

Preface

«...all sciences become mathematical by nature as long as they improve»

N. Whitehead, English Mathematician and Philosopher

«...during the last 5 years, the relations between individual sciences and between science and technology have changed. The growing awareness and effectiveness of scientific methods has enabled fruitful application of one science to another science... Meanwhile, the engineering sciences have become so complicated that the empirical methods alone have become helpless. In short, the science has become both feasible and mandatory to use in the engineering. The difference between aspirations still remains and frequently happens to be decisive, while methods and challenges are growing more and more similar»

G. Smith, American Mathematician

«The friction phenomena attract both the physicist and the engineer alike; their studies relate to the hardest sphere of the physical boundary-value problems»

W. Hardy, British Tribologist

The progress of engineering and technology stimulated the ideas of friction from the simplest mechanistic views of Leonardo da Vinci and Charles-Augustin de Coulomb to the modern tribophysical viewpoint considering the friction as the superposition of adhesive and cohesive forces. It presumes that friction belongs to the category of “nanotheries”, though now we are more accustomed to using the terms “microlevel”, “micromechanisms”, etc.

Unfortunately, the development of models describing the process of friction and wear using the ideas of the matter electron molecular structure confronts if not principal then considerable challenges. The fact can be related to them that the matter structure changes during friction at the microlevel which is hard to trace and, therefore, hard to study. The structure of the substance exposed to friction is in the dynamically mobile variable state having the properties hard to assess or predict.

The empirical descriptive approach prevails in the most theoretical tribological works without using comprehensively the modern physical apparatus. A. S. Akhmatov authored the outstanding book “Molecular Physics of Boundary Friction”; it is exceptional book confirming the rule. The author manifests that the achievements of the modern physics of solids permit to approach close to at least the correct physical description of the microprocesses governing the tribounit macrocharacteristics, like the wear rate and the friction coefficient. A. I. Sviridenok, the Belarusian tribologist, believes that “all triboeffects display themselves at the macroscale, while the phenomena causing and accompanying them evolve at the microlevel”.

The authors endeavor to describe in the present paper theoretically correctly the transformations the friction forces induce in the substance structure using the ideas and the apparatus of crystal physics, the solid body quantum and the chemical bonding theories. When writing, the authors were surprised to discover that the book was structured so that it resembled the above-mentioned book of A. S. Akhmatov. The present book continues, in some aspects, the monograph “Modern Tribology” published earlier. We describe it in much more detail the microprocesses in which Professor D. N. Garkunov shared when reviewing the preceding works. The detailed elaboration and more profound revision of the material narrowed the framework of the problems elucidated omitting a variety of the appealing problems from the study while they are worthwhile to be described separately.

The book highlights, in the first place, the transformations evolving in the crystalline lattice in friction, how these transformations influence the appearance of overactive state capable to become reactive states and some little-known phenomena affecting the friction characteristics. The findings in recent decades expanded substantially the tribological knowledge which relates in this or another way to the application of relativistic ideas based on the theory of relativity approaches to the friction physics study. The discovery by B. V. Deryagin and colleagues of the mechanic emission electrons and X-ray photons from the friction surface served the experimental basis; A. L. Zharin, Belarusian tribologist, discovered the dependence of the electron work from the surface of metallic parts on the extent of friction deformation of surface layers; the discovery by the physicists of the school of B. V. Deryagin of the ability of free surfaces of solids to emit heavy particles in friction, etc. The authors of the present book have attempted to adapt the ideas of the relativistic mechanics to the description of tribophysical phenomena.

The paper provides physical grounds to validate new models and mechanisms of triboprocesses. They served as the physical grounds for the tribological concept which the authors adhere. The concept implies development of the model of mechanisms of appearance of the third body as the most essential factor of evolution which governs the main tribosystem behavior features. The reader of this book will need certain knowledge of the solid body physics, electrodynamics, continuum physics, and quantum mechanics. It is intended for the prepared reader for whom the contents may be appealing.

The contents of the present monograph are at the borderline between different trends of natural and engineering sciences, like electrodynamics, the theory of relativity, the quantum mechanics, the solid body and the surface physics, the physical and chemical kinetics, and others. Each of the above-listed sections contains a long established system of common designations, constants, and values. These designations coincide sometimes. For instance, one and the same symbol “ S ” designates the fundamental values, such as “action” in the mechanics, “entropy” in the thermodynamics, “spin” in the quantum theory, “Umov-Pointing vector” in the electrodynamics, and others. This symbolic designation is so much common that any effort to change it can cause confusion in the perception of formulas like the use of similar symbols can be misleading. Therefore, the formulas are deciphered the way they are written in the text; in addition, the book contains at the end the list of main designations included into the formulas in each chapter.

With sincere respect to our readers who open this book for the first time,

Shahty, Russia

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Gomel, Belarus

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Micromechanisms of Friction and Wear

Introduction to Relativistic Tribology

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