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STABILITY THEORY METHODS AND MODELLING PROBLEMS IN MECHANICS

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ABSTRACT

This paper is devoted to the elaboration of modelling and methods of analysis in Mechanics. Generalized methodology based on Lyapunov's methods and Chetayev's ideas, considering from unified view point all mechanical systems as singular ones, in sense of Tikhonov, Nayfeh, Campbell, makes it possible to extend the reduction principle for general qualitative analysis; to elaborate regular technique for modelling in Mechanics.

Keywords: A.M. Lyapunov stability theory, N.G. Chetayev methods, modelling, mechanics.

INTRODUCTION

The present work is devoted to the different aspects of mathematical modelling and qualitative analysis in dynamics of complex nonlinear systems, that are generated by applied problems of engineering practice. The main objectives are the problems of optimal mechanical-mathematical modelling and the regular schemes of decomposition in engineering design. Multiconnectivity, high-dimensionality, nonlinearity of original statement under good detalization of full initial system lead to the necessity of the problem narrowing. The generalization of reduction principle, well-known in stability theory of A.M.Lyapunov, is important goal for engineering practice.

Uniform methodology, based on Lyapunov's methods, in accordance with Chetayev's stability postulate, is developed. The presented approach, with combination of stability theory and perturbations theory methods, allows to elaborate the general conception of the modelling, to build regular algorithm for constructing of the effective mechanical-mathematical models, to work out the simple schemes of engineering level for decomposition-reduction of full systems and dynamic properties.

RESULTS AND CONCLUSIONS

The main problems considered in tha analysis are the following: (i)-the elaboration of systematic procedures for decomposition-reduction of complex mechanical systems; (ii)-the construction of shortened models (comparison ones) by strict mathematical manners; (iii)-the development of regular methods for acceptability and correctness.

Here formulated problems are solved by strict stability theory methods. General approach, founded by A.M.Lyapunov, used by N.G.Chetayev for modelling problems in Mechanics, added by P.A.Kuzmin for stability problems under parametric perturbations and by V.V.Rumyantsev for stability problems on variables part, is worked out for mechanical systems of singular class. Theorems on qualitative equivalence are obtained.

The main questions discussed in this research are as follows:

- the methodology of the building optimal shortened-reduced models;
- development of the idealization rigorous manners, of methods for both physical and mathematical decomposition;
- the substantiation of legitimacy of reduced models in dynamics;
- the determination of the qualitative equivalence conditions;
- the separation of systems parameters on substantial and non-substantial ones;
- the revealing of main degrees of the system freedom;
- the acceptability of the transition to the shortened mechanical (electromechanical,…) model;
- the properties idealization in original model (technical object).

This research presents a powerful tool, based on stability theory methods, for regular solving of important problems in dynamics of complex systems.

With reference to a mechanics problem, in regard to the specific cases of aviation and aerospace systems, it leads to the singularly perturbed problems with the different singularities types, with critical cases, with the non-linear generating systems, that are also singular systems.

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