Nat. Volatiles & Essent. Oils, 2021; 8(5): 10763 - 10769

NVEO
Natural Volatiles &
Essential Oils

Periodic volatile modes in the working organ of a cotton purifier

Kholmirzaev Javlonbek Zakirjanovich[1,*], Kuchkorov Sobirjon Karimjonovich[2] and Akbarov Ilhom Gulomjanovich[3]

[1]Candidate of technical sciences, Associate professor, Namangan Engineering Construction Institute, Namangan, Uzbekistan

[2,3]PhD, Namangan Engineering Construction Institute, Namangan, Uzbekistan

Abstract

Compiled dynamic and mathematical models of the movement of volatiles with blows on the grates of the purifier organs. An analytical method has been developed for calculating the periodic regimes of the movement of fumes on a serrated drum with impacts on the grate, conditions and regions of existence and stability of the sought regimes have been found. The law of motion of cotton flyers is constructed for regimes characterized by alternate blows of the flyers against the grates.

Keywords: Dynamic and mathematical models, flywheel, grate, cotton cleaner, batch mode, serrated drum, law of motion of the flywheel

Introduction

A dynamic model is considered, the motion of the fly with impacts on the grate, which allows calculating the conditions for the existence and stability of periodic regimes. [1,2] Vibroimpact is called a system that performs an oscillatory motion, during which collisions occur between its individual links. [3,4,5]

Collisions in kinematic pairs lead to dynamic errors, to an increase in dynamic loads on the links, reduce the durability and reliability of the mechanism, and change its dissipative properties. The conditions for the emergence and elimination of such regimes, the issues of their dynamics and stability are becoming more and more important. [6,7,8]

In [9, 10], a mathematical model of a vibroimpact mechanism is presented, the structure of the phase space is considered, and general formulas for finding the simplest periodic motions are indicated. However, the question of the dependence of the regions of existence of stable periodic and more complex modes of motion on the parameters of the mechanism remains open.

Equations of motion

In the working body, round grates with a beveled flat platform are located along a circle of radius R * and inclined to it at a fixed angle β. Accordingly, the projection on the coordinate axis of the point mass and its velocity in the projection on the axis of the fixed rectangular coordinate system XOY are determined by the relations:

$$\left.\begin{aligned} x &= L\cos\varphi + l\cos(\varphi-\eta) \\ y &= L\sin\varphi + L\sin(\varphi-\eta) \end{aligned}\right\}, \tag{1}$$

$$\left.\begin{aligned} \dot{x} &= -L\dot{\varphi}\sin\varphi - l(\dot{\varphi}-\dot{\eta})\sin(\varphi-\eta) \\ \dot{y} &= L\dot{\varphi}\cos\varphi + l(\dot{\varphi}-\dot{\eta})\cos(\varphi-\eta) \end{aligned}\right\}, \tag{2}$$

Where L is the radius of a serrated drum rotating at a constant angular velocity $\dot{\varphi} = \varphi / t$, l is the average length of the fly, the position of which is determined by the angle γ relative to $L(\eta = \pi - \gamma)$.

Next, the Cartesian coordinate system X1RU1 is introduced, where the PX1 axis is directed along the grate, and RU1 is in the direction of rotation of the serrated drum. Then the projections of the absolute velocity m. A onto the coordinates of this system take the form.

$$\left.\begin{aligned} \dot{x}_1 &= -L\dot{\varphi}\left[tg\lambda \sin(\varphi-\beta) + \cos(\varphi-\beta)\cos\lambda\right] - l(\dot{\varphi}-\dot{\eta})\left[tg\lambda \sin(\varphi-\beta-\eta) + \cos\lambda \cos(\varphi-\beta-\eta)\right] \\ \dot{y}_1 &= -L\dot{\varphi}\left[tg\lambda \cos(\varphi-\beta) - \sin(\varphi-\beta)\cos\lambda\right] + l(\dot{\varphi}-\dot{\eta})\left[tg\lambda \cos(\varphi-\beta-\eta) - \cos\lambda \sin(\varphi-\beta-\eta)\right] \end{aligned}\right\}, \quad (3)$$

Where $\lambda = 2\pi / N$ (N is the number of grates).

Study of the regions of existence and stability of periodic motions of the system

Two phases of impact were considered. In the first phase, a relative convergence of the fly-bar and the grate occurs, ending at the time when the projection of the velocity ý1 onto the axis perpendicular to the grate turns to zero. [11]

In the second phase of the impact, the speed of the fly is restored. Here the hypothesis is accepted that normal impulses in the first and second phases of the impact are related by the ratio

$$J_2 / J_1 = r,$$

Where r is the velocity recovery factor on impact.

The values of the speeds before and after the impact are distinguished by the indices "-" and "+". The change in velocity occurs because of the normal shock impulse J and the tangent $J_f = J \cdot f \ \sin \ \dot{x}_1$, where f is the dry friction coefficient. From the condition ý1 = 0 we find at this moment of time.

$$(l\dot{\eta})_* = \dot{\varphi}\left\{ l + \frac{L\left[tg\lambda \cdot \cos(\varphi-\beta) - \sin(\varphi-\beta)\cos\lambda\right]}{tg\lambda \cdot \cos(\varphi-\beta-\eta) - \sin(\varphi-\beta-\eta)\cos\lambda} \right\}, \quad (5)$$

Taking into account that in the first phase of the impact ẋ1 and, therefore, J changes sign to the opposite, we will consider two intervals in this phase, the boundary between which is to wake up ẋ1 = 0.

From the impulse theorem for the first interval of the first impact phase, we obtain

$$J_1' = \frac{m(l\dot{\eta}) -}{\Phi_1(\lambda,\ \varphi, \beta, \eta) + f\Phi_2(\lambda, \varphi, \beta\ \eta)}, \quad (6)$$

where

$$\Phi_1(\lambda,\ \varphi, \beta, \eta) = tg\lambda \cos(\varphi-\beta-\eta) + \cos\lambda \sin(\varphi-\beta-\eta),$$

$$\Phi_2(\lambda,\ \varphi, \beta, \eta) = tg\lambda \sin(\varphi-\beta-\eta) + \cos\lambda \cos(\varphi-\beta-\eta)$$

Based on the momentum theorem for the second interval, we find

$$J_1'' = -\frac{m(l\dot{\eta})_*}{\Phi_1(\lambda, \varphi, \beta, \eta) - f\Phi_2(\lambda, \varphi, \beta, \eta)} \qquad (7)$$

Here the value is determined from the formula (5)

The total normal impulse is determined by the formula

$$J_1 = J_1' + J_1'' \qquad (8)$$

The impulse theorem for the second phase of the impact gives

$$m = [(l\dot{\eta})_* - (l\dot{\eta})_+] = rS_1[\Phi_1(\lambda, \varphi, \beta, \eta) - f\Phi_2(\lambda, \varphi, \beta, \eta)], \qquad (9)$$

Substituting (8) into (9), we find

$$(l\dot{\eta})_+ = -r(l\dot{\eta})_- \frac{\Phi_1(\lambda, \varphi, \beta, \eta) - f\Phi_2(\lambda, \varphi, \beta, \eta)}{\Phi_1(\lambda, \varphi, \beta, \eta) + f\Phi_2(\lambda, \varphi, \beta, \eta)} + (1+r)(l\dot{\eta})_* \qquad (10)$$

Using the fitting method, we find the law of motion for modes characterized by successive strikes against the grate. Let us write the differential equations of the relative motion of the fly in the form:[12]

$$\ddot{S} + p^2 S = 0, \qquad (11)$$

The boundary conditions for the sought mode have the form

$$\left.\begin{array}{l} t = 0, \quad S = S_0, \ \dot{S} = \dot{S}_+ = (l\dot{\eta})_+; \\ t = T = \dfrac{2\pi}{N} \cdot \dfrac{L+l}{L\dot{\varphi}}, \quad S = S_0, \ \dot{S}_- = (l\dot{\eta})_- \end{array}\right\}, \qquad (12)$$

Where η is the angular coordinate that determines the position of the end of the cotton bat in a relatively rotating drum; p-natural frequency of oscillations of the flywheel, s-1; ή + - angular velocity before impact, a ή - = - ή + - angular velocity after impact; T-period of periodic regimes of collision of the fly with the grate, characterized by the constancy of the angular coordinate of the collision η0.

Taking into account the boundary conditions at t = 0, the solution to equation (11) has the form:

$$S = S_0 \cos pt + \frac{(l\dot{\eta})_+}{p} \sin pt, \qquad (13)$$

After imposing the boundary conditions at t = T, we find

$$S_0 = -\frac{(l\dot{\eta})_-}{p} ctg \frac{pT}{2}, \quad (l\dot{\eta})_- = (l\dot{\eta})_+, \qquad (14)$$

Based on the existence of periodic modes, the angular coordinate S0, taking into account the translational motion and the vanishing of the absolute velocities upon collision, will be determined from the equation

$$S_0 = \frac{(1+r)}{p(1-r)}\dot{\varphi}\left\{l + \frac{L\left[tg\lambda\cos(\varphi-\beta) - \sin(\varphi-\beta)\cos\lambda\right]}{tg\lambda\cos(\varphi-\beta-\eta) - \sin(\varphi-\beta-\eta)\cos\lambda}\right\}ctg\,\frac{pT}{2}, \tag{15}$$

From equation (11) under condition (12), the law of variation S = S (t) during one period is determined by the following relation

$$S = S_0\,\frac{\cos p(t-T/2)}{\cos(pT/2)},$$

where S without regard to the friction force (f = 0) has the form (10)

$$\eta_+ = -r\dot{\eta}_+\,\frac{\Phi_1(\lambda,\,\varphi,\beta,\eta) - f\Phi_2(\lambda,\,\varphi,\beta,\eta)}{\Phi_1(\lambda,\,\varphi,\beta,\eta) + f\Phi_2(\lambda,\,\varphi,\beta,\eta)} + (1+r)\dot{\eta}_*$$

here $\Phi_1(\lambda, \phi, \beta, \eta)=tg\lambda \cos(\phi-\beta-\eta)+ \cos\lambda \sin(\phi-\beta-\eta)$,

$\Phi_2(\lambda, \phi, \beta, \eta)=tg\lambda \sin(\phi-\beta-\eta)+ \cos\lambda \cos(\phi-\beta-\eta)$,

In the case under consideration, Eq. (15) admits a set of solutions with respect to η0 under periodic regimes. However, for the existence of such a regime, it is sufficient to determine one value of η0 of the closest to the dynamic equilibrium of the fly (without the presence of grates η = ηg) [13, 14]. In this case, this value will be determined from the equation

$$\frac{1}{\eta-\eta_g} = \frac{KL}{l+\Phi(\beta,\,\varphi(\eta),\eta)},$$

Where

$$\Phi(\,\beta,\varphi,\eta) = \frac{tg\lambda\cos(\varphi-\beta) - \sin(\,\varphi-\beta)\cos\lambda}{tg\lambda\cos(\varphi-\beta-\eta_0) - \sin(\,\varphi-\beta-\eta_0)\cos\lambda};$$

$$K = \frac{Pl(1-r)}{(1+r)L\dot{\varphi}}\,tg\,\frac{PT}{2},$$

An idea of the nature of the existence of a solution with the following data:

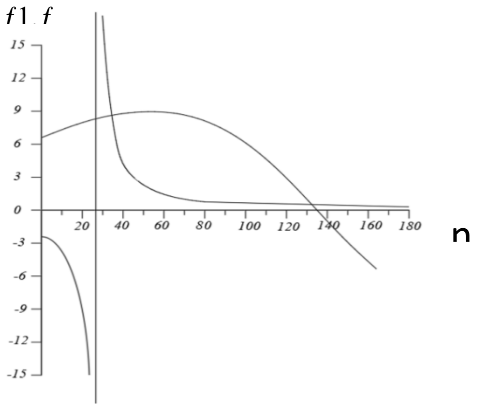
K = 0.3569, P = 204 s-1, λ = 22.5 °, L = 0.24 m, l = 0.022 m, r = 0.23, β = 25 °, η0 = 8.0947 °, ηg = 27 ° can be obtained from Fig. 1 ...

1. Determination of the region of existence of periodic regimes

This study was carried out with respect to small perturbations of the phase coordinates of the system. To simplify the presentation, we restrict ourselves to the case f = 0, which retains all the main features of the qualitative picture of stability. [15]

In accordance with (11), we write the equation of the disturbed motion after an arbitrary v-th impact in the form

Figure 1. Determination of the region of existence of periodic regimes



$$\left.\begin{aligned}\eta &= (\eta_0 + \Delta\eta_v)\cos pt + (\dot{\eta}_+ + \Delta\dot{\eta}_+)\frac{\sin pt}{p} \\ \dot{\eta} &= -(\eta_0 + \Delta\eta_v)p\sin pt + (\dot{\eta}_+ + \Delta\dot{\eta}_+)\cos pt\end{aligned}\right\}, \tag{16}$$

where ήv and Δήv + are small increments of the angular coordinate and angular velocity at the moment after the v-th impact. Let us find the increments of the phase coordinates at the next (v + 1) th impact. Substituting in (16) t = T + δv, η = η0 + Δηv + 1, ή = ή_ + Δήv + 1, we obtained after linearization of the equations in perturbations

$$\left.\begin{aligned}\Delta\eta_{v+1} &= \Delta\eta_v \cos pT + \frac{\Delta\dot{\eta}_v}{p}\sin pt + \delta_v\dot{\eta}_- \\ \Delta\dot{\eta}_{(v+1)_-} &= -\Delta\eta_v p\sin pT + \Delta\dot{\eta}_{v+}\cos pT + \delta_v p^2\eta_0\end{aligned}\right\}, \tag{17}$$

Denoting the angle between the grate attachments around the circumference of the radius L + l through λ, based on the collision condition, we will have (L+*l*)λ=S*+(L+*l*) $\dot{\varphi}$ ·t where is the angular speed of the portable movement of the drum.

If you put this expression in place, then you can define

$$\delta\nu = \frac{L\sin^2\eta\left(1 - \frac{L\cdot\cos\eta}{\sqrt{(L+l)^2 - L^2\sin^2\eta}}\right) - \cos\eta\left(L\cos\eta - \sqrt{(L+l)^2 - L^2\sin^2\eta}\right)}{\dot{\varphi}\sqrt{(L+l)^2 - \left[\sqrt{(L+l)^2 - L^2\sin^2\eta}\sin\eta - L\cos\right]^2}(L+l)}\delta\eta,$$

Let's get the connection between the increment of angular velocities before and after impact

$$\Delta\dot{\eta}_{v+} = -r\Delta\dot{\eta}_{v-} - B\Delta\eta_v,$$

where

$$B=(1+r)\left\{\frac{-\dot{\varphi}L(P_1(\beta,\eta)P_2(\beta,\eta)-P_3(\beta,\eta)P_4(\beta,\eta)\left(L\sin^2\eta\left(\frac{L\cos\eta}{1-P_5(\beta,\eta)}\right)-\cos\eta(L\cos\eta-P_5(\beta,\eta)\right.}{l(P_1(\beta,\eta))^2\dot{\varphi}\sqrt{(L+l)^2-(P_5(\beta,\eta)\sin\eta-L\cos\eta)^2}}\right.$$

$P_1(\beta,\eta)=tg\lambda\cos(\beta+\eta)+\sin(\beta+\eta)\cos\lambda;$ $P_2(\beta,\eta)=tg\lambda\sin\beta-\cos\beta\cos\lambda;$

$P_3(\beta,\eta)=tg\lambda\cos\beta+\sin\beta\cos\lambda;$ $P_4(\beta,\eta)=tg\lambda\sin(\beta+\eta)-\cos(\beta+\eta)\cos\lambda;$

$P_5(\beta,\eta)=\sqrt{(L+l)^2-L^2\sin^2\eta}$

Using the impulse theorem before and after impact, we obtain the relation

$$(l\dot{\eta})_+=-r(l\dot{\eta})_-\frac{\Phi_1(\lambda,\varphi,\beta,\eta)-f\Phi_2(\lambda,\varphi,\beta,\eta)}{\Phi_1(\lambda,\varphi,\beta,\eta)+f\Phi_2(\lambda,\varphi,\beta,\eta)}+(1+r)(l\dot{\eta})_*, \quad (18)$$

Here $\dot{\eta}_+=-\dot{\eta}_-$

$$\dot{\eta}_*=\dot{\varphi}\left\{1+\frac{L[tg\lambda\cos(\dot{\varphi}t-\beta)-\sin(\dot{\varphi}t-\beta)\cos\lambda]}{l[tg\lambda\cos(\dot{\varphi}t-\beta-\eta)-\sin(\dot{\varphi}t-\beta-\eta)\cos\lambda]}\right\}$$

Taking into account the indicated relations, system (21) goes over to the following

$$\frac{2\Delta\eta_{v+1}}{1-r}-\Delta\eta_v\left[\frac{1+r}{1-r}+\cos pT-\frac{B}{P}\sin pT\right]+\Delta\dot{\eta}_{v-}\frac{r}{p}\sin pT=0$$

$$\Delta\eta_{v+1}\frac{1+r}{1-r}pctg\frac{pT}{2}\Delta\eta_v\left[\frac{1+r}{1-r}pctg\frac{pT}{2}p\sin pT-B\cos pT\right]+\Delta\dot{\eta}_{(v+1)\_}+\Delta\dot{\eta}_{v-}r\cos pT=0$$

The characteristic equation of which has the form:

$$2x^2-x\left[(1+r)^2+(1-r)^2\cos pT-(B/p)(1-r)\sin pT\right]+2r^2=0$$

According to the Schur criterion, the following inequalities must be fulfilled in order to comply with the stability condition

$$r^2\prec 1,\quad \frac{\left|(1+r)^2+(1-r)^2\cos pT-(B/p)(1-r)\sin pT\right|}{2(1+r^2)}\prec 1, \quad (19)$$

For the found value of B for various input parameters β, λ,, η, a PC program was compiled and implemented, on the basis of which the zones of stability of periodic modes were identified. [16,17].

REFERENCES

B.M.Mardonov, Kh.S.Usmanov, FN Sirozhiddinov Theoretical study of the process of separating small trash impurities from cotton wool. "Problems of textiles" scientific and technical journal 2019, No. 4, p.411.

B.M. Mardonov, Kh.S.Usmanov, F.N.Sirozhiddinov, S.Sh.Tashpulatov, G.I. Makhmudova, M.S. Technology of the textile industry in 2020, No. 2 (386), pp. 79-84.

Vibrations in Technology: A Handbook. T.2. Oscillations of Nonlinear Mechanical Systems, Ed. I.I.Blekhman. - M .: Mashinostroenie, 1979 .-- 351 p.

Metrikin V.S., Shilkov V.A. Existence and stability of modes of motion of a shock vibration mechanism // Izv. universities. Mechanical engineering. 1985. No. 4. P. 98–103.

Zhuravlev V.F. Equations of motion of mechanical systems with ideal one-way connections // Prikl. 1978. T. 42. Issue. 5.p. 781-788.

Kholmirzaev Zh.Z., Kuchkorov S.K., Eksanova S.Sh. Impact - rotational dynamic model of the working body of the cotton cleaner. In the collection: Concepts and models of sustainable innovative development of society. collection of articles on the results of the International Scientific and Practical Conference. Sterlitamak, 2020.S. 137-140.

Kholmirzaev Zh.Z., Akbarov I.G., Abdullaev R.K. Yўl қurilishda foydalaniladigan pneumoғildirakli machinearning rul boshқarmasi va old kўprigining kўrsatkichlarni asoslash. International Scientific Journal. 2016. No. 5-2. p. 8-10.

Inoyatov K.M., Kholmirzaev Zh.Z., Abdullaev R.K. Improving the quality and durability of highways by optimizing technological processes for compaction of asphalt concrete pavements. Science Time. 2016. No. 5 (29). p. 259-264.

Metrikin V.S., Nikiforova I.V. To the theory of vibroimpact system with a crank-connecting rod vibration exciter // Bulletin of the Nizhny Novgorod University, 2010, No. 5 (1) p.185-192

Metrikin V.S., Nikiforova I.V. Dynamics of two piston vibroimpact mechanism // Mathematics. A computer. Education: Sat. scientific papers. Volume 2 / Ed. G.Yu. Riznichenko and A.B. Rubin. Moscow – Izhevsk: Research Center “Regular and Chaotic Dynamics”, 2009. pp. 71–77.

Dimentberg M.F. Statistical Dynamics of Nonlinear and Time-Varying Systems. N.Y. etc., Wiley; Taunton: Research Studies Press, 1988. 609 p.

Dimentberg M.F., Iourtchenko D.V. Towards incorporating impact losses into random vibration analyses: a model problem // Probabilistic Eng. Mech. 1999. V. 14. № 4. P. 323-328.

Iourtchenko D.V., Dimentberg M.F. Energy balance for random vibration of piecewise-conservative systems // J. Sound and Vibrat. 2001. V. 248. № 5. P. 913-923.

Bolotin V.V. Random vibrations of elastic systems. Moscow: Nauka, 1979.335 p

Feygin M.I. Forced oscillations of systems with discontinuous nonlinearities. Moscow: Nauka, 1994.285 p.

Babitsky V.I. Theory of vibroimpact systems. Moscow: Nauka, 1978.352 p.

Babitsky V.I., Krupenin V.L. Oscillations in highly nonlinear systems. Moscow: Nauka, 1985.320 p.