Preface

This book is devoted to a systematic statement of the principles of nonlinear wave mechanics—a new branch of mechanics—which is a scientific basis for wave technologies, having no analogues in world practice.

New wave and oscillating phenomena and effects, which form the basis of highly intensive wave technologies, are discovered during the development of nonlinear wave mechanics. These wave technologies have applications in numerous industries, i.e., in oil and gas production for the enhancement of oil-and-gas condensate recovery of layers, in the energy sector, in engineering, in process industries such as oil refining and petrochemistry, in the food industry, in ecology, in material science including production of building materials and nanocomposites, in the cosmetics industry, in pharmaceuticals, etc.

The results of the application of wave technologies in most cases cannot be obtained in practice by the methods known at present concerning the quality of the materials and products, the power inputs (a high quality of the products obtained using wave technologies is achieved at a significant reduction of power inputs), and other indicators. The necessity to implement the wave technologies in practice has led to the development of a new area of mechanical engineering, namely, wave engineering.

One of the specific peculiarities of wave mechanics is the fact that the formulations of the mechanical and mathematical problems, to the solution of which wave mechanics is devoted, have arisen directly from the needs of modern practice, namely, from the analysis of typical technologies in many industries, or to intensify substantially and to reduce the power inputs during a technological process, or from the necessity to work out fundamentally new science-intensive technologies, for example, for obtaining materials and products with unique properties, etc.

It should be noted that nonlinear wave phenomena and effects, which were first established theoretically, have been, as a rule, verified many times in experiments not only in vitro, but also in full-scale experiments. They are the basic principles employed while working out the wave machines and apparatus, and implementing highly intensive wave technologies.

Various and rather complicated original mathematical models have been applied to the development of the scientific foundations of nonlinear wave mechanics. The investigation of these models has been carried out not only by means of the most modern numerical methods of computer simulating, but also by using a powerful analytical apparatus of classical methods of nonlinear mechanics (methods of small parameters of Henri Poincaré, asymptotic methods of Nikolay N. Bogolyubov and Nikolay M. Krylov, different variants of the averaging method, stability theory of motion according to Aleksandr M. Lyapunov, etc.), which have been modified for the cases of nonlinear resonances. It should be noted that it is mathematically rigorous analytical methods of nonlinear mechanics that have played a major role in determining wave phenomena and effects. Analytical methods have become the "core," around which the technique of establishment of the wave and oscillating phenomena of nonlinear wave mechanics and understanding of their mechanisms has been generated.

The main results (nonclassical formulations of the problems, methods of investigation, new relationships of wave and oscillating processes in multiphase systems, wave mechanisms of motions and of stabilization, wave and oscillating phenomena and effects), presented in detail in this book, show quite conclusively that a number of wave phenomena and effects can hardly be obtained (even using the most ultimate modern supercomputers) without a successful preliminary analytical procedure of the establishment of the modes of motion. Here, analytics provides a clear understanding of the physics and mechanics of nonlinear wave phenomena. These moments are likely to be taken as a rather natural approach by physicists and engineers delving into complex nonlinear wave and oscillating processes, especially at the conditions of nonlinear resonances. Certainly, in order to successfully solve such complex problems, it is necessary to reveal a certain art while formulating the problems on mechanics, based on the experience of work in the field of nonlinear oscillations and practical observations over oscillating and wave processes.

This book is mainly devoted to the description of the fundamental principles of nonlinear wave mechanics, including the theory of nonlinear oscillations of multiphase systems and wave mechanisms of motion, phenomena and effects, discovered within this theory, that have practical applications (during the development of science-intensive technologies). Significant attention is also paid to the description of the developed typical wave technologies and wave machines and apparatus, and implementing these technologies, that is, to a wave engineering. Several results of practical implementations in different technological sectors and further perspectives of the development of both nonlinear wave mechanics and wave technologies are also stated.

Nonlinear wave mechanics and wave technologies are created, verified in experiments, tested in practice, and in some cases implemented by both the authors of this book themselves and the team under their scientific guidance (their apprentices and colleagues) from the Scientific Center for Nonlinear Wave Mechanics and Technology of the Russian Academy of Sciences, in close contact with different engineering organizations. The main part of the results is published in the books and papers of the collaborators of this team and is protected by patents in Russia and abroad.

A number of sections of this book are written by the authors together with certain collaborators and their colleagues, whose level of participation is indicated in the corresponding sections.

The authors would like to express their deep gratitude to all these collaborators.