
REVIEWED BY O. VINGSBO

The book consists of 28 papers, presented at the NATO Advanced Study Institute on the Fundamentals of Friction, held in July 1991 in the German Harz mountains. The objective of the Institute was to bring together experts from the two fields of "classical" macroscopic surface mechanics, and "modern" surface science, including molecular dynamics and point contact microscopy of atomic resolution. Thus, friction phenomena are approached by macroscopic models and experiments, as well as by what is being learned at the microscopic level (in current jargon referred to as nano tribology).

The papers are divided into seven chapters. Five deal with the classical macro aspects, while, not unexpectedly, only one is devoted to the atomic scale approach. One final chapter brings together three papers on self-induced stick-slip vibrations and instabilities in friction systems.

The five macromechanical papers are mainly based on K. L. Johnson's continuum mechanical formulation of surface mechanics. (Johnson contributes an Appendix, summarizing the concepts of his well-known book "Contact Mechanics.") After an initial chapter with broader perspectives on energy dissipation (by D. Tabor) and fluctuations in friction (by E. Rabinowicz), a second chapter is focused on adhesion contributions to frictional forces, both between smooth and rough surfaces and between particles in granular materials. Chapter 3 deals with fracture, deformation, and shear of the sliding interfaces, while Chapters 4 and 5 treat lubricated contacts from the tribochemical point of view and with respect to molecularly thin surface films.

The sixth chapter represents the atomic scale approach to friction. An introductory paper by McCllelland and Glosli presents two atomistic models for friction as well as frictionless and wearless sliding contacts. The models are applied in molecular dynamics calculations of frictional force and energy and are compared to the results of atomic force microscope (AFM) measurements. In a second paper a team of researchers from the Institute of Physics at the University of Basel gives an update on Friction Force Microscopy (FFM). The authors also report experiments on dry mica and magnetooptical disks, and of 2 and 4-molecular-layer soap films. A final group of three papers deal with computational and simulation techniques for atomic scale surface contacts. Ferrante and Bozolo from NASA Lewis Research Center in Cleveland discuss the use of different potential functions (first principles compared to pair, many body, and semi-empirical potentials) for modeling surface energy and friction forces. Uzi Landman's pioneering group from Georgia Institute of Technology in Atlanta give a detailed report of their computer simulations of the contact between an atomically sharp tip and a surface. Based on large-scale molecular dynamics calculations they demonstrate the atomic interaction processes of jump-to-contact, elastic and plastic yield, necking, wetting, stick-slip and materials transfer, in metallic, ionic and covalent crystal structures as well as in alkane films. A final paper by Belak and Stowers from Lawrence Livermore National Laboratory describes a similar molecular dynamics method for two and three-dimensional simulations of indentation and scraping. The method is also applied to two-dimensional orthogonal metal cutting.

To a professional tribologist, this book is extremely interesting. It gives a broad overview of the current front line in friction research, and at the same time provides examples of spearhead projects and techniques. The chapter on new approaches on the nano and atomic scale is particularly fascinating.


REVIEWED BY J. A. WALKER

In 1892 there appeared a remarkable Russian memoir entitled "The General Problem of The Stability of Motion." This work served as a doctoral dissertation for the great Russian mathematician Aleksandr Mikhailovich Lyapunov (1857-1918). In it the question of stability or instability of motions (and equilibria) of mechanical systems was considered with unprecedented depth and clarity. The stability theory of today is based upon this seminal work.

Only a few pages of this lengthy memoir (250 pages) were devoted to a brilliantly simple idea, which Lyapunov called a "second method" of stability analysis. Consider the real n-dimensional evolution equation

$$\dot{x}(t) = f(x(t)), \quad t \geq 0$$

with initial data $x(0) = x_0$. Let $V(x)$ be any known real-valued function of $x$ such that the function

$$V(x) = (\nabla V(x))^T f(x)$$

is non-negative on some set $S$. This implies that $V(x(t))$ is nonincreasing during any time interval over which $x(t)$ remains in $S$. Using this "obvious" result, Lyapunov obtained surprisingly simple sufficient conditions for both the stability
and the instability of an equilibrium \( x(t) = \text{constant} \). Today this method of stability analysis is called both Lyapunov's Second Method and Lyapunov's Direct Method, and the function \( V \) is called a Lyapunov function on \( S \).

For the next half century neither Lyapunov nor anyone else paid much attention to this particular idea. Useful Lyapunov functions seemed to be too difficult to construct. Neglect ended with World War II and our ensuing dependence upon control systems, for which stability is essential. Stability analysis suddenly became an important concern of engineers, the direct method was seen to be the heart of this subject, and useful Lyapunov functions became worth the effort of their construction. Although Lyapunov is famous today for having had many good ideas in several areas, the direct method may well have been his best idea.

The book under review is the first English translation of Lyapunov's 1892 Russian memoir. More precisely, it is an English translation of a French translation published in 1907. The French translation is quite literal and preserves much of the often difficult sentence structure of the Russian language; so does this rather literal translation of the French version. Nonetheless this book is not too difficult to read and, all things considered, the translators have done an excellent job of making this classic available to the English-speaking public.