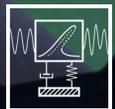


# QUALITY AND RELIABILITY OF TECHNICAL SYSTEMS: THEORY AND PRACTICE

ANDRII GOROSHKO VILEN ROYZMAN MARYNA ZEMBYTSKA

JVE Book Series on Vibroengineering  
August 2018 | Volume 2 | ISSN 2351-5260



# **Quality and Reliability of Technical Systems: Theory and Practice**

## **JVE Book Series on Vibroengineering**

### **Aims and Scope**

JVE Book Series on Vibroengineering covers a wide area of topics describing modern developments in vibroengineering of dynamical systems (macro-, micro-, nano- mechanical, mechatronic and biomechanical systems).

The following subjects are principal topics:

- Vibration and wave processes; Vibration and wave technologies;
- Nonlinear vibrations; Vibroshock systems; Generation of vibrations and waves;
- Vibrostabilization; Transformation of motion by vibrations and waves;
- Dynamics of intelligent mechanical systems;
- Vibration control, identification, diagnostics and monitoring.

### **About this Book**

The monograph provides original approaches to the quality and reliability improvement in mechanical engineering, taking into account the functionally oriented management. The outlined studies validate the methods facilitating the increased reliability and durability of rotor systems and vibration processes. Methods for increasing the reliability and wear resistance of machine parts and units under dynamic and shock loads are considered and proposed. The issues of creation of new materials in mechanical engineering, in particular, nanostructures are studied and investigated. New quality and reliability improving methods for electronic equipment and energy systems are offered. The research also considers the issues of reliability and durability of construction materials.

The monograph is intended for scientists, graduate students and professionals in the field. It may also be useful to students of technology.

# JVE Book Series on Vibroengineering

---

ISSN 2351-5260. AUGUST 2018. VOLUME 2, ISBN 978-609-96036-0-5

## Quality and Reliability of Technical Systems: Theory and Practice

**Andrii Goroshko**

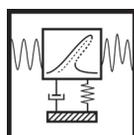
Khmelnytskyi National University, Ukraine

**Vilen Royzman**

Khmelnytskyi National University, Ukraine

**Maryna Zembytska**

Khmelnytskyi National University, Ukraine



**JVE**  
INTERNATIONAL

**Published by**

JVE International Ltd.  
Naugarduko 41-906, Vilnius, LT-03227, Lithuania  
<https://www.jvejournals.com>

**JVE Book Series on Vibroengineering**

**QUALITY AND RELIABILITY OF TECHNICAL SYSTEMS: THEORY AND PRACTICE – Vol. 2**

Copyright © 2018 by JVE International Ltd.

*All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system now known or to be invented, without written permission from the Publisher.*

The bibliographic information about the publication is available in the National Bibliographic Data Bank (NBDB) of the Martynas Mažvydas National Library of Lithuania

ISSN 2351-5260

ISBN 978-609-96036-0-5

Printed in Lithuania by UAB “BMK Leidykla”

## Introduction

Creation of new technical systems necessitates the search for solutions aimed at improving their quality, reliability and durability. In this regard, the most important task in their design, manufacture and operation consists perhaps in ensuring the reliability of technical systems.

When manufacturing the machine, the necessary quality is ensured both by the quality of the parts, and by the quality of the assembly of the machine and its units, by finishing methods and other process indicators. The modern level of development of science and technology makes it possible to achieve any indicators of machine reliability. The decision on the need to improve the quality of products should be based on an economic analysis.

Modern development of technology is characterized by the intensification of its operating modes, greater construction complexity, unification of machines and devices in process lines, and process automation. These factors increase the likelihood of failures in operation and cause multiple problems with machinery hampering its stability and smooth running. The reliability is significantly reduced during the operation due to aging of the equipment as a result of wear, corrosion, fatigue, etc.

In order to be considered as reliable, a technical system shall perform all its functions for a certain specified operating time and under the required operating conditions while maintaining all the necessary performance characteristics of machinery and products within the specified limits.

This monograph outlines research findings, primarily the methods of increasing the reliability of various technical systems: machines and electronic equipment, power engineering facilities and building structures at the main stages of their life cycle.

The ISO 9000 standards contain recommendations and tools for companies and organizations (regardless of the scope of their activities) which want their products and services to meet constantly the customer's requirements, and their quality is constantly improved. The suggested monograph analyzes the existing approaches to process and functional management, as well as the formation of a process model of modern machine building organizations (based on the example of an enterprise for manufacturing modern compressor equipment), taking into account the requirements of ISO 9001:2015. The reorientation of organizations to process management will allow producers of compressor equipment to survive and develop under contemporary conditions.

The monograph primarily focuses on the ways of increasing the reliability of rotor systems and vibration technologies. The basic problem of these machines is the necessity to decrease their vibroactivity. The results of an experimental and theoretical research of fluid behavior in passive self-balancing devices, which are installed in rotors with vertical and horizontal rotation axes when passing the resonance, are given. Received relations show that automatic balancing by fluid is effective for elastically deformed rotors or (and) a rotor on elastic supports, where there is a difference in phases between the direction of centrifugal force and flexure (or movement) of the rotor. According to the experimental findings, this difference in phases occurs when the rotor reaches the resonance speed and increases up to 180° while passing the resonance. In this case, the tangential force occurs, which influences the fluid to move to the side of flexure, opposite to imbalance, and further equilibration of the rotor takes place at the resonance rotation frequency.

The research introduces a method of indirect measurement of spindle vibrations based on the results of the vibration measurements of the spindle unit housing and theoretical compliance function. The method is based on the carried out experimental and theoretical studies of the spindle unit dynamic behavior, mounted on a special test rig with a low natural frequency.

The studies within this monograph, in particular, cover the creation of blood flow pulsations and the provision of the stable controlled behavior of the rotor in pulsating modes of functioning of the axial LVAD with magnetic bearings. The developed methods for ensuring the required rotor dynamics are accurate, fast, economical in the sense of the values of control currents, and most importantly reliability, which in general ensures the safety enhancement for the life support system – left ventricular assist device.

The studies are also aimed at solving the issues of increasing the productivity of turning parts

at a rotational speed up to 10,000 rpm. The methods of studying the dynamic behavior of the lathe are reviewed, and the way of changing system properties to improve stability in the increased cutting conditions and productivity are reviewed too.

The authors also suggest methods for increasing the reliability and wear resistance of cylindrical blocks with surface plastic deformation. The findings, which were obtained by studying the efficiency of hardening the parts working in spalling conditions through reeling with rollers with the help of physical simulation, show a major effect of cast steels hardening. The process of the contact friction surface wear during reeling with consideration of slippage is investigated. A procedure for determining conditions of reeling with a wedge roller is developed.

The current series provides the analysis of high-rate elastic-plastic deformation of the elements of modern technology, taking into account the change of the material properties in the process of deformation under the impact and impulse loads. It is shown that multilayered protective elements more effectively withstand impact loads. A parametric analysis of technological processes of connecting and separating the elements due to the explosion energy is carried out.

A greater part of the work is devoted to the study of new materials, particularly the study of energy ions, their varieties and charge temperature, rate of temperature rise, thermal stresses, and also to the size, volume, number of particles in nanostructures and effective current density for nanostructures. The study is also concerned with the effect of technological factors on the electromagnetic wave absorption properties of polymer composites as well as with the investigation of the superhydrophobic surface properties.

The monograph covers the problems of the quality and reliability improvement of electronic equipment and power systems and introduces a modified method of spectral analysis of a reflection signal for damage detection systems in power lines, suggesting an algorithm for spectral analysis based on a change in the width of the analysis window.

The authors attempt to solve the current issues of rank analysis in the problems of optimization of local power engineering. The issue of application of the techno-enological approach for the optimal management of energy consumption with the use of rank analysis, which includes the procedures of interval estimation, parametric rationing, forecasting and standardization of consumption of resources is considered.

The paper represents the development principles invariant to disturbing factors of piezoresonance units with controlled dynamics, which are assumed to be an adaptive control system with predictive reference model.

The final part of the book is devoted to the problem of increasing the reliability and durability of building materials. The condition of the building industry and the building materials industry in Ukraine is considered, the production and sale of building materials is shown in dynamics. A new study of sound propagation in an impedance tube is presented, which is the basis of the sound absorption coefficient determination with greater simplicity.

The research findings presented in this book, which are aimed at ensuring the reliability of various technical systems, may be useful in the design, manufacture and operation of new machine-building products.

The monograph is primarily intended for specialists engaged in ensuring the reliability of machines, tools and equipment, as well as for researchers and engineers, students of technology interested in the issues discussed.

Andrii Goroshko, Vilen Royzman and Maryna Zembytska  
Editors

# Contents

<b>INTRODUCTION</b>	<b>v</b>
<b>CHAPTER 1.</b>	<b>1</b>
<b>NEW METHODS FOR IMPROVING QUALITY AND RELIABILITY IN MECHANICAL ENGINEERING</b>	
<b>1.1. APPLICATION OF PROCESS AND FUNCTIONAL APPROACHES TO QUALITY MANAGEMENT IN THE MACHINE-BUILDING ORGANIZATION</b>	<b>2</b>
WILIAM ZALOGA, KOSTIANTYN DYADYURA, IRYNA RYBALKA	
<b>1.2. CURRENT TRENDS IN MECHANICAL ENGINEERING</b>	<b>14</b>
STEPAN D. POSTIL	
<b>CHAPTER 2.</b>	<b>25</b>
<b>DYNAMICS OF ROTOR SYSTEMS AND VIBRATION PROCESSES</b>	
<b>2.1. SYSTEM ANALYSIS OF AUTOMATIC BALANCING (SELF-BALANCING) MACHINE ROTORS WITH LIQUID WORKING BODIES ON THE EXAMPLE OF DRUM TYPE WASHING MACHINES</b>	<b>26</b>
ILONA DRACH, VILEN ROYZMAN, VITALII TKACHUK, ANDRII GOROSHKO	
<b>2.2. SPINDLE UNITS ON ROLLING BEARINGS DIAGNOSTICS BY INDIRECT MEASUREMENT OF SPINDLE VIBRATION</b>	<b>60</b>
YURIY DANYLCHENKO, ANDRIY PETRYSHYN	
<b>2.3. METHODS OF ENSURING THE REQUIRED DYNAMICS OF AN AMB SUPPORTED AXIAL LVAD ROTOR</b>	<b>74</b>
YULIA BOGDANOVA, ALEXANDER GOUSKOV	
<b>2.4. INCREASING OF EFFICIENCY OF PARTS TURNING AT SPINDLE SPEED FROM 5,000 TO 10,000 RPM BY CONTROLLING THE DYNAMICS OF MACHINING</b>	<b>90</b>
WILIAM ZALOGA, YURII SHAPOVAL, VITALII KOLESNYK	
<b>CHAPTER 3.</b>	<b>103</b>
<b>INCREASING THE STRENGTH OF MACHINES UNDER STATIC, CYCLIC AND DYNAMIC LOADS</b>	
<b>3.1. INCREASE OF RELIABILITY AND WEAR RESISTANCE OF CYLINDRICAL BLOCKS WITH SURFACE PLASTIC DEFORMATION</b>	<b>104</b>
ALEKSANDR DYKHA, DMITRY MARCHENKO	
<b>3.2. PROBLEMS OF HIGH-RATE DEFORMATION OF ELEMENTS OF MODERN TECHNOLOGY UNDER THE INFLUENCE OF IMPACT AND IMPULSE LOADS</b>	<b>119</b>
YURII VOROBIOV, NATALIIA OVCHAROVA	

<b>CHAPTER 4.</b>		<b>133</b>
<b>CREATION OF NEW MATERIALS</b>		
<b>4.1.</b>	<b>STUDY OF ENERGY IONS, THEIR VARIETIES AND CHARGE ON TEMPERATURE, RATE OF TEMPERATURE RISE, THERMAL STRESSES, AND ALSO ON THE SIZE, AMOUNT OF VOLUME, NUMBER OF PARTICLES IN NANOSTRUCTURES AND EFFECTIVE CURRENT DENSITY FOR NANOSTRUCTURES</b> GENNADIY KOSTYUK	<b>134</b>
<b>4.2.</b>	<b>PREDICTION OF THE PHYSICAL AND MECHANICAL CHARACTERISTICS, THE REMOVABLE MATERIAL VOLUME FOR THE DURABILITY PERIOD, CUTTING TOOLS DURABILITY AND PROCESSING PRODUCTIVITY DEPENDING ON THE GRAIN SIZE OF THE COATING OR CUTTING TOOL BASE MATERIAL</b> GENNADIY KOSTYUK	<b>163</b>
<b>4.3.</b>	<b>EFFECT OF TECHNOLOGICAL FACTORS ON ELECTROMAGNETIC WAVE ABSORPTION PROPERTIES OF THE POLYMER COMPOSITES</b> TAMAZ NATRIASHVILI, JIMSHER ANELI, LANA SHAMANAURI	<b>184</b>
<b>4.4.</b>	<b>STUDYING OF THE SEAWATER DROPS PROPERTIES ON SUPERHYDROPHOBIC SURFACE</b> TATIANA POPOVA, ALEKSEI UKOLOV	<b>198</b>
<b>CHAPTER 5.</b>		<b>213</b>
<b>IMPROVING THE QUALITY AND RELIABILITY OF ELECTRONIC EQUIPMENT AND POWER SYSTEMS</b>		
<b>5.1.</b>	<b>ACOUSTIC EMISSION DIAGNOSTICS OF SOLDER JOINTS ON PRINTED CIRCUIT BOARDS</b> IGOR KOVTUN, VILEN ROYZMAN, ANDRIY VOZNYAK	<b>214</b>
<b>5.2.</b>	<b>MODIFIED METHOD OF SPECTRAL ANALYSIS OF THE REFLECTION SIGNAL FOR DAMAGE DETECTION SYSTEMS IN POWER LINES</b> KOSTYANTYN HORIASCHENKO, VICTOR STETCUK	<b>230</b>
<b>5.3.</b>	<b>RANK ANALYSIS IN THE PROBLEMS OF OPTIMIZATION OF LOCAL POWER ENGINEERING</b> SERHII DENYSIUK, VASYLENKO VIRA	<b>246</b>
<b>5.4.</b>	<b>PRINCIPLES OF CONSTRUCTING INVARIANT PIEZORESONANCE DEVICES BASED ON ADAPTIVE MULTIFREQUENCY SYSTEMS WITH A PREDICTIVE STANDARD</b> SERGEY PIDCHENKO, ALLA TARANCHUK	<b>255</b>
<b>CHAPTER 6.</b>		<b>275</b>
<b>INCREASING THE RELIABILITY AND DURABILITY OF BUILDING MATERIALS</b>		
<b>6.1.</b>	<b>THE INDUSTRY OF BUILDING MATERIALS OF UKRAINE IN THE CONTEXT OF GLOBALIZATION</b> PETRO V. ZAKHARCHENKO, OLEKSANDR M. GAVRYSH, ROMAN D. ZAKHARIENKOV	<b>276</b>
<b>6.2.</b>	<b>A NEW METHOD FOR DETERMINING AN ACOUSTICAL CHARACTERISTIC OF BUILDING MATERIALS</b> TAMAZ NATRIASHVILI, MERAB CHELIDZE, DAVID NIZHARADZE, JEMAL JAVAKHISHVILI	<b>293</b>
	<b>INDEX</b>	<b>309</b>