European Community on Computational Methods in Applied Sciences

ECCOMAS Congress 2016

VII European Congress

on Computational Methods in Applied Sciences and Engineering

PROCEEDINGS

Volume IV

M. Papadrakakis, V. Papadopoulos, G. Stefanou, V. Plevris (Eds)

ECCOMAS Congress 2016
VII European Congress on Computational Methods in Applied Sciences and Engineering
M. Papadrakakis, V. Papadopoulos, G. Stefanou, V. Plevris (eds.)
Crete Island, Greece, 5–10 June 2016

COMPUTATIONAL METHOD OF DETERMINATION OF INTERNAL EFFORTS IN LINKS OF MECHANISMS AND ROBOT MANIPULATORS WITH STATICALLY DEFINABLE STRUCTURES CONSIDERING THE DISTRIBUTED DYNAMICALLY LOADINGS

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Keywords: Manipulators, Mechanisms, Distributed Inertia Forces, Internal Loads, Kinematic Characteristic, Animation.

Abstract. *The technique of analytical determination of internal loads in links of planar rod mechanisms and manipulators with static definable structures taking into account the distributed dynamic stress, a self weight and the operating external loads is designed in this paper. The programs using the MAPLE are made on the given algorithm and animations of the motion of mechanisms with construction on links the intensity of cross and longitudinal distributed inertia loads, the bending moments, cross and longitudinal stress, depending on kinematic characteristics of links are obtained.*

1 INTRODUCTION

There are a variety of graph-analytical and numerical calculation methods on durability and rigidity of rod robotic systems and mechanisms, in which the distributed inertia forces of difficult character aren't considered [1-4]. The groups of Assur, that form the designed scheme of mechanism, can be statically definable, and also statically indefinable in concept of determination of internal stress. In this paper a new analytical approach of solution of problems of dynamic calculation on durability and rigidity taking into account the distributed dynamic stress in links of robotic systems and mechanisms with statically definable structures is proposed.

The distributed inertia forces of difficult character appear in links of rod mechanisms within the motion process. The intensity of distribution of inertia forces along the link depends on the mass distribution along the link and the kinematic characteristics of the mechanism changing rapidly. Rise of that sort of loads causes a set of problems, namely, breaking problems, which are specified by large-scale inertia forces; significance of elastic deformation of mechanism, that puts the mechanism out of action; because of deformation of links the mechanism can't meet kinematic claims.

Therefore, relations between the intensity of distributed inertia forces and a self weight of links with geometrical, physical and kinematic characteristics are determined in our work. The laws of distribution of inertia forces and self weight allow to output laws of distribution of internal forces on the axis of link in each position of links, where there is a force attached to any point of a link. Their maximum values allow to optimize the design data of a link, which provides durability and rigidity of links and, entirely, of robotic systems and mechanisms.

As internal loads of each continual link are defined unambiguously by a set of internal loads in its separate cross-sections and by the matrixes of approximations, so the task is to calculate the internal loads in finite number of cross-sections of elements.

As a result, we refer to discrete model of elastic calculation of links of rod mechanisms. For elastic calculation of rod mechanisms based on Dalamber's principle, mechanisms are casted to structures which degree of freedom is equal to zero. For definition of internal loads in links of designed scheme of mechanism, the structure is divided into elements, both the hinged and rigid joints. The elements are divided into three types of beams for the first time. Discrete models of these three types of the beams with constant cross-sections which are under the action of cross and the longitudinal distributed loads of a trapezoidal view are constructed. The constructed discrete models for these three types of beams with constant cross sections along the axis allow to determine quantity of the independent dynamic equations of balance, components of a vector of forces in calculated cross-sections and to construct discrete model of all structure.

The dynamic equations of balance for discrete model of an element of the link with constant cross-sections which is under the influence of cross and longitudinal inertial loads of a trapezoidal look are also received in this work as well as the equations of balance of hinged and rigid knots expressed through required parameters of internal forces.

If we unite the equations of dynamic balance of elements and knots in one system, we will receive the equations of dynamic balance of all discrete model of system. A sort of systems of equations is sufficient for definition of internal forces in links of mechanisms, which structure is a static definable. The vector of forces and vector of loads in calculated cross-sections of discrete models of mechanisms are formed from vectors of forces and vectors of loads in calculated cross-sections of their separate elements. On the given algorithm the programs in the MAPLE system are made and animations of the motion of mechanisms with construction

6. CONCLUSIONS

The developed technique can be applied in the study of stress-strain state of the projected and existing mobile and fixed beam systems with statically definable structures (planar rod mechanisms, manipulators, frames, etc.).

REFERENCES

[1] Du Zhaocai, Yu Yueqing, Yang Jianxin. *Analysis of the dynamic stress of planar flexible-links parallel robots*. Vol. 2, Issue 2, pp 152-158. Higher Education Press and Springer-Verlag, 2007.

[2] Santosha K.D., Peter E. *Dynamic analysis of flexible manipulators: A literature review*. Mechanism and Machine Theory, 2006, 41: 749-777.

[3] Gaultier P.E. *Modeling of flexible manipulator dynamics: A literature survey*. 1st nat. Applied Mechanics Conference, Cincinnati, 1989, 2C-3: 1-10.

[4] Kang B, Mills J.K. *Dynamic modeling of structurally-flexible planar parallel manipulator*. Robotica, 2002, v20: 329-339.

[5] Utenov M.U. *Investigations of forces, arising from the self mass of links with constant and variable cross-sections in their plane-parallel motion*. Proceedings of the First International Scientific and Practical Conference, Vol. 2, pp 30-34. Almaty, 2000.

[6] Utenov M.U. *The matrix of approximation of element force under the action of distributed load with parabolic intensity*. Proceedings of the First International Scientific and Practical Conference, Vol. 2, pp 55-58. Almaty, 2000.

[7] Utenov M.U. *Construction of discrete models of planar rod mechanisms in the elastic calculation*. Bulletin of the Kazakh Academy of Transport and Communications. №6 [12].-2001,- pp 61-64.

[8] Chiras A.A. Structural mechanics. – M.: Stroyizdat, 1989. – 255 p.