Computer modelling of dynamics of the thread in technological process

To cite this article: Aziza Adizova *et al* 2022 *J. Phys.: Conf. Ser.* **2373** 022060

Computer modelling of dynamics of the thread in technological process

Aziza Adizova[1], Gulara Abdieva[2] and Tulkin Mavlanov[3]

[1]Bukhara Engineering Technological Institute, Bukhara, Uzbekistan
[2]Regional center for retraining and advanced training of public education workers of the Tashkent region, Tashkent, Uzbekistan
[3]Tashkent Institute of Engineers of Irrigation and Agricultural Mechanization, Tashkent, Uzbekistan

E-mail: aziza_adizova@mail.ru

Abstract. The article covers the technology of computer modeling of technological processes on example of the research of transverse oscillations of the thread in weaving process. During the formation of the fabric, various dynamic processes took place, including fluctuations in the threads. As an example, the longitudinal oscillations and tension of the threads in the process of surf on a loom are considered. The program and the results of the calculation are given using the software package "Mathcad".

1. Introduction

Any other object that fully or partially matches the original characteristics of individual properties is a physical model. Since this model is expensive or inconvenient, it cannot be carried out on a real object, this model is created only for research. The main goal of creating models is:

- to determine whether variables are related to each other, the laws of change in quantities associated with variables over time. Alternatively, dependencies directly related to its performance are defined in the equations;
- to be able to anticipate its movement and control different movements by experimenting with various motion control options in the considered model;
- using models to determine the best options for the interdependence of parameters and the best mode of operation [1].

Computer model is a software expression of a mathematical model filled with programs designed to perform various tasks. The computer model is the representation in the computer when the properties of the physical model, i.e. the indefinite components, are represented by programs [2]. Computer model is not only a program, but also an integral part of experimental stands and virtual laboratories as a material device. Computer modeling is very convenient for changing mathematical models without much difficulty, and high-precision results can be obtained using computer modeling. [3].

2. Materials and methods

Let us consider a mechanical system consisting of threads and parts of a loom. In this case, during the formation of the fabric, various dynamic processes occur, including vibrations of the threads, in particular, longitudinal and transverse vibrations. Longitudinal vibrations are described by second-order equations, and transverse vibrations are described by a fourth-order differential equation, respectively:

$$A_1 \frac{\partial^2 u}{\partial x^2} + A_2 \frac{\partial u^2}{\partial t^2} + A_3 u = F_1(x,t), \quad (1)$$

$$B_1 \frac{\partial^4 w}{\partial x^4} + B_2 \frac{\partial^2 w}{\partial x^2} + B_3 w = F_2(x,t) \quad (2)$$

After applying the method of separation of variables, equation (1) is reduced to ordinary differential equation with respect to time:

$$\frac{d^2 y}{dx^2} + k^2 y = f(t) \quad (3)$$

With a number of assumptions (linearity of the restoring force, absence of a disturbing force, a certain relationship between the m, a, k parameters), a simplified mathematical model can be used [4]

$$x(t) = A\sin(kt + \alpha) \quad (4)$$

Using (4), the solution of a less complicated differential equation (4) is written in explicit form. For the mathematical models (4), (3), a computer model can be created. Figure 2 shows a model created using the «Mathcad».

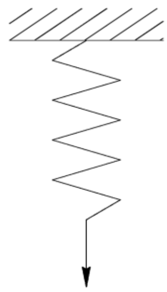

Figure 1. Vibration of the thread

Mathematical model 1;

$$m\frac{d^2 y}{dt^2} + k^2 y = f(x,t)$$

Mathematical model 2;

$$y = A\sin(kt + \alpha$$

Physical model;

$$y = \begin{bmatrix} 0 \\ 0 \end{bmatrix};$$

$$D(t,x) = \begin{bmatrix} y \\ -k^2 \cdot y + 50 \cdot \sin(0{,}05t) \end{bmatrix};$$

$$z = rkfixed(y, 0.100{,}400, D);$$

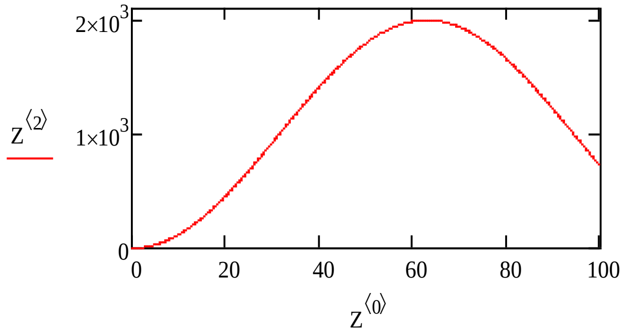

Figure 2. Computer modeling.

The process of building and research the computer models is called a computational experiment. For this, the following steps are needed [5]:

- Highlight the essential properties of the objects under consideration
- Debugging a computer model
- Assessment of the adequacy of model constructed
- Research the model
- Analysis of obtained results

As an example, we consider the longitudinal oscillations and tension of the threads during the surf on a loom [6]. We consider that one end of the thread is fixed on a rock, and impact is made on the other end. Let the end of the main thread at the edging be connected with the reed, so the speed of this end during the surf is equal to the speed of the reed, and this speed can be considered linear $v = v_0 - \beta t$, where $\beta = v_0 / t_{\text{ïð}}$; $t_{\text{ïð}}$ is surf time. In contrast to [7], we will consider the thread to be viscoelastic [8]. Then the integral-differential equation of motion of the thread will be written as follows:

$$\frac{1}{a^2}\frac{\partial^2 u}{\partial x^2} = \frac{\partial^2 u}{\partial t^2} + \frac{1}{a^2}\int_0^t F(t-\tau)\frac{\partial^2 u}{\partial x^2}d\tau, \quad \frac{\partial u}{\partial x} = 1 + \alpha[T - \int_0^t G(t-s)u(s)ds]$$

Boundary and initial conditions must be added to this system of equations:

$$u(0,t) = 0, \; u(l,t) = v_0 t - 0.5\beta t^2, \; u(x,0) = 0, \; \dot{u}(x,0) = 0 \text{ at } 0 \le x < l \text{ and } \dot{u}(x,0) = v_0$$

at $x = l$.

Therefore, the mathematical model of the task has been built, and now we need to write a program that implements it [9].

The program and calculation results are shown in Figure 3. In this case, the software package "Mathcad" has been used.

$$v_0 = 2; \; b = 3; \; a = 3; \; l = 12; \; \omega_s = 25; \; \varepsilon = 0{,}5; \; \alpha = 2; \; k = 1,2,\dots,10;$$

$$x = 2; \; t = 2;$$

$$b(k) = \sqrt{\alpha \cdot \mu} \cdot \beta \cdot \frac{l}{k \cdot \pi};$$

$$p(k) = \pi \cdot \frac{k}{l \cdot \sqrt{\alpha \cdot \mu}};$$

$$a(k) = \frac{(-1)^k}{k^2};$$

$$u_1(x,t) = 2 \cdot \sqrt{\alpha \cdot \mu} \cdot \frac{l}{\pi^2};$$

$$u_2(x;t) = \exp(-0{,}5 \cdot \varepsilon \cdot \omega_s \cdot \lambda n \cdot t;$$

$$u_3(x;t) = (-1)^n \cdot 2 \cdot b \cdot l^2 \cdot (\cos(l - 0{,}5 \cdot \varepsilon \cdot \omega_s) \cdot \lambda n \cdot t) \cdot (a^2 \cdot \pi \cdot n)^{-3};$$

$$u_4(x;t) = (-1)^n \cdot 2 \cdot v_0 \cdot b \cdot l^2 \cdot (\cos(l - 0{,}5 \cdot \varepsilon \cdot \omega_s) \cdot \lambda n \cdot t) \cdot (a^2 \cdot \pi \cdot n)^{-3};$$

$$u(x,t) = u_1(x,t) + \sum_{n=1}^{100} [(u_2(x,t) \cdot (u_3(x,t) - u_4(x,t)) \cdot \sin(\lambda n \cdot a^{-1} \cdot x)];$$

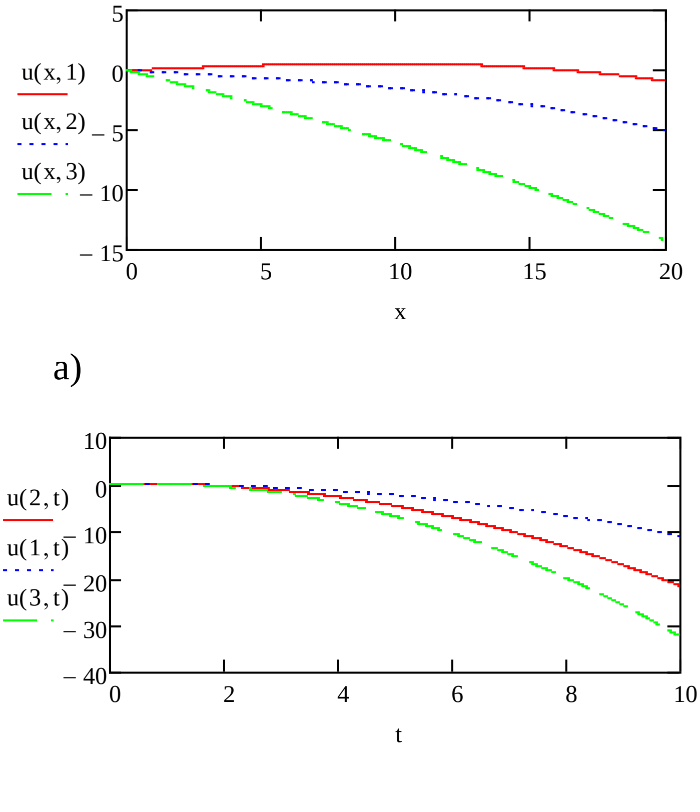

Figure 3. Changes in displacement components: a) changes in displacement depending on x; b) changes in displacement depending on t;

The expected result can be obtained by trying several experiments or models several times [10]. Our main goal is parametric optimization of initial values. A separate run of the model is used to solve this problem. Several parameter values included in the equations of motion are achieved by optimizing algorithms [11]. Numerical experiments of input parameters are achieved by assigning different values to these parameters [12].

3. Results and discussion

In this case, it consists in determining the special values of the coefficients that improve the quality of the behavior of the model [13]. To this end, let us consider the analysis of numerical results (Figure 3-5). Figure 3 shows a graph of changes in time for different values of the initial voltage. In this case, the lower curve corresponds to the initial tension value $T_0 = 2$, the middle one corresponds to $T_0 = 4$ and the upper one $T_0 = 6$. Similar curves are shown in Figure 4. In this case, the values of the initial speed varied from 0,2 to 1,2 m/s. The results show that the value of the initial speed of the thread should not exceed 1,2 m/s.

The nature of the change in tension depending on the x coordinate is shown in Figure 5. In this case, as in the previous example, the curves are plotted for different values of the initial speed, and the time is fixed [14].

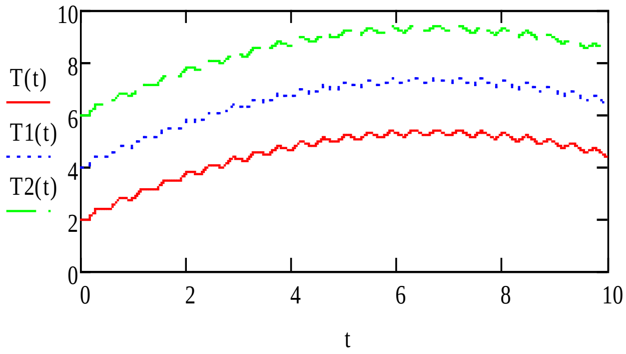

Figure 4. Changes in thread tension depending on time for different values of the initial tension.

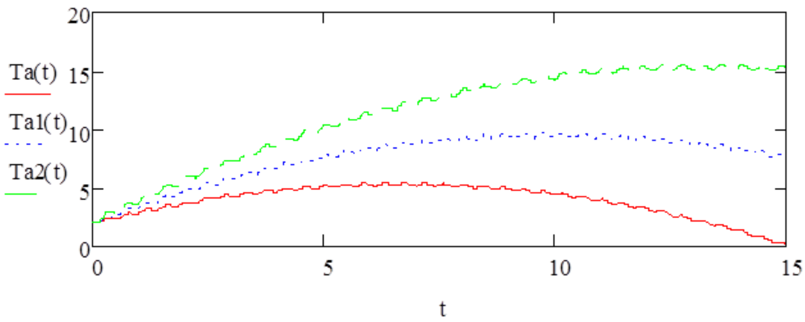

Figure 5. Changes in tension as a function of x for different values of initial tension at a fixed value of time.

Determining the optimal values of the characteristic quantities for this example is not very difficult. In the general case, to use numerical expressions in determining the optimal values of input parameters that qualitatively improve the nature of the problem under study, it is necessary to know their existence and be able to estimate the search range of the required parameters [15].

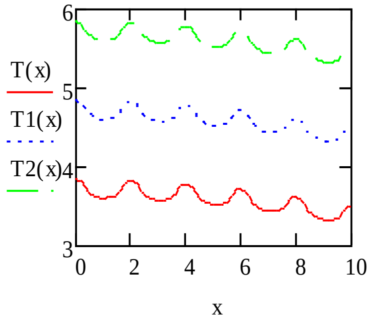

Figure 6. Changes in tension depending on time for different values of the speed

4. Conclusion

Figure 6 shows the change in tension depending on x for different values of the initial tension at a fixed value of time. The following in our case are the parameters for the most optimal values included in the resolving equations:

$$T_0 = 6;\ v_0 = 1{,}2;\ \alpha = 0{,}2;\ \beta = 0{,}4;\ A = 0{,}125.$$

Methods of technology of computer modeling the dynamic processes on the example of the transverse vibration of the thread during the weaving process has been proposed, and the optimal values of the input parameters have been determined.

References

[1] Ilyushin A A and Pobedrya B E 1970 *Fundamentals of the mathematical theory of viscoelasticity* (M.: Nauka)
[2] Adizova A, Abdieva G and Mavlanov T 2021 *AIP Conference Proceedings* **2402** 070034
[3] Bekchanov F, Ergashev A, Mavlanov T and Glovatskiy O 2019 *E3S Web of Conferences* **97**
[4] Khudainazarov Sh, Mavlanov T, Qosimov J and Nurova O 2020 *IOP Conference Series: Materials Science and Engineering* **869** 052047
[5] Myachenkov V I and Maltsev V P 1984 *Methods and algorithms for calculating spatial structures on a computer* (M., Mashinostroenie)
[6] Mavlanov T and Khudainazarov Sh 2019 *E3S Web of Conferences* **97** 04054
[7] Abdieva G B 2021 *Education and science in the XXI century*
[8] Norov S N, Abrorov A S, Hamroeva M F, Muxamedjanova S F and Zaripov G B 2020 *Journal of Physics: Conference Series* **1515(4)**
[9] Adizova A J 2021 *International scientific journal* **9(80)** 8-10
[10] Abdieva G, Adizova A, Mavlanov T and Rakhimova D 2021 *Academicia: An International Multidisciplinary Research Journal* **11(4)** 322-7
[11] Yakubovskiy Yu V, Jivov V S, Korytisskiy Ya I and Migushov I I 1973 *Fundamentals of thread mechanics* (M: Light industry)
[12] Adizova A J 2020 *Scientist Of The XXI Century* **12-2(71)** 13-6
[13] Salimov Sh M, Yusupov G U and Abdiyeva G B2020 Computer modeling of strain process of flexible rods with nonlinear and viscoelastic characteristics *International Scientific Conference, Construction Mechanics, Hudraulics and Water Resources Engineering CONMECHYDRO, 2020*
[14] Koltunov M A 1976 *Creeping and relaxation* (M: Higher school)
[15] Adizova A J 2021 *Scientist Of The XXI Century* **9(80)** 11-3