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FUNDAMENTALS OF ANALYSIS AND DESIGN OF VIBRATORY MACHINES

Book 1

Theory and Practice of Development of Vibratory Machines with Harmonic Motion of the Working Element

Tutorial

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Abstract. The main aim of the tutorial is to reveal the principles of development of vibratory machines, providing the base for understanding and the ability to design such structures by your own. For this purpose, the tutorial expounds in detail the basic approaches of analysis and design of vibratory machines of various technological functions, types and operation modes, the motion of the working element of which is carried out according to the harmonic law. The material is presented in an accessible form for a wide range of readers: sequentially from the simpler one to more complex one, with insertions for in-depth interpretation, which are separately stood out and presented in a smaller font.

In order to ensure the convenience while learning the material, the tutorial is divided into three parts devoted to consideration of one-, two- and three-mass vibratory machines comprising most of the existing structures. In the opinion of the author, this is justified, since one-mass systems are usually used to develop non-resonant vibratory technological equipment based on an inertial drive; two-mass systems are usually resonant structures, in drives of which the electromagnetic vibration exciters are often used; sometimes these systems are driven by inertial vibration exciters; also these systems are used for implementation of dynamically balanced structures with eccentric drive; three-mass systems are the least widespread ones, however, on the basis of them it is possible to synthesize highly-efficient vibratory systems (scientific area, in which the author carries out his investigations). At once, such a division allowed to localize the material according to the class of machines. The readers who have sufficient education can learn these three parts independently of each other.

Each part of the tutorial starts with the applied theory of one-, two- or three-mass oscillatory system, to which the structure of the vibratory machine of the certain class is reduced. The theory of analysis (calculation) is presented with the derivation of the basic analytical dependencies that define the parameters of oscillatory systems with

the most widespread types of disturbance, namely, with electromagnetic, inertial and eccentric vibration exciters. The application of the certain drive causes the use of the definite mode of the equipment being designed (before-resonant or after-resonant), thus imposing the specific features on its calculation and development. Further, in the applied chapters, a staged development of vibratory machines with corresponding references to theoretical explanations and statements is adduced. This allows one to better understand the features and to grasp the design theory of such type of technological equipment.

The tutorial consists of many figures (diagrams, drawings, solid state models of vibratory machines). Numerous practical calculations and explanations are provided in the course of theoretical material presentation. In the opinion of the author, this facilitates a better mastering of the material. Almost all presented in the tutorial analytical dependencies for determination of the parameters of oscillatory systems and units of vibratory machines are derived. This helps to understand their mathematical and physical meaning. To most of the structures of vibratory machines, which are analyzed in detail, the techniques of formation of their mathematical models are presented and the results of simulations are shown. In the tutorial, the chapters dealing with analyzing and calculation of the most important elements of vibratory machines, namely, elastic units and vibratory drive, are presented. The history of the origin of vibratory machinery is briefly adduced. All this is a good material for students course works and qualification works and it may be taken as a basis or as an analogue.

In the tutorial, the emphasis is put on the presentation of the basic means necessary for the structural and parametric synthesis of the separate unit of vibratory equipment without plunging into the substantiation of technological parameters. This affected a content of the tutorial that had been formed more in design direction. Thus, having the predefined technological parameters of the motion of the working element (amplitude and frequency of its oscillations, loading mass, etc.), the designer must develop a workable unit of equipment. To do this, taking into account the technological purpose of the vibratory machine and the possible recommendations for its further operational conditions, based on the technological parameters that it must ensure, its functional diagram is to be formed and the type of drive and the operation mode are to be chosen. Inertial, stiffness and power parameters of the oscillatory system are to be determined, on the basis of which the structural parameters of the vibratory machine are to be defined and its structure is to be developed. A simulation of its operation is to be carried out, which allows preliminary estimation of the workability of the future plant. If it is necessary, the obtained results are to be corrected and implemented while manufacturing the separate unit of equipment. The actual modes and technological parameters provided by this unit are to be experimentally defined. Thus, the integrity of the methodology of the development of vibratory technological equipment is demonstrated.

The tutorial is intended for students of technical universities, who study corresponding subjects related with the design of vibratory equipment, and for postgraduate students working in this area of research. It may be useful for engineers working on the development of vibratory machines.