ENGINEERING STRUCTURE OF ENERGETICALLY AND ECOLOGICALLY BALANCED MANUFACTURING SYSTEM

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Abstract: *Basic elements in the engineering structure of the system are the integrated manufacturing plants (IMP). The cores in the IMP's structure are the typical technological modules and objects, designed for: drying and storing the agricultural production; hothouse vegetables manufacturing; eggs, fertilizers and biogas manufacturing; meat, milk, fertilizer and biogas manufacturing; forage manufacturing; workshops and office buildings. All features concerning plants structure are synthesized, together with the generalized parameter schemes of the system modules.*

Key words: *energy, alternative sources, engineering, stationary agricultural production, ecological manufacturing system, structure.*

INTRODUCTION

The stationary technological processes in the agricultural sector need new systems and new engineering structure providing: effective utilization of the energy of the alternative energy sources; energetical and production compatibility between technological modules; balance between available energy sources and manufacturing capacity of the technological modules; seasons changes and there influence on the energy and mass exchange of the manufacturing processes in the integrated modules [10].

The engineering structure of the manufacturing systems with alternative energy supply should be designed on the basis of the synthesized structural schemes – technological modules for drying and storing of agricultural production utilizing alternative energy sources [5, 14], energy saving buildings [4, 6, 7], production lines for processing of the vegetable production [8]. All principles that allow the construction of the single energetical and technological modules are prerequisites for design of engineering structure of the complex manufacturing system based on alternative energy sources [8].

The defining parameters of the complex manufacturing system are: energetical compatibility between technological modules; balance between available energy sources and manufacturing capacity of the technological modules; seasons changes and there influence on the energy and mass exchange of the manufacturing processes in the integrated modules [1, 2, 3].

The engineering scheme of the manufacturing system is based on the analysis of the microclimate systems, technological equipment, developed energy loops models [9] and the patents for poultry and livestock breeding [11, 12, 13]. The scheme is all new as a concept and distinguishes from all the other manufacturing schemes for ecological production of meat, eggs, dried fruits and vegetables, biogas and fertilizers, utilizing alternative energy sources in the manufacturing process.

EXPOSITION

1. Structure of the system

Basic elements in the engineering structure of the complex manufacturing system are the integrated manufacturing plants (IMP) (Fig. 1.). The organization of each one of the IMP can vary. The core of the structure is the technological modules for production drying and storing. They can be combined with all other technological modules in following manner:

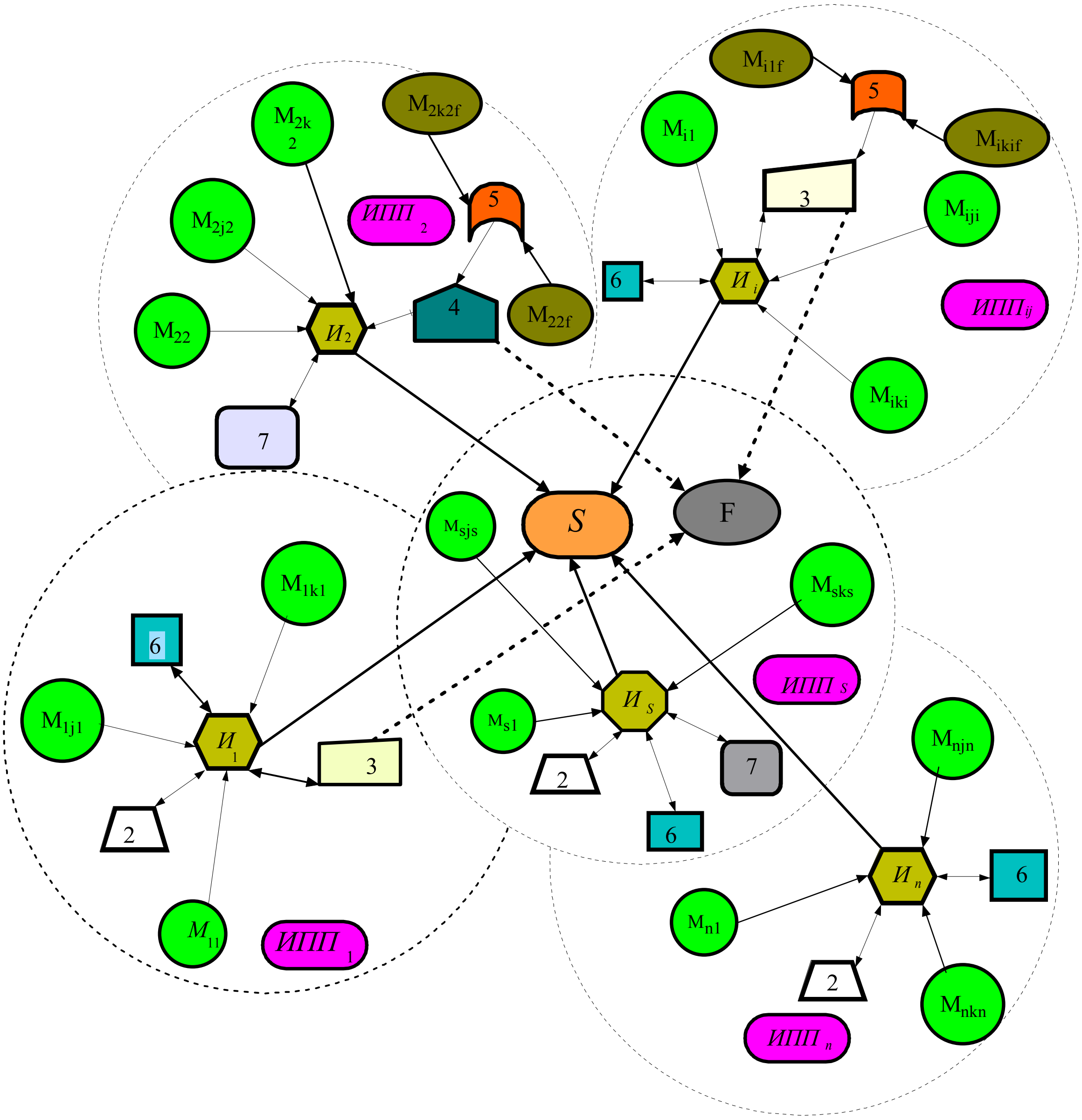

Figure 1. Engineering structure of the manufacturing system with alternative energy supply

$И_1, И_2, \ldots, И_l, \ldots, И_s, \ldots, И_n$ – technological modules for production drying and storing with alternative energy supply; S –packaging and expedition unit; F – unit for processing of the livestock products (dairy, butchery, etc.); $ИПП_1$, $ИПП_2$,, …, $ИПП_n$ – integrated manufacturing plants; 2 – technological modules for hothouse vegetables manufacturing; 3 - technological modules for eggs, fertilizers and biogas production with alternative energy supply; 4 - technological modules for meat, fertilizers and biogas production with alternative energy supply; 5 - technological modules for forage manufacturing; 6 –residential buildings; 7 – manufacturing; $M_{11}, M_{1j1}, \ldots, M_{1k1}$; …; $M_{i1}, M_{iji}, \ldots, M_{iki}$; … $M_{n1}, M_{njn}, \ldots, M_{nkn}$ - sources for row materials for production drying or storing; $M_{22f}, \ldots, M_{2k2f}$; …; $M_{i1f} \ldots, M_{ikif}$ - sources for row materials for forage manufacturing.

1. $IMP_1(ИПП_1)$ – object $И_1$ (technological module for products drying and storing [13]) – object 2 (technological module for hothouse vegetable manufacturing)

– object 3 (technological module for eggs, fertilizers and biogas manufacturing [11]) – object 6 (residential building);

2. IMP$_2$ (ИПП$_2$) – object И$_2$ (technological module for products drying and storing [13]) - object 4 (technological modules for meat, fertilizers and biogas production [12]) – object 7(workshops and office buildings) – object 5 (technological module for forage manufacturing []);

3. ИПП$_{ij}$ – object И$_i$ (technological module for products drying and storing [13]) - object 3 (technological module for eggs, fertilizers and biogas manufacturing [11]) – object 5 (technological module for forage manufacturing []) – object 6 (residential and office buildings);

4. IMP$_S$ (ИПП$_S$) – object И$_S$ (technological module for products drying and storing [13]) – object 2 (technological module for hothouse vegetable manufacturing – object 6 (residential and office buildings) – S (workshop for products packaging and expedition) – object 7(offices and manufacturing buildings) – F (workshop for processing of the livestock material);

5. IMP$_n$ (ИПП$_n$) – object И$_n$ (technological module for products drying and storing [13]) – object 2 (technological module for hothouse vegetable manufacturing – object 6 (residential and office buildings);

2. Structuring of the IMP

Each one of the integrated manufacturing plants (IMP) can be structured on the basis of the synthesized principle scheme of the mutual relations and features [10], (Fig. 2.), in following manner:

Energetical compatibility: It is achieved by establishing connection for energy and mass exchange between the technological module for drying *И,* with the technological modules for production storing *И$_{CX}$, eggs,* biogas and fertilizer manufacturing 3 or meat, biogas and fertilizer manufacturing 4. The residual heat energy goes back to the objects trough thermo pumps *ТП.*

Energy and manufacturing capacity balance:

total power balance:

$$P_k = P_И + P_S + P_F + P_2 + P_3 + P_4 + P_5 + P_6 + P_7 \qquad (1)$$

where P_k is the power of the main energy supply agent (boiler or Co-generator central), kW ;

$P_И$ - power of the technological module for drying, kW ;

P_S , P_F - power of the units for packaging and expedition and for livestock products processing, kW ;

P_2, P_3, P_4, P_5 - power of the technological modules for hothouse production and for eggs, meat, biogas and fertilizers manufacturing, kW ;

P_6, P_7 - power for heating the residential and manufacturing building, kW ;

local balance:

$$P_И = P_3 \quad or \quad P_И = P_4 \quad or \quad P_И = P_2 \qquad (2)$$

$$P_И = P_2 + P_6 \quad or \quad P_И = P_2 + P_7 \quad or \quad P_И = P_2 + P_6 + P_7 \qquad (3)$$

The local balance, according the conditions (2) и (3), assumes equality between power of the technological module for drying and the other modules connected to it in a single manufacturing system. The power of the boiler (Co generator) must cover the manufacturing process and all energy needs. The alternative energy supply agents are part of the total balance and help to decrease the energy consumption of the boiler.

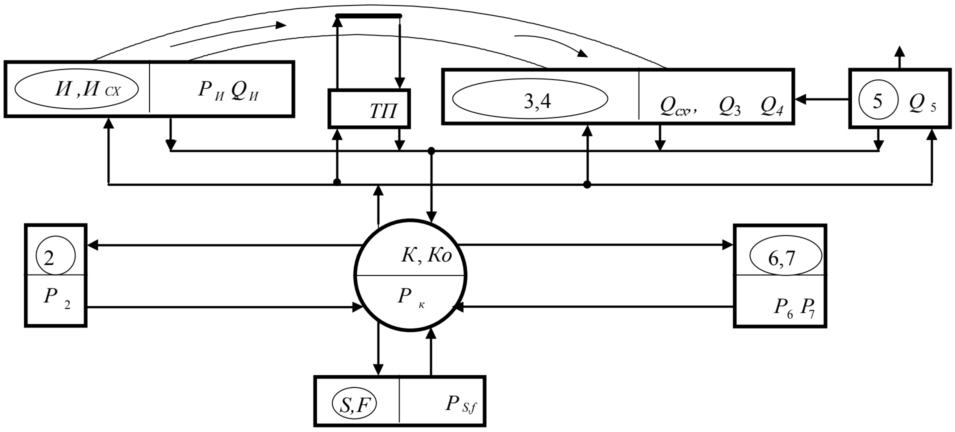

Figure 2. Principle scheme of the mutual relations between the features for structuring of the manufacturing system.

И, И$_{CX}$ – the technological modules for drying and storing of the production; ТП – thermo pump contours; 2,3,4,5 technological modules for production of hothouse vegetables, eggs, meat, forage; 6,7 – residential and manufacturing buildings; S, F - manufacturing units for packaging and expedition; K, Ko - boiler or Co-generator.

Seasonal changes in energy and mass exchange, and its influense for covering the manufacturing needs in the integrated modules It is achieved trough thermo pump contour ТП. During the summer ТП detracts the residual heat from the outgoing from the drying chamber air flow and gets it back to the entrance of the chamber. The cooled air is passed trough the poultry 3 and livestock 4 sectors. The drying chamber И and the chamber for production storing И$_{CX}$ acts in a similar manner. The energy loses toward surrounding area is minimized and there is increase in the energy efficiency of the manufacturing system.

2. Generalized parametric scheme of the modules

Summer mode (drying of the agro production). During the summer the manufacturing system can be characterized with the balance of the energy flows and the energy income the scheme given at Fig. 3. The flows from the alternative sources dominates – solar radiation (q_c, W_C), atmospheric air (q_0, W_0; ΔX_0), heat utilization trough thermo pumps (q_6, W_6; q_{15}, W_{15}) , energy saving building (q_8, W_8) and canals of the drying chamber (q_3, W_3). Generalized dependences describing the flows are given in Table 1.

Table 1. Dependences, defining the power of the alternative energy sources and the energy income

- from the sun: $q_c = C_v.A_s.(T_1 - T_0)$, $W_c = \int_0^{t_z} q_c.dt$, (4) - from heat utilization during the night:	- from the thermo pump toward the chamber: $q_6 = C_v.A_s.(T_2 - T_1)$, $W_6 = \int_0^{t_z} q_6.dt$, (6) $q_{15} = C_v.A_s.(T_3 - T_6)$, $W_{15} = \int_0^{t_z} q_{15}.dt$, (7)	- from the thermo pump toward the building: $q_8 = C_v.A_B.(T_{10} - T_8)$, $W_8 = \int_0^{t_z} q_8.dt$, (8) - moisture going out with the athmospheric air:

$q_3 = C_v.A_s.(T_3 - T_0)$, $W_3 = \int_0^{t_z} q_3.dt,$ (5)		$\Delta X_0 = \int_0^{t_z} A_s.(X_3 - X_0).dt,$ (9)

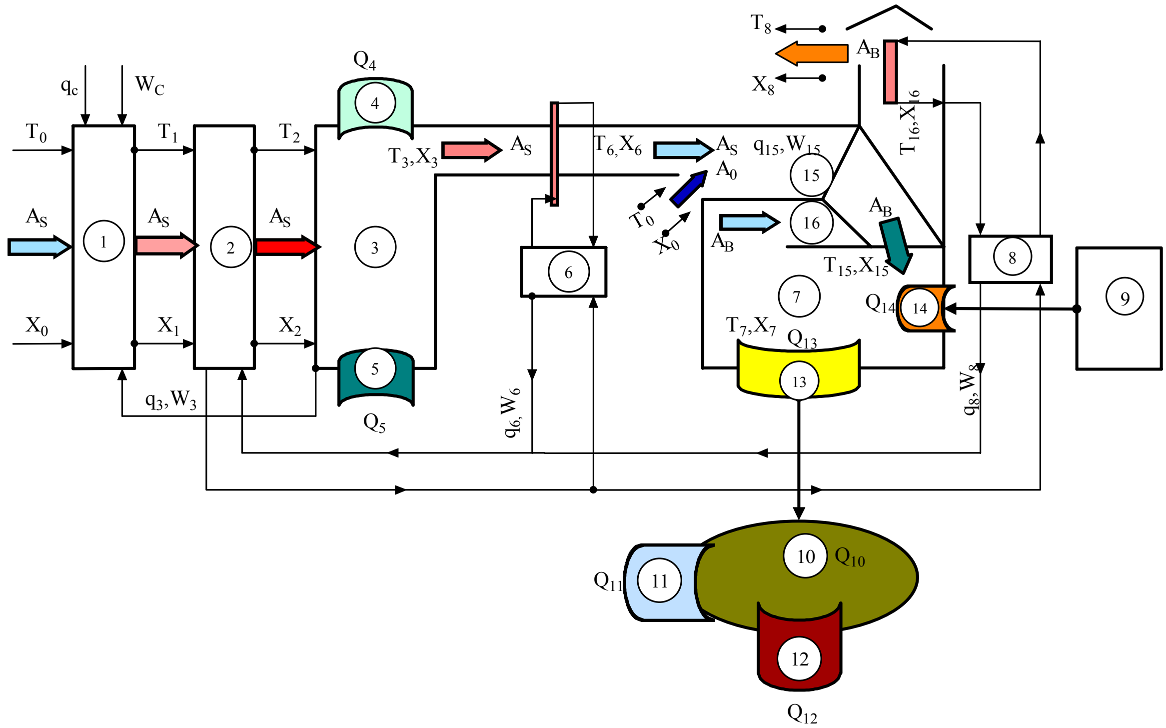

Figure 3. Generalized parametric scheme of the modules during the summer (Livestock breeding and dryed products)

1 – Solar collectors of the drying chamber; 2 – heat exchanger of the drying chamber; 3 – drying chamber; 4 – dried products; Q_4 - quantity of the dried products; 5 – incoming products for drying; Q_5 - quantity of the incoming products for drying; 7 – energy saving livestock building; 6,8 – thermo pumps contours; 9 – forage installation ; 10 – biogas generator; 11 – biogas flow; 12 – fertilizer flow; 13 – fecal mass outgoing flow; 14 – incoming into the building forage flow; 15 – income canals; 16 – sucking canals; Q_{11} - quantity manufactured biogas; Q_{12} - quantity manufactured fertilizer; Q_{13} - quantity of the outgoing fecal mass; Q_{14} - quantity of the forage income into the building; q_c, W_C - the flow and the quantity of the solar energy, ($kW, kW.h$); q_3, W_3 - the flow and the quantity of the utilized heat from the drying chamber in case of night drying mode, ($kW, kW.h$); q_6, W_6 - the flow and the quantity of the energy from thermo pump contour toward the drying chamber, ($kW, kW.h$); q_8, W_8 - the flow and the quantity of the energy from the thermo pump contour toward the livestock chamber, ($kW, kW.h$).

Winter mode (products storing).

The drying chamber is in fresh products storing mode. In this mode the energy from the atmospheric air dominates. In the temperature range -5 ^{0}C - 7 ^{0}C there is no need from extra heating or cooling. In this mode the connection between thermo pump aggregates 6 and 8 is cut (Fig .4). The thermo pump 6 is in convertible cycle -

it heats the incoming into the building 7 air and cools the flow in the heat exchanger 2 or conversely, depending by the temperature of the atmospheric air. The heat detracted by the thermo pump 8 goes for building heating.

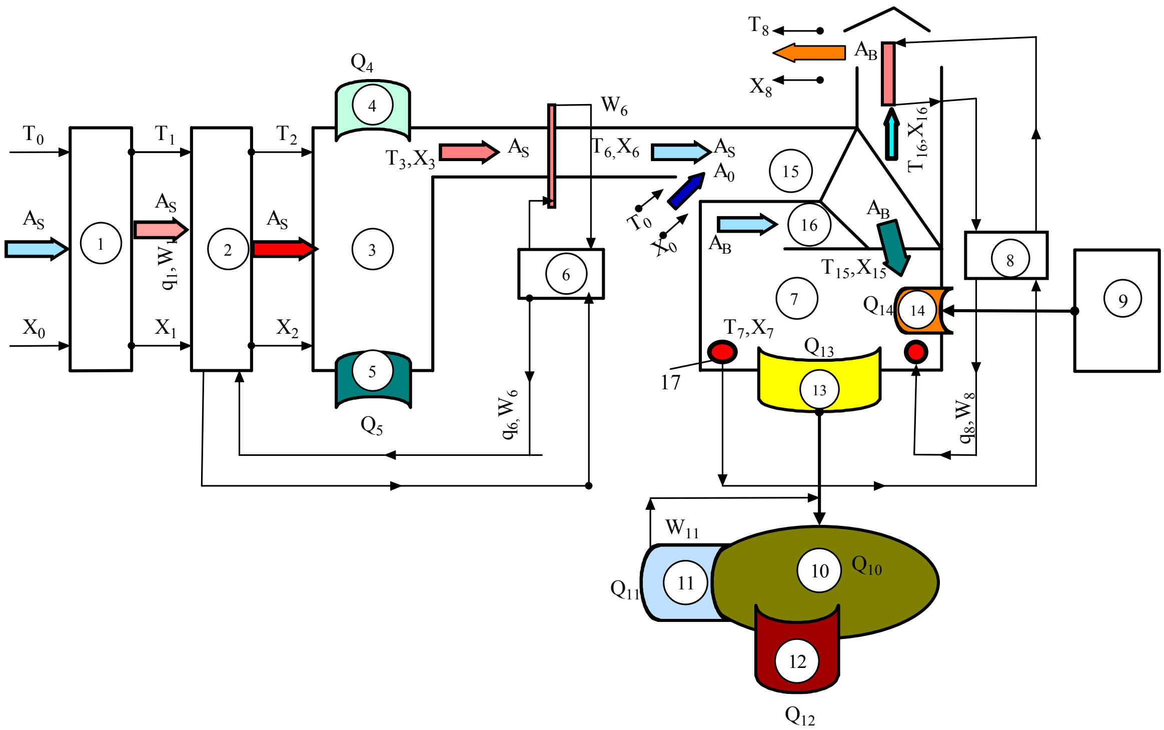

Figure 4. Generalized parametric scheme of the modules during the winter (Livestock breeding and fresh products storing)

1 – collecting canals; 2 – heat exchanger of the chamber; 3 – drier chamber in fresh products storing mode; 4 – outgoing production; Q_4 - quantity of the stored products; 5 – incoming products for storing; Q_5 - quantity of the incoming products for storing; 6,8 – thermo pump contour; 9 – forage installation ; 10 – biogas generator; 11 – biogas flow; 12 – fertilizer flow; Q_{11} - quantity manufactured biogas; Q_{12} - quantity manufactured fertilizer; Q_{13} - quantity fecal mass brought out from the building; Q_{14} - quantity of the forage brought into the building; q_1, W_1 - the flow and the quantity of the energy from the atmospheric air during the product storing, $(kW, kW.h)$; q_3, W_3 - the flow and the quantity of the energy from the utilization of the heat from the chamber during the products storing, $(kW, kW.h)$; q_6, W_6 - the flow and the quantity of the energy from the thermo pump contour toward the chamber during the products storing mode, $(kW, kW.h)$; q_8, W_8 - the flow and the quantity of the energy from thermo pump contour toward the livestock chamber, $(kW, kW.h)$; q_{6p}, W_{6p} - the flow and the quantity of the energy from the thermo pump contour toward livestock building, $(kW, kW.h)$.

CONCLUSION

The represented engineering structure of the complex manufacturing system with alternative energy supply shows :

- the embedding of the energetical processes (and the objects) into the energy fields of the surrounding area is a prerequisite for design of new manufacturing systems in the agro sector, where the manufacturing efficiency is based on mutual relations of energy and mass exchange;

- New engineering models for optimization of the manufacturing of meat, eggs, dried fruits and vegetables, forage, etc. with utilization of alternative energy sources is to be developed.
- The production of livestock products, dried fruits and vegetables, forage etc. should be based on alternative energy sources and technologies with no waste.
- It is possible to embed into a single manufacturing object the natural circuit of the substances in the nature: transformation of the chemically connected energy from the forage into chemically connected energy in the animal and poultry products and transformation of the chemically connected energy from fecal mass into inorganic mass (fertilizers, biogas);
- it is possible to connect in a single balanced system all technical equipment, the building and the processes with no transport operation an with no mass losses.;
- the design and management of the system can be adequate to biological status of the animals and poultry, the energetical state of the surrounding area, thus minimizing the manufacturing costs.;
- it is possible to provide a microclimate and ecological status close to those of the surrounding area.;
- the organization and the management of the technological modules can be centralized, optimizing the investment costs.

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