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Design and Technological Solution of the Livestock Facility as a Factor in the Rational Use of Land Resources

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Abstract. There has been considered the acute economic problem in the livestock industry and its generating factors. Among them, the focus is on resource saving and one of its basic components – sustainable land use at the level of livestock facilities. In the article, according to the results of the analysis of the design development of livestock facilities, there has been indicated to the irrational use of land resources or building areas of livestock farms, the area under individual production facilities. There has been given the wide variation in the indicators of land plot utilization within the framework of design and technological solutions developed and recommended for use for cattle farms and individual facilities. There has been revealed a set of estimate indicators for substantiating the effectiveness of the developed design and technological solutions regarding the area under the livestock facility, the choice of building structures and the mechanized technology of the cattle maintenance. There has been proposed a design and technological solution of the livestock farm for 50 dairy cows and the production area for the animals according to the technological scheme – a full herd turnover.

1. Introduction

The basic task of the animal husbandry as one of the branches of agriculture is the production of high-quality raw materials (milk, meat, etc.) in sufficient quantities to saturate the country's market with food products affordable in price and quality.

As the analysis shows, for the given period of time, the production of livestock products does not meet the requirements in terms of the number of products produced, competitiveness with respect to foreign producers and mainly the price component for the population of our country. Therefore, it is necessary to search and implement new efficient technological solutions provided by resource-saving systems and means of mechanization of production processes [1, 2].

At the same time, an important factor for the cattle facilities is the development and implementation of rational design and technological solutions that take into account the effective link between the introduced production technology, the direction of mechanization of technological processes, modern developments in the field of construction of buildings and structures for agricultural purposes and land plot (resource) for the construction of a farm, an individual building and facility. The introduction of new resource-saving and environmentally friendly technologies at cattle-breeding facilities, technologically based mechanized lines, separate machines and equipment of domestic and foreign production requires the development of new technological and space-planning solutions, both



cattle farms and individual industrial buildings and structures, at the level of new construction, with the reconstruction of existing facilities [3, 4, 5, 6].

2. Results and discussion

Our analysis of the production activity of the livestock industry according to the dynamics of the number of cattle livestock (Figure 1) shows that a clear increase in the number of livestock as one of the main indicators of productive development hasn't been observed. At the same time, there has been established a tendency to increase the cost of products manufactured, which reduces the accessibility of a part of the population, especially disadvantaged social groups, to such necessary products as milk and meat. Therefore, it is necessary to search for new technical and technological and design solutions that will increase the production efficiency at cattle farms. We believe that one of the ways to increase production efficiency can be the development of space-planning technical and technological solutions that ensure the rational use of room for one animal relative to the working facility and the farm as a whole and as well as the land resource of the livestock facility.

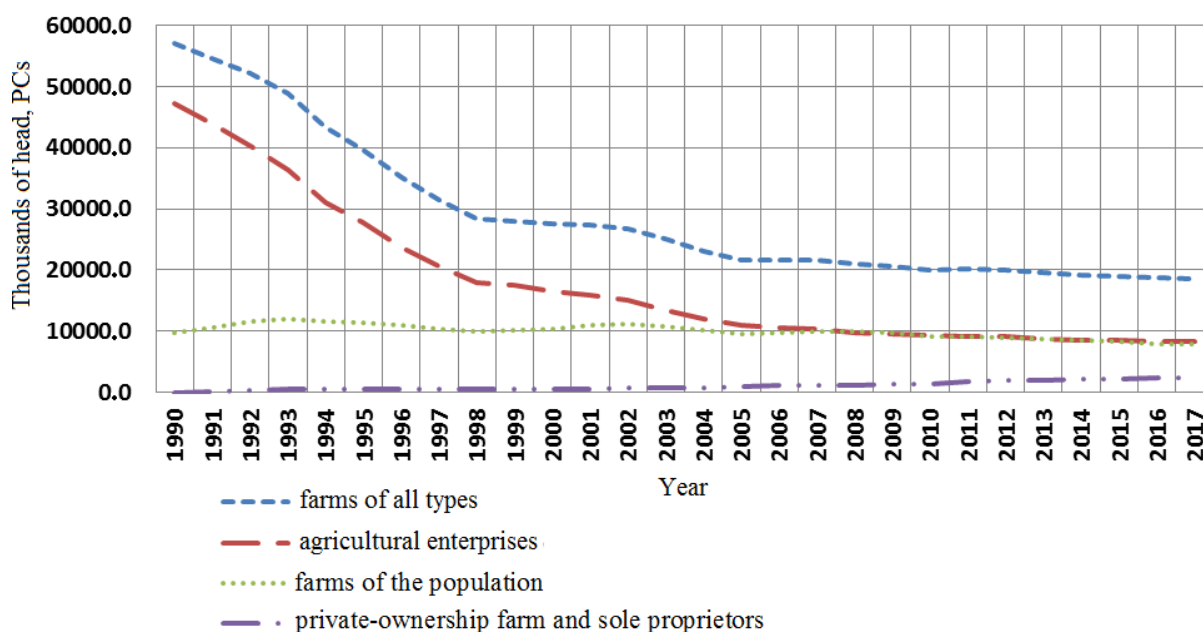


Figure 1. Dynamics of change in the number of cattle

As a result of the structural analysis of the design solutions for livestock farms in relation to peasant and individual farms, we found that when using such economic indicators as land-to-building ratio (R_b) and land plot ratio (R_p) there has been observed a significant variation in the values: 0.02...0.47 according to the land-to-building ratio, 0.3...0.58 according to the land plot ratio [7, 8, 9, 10].

Research has also found that, while observing sanitary requirements for the design solution of a farm plot, technological requirements for the layout of buildings and structures and for the features within the farm, production processes are not always used rationally. In this matter, it should be noted that in the development and implementation of design solutions for a farm plan, the factor of technological blocking of individual buildings and structures is not sufficiently taken into account, bearing in mind modern developments in individual technological processes (for example, processing and storage technologies for coarse and succulent fodder as bales, rolls, special sleeves and containers). The study of this issue carried out shows that the logically built blocking of auxiliary buildings and structures with basic production buildings makes it possible to increase the efficiency of using a farm plot, reduce the length of intra-farm traffic roads and as a result, provide resource-saving for capital costs. In accordance with the results of research, we have developed and proposed to use a

planning solution for a cattle farm using the method of blocking individual production facilities Figure 2.

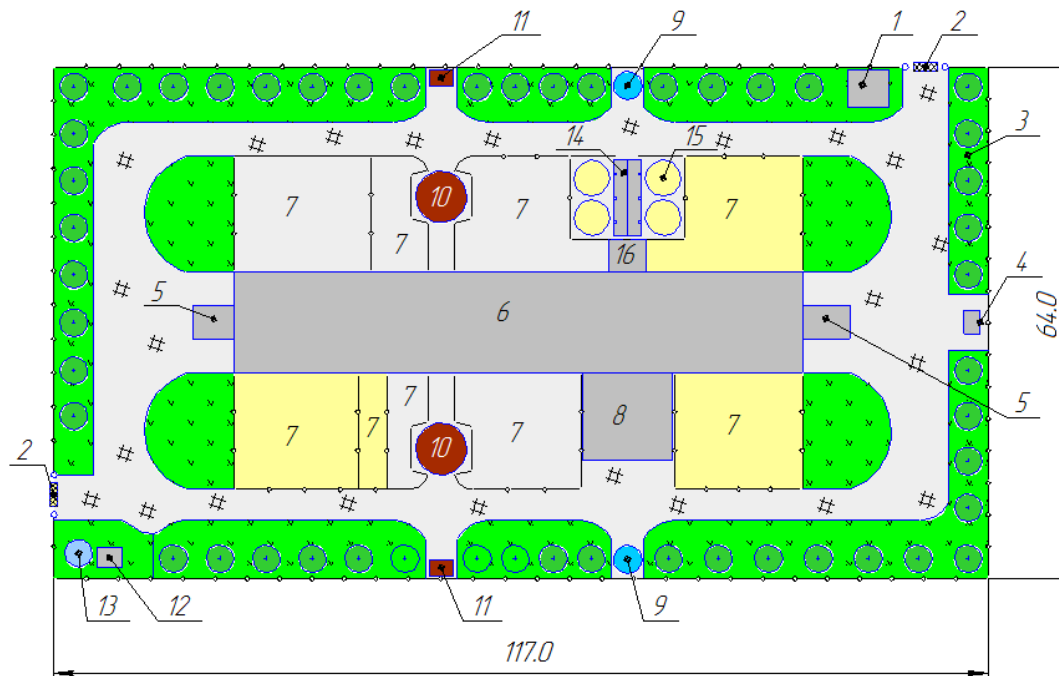


Figure 2. Technological planning solution for a cattle farm:

1 – sanitary inspection room; 2 – disinfectant barrier; 3 – landscape gardening; 4 – transformer substation; 5 – root crops storage facility; 6 – cowshed for 50 dairy cows; 7 – paddocks; 8 – workshop for primary milk processing and production of dairy products; 9 – firefighting tank ($V = 25...50 \text{ m}^3$); 10 – temporary storage plots for manure; 11 – liquid manure collectors ($V = 20 \text{ m}^3$); 12 – pumping station; 13 – water tower; 14 – platform for temporary storage of grain; 15 – grain storage tanks

The proposed design and technological development of the farm includes a resource-saving factor in the process of livestock production. It is implemented at the expense of blocking premises and facilities for various technological purposes (stocking and storage of forage; refinement of cereals; primary processing and storage of dairy products), due to the adopted internal planning solutions of the production building (cowshed) and, accordingly, due to rational use of the land plot for the farm. Production building for the maintenance of cattle and the production of final output) directly affects resource-saving. In this case, the range of resource-savings may include: capital costs for the construction and use of technological equipment; maintenance charges for the number of employees and remuneration of their labour; maintenance charges for heat supply, energy and water supply of a technological object (cowshed) [1, 8]

When developing a design and technological solution for a production facility for placing animals with a full herd turnover, we have analyzed well-known planning solutions at the level of design developments and design solutions used in production.

After analyzing the norms of technological design and research of a number of design solutions for production buildings for cattle keeping, we have discovered that the data variability at the floor area utilization rate by animals (R_{au}) is quite wide with relatively identical animal keeping technologies Figure 3 [11]. This suggests that an equal size of livestock building may accommodate more animals and therefore provide more livestock products (in our case, milk).

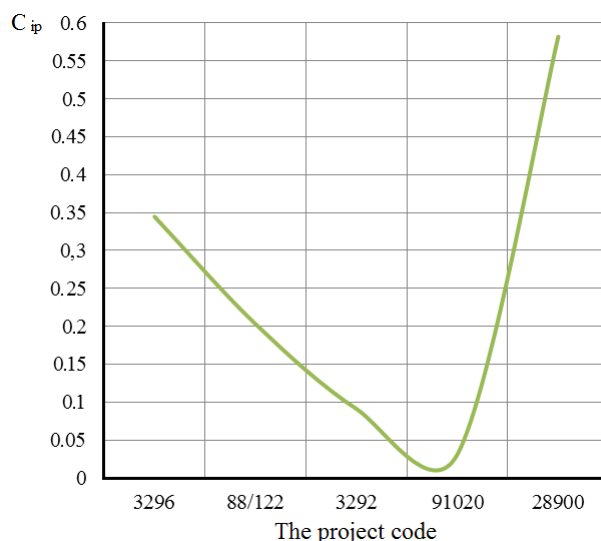


Figure 3. Graph of Rau change at options for technological design solutions:

3296 – private-ownership farm “Village of Mikhailovka” (project of the developer company: Institute “Volgovyatagropromproject”); 88/122 – Farm for 50 animals with a complete herd turnover at the Pobeda state farm in the Ustra district of the Novosibirsk region (project of the developer company: Institute «Zapsibniapiagroprom»); 3292 – a farm for 50 cows growing young stock to produce of milk, sour cream, Adygeisky cheese (project of the developer company: (Institute «Sevkavniapiargoprom»); 91020 – mini-farm for 50 animals of all age groups (project of the developer company: Institute «Sakhalinagropromproject»); 28900 – a farm for the production of milk using the experience of the Netherlands (project of the developer company: AP Institute «Mosgiproniiselstroy»)

This allows us to conclude that the effectiveness of the selected technological space-planning solutions should be based on certain evaluation criteria. We propose the following composition of evaluation criteria of: 1. Use of the stabling area of a production building – C_s ; 2. The use of technical and technological area of the building – C_{lt} ; 3. Use of organizational serving area (passages) – C_{sa} ; 4. Densities of animal accommodation – $C_{a.a}$; 5. Construction and technological blocking – C_{ctb} ; 6. The use of spaced area space – C_{vs} ; 7. Compactness of the planning solution – C_{pd} ; 8. The cost of a single room for an animal – C_{ra} .

When making calculations, each of the criteria for optimizing the technological space-planning solution should tend to the maximum or to the minimum.

The following data are recommended for calculating the assessment criteria: the area occupied by one animal; total area occupied by animals; area occupied by technological equipment; regulatory area under the aisles; the capacity of the building structure replaced by a technological element; dimensional parameters of the building; cost data of a building.

To determine the maximum capacity of the building (its individual parts), we propose the following basic calculation formula

$$N_{bl} = n_{tl} \times l_{tl} : b_r, \text{ head}, \quad (1)$$

where N_{bl} – the number of head of cattle accommodated in a building or in a separate part of the building

n_{tl} – the number of technological lines for accommodating animals in stalls or in boxes ($n_{tl} = B_{in} : b_{te}$); B_{in} – the internal width of the livestock building (cowshed); b_{te} – the total width of the technological elements of the cowshed (technological passages; feed ing lines (feeders); manure channels; l_{tl} – the length of the technological line for accommodating animals ($l_{tl} = L_{BH} - l_{T3}$); L_{in} – internal length of the cowshed; l_{te} – the total length of technological elements along the length of the building; b_r – the width of a stall or a box.

In order to save resources and increase the efficiency of livestock production, we propose a technical and technological and planning solution (Figure 3) for the cowshed with a full herd turnover, providing for the blocking of separate building and technological elements and two-level usage of internal space of the cowshed Figure 4.

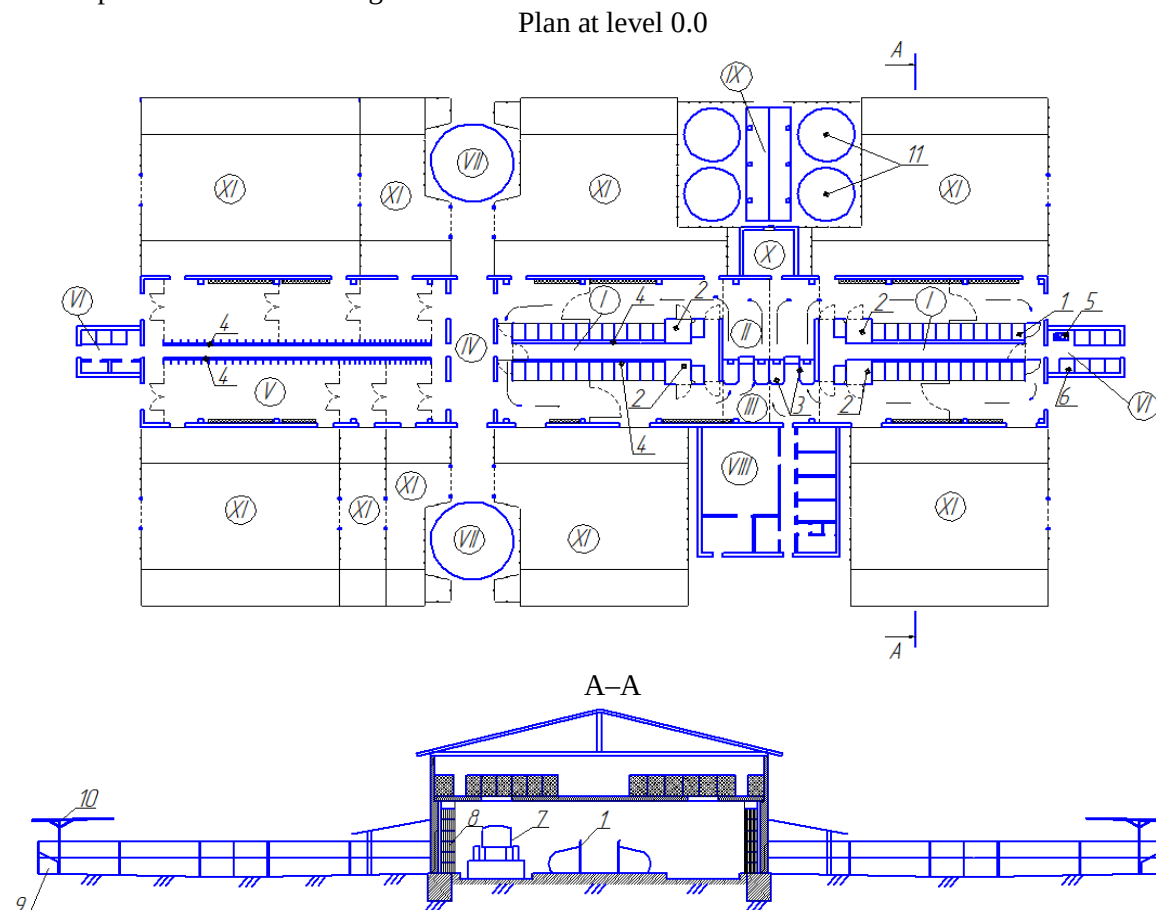


Figure 4. Technological space-planning solution of the cowshed:

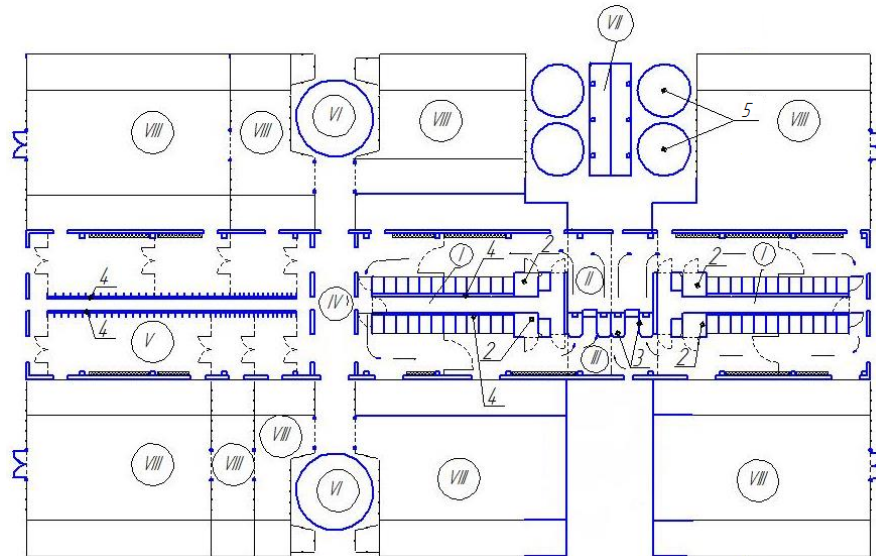
I – cowshed; II – milking parlor; III – milking pen; IV – manure lateral; V – calf shed;
 VI – root crops storage facility; VII – manure storage area; VIII – block for storage and processing of milk; IX – grain feed storage area; X – unit for the production of concentrated feed; XI – paddocks;
 1 – boxing equipment; 2 – machine for down-calving cows and fresh cows; 3 – milking machine UDS;
 4 – feed line; 5 – shredder of root crops; 6 – containers for root crops; 7 – a mobile device for removing manure; 8 – self-feeders for coarse fodder; 9 – feeding troughs for paddocks; 10 – canopy over the feed line; 11 – silage for storing forage

The proposed design and technological solution of the cowshed can reduce the total capital costs of the construction of the cowshed, while observing the basic zootechnical and technological requirements for the maintenance and implementation of technological processes of animal service. However, the adopted layout of the unit for the production of concentrated feed and storage and primary processing of milk as separate premises adjacent to the cowshed, the lack of separate premises for storing inventory and litter, premises for repairing technological equipment, rest of the auxiliary service personnel requires additional study of the design and technological solution for the cowshed.

In order to increase the efficiency of livestock production due to resource-saving, we propose a design and technological solution for the cowshed that provides an increase in the importance of the criterion for the use of the internal spaced area of the cowshed (C_{ic}). The design and technological solution of the cowshed according to the second variant is shown in Figure 5 [10].

According to this design and technological solution, the processes of production of mixed fodders, storage and primary processing of milk, storage of feed, litter and inventory, as well as the room for support personnel are transferred to the attic spaced area. This allows not only efficient use of the total internal spaced area of the cowshed (with the same dimensional parameters of the cowshed in terms of increasing its capacity), but also the area adjacent to the cowshed premises.

Plan at level 0.0



Plan at level 2.7... 3.0

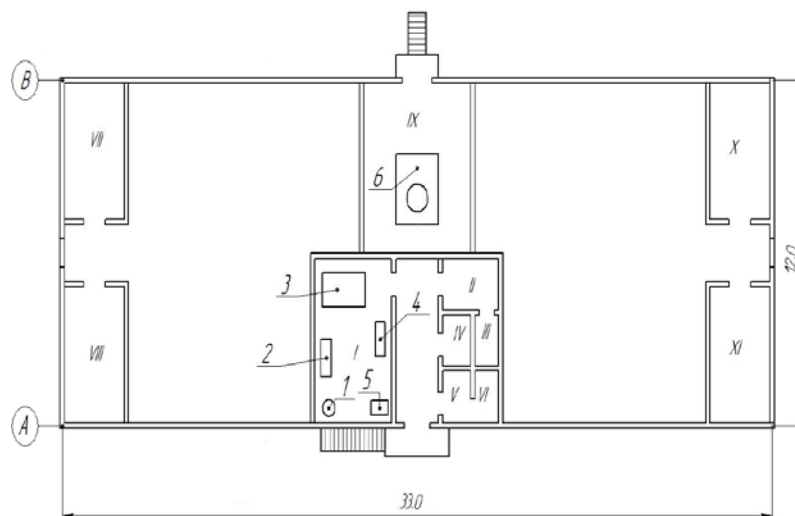


Figure 5. Design and planning solution of the cowshed:

plan at Level of 0.0: I – cowshed; II – milking unit; III – milking pen; IV – manure lateral; V – calf shed; VII – manure storage area; IX – storage area for grain feed; XI – paddocks; 1 – boxing equipment; 2 – machine for down-calving cows and fresh cows; 3 – milking machine UDS; 4 – feed line; 5 – silage for storing forage;

plan at Level of 2.7 ... 3.0: I – milking unit; II – staff room; III – bathroom unit; IV – thermal unit; V – switchboard premises; VI – vacuum pump; VII – room for inventory (calves, young animals); VIII – litter storage premises; IX – feed preparation room; X – room for inventory (cowshed); XI – room for litter (down-calving cows, fresh cows); 1 – VEP electric water heater; 2 – office desk; 3 – milk cooler tank; 4 – installation for washing milk utensils; 5 – spare parts cabinet

3. Conclusions

1. Technologically justified blocking of production, auxiliary and warehouse premises, structures, and technological platforms allow reducing the length of transport roads inside the farm, its building area and total area, and rational use of the land resource.

2. The transfer of the working stock of feed to the area of technological and construction elements of an industrial building (paddocks; operated roofs; building envelop of the building) using a feed bank with self-feeders reduces the inefficient use of land resources for the farm, the cost of capital construction costs

3. The transfer of separate auxiliary premises, a milking unit and a unit for preparing grain feeds for feeding into the operated roof area of the production building allows increasing the efficiency of using the land plot adjacent to the production building and reducing the capital costs of its construction.

4. The proposed design technological solution of the cowshed allows, with equal dimensions, to increase the floor area utilization rate by animals and its capacity.

5. When choosing technical and technological planning solutions, it is necessary to take into account evaluation criteria, and as basic ones: criteria for the use of a farm plot and the floor area of a livestock building.

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