

the authors attempt to unify various modes of boundary deformation with lubrication theory. The author's objective in preparing this book was to fill the gap between works on elastohydrodynamic lubrication and the other modes of boundary deformation that occur in metalworking lubrication and foil bearing operation.

In order to give the reader the proper background to deal with the subject matter in these three specialized areas, background information in hydrodynamics, elastic and plastic theory is covered in the text. This material is presented not only to make the text self-contained but also to present a modern treatment of these topics as they relate to lubrication theory.

The first chapter of the text is devoted to providing the reader with background information. Information is also provided about Cartesian tensors. The authors then develop in Chapter 2 the background information for the hydrodynamic theory of lubrication. The Navier-Stokes equations are first presented which are reduced first to the boundary layer equations and then the Reynolds equations. Simple examples of slider and journal bearings are presented to illustrate the use of the Reynolds equation. The chapter concludes with the presentation of the energy equation.

Chapter 3 derives the basic mathematical principles of elasticity as they relate to the boundary deformation of a lubrication contact. Within the chapter the Hertzian contact problem is presented which determines the size of the contact zone and the pressure for a given geometry, elastic properties and load.

Having developed the Reynolds and elasticity equations, the authors then couple these effects in Chapter 4 to give the elastohydrodynamic lubrication of line contacts as first derived by Grubin. Dowson and Higginson's minimum film thickness formula for line contacts is also presented. The chapter concludes with a discussion of thermal elastohydrodynamic lubrication including design curves and experimental results. The reviewer found this chapter inadequate since it does not cover developments of the last ten years on lubricant starvation, elastohydrodynamic lubrication of low elastic modulus materials, and point lubrication.

Chapter 5 briefly describes the principles of plasticity as they relate to lubrication theory. Chapter 6 then makes use of these principles to describe metalworking lubrication. Within this chapter the sheet rolling process and the axisymmetric deformation processes are presented. The material presented in this chapter represents the first complete presentation of metalworking lubrication in a text and therefore represents a major contribution by the authors.

The final chapter is devoted to foil bearing theory. Within the chapter the authors cover the perfectly flexible and the elastic foil types, as well as the bending-dominated foil bearing. Design curves are also presented.

In conclusion the reviewer feels that the book would be a good addition to the library of the lubrication engineer. In particular it is felt that the chapters on metalworking and foil bearing operations will be of great use. Furthermore, the background chapters on hydrodynamic lubrication, elasticity and plasticity should also be helpful. However, the reviewer feels that the chapter on elastohydrodynamic lubrication does not adequately describe the subject matter.

Modern Lubricating Greases, C. J. Boner, Scholium International Inc., Flushing, New York, July 15, 1976, 339 pp., \$27.00.

REVIEWED BY G. L. HARTING¹

A review of lubricating grease technology entitled, *Modern Lubricating Greases* has recently been introduced by Scientific Publi-

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cations Ltd. This text was authored by C. J. Boner and is essentially an addendum to his *Manufacture and Application of Lubricating Greases* which was published in 1954. Boner's new book is primarily based on literature and patent sources which appeared between 1955 and 1974.

In assessing the merits of *Modern Lubricating Greases* it is important at the outset to state that the book does not contain any original contributions to lubricating grease technology. If the reader is hoping to find any new insights into how greases function or the mechanisms by which grease compositions influence performance, he will be sorely disappointed. The author simply presents a compendium of literature references which had been previously published and makes no attempt to translate this information into any unified theories of grease technology.

Modern Lubricating Greases is an expanded bibliography of the technical literature related to grease technology which has appeared within the last 20 years and as such constitutes a useful reference for both grease formulators and lubrication engineers. The text covers a wide range of subjects from the microstructure of greases to advice on practical applications and is well footnoted so that the reader can easily refer to the original sources of any item of interest for additional details. The author has concentrated on those contributions to grease technology which were most significant and has not included subjects of marginal importance. In *Modern Lubricating Greases* the author has also simplified the text by avoiding the use of detailed grease formulations and has relied on more general descriptions of grease compositions.

However, as a bibliography *Modern Lubricating Greases* is not without its faults, the most serious of which is a lack of organization. An example of poor organization is found in the second chapter of the text in which the author reviews the influence of various components on finished grease properties. The chapter opens with summaries of the ways in which both base fluids and soap gellants contribute to the properties of a grease. At this point, however, the text abruptly digresses into discussions of definitions of various grease properties, the dielectric constants of greases, friction reduction, etc. Only later does the text return to the initial topic, the influence of components on properties, by reviewing the influence of inorganic gellants, polymers and additives. This interruption of the primary topic of the chapter made the text less readable than it might have been.

Poor textual organization was also evidenced by the occasional inclusion of topics in chapters which were not appropriate to their subject matter. For instance, a discussion of the factors which influence the performance of greases in rolling element bearings is located in a chapter entitled "Containers, Equipment and Methods for Application." This topic would have been more appropriately placed in the subsequent chapter in which Application Recommendations were discussed. A carefully detailed Index might have served to compensate for this poor topical organization. Unfortunately, the Index is not extensive and consequently is of little help in locating topics in the text.

Overall, *Modern Lubricating Greases* successfully distills 20 years of grease literature into a single volume, and, if the reader can decode the logic of its organization, it could be a useful reference book for the grease technologist.

Principles of Tribology, J. Halling (editor), Scholium International Inc., 130 East 31 Street, New York, NY 11354, 401 pages, 1976, \$22.50.

REVIEWED BY R. A. BURTON¹

The field of tribology is still in a developmental stage where textbooks come and go rapidly. A few years ago a treatment of lubrication would have dealt almost exclusively with hydrodynamic bearings, and

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the only treatment of frictional contact available would be that of the mechanics books, which still speak of "smooth" surfaces as "frictionless." In such a rapidly developing field no textbook will cover all of the important topics and none will give the precise emphasis a particular teacher desires for the topics covered. This may not be a problem, however, when one considers how the textbook will be used. Its purpose is to provide a structure about which a full treatment of the field can be developed by the lecturer. It should be sufficiently detailed so that home study can be fruitful, and it should avoid out of date or questionable treatments which have to be countered by the instructor. In my opinion, Halling and his associates have done an excellent job of putting together such a book. I find attractive the prospect of using it in a one term course for senior engineering students.

Although beginning with an introduction by Peter Jost, the patron saint of Tribology, the text fortunately avoids discoursing too much on the socio/political importance of the field.

Topics treated include surface texture, with an introduction to statistical descriptions of roughness. This is followed by the idea of contact stress, going from Boussinesq to Hertz to interferograms for elastohydrodynamic contact, including discussion of the elasto-plastic

transition. A brief but useful (4 page) treatment of heating effects is also included.

The book continues with a fairly complete discussion of friction and wear and includes plastics. There is treatment of stick slip which is overly long (about 25 pages) compared with, say, thermal effects.

Rolling contact is dealt with in sufficient detail, followed by about 50 pages of fairly standard discussion of hydrodynamic films, including such things as herringbone bearings and gas bearings. Hydrodynamic instability strangely rates only about 5 pages, while elastohydrodynamic contact receives nearly 20 pages.

Hydrostatic and hybrid bearings are treated quite thoroughly in 50 pages. This is all followed by a mere 8 pages on how the tribologist should put all this together to provide a suitable tribological solution for an engineering problem. An editorial decision was apparently made to keep reference lists short and avoid the disjointed treatment which results when one tries to credit each contributory piece of work. It follows that this is not a book for researchers. It nevertheless serves as a good introduction for the person who wishes to assess the possibilities of the field. It is a lucid, beautifully printed book one would be pleased to give to the non-tribologist engineer and say, "Read this and you will know what tribology is about."