Technical science and innovation

Volume 2020 | Issue 2 Article 11

5-20-2020

SOLUTIONS OF THE PROBLEM OF RANDOM VIBRATIONS IN HEREDITARY-DEFORMABLE SYSTEMS USING IMPULSIVE FUNCTIONS

Inobat Xaldibayeva
Tashkent State Technical University, aqobil1995@mail.ru

Recommended Citation
Xaldibayeva, Inobat (2020) "SOLUTIONS OF THE PROBLEM OF RANDOM VIBRATIONS IN HEREDITARY-DEFORMABLE SYSTEMS USING IMPULSIVE FUNCTIONS," *Technical science and innovation*: Vol. 2020: Iss. 2, Article 11.
DOI: https://doi.org/10.51346/tstu-01.20.2-77-0054
Available at: https://btstu.researchcommons.org/journal/vol2020/iss2/11

10. Kafarov, V.V. Meshalkin, V.P. Analysis and synthesis of the chemical-technological systems: textbook for the universities / V.V. Kafarov, - Moscow: Chemistry, 1991. - P – 432 (in Russian).
12. Verdian, M.A. Fundamentals of the cybernetic approach to the study of the cement materials grinding processes / V.V. Kafarov, // Cement. - 1976. - №4. - Pages – 4-5 (in Russian).
13. Kafarov V.V. System analysis of chemical technology processes. Crushing and mixing processes of the bulk materials / V.V. Kafarov, I.N. Dorokhov, S.Yu. Arutyunov. - Moscow: Nauka, 1985. - P – 440 (in Russian).
14. Artamonov, A.V. Properties of cement ground on the centrifugally shock mill. // Building materials and products: inter-university collection of scientific articles. - Magnitogorsk: MSTU, 2000. - Pages – 144-149 (in Russian).
15. Denisov D.G. Simulation of the crushing process in the impact crushers. ISEU Bulletin (Ivanovo State Energy University). Vol - 2 2006 y.
16. Artikov A., Akobirova L., Djurayev H. Multistage thinking about modeling the object of a cone shredder. Scientific and Technical Journal. Development of Science and Technology No. 5, Bukhara, 2019. - Pages – 193-199 (in Russian).

UDK 539.3

SOLUTIONS OF THE PROBLEM OF RANDOM VIBRATIONS IN HEREDITARY-DEFORMABLE SYSTEMS USING IMPULSIVE FUNCTIONS

A.Abdukarimov[1], I.T. Xaldibayeva[1], E.N.Gribanov[2]

1*Tashkent State Technical University named after I.Karimov*

[2]*Department of Mathemathics, KuzSTU, Kuzbass city, Russia*

Abstract. *In recent years, probabilistic-statistical methods for studying various problems of mechanics of solid deformable bodies are being applied more than ever.*

The principal part of its field of application is the development of a general theory of strength and a hereditarily deformed solid. As known, the theory of random oscillations is increasingly being used in technology.

Current research is aimed to present a numerical-analytical approach for studying the dynamic response of a hereditarily deformable system to unsteady input influences.

It is established that the dynamic reaction of hereditarily deformable systems to an arbitrary form of random perturbations can also be represented as the Duhamel integral if the impulse transition function satisfies special Cauchy problems for the integro-differential equation (IMU).

A study proposes an accurate analytical solution to the IMU of an impulsive transition function in existing weakly singular Rzhanitsyn-Koltunov nucleuses.

Key words: *step function, integro-differential equation, impulsive transient function, dynamic coefficient, frequency, degree of freedom, vibration, friction.*

Among the wide variety of dynamic statistical problems of mechanics of solid deformable bodies, an important role is dedicated to the tasks and reactions of hereditarily deformable systems to random dynamic external influences. This work is aimed to present a numerical-analytical approach for studying the dynamic reaction of a hereditarily deformable system to unsteady input influences.

The reaction of a physical system to a unit step function, as is known [1, 2], is called the transitional conductivity of the system *A(t).* We find the reaction of a linear hereditarily deformable system to a unit step function. Consider the integral differential equation (IDE)

$$\ddot{y}(t) + p^2(1 - R^*)\, y(t) = I(t) \qquad (1)$$

with the initial conditions

$$y = \dot{y}(t) = 0 \text{, for } t = 0 . \qquad (2)$$

here

$$R^* y(t) = \int_0^t R(t-\tau)\, y(\tau) d\tau ,$$

where $R(t)$ is a weakly singular Abel-type heredity kernel, i.e.

$$R(t-\tau) = c\, e^{-\beta(t-\tau)} (t-\tau)^{\alpha-1} \qquad c > 0, \quad \beta > 0, \quad 0 < \alpha < 1 .$$

According to the method of fundamental system of solutions [3], the general solution of the IDE (1) has the following form

$$y(t) = \frac{1}{p^2} + c_1 y_1(t) + c_2 y_2(t) . \qquad (3)$$

here

$$y_1(t) = \cos pt + c\phi\, pt, \qquad y_2(t) = \sin\, pt + s\phi\, pt$$

Where $c\phi\, pt$ and $s\phi\, pt$ are functions of the cosine and sine of fractional order accordingly [4]

$$y_2(t) = p\int_0^t y_1(\tau) d\tau \qquad (4)$$

Using the initial conditions (2) we obtain

$$A(t) = y(t) = \frac{1}{p^2}\left[\Pi(t) - \frac{d}{dt}\int_0^t \Pi(t-\tau)\, y_1(\tau) d\tau\right] I(t) , \qquad (5)$$

where $\Pi(t) = 1 + \int_0^t K(\tau) d\tau$ is a creep function. In case of perfectly elastic system $K(t) = 0, \quad c\phi\; pt = 0$ and formula (5) will transform as follows:

$$A(t) = y(t) = \frac{1}{p^2}(1 - \cos pt) I(t) \qquad (6)$$

The shift of the perfectly elastic system with a static application of the load is equal $1/p^2$ when $\cos pt = -1$ (see Fig. 1), i.e. when the shift from the application of the step load is $2/p^2$.

$$\frac{1}{p^2}\left[\Pi(t) - \frac{d}{dt}\int_0^t \Pi(t-\tau) y_1(\tau) d\tau\right]$$

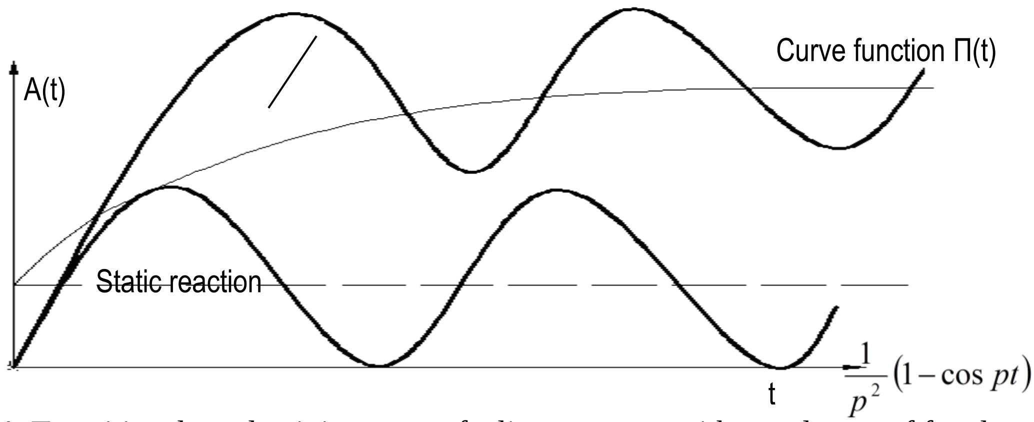

Fig. 1. Transitional conductivity curve of a linear system with one degree of freedom

Thus, a unit step function causes a cast equal to two, i.e. the dynamic coefficient in the elastic case is $\lambda = 2$.

The great importance of the analysis of vibrational systems is devoted to the response of the system to a δ-function, which can be considered as a derivative of a unit step function. The response of the system to the δ-function is called the pulse transition function $h(t)$. For example, consider an equation which has the formulae:

$$\left.\begin{aligned} &\ddot{y} + p^2(1-R^*)y = \delta(t), \\ &y = \dot{y} = 0 \ \text{при} \ \ t \le -\varepsilon \ (\varepsilon > 0). \end{aligned}\right\} \tag{7}$$

By integrating equation (7) from –ε to ε, where ε – is small number, we get

$$\int_{-\varepsilon}^{\varepsilon} \frac{d^2 y}{dt^2} dt + p^2 \int_{-\varepsilon}^{\varepsilon} (1-R^*)\, y dt = 1. \tag{8}$$

The first integral can be transformed as follows:

$$\int_{-\infty}^{\varepsilon} \frac{d}{dt}\left(\frac{dy}{dt}\right) dt = \int_{-\varepsilon}^{\varepsilon} d\left(\frac{dy}{dt}\right) = \frac{dy}{dt}\Big|_{-\varepsilon}^{\varepsilon} = \left(\frac{dy}{dt}\right)_{t=\varepsilon},$$

since $\left(\frac{dy}{dt}\right)_{t=-\varepsilon} = 0.$

The second integral (8) tends to zero, since in a area of $t = 0$ y is a finite quantity, i.e. $|y| < M$ ($M > 0$ is constant) and the integral is bounded by $2M\varepsilon,$ which tends to zero in the limit at $\varepsilon \to 0$. Therefore, in the limit, relation (8) takes the form

$$\left(\frac{dy}{dt}\right)_{t=\varepsilon} = 1.$$

Therefore, the original equation (7) will be equivalent to the system of equations

$$\ddot{y} + p^2(1-R^*)y = 0, \quad t > 0, \tag{9}$$

$$y = 0, \ \ \dot{y} = 1, \ \ t = (0+), \tag{10}$$

which has the following solution

$$h(t) = y(t) = \frac{1}{p}\left(\sin\ pt + s\phi\ pt\right). \tag{11}$$

In case of an ideal elastic system:

$$h(t) = y(t) = \frac{1}{p}\sin\ pt$$

The relation between the transition conductivity of the system and the pulse transition function has the following form:

$$h(t) = \frac{d\,A}{d\,t}.$$

If we take into account external friction, that occurs during free oscillations proportional to the speed of movement, then equation (9) takes the form

$$\ddot{y} + 2\,\eta\,\dot{y} + p^2(1 - R^*)y = 0, \tag{12}$$

where η is external damping factor.

Then, according to [3,4], the solution of the IDE (12) under the initial conditions (10) can be written in the form

$$h(t) = y(t) = \frac{1}{\omega_\eta}e^{-\eta t}\left[\sin\ \omega_\eta t + s\phi\,\omega_\eta t\right], \tag{13}$$

where ω_η is natural frequency of an ideal elastic system, calculated with adjustment for the force of external friction,

$$\omega_\eta = \sqrt{p^2 - \eta^2}\ .$$

Note that using the pulse transitions of functions (11) and (13), we can analyze the reaction of both elastic and hereditarily deformable systems to random disturbances. In this case, the reaction of the construction to an arbitrary form of random disturbance $q(t)$ can be represented as the Duhamel integral [2, 5]:

$$y(t) = \int_0^t q(\tau)\,h(t-\tau)d\tau = \int_0^t h(\tau)q(t-\tau)d\tau\,, \tag{14}$$

where $q(t) = 0$ for $t < 0$

$h(\tau)$ is impulse transient function

$h(\tau) = 0$ for $\tau \le 0.$

Thus, using pulsed transient functions, it is possible to determine expectation and moments of the output process; correlation functions; spectral densities, etc. In other words, all methods aimed at solving the problem of statistical dynamics are designed specifically for this method of probable description.

If a random vector function $q(t)$ admits a spectral representation, i.e., it can be represented as a finite or infinite series

$$q(t) = \sum_k a_k\varphi_k(t)\,, \tag{15}$$

where $\varphi_1(t), \varphi_2(t), \ldots$ is a some system of nonrandom functions; $Q_1, Q_2, \ldots$ are random variables. Then, according to formula (14), we have

$$y(t) = \sum_k Q_k \int_0^t h(\tau)\,\varphi_k(t-\tau)d\tau \tag{16}$$

By calculating this integral by the trapezoidal method and using discrete representations of transient impulsive functions obtained from a numerical solution of the IDE (12) by eliminating weakly singular singularities of integral and IDE [3,4], i.e.

$$h_i = \frac{1}{(1+\eta\Delta t)}\left\{ t_\eta - \sum_{j=0}^{i-1} A_j \left[2\eta h_j + p^2 \left(t_i - t_j\right)\left(h_j - \frac{c}{\alpha}\sum_{n=0}^{j} B_n e^{-\beta t_n} h_{j-n} \right)\right]\right\} \quad i = 1,\ 2...\ , \quad (17)$$

where $h(t_i) = h_i,\ \ t_i = \Delta t i,\ \ A_0 = A_i = \frac{\Delta t}{2},\ \ A_j = \Delta t,\ \ j = \overline{1,\ i-1}$

$$B_0 = \frac{(\Delta t)^\alpha}{2},\ \ B_n = \frac{(\Delta t)^\alpha}{2}\left[(n+1)^\alpha - (n-1)^\alpha\right],\ n = \overline{1,\ j-1},\ \ B_j = \frac{(\Delta t)^\alpha}{2}\left[j^\alpha - (j-1)^\alpha\right],$$

It is possible to find numerical solutions to the problem of random oscillations of hereditarily deformable systems by the formulas.

$$y_n = \sum_k Q_k \sum_{i=0}^{n} A_i h_i\, \varphi_{k,\ n-i} \qquad (18)$$

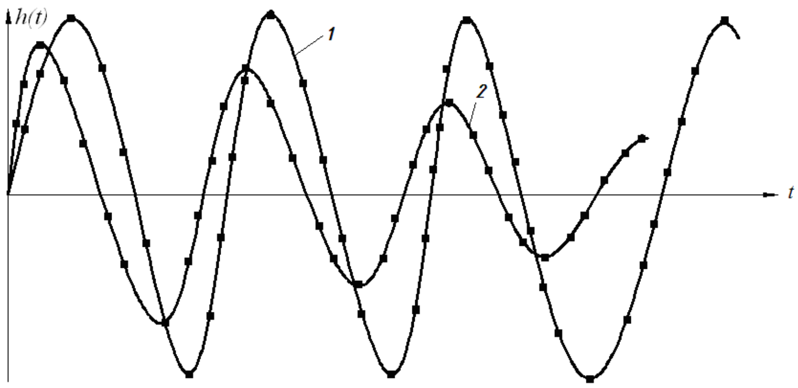

Fig 2. The law of change of the impulsive transition function in time at η=0,05, α=0,25 is an exact solution by formulas (13), … is an approximate solution calculated by formulas (17)

Fig. 2. Presents the law of variation of the impulsive transition function within the time for perfectly elastic (curve 1) = 0 and viscous elastic (curve 2) = 0.1 cases.

Thus, if a random load tolerates spectral representations, then the method proposed above allows numerical solutions to the problem of random vibrations of hereditarily deformed systems.

References

1. Abdukarimov, A. (2004). Application of the method of fundamental systems of solutions to the numerical solution of nonlinear integral differential equations of dynamic problems of hereditarily deformable systems. (in Russian). Problems of Mechanics: A Scientific Journal, 5-6, pp12-14.
2. Abdukarimov, A. (2013). Studies of random vibrations of hereditarily deformed systems. (in Russian). Works of the international scientific and practical conferences dedicated to the 70th anniversary of South Kazakhstan State University named after M. Auezova. pp 44-47
3. Abdukarimov, A. & Shodmanov, G. (2019). The solution of the problem of random oscillations of hereditarily deformed systems with a finite number of degrees of freedom. (in Russian). The problems of science, 4, p40.
4. Badalov, F. B. & Abdukarimov, A. (2004). Fractional-order sine and cosine functions and their application to solving dynamic problems of hereditarily deformable systems. (in Russian). Tashkent: FAN, p155.
5. Badalov, F. B. & Abdukarimov, A. (2007). Random vibrations of linearly distributed hereditarily deformed systems. (in Russian). Reports of the Academy of Sciences of the Republic of Uzbekistan. Publishing house "Fan".

6. Badalov, F. B. & Abdukarimov, A. (2011). The reaction of hereditarily deformed systems to random influences. (in Russian). Publishing house “Fan”.
7. Badalov, F. B. (1987). Methods for solving integral and integro-differential equations of the hereditary theory of viscoelasticity. (in Russian). Tashkent: Mehmat, p267.
8. Badalov, F. B., Abdukarimov, A. & Hudayarov, B. A. (2007). Investigation of the influence of the nucleus of heredity on the solution of linear and nonlinear dynamic problems of hereditarily deformable systems. (in Russian). Problems of mechanical engineering and machine reliability, Moscow, 4, pp31-39.
9. Badalov, F. B., Abdukarimov, A. & Hudayarov, B. A. (2007). A numerical study of the influence of rheological parameters on the nature of oscillations of hereditarily deformed systems. (in Russian). Computing Technologies, 12, pp17-25.
10. Bolotin, V. V. (1979). Random vibrations of elastic systems. (in Russian). M.: Science, p331.
11. Hamada M., Akimoto T. & Izumi A. (1974). Dynamic Stress of submerged Tunnels during Earthquake – 6. WCEE. V.4.
12. Makarevskiy, A. I. (1975). Strength of an aircraft. (in Russian).M.: machinery, p277.
13. Nikolayenko, N. A. (1967). Probabilistic methods for the dynamic calculation of engineering structures. (in Russian). M.: machinery, p365.
14. Shigeo, N & Osami, K. (1975). Observation of the Dynamic Behavior of Kinnaura Submerged Tunnels during Earthquake – 6. WCEE, V.7.
15. Zeldovich Y.B., Myshkis A.D. (1965) Elements of applied mathematics. (in Russian). Science. p615.

UDC:625.7/8

DEVELOPMENT OF A TECHNOLOGICAL IMAGE OF A STONE CRUSHING MACHINE

R. Karimov[1], S.Yadgarov[1], Sh. Abdiqodirov,[1]

[1]*Termez branch of Tashkent State Technical University*

Abstract: *The article explores the structure of the grinding machine, which is a pole to the body, and the disk to the disk with a screwdriver and a toothbrush, and to the shaft with a disc and a screwdriver. On the upper side of the body of the machine is placed an anchor at an inclined angle. The tooth is used as a working element and can be adjusted using a rack in the process of researching the disc. We also paid attention to the creation of a machine: the analysis of scientific resources in this area, the technological process being studied in a laboratory setting. The following research has been carried out to develop a model of stone crusher model and some of its dimensions: an overview of the existing technology of building work, the study of some properties of stones, the optimal methods of building work, the diameter and weight of stone. The technological process of the machine is studied; the performance of the new machine is calculated. Experimental tests have shown that the total crushing of a machine with a 2.0-fold increase compared to existing machines will increase by 2.0 times. Thus, based on the results of our preliminary experiments, we came to the following conclusions: The creation of a grinding machine allows for the shortest period of construction work. Unless the creation of a crushing machine does not require the creation of precious stone crushers.*

Keywords: *Stone, machine, body, tooth, work authority, the holder of the tooth and disk.*

Introduction: In a number of speeches, the President pays special attention to the development and monitoring of the projected parameters of the mining, construction and road construction programs. Further development of mining, construction and a wide network of highways in the