Overview

There is a continuing interest in extending the reliability and materials capabilities in mechanical systems, both at ambient and elevated temperatures. Tribological applications are excellent examples of situations where stringent requirements have mandated that materials perform at levels previously believed to be unrealistic. Such demanding requirements have served as an impetus for new material development. Taken as a group, advanced materials have been, in many cases, successfully deployed in areas in which conventional materials are no longer satisfactory.

Broadly defined, advanced materials include intermetallic alloys, advanced polymers, engineering ceramics, composites based on metal, polymer, or ceramic matrices. Composites may be classified further into particulate, whisker, and continuous fiber-reinforced varieties. Despite significant advances in materials research, testing techniques and evaluation methodology have not developed at the same pace. As in many other instances, an understanding of material limitations and suitability to task has come by way of an empirical approach at best. Each individual designer/engineer or organization/group has used his/her unique methodology to find advanced materials solutions for a particular problem. While this may be a reasonable practice on a small local scale, communication with the rest of the world, of the success or failure of a material, based on results from this "homemade" approach is not always helpful to others in solving similar, but not identical, problems. Needless to say, to an engineer interested in using these materials in his/her design or application, the lack of standardization poses a difficult problem. As the world economies become increasingly interdependent, and international trade increases, a global consensus on materials testing issues would be extremely beneficial to all parties concerned. More specifically, in light of the potential uses of advanced materials in severe service wear applications, it is vital that their evaluation be done in a systematic, universally acceptable fashion.

The literature on testing practices and standards for advanced materials is unorganized and uncoordinated. ASTM has sponsored several symposia on this and related subjects. Readers are referred to two resulting publications, namely, ASTM STP 1010, *Selection and Use of Wear Tests for Ceramics*, 1988 (Yust/Bayer, Eds.) and ASTM STP 1105, *Tribological Modeling for Mechanical Designers*, 1991 (Ludema/Bayer, Eds.). Another recently issued, noteworthy publication is *The Tribology of Composite Materials*, 1991 (Rohatgi/Blau/Yust, Eds.). In the hope of further improving the status of wear testing of materials and encouraging the engineering community to explore standardization issues, a symposium on Wear Testing of Advanced Materials was held in November 1990 in San Antonio, TX. The objective of the symposium was to review current practices for testing advanced materials and to explore standardization issues. This symposium, held under the auspices of ASTM Committee G-2 on Wear and Erosion, was attended by a wide variety of international experts from universities, government, and industry. This book represents a select collection of eleven peer-reviewed papers from that symposium.

The papers included in this STP can be roughly classified into two categories, namely, wear test methods for advanced materials specifically related to different applications and analysis and interpretation of results from wear tests. Although not all types of wear testing are covered, the book does give the reader a good overview of the more common tests currently used to characterize advanced materials.

Wear Test Methods for Advanced Materials

The first paper in this section discusses the effect of different test configurations and different counterface materials on the tribological characteristics of alumina. The discussion shows that the wear rate of alumina depends on the test configuration in use and the counterface material, whereas it is not affected by the orientation of the sample or the method of surface preparation (except when the surface was diamond ground).

The next paper details the influence of the mechanical response of the test system on the wear and friction results. The author illustrates how a variation of two orders of magnitude is obtained in the wear rates of alumina as a result of changes in the dominant wear mechanism induced by altering test machine dynamics. Also discussed here is an interesting attempt to correlate mechanical response spectra for different configurations with wear and friction results.

Evaluation of wear coatings for seal applications using an accelerated bench wear test is discussed next. This is followed by two articles related to bearing applications, the first of which deals with the development of a unique wear tester to screen candidate materials for thrust bearing applications. The authors show how this tester is used to screen candidate advanced bearing materials for down-hole drilling applications. The second article discusses the test methodologies used to identify polymer and metal matrix composites and ceramics for self-lubricating journal bearings, bearing liners, and hybrid bearings. Materials are evaluated with pin-on-disc, block-on-ring, and rolling four-ball apparatus in both dry and lubricated tests.

The next paper deals with the friction and wear of high performance polymer composites. The influence of the type of reinforcement and the properties of the counterface used in the fretting wear of continuous fiber-reinforced polymer composites is studied in detail. Two papers on slurry erosion are included. They relate to the development of a slurry jet erosion apparatus and a model to predict abrasive particle trajectories using a streamline analysis. The first paper shows that particle velocity and local impact angles vary along the surface of the target material, depending on fluid viscosity, slurry velocity, and particle size. The second paper uses slurry erosion tests to measure wear coefficients in centrifugal slurry pumps. It also discusses the shortcomings of separately simulating two mechanisms, that is, particle impact and scouring, responsible for slurry erosion wear. The authors give possible reasons for discrepancies in wear coefficients between predictions based on the above mechanisms and actual measurements on components. An alternative approach is proposed, based on the coupling of finite-element modeling of fluid flow and actual wear measurements in pump casings.

Analysis and Interpretation of Wear Tests

As an introduction to this section, the first paper is a fairly comprehensive report on results of a round-robin series of tests in the sliding wear of alumina. The effect of changes in test conditions, such as load, sliding speed, humidity level, and load on tribological characteristics, are discussed. It is also reported that a decrease in humidity is accompanied by a significant increase in both friction and wear of alumina. This is attributed to the formation of interfacial layers of hydrated alumina. The use of wear maps is illustrated in the sliding wear of silicon nitrides. They show in three-dimensional representation of the dependence of wear rate on different test variables.

The final paper in this book is a discussion of sliding wear testing and data analysis strategies for advanced ceramics. It discusses the advantages and disadvantages of commonly used techniques to measure friction and wear behavior and suggests alternatives to improve the wear characterization of engineering ceramics.

The editors believe that this book will be a valuable and useful reference for scientists and engineers facing friction and wear problems. In conclusion, the symposium chairmen gratefully acknowledge the expert contributions of the authors and reviewers. They also express deep appreciation for the help and sponsorship of ASTM Committee G-2 on Wear and Erosion and the tireless efforts of ASTM staff, Monica Siperko and Rita Hippensteel, in making this STP possible.

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