

Ширину валка (від 1,2 до 1,8 м) встановлюють залежно від врожайності трав, погодних умов і способу подальшого збору. Валок максимальної ширини формують при фіксації боковин в крайніх положеннях.

#### Список посилань

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### SIMULATION OF THE SPATIAL STIFFNESS OF TECHNOLOGICAL ROBOTS BY PARTS

In modern automated production processes industrial robots are often used in technological processes for the machining operations with machine tools (Fig. 1). In this case, the accuracy of processing depends on the properties of the elastic system (ES) work, in particular on the characteristics of rigidity in the cutting zone. The static rigidity of the ES along the X axis is defined as  $J_X = P_X / \Delta_X$ . On other axes - similar. In [1,2], it was shown that the spatial rigidity of a ES of a robot is geometrically represented as an ellipsoid with a center in the cutting zone. In dynamic operating modes, the ellipsoid changes its size depending on the frequency of the active force.

The presence of unified elements, complete nodes, mechatronic modules allows you to create a variety of layouts of robots with a minimum number of original elements (Fig. 2). This makes it possible to increase their flexibility, reparability, ease of modernization, significantly shorten the design and production lines, and reduce the cost of the machine.

The designer needs to know the characteristics of individual elements, which in designing can evaluate the characteristics of the robot as a whole.

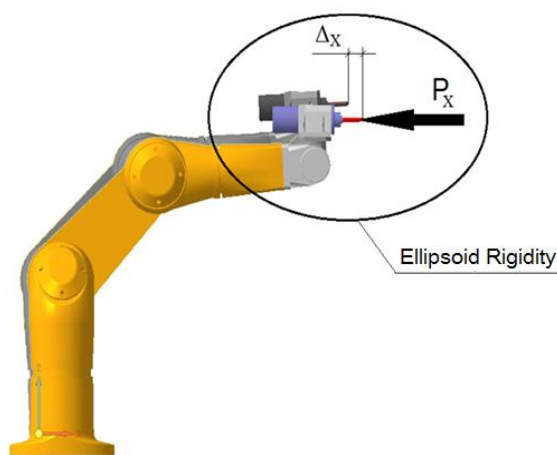


Fig. 1 – The elastic properties of a robot machining:  $P_X$  - cutting force,  $\Delta_X$  - deformation

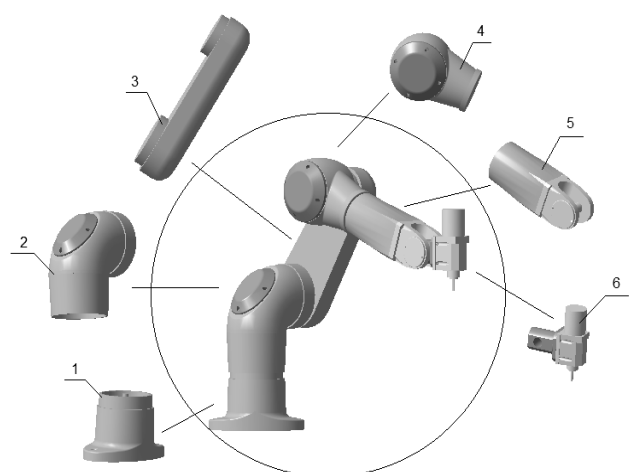


Fig. 2 – Modular Robot Scheme:  
1 – base, 2 – knee, 3 – shoulder, 4 – joint,  
5 – hand, 6 – working body

Dynamic model of elastic system "one-armed" robot (Fig. 3) is a chain system of  $n$  elements. It can be conventionally divided into two enlarged subsystems - ES1 and ES2 (Fig. 4). When dividing the system (Fig. 4a) at the junction of elements (elastic-damping stitching), the uncertainty of the unshielded ES1 (Fig. 4b) overcomes its fixation to the "ground". As a result, we obtain two partial subsystems that can be investigated independently (Fig. 4c,d). Subsystem PS2 can be divided in a similar way (etc.).

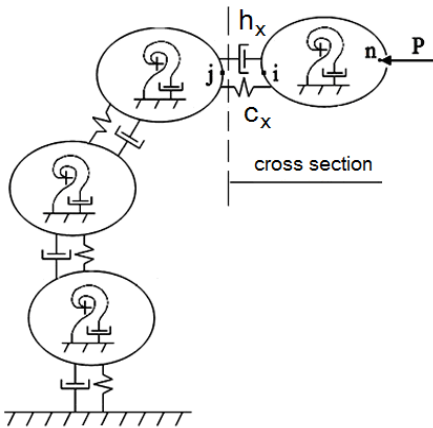


Fig. 3 – Dynamic model of elastic robot system

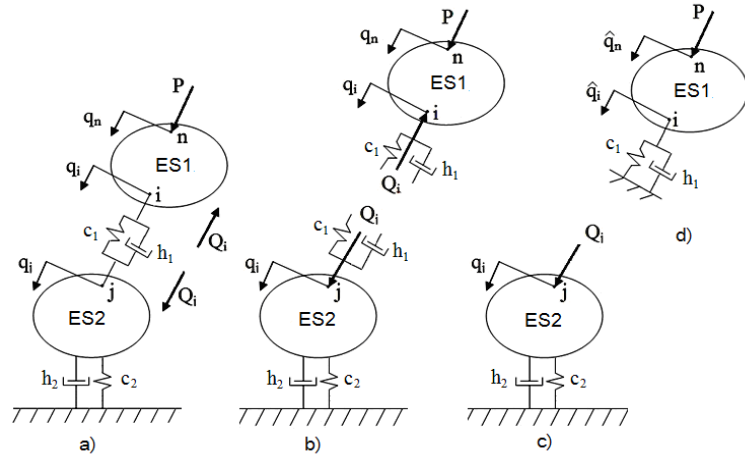


Fig. 4 – A consolidated dynamic model (composed of two subsystems - ES1 and ES2)

To determine the static and dynamic characteristics, it is expedient to describe the elastic properties of the system by transfer functions (TF) of the form  $W_{P_1}^{q_1}(p)$ ,  $W_{q_2}^{q_1}(p)$ , and their frequency analogs  $W_{P_1}^{q_1}(i\omega)$ ,  $W_{q_2}^{q_1}(i\omega)$  [3].

In this model (Fig. 4), the TF ES1 can be found in the complete system as

$$\hat{W}_{P_1}^{q_1} = W_{P_1}^{q_1} - \hat{W}_{q_2}^{q_1} W_{P_1}^{q_2} . \quad (1)$$

TF of the complete system can be determined by the TF of its subsystems as

$$W_{P_1}^{q_1} = \left[ E - \hat{W}_{q_2}^{q_1} \begin{matrix} \leftarrow \\ \leftarrow \end{matrix} \begin{matrix} \leftarrow \\ \leftarrow \end{matrix} \hat{W}_{q_2}^{q_2} C_{22} \begin{matrix} \rightarrow \\ \rightarrow \end{matrix} \hat{W}_{q_2}^{q_2} C_{21} \right]^{-1} \hat{W}_{P_1}^{q_1} . \quad (2)$$

These expressions show both in the complete system to determine the TF of isolated subsystems ES1 ( $\hat{W}_{P_1}^{q_1}$  i  $\hat{W}_{q_2}^{q_1}$ ) and ES2 ( $\hat{W}_{q_2}^{q_2}$ ), as well as with known complex ligaments  $C_i = c_i + j \cdot h_i$  (blocks  $C_{21}$  and  $C_{22}$  of matrix  $C$ ), it is possible to switch from TF isolated subsystems ES1 and ES2 to the TF of the complete elastic system.

The developed theory of modeling of the dynamics of chain systems should be used in the simulation of "one-armed" robots in parts (nodes). Also, the theory should be used in the analysis and synthesis of their characteristics. It allows to determine the dynamic spatial stiffness of the robot design, choose rational modes of processing and predict the accuracy of the machined parts.

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