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Analytical Technique for Definition of Internal Forces in Links of Robotic Systems and Mechanisms with Statically Indeterminate and Determinate Structures Taking into Account the Distributed Dynamical Loads and Concentrated Forces

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Abstract : The distributed inertia forces of complex nature appear in links of rod mechanisms within the motion process. Such loads raise a number of problems, as the problems of destruction caused by a large force of inertia; elastic deformation of the mechanism can be considerable, that can bring the mechanism out of action. In this work, a new analytical approach for the definition of internal forces in links of robotic systems and mechanisms with statically indeterminate and determinate structures taking into account the distributed inertial and concentrated forces is proposed. The relations between the intensity of distributed inertia forces and link weight with geometrical, physical and kinematic characteristics are determined in this work. The distribution laws of inertia forces and dead weight make it possible at each position of links to deduce the laws of distribution of internal forces along the axis of the link, in which loads are found at any point of the link. The approximation matrixes of forces of an element under the action of distributed inertia loads with the trapezoidal intensity are defined. The obtained approximation matrixes establish the dependence between the force vector in any cross-section of the element and the force vector in calculated cross-sections, as well as allow defining the physical characteristics of the element, i.e., compliance matrix of discrete elements. Hence, the compliance matrixes of an element under the action of distributed inertial loads of trapezoidal shape along the axis of the element are determined. The internal loads of each continual link are unambiguously determined by a set of internal loads in its separate cross-sections and by the approximation matrixes. Therefore, the task is reduced to the calculation of internal forces in a final number of cross-sections of elements. Consequently, it leads to a discrete model of elastic calculation of links of rod mechanisms. The discrete model of the elements of mechanisms and robotic systems and their discrete model as a whole are constructed. The dynamic equilibrium equations for the discrete model of the elements are also received in this work as well as the equilibrium equations of the pin and rigid joints expressed through required parameters of internal forces. Obtained systems of dynamic equilibrium equations are sufficient for the definition of internal forces in links of mechanisms, which structure is statically definable. For determination of internal forces of statically indeterminate mechanisms (in the way of determination of internal forces), it is necessary to build a compliance matrix for the entire discrete model of the rod mechanism, that is reached in this work. As a result by means of developed technique the programs in the MAPLE18 system are made and animations of the motion of the fourth class mechanisms of statically determinate and statically indeterminate structures with construction on links the intensity of cross and axial distributed inertial loads, the bending moments, cross and axial forces, depending on kinematic characteristics of links are obtained.

Keywords : distributed inertial forces, internal forces, statically determinate mechanisms, statically indeterminate mechanisms
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