# Justin C. Mach

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## Profile

Experienced R&D lead engineer and analyst with background in manufacturing, FEA, and solid mechanics.

## Experience

**Senior Target Systems R&D Engineer, Oak Ridge National Laboratory, TN — 2021-Present**
**Second Target Station, Spallation Neutron Source**

- Leading the development of the manufacturing process for the target segments, including simulation of the hot isostatic pressing process, prediction of the residual stress, and verification through neutron and X-ray diffraction-based techniques (ongoing).
- Leading R&D tasks to characterize unirradiated and irradiated material properties of the target assembly materials including tungsten, tantalum, copper, and Inconel. Utilized fracture testing and simulation of tantalum-clad tungsten samples, vacuum hot pressed sample failures, and an analytical understanding of interface fracture mechanics to characterize the potential for cracks to penetrate or delaminate bonded material interfaces of the target segment (ongoing).
- Led a multi-directorate team to develop and execute a proton beam impact test of tantalum and niobium clad-tungsten target blocks to verify transient dynamic analysis results.
- Created the initial R&D plans for STS Target Systems, incorporating requirements from each of the subsystem lead engineers.

**Mechanical Engineering Analyst, Oak Ridge National Laboratory, TN — 2019-2021**
**Neutron Sciences Directorate, Spallation Neutron Source**

- Led the structural analysis effort for the Proton Power Upgrade (PPU) 2 MW mercury target preliminary and final designs. Improved and developed static, dynamic, and fatigue analysis processes for the mercury target base material and welds. Documented best practices and updated the mercury target structural design criteria.
- Led a team of engineers and scientists across three directorates to create a research proposal for machine learning (ML)-enabled optimization of the mercury target dynamic analysis. Funding was awarded as part of a larger proposal for a DOE ML award that focused on applying machine learning to address user facility reliability issues.
- Performed other engineering mechanics analyses using hand calculations and custom codes for the mercury process system and service bay piping.
- Served as the Abaqus software administrator for SNS and across ORNL through active management and improvement of user communication, support documentation, and license renewal process. Performed HPC parallel performance studies to optimize CPU and license usage on the SNS cluster.

**Engineering Specialist (R&D), Caterpillar Inc., Mossville, IL — 2015-2019**
**Senior Engineer (R&D), Caterpillar Inc., Mossville, IL — 2012-2015**
**Manufacturing Technology & Solutions, Innovation & Technology Development Division**

- Led R&D projects through Technology Readiness Level (TRL) 1-4 and technology transfer to first adopters within the company.
- Supervised and prioritized work for three simulation engineers, as the simulation team lead and knowledge owner for welding process simulation.
- Performed welding process simulation and optimization to support new product introduction and continuous product improvement.
- Conducted high energy x-ray diffraction experiments to validate welding residual stress predictions and to measure residual stress in heat treated components.
- Performed fracture mechanics analysis using the finite element alternating method (FEAM).

**FEA Engineer (Eng III-IV), ATK (now Northrop Grumman), Independence, MO — 2010-2012**
**Small Caliber Systems, Research & Development**

- Finite element modeling and simulation of small caliber ammunition manufacturing processes and performance: performed non-linear, explicit transient-dynamic analysis of metal forming, assembly, and internal/external ballistic events.
- Mentored FEA intern and co-op students.

**Postdoctoral Research Associate, University of North Texas, Denton, TX — 2009**
**Department of Materials Science and Engineering**

- Testing of a mesoscale plasticity model based on field dislocation mechanics for the analysis of gradient effects in fracture and fatigue problems.

**Research Assistant, University of Illinois, Urbana-Champaign, IL — 2006-2009**
**Department of Mechanical Science & Engineering**

- Developed a continuity requirement on the elastic rotation field for classical crystal viscoplasticity, which is founded on the theoretical basis of field dislocation mechanics. Implemented theory in a 3D, parallel, Matlab finite element code to verify the effects of the continuity condition on texture evolution and hardening.
- Completed a parametric study of delamination fracture in Al-Li alloys for NASA project concerning mechanical behavior of aluminum alloys for next generation space vehicle.

- Adapted the mechanical threshold stress (MTS) constitutive model for high temperature deformation of a medium carbon steel with high harden-ability.

**Engineering Intern, Caterpillar Inc., Peoria, IL — 2006**
**Advanced Materials Technology, Technology & Solutions Division**

- Automated an abrasive wear simulation including implementation of re-meshing and state variable mapping and performed scratch and abrasive wear tests for wear model verification.

**Research and Teaching Assistant, Northwestern University, Evanston, IL — 2004-2006**
**Department of Mechanical Engineering**

- Developed an improved mesh-free nodal integration technique to eliminate displacement field oscillations.

- Taught two discussion sections of an undergraduate statics and dynamics course.

**Engineering Intern, Sandia National Laboratory, Livermore, CA — 2005**
**Engineering Sciences Summer Institute**

- Investigated the use of nodal integration techniques in mesh-free simulation of penetration and perforation of materials

**Engineering Intern, Sandia National Laboratory, Livermore, CA — 2004**
**Engineering Sciences Summer Institute**

- Supported the W87 redeployment project through a computational performance comparison of hex and shell elements in 3D transient dynamics code PRESTO.

**Engineering Intern, Lawrence Livermore National Laboratory, Livermore, CA — 2003**
**Computational Materials Science and Chemistry Summer Institute**

- Studied void growth in aluminum using molecular dynamics to verify an interatomic potential and void growth mechanism (prismatic loop formation) by matching simulation with experimental observation.

**Research Assistant, University of Illinois, Urbana-Champaign, IL — 2002-2004**
**Department of Mechanical Engineering**

- Numerical study of the interaction of cracks and dynamic strain ageing in aluminum: a 3D cohesive element was added to an existing parallel polycrystal plasticity finite element code.

**Engineering Intern, Product Design Services, Inc. (now DiMonte Group), Aurora, IL — 2002**

- Modeling and design of industrial machinery using SolidWorks.

**Packer Engineering, Inc., Naperville, IL — 1997-2002**

- Supported the Materials, Mechanical, Chemical, and Transportation Engineering departments with engineering mechanics analyses, failure analysis testing and evaluation, and accident investigation. Assisted in the development and improvement of the summer intern program.

## Education

University of Illinois, Urbana-Champaign, IL — Ph.D., Mechanical Engineering, 2009
Thesis: Continuity in Rigid Viscoplastic Flow

University of Illinois, Urbana-Champaign, IL — M.S., Mechanical Engineering, 2004
Thesis: Numerical Simulation of Dynamic Strain Ageing and Fracture in Aluminum

University of Illinois, Urbana-Champaign, IL — B.S., Mechanical Engineering, 2002
with Honors

## Publications

**Mach, Justin,** et al., "Second Target Station Project: LANSCE WNR Target 2 (Blue Room) Experiment 2022". United States. https://www.osti.gov/servlets/purl/1989568, 2023.

Radaideh, M. I., H. Tran, L., H. Jiang, D. Winder, S. Gorti, G. Zhang**, J. Mach**, and S. Cousineau, "Model calibration of the liquid mercury spallation target using evolutionary neural networks and sparse polynomial expansions", Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Vol. 525, pp. 41-54, 2022.

Johns, K., **Mach, J.**, Gorti, S., and Jiang, H., "Design and Structural Assessment of the Spallation Neutron Source 2.0 MW Target", Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Vol. 1018, 165799, 2021.

**Mach, J.,** Johns, K., Gorti, S., and Jiang, H., "Fatigue analysis of the Spallation Neutron Source 2 MW target design", Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Vol. 1010, 165481, 2021.

Winder, D., Lin, L., and **Mach, J., "**Incorporating bubble growth volume feedback to improve simulation of the response of a structure containing liquid and gas to sudden energy input", Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Vol. 1005, 165371, 2021.

L. Lin, S. Gorti, **J.C. Mach**, H. Tran, D.E. Winder, "Application of Machine Learning to Predict the Response of the Liquid Mercury Target at the Spallation Neutron Source, Proceedings of the 12th International Particle Accelerator Conferences, pp. 3340 to 3343, 2021.

**Mach, J.**, C. Gales, J.S. Park, J. Okasinski, C. Budrow, A. Beaudoin, K. Swartz, M. Miller, and T. Gnaupel-Herold, "FD&E Total life T-sample residual stress analytical predictions and measured results", SAE Technical Paper, No. 2019-01-0528, 2019.

Yalamanchili, V. K., D. A. Galindo, and **J. C. Mach**, "Robust Virtual Welding Process Optimization" Procedia Computer Science 140: 342-350, 2018.

**Mach, J.C.,** C.J. Budrow, D.C. Pagan, J.P.C. Ruff, J.-S. Park, J. Okasinski, A.J. Beaudoin, and M.P. Miller, "Validating a Model for Welding Induced Residual Stress Using High Energy X-ray Diffraction", Journal of Materials, Vol. 69, Issue 5, pp. 893-899, 2017.

Pan, L., B.P. Athreya, J.A. Forck, W. Huang, L. Zhang, T. Hong, W. Li, W. Ulrich, and **J.C. Mach**, "Welding residual stress impact on fatigue life of a welded structure", Welding in the World, Vol. 57, Issue 5, pp. 685-691, 2013.

Beaudoin, A.J., M. Obstalecki, R. Storer, W. Tayon, **J. Mach**, P. Kenesei, and U. Lienert, "Validation of a Crystal Plasticity Model Using High Energy Diffraction Microscopy", Modeling and Simulation in Materials Science and Engineering, Vol. 20, No. 2, 2012.

**Mach, J.** and M. Lee, "Ballistic Performance of Steels and Aluminums in FE Firing Simulations", Proceedings of the 26th International Symposium on Ballistics, Miami, FL, 2011.

**Mach, J.C.**, A.J. Beaudoin, and A. Acharya, "Continuity in the Plastic Strain Rate and its Influence on Texture Evolution", Journal of the Mechanics and Physics of Solids, Vol. 58, pp. 105-128, 2010.

**Mach, J.C.**, J. Kang, A.J. Beaudoin, and D.S. Wilkinson, "Heterogeneity in Plastic Deformation", Materials Science Forum, Vols. 519-521, pp. 85-92, 2006.

## Presentations

**Mach, J.**, X. Chen, D. Erdman III, B. Garrison, A. Jacques, A. Kubik, D. Kyle, Y.J. Lee, J. Montross, T. Muth, J. Osborne, "Current Status of the STS Target Segment Manufacturing Development & Evaluation", 15th International Workshop on Spallation Materials Technology, Santa Fe, NM, 2023.

**Mach, J.**, C. Gales, J.S. Park, J. Okasinski, C. Budrow, A. Beaudoin, K. Swartz, M. Miller, and T. Gnaupel-Herold, "FD&E Total life T-sample residual stress analytical predictions and measured results", WCX SAE World Congress Experience, Detroit, MI, 2019.

**(invited) Mach, J.,** "Characterization of residual stress for process and product validation of heavy equipment using high-energy x-ray diffraction", New Industrial and Scientific Opportunities for Structural Materials: Data, Modeling, Manufacturing, CHESS-U Workshops 2016, Ithaca, NY, 2016.

**Mach, J.C.,** and M. Lee, "Ballistic Performance of Steels and Aluminums in FE Firing Simulations", International Infantry & Joint Services Small Arms Systems Symposium, Exhibition & Firing Demonstration, Indianapolis, IN, 2011.

**Mach, J.C.**, A.J. Beaudoin, and A. Acharya, "Partial Continuity of the Plastic Strain Rate and its Influence on Texture Evolution", International Symposium on Plasticity, St. Thomas, U.S. Virgin Islands, 2009.

**Mach, J.C.**, A.J. Beaudoin, and A. Acharya, "Texture Evolution & Partial Continuity of the Plastic Strain Rate", Fourth International Conference on Multiscale Materials Modeling, Tallahassee, FL, 2008 (poster presentation by A.J. Beaudoin).

**Mach, J.C.** and A.J. Beaudoin, "A Gradient-Based Work-Hardening Model for Metals", ASME International Mechanical Engineering Congress and Exposition, Seattle, WA, 2007.

**Mach, J.C.** and A.J. Beaudoin, "Heterogeneity in the Plastic Deformation of Solution Strengthened Aluminum Alloys", Materials Science & Technology Conference and Exhibition, Detroit, MI, 2007.

## Patents

- US10325036B2, "Method and system for determining welding process parameters", Vijay K. Yalamanchili, **Justin C. Mach**, Joshua D. Webb, Julian Norato, Badrinarayan P. Athreya

## Recognitions, Honors, Awards, and Fellowships

- 2020 Significant Event Award, UT-Battelle, Proton Power Upgrade target design
- 2018 Application Award for Best Paper, Complex Adaptive Systems Conference, Vijay K. Yalamanchili, Diego A. Galindo, **Justin C. Mach**, "Robust Virtual Welding Process Optimization"
- 2015 Caterpillar Group President's Award for Process Quality, "Weld Sequence Optimization"
- 2004 NSF IGERT graduate student fellowship, Northwestern University

## Science & Technology Engagement

- ASM Residual Stress Technical Committee, Member
- Society of Automotive Engineers (SAE) Fatigue Design & Evaluation (FD&E) (www.fatigue.org)
    - Committee member and Residual Stress sub-committee member
    - 2015-2019: active contributor to Total Life project (https://www.fatigue.org/projects/total-life-project/)
    - Associated publication: **Mach, J.,** C. Gales, J.S. Park, J. Okasinski, C. Budrow, A. Beaudoin, K. Swartz, M. Miller, and T. Gnaupel-Herold, "FD&E Total life T-sample residual stress analytical predictions and measured results", SAE Technical Paper, No. 2019-01-0528, 2019.
- 2019, Reviewer for Journal of Nuclear Science & Technology

- Industrial Impact at CHESS. Q&A with Justin Mach, an Engineer at Caterpillar Inc. | CHESS (cornell.edu) (https://www.chess.cornell.edu/industrial-impact-chess-qa-justin-mach-engineer-caterpillar-inc)

- American Society of Mechanical Engineers, Member

## Certifications and Licenses

- 2018 Six Sigma DMAIC & CPS (Caterpillar Production System) Black Belt Training

- 2002 Professional Engineer Intern, #061030368

## References

- Armand J. Beaudoin, Jr., PhD, [redacted], abeaudoi@illinois.edu, (thesis advisor and research collaborator)

    - Professor Emeritus, University of Illinois at Urbana-Champaign, Mechanical Science and Engineering

    - Industrial Liaison, Cornell High Energy Synchrotron Source (CHESS)

- Professor Matthew P. Miller, Cornell University, Mechanical and Aerospace Engineering, [redacted], mpm4@cornell.edu, (research collaborator)

- Robert H. Dodds, Jr., PhD, NAE, [redacted], rhdodds@gmail.com (research collaborator), M.T. Geoffrey Yeh Endowed Chair Professor (Emeritus), Department of Civil & Environmental Engineering, University of Illinois at Urbana-Champaign

- Dr. Badri Athreya, [redacted], badri.athreya@gmail.com, (former team leader and colleague at Caterpillar)

- Mr. Mark Lee, Northrop Grumman Corporation, [redacted], mark.d.lee@ngc.com, (former mentor and colleague at ATK, now Northrop Grumman)