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STUDY ABOUT DYNAMIC BEHAVIOR OF SUSPENDED SIEVE TO MACHINE OF SORTED SELF-PROPELLED KT 45/18/13

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ABSTRACT

In his work studied machine of sorted self-propelled KT 45/18/13. This is a made in product brand name Romania S. C. RALLY-BM. Com. Srl and is used-up for the assortment through material vibrations of grain miscellaneous (in the gravel chief and residues of marmora) achieved the theoretical study of the dynamics of the box of the sieve, establishing the dynamic features ale this motion the and in chief the localization of the resonance phenomenon.

1. Introduction

Machine of sorted self-propelled KT 45/18/13 is a made in product brand name Romania S. C. RALLY BM.COM. S. R. L. Braila. Machine is used-up for the assortment through material vibrations of the grain of diverse sizes (of habits his gravels marble residues). In abaft experimentation produced the in conditions of career were one consider anomalies to the dynamic behavior of suspended sieve, binded of phenomenal of which resonance drove to the of a appearance fissures in frame of the sieve. In fig. no. 1 is presented a general image, laterally what he presents pozitionarea of the sieve on machine of sorted.

Fig. 1. Position of detail the suspended sieve on machine of sorted KT 45/18/13.

The work present proposes to tackle, below theoretical appearance, on mathematical model, the appearances motional hers of the sieve in the identification aim of dynamic regimes which drove to the appearance of inadequate dynamic phenomenal. General appearances of dynamic behavior of the machine were abordate in [1,2], and the experimental appearances in [3].

2. The dynamic model of the sieve suspended

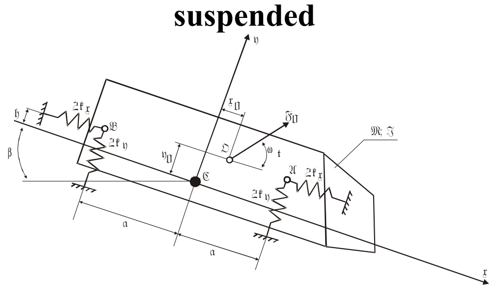

Fig. 2. The model of suspended sieve
C-the centre of table; A; B the points of elastic liaison to chassis; O - place of location of harmonic excitatorului; M-massage the sieve; J-the moment of inertia axial mechanic against C; F_0 the amplitude of the force of excitation.

For the model from fig. no. 2 characterized of symmetry against the xcy plan, or considered the coordinate next law generalize: X-the movement of glide the center of table c, of the sieve; Y-the movement of gallop the center of table c, of the sieve;

φ - the angular movement of overturn, of the sieve.

Estimating the kinetic energy of the sieve, the potential energy of the connections and the forces generalizate of excitation and applying the equations Lagrange sp. II, as per [1, 2], he results the mathematical model of the suspended sieve of the elastic and excited forcedly of rotative excitation, in the likeness of the system of equations:

$$\begin{cases} \ddot{x} + d_{xx}x + d_{x\varphi}\varphi = f_0 \cos\omega_t \\ \ddot{\varphi} + d_{\varphi x}x + d_{\varphi\varphi}\varphi = \mu_0 \sin(\omega t - \alpha) \\ \ddot{y} + d_{yy}y = f_0 \sin\omega t \end{cases} \quad (1)$$

where:

$d_{xx} = 4k_x / M$ -he the dynamic factor represents of slide; $d_{x\varphi} = 4k_x h / M$ -the dynamic factor of the overturn glide; $d_{\varphi x} = 4k_x h / J$ -the dynamic factor of the slide overturn; $d_{\varphi\varphi} = 4(k_x h^2 + k_y a^2)/J$ - dynamically of overturn; $d_{yy} = 4k_y / M$ - dynamically of gallop; $f_0 = 2m_0 r_0 \omega^2 / M$ -the linear acceleration of excitation; $\mu_0 = 2m_0 r_0 e\omega^2 / M$ -the angular acceleration of excitation; $e = \sqrt{x_0^2 + y_0^2}$ -the excentricity couple of excitation; $\alpha = arctg(y_0 / x_0)$ - lagging couple of excitation.

3. The determination of dynamic features

Departing from the model (1) consisted as the motions of glide the overturn am coupled and the motion of gallop is disconnect. Is analysed the behavior to vibration of the sieve after first two homogeneous equations ale of the system (1) for the coupled motions of glide gallop and on free homogeneous equation for gallop, utilizing classic procedure of tackle [5].

3. 1. For the own motions ale of the sieve

- of the motion of gallop.

The own throb motion of gallop, is:

$$p_g = \sqrt{d_{yy}} = 2\sqrt{\frac{k_y}{M}};\ [s^{-1}] \quad (2)$$

And the own motion of gallop, is described of the relation:

$$y = g_0 \sin(p_g t + \theta);\ [m] \quad (3)$$

where: g_0 and θ arises from the initial conditions ale own motion.

- the own coupled motions of glide the overturn.

The own individual throbs of slide and overturn, am:

$$p_a = \sqrt{d_{xx}} = 2\sqrt{\frac{k_x}{M}};\ [s^{-1}] \text{-slide} \quad (4)$$

$$p_r = \sqrt{d_{\varphi\varphi}} = 2\sqrt{\frac{k_x h^2 + k_y a^2}{J}};\ [s^{-1}] \text{-overturn} \quad (5)$$

The pulsatory equations coupled own for the motion of glide the overturn, arises from the constraint of the condition [5];

$$p^4 - (d_{xx} + d_{\varphi\varphi})p^2 + (d_{xx}d_{\varphi\varphi} - d_{x\varphi}d_{\varphi x}) = 0 \quad (6)$$

He results the pulsatorys expression own of vibrations coupled slide and overturn:

$$p_{1,2}^2 = 2\frac{k_x}{M}\left\{ \left[1 + \frac{Mh^2}{J}(1 + \frac{k_y}{k_x}\cdot\frac{a^2}{h^2})\right] \pm \sqrt{\left[1 + \frac{Mh^2}{J}(1 + \frac{k_y}{k_x}\cdot\frac{a^2}{h^2})\right]^2 - 4\frac{M_a{}^2}{J}\frac{k_y}{k_x}} \right\} \quad (7)$$

The own vectors have the coupled motions the by-pathes:

$$\mu_1 = \frac{p_1^2 - d_{xx}}{d_{x\varphi}};\quad \mu_2 = \frac{p_2^2 - d_{xx}}{d_{x\varphi}} \quad (8)$$

Respectively:

$$\mu_1 = \frac{J}{2Mh}\left\{ -1 + \frac{Mh^2}{J}(1 + \frac{k_y}{k_x}\cdot\frac{a^2}{h^2}) + \sqrt{\left[1 + \frac{Mh^2}{J}(1 + \frac{k_y}{k_x}\cdot\frac{a^2}{h^2})\right]^2 - 4\frac{M_a{}^2}{J}\frac{k_y}{k_x}} \right\} \quad (9)$$

$$\mu_2 = \frac{J}{2Mh}\left\{ -1 + \frac{Mh^2}{J}(1 + \frac{k_y}{k_x}\cdot\frac{a^2}{h^2}) - \sqrt{\left[1 + \frac{Mh^2}{J}(1 + \frac{k_y}{k_x}\cdot\frac{a^2}{h^2})\right]^2 - 4\frac{M_a{}^2}{J}\frac{k_y}{k_x}} \right\} \quad (10)$$

The solutions of free coupled vibrations of overturn and slide, am:

$$\begin{aligned} \varphi_{(t)} &= C_1 \sin(p_1 t + \theta_1) + C_2 \sin(p_2 t + \theta_2); [rad] \\ x_{(t)} &= \mu_1 C_1 \sin(p_1 t + \theta_1) + \mu_2 C_2 \sin(p_2 t + \theta_2); [m] \end{aligned} \quad (11)$$

The constants C_1 and C_2 are infered from the initial conditions ale of dynamic process, respectively (t=0; x=0; φ =0; $\dot{x}$ =0; $\ddot{\varphi}$ =0).

3. 2. for the constrained motions ale of the sieve

- **of the motion of gallop.**

The general solution motion of gallop, is:

$$y = g_0 \sin(p_g t + \theta) + \frac{f_0}{\omega^2 - p_g^2} \sin \omega t \qquad (12)$$

Because the solution of homogeneous equation, former the term from the equation (12), is decreased as effect after the transitory regime, the motion of gallop stabilizata is formal:

$$y = y_0 \sin \omega t \qquad (13)$$

where: Y_0 is the amplitude motion of gallop which causes the detachment of the particles from the sieves of the sieve, what he has the expression:

$$y_0 = 2\frac{m_0}{M} r_0 \frac{1}{1 - \eta_g^2};\ [m] \qquad (14)$$

where: $\eta_g = \omega / p_g$ -the relative throb of gallop the sieve, what he causes resonance to gallop for $\eta_g = 1$, respectively $\omega = p_g$.

If is noted:

$$y_0 = 2\frac{m_0}{M} \cdot r_0 \qquad (15)$$

The amplitude of linear excitation of the system, and

$$A_g = \frac{y_0}{y_e} \qquad (16)$$

the factor of amplification of the vibration of gallop, results

$$A_g = \frac{1}{1 - \eta_g^2} \quad [rad] \qquad (17)$$

- **the coupled motions of slide and overturn.**

The general solution motions of glide the overturn is mature from the equations (11) whereat is added for each equation the solutions constrained motions, falled across phrasal:

$$x_{(t)} = x_0 \sin(\omega t - \theta_x) \text{ si } \varphi_{(t)} = \\ = \varphi_0 \sin(\omega t - \theta_\varphi) \qquad (18)$$

where: X_0- the amplitude motion of slide and φ_0-the amplitude motion of overturn, and, $\theta_x \theta_\varphi$ - he represents the phases motions of slide, respectively overturn. Enforcing the condition as the the solutions (18) to verify the proper equations ale of the system (1), he results the system:

$$\begin{cases} x_0(d_{xx} - \omega^2)\cos\theta_x + d_{x\varphi}\varphi_0 \cos\theta_\varphi - f_0 = 0 \\ x_0(d_{xx} - \omega^2)\cos\theta_x + d_{x\varphi}\varphi_0 \cos\theta_\varphi = 0 \\ x_0 d_{\varphi x} \cos\theta_x + \varphi_0(d_{\varphi\varphi} - \omega^2)\cos\theta_\varphi - \mu_0 \cos\alpha = 0 \\ x_0 d_{\varphi x} \sin\theta_x + \varphi_0(d_{\varphi\varphi} - \omega^2)\sin\theta_\varphi - \mu_0 \sin\alpha = 0 \end{cases} \qquad (19)$$

Unknown where by-path $x_0; \varphi_0; \theta_x; \theta_\varphi$.

The solution of the system (19) is achieved, unknown considering:

$$x_{11} = x_0 \cos\theta_x;\ x_{22} = \\ = x_0 \sin\theta_x;\ \varphi_{11} = \\ = \varphi_0 \cos\theta_\varphi;\ \varphi_{22} = \varphi_0 \sin\theta_\varphi \qquad (20)$$

Whence he results:

$$x_0 = \sqrt{x_{11}^2 + x_{22}^2};\ \varphi_0 = \\ = \sqrt{\varphi_{11}^2 + \varphi_{22}^2};\ tg\theta_x = \\ = \frac{x_{22}}{x_{11}};\ tg\theta_\varphi = \frac{\varphi_{22}}{\varphi_{11}} \qquad (21)$$

Respectively:

$$x_0 = \\ = 2\frac{m_0}{M} r_0 \omega^2 \frac{\sqrt{(p_r^2 - \omega^2)^2 - 2\frac{My_0}{J}(p_r^2 - \omega^2)d_{x\varphi} + \frac{e^2M^2}{J^2} d_{x\varphi}^2}}{(\omega^2 - p_1^2)(\omega^2 - p_2^2)};\ [m] \qquad (22)$$

$$\varphi_0 = \\ = 2\frac{m_0}{J} e r_0 \omega^2 \frac{\sqrt{(p_a^2 - \omega^2)^2 - 2\frac{Jy_0}{Me^2}(p_a^2 - \omega^2)d_{\varphi x} + \frac{J^2}{e^2M^2} d_{\varphi x}^2}}{(\omega^2 - p_1^2)(\omega^2 - p_2^2)};\ [rad] \qquad (23)$$

$$\theta_x = \operatorname{arctg} \frac{\frac{x_0 M}{J} d_{x\varphi}}{(p_r^2 - \omega^2) - \frac{y_0 M}{J} d_{x\varphi}};\ [rad] \qquad (24)$$

$$\theta_\varphi = \operatorname{arctg} \frac{\frac{x_0 M}{J}(p_a^2 - \omega^2)}{d_{\varphi x} - \frac{y_0 M}{J}(p_a^2 - \omega^2)};\ [rad] \qquad (25)$$

Is fall-backed on the notation (15), where:

$$x_e = y_e = 2\frac{m_0}{M} r_0;\ [m]$$

Represents the amplitude of the linear excitation and

$$\varphi_e = 2\frac{m_0 r_0 e}{J};\ [rad] \qquad (26)$$

He represents the amplitude of the angular excitation and

$$A_a = \frac{x_0}{x_e};\ [ad];\ A_r = \frac{\varphi_0}{\varphi_e};\ [ad] \qquad (27)$$

He represents: The factor of amplification of the vibration of slide, respectively the factor of amplification of the vibration of overturn.

Considering the relative throbs of slide $\eta_a = \omega / p_a$, of coupled $\eta_r = \omega / p_r$ overturn of slide overturn, $\eta_1 = \omega / p_1, \eta_2 = \omega / p_2$; replaced the in 27, results:

$$A_a = \frac{\eta_1^2\eta_2^2}{(\eta_1^2-1)(\eta_2^2-1)} \cdot \frac{\sqrt{\eta_a^4(1-\eta_r^2)^2 - k_1\eta_a^2\eta_r^2(1-\eta_r^2) + k_2\eta_r^4}}{\eta_r^2 \cdot \eta_a^2}; \quad (28)$$

$$A_r = \frac{\eta_1^2\eta_2^2}{(\eta_1^2-1)(\eta_2^2-1)} \cdot \frac{\sqrt{(1-\eta_a^2)^2 - k_3(1-\eta_a^2) + k_4}}{\eta_a^2}; \quad (29)$$

$$\theta_x = \mathrm{arctg}\frac{k_5\eta_r^2}{\eta_a^2(1-\eta_r^2) - k_6\eta_r^2}; \quad (30)$$

$$\theta_\varphi = \mathrm{arctg}\frac{1-\eta_a^2}{k_7 - k_8(1-\eta_a^2)}; \quad (31)$$

Where:

$$k_1 = 2\frac{My_0h}{J};\ k_2 = \frac{Me^2h^2}{J^2};\ k_3 = 2\frac{hy_0}{e^2};\ k_4 = \frac{h^2}{e^2};\ k_5 = \frac{Mx_0h}{J};\ k_6 = k_1;\ k_7 = h/x_0;\ k_8 = \frac{y_0}{x_0}$$

Am the specific coefficients of the model of the analysis.

The relations (28); (29); (30); (31) exprimates depending on the throb of excitation am:

$$A_a = k_r\omega^2\frac{\sqrt{\left(1-\omega^2/p_r^2\right)^2 - k_1\left(1-\omega^2/p_r^2\right) + k_2}}{\left(1-\omega^2/p_1^2\right)\left(1-\omega^2/p_2^2\right)}; \quad (32)$$

$$A_r = k_a\omega^2\frac{\sqrt{\left(1-\omega^2/p_a^2\right)^2 - k_3\left(1-\omega^2/p_a^2\right) + k_4}}{\left(1-\omega^2/p_1^2\right)\left(1-\omega^2/p_2^2\right)}; \quad (33)$$

$$\theta_x = arctg\left(tg\alpha - k_5(1-\omega^2/p_r^2)\right); \quad (34)$$

$$\theta_\varphi = arctg\left(tg\alpha - k_6/(1-\omega^2/p_a^2)\right); \quad (35)$$

After the relations (33), (34), (35), (36) they represented the variations of the factors of amplification and of laggings.

4. The dynamic simulations numerical process.

Characteristic sizes ale of physical model of the suspended sieve. The what sizes characterizes the model, obtained through mensurations, [2] are:

$k_x = 11 \cdot 10^4\ N/m;\ k_y = 50 \cdot 10^4\ N/m$;

M=3496 kg; m_a=37,1 kg; r_a=0,1138 m; e=0,6 m;a=1,311 m; h=0,087 m; x_0=0,55 m; y_0=0,242 m; J=4169 kgm²; $\beta = 15\,grd$;

$\omega \in [0 \div 188{,}5]\ rad/sec$.

- **Characteristic sizes ale of numerical model.**

The what sizes characterizes the dynamic process of the suspended sieve, obtained by-computation, i am:

Dynamics factors: $d_{xx} = 125{,}86\ s^{-1}$;

$d_{x\varphi} = 10{,}95\ m/s^2$; $d_{\varphi x} = 9{,}18\ m^{-1}/s^{-2}$;

$d_{\varphi\varphi} = 290{,}5\ s^{-2}$; $d_{yy} = 572{,}08\ s^{-2}$;

the own throb: $p_a = 11{,}22\ s^{-1}$;

$p_r = 28{,}73\ s^{-1}$; $p_g = 23{,}92\ s^{-1}$;

$p_1 = 12{,}44\ s^{-1}$; $p_2 = 25{,}9\ s^{-1}$; the own vectors: $\mu_1 = 3{,}15$; $\mu_2 = 59{,}4$; amplitudes: $y_0 = x_e = 2{,}42 \cdot 10^{-3}\ m$; $\varphi_e = 1{,}22 \cdot 10^{-3}\ rad$;

constants:

$k_r = 7{,}95 \cdot 10^{-3}$; $k_a = 1{,}2 \cdot 10^{-3}$; $k_1 = 0{,}0122$; $k_2 = 4{,}44 \cdot 10^{-5}$; $k_3 = 0{,}266$;

$k_4 = 0{,}02$; $k_5 = 371{,}4$; $tg\alpha = 0{,}44$; $k_6 = 0{,}36$

The images obtained for the variations of the factors of amplification of laggings is presented the in the figures of hereinafter.

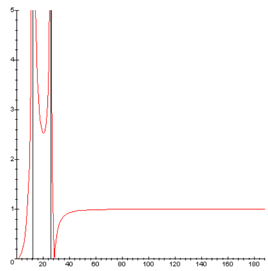

Fig. 3. The variation of the amplification factor -A_a, depending on the throb of excitation. $A_a = f(\omega)$.

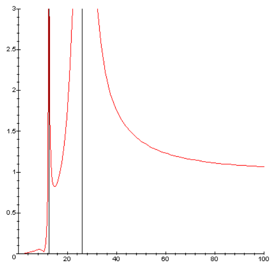

Fig. 4, The variation of the amplification factor -A_r, depending on the throb of excitation. $A_r = f(\omega)$.

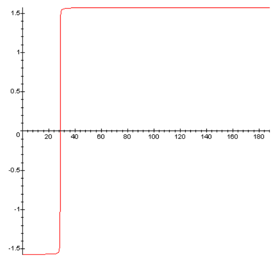

Fig. 5. The laggings variation. $\theta_x = f(\omega)$

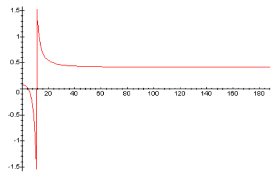

Fig. 6. The laggings variation $\theta_\varphi = f(\omega)$.

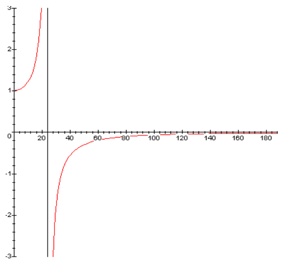

Fig. 7. The variation of the amplification factor - A_g, depending on the throb of excitation $A_g = f(\omega)$.

5. Conclusions.

In abaft study achieved about dynamic behavior of suspended sieve to machine of sorted self-propelled KT 45/18/13, i can formulated next conclusions:

He operates the in rezonance, the area of thing of throb of excitation be far-off of the zones of resonance, carry is placed up to 30 s^{-1}, incite for how much amplitudes the si for phases.

He is good from dynamic viewpoints the phenomena of breach consider of technological due to what causes the object other studies.

Enabled to established an adding employable algorithms for the study altor sieves and to propose solutions of improve dynamic operation through the reorganization pozitionals the suspended sieve on equipment [2].

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