3.$$

$$(7)\quad S_4 = D_3\left(1+y\left(T_Z+n_0\right)\right).$$

$$(8)\quad D_4 = S_4 - U_4.$$

$$(9)\quad S_0 = K_1\left(1+yT_{ZP}\right)+K_2\left[1+y\left(n_2+n_3\right)\right]+K_3\left(1+yn_3\right).$$

$$(10)\quad S_{01} = S_0\left(1+yT_{ZP}\right).$$

$$(14)\quad S_{03} = D_{02}\left(1+yT_{ZP}\right).\ (44)\quad D_{03} = S_{03}-U_{03}.\ (45)\quad \Delta S = D_{03}-D_4.$$

where:

T_Z	continuance of the technological cycles for animal breeding	Days
T_{ZP}	continuance of the technological cycles for animal breeding including the pause n_0	Days
n_0	continuance of the pause for preparation and recharging the lots	Days
$n_{11},\ldots,n_{1p}$; $n_{21},\ldots,n_{2l}$; $n_{31},\ldots,n_{3d}$	continuance of the stages for assimilation of the transactions distributed between technological cycles during the reconstruction, without breaking the production process	Days

n_1, n_2, n_3	number of days necessary for assimilation of the transactions during the reconstruction with breaking the production process	Days
K_1, K_2, K_3	number and value of the transactions during the reconstruction with breaking the production process	Days
$K_{11},\ldots,K_{1P}$; $K_{21},\ldots,K_{2L}$; $K_{31},\ldots,K_{3D}$	number and value of the transactions K_1, K_2 and K_3 during the reconstruction without breaking the production process	Days
S_0, S_{01}, S_{02}, S_{03}	money accumulated before the beginning of each technological cycle during the reconstruction with breaking the production process	BGL (DM)
U_{01}, U_{02},U_{03}	income at the end of each technological cycle during the reconstruction with breaking the production process	BGL (DM)
D_{01}, D_{02}, D_{03}	availability before beginning of each technological cycle during the reconstruction with breaking the production process	BGL (DM)
S_1, S_2, S_3, S_4	money accumulated before the beginning of each technological cycle during the reconstruction without breaking the production process	BGL (DM)
U_1, U_2, U_3, U_4	incomes at the end of each technological cycle during the reconstruction without breaking the production process	BGL (DM)
D_1, D_2, D_3, D_4	availability before beginning of each technological cycle during the reconstruction without breaking the production process	BGL (DM)
ΔD_1, ΔD_2 ,ΔD_3, ΔD_4	differences in availabilities at the beginning of each technological cycle	BGL (DM)

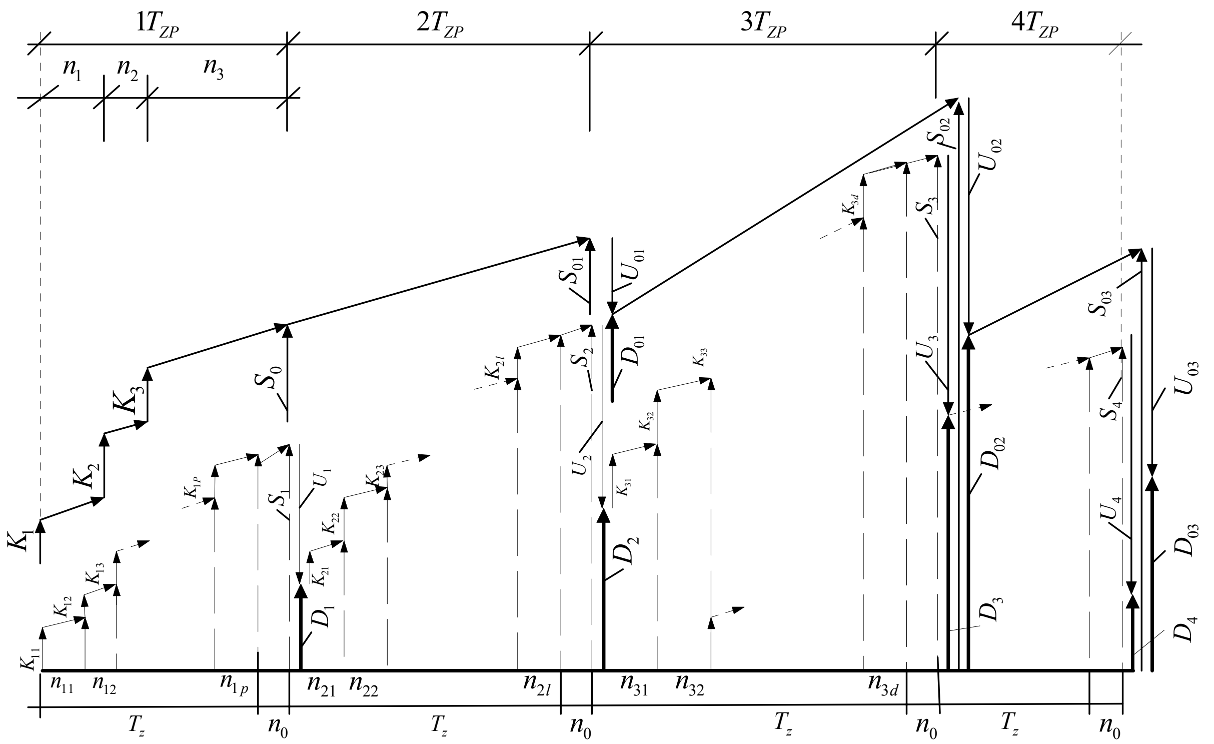

Figure 2. Business scheme for effective reconstruction.

The effectiveness of the scheme is tested in case of pig breeding (7–25 kg). The continuance of the technological cycles is T_z = 25 days, the continuance of the pause n_0 = 15 days. The transactions are assimilated within three cycles: n_1 = 15 days; n_2 = 30 days; n_3 = 25 days. The expected income from the production is examined by (Spasov, 1988). The expected profit is 2.5% (in relation to general expenses for each cycle). The whole investment amount is 37 179 BGL (DM). It is divided on transactions as follows: K_1 = 4 475 BGL (DM); K_2 = 15 300 BGL (DM); K_3 = 17 404 BGL(DM). The results from comparative evaluation are given in Table 2. The advantages of the suggested business scheme are clearly seen from the margins at the end of each technological cycle. They are higher at the beginning of the second cycle – 34 187 BGL (DM); after the second cycle – 23 038 BGL (DM); after the third cycle – 7 106 BGL (DM); after the forth cycle they are 7 136 BGL (DM).

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