Contents:

Special Issue on Cavitation

Guest Editors: Toshiharu Kazama and Yaakov Meged

Overview

985 Experimental and Numerical Investigation of Damage on an Aluminum Surface by Single-Bubble Cavitation—Hemant J. Sagar, Stefanie Harke, Martin Underberg, Chaojie Feng, Ould el Moctar, and Sebastian A. Kaiser

1004 Cavitating Flow Luminescence as a Potential Source for Analytical Spectroscopy—Claire M. F. Whitfield, Michael E. Foulkes, and E. Hywel Evans

1018 Analysis of Co-Flow Water Cavitation Peening of Al7075-T651 Alloy Using High-Speed Imaging and Surface Pitting Tests—Andrea Marcon, Shreyes N. Melkote, Minami Yoda, and Daniel Sanders

1041 Jet Cavitation Erosion in Chamfered and Tapered Cylindrical Passages: Comparison with Visualization and Simulation—Toshiharu Kazama and Tatsuya Niota

1058 Recommended Procedures to Test the Resistance of Materials to Cavitation Erosion—Georges L. Chahine

1093 Cavitation Erosion Performance of Steel, Ceramics, Carbide, and Victrex PEEK Materials—Spencer Court, Ilaria Corni, and Nicola Symonds

1107 Cavitation Erosion Resistance Assessment and Comparison of Three Francis Turbine Runner Materials—Markku Ylönen, Pentti Saarenrinne, Joha Mettinen, Jean-Flame Franc, Marc Fivel, and Tuomo Nyysönen

1127 Improved Resistance of Nanoparticle-Laden Polymer Coatings Subjected to Combined Silt and Cavitation—C. Syamsundar, Dhiman Chatterjee, and M. Kamaraj

1151 Analysis of Oil Film Characteristics of Two-Axial Groove Sleeve Bearings—Li-ll Wang, Yu-lan Wei, Guo-teng Yuan, Xing-tang Zhao, and Huan Geng

1164 Novel Pack Cementations: Alternating Current Field Enhanced Pack Cementations—Fei Xie, Shaogong Xu, and Jianwei Pan
**Editorial Objectives**

Materials Performance and Characterization is published online by ASTM International, a nonprofit technical organization that develops and publishes voluntary consensus standards and related information for materials, products, systems, and services.

Contributions are peer reviewed prior to publication.

**Purpose and Scope**

The journal publishes high-quality, original articles, including full papers, review papers, and technical notes, on both theoretical and practical aspects of the processing, structure, properties, and performance of materials used in mechanical, transportation, aerospace, energy systems, and medical devices. These materials include metals and alloys, glass and ceramics, polymers, composite materials, textiles, and nanomaterials. The journal covers topics related to the integrity of materials which encompasses mechanical testing, fatigue and fracture, corrosion, wear, and erosion, as well as the integrity of components and systems such as rolling element bearings, piping and pressure vessels, fasteners, space technology, and nanotechnology. The journal publishes articles on both qualitative and quantitative methods used to characterize materials including all forms of microscopy, chemical analysis, and nondestructive evaluation.

**Editorial Board**

- **Dr. Ing. Menahem Bamberger**
  Technion-Israel Institute of Technology
  Haifa, Israel
- **Dr. Lutz-Michael Berger**
  Fraunhofer Institute for Ceramic Technologies and Systems IKTS
  Dresden, Germany
- **Rodney Boyer**
  RBTI Consulting
  Issaquah, WA, USA
- **Prof. Lauralice Canale**
  EESC-Universidade de São Paulo
  São Carlos, SP, Brazil
- **Mr. Brian Cochran**
  Wabash, IN, USA
- **Dr. Ana Sofia C. M. D’Oliveira**
  Universidade Federal do Paraná
  Curitiba, PR, Brazil
- **Dr. Richard J. Fields**
  Grayson, GA, USA
- **Mr. Robert J. Glodowski**
  East Metals North America LLC
  Pittsburgh, PA, USA
- **Dr. Stephen M. Graham**
  United States Naval Academy
  Annapolis, MD, USA
- **Dr. Jianfeng Gu**
  Shanghai Jiao Tong University
  Shanghai, China
- **Dr. Nikhil Gupta**
  New York University
  Brooklyn, NY, USA
- **Dr. Mohamed Hamed**
  McMaster University
  Hamilton, ON, Canada
- **Dr. Volker Heuer**
  ALD Vacuum Technologies GmbH
  Hanau, Germany
- **Dr. W. Steven Johnson**
  Georgia Institute of Technology
  Atlanta, GA, USA
- **Dr. Toshiharu Kazama**
  Muroran Institute of Technology
  Hokkaido, Japan
- **Prof. Dr.-Ing Olaf Kessler**
  University of Rostock
  Rostock, Germany
- **Dr. Fred Klaessig**
  Pennsylvania Bio Nano Systems
  Doylestown, PA, USA
- **Dr. Nikolai Kobasko**
  Technologies Inc.
  Akron, OH, USA
- **Dr. Antti S. Korhonen**
  Aalto University of Science and Technology
  Aalto, Finland
- **Dr. Hong Liang**
  Texas A&M University
  College Station, TX, USA
- **Dr. Stephen Liu**
  Colorado School of Mines
  Golden, CO, USA
- **Dr. Roberto Lopez-Anido**
  University of Maine
  Orono, ME, USA
- **Dr. Reto Lugibihl**
  R&D Foundation
  Bettlach, Switzerland
- **Dr. Jianbin Luo**
  Tsinghua University
  Beijing, China
- **Prof. Xinmin Luo**
  Jiangsu University
  Zhenjiang, Jiangsu, China
- **Dr. Kemmylesh K**
  Portland State University
  Portland, OR, USA
- **Dr. Rafael David Mercado-Solis**
  Universidad Autonoma de Nuevo Leon
  Nuevo Leon, Mexico
- **Ms. Marybeth Miceli**
  Miceli Infrastructure Consulting, LLC
  Los Angeles, CA, USA
- **Prof. Dr. Ing. Menahem Bamberger**
  Technion-Israel Institute of Technology
  Haifa, Israel
- **Prof. Dr. Ing Olaf Kessler**
  University of Rostock
  Rostock, Germany
- **Dr. Fred Klaessig**
  Pennsylvania Bio Nano Systems
  Doylestown, PA, USA
- **Dr. Nikolai Kobasko**
  Technologies Inc.
  Akron, OH, USA
- **Dr. Antti S. Korhonen**
  Aalto University of Science and Technology
  Aalto, Finland
- **Dr. Hong Liang**
  Texas A&M University
  College Station, TX, USA
- **Dr. Stephen Liu**
  Colorado School of Mines
  Golden, CO, USA
- **Dr. Roberto Lopez-Anido**
  University of Maine
  Orono, ME, USA
- **Dr. Reto Lugibihl**
  R&D Foundation
  Bettlach, Switzerland
- **Dr. Jianbin Luo**
  Tsinghua University
  Beijing, China
- **Prof. Xinmin Luo**
  Jiangsu University
  Zhenjiang, Jiangsu, China
- **Dr. Kemmylesh K**
  Portland State University
  Portland, OR, USA
- **Dr. Rafael David Mercado-Solis**
  Universidad Autonoma de Nuevo Leon
  Nuevo Leon, Mexico
- **Ms. Marybeth Miceli**
  Miceli Infrastructure Consulting, LLC
  Los Angeles, CA, USA
- **Dr. Jin K. Montclare**
  New York University
  New York, NY, USA
- **Dr. Rosa Simencio Otero**
  Universidade de São Paulo
  São Carlos, Brazil
- **Dr. K. Karayan Prabhu**
  National Institute of Technology
  Karnataka State, India
- **Barbara Rivolta**
  Politecnico di Milano
  Milano, Italy
- **Dr. Jeremy Robinson**
  University of Limerick
  Limerick, Ireland
- **Dr. Santyam Sahay**
  John Deere Technology Center
  India
- **Dr. Mehmet S. Sari**
  Materials & Technology Co., Ltd.
  Shanghai, China
- **Dr. Richard W. Neu**
  Georgia Institute of Technology
  Atlanta, GA, USA
- **Dr. Rosa Simencio Otero**
  Universidade de São Paulo
  São Carlos, Brazil
- **Dr. Preet Singh**
  Georgia Institute of Technology
  Atlanta, GA, USA
- **Dr. Richard D. Sisson, Jr.**
  Worcester Polytechnic Institute
  Worcester, MA, USA
- **Dr. Babu Thomas**
  Mahatma Gandhi University
  Kottayam, India
- **Dr. Simon C. Tung**
  Tung Innovation Technology Consulting Inc.
  Rochester Hills, MI, USA
- **Dr. Mathias Woydt**
  BAM Federal Institute for Materials Research and Testing
  Berlin, Germany
- **Dr. Jin K. Montclare**
  New York University
  New York, NY, USA
- **Dr. Rosa Simencio Otero**
  Universidade de São Paulo
  São Carlos, Brazil
- **Dr. K. Karayan Prabhu**
  National Institute of Technology
  Karnataka State, India
- **Barbara Rivolta**
  Politecnico di Milano
  Milano, Italy
- **Dr. Jeremy Robinson**
  University of Limerick
  Limerick, Ireland
- **Dr. Satyam Sahay**
  John Deere Technology Center
  India
- **Dr. Mehmet S. Sari**
  Materials & Technology Co., Ltd.
  Shanghai, China

**ASTM International’s Materials Performance and Characterization is ONLINE.**

**TAKE ADVANTAGE OF THESE BENEFITS:**

- Search Papers & Authors
- View Abstracts
- View Table of Contents
- Download Individual Papers

**IP access is available. FOR INFORMATION VISIT:** www.astm.org

Materials Performance and Characterization (E-ISSN 2165-3992, print ISSN 2379-1365) is published online by ASTM International. The views expressed in this journal are not those of ASTM International. The data and opinions appearing in the published material were prepared by and are the responsibility of the contributors, not of ASTM International.

Copyright © 2018 by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959. All rights reserved. This material may not be reproduced or copied, in whole or in part, in any printed, mechanical, electronic, film, or other distribution and storage media without the written consent of the publisher.

**Subscriptions** include online access. Individual subscriptions: $252.00 for 1 year online access. Institutional subscriptions (one geographic site via IP access): $422.00 for 1 year online access. Multisite access also available; please contact sales@astm.org or call 1-877-909-ASTM. To subscribe, please send prepaid order to ASTM International, Customer Service, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959 or visit www.astm.org.

**Photocopy Rights:** Authorization to photocopy items for internal, personal, or educational classroom use, or the internal, personal, or educational classroom use of specific clients, is granted by ASTM International provided that the appropriate fee is paid to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, Tel: (978) 646-2600; http://www.copyright.com

Periodicals postage paid at W. Conshohocken, Pa., and at additional mailing offices.

**POSTMASTER:** Send address change to ASTM International—MPC, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.

Printed in the USA

Visit our website: www.astm.org.
Overview

Special Issue on Cavitation

Cavitation is an extremely complex phenomena, as Knapp et al. stated in their classical text: “It is difficult to give a concise definition of cavitation and at the same time convey much significant information about it...” Some of the essential characteristics and issues can be: cavitation is a liquid phenomenon; cavitation is the result of pressure reductions in the liquid; cavitation is concerned with the appearance and disappearance of cavities in a liquid including water, oil, and liquid metals; and cavitation is a dynamic phenomenon. Moreover, the damage by collapsing cavitation bubbles is a serious surface wear problem, designated as cavitation erosion.

Cavitation is affected by pressure, velocity, temperature, vapor pressure, surface tension, viscosity, compressibility, and content air. Bubbles due to cavitation can be principally categorized into two types, vaporous and gaseous. Comparing water and oil, water is high vapor pressure and, in contrast, oil contains much air. Therefore, cavitation of water generates vapor bubbles, while that of oil generates gas bubbles.

Cavitation causes degradation and noise of fluid machinery such as turbo pumps, water mills, hydraulic equipment, marine propellers, pipe lines, and hydrodynamic bearings. The most important parameter of pumps would be the net positive suction head which corresponds to limitation of the operation based on cavitation. The performance and limitation of machines and propellers in relation to a liquid are determined by cavitation. Cavitation also causes erosion when the cavitation bubbles collapse near the solid walls. The motion of the bubbles is basically formulated by the Rayleigh-Plesset equation. Furthermore, when an acoustic bubble expands and contracts reputedly by fluctuating circumferential pressure, the bubble emits light and high temperature due to adiabatic compression known as sonoluminescence.

On the other hand, cavitation can be used effectively for surface treatment, cutting, chemical reaction, and cleaning. For example, the high pressure caused by collapsing bubbles may contribute to residual stresses on solid surfaces and emulsification of liquids.

Cavitation erosion is multifaceted and there are several tests including ultrasonic vibration, cavitating jets, high-speed cavitation tunnel, and rotating discs. The representative standards can be listed ASTM G32, Standard Test Method for Cavitation Erosion Using Vibratory Apparatus and G134, Standard Test Method for Erosion of Solid Materials by a Cavitating Liquid Jet.

This Special Issue on Cavitation presents 10 papers on bubble dynamics, damage, erosion, materials, jet flow, luminescence, test method, application, and related subjects that include a wide variety of cavitation phenomena. This includes two papers on bubble dynamics and flow luminescence; two papers on cavitating jets and flow; four papers on material evaluation and test methods; and two papers on bearings and processing. Although these papers are categorized for convenience, each paper deals experimentally and theoretically with one or more subjects.

Producing this special issue required significant efforts from authors, reviewers, editors, and the publication team, which is gratefully acknowledged. The guest editors are also grateful for the support from
their respective organizations. The guest editors of this issue would especially like to thank Dr. Richard W. Neu and Dr. George E. Totten for their guidance and support in compiling this issue.

Toshiharu Kazama, PhD
Muroran Institute of Technology

Yaakov Meged
The Technion, Haifa, Israel
Information for Authors

For details regarding paper submission go to http://mc04.manuscriptcentral.com.

The subject matter must not be of a speculative nature and the contents must not include materials of an advertising nature. The paper must not be seriously defective as to literary form and structure, continuity of thought, and clarity of expression. The substance of the paper should not have been published previously in the open literature.

Authors preparing papers for submittal should observe the conventions of style explained in the ASTM Style Manual. Since the journal does not request page charges, the author is expected to conform to these standard conventions for style. SI units are to be used throughout; if data were not measured in SI units, a note should appear to that effect and the original units should be included in parentheses after the SI units.

IN APPRECIATION

The high quality of the papers that appear in this publication is a tribute not only to the obvious efforts of the authors represented but to the unheralded, though essential, efforts of their reviewers. It is to the reviewers dedication to upholding the high standards of their profession that this note pays tribute. On behalf of ASTM International and the authors as well, we acknowledge with appreciation their important contribution to the success of this journal.
Contents:

Special Issue on Cavitation

Guest Editors: Toshiharu Kazama and Yaakov Meged

- Overview
- Experimental and Numerical Investigation of Damage on an Aluminum Surface by Single-Bubble Cavitation—Hemant J. Sagar, Stefanie Hanke, Martin Underberg, Chaojie Feng, Ould el Moctar, and Sebastian A. Kaiser
- Cavitating Flow Luminescence as a Potential Source for Analytical Spectroscopy—Claire M. F. Whitfield, Michael E. Foulkes, and E. Hywel Evans
- Analysis of Co-Flow Water Cavitation Peening of A7075-T651 Alloy Using High-Speed Imaging and Surface Pitting Tests—Andrea Marcon, Shreyes N. Melkote, Minami Yoda, and Daniel Sanders
- Jet Cavitation Erosion in Chamfered and Tapered Cylindrical Passages: Comparison with Visualization and Simulation—Toshiharu Kazama and Tatsuya Noda
- Recommended Procedures to Test the Resistance of Materials to Cavitation Erosion—Georges L. Chahine
- Cavitation Erosion Performance of Steel, Ceramics, Carbide, and Victrex PEEK Materials—Spencer Court, Ilaria Corni, and Nicola Symonds
- Cavitation Erosion Resistance Assessment and Comparison of Three Francis Turbine Runner Materials—Markku Ylönen, Pentti Saarenrinne, Juha Miettinen, Jean-Flame Franc, Marc Fivel, and TuomoNyssönen
- Improved Resistance of Nanoparticle-Laden Polymer Coatings Subjected to Combined Silt and Cavitation—C. Syamsundar, Dhiman Chatterjee, and M. Kamani
- Analysis of Oil Film Characteristics of Two-Axial Groove Sleeve Bearings—Li-jil Wang, Yu-jiang Wei, Guo-teng Yuan, Xing-tang Zhao, and Huan Geng
- Novel Pack Cementations: Alternating Current Field Enhanced Pack Cementations—Fei Xie, Shaopeng Xu, and Jianwei Pan