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Liner motor drive of cattle farm feeders

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Liner motor drive of cattle farm feeders

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Abstract. This article discusses feed distribution control using a linear electric drive for small cattle farms. Electrification feeders are difficult complex units which in addition to the dispenser, they are equipped with working bodies that perform various technological functions. Given the above, we can conclude that this type of farm use a lot electro energy to low this effect we need use automation systems to electro mechanic units. In this article given results of experimental work in using of liner motor drives in cattle farms and mathematic explanation of electro safety according to proposed technology.

1. Introduction

1.1. The state of development of livestock

Currently, livestock products are mainly produced by farms, the private sector and partially medium and large specialized farms and complexes. The number of livestock farms in the country is increasing annually. In some areas, the share of farmers' products reaches 40-50% of the gross agricultural output. In some areas, the share of farmers' products reaches 40-50% of the gross agricultural output. One of the main lack of electromechanization and automation of labor-intensive production processes in feed plants and farms. This is due to the lack of appropriate technology machines and equipment. They are produced by the CIS countries for livestock farms, designed mainly for large complexes or industrial farms with a large livestock and main value of production and therefore, the use of this high-performance, metal-intensive and energy-intensive equipment for small farms is unprofitable or simply impossible [1-5].

The main technological processes in animal husbandry are the harvesting, storage and transportation of feed to the farm, their preparation (washing, processing and mixing), transportation of all types of cargo on the territory of the livestock farm, distribution of all types of feed and their mixtures, cleaning, loading and transportation of manure. The complexity of these processes is up to 70% of the total labor costs of caring for animals. Therefore, to ensure the further growth of livestock breeding, the continuous improvement of electro mechanization and automation of production processes is of great importance and effective use of new technologies [2-5].

1.2. Technological schemes of feed distribution

The solution to problems for small farms is the development of integrated technology, both in keeping animals and in the storage and preparation of feed. Here on Fig.1 given one of the technological schemes for the maintenance and fattening of young cattle for small farms. It can be seen from the diagram that along with keeping animals, work is underway on the preparation, storage and distribution of feed, cleaning and storage of manure [6].

In animal husbandry, platform feed distributors are one of the most promising and used regardless of technology and design [9, 10].

The platform-based feed distributor with linear electric drive, developed on the basis of research, refers to the distributors inside the feeder with the free keeping of young cattle in boxes (group machines). Technical characteristics of the platform feed dispenser are given in Table 1. A more detailed description of the proposed feed distribution technology, the design of the platform feed dispenser and its technical and economic indicators are given in [11].

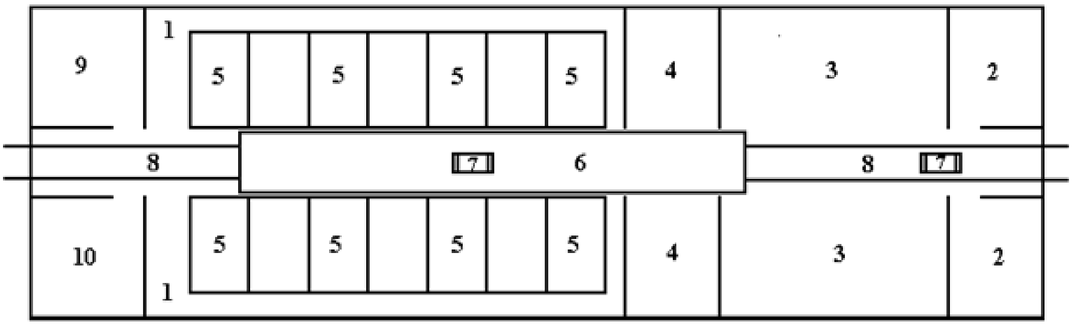

Figure 1. Content and Feeding Technology for little cattle farms: 1 – livestock room; 2 – feed storage; 3 – compound feed plant; 4 – storage of prepared feed; 5 – boxes for cattle; 6 – feeder platform; 7 – electro motor; 8 – directory of feeding platform ; 9 – inventory; 10 – manure storage

Electrification feeder is complex and which, in addition to the dispensing device, are equipped with working bodies that perform various technological functions.

For consistency in the work of the working bodies, use appropriate control systems for linear asynchronous electric drives.

Such drives allow integration with the working body with the exception of mechanical converters (Figure 2), as a result, material costs and energy consumption are reduced, and the reliability of agricultural machines as a whole is increased [2-9].

Thus, the feed distributor consists of a feed distribution platform, with the possibility of translational movement on rollers among the direction. The bottom of the feeding platform is made of ferromagnetic material with a thickness of 1.5 ... 2.5 mm, which simultaneously performs the functions of a secondary element of a linear asynchronous motor, which defines the forward movement of the feeding platform.

Table 1. Technological characteristic of feed distribution platform

Name and units of measure	Numerical value
2	3
Model project 819-215 , м	22 x 84
The number of cattle	6...10
Feeder capacity, cube/m	60
The total length of the system, m	170
The length of the front of feeding, m	80
Width of the feeder, m	1.2
Feed weight, kg/m	12...60
Feeding speed, m/s	0.5...1.0

Work is underway to develop a linear asynchronous electric drive for various technological equipment such as platform feeders, vibration mixers, a high-voltage switch, shutters of hydraulic structures, actuators for precise positioning [2-4, 6, 7].

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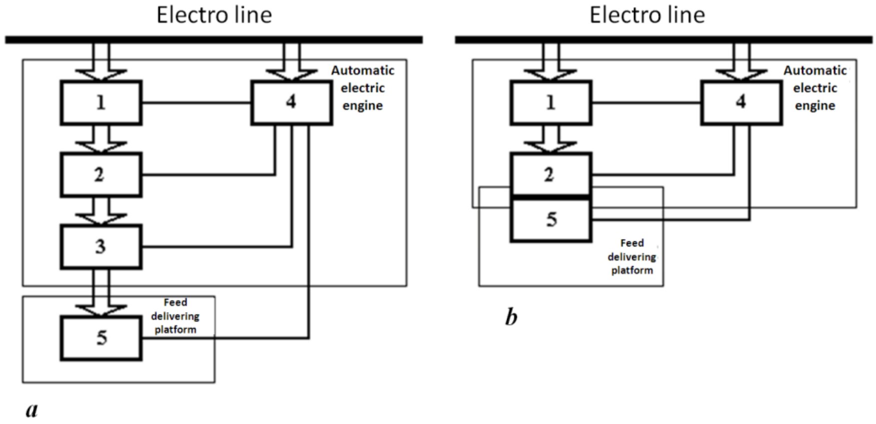

Figure 2. Tradition structure scheme asynchrony electro engine (*a*) and liner asynchrony electro engine (*b*): Automatic electrical engine (AEE): FDP – feed delivering platform; 1 - converter device; 2 - электродвигательное устройство; 3 – transmission device; 4 - control device; 5 - feeding platform

2. Methods

In [10-14] given the mathematical model of an induction motor with an open magnetic circuit and realization in program to AEE given in [11], allows you to determine the distribution of instantaneous electromagnetic parameters (current, magnetic induction, flux, etc.) along the grooves of the inductance of the magnetic circuit, taking into account the discreteness of the structure of various winding circuits. In addition, the parameters and indicators of the power source are taken into account.

Electromagnetic processes in the engine are described by the following equations in matrix form

$$\left.\begin{array}{c} A \cdot I_o = 0 \ ; \\ C \cdot U_o = C \cdot E_i \ ; \\ U_o = Z_o \cdot I_o + j\omega \cdot w \cdot G_o^T \cdot F \ ; \\ R_{„} \cdot F = w \cdot G_{„} \cdot I_{„} + I_{\_} \ ; \\ Z_c \cdot I_c = -V_c \cdot F \ . \end{array}\right\} \quad (1)$$

The matrices *A* and *C* in the system of equations (1) are determined by the unit and some *F* submatrices [8, 10] and are related by this equivalence

$$C = (F, 1), \qquad A = (1, F^{-T}) \quad (2)$$

This relation holds for any scheme if the rules for compiling equations based on Kirchhoff's laws are satisfied.

In [8, 10, 14], a structural matrix of the inductor winding is proposed, which characterizes the distribution of the winding sections in grooves:

$$I_p = w \cdot G \cdot I_f , \quad (3)$$

where I_p - vector of grooved current;
w - number of turns per section;
I_f - vector of currents of the branches of the winding, laid in the grooves of the inductor;
G - inductor winding structural matrix.

However, in addition to the branches formed by sections laid in the grooves of the inductor, the winding may contain additional switching branches, non-forming magnetomotive force Therefore, we introduce a modernized structural matrix of the inductor winding G_o

$$I_p = w \cdot G_o \cdot I_o , \quad (4)$$

where I_o - vector of currents of all branches of the winding.

In matrix $G_o = (G1, G2)$ submatrices have dimensions $N_z \times (q - 1)$ and $N_z \times p - (q - 1)$, where N_z - the number of grooves of the inductor of the engine.

After a series of transformations [10] control system (1) takes following form

$$\left.\begin{aligned} \mathrm{F}\cdot\mathrm{E1}+\mathrm{E2} &= \mathrm{Z}_{\text{тм}}\cdot\mathrm{I2}+\mathrm{j}\omega\cdot w\cdot\mathrm{K}_{\bullet\mathrm{p}}\cdot\mathrm{F}\,; \\ \mathrm{R}_{«}\cdot\mathrm{F} &= \mathrm{I}_{\_}+w\cdot\mathrm{K}_{\bullet\mathrm{p}}\cdot\mathrm{I2}\,; \\ \mathrm{Z}_{\_}\cdot\mathrm{I}_{\_} &= -\mathrm{V}_{\_}\cdot\mathrm{F}\,. \end{aligned}\right\} \tag{5}$$

where $\mathrm{Z}_{\text{тм}}=\mathrm{F}\cdot\mathrm{Z1}\cdot\mathrm{F}^{\mathrm{T}}+\mathrm{Z2}$; $\mathrm{K}_{\text{Њ}}=\mathrm{F}\cdot(\mathrm{G1})^{\mathrm{T}}\cdot(\mathrm{G2})^{\mathrm{T}}$; $\mathrm{K}_{\bullet\mathrm{p}}=\mathrm{G1}\cdot\mathrm{F}^{\mathrm{T}}+\mathrm{G2}$, and $K_e=(K_p)^T$.

To build winding matrices using the developed programs [11], it is necessary to specify the following initial data - the number of branches (chain sections from node to node) and circuit nodes, a table of numbers of grooves G_o, in which each branch is laid, and table F. Table of groove numbers G_o formed in accordance with [8] and the rules adopted in the design practice of electrical engineering [10-14].

LAE relate to special electric machines, their development and production is carried out in relatively small series. Therefore, instead of generalized indicators, it is more convenient to apply particular optimality criteria that reflect only the most characteristic requirements for a linear electric drive, for example: product efficiency power factor, the ratio of engine power to the area of the active surface (specific power), the ratio of power to the mass of the engine (or inductor), or similar «power-power» indicators, specific force, «power-mass», etc.

Specific Tractive Force

$$F_{c.}=\frac{1.58}{\mu_o\tau}B_\delta^2k_\mu\delta_э\varepsilon\cos^2\psi_2k_F\ . \tag{6}$$

The ratio of traction to the mass of active materials

$$F_G=\frac{F_{2\tau}k_F}{2\tau\left[k_{12}h_nk_{з.м}g_м\left(2b+k_{лоб}\tau\right)+2bg_c\left(h_a+h_n\left(1-k_{12}\right)\right)\right]} \tag{7}$$

EMF coefficient:

$$k_{\mathrm{E}}=\frac{1}{\cos\psi_2}\sqrt{\frac{1+\left(\varepsilon+tg\psi_2\right)^2}{\left[1+tg^2\psi_2+\varepsilon tg\psi_2+x_{1*}\right]^2+\left[\varepsilon+r_{1*}\left(\varepsilon+tg\psi_2\right)^2+r_{1*}\right]^2}} \tag{8}$$

Energetic factor

$$\eta\cos\varphi=\frac{k_{\mathrm{E}}\varepsilon\cos\psi_2\left(1-s\right)k_\eta}{\sqrt{1+\left(\varepsilon+tg\psi_2\right)^2}} \tag{9}$$

Calculation of the winding data of the inductor frets is made by known methods [8, 10]. At the end of preliminary calculations, refinement of the characteristics and indicators of linear induction motors **(**LIM), and in some cases the correction of some of their parameters can be carried out using more complex mathematical models, allowing taking into account both the design features of LIM and the features of their operation modes.

3. Results and Discussions

In order to increase the energy and traction performance of linear induction motors (LIM), to confirm the correctness of the mathematical model and theoretical studies and to determine the technical indicators of linear asynchronous electric drives of technological equipment, experiments were conducted on physical models (on arc, cylindrical and flat linear induction motors with various schemes for connecting the inductor windings, designs of the secondary element and modes). The characteristics of idling, short circuit, working, mechanical, distribution of magnetic indicators in the yoke, teeth and air gap along the length of the LIM inductor was taken. Based on the results of numerical and physical experiments, one can judge about a sufficient coincidence, which is given in [8, 10].

The mathematical apparatus makes it possible to study the magneto-motive force of complex windings - when solving, the vector of the slot currents is calculated, knowing which it is easy to calculate the spatial distribution of the magneto-motive force. And the more perfect the algorithm for the automatic formation of winding matrices, the more effective the application of the proposed apparatus.

In Figure 3-6 are the dependencies *F, I, η, cosφ = f(s)* at various values of the number of turns in the coil of the winding of the inductor IDRM with a ferromagnetic shielded secondary element *(d_2 = 1 мм; δ = 1 мм).*

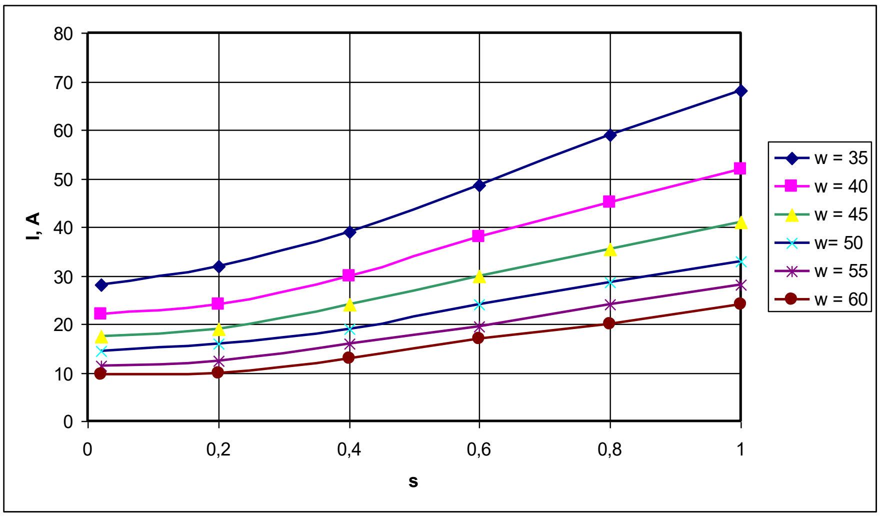

Figure 3. Dependence I = f (s) for various values of the number of turns in the coil

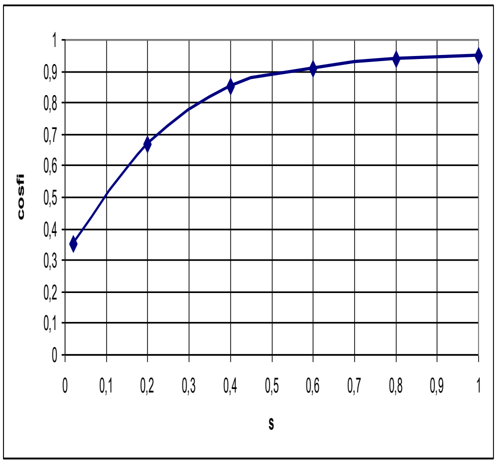

Figure 4. Dependence *cosφ = f(s)*

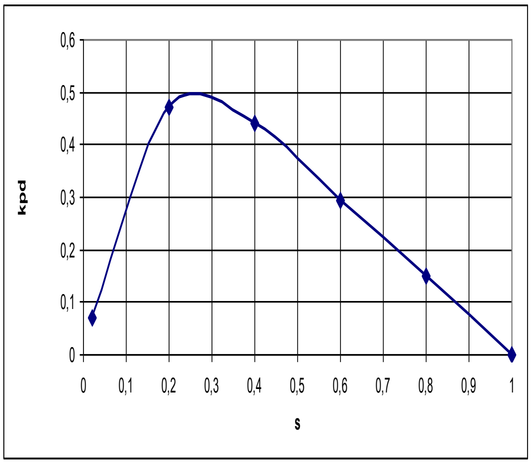

Figure 5. Dependence *η = f(s)*

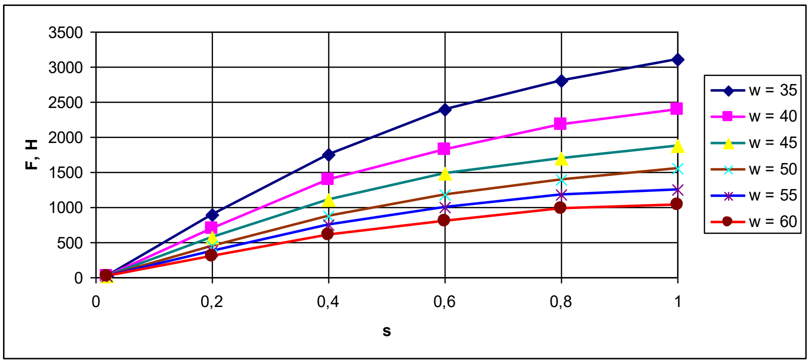

Figure 6. Traction characteristic of LAD at various values of the number turns of the stator winding

A decrease in the number of turns in the coil leads to an increase in current (Fig. 3). according to the calculated curves η, $cos\varphi = f(s)$ with a change in the number of turns of the coil, they are very slightly different from each other; therefore, in Fig. 4 and Fig. 5 they are shown by the same curve for all values of the number of turns in the coil.

Based on the analysis of the curves (Figure 6), it can be seen that the traction force of the engine, with constant structural dimensions, depends on the number of turns in the coil. a decrease in the number of turns increases the traction force of the LAD. The increase in the average phase current and traction with decreasing number of turns in the coil is explained by the fact that the wire cross section increases with constant values of geometric dimensions and the fill factor of the inductor groove with copper and a slight change in the current density.

When designing, it is necessary to take into account the operating mode and engine starting conditions in the drive mechanisms. As can be seen from Fig. 6, to drive mechanisms with high starting pulling force with a short-term mode of operation, it is more efficient to use LAD with a small number of turns and a large cross section of the wire of the inductor winding coil. However, with frequent switching on of such mechanisms, it is necessary to have an engine supply for heating.

4. Conclusions

1. To provide the population with livestock products, it is necessary to develop farms, medium and large specialized farms and complexes.
2. It is necessary to conduct research in order to create standard projects for unified livestock complexes in conjunction with feed shops and the corresponding sets of mini-technological equipment.
3. A platform feed distributor for fattening young cattle on an industrial basis is one of the most rational distributors;
4. Based on the analysis of the drive characteristics of technological equipment, to improve and develop energy-saving combined electrical systems without mechanical converters based on linear asynchronous electric motors.
5. A mathematical model based on a numerical method for calculating the electromagnetic processes of a linear induction motor based on detailed equivalent circuits of electric and magnetic circuits allows us to correctly study their characteristics.
6. The use of a linear induction motor eliminates transmission mechanical devices in the electric drive of the platform feed distributor, which allows to simplify the design, reduce energy consumption, and improve the performance of the electric drive as a whole.

References

[1] Matchonov RD, Usmanov AS 2002 Infobook: Agricultural machines, Yangi asr avlodi, Tashkent.
[2] Potapov GP, Voloshin NE 1987 Transporters in animal husbandry, Agropromizdat, Moscow.
[3] Degterev GP 1986 Handbook of machinery and equipment for livestock, Agropromizdat, Moscow.
[4] Yunusov RF 1988 Electric drive of agricultural machines, South Ural State Agrarian University, Chelyabnsk.
[5] Sirozhiddinov AS, Makhamataliev AM, Yunusov RF 2001 Small machinery for agricultural production, TSAU, Tashkent, pp 236-237.
[6] Pyastolov AA 1987 Electric drive based on engines with an open magnetic circuit for machines of the Agro-industrial complex, South Ural State Agrarian University, Chelyabnsk.
[7] Yunusov RF 2000 Patent RUz № IDP 04319, МПК[6] A01K5/02. Platform feed dispenser, BI №3.
[8] Yunusov RF 1998 Mathematical model of a linear induction motor, Aspects of mathematical modeling in agroingeenering, TIIAME, Tashkent, pp 187-195.
[9] Yunusov RF 2003 Linear electric drive for agricultural machines, Materials of international scientific and practical, KNAU-NPTSMSH, Almaty, pp 99-102.
[10] Veselovsky ON, Konyaev AYu, Sarapulov FN 1991 Linear induction motors, Energoatomizdat, Moscow.
[11] Kopylov IP 1980 Design of Electrical Machines, Energy, Moscow.

[12] Vilnitis AYa, Drits MS 1981 End effect in linear induction motors: Tasks and methods of solution, Zinatne, Riga.
[13] Yamamura S 1983 Theory of linear induction motors: Translated from English, Energoatomizdat, Leningrad.
[14] Voldek AI 1970 Induction magnetohydrodynamic machines with a liquid metal working body, Energy, Leningrad.