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Linear induction motors for non-ferrous metallurgy

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Application of linear induction motors (LIM) on enterprises of non-ferrous metallurgy involves accomplishing specific engineering and economic tasks of building a power unit of electric drive, engineering, modeling, designing, as well as technical and economic assessing of electric drive indicators. The paper presents an overview and analytical information on these issues, which allows industry specialists to perform a feasibility study of LIM usage. The prospects of LIM application in electric drives of processing and auxiliary equipment of non-ferrous metallurgy sub-sectors are justified and respective examples are given. The designing tasks of layout synthesis and calculation of the output characteristics with corresponding modeling aids are classified. It is established that there are no methods and means of solving both problems currently prevalent and accepted by professional community. Low operating rate of an electric drive and edge effects reduce energy data of LIM. At the same time, electric drives based on LIM or rotary motion electric motors are competitive variants of a linear electric drive. A mathematical model for layout synthesis of LIM is suggested. The model includes the means of forecasting estimation of electromagnetic, technical, weight-size and dynamic parameters of the object. On this basis, the main magnetic field of LIM was calculated. The LIM service life model calculation is implemented, what has allowed to evaluate cost-effectiveness of LIM application. It is established that in certain situations the use of a linear electric drive with LIM is advisable and cost-effective. The question of expediency of LIM usage in each concrete case should be settled based on a feasibility study.

Key words: non-ferrous metallurgy, linear electric drive, technical and economic assessment, linear induction motor, layout synthesis, mathematical model, economic evaluation.

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Introduction

Enterprises of non-ferrous metallurgy are characterized by a high level of mechanization of industrial processes. In the absolute majority of cases, its basis is formed by various electric drives of machine tools of processing and auxiliary equipment. These are electric drives of the main and auxiliary processing equipment, such as converters, roasting kilns, casting machines, feeders, mixers, agitators, stripper machines and other units. Besides, in non-ferrous metallurgy there also operates electric drives of auxiliary production equipment, such as handling machinery, pumps, compressors, air blowers. The electrical equipment of concentrating mills should also be noted, in particular, jaw crushers, ball and rod mills, classifiers, concentrators, vacuum filters.

The above mentioned and other electric drives differ in their purpose, power and degree of involvement into the main engineering process, but almost all of them are based on the rotary motion induction motors (IM). This assumes a material-intensive and relatively unreliable two- or three-link kinematic diagram of the power part of the drive: IM; reduction gear– for electric drives of rotary motion or IM; reduction gear, movement type converter — for linear electric drives. Another design modification of an induction motor is less known. Namely, this is a linear induction motor (LIM), which makes it possible to implement a single-link and reliable drive with low material capacity.

LIMs are usually associated with traction electric drives of high-speed land transport (HSLT). At the same time, a promising area for LIM implementation is formed by low-speed electric drives of non-ferrous metallurgy, the working bodies of which perform linear movements at a speed of 1–3 m/s or rotary movements with a frequency of 0.1–0.3 s^{-1}.

Electric drives with LIM are characterized by:

– kinematic simplicity and reliability;

– high operation life;

– low material capacity;

– the possibility of implementing complex motion paths of machine working bodies, for example, a spiral classifier, by means of a modular construction of an electric drive;

– the possibility of non-contact impact on working bodies of an electric drive.

In essence, the implementation of mechanical motion by means of LIM is an innovative technology that combines in a single device the functions of electromechanical energy conversion, movement rate reduction and movement type transformation. At that, energy efficiency of LIMs is at a level of indicators of classical electric drives with IM, what makes them competitive technologies for solving a transport problem.

Manufacturing application and operation of an electric drive based on LIM is associated with the solution of a number of specific engineering and economic tasks. Features of the linear electric drive concerning the specificity of electromagnetic processes, engineering, designing, production and control are the aggregate reason that LIM realizes its competitive advantages provided that it is developed for a specific working machine. Sometimes, short-run linear traction modules for working machines of the same type are developed and offered for implementing the stereotyped operations. However, the linear electric drive is, as a rule, individually developed and produced by a specialized organization by request of the operating enterprise. At the same time, specialists of the operating enterprise should be acquainted with the subject area in sufficient detail for technical and economic assessment of the classical linear electric drive replacement by the drive with LIM. In particular, it includes the questions of constructing the power part of electric drive, engineering, and specifics of electromagnetic processes, modeling, designing, as well as technical and economic evaluation of LIM. In preparation of this article, the authors have posed themselves the task of providing the specialists of non-ferrous metallurgy with a survey of these questions. The authors intend to go to the heart of the matter in prospective publications on the issues of LIM modeling and the study of its characteristics.

State of the theory, designing and modeling of LIM

In the field of LIM theory, works of A. I. Voldek and S. Yamamura [1—2] that contain a general theoretical description, approaches to simulation as well as studies of electromagnetic field and electromechanical characteristics of LIM still remain significant. These scientific papers have identified the LIMs into a separate class of physical and technical objects, the processes in which are qualitatively different from corresponding processes in the rotary motion induction motors. Distinctions, the combination of which was called the longitudinal edge effect, consist primarily in the distribution and nature of the movement of the main magnetic field of electric machine. It was found that LIM windings create a complex nonharmonic field that moves in the central zone of the machine and pulsates in its edge regions. At the same time, Ya. Ya. Valdmanis, D. K. Dukovich, M. Kant and A. Maulet [3—5] have justified the theoretical statement that physical and topological nature of LIM corresponds to a special nonharmonic excitation of the main magnetic field.

The specificity of electromagnetic processes and the variety of design modifications make mathematical models the primary tool for LIM designing. In this case, the following two design tasks are distinguished with appropriate modeling aids.

First, this is the task of layout synthesis, which is performed at the stage of feasibility study of LIM development. At this stage, the design modification of LIM is selected, the key engineering and design decisions are made, the main dimensions, materials, electromagnetic loads and the exciting current distribution are determined. To a first approximation, the main technical, dynamic, weight-size and economic parameters are determined. Mathematical models [6—9] for this stage have a low construction level of detail, are focused on analytical or numerical-analytical solutions, and allow wide variations in the sizes, environment characteristics and the exciting current distributions.

Second, this is the task of calculating the output characteristics, to the solution of which the final step of LIM designing corresponds. At this stage, the adjusted calculation of technical, energy and economic indicators of LIM is carried out using CAD systems based on 2-D and 3-D models of machine design and its physical fields. Models and calculation methods based on them are also used [8, 10—15].

At the same time, generalized empirical material used as the basis of designing, as well as the methods for solving both problems, existing and accepted by professional community, are currently absent.

Structure and energy efficiency of a linear electric drive

Fig. 1, *a* depicts the structure of the power unit of the classical linear electric drive based on IM, and Fig. 1, *b* represents that of a linear electric drive based on LIM.

The linear electric drive based on LIM, as noted above, structurally and functionally combines the elements of reducing and the movement type transforming in the electric motor, making the drive kinematic diagram extremely simple and functional.

The energy efficiency of the linear electric drive implementation options can be estimated according to the block diagrams of Fig. 1, *a*, *b*, taking the following averaged values of efficiency factor: η_1 = 0.9 for IM, $\eta_2 = \eta_3$ = 0.75 for reduction gear and the movement type converter with due regard for a high reduction coefficient need to ensure the electric drive working element speed of 1—3 m/s. Then according to Fig. 1, *a*, the linear electric drive efficiency value is as follows:

$$\eta = \eta_1 \cdot \eta_2 \cdot \eta_3 = 0.9 \cdot 0.75 \cdot 0.75 = 0.51,$$

that is like an efficiency level of low-speed LIMs in Fig. 1, $b - \eta_4 = (0.4 - 0.6)$.

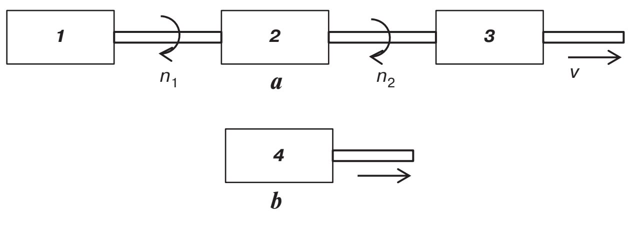

Fig. 1. The structure of a power unit of electric linear drive (*a* — based on IM, *b* — based on LIM):
1 — IM, *2* — line-dropping reducer, *3* — movement type converter of rack-and-gear or screw-gear drive, n_1 — IM shaft speed, n_2 — speed of the reducer output shaft rotation, *v* — rate of movement of the linear electric drive operating element, *4* — LIM

Thus, we can say that LIM is competitive with classical electric drive based on IM by energy efficiency, beating it in terms of functionality, kinematic simplicity, material capacity and reliability.

Embodiments of LIM

The prevalent embodiments of LIM are flat and tubular. For implementation of low-frequency rotary motion, an arc-type stator version of a linear electric motor is also used.

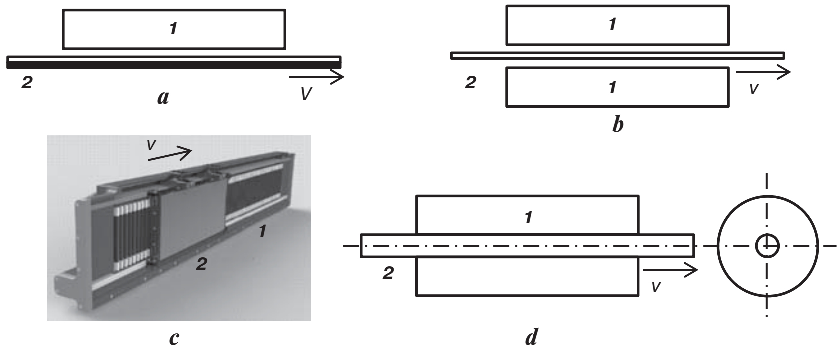

Fig. 2. Designs of LIM for in-line motion:
1 — inductor, *2* — secondary element

Fig. 2 shows structures of a LIM for in-line motion.

The LIM inductor is produced in the form of a laminated package made of electrical steel, in the grooves of which a multiphase winding is placed. Secondary element (SE) designs may differ depending on characteristics of working machine of the electric drive, such as transfer, stroke length, the nature of movement. In Fig. 2, *a, b* there are shown the unilateral and bilateral LIM designs with secondary elements that combines the layers of aluminum alloy and ferromagnetic steel (Fig. 2, *a*) and in the form of aluminum alloy (Fig. 2, *b*). Such LIM designs may be used in conveyor electric drives, lifting equipment, machines, intrashop and storage transport. Fig. 2, *c* illustrates LIM design with a short SE in the form of a carriage. Such constructions may be applied when implementing run transfers of up to 1 m of electric machine feed drive and vibratory motion of electric drives of rake classifiers, screening and washing machines, as well as for a positional hold of operating components of the electric drive. Fig. 2, *c*, cited according to [16], depicts the LIM, designed to move and hold the doors of processing chambers. Fig. 2, *d* shows a tubular LIM designed for SE movements by a value of 0.1–0.3 m order. In comparison with flat constructions, the tubular LIMs feature more intense thermal conditions, and therefore they are operated in short-time and intermittent duty of electric drives of contact equipment, pipeline flaps, track switches.

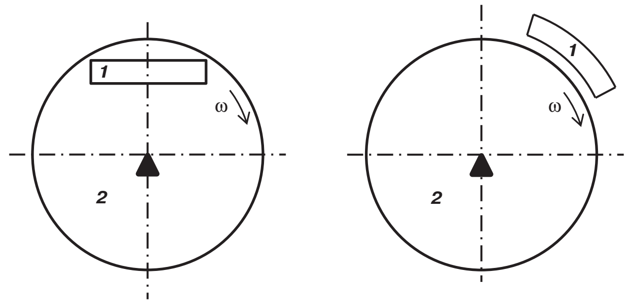

Fig. 3. Designs of low-frequency rotary motion electric motors:
1 — inductor, *2* — secondary element

Fig. 3 demonstrates the designs of low-frequency rotary motion electric motors with a flat linear inductor (Fig. 3, *a*) and with an arc-type stator inductor (Fig. 3, *b*). The electric motor secondary element for both constructions is a disk made of aluminum alloy or in the form of a lamellar structure made of aluminum and ferromagnetic steel.

Such embodiments are promising for electric drives of conveyors, screens, tippers of mine bogies, mills and lifting equipment. In metallurgy, the design according to Fig. 3, *b* is used in magnetohydrodynamic plants for induction heating and mixing of liquid metal.

Using the construction of Fig. 3, *b*, let us consider an example of LIM application in non-ferrous metallurgy for the drive of a horizontal converter of copper and nickel mattes.

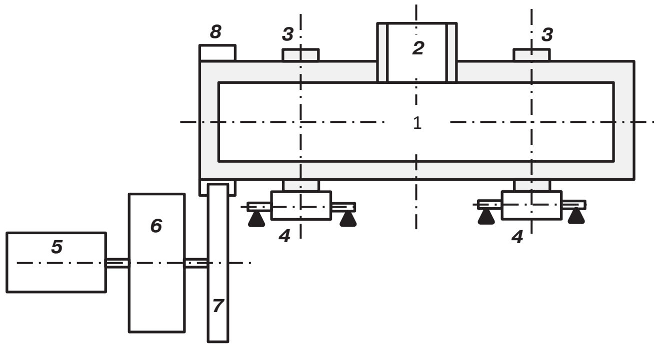

Fig. 4. Kinematic diagram of a converter driven by IM

The kinematic diagram of an operating converter driven from IM is shown in **Fig. 4**. Here are demonstrated: *1* — converter barrel, *2* — converter mouth, *3* — supporting tyres, *4* — trunnion, *5* — IM, *6* — reduction gear, *7* — driving gear, *8* — gear ring. The horizontal converter is a cylindrical container — a barrel trunnion-supported by supporting tyres. In the upper part of the barrel, there is a vessel mouth for matte pouring, feeding fluxes and cold materials, tapping the melt and removing gases. Rotation of the barrel relative to the horizontal axis is carried out from IM through a reduction gear and gear set, which includes a gear ring covering the barrel and a driving gear. In addition to the working drive, there is also an emergency DC drive powered by a storage battery. The power of the working electric motor is 30–60 kW, depending on the barrel capacity. The power of an emergency electric motor is 20–30 kW.

The kinematic diagram of the upgraded converter driven by LIM is shown in **Fig. 5**. Compared with the scheme of an existing drive, here are deleted: IM — *5*, a reduction gear — *6* and the gear set — *7*, *8*; instead of them there are installed the arc-type stator inductors *5*, the torque of

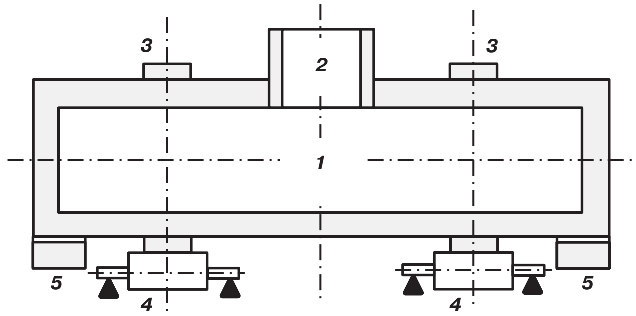

Fig. 5. Kinematic diagram of a converter driven by LIM

which acts directly on the converter barrel steel body. To increase the torque, the barrel body can be covered with a layer of copper or aluminum alloy at the installation place of inductors.

The reduction gear and the gear set removal from the electric drive power unit greatly reduces material capacity and increases reliability of the converter. Besides, the gear set removal reduces the load moments of the main and emergency electric motors, which contributes to a decrease in their rated power.

Specific character of electromagnetic processes in LIM

The specificity of electromagnetic processes in LIM is reflected by the term “a longitudinal edge effect”. It is understood as a set of physical phenomena caused by topological features of the electric motor design: the excitation current fail and discontinuous change in the magnetic properties at the inductor edges located in the direction of SE movement. In technical terms, the longitudinal edge effect becomes apparent in the form of:

— nonharmonic distribution and complicated nature of the main magnetic field movement. The wave of the main magnetic field is close to travelling one in the central region of inductor and close to pulsating one in its edge zones;

— uneven distribution of the main inductive resistance across the coils of the inductor winding phases. This edge effect, called “primary”, is most pronounced in two-pole embodiments of LIM inductor winding and practically disappears at 6–8 poles of inductor winding;

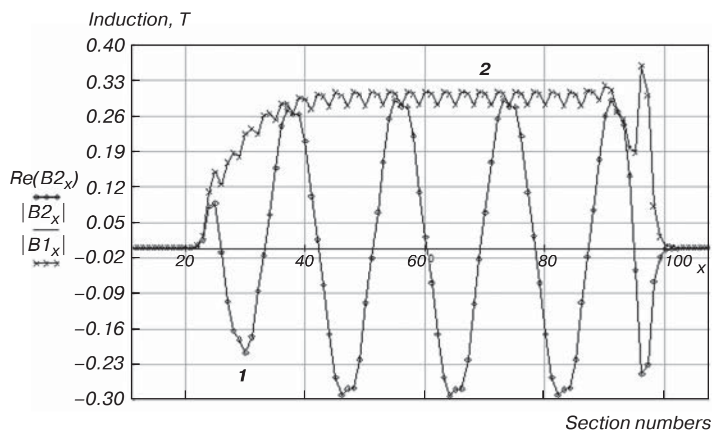

Fig. 6. Distribution of the main magnetic field of LIM:
1 — instantaneous distribution, *2* — enveloping curve

— stepwise EMF rise of SE circuits in the zone of their input into inductor and stepwise EMF falling of SE circuits in the zone of their output from inductor. This edge effect, called “secondary”, is most distinct in high-speed and high-Q motors for HSLT electric drives. Its influence in low-speed LIMs of industrial electric drives is relatively small, but it does occur.

These signs of edge effect taken together lead to the fact that the process of electromechanical energy conversion is localized mainly in the central area of inductor, practically without capturing its edge zones. This reduces the use of installed capacity and efficiency of the electromechanical energy conversion in this electrical machine.

Fig. 6, cited according to [16], illustrates the impact of edge effect on the main magnetic field of a low-speed LIM. The figure depicts the magnetic induction distribution curves of the main magnetic field of an 8-pole electric motor. An inductor winding with a three-phase sine-wave current of industrial frequency has excited the magnetic field, and SE has moved at a speed of 4 m/s in the direction of the spatial coordinate x increment.

In Fig. 6, the spatial coordinate is laid off in tooth pitches. The coordinate values $x = (0 - 20)$ correspond to the area in front of the inductor, values $x = (20 - 100)$ — to the inductor, values $x = (100 - 120)$ — to the area behind the inductor. As the above curves evidence, the edge effect influence on the low-speed LIMs is quite noticeable. The area of SE input to the inductor $x \approx (20 - 40)$ is extensive and covers about 25% of the inductor length. At the same time, the magnetic field intensity value in the input region is about 50% of that in the inductor central area $x \approx (40 - 90)$. An area of SE output from the inductor $x \approx (90 - 100)$ is relatively small. There are observed abrupt and various-directional changes in the magnetic field intensity with an approximate maintenance of its average value. The produced estimated values indicate that LIM uses its installed capacity by approximately 87% because of the edge effect influence.

Mathematical model of LIM

Simplified analytical models with a one-dimensional electromagnetic field are used to solve the problems of layout synthesis of LIM. A one-dimensional analytical model of a two-sided flat LIM is shown in **Fig. 7**.

The LIM inductor consists of two ferromagnetic cores of height h, on the inner surfaces of which in the interval $|x| \leq a$ there are placed the conductors of three-phase winding with primary current that is distributed

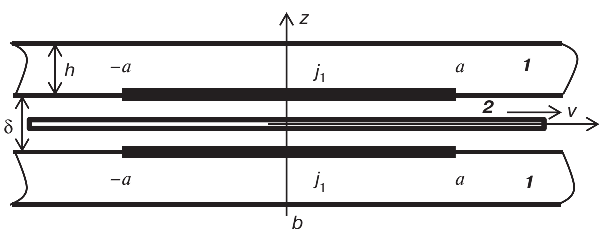

Fig. 7. Analytical model of LIM:
1 — inductor, *2* — secondary element

over the inductor with a linear density of $j_1 = j_1(x, t)$. It is assumed that the phase currents of the inductor winding are sinusoidal and have an angular rate ω_1. In the gap between the cores with the value of δ, there is a non-magnetic SE moving at a speed of v in the positive direction.

To write down the following expressions of the mathematical model, the system of relative units is used. The basic values for the functions and parameters of the model are summarized in the **Table 1**.

Table 1

Base values of LIM parameters

Parameter	Base value
Line density of inductor current — J_1 (independent base value)	J_b, $A{\cdot}m^{-1}$
Conductivity of SE — σ (independent base value)	σ_b, $Ohms^{-1}{\cdot}m^{-1}$
Magnetic conductivity of inductor cores — μ	$\mu_b = \mu_0 = 4\pi 10^{-7}$, $H{\cdot}m^{-1}$
Linear dimensions — x, δ, h, a, c	$x_b = a$, m
Vector magnetic potential of the main magnetic field — A	$A_b = \frac{\mu_b}{\delta} J_b x_b^2$, $Wb{\cdot}m^{-1}$
Spatial field attenuation coefficient — β	$\beta_b = (x_b)^{-1}$, m^{-1}
Time — t	$t_b = \sigma_b \mu_b x_b^2$, s
Angular rate — ω_1	$\omega_b = (t_b)^{-1}$, s^{-1}
SE speed — v	$v_b = (\sigma_b \mu_b x_b)^{-1}$, $m{\cdot}s^{-1}$
Electromagnetic force and load force — F, F_c	$F_b = A_b \cdot J_b \cdot x_b$, N
Mass of the moving part — m	$m_b = F_b \cdot t_b \cdot v_b$, kg

The mathematical model of LIM, written down in terms of the complex amplitudes of electromagnetic quantities in relative units, has the form as follows:

$$A_{xx} - \beta^2 A - \sigma(j\omega_1 A + vA_x) = -J_1, \quad (1)$$

$$F = Re(2c\int_{-a}^{a} A_x \cdot con(J_1)dx) \quad (2)$$

where $2c$ is a transverse width of the inductor; $con(J_1)$ is a conjugated vector with respect to the vector of the inductor current linear density J_1; A_x, A_{xx} — first- and second-order partial derivatives of the complex amplitude of the vector magnetic potential with respect to the x-coordinate, Re is a symbol of taking the real part of complex expression,

$$\beta = \sqrt{\frac{1}{\mu \cdot \delta \cdot h}} \quad (3)$$

is a coefficient of the magnetic field spatial attenuation with distance from its exciting current, j is imaginary unit.

Solution of equation (1) by the method of the integral Fourier transform [9] yields the expression:

$$A(x) = (g * J_1)(x) = \int_{-\infty}^{\infty} g(x - s) \cdot J(s)ds, \quad (4)$$

where "*" is a symbol of convolution operation,

$$g(x) = \frac{1}{2\lambda} \cdot e^{\frac{\sigma v}{2}x} \cdot e^{-\lambda|x|}, \quad (5)$$

is Green's function,

$$\lambda = \sqrt{\beta^2 + 1/4(\sigma v)2 + j\sigma\omega_1} \quad (6)$$

is a complex parameter.

The issues of LIM designing

The layout synthesis and feasibility study of LIM is suggested to implement according to the model (2) – (6). At given values of electromagnetic force — F, SE velocity — v and the supply voltage angular rate — ω_1, its ratios allow to select by iterative or another way the major dimensions of LIM — $2a$, $2c$, h, δ, physical characteristics and materials of the inductor and SE cores — μ, σ, the moving part mass — m, as well as the intensity and distribution of the inductor current linear density $J_1(x)$. In this case, certain criteria are used for the successful engine layout implementation: maximum starting force, weight and size restrictions, minimum SE shift during acceleration and others.

The most commonly used way to excite a LIM is exciting by sinusoidal 2p-pole current wave:

$$J_1(x) = J_{1m}\begin{cases} e^{-j\pi px}, |x| \le 1 \\ 0, |x| > 1 \end{cases}. \quad (7)$$

In this and other cases, it is advisable to choose J_{1m} for the LIM being guided by the current loads of three-phase transformers with natural air cooling.

As an example, the calculation results of the main magnetic field for LIM inductor excited by a two-pole wave of sinusoidal current with $J_{1m} = 1$, $\sigma = 0$ are given below. In this case, expressions (4) – (6) give the following distribution of the vector magnetic potential over the inductor length $-1 \le x \le 1$

$$A(x) = \frac{e^{-\beta x}}{\beta - j\pi}\left(\frac{e^{(\beta - j\pi)x} + e^{-\beta}}{2\beta}\right) + $$

$$+ \frac{e^{\beta x}}{\beta + j\pi}\left(\frac{e^{-(\beta + j\varpi)x} + e^{-\beta}}{2\beta}\right). \quad (8)$$

In accordance with expression (8), it can be stated that the excitation of an electric motor of the form (7) generates in it not only a travelling wave of the electromagnetic field, but also pulsating fields distributed exponentially along the inductor length. The latter play a negative role in the process of electromechanical energy conversion, creating retarding electromagnetic forces and increasing energy losses in electric motor. **Fig. 8** represents the enveloping curve of the wave of the vector magnetic potential of the LIM main magnetic field, constructed by expression (8) for $\beta = 6$.

The curve records significant decreases in the intensity of the LIM main magnetic field at the inductor edges, caused by the action of exponential pulsating waves.

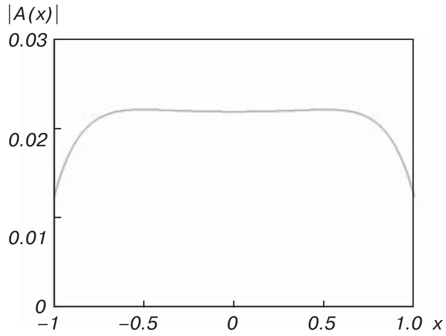

Fig. 8. Distribution of the main magnetic field of LIM

The electric motor dynamic behaviour plays a significant role in LIM designing. This relates to the fact that the SE movements are limited by the maximum stroke value, during which LIM may not reach the nominal operating conditions. To evaluate the LIM dynamic properties, the following approximate procedure is proposed.

The SE current speed calculation is carried out according to equation:

$$v(t) = \frac{1}{m}\int_0^t F(v)dt, \tag{9}$$

where the expression for the mechanical characteristics $F(v)$ is determined by the model (2) – (6).

The current SE transfer is determined by the solution of equation:

$$s(t) = x_0 + \int_0^t v(t)dt, \tag{10}$$

where x_0 is SE initial position coordinate.

The dependences $v(t)$ and $s(t)$ obtained in this way permit to evaluate the dynamic behaviour of LIM even at the stage of layout synthesis. In case of unsatisfactory values of SE speed and transfer, the main dimensions and electromagnetic loads of LIM should be adjusted.

Economic aspects of LIM usage

The main competitive advantage of LIM is its high reliability, which is realized by a longer operation life as compared with IM. High reliability results from the fact that the secondary element of LIM, as a rule, is a unitary and homogeneous physical body, in contrast to the complex and heterogeneous design of IM rotor. Besides, the elements that ensure the SE fixation and movement are run at essentially lower rates, mechanical and thermal loads than similar elements of LIM. In this connection, the least reliable component of LIM is an inductor winding, that has the same reliability indicators as the stator winding of IM. At the same time, the reliability of LIM as a whole is higher than that of IM.

Let's compare the costs of purchasing linear electric drives of the same power based on IM (Drive 1) and LIM (Drive 2), considering the operating spendings for both options to be the same.

The evaluation of the service life duration for IM and LIM has been carried out based on the Kolmogorov equations. The system graph and appropriate mathematical model are given in [17]. At this, the model parameters have been kept for IM, while the failure rate of the nodes that ensure SE fixation and movement was reduced for LIM by 1.5 times. The service life duration was understood as a time period in which the probability of the electric motor no-failure operation – p0(t), has a value no less than 0.85. **Fig. 9** illustrates the calculation results.

The figure shows the no-failure operation probability for IM and LIM depending on the operation time in hours. The operation life values T_1 = 20,000 hours for IM and T_1 = 40,000 hours for LIM are also given. This is approximately equivalent to 4 and 8 years of running assuming 5,000 running hours per year. Hence, it can be stated that Drive 1 will reach the end of its service life after 4 years of operation and will require a replacement, whereas Drive 2 will continue to work for another 4 years.

Let Drive 1 costs C rubles and Drive 2 costs no more than $2C$ rubles, taking into account its non-serial manufacturing.

The total cost of two sets of Drive 1 for 8 years of operation will be equal to

$$C_1 = C + C(1 + d)^4 = C[1 + (1 + 0.05)^4] = 2.22C,$$

where d = 0.05 is the annual rate of cost increase.

The total cost of Drive 2 for 8 years of operation is equal to

$$C_2 = 2C.$$

This means that year on year Drive 2 will yield the capital cost savings

$$\frac{C_1 - C_2}{8C}100 = \frac{2.22C - 2C}{8C}100 = 2.8\%.$$

Thus, it can be stated that application of a linear electric drive with LIM in certain conditions is reasonable and cost-effective. Crucial importance here is the cost of manufacturing and supplying of this electric drive. In each specific case, the question of the advisability of LIM usage should be settled considering a feasibility study, the materials for which are given in this paper.

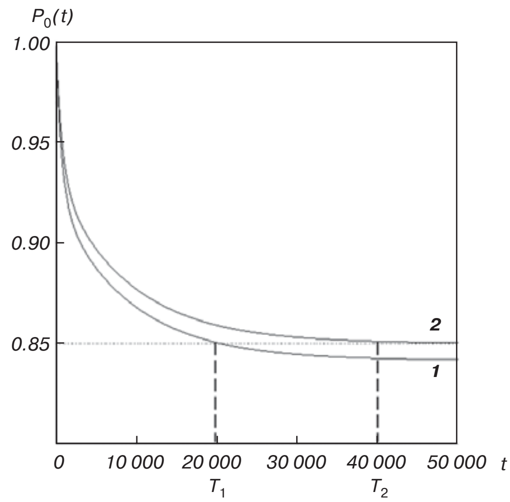

Fig. 9. Probability of no-failure operation:
1 – IM, *2* – LIM

Conclusions

Electric drives of processing and auxiliary equipment of non-ferrous metallurgy sub-sectors are promising goal area for application of low-speed LIMs. This is promoted by their reliability, kinematic simplicity, low material capacity, and functionality.

The introducing and operating an electric drive based on LIM is coupled with the solution of a number of specific engineering and economic tasks in the areas of building the electric drive power unit, engineering, modeling, designing, as well as technical and economic assessment of the electric drive indicators.

The specificity of electromagnetic processes and the variety of structural modifications make mathematical models the primary tool for LIM designing. At that, the designing tasks of layout synthesis and calculation of output characteristics with the corresponding modeling software are featured. At the same time, the established and generally accepted methods and means for solving both problems are currently absent.

The embodiments of LIM are diverse and permit to implement various types of mechanical movement, including complex linear-rotational combinations.

Low speed and the edge effects inherent to LIM significantly reduce the electric motor engineering and energy performance. At the same time, the indicators of linear electric drives based on LIM and IM are on the same level, what makes them competitive technologies for solving the transport problem.

In the paper, a mathematical model for layout synthesis of LIM is suggested. The model includes the means of forecasting estimation of electromagnetic, technical, weight-size and dynamic characteristics of the object. The LIM main magnetic field calculation is performed based on it.

The LIM service life model calculation is fulfilled, what has allowed estimating the economic efficiency of LIM application. It is established that usage of a linear electric drive with LIM in certain conditions is opportune and cost-effective. In each specific case, the question of the practicability of LIM application should be settled considering a feasibility study.

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