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Evaluation of Existing and New Sensor Technologies for Fatigue, Fracture and Mechanical Testing

STP 1584

Editors
Jidong Kang
David Jablonski
David Dudzinski

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Overview

New sensor technologies are used in fatigue, fracture, and mechanical testing to determine a variety of properties that are subject to ASTM standards. As these standards are used in practical applications, issues with existing and new sensors specified in the standards need to be resolved.

The *4th Symposium on the Evaluation of Existing and New Sensor Technologies* is intended to provide a forum to disseminate state-of-the-art advances in sensor technology, as well as to identify the limitations of existing sensor technology as it applies to fatigue, fracture, and mechanical testing. This symposium is the fourth in a series of symposia addressing issues with existing sensors and development in new sensor technologies for fatigue, fracture, and mechanical testing.

In the last decade, digital image correlation (DIC) has been seen as a rapidly growing noncontact strain-measuring technique and has been used extensively in many applications. The first four papers reflect this trend. Bruhis et al. demonstrate how to use DIC to measure mechanical properties of fillet arc T-welded aluminum alloy AA7xxx extrusions. Kang and Gong show the use of DIC to determine fracture behavior of AA6060 aluminum alloy extrusion in specimens with a wide range of stress triaxiality. Williams et al. present an application of DIC in assessing yield and forming limit criteria for sheet material deformation and forming. The final paper in this section by Barhli et al. reviews recent work on the analysis of 2D and 3D damage in engineering materials, and describes developments in quantitative analysis of defects by 2D and 3D image correlation.

The next three papers address new developments in potential drop techniques for crack-length monitoring in fracture-toughness testing. Tarnowski et al. present an experimental investigation that quantifies the apparent crack extension, purely as a result of plasticity, in the absence of physical crack growth in a variety of specimen geometries when using potential drop techniques. Chen et al. show results of applying direct current potential drop techniques to derive the J-integral versus a crack-growth-resistance curve (J–R curve) for fracture-toughness characterization of structural materials. The third paper in this section by Glasser et al. presents an experimental technique using surface strain gauges to determine a calibration curve in terms of strain range versus crack length as a function of loading cycles. By using multiple strain gauges across the width of the specimen, it is possible to map out the crack front and its change in position as a function of loading cycles.

There have been continuous efforts in exploring new applications using various sensors. Cuadra et al. present a hybrid optico-acoustic approach combining DIC and acoustic emission (AE) to account for both surface and volume effects and to provide cross-validation when using in situ nondestructive evaluation (NDE) methods. Sebastian et al. describe an optical sensor that utilizes an extrinsic Fabry–Perot interferometer to measure thermal and mechanical strain on a variety of substrates at temperatures up to 870°C.

The last two papers discuss sensors for use in elevated-temperature applications. Bailey discusses the use of infrared thermography for the measurement of temperature during fatigue testing and a method to adjust the test frequency using an adaptive frequency control algorithm to keep the specimen temperature constant. In the last paper, Jones et al. demonstrate the use of infrared thermography as a noninvasive temperature-measurement technique, and use it in cyclic high-temperature loading. They demonstrate that it is important to coat the specimens with a thin layer of material that has a stable emissivity to obtain accurate temperature measurements.

It is interesting to note that some existing technologies, for example, the potential drop technique, have been in practice for a long time but yet need standardization. In the meantime, some new sensor technologies, for example, DIC, need guidance in practice; thus, the interpretation of results could be fairly compared and understood well. It is the intent of the Sensor Technologies Task Group (E08.03.03) within ASTM E08.03 to revisit the existing corresponding standards and work together with their peers within ASTM to develop new ASTM standards in suitable areas to better serve the fatigue, fracture, and mechanical testing community. This symposium has, no doubt, provided a timely opportunity to stimulate critical thinking and planning.

The editors express their gratitude to all of the authors and co-authors responsible for the papers included in this STP and the presentations made during the symposium. We also thank all of the reviewers for their great efforts and professionalism ensuring the high quality of this STP. Finally, the editors are grateful for the ASTM planning and to the editorial staff for their tireless assistance in making this symposium and STP a great success.

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Foreword

This compilation of *Selected Technical Papers*, STP1584, *Evaluation of Existing and New Sensor Technologies for Fatigue, Fracture and Mechanical Testing*, contains 11 peer-reviewed papers presented at a symposium held May 7–8, 2014 in Toronto, Ontario, Canada. The symposium was sponsored by ASTM International Committee E08 on Fatigue and Fracture and Subcommittee E08.03 on Advanced Apparatus and Techniques.

The Symposium Chairpersons and STP Editors are Jidong Kang, Canmet MATERIALS, Hamilton, Ontario, Canada, David Jablonski, Thermo Fisher Scientific, Tewksbury, Massachusetts, USA, and David Dudzinski, Derivation Research Laboratory, Inc., Ottawa, Ontario, Canada.

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Sensors for Elevated Temperature Applications

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