## 5.2. TEXTILE AND POLYMERIC MATERIALS

### 5.2.1 DYNAMICS OF ULTRASONIC OF TECHNOLOGICAL SYSTEMS

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Working process of ultrasonic technological machine [1, 2] carried out by a working organ, which except for shape-generating motion of serve in relation to the processed good the high-frequency (to the ultrasound) vibrations of certain direction, frequency and intensity are reported. Ultrasonic technological machines behave to the general class of oscillation machines, however they are distinguished in a separate group on next principal reasons.

The first is determined by the educed numerous experiments by the fundamental features of conduct of materials and environments in the ultrasonic field. These features show up in the radical change of looked after in the experiment of their descriptions of resilient- plastic and reologik properties. So, for example, a dry friction in the area of contact of two surfaces under act of ultrasonic vibration will grow into viscid. At cutting of materials a knife which get ultrasonic vibrations is the substantial diminishing of cutting [3].

The second reason is conditioned by the specific of construction of basic elements of machine, which are cored shake by systems, made, as a rule, from heterogeneous areas and that work in the mode of waveguides. On this account at description of vibrations separate elements are designed by the systems with the up-diffused parameters and described by differential equalizations with the derivatives of part. As such oscillating systems have high good quality, ultrasonic machines can effectively work only in the resonance modes which allow to get sufficient for realization of technological process of amplitude of vibrations of working organ.

Two types of nonlinear effects take place during work of ultrasonic technological machine. The first is related to the mentioned higher looked after change of descriptions of material in the ultrasonic field. These nonlinear effects got explanation by means of nonlinear dynamic descriptions of these

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technological processes. The second type of nonlinear effects is related to reverse influence of technological process on dynamic descriptions of the oscillating system. These effects appear as a result of consideration of dynamics of the system which works on the nonlinear technological loading. As a result the basic parameters of process, putting in the middle speed his flowing, which characterize the productivity of machine, her output-input ratio and efficiency succeeds to be bound to the basic parameters of machine.

On rice. 1 two generalized charts of ultrasonic technological machines are shown. Here 1 is some ultrasonic oscillating system, working organ 2 which co-operates with the technological loading 3, that designs a working process. Charts differ in the method of serve of the system. In a chart on Fig. 1, and a serve is carried out with permanent speed $v$ from the occasion of serve. Such serve will name a kinematics.

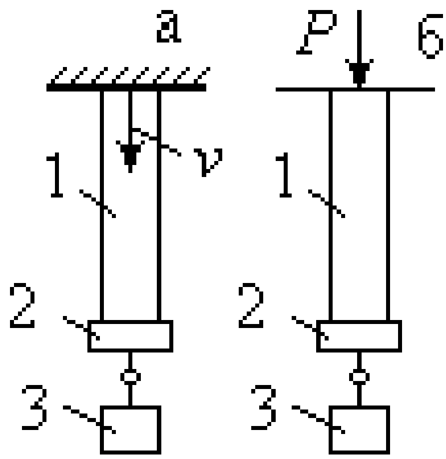


**Fig. 1. Generalized charts of ultrasonic technological machines**

In a chart on Fig. 1, a serve is carried out by permanent force $P$. Such serve will name power. In the end methods differ in that in first case the force $P$ of serve created by an occasion, and in the second is middle speed of process $v$ depend on the parameters of vibrations and dynamic description of process.

The oscillating system is considered linear with the known dynamic descriptions. The technological loading is created as a result of co-operating of working organ with the processed good. Force of co-operation will present as power dynamic description $f = f(u, \dot{u})$ of working process which binds operating on good force of $f$ to moving $u$ and speed $\dot{u}$ of working organ. Examining motions of working organ of kind

$$u(t) \approx vt + u^0(t) = vt + \hat{a}\exp(j\omega t), \qquad (1)$$

where $v$ is middle speed; $u^0(t)$ - periodic to composition of process, $\hat{a}_l$ - complex amplitude of vibrations of working organ.

Will conduct the harmonious linearizing of nonlinear description:

$$f_l(u_l, \dot{u}_l) \approx P_l(v, a_l) + [k(v, a_l) + j\omega b(v, a_l)]u^0 .$$

Here $P(v,a)$ is a permanent constituent of force of co-operation of instrument with good. Coefficients $k(v,a)$ and $b(v,a)$ the equivalent characterize resilient and dissipative constituents of the nonlinear loading and determine influence of technological process on the dynamics of the oscillating system.

The coefficients of linearizing are calculated on formulas:

$$P(v,a) = \frac{1}{T}\int_0^T f\left[u(t), \dot{u}(t)\right]dt, \qquad (2)$$

$$\begin{aligned} k(v,a) &= \frac{2}{Ta}\int_0^T f\left[u(t), \dot{u}(t)\right]\cos\omega t dt; \\ b(v,a) &= -\frac{2}{T\omega a}\int_0^T f\left[u(t), \dot{u}(t)\right]\sin\omega t dt. \end{aligned} \qquad (3)$$

A formula (2) gives connection of permanent component force $P$ of co-operation and speed of $v$ process depending on the parameters of vibrations.

At any method of serve the effect of influence to the ultrasound is arrived at the values of speed of serve $v < a\omega$ and force of serve $P < D$. These results comport with data of experiments. The most effect of decline of static force of cutting is arrived at treatment of hardly-plastic material $k_0 \to \infty$.

Will consider the dynamics of ultrasonic technological machine now. Let the vibrations of working organ of machine in default of the technological loading be known $u^*(t) = \hat{a}^*(\omega)\exp(j\omega t)$, where $\hat{a}^*(\omega)$ is complex amplitude of vibrations on idling. Then oscillation in an operating condition will describe next equalization:

$$u(t) = u^*(t) - L(p)\, f(u, \dot{u}), \qquad (p = \partial / \partial t) \tag{4}$$

where $L(p)$ is an operator of dynamic pliability of the system in the point of action of loading;

Taking into account character of these motions (1), conducting the harmonious linearizing (3) and considering $p = j\omega$, for complex amplitude of vibrations of working organ on-loading will get:

$$\hat{a} = \frac{\hat{F}(\omega)}{W(j\omega) + k(v,a) + j\omega b(v,a)}, \tag{5}$$

where $W(j\omega) = L^{-1}(j\omega)$ - dynamic inflexibility is known; $\hat{F}(\omega) = a^*(\omega)W(j\omega)$ - the force over of excitation of the system brought to the working organ.

Coefficients $k$ and $b$ it is possible to present in a kind:

$$k(v,a) = \frac{D\omega}{\pi v} K\left(\frac{v}{a\omega}\right) \quad , \quad b(v,a) = \frac{D}{\pi v} B\left(\frac{v}{a\omega}\right) \tag{6}$$

In any case equalization for being of amplitude of vibrations of working organ comfortably to present in a kind:

$$a\omega = \left| \frac{\omega \cdot F(\omega)}{U(\omega) + k(v, a\omega) + j\left[V(\omega) + \omega b(v, a\omega)\right]} \right|, \tag{7}$$

where $U(\omega) = \operatorname{Re} W(j\omega)$, $V(\omega) = \operatorname{Im} W(j\omega)$.

At most resonance curve coincides with the intersection of skeletal curve lines of maximum amplitudes, equalizations of which look like, :

$$U(\omega) + k(v, a\omega) = 0\,,$$

$$a\omega = \frac{\omega F(\omega)}{V(\omega) + \omega b(v, a\omega)}\,.$$

On the set force $P$ there is a corresponding value of size $(v / a\omega) = C_P$.which gives the corresponding values of sizes $K = K_P$ and $B = B_P$. Now formula (6) for the coefficients of linearizing assume an air :

$$k(a) = \frac{D}{C_P \pi a} K_P;$$
$$b(a) = \frac{D}{C_P \pi a \omega} B_{P,}. \qquad (8)$$

and equalization (7) for amplitude of vibrations of working organ:

$$a = \left| \frac{F(\omega)}{U(\omega) + k(a) + j\left[V(\omega) + \omega b(a)\right]} \right|. \qquad (9)$$

There is a dramatic change of type of resonance curve at exceeding of critical value of force of serve. Thus an output on the resonance mode can be carried out or tightening of vibrations from an area higher frequencies, or by a hard start, revealing to the system additional energy. Continuous striolas are show skeletal curves and that rounds resonance amplitudes.

From the brought general picture over of change of gain-frequency characteristics those difficulties which must be overcame at excitation of the resonance modes by an external action are obvious. Exactly these difficulties and ununderstanding of physical picture of processes, which take place, and are the basic obstacle of practical deployment of ultrasonic technological machines.

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