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Engineering & Scientific Consulting

Joe Tucker, Ph.D., P.E.

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Professional Profile

Dr. Tucker specializes in materials science and metallurgical engineering with specific expertise in turbomachinery for aviation/aerospace (e.g., fixed wing, rotor wing, engine/powerplant, aircraft groundings, accident investigations, and MRO (maintenance, repair, and overhaul)) and power generation (e.g., turbine/stator blade cracking and fleet assessments for extent of condition and crack detection).

Dr. Tucker's experience is with a variety of alloys (specifically nickel-based superalloys and titanium as well as aluminum, copper, steel, and other superalloys to name a few).

He applies his expertise to investigations of all types (e.g., involving aerospace, automotive, fall protection, locomotive, mining, power generation, and transmission pipelines). Dr. Tucker also has experience in engineered component compliance with relevant specifications, codes, standards, regulations, and fitness for service.

Dr. Tucker has spent over a decade researching a variety of materials science, metallurgy, and mechanical areas. Previously, he was a research scientist at Air Force Research Laboratories, focusing on jet engine rotating parts and aerospace structural materials as it relates to aircraft failure mechanisms. He has specific expertise in fatigue, metallurgical processing (e.g., casting, forging, rolling, heat treating), and material selection for structural applications.

Dr. Tucker is a voting member on ASTM Metallography and SAE Aerospace Materials committees.

Academic Credentials & Professional Honors

Ph.D., Materials Science and Engineering, Carnegie Mellon University, 2013

M.S., Materials Science and Engineering, Carnegie Mellon University, 2010

B.S., Materials Science and Engineering, University of Michigan, Ann Arbor, 2009

Edgar B. Speer Scholarship, 2010

Fontana-Leslie Scholarship, 2008

Alpha Sigma Mu, Materials Science & Engineering Honors Society

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Licenses and Certifications

Professional Engineer Mechanical, California, #38369

Professional Engineer, Illinois, #062.072369

Professional Engineer, Michigan, #6201070364

Professional Engineer, New York, #107861

Prior Experience

Research Scientist/Government Contractor, Air Force Research Laboratories, Materials and Manufacturing Directorate, Structural Materials Division, Metals Branch, 2013-2015

Visiting Scientist, General Electric Aviation, Structural Materials Development Section, 2012

Visiting Scientist, General Electric Research, Aero-Thermal Mechanical Systems Lab, 2011

Professional Affiliations

American Society of Metals — ASM

Failure Analysis Society — FAS

The Minerals, Metals, and Materials Society — TMS

Technical Committees

American Society for Testing and Materials — ASTM, Voting Member, Committee E04 on Metallography

SAE International, Voting Member, Aerospace Materials Specification Committee G on Titanium and Refractory Metals

Publications

Tucker JC, Spear AD. A Tool to Generate Grain-Resolved Open-Cell Metal Foam Models. Integrating Materials and Manufacturing Innovation 2019; 8(2):247-256.

Kramer SLB, Jones A, Mostafa A, Ravaji B, Tancogne-Dejean T, Roth CC, Gorji MB, Pack K, Foster JT, Behzadinasab M, Sobotka JC, McFarland JM, Stein J, Spear AD, Newell P, Czabaj MW, Williams B, Simha H, Gesing M, Gilkey LN, Jones CA, Dingreville R, Sanborn SE, Bignell JL, Cerrone AR, Keim V, Nonn A, Cooreman S, Thibaux P, Ames N, Connor DO, Parno M, Davis B, Tucker J, Coudrillier B, Karlson KN, Ostien JT, Foulk III JW, Hammetter CI, Grange S, Emery JM, Brown JA, Bishop JE, Johnson KL, Ford KR, Brinckmann S, Neilsen MK, Jackiewicz J, Ravi-Chandar K, Ivanoff T, Salzbrenner BC, Boyce BL. The third Sandia Fracture Challenge: deterministic and probabilistic modeling of ductile fracture of additively-manufactured material. International Journal of Fracture 2019; 219(1-2):209-229.

J.C. Plumb, J.F. Lind, J.C. Tucker, R. Kelley, A.D. Spear. Raw and Processed Data to Generate Three-Dimensional Grain Map of Open-Cell Aluminum Foam, NIST Materials Data Repository, 2018.

Plumb JC, Lind JF, Tucker JC, Kelley R, Spear AD. Three-dimensional grain mapping of open-cell metallic foam by integrating synthetic data with experimental data from high-energy X-ray diffraction microscopy. Materials Characterization 2018; 144:448-460.

Pilchak AL, Shank J, Tucker JC, Srivatsa S, Fagin LF, Semiatin L. A dataset for the development, verification and validation of microstructure-sensitive process models in near-alpha titanium alloys. Integrating Materials and Manufacturing Innovation; DOI: 10.1186/s40192-016-0056-1.

Tucker JC, Cerrone A, Ingraffea A, Rollett AD. Crystal plasticity finite element analysis for René88DT statistical volume element generation. Modelling and Simulation in Materials Science and Engineering 2015; 23(3):035003.

Donegan SP, Tucker JC, Rollett AD, Barmak K, Groeber M. Extreme value analysis of tail departure from log-normality in experimental and simulated grain size distributions. Acta Materialia 2013; 61(15):5595-5604.

Tucker JC, Chan LH, Rohrer GS, Groeber MA, Rollett AD. Comparison of grain size distributions in a Ni-based superalloy in three and two dimensions using the Saltykov method. Scripta Materialia 2012; 66:553-557.

Tucker JC, Chan LH, Rohrer GS, Groeber MA, Rollett AD. Tail departure of log-normal grain size distribution in 3D synthetic microstructures. Metallurigcal and Materials Transaction A 2012; 43(8):2810-2822.

Gangireddy S, Karlsdottir SN, Norton SJ, Tucker JC, Halloran JW. In situ microscopy observation of liquid flow, zirconia growth, and CO bubble formation during high temperature oxidation of zirconium diboride-silicon carbide. Journal of the European Ceramic Society 2010; 30(11):2365-2374.

Book Chapters

Pilchak AL, Tucker JC, Weihing TJ. Chapter 2—Determining the Probability of Occurrence of Rarely Occurring Microstructural Configurations for Titanium Dwell Fatigue. From Microstructure Investigations to Multiscale Modeling: Bridging the Gap. Wiley, 2017.

Conference Proceedings

Budiansky N, Dennies DP, Forman J, Wong D, Tucker J. Computed X-ray Tomography of Powder Metallurgy Product for Rapid, Quantitative Size and Shape Distribution Analysis. Microscopy and Microanalysis 2016; 22(Suppl 3):1756-1757.

Tucker JC, Groeber MA, Semiatin SL, Pilchak AL. Synthetic Building and Targeted Analysis of Life-Limiting Microtextured Region. Proceedings of the 13th World Congress on Titanium 2016; 1913-1918.

Cerrone A, Spear A, Tucker J, Stein C, Rollett A, Ingraffea A. Modeling crack nucleation at coherent twin boundaries in nickel-based superalloys. Materials Science & Technology, Pittsburgh, PA, 2012.

Cerrone A, Tucker J, Stein C, Rollett A, Ingraffea A. Micromechanical modeling of René88DT: From characterization to analysis. 2012 Joint Conference on the Engineering Mechanics Institute and the 11th ASCE Joint Specialty Conference on Probabilistic Mechanics and Structural Reliability, Notre Dame, IN, 2012.

Presentations

Zhao D, Tucker J, Spear AD. High-fidelity numerical simulation of open-cell aluminum foams using crystal plasticity modeling. 11th International Conference on Porous Metals and Metallic Foams (MetFoam), Dearborn, Michigan, August 2019.

Tucker J, Spear AD. A tool to generate representative grain-resolved open-cell foam models. 5th World Congress on Integrated Computational Materials Engineering (ICME), Indianapolis, Indiana, July 2019.

Jha SK, Pilchak AL, Tucker JC, Larsen JM, John R. Probabilistic Dwell Fatigue Life Prediction in Microtextured Ti-6Al-4V. TMS 2019, San Antonio, TX, March 2019.

Jha SK, Pilchak AL, Tucker JC, Larsen JM, John R. Probabilistic Dwell Fatigue Life Prediction of Microtextured Ti-6Al-4V. International Conference on Strength of Materials (ICSMA 2018), Columbus, OH, July 2018.

Plumb J, Lind J, Tucker J, Kelley R, Spear AD. 3D Grain Mapping of Open-Cell Aluminum Foam by Synthetic-Data Fusion with Experimental Data from HEDM. 4th International Congress on 3D Materials Science (3DMS) 2018, Helsingør (Elsinore), Denmark, June 2018.

Jha SK, Pilchak AL, Tucker JC, Larsen JM, John R. Probabilistic Dwell Fatigue Life Prediction of Microtextured Ti-6Al-4V. Propulsion Safety and Sustainment Conference (PS&S 2018), Jacksonville, FL, April 2018.

Tucker J, Welk B, Broderick T. Reconstructing Prior Beta Grains in Alpha+Beta Processed Ti Alloys. Materials Science & Technology 2017, Pittsburgh, PA, October 2017.

Budiansky ND, Dennies DP, Forman JC, Wong DT, Tucker JC. Computed X-Ray Tomography of Powder Metallurgy Product for Rapid, Quantitative Size and Shape Distribution Analysis. Microscopy & Microanalysis 2016, Columbus, OH, 2016.

Tucker JC, Weihing TJ, Groeber MA, Pilchak AL. Modeling the Probability of Occurrence of Rarely Occurring Critical Microstructural Features. 3rd International Congress on 3D Materials Science 2016, Chicago, IL, July 2016.

Tucker JC, Pilchak AL, Groeber MA, Semiatin L. Objective Characterization, Synthetic Building and Targeted Analysis of Microtextured Regions from Electron Backscatter Diffraction Data. The 13th World Conference on Titanium 2015, San Diego, CA, August 2015.

Tucker JC, Weihing TJ, Pilchak AL, Groeber MA. Probabilistic Occurrence of Weakest Link Microstructural Features in Two-Phase Titanium. Integrated Computational Materials Science 2015, Colorado Springs, CO, June 2015.

Pilchak AL, Tucker JC. Finding the weakest link within the hierarchy of microstructure in titanium alloys. TMS 2015, Orlando, FL, March 2015.

Tucker JC, Weihing TJ, Pilchak AL, Groeber MA. Instantiating microtextured regions in alpha+beta titanium alloys. Materials Science & Technology 2014, Pittsburgh, PA, October 2014.

Pilchak AL, Li J, Sha G, Groeber M, Tucker JC, Rohklin SI. A quantitative assessment of microtexture in titanium alloys using destructive and nondestructive methods. Microscopy and Microanalysis 2014, Hartford, CT, August 2014.

Tucker JC, Pilchak AL, Groeber MA. Quantify and representing non-primary phases in metallic microstructure. 3D Materials Science 2014, Annecy, France, July 2014.

Pilchak AL, Schwalbach EJ, Tucker JC, Szczepanski CJ, Semiatin SL. Simulating the evolution of microtextured regions during hot-working of a near-alpha titanium alloy. TMS 2014, San Diego, CA, February 2014.

Cerrone AR, Spear AD, Tucker J, Stein C, Rollett AD, Ingraffea AR. Modeling crack nucleation at coherent twin boundaries in nickel-based superalloys. The Materials Science & Technology Conference, Montreal, Canada, October 2013.

Cerrone AR, Tucker JC, Stein C, Spear AD, Rollett AD, Ingraffea AD. Characterizing and simulating fatigue cracking mechanisms in LSHR. TMS Annual Meeting and Exhibition, San Antonio, Texas, March 2013.

Tucker JC, Cerrone A, Rollett AD, Ingraffea A. Synthetic microstructure-based lifing of Ni-based superalloys. Materials Science & Technology 2012, Pittsburgh, PA, October 2012.

Tucker JC, Cerrone A, Rollett AD, Ingraffea A. Microstructure-based life modeling of Ni-based superalloys. 3D Materials Science 2012, Seven Springs, PA, July 2012.

Tucker JC, Stein C, Chan LH, Cerrone AR, Ingraffea AR. Fatigue interrogating 3D synthetic microstructures of Ni-based alloys. TMS 2012, Orlando, FL, March 2012.

Tucker JC, Stein C, Sintay S, Chan LH, Rollett AD. Stereology of synthetic microstructures representing Ni-based superalloys. Materials Science & Technology 2011, Columbus, OH, October 2011.

Tucker JC, Rollett AD, Stein C, Loghin A, Chan L. Matching statistics of synthetic microstructures to experimental grain size. Integrated Computational Materials Science 2011, Seven Springs, PA, July 2011.

Tucker JC, Rollett AD, Stein C, Loghin A, Chan L. Matching statistics of synthetic microstructures to experimental grain size. Department of Defense High Performance Computer Modernization Program Users Group Conference 2011, Portland, OR, June 2011.

Tucker JC, Brahme A, Fridy J, Lee S-B, Groeber M, Sintay S, Dillon S, Li J, Roberts C, Rohrer GS, Uyar F, Hu L, Chan L, Wilson SR, Suter RM, Lee SF, Hefferan C, Jnd L, Rollett AD, Laflen J, Loghin A. Tail departure of log-normal grain size distribution in 3D synthetic microstructures. TMS 2011, San Diego, CA, March 2011.

Tucker JC, Gangireddy S, Halloran JW. Novel optical microscopy for imaging beneath the surface of oxide scales on ZrB2-SiC. Materials Science & Technology 2008, Pittsburgh, PA, October 2008.

Project Experience

Selected project experience is summarized below.

Aviation/Aerospace

Executed government contracts involving microstructural data and investigating titanium alloy life limiting behavior in aerospace structural applications.

Worked with commercial jet engine companies and suppliers to address manufacturing defects in titanium alloys for rotating parts.

Principal investigator for a fixed wing single engine accident. Work included review of technical accident investigation reports, inspection of wreckage, and analysis of a thrust bearing for installation defects during engine overhaul.

Assisted in developing a novel open-celled aluminum foam material for light-weight, load bearing structures. Work included modeling the ligament structure to optimize properties (e.g., crush strength), in direct collaboration with the foam manufacturer.

Fall Protection

Investigated gate burst out of twin lanyard snap hooks involving testing to ANSI Z359.1. Work included inspection of the incident tower and metallurgical testing of the snap hooks.

Investigated damage to a cable grab device that failed to arrest a fall. Work included inspection of the incident tower and metallurgical testing of the cable grab.

Transmission and Process Piping

Large-scale international arbitration involving continuous casting of very-thick-walled pipeline steel with hard spots. Responsible for quality control, quality assurance, non-destructive testing, fracture mechanics, hydrogen-induced cracking, and sulfide stress cracking aspects of the matter.

Principal investigator for a pinhole failure of copper residential piping. Work included metallurgical testing of the failed pipe to determine cause of failure.

Executed transmission integrity management programs for utility involving reviewing preventative and maintenance tasks to determine disposition and recommend mitigation. Investigated a brass fitting failure in a pressure reducing valve.

Investigated a brass fitting pinhole failure in a pressure reducing valve. Work included metallurgical testing of the brass fitting to determine cause of failure.

Mining

Large-scale international arbitration involving numerous mechanical and materials claims related to a polymetallic ore mine. Work included analysis of material selection in hypersaline brines and review of large volumes of isometrics and piping and instrumentation diagrams (P&IDs) to assess the number and magnitude of errors as it relates to standard of care.

Power Generation

Large-scale international arbitration involving numerous mechanical and materials claims related to nuclear power plant. Work included analysis of the Nuclear Regulatory Commission (NRC) approval process and ASME Boiler and Pressure Vessel Code Section III to determine component conformance.

Performed a direct-cause assessment (DCA) of failures in blade locking hardware of combustion turbine engines. Work included metallurgical testing of the Ni-based superalloy bolt and stainless steel components to determine if the properties conformed to the technical specification.

Principal investigator for a DCA of a compressor turbine blade liberation event. Work included on-site disassembly of the gas turbine, metallurgical testing, and review of documents (e.g., inspection reports, major outage reports, and operational PI data).

Principal investigator for a fleet assessment of gas turbine units that had experienced multiple compressor diaphragm failures across the fleet. Work included analysis of operational PI data, review of similar historical failures, analysis of diaphragm welds for nonconformities, metallurgical testing of the weld, fracture mechanics to estimate crack propagation to failure, and review of maintenance and inspection intervals.

Intellectual Property

Participated in a patent infringement litigation related to specialty steel. Responsible for analysis of all processing steps, including: slab heating, hot rolling, hot band annealing, cold rolling, decarburization, nitriding, and finish annealing.

Automotive

Principal investigator for a failed safety chain analysis in a fatal trucking accident. Work included testing the safety chain to determine conformance to the design properties.

Examined motorcycle main frame fracture surfaces to determine failure mode and analyze different model motorcycle recalls for relevance.