WAVE TECHNOLOGY IN MECHANICAL ENGINEERING

Industrial Applications of Wave and Oscillation Phenomena

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Preface

The first and second editions of this book created great interest among a broad spectrum of readers. With the entire run of the first editions out of print, the need occurred to reissue. Also, new results obtained after the first editionsubstantially broadened application capabilities of wave and oscillation phenomena for the creation of high technologies in the industries. Therefore, this third edition is significantly reworked and expanded.

Major attention in reworking the book was devoted to issues of the practical implementation of wave technologies in specific industries. It relates to the engineering, chemical industry, materials technology, construction, food, oil and gas production industry, etc. Subjected to reworking were sections related to the wave activation of cements and cement-limestone compositions with respect to facility of understanding and demonstrability of the presented material. The section devoted to the issues of loose component dosage metering and wave metering devices was amended.

The section devoted to wave technologies of developing composite materials including nanocomposite materials was considerably updated. This technology enables, on a conceptually new level, the solving of many currently urgent tasks for producing finely dispersed emulsions and suspensions, including high-viscosity dispersion medium as well as highly-filled composite materials with finely dispersed fillers.

The authors also used results obtained by a number of employees at the Centre of nonlinear wave mechanics and technology RAN to whom the authors are grateful [1–12].

1

Introduction: Capabilities and Perspectives of Wave Technologies in Industries and in Nanotechnologies

Wave technologies are groundbreaking (fundamental) innovations based on fundamental scientific achievements in the domain of nonlinear wave mechanics – a new area of mechanics developed by the Scientific Centre for Nonlinear Wave Mechanics and Technologies of Russian Academy of Sciences (NC NVMT RAN). They enable the solution of earlier inaccessible technologic problems. They also enable a qualitatively

new approach to the already known technologic processes, substantially (multiply) increasing their efficiency. In essence, wave technologies is Russia's competitive national advantage on the world market of technologies and the foundation for the implementation of wide-ranging innovations in various industrial disciplines offering high-efficiency solutions of technological problems based on wave phenomena and effects [1–16].

This book does not have the objective of describing wave phenomena and effects discovered in the process of developing nonlinear wave mechanics, which is the scientific base of wave technologies. The objective of this book is to show their conceptual capabilities in the creation of new materials and products or in their multiple improvements for increasing the efficiency of numerous technological processes. The scope of such technologies is huge (not all areas of possible applications are reviewed here) – from materials, in particular building materials, composite materials, nanocomposite materials to petrochemicals, food and medical industries, pharmacology, etc. Reviewed is a wide range of practical issues in these domains. It is possible simply to name new specific results. However, to

understand fully their significance, it is no less important also to know how they were obtained. It means understanding on which new phenomena and effects they are based. Nonlinear wave mechanics, wave phenomena and effects are presented in sufficient detail and mathematically stringently, with experimental support and a wide range of applications based on the works of members of the NC NVMT RAN. Most recent achievements are presented in monographs and articles [1–16]. That is why it is inexpedient to again quote their contents. The objective of this book is totally different. It is: to provide a wide range of interested readers with the first idea of basic applied works in the domain of wave technologies. It is to provide them with the information about new results and further perspectives. It is to show the breadth of problems in solving specific type technologic tasks and in developing controlled wave machines and apparatuses, which implement these tasks.

Speaking of groundbreaking technologies in the industries, it is necessary to understand clearly that the time of easy and simple solutions has long gone. Groundbreaking technologies in the 21st century may be created only based on achievements in fundamental, abstract sciences

obtained in multiannual research of scientific schools. In the current environment in Russia, the amount of such fundamental, abstract scientific achievement both in industrial and in educational agencies of the country is far from sufficient. The stake of using foreign scientific potential will throw Russia back to secondary positions. The reason is that not a single state and not even a single organization or agency would ever sell the most up-to-date, most perspective developments and technologies. At the same time, in the institutions of the Russian Academy of Sciences there are both scientific schools with century-long history and fundamental scientific developments in physics, mechanics, chemistry, biology, etc., capable of becoming the foundation of new groundbreaking technologies, technologies of the 21 century. In its domain the Scientific Centre for Nonlinear Wave Mechanics and Technologies, RAN has its own fundamental scientific developments in the new area of mechanics. These are nonlinear wave mechanics and wave technologies capable of becoming the foundation of a host of high technologies.

Most of these advances are prepared for rapid implementation of groundbreaking wave technologies based on fundamental abstract science and

newly discovered phenomena and effects. Working on the scale of the entire industrial branches and Russia as a whole, they could provide tangible economic effect within the near future.

Mutual understanding is needed here between political leaders, scientists, engineers and businessmen. What is necessary is clear and obvious examples in order not to look for new technologies only abroad. As the "father of Russian aviation" Prof. N.E. Zhukovsky wrote in his time, "Examples in science are no less didactic than the rules" (quoted from memory). We will provide a few examples.

The first example will be relatively simple for understanding technologic problem, fragmentation, fragmentation and activation of solid particles (dry mixes). This problem is quite common in materials technology, in petrochemicals, in food industry, pharmacology, etc., and also in nanotechnologies. Currently, in this area, both scientifically and practically, traditional methods actually reach the limit or in many cases are inefficient and not always economical. At NC NVMT, we managed to identify and practically implement a phenomenon of controlled turbulization in an aggregate of solid particles (in a

flow or in closed volume), the phenomenon which efficiently solves this problem. In this case occurs material self-fragmentation. And due to possible nonlinear resonance, it implemented intense turbulization, which creates an environment for the destruction of solid particles reasonably economically and with sufficient purity of the material. (Very little material is carried out of the apparatus walls.) The corresponding wave machine is relatively simple. Here as well are proposed effective metering devices and classifiers, their controlling elements, which enable the creation of automated technological trains for ideal mixing (including with minor additives), pulverization and activation of solid particles.

A second example is the effect of accelerated liquid flow (100–1,000 and more) in thin capillaries and porous media (on the order of 10 μm and less) under wave action. The amplitude of running waves in capillaries is about 1/100 to 1/1,000 of a capillary diameter, i.e., at the level of nanometers. The mechanism of such flow is nonlinear (this is clearly observed when reviewing the flow equations) [4].

Some time ago, this phenomenon was used by the authors for increasing oil yield by reservoirs [10]