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Local supply of drugs by a device with impulse excitation

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Introduction

For the purpose of supply of drugs [1, 2, 3, 4] it is possible to use various methods and devices. In the analysed problems it is considered that the supplying element is of a small size, for example having the diameter smaller than 0.5mm. In such cases of the supplying element it may be advantageous to locate the source of excitation outside of the human organism. Here the system of such a type is analysed consisting of the supplying element at one end where the drugs are located and at the other external end the source of excitation is located. The supplied impulse of excitation by the wave deformation reaches the end of the supplying device on which the drugs are located and the drugs are abolished from the supplying element.

The device of the described type is shown in Fig. 1. Here the impulse of electrical voltage is applied to the piezoactuator 1, which excites in the metallic element 2 the wave of longitudinal deformations. The latter wave reaches the drugs 3 and if the impulse is of a sufficient amplitude and of an appropriate shape it separates the drugs from the supplying element in the desired part of the organism 4.

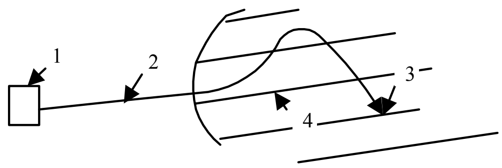

Fig. 1. **The system of supply of the drop of drugs: 1 – piezoactuator, 2 – the supplying element, 3 – the drop of drugs, 4 – organism**

There is no need to analyse the transformation of the impulse of electrical voltage through the piezoactuaror 1 and the supplying device 2 itself and it is sufficient to limit oneself by the analysis of the conditions of separation of the end of the supplying element with the drugs.

Model of the system

For this purpose an approximate model is constructed which is described by the differential equation of the following type:

$$m x_{tt} + \mathrm{F} = 0, \qquad (1)$$

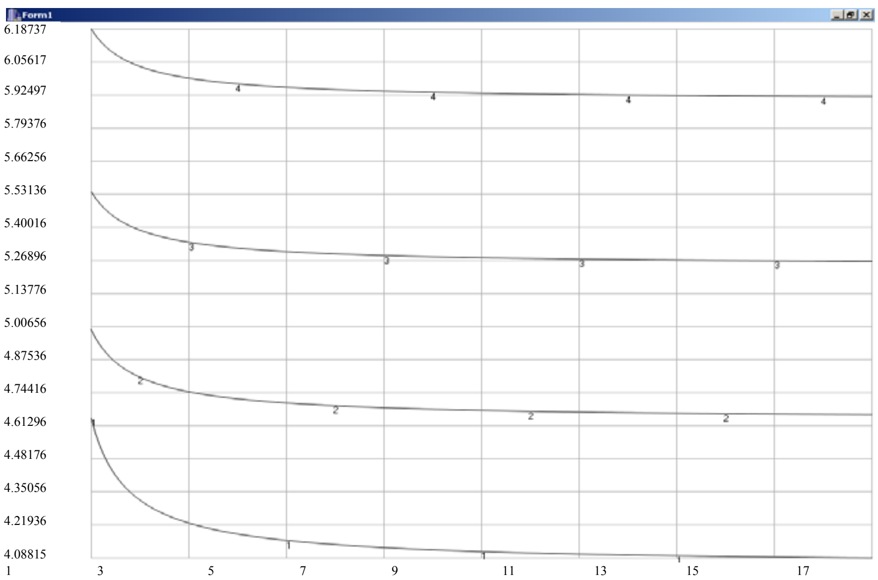

Fig. 2. **The time of separation of the drop of drugs as a function of the amplitude A when 2*h*=0.5, p^2=1 and $T=\pi/2+\pi(i-1)/3$, *i*=1,2,3,4 is the number of the curve**

where:

$$\mathrm{F} = \mathrm{F}(x_t - x_{0t}, x - x_0 - L),$$

when $(x - x_0 - L) < (x - x_0 - L)_k$,

$$0, \text{ when } (x - x_0 - L) >= (x - x_0 - L)_k, \qquad (2)$$

where m is the reduced mass of the drop of drugs, x is the reduced absolute displacement of the drop of drugs, x_0 is the absolute displacement of the end of the supplying element with the drugs, L is the deflection of the coordinate of the drop of drugs from the end of the supplying element x_0 in the status of statical equilibrium, $(x - x_0 - L)_k$ is the position of separation of the drop of drugs from the supplying element.

In the general case:

$$\mathrm{F} = \mathrm{F}_1(x_t - x_{0t}) + \mathrm{F}_2(x - x_0 - L), \qquad (3)$$

where F_1 and F_2 are nonlinear functions of their own arguments and the impulse of accelerations:

$$x_{0tt} = \mathrm{F}_{x0}(t) \qquad (4)$$

is a given function of the time, for example in the case of the impulse of harmonic shape:

$$x_{0tt} = A \sin \pi t / T, \text{ when } t \in (0,T),$$

$$0, \text{ when } 0 > t > T. \qquad (5)$$

The main characteristics of the system are the impulse of accelerations of x_0, and the time of separation of the drop of drugs t_a.

According to Eq. 5:

$$(x_{0t})_{t=\mathrm{T}} = 2AT / \pi. \qquad (6)$$

The case is analysed when:

$$x_{tt} + F / m = 0, \qquad (7)$$

where:

$$\mathrm{F/m} = 2h(x_t - x_{0t}) + p^2 (x - x_0 - L),$$

when $(x - x_0 - L) < (x - x_0 - L)_k$,

$$0, \text{ when } (x - x_0 - L) >= (x - x_0 - L)_k, \qquad (8)$$

where $2h = H/m$ is the coefficient of the viscous dissipative force, $p = C/m$ is the eigenfrequency, C is the coefficient of stiffness.

According to Eq. 6-8 the graphical relationships of the characteristics are obtained (Fig. 2-5).

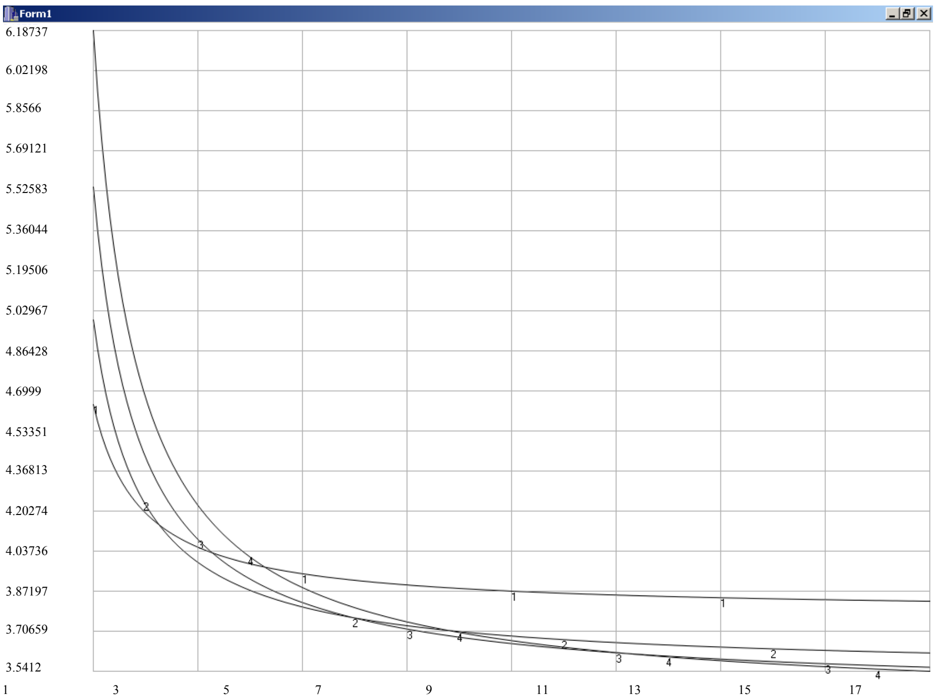

Fig. 3. **The time of separation of the drop of drugs as function of the amplitude A when $2h$=0.5, p^2=1 and $(x_{0t})_{t=T}=2AT/\pi$=const, $AT=\pi/2+\pi(i-1)/3$, i=1,2,3,4 is the number of the curve**

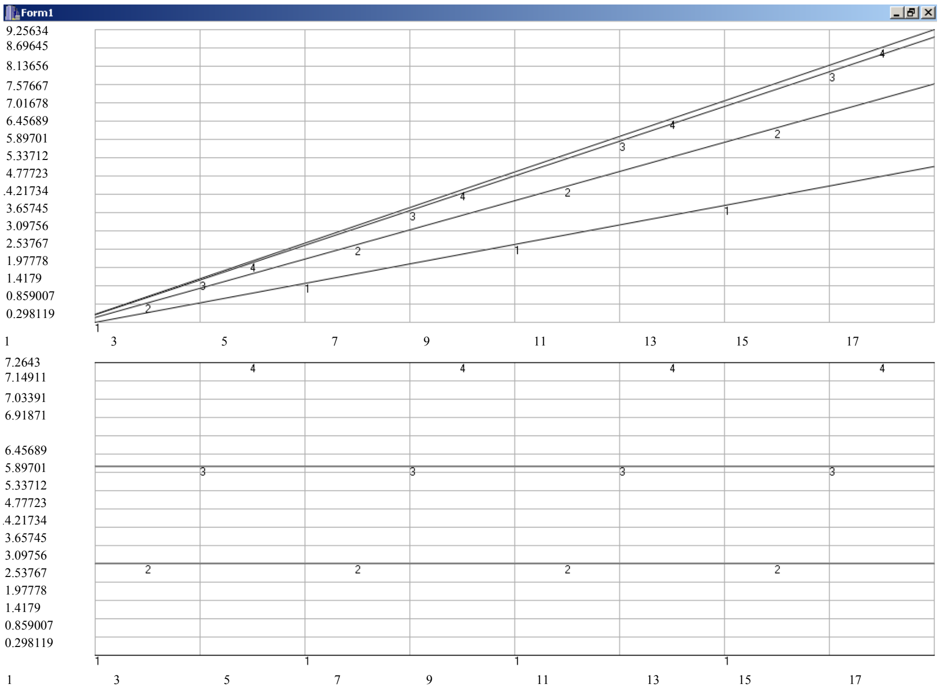

Fig. 4. **Maximum position without taking separation into account as function of the amplitude and the time of the maximum position when $T=\pi/2+\pi(i-1)/3$, i=1,2,3,4 is the number of the curve**

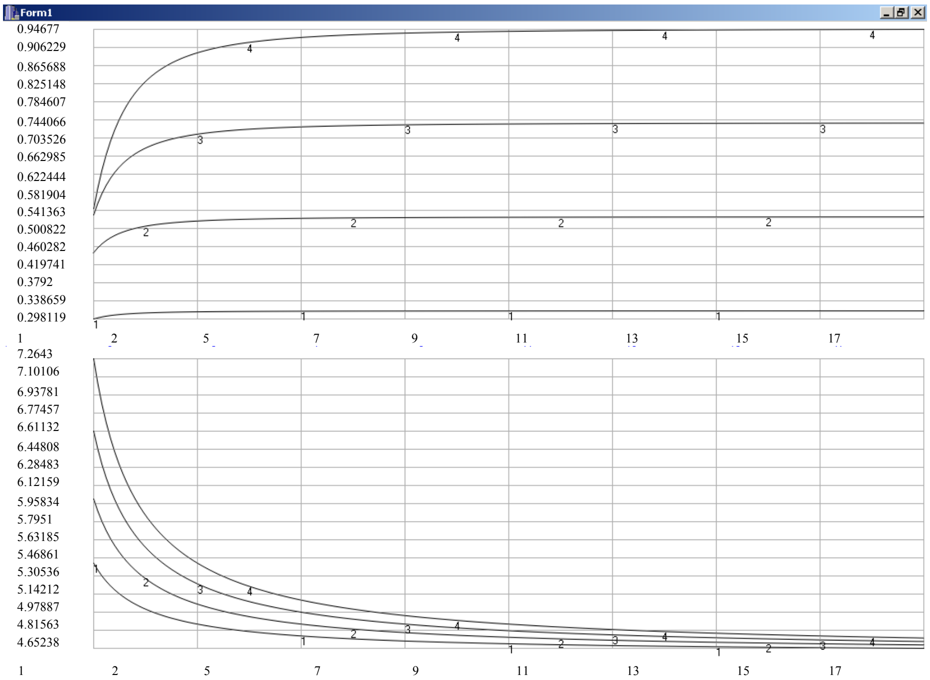

Fig. 5. **Maximum position without taking separation into account as function of the amplitude and the time of the maximum position when $AT=\pi/2+\pi(i-1)/3$, i=1,2,3,4 is the number of the curve**

Conclusions

The supply method of drugs is proposed which is based on the impulse acting to the supplying device by using the piezoactuator from the outside of the human organism. The model of the system is obtained and the main characteristics are determined.

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Lokalinis vaistų dozavimas impulsiškai sužadinamu įtaisu

Reziumė

Straipsnyje aprašomas originalus įtaisas vaistams dozuoti panaudojant aukštojo dažnio virpesių šaltinį. Sudarytas tiekimo ir dozavimo sistemos modelis aprašytas diferencialinėmis lygtimis. Grafine forma pateiktos teorinės pagrindinės sistemos charakteristikos ir išvados.

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