10. *Law* Ukraine from 18.03.2004. №1629-IV "On the National Program of Adaptation of Ukraine to the European Union" electronic resource http://zakon4.rada.gov.ua/laws/show/1629a-15

Sharing Rassmotrenы Main elements of the organization doenyya cows. Opredelenы shortcomings suschestvuyuschyh typical machines for bottling milk. On the basis razrabotanы s pryntsypyalnaya offensive scheme and capping svezhevыdoennoho milk uchytыvayuschaya Main factors of influence on the process of production of milk.

The system transportyrovanye, milk, glaring.

The general organization of basic elements of milking cows. Identified shortcomings of existing types of filling machines based on its have developed scheme spill and closing svezhevydoennogo milk, taking into account main factors influencing process of milk production.

System, transportation, milk, flood.

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WAVE CUTTING longitudinal oscillations of elastic elements Conveyor

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A discrete-continuous simulation and offered reasonable method to reduce wave longitudinal oscillations of elastic elements scraper conveyor. These fluctuations are considered as a superposition of two traveling towards each other weakly damped waves.

Discrete-continuous simulation damping device longitudinal vibrations, elastic elements, conveyor.

Problem. Elastic elements of modern scraper conveyors are a closed circuit consisting

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from compliant sites relatively small mass, separated from each other by a massive hard elements (scrapers laden). Compliance elastic elements results in that when the scraper conveyor belt outline some areas acquire the properties of oscillating systems where dynamic processes can have a wave nature.

An effective way to avoid the reflected wave is link conveyor is input to the design of the moving belt tensioning mechanism of elastic-dissipative elements. Ensuring consistency branches and tensioning mechanism eliminates the occurrence of resonance in the result of the addition of the incident distribution of dynamic loads both in the periphery and in other units and parts conveyor drive.

Analysis of recent research. In [1, 2] proposed and theoretically justified method of reducing vibration of machine elements based on the idea of coordination by avoiding excitation system capacity, the existence and distribution of the reflected waves.

In particular, the example of twisting vibrations transmission [1] and the bending vibration of beams [2] shows that coordination can be achieved by using end-quencher without reflection waves completely absorb energy disturbances which propagate from the source.

The purpose of research is coherent justification ideas quencher, which can reduce the viscoelastic longitudinal vibrations of elastic elements scraper conveyor.

Results. Consider a discrete model of scraper conveyor (the branch) as a chain of similar weight and weightless elastic elements with internal friction (Fig. 1). At one end branches operating periodic external force, and another set clamp consisting of inertial damper and spring element.

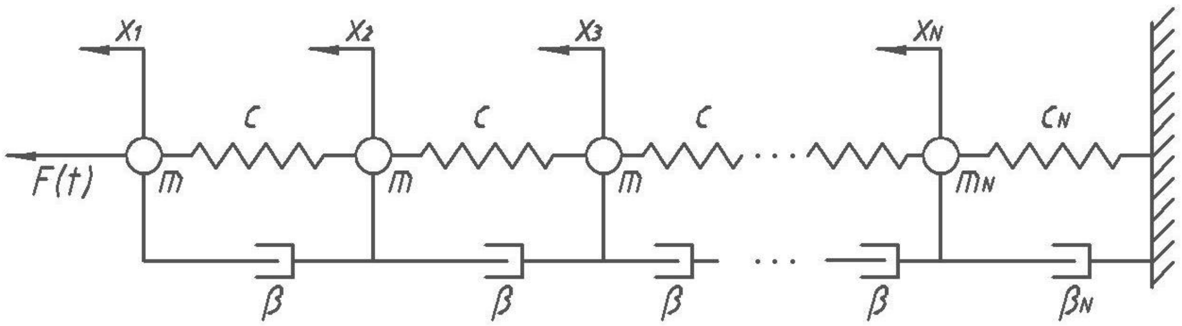

Fig. 1. Diagram of the conveyor.

Longitudinal vibrations of the system described by equations:

$$\begin{cases} m\ddot{x}_1 + c\cdot(x_1 - x_2) + \beta\cdot(\dot{x}_1 - \dot{x}_2) = F_0\cdot e^{i\omega t}, \quad i^2 = -1; & (1)\\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots & \\ m\ddot{x}_n + c\cdot(2x_n - x_{n-1} - x_{n+1}) + \beta\cdot(2\dot{x}_n - \dot{x}_{n-1} - \dot{x}_{n+1}) = 0, \quad n = 2,3,\dots,N-1; & (2)\\ m_N\ddot{x}_N + c_N x_N + c\cdot(x_N - x_{N-1}) + \beta_N\dot{x}_N + \beta\cdot(\dot{x}_N - \dot{x}_{N-1}) = 0, & (3) \end{cases}$$

where n - Serial number of mass chain; x_n - Longitudinal movement *n*th element (scraper) with respect to the equilibrium position; m, c - Mass and longitudinal rigidity link scraper conveyor; β - Factor for the loss in the pipeline joints; m_N, c_N, β_N - Mass, stiffness and damping factor of the final consolidation of branch conveyor; F_0, ω - The amplitude and frequency of the external force.

The wave that spreads from the source disturbance vpodovzh chain masses after interaction with the end-fixing is reflected from it and extends in the opposite direction. Therefore, longitudinal movement *n*ies weight chain can be represented as a superposition of two waves damped

$$x_n(t) = A \cdot \exp\{i \cdot (\omega \cdot t - \gamma \cdot n \cdot a)\} + B \cdot \exp\{i \cdot (\omega \cdot t - \gamma \cdot n \cdot a)\}, \quad (4)$$

where A - Amplitude perturbations; B - The amplitude of the wave reflected from consolidation; ω - Frequency waves; $\gamma = k - i\alpha$ - Complex wave number; a - Step scraper conveyor.

Substituting the solution in the form of a traveling wave $x_n \sim \exp[i \cdot (\omega \cdot t \pm \gamma \cdot n \cdot a)]$ in equation (2) we obtain the ratio, which connects the complex wave number $\gamma = k - i\alpha$ and frequency ω (So-called dispersion relations)

$$ch\{i \cdot \gamma \cdot a\} = \left(c - m\omega^2 / 2 + i \cdot \beta \cdot \omega\right) / (c + i \cdot \beta \cdot \omega). \quad (5)$$

From (5) it follows that the parameters k and α are nonlinear functions of frequency ω. Consider a few specific cases.

The case of disturbances with large wavelength ($k \cdot a << 1$) When the mass chain with properties close to the viscoelastic rod with (5) will have a linear law for k

$$k \cdot a = \left(\frac{m}{c}\right)^{1/2} \cdot \omega, \quad (6)$$

and quadratic frequency dependence for the parameter α Which characterizes the exponential wave damping circuit vpodovzh

$$\alpha \cdot a = \beta \cdot \left(\frac{m}{c}\right)^{1/2} \cdot \omega^2 / (2c). \quad (7)$$

If we neglect losses in the system ($\beta = 0$), Then from (5) implies universal dispersion relation, which is typical for many discrete systems [4]:

$$\omega = 2 \cdot \left(\frac{c}{m}\right)^{1/2} \cdot \sin\left[\frac{ka}{2}\right]. \quad (8)$$

In particular, the same dispersion law holds for the system, which is used as a model for calculating the reduced torque fluctuations transmissions [1].

Substituting the solution (4) in the final circuit equations of motion (3) we find the relationship between the amplitudes of the incident (*And*) And backward (*In the*) Waves moving at the borders threads

$$\frac{B}{A} = \exp\{-2 \cdot i \cdot \gamma \cdot N \cdot a\} \cdot \frac{(z_0 - z_N)}{(z_0 + z_N)}, \tag{9}$$

where

$$\begin{aligned} z_N &= \beta_N + i \cdot (m_N \cdot \omega - c_N/\omega) + (\beta - ic/\omega) \cdot (1 - ch[i \cdot \gamma \cdot a]), \\ z_0 &= (\beta - ic/\omega) \cdot sh[i \cdot \gamma \cdot a]. \end{aligned} \tag{10}$$

In (9) is a complex quantity z_N That depends on the wave frequency ω Parameters of the final fixing parameters characterizing impedance circuit and the final consolidation. Size z_0 defines uniform impedance circuit masses of internal friction.

From (9) shows that the reflected wave from the fixed end are missing ($B/A = 0$) If the impedance is the impedance fixing circuit weight $z_0 = z_N$. This connection chain and final branch will be called consistent.

For coordinated load connection parameters consolidation m_N, c_N, β_N and semi m, c, β must satisfy the relation:

$$\begin{cases} m_N \cdot \omega^2 - c_N - c \cdot (1 - \exp[\alpha \cdot a] \cdot \cos ka) - \beta \cdot \omega \cdot \exp(\alpha \cdot a) \cdot \sin ka = 0, \\ \beta_N \cdot \omega + \beta \cdot \omega \cdot (1 - \exp[\alpha \cdot a] \cdot \cos ka) - c \cdot \exp(\alpha \cdot a) \cdot \sin ka = 0, \end{cases} \tag{11}$$

where α, k and frequency ω connected by equation (5).

Thus, the original problem is reduced to the study of systems of two equations (11) to determine the three parameters consolidation m_N, c_N, β_N set parameters for circuit m, c, β and frequency perturbation ω.

At $\beta = 0$ from (11) we have provided the coordination, found similar to torque transmission systems [1]. In this case, the damping coefficient fixing must be equal to the impedance of the circuit masses:

$$\beta_N = \beta_N^* = (mc - m\omega^2/4)^{1/2}, \tag{12}$$

and the mass and stiffness fixing satisfy the equation:

$$m_N = m_N^* = m/2; \; c_N = c_N^* = 0, \text{ або } (m_N^* - m/2)/c_N^* = \omega^2 . \tag{13}$$

It is clear that the solution of the problem of search parameters final fixing branches, which does not reflect the waves makes sense only weakly damped waves, when the loss in small joints of the scraper conveyor ($\beta \cdot \omega << c$).

At $\beta \cdot \omega << c$ damping coefficient fixing β_N close to the value β_N^* Which is calculated in the absence of losses

$$\beta_N = \beta_N^* \cdot \exp(\alpha \cdot a) - \beta \cdot [1 - \exp(\alpha \cdot a) \cdot \cos(k \cdot a)]. \tag{14}$$

Considering the mass and stiffness securing equal $m_N = m_N^* = m/2$, $c_N = c_N^* = 0$ we reach full coordination on border branches ($B/A \neq 0$). However, the advantage of damping device with these parameters is that it has no resonance properties and therefore not critical to small changes in frequency perturbation ω and system parameters.

The dependence of the reflection coefficient B/A This case also has a resonant character and takes the following form:

$$|B/A| = -\exp\{-2 \cdot \alpha/(N \cdot a)\} \cdot \frac{[\beta \cdot p - c \cdot q/\omega]}{\left[4 \cdot (c \cdot p/\omega + \beta \cdot q)^2 + (\beta \cdot p - c \cdot q/\omega)^2\right]^{1/2}}, \qquad (15)$$

where $p = ch(\alpha \cdot a) \cdot \sin(k \cdot a)$, $q = sh(\alpha \cdot a) \cdot \cos(k \cdot a)$.

In particular, the $\beta \cdot \omega << c$ reflectance $|B/A|$ not exceed the $\beta \cdot \omega/(4c)$.

Numerical calculations for the scraper conveyor with rubber-metal elements (hinges) and parameters $m = 8{,}96\,кг,\ a = 0{,}14\,м,\ c = 10^7\ Н/м,\ \beta = 1{,}7 \cdot 10^3\,кг/с$ Close to the experimental studies at a frequency perturbation $\omega = 200c^{-1}, m_N = m/2, c_N = 0$ to give β_N value $\beta_N = 9{,}465 \cdot 10^3\,кг/с$.

It should be noted that the coefficient of damping fixing β_N depending on the frequency ω Ie coordination can be achieved only at a certain frequency. However, in case of disturbances with large wavelength ($k \cdot a << 1$) Damping coefficient fixing can be considered constant and not dependent on the frequency of disturbance:

$$\beta_N = (m \cdot c)^{1/2}. \qquad (16)$$

Consequently, the $k \cdot a << 1$ harmonization achieved on almost all frequencies in this range of fixed and semi final consolidation.

Consider another model of the scraper conveyor, which describes the asymmetric longitudinal angular fluctuations of its elements. This design scheme will meet the problem of mechanical transmission line model (Fig. 2). Fig. 2 shows a half scraper conveyor relative to its central axis.

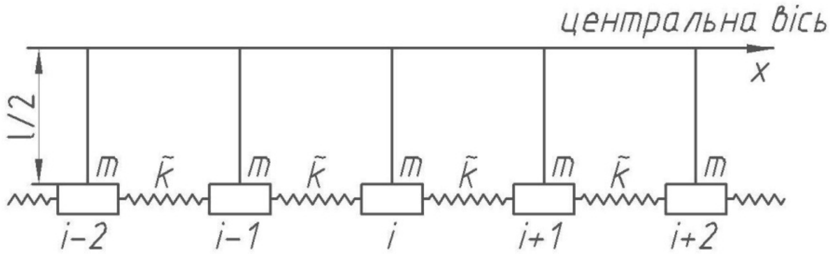

Fig. 2. Design model to model mechanical transmission line (*l* - Width cloth belt).

In this model the mechanical transmission line (Fig. 2) Conveyor presented as a system of pendulums connected by a spring stiffness $\tilde{k}$. We introduce the following notation: φ_i - Angle from vertical *and*th pendulum; p - Tension, which assumed the same for all pendulums; χ - Kvazipruzhnyy factor; m - Weight of each cargo ($1/2$ mass of one scraper laden). The equations of motion *and*th pendulum with a view (in the so-called approximation "close neighbors")

$$m \cdot \frac{d^2\varphi_i}{dt^2} = \tilde{k} \cdot \left(\varphi_{i+1} + \varphi_{i-1} - 2\varphi_i\right) - p \cdot \sin\varphi_i, \qquad (17)$$

where *t* - Time.

Of course, knowing φ_i easy to find moving *and*th pendulum: $\xi_i = \frac{l}{2} \cdot \varphi_1$. We introduce the dimensionless more "distance" $\chi = i \cdot \sqrt{p/k}$ and time $\tau = t \cdot \sqrt{p/m}$. In such notation equation (17) is reduced to the so-called sine-Gordon equation:

$$\partial^2\varphi/\partial\xi^2 - \partial^2\varphi/\partial\tau^2 = \sin\varphi. \qquad (18)$$

In the linear approximation, of course, this equation describes the distribution vpodovzh transmission line harmonic oscillations described by the dispersion equation for k (Wave vector) and angular frequency ω wave has the form

$$k^2 = 1 + \omega^2. \qquad (19)$$

Turning to the consideration of nonlinear oscillations of the system, look for a solution in the form $\varphi = \varphi(\tilde{\xi})$Where $\tilde{\xi} = x - u \cdot t$ Where u - The group velocity of wave propagation. Then come to the differential equation describing Running nonlinear waves:

$$d\varphi/d\tilde{\xi} = \sqrt{2 \cdot \left(\tilde{E} - \cos\varphi\right)/\left(1 - \tilde{u}^2\right)}, \qquad (20)$$

where $\tilde{E}$ - Constant of integration that makes sense dimensionless initial energy of a pendulum, and $\tilde{u}$ - The value of the dimensionless group velocity of wave propagation $\tilde{u} = d\chi/d\tau$. For case ($\tilde{E} = 1$) Have a solution (20)

$$\varphi = arctg\left\{\exp\left\{\left[\tilde{\xi}/(l/2)\right]/\sqrt{1 - \tilde{u}^2}\right\}\right\}, \qquad (21)$$

describing the distribution vpodovzh line disturbances angular features in the form kinks: $\varphi(\pm\infty) = \pm\pi/2$. If the module $E < 1$ and dimensionless speed $\tilde{u} > 1$Then the desired function is expressed through elliptic sine:

$$\varphi = 2\arcsin\left(\bar{\gamma}\cdot sn\left\{\left[\tilde{\xi}/(l/2)\right]\Big/\sqrt{\tilde{u}^2-1}\right\}\right),\ \bar{\gamma}^2 = \left(1-\tilde{E}\right)\Big/2, \qquad (22)$$

herewith $\varphi = 2\arcsin\gamma$ And we arrive at a solution of salt ton type.

Provided $\tilde{E} < 0,\ \tilde{u}^2 < 1$ (Or $\tilde{E} > 2,\ \tilde{u}^2 > 1$) Can spiral waves:

$$\frac{d\varphi}{d\tilde{\xi}} = \pm\left\{\left|\left(4\cdot\sin^2(\varphi/2) - 2\tilde{E}\right)\Big/\left(u^2-1\right)\right|\right\}^{1/2}. \qquad (23)$$

Such waves $\varphi\left(\tilde{\xi}\right)$ or monotonically increases or decreases monotonically.

At $\tilde{E} = 0,\ \tilde{u}^2 < 1$ (Or $\tilde{E} = 2,\ \tilde{u}^2 > 1$) Solution has the form

$$tg[(\varphi+\pi)/4] = \pm\exp\left[\pm\frac{2}{l}\left(\tilde{\xi}-\tilde{\xi}_0\right)\Big/\sqrt{\tilde{u}^2-1}\right],\ \tilde{\xi}\Big|_{t=0} = \tilde{\xi}\Big|_{\tau=0} = \tilde{\xi}_0. \qquad (24)$$

This solution describes a single loop size 2π. In the latter case ($\tilde{E} = 0$) Can not find the exact solution, which describes the interaction of waves

$$\psi = tg\left(\frac{\tilde{\xi}\cdot 2}{4\cdot l}\right) = tg\left(\frac{\tilde{\xi}}{2\cdot l}\right) = \frac{\tilde{u}\cdot sh\left\{(2x/l)\Big/\sqrt{1-u^2}\right\}}{ch\left\{\tilde{u}\cdot\tau\Big/\sqrt{1-u^2}\right\}}. \qquad (25)$$

At $t \to \pm\infty$ we have the following asymptotic

$$\psi = \mp\exp\left[\frac{2}{l}(\mp x + u\cdot t)\Big/\sqrt{1-u^2}\right] \pm \tilde{u}\cdot\exp\left[\frac{2}{l}\left(\tilde{\xi}\right)\Big/\sqrt{1-u^2}\right]. \qquad (26)$$

This solution describes personified waves moving in opposite directions. Positive loop coming from ($-\infty$) In the interaction moves a distance

$$2\cdot\Delta x/l = 2\cdot\sqrt{1-\tilde{u}^2}\cdot\ln(1/\tilde{u}). \qquad (27)$$

Conclusions

1. Obtained in the dynamic model scraper conveyor describing longitudinal oscillations and longitudinal oscillations and waves Corner distributed vpodovzh its axis, revealed the main characteristics of such disturbances.
2. The results in the future may be used to refine and improve existing engineering methods for calculating the dynamic characteristics scraper conveyors and stages of their design / construction and real operation to remove unwanted hvyleutvoren that reduce the reliability and durability of these pipelines by using the quencher fluctuations special design with the parameters defined in this study.

References

1. *Vesnytskyy AI* MATCHING transmyssyy fluctuations in krutylnым / *AI Vesnytskyy, IV Myloserdova* // Izv. universities. Mashinostroenie. - 1991. - № 4-6. - P. 86-90.
2. *Vesnytskyy AI* Sohlasovannыy tortsevoy absorber yzhybnыh fluctuations beams / *AI Vesnytskyy, IV Myloserdova* // Akustycheskyy magazine. - 1995. - T.41. - № 4. - P. 572-575.
3. *V. Platonov* Dynamics and nadezhnost caterpillar dvyzhetelya / *VF Platonov*. - M .: Mashinostroenie, 1973. - 231s.
4. *Rabinovich MI* Introduction to the Theory of oscillations and waves / *MI Rabinovich, DI Trubetskov*. - M .: Nauka, 1984. - 432p.

A discrete-kontynualnoe Modeling and suggestions obosnovannыy volnovoy method Reduction prodolnыh fluctuations elastic elements scraper conveyor. Ukazannыe fluctuations rassmotrenы How superposition of two Running navstrechu each other poorly zatuhayuschyh waves. Shown something Reduction fluctuations vetvey conveyor Can bыt mature putem Selection parameters dempfyruyuscheho Device kotoroe snyzhaet otrazhennыe volnы border services vetvy.

Discrete kontynualnoe Modeling, dempfyruyuschee Device Reduction, prodolnыe fluctuations, upruhye elements, skrebkovыy conveyor.

Discrete-continual modeling is carried out and the reasonable wave method of decrease in longitudinal oscillations of elastic elements of scraper conveyor is offered. These oscillations as superposition of two poorly damped waves running towards each other are considered. It is shown that reduction of conveyors branches oscillations can be reached by selection of damping's device parameters which reduces reflected waves on branch border.

Discrete-continual modeling, damping device, longitudinal oscillations, elastic elements, scraper conveyor.