

# Sandip Dayani

Constitutive Modeling & Large Deformation Theory | Solid Mechanics & Multiscale Material Modeling | Implicit & Explicit FEA (Abaqus, LS-DYNA) | Instrumented Material Characterization & Multiscale Validation  
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## SUMMARY

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Materials and mechanics engineer with a PhD in Mechanical & Mechatronics Engineering from the University of Waterloo (2026) working at the boundary between material science and mechanical engineering. Develops constitutive models from first principles within a finite deformation framework, derives them to be thermodynamically consistent, and implements them at solver level as Fortran user material subroutines that extend commercial finite element codes beyond their built in material libraries. Designs the experiments that characterize materials and runs highly instrumented tests (full field digital image correlation, high speed infrared thermography, EBSD microstructure and texture measurement, mechanical testing across strain rates) to calibrate and challenge those models. Validates predictions from the bottom up, connecting microstructural mechanisms through coupon response to component scale behaviour in implicit and explicit FEA, and identifies where models stop being trustworthy. Communicates methods and results to industrial partners, in refereed journals, and at international conferences.

## TECHNICAL SKILLS

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**Constitutive Modeling & Large Deformation Theory:** Development of constitutive models from first principles; finite deformation and large strain kinematics; rate and temperature dependent plasticity; free energy and dissipation inequality formulations; thermodynamically consistent damage evolution; parameter calibration against experimental data and assessment of model validity limits

**Solid Mechanics & Multiscale Modeling:** Continuum and solid mechanics; crystal plasticity linking crystallographic slip and texture to macroscopic response; micromechanical representative volume element modeling of fibre reinforced polymer composites; damage and fracture mechanics; localization and instability; bottom up connection of microstructure to component behaviour

**Finite Element Analysis:** Implicit and explicit FEA (Abaqus, LS-DYNA, ANSYS Mechanical); nonlinear large deformation analysis; coupled thermal mechanical analysis; contact and forming simulation; mesh sensitivity, convergence, and parametric studies

**Material Characterization & Instrumented Testing:** Design of material characterization experiments and test matrices; tensile testing across strain rates; V bend formability testing; full field digital image correlation (DIC); high speed infrared thermography; EBSD microstructure and texture measurement; metallographic specimen preparation; instrumented test platform design and data acquisition

**Verification & Validation:** Systematic validation across scales, from single element and coupon response through to component behaviour; correlation against highly instrumented test data; quantification of predictive accuracy and identification of model gaps

**Solver Development & Programming:** Fortran user material subroutines (UMAT, VUMAT) extending commercial solvers with custom constitutive physics; modification and extension of an existing in house crystal plasticity code; Python (NumPy, pandas, scikit-learn, PyTorch) and MATLAB; automated simulation and post processing pipelines; machine learning surrogate models (DeepONet)

**Communication & Collaboration:** Refereed journal publication and invited international conference presentation; technical reporting to an industrial partner under confidentiality; cross functional work with experimental and industry teams

## RESEARCH & ENGINEERING EXPERIENCE

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### Doctoral Researcher — Constitutive Modeling, Characterization & Validation

Jan 2022 – Aug 2026

*University of Waterloo, Waterloo, ON, Canada (industry sponsored programme, General Motors)*

- Developed constitutive models for engineered metals within a finite deformation framework: derived a thermodynamically consistent damage model from first principles using free energy and dissipation inequality arguments, capturing void nucleation, growth, and coalescence across strain rate and temperature.
- Advanced the mathematical description from the microstructure upward, using crystal plasticity to connect crystallographic slip, texture, and phase constituents to macroscopic flow, localization, and failure behaviour.
- Implemented the models at solver level as Fortran user material subroutines (UMAT, VUMAT) inside commercial finite element codes, and modified and extended an existing in house crystal plasticity code, extending predictive capability beyond built in material libraries.
- Designed the experiments that characterize the materials: defined test matrices and ran tensile testing across strain rates, V bend formability testing, full field DIC strain measurement, high speed infrared thermography, EBSD microstructure and texture measurement, and metallographic specimen preparation.
- Validated models bottom up across scales, from single element and coupon response through to component behaviour in implicit and explicit FEA (Abaqus, LS-DYNA), comparing predictions against highly instrumented test data, calibrating parameters from measurement, and identifying the gaps where predictions degraded.

- Built machine learning surrogate models (DeepONet in PyTorch) to predict formability and mechanical response without full solver runs, improving generalization by encoding physically meaningful crystallographic descriptors.
- Reported to an industrial partner under confidentiality and published the methods: first author paper in the International Journal of Plasticity, two further first author papers submitted or under review, and an invited international conference presentation; mentored undergraduate engineers (ME219, ME559).

**Master Thesis Researcher — Coupled Simulation & Experimental Validation**

Jul 2020 – Apr 2021

*Fraunhofer Institute (UMSICHT), Oberhausen, Germany*

- Developed transient CFD models (ANSYS Fluent) of conjugate heat transfer with phase change, ran sensitivity and convergence studies, and specified, designed, and built an instrumented experimental test platform with data acquisition to generate validation data and correlate model against measurement. (MSc thesis.)

**Research Assistant — Coupled CFD, FE & Design Optimization**

Jul 2020 – Mar 2021

*Fraunhofer Institute (IWS), Dresden, Germany*

- Analyzed a laser deposition shielding nozzle through coupled CAD, finite element, and CFD analysis (ANSYS CFX), applying parametric optimization across design variants and validating thermal and structural performance against operating requirements.

**Research Intern — Thermal Structural Simulation of Composite Processing**

Sep 2019 – Dec 2019

*German Aerospace Centre (DLR), Augsburg, Germany*

- Performed coupled thermal structural finite element analysis of an aerospace polymer composite manufacturing process; defined boundary and load conditions, predicted transient temperature fields through the process cycle, and validated predictions against experimental measurements.

**Research Project Assistant — Micromechanical Modeling of Polymer Composites (RVE)**

Apr 2019 – Aug 2019

*Technische Universität Chemnitz, Germany*

- Built micromechanical representative volume element models in ANSYS for fibre reinforced polymer composites, computing effective engineering constants including nonlinear behaviour for macro scale structural analysis, a bottom up homogenization from constituent behaviour to structural response.

## WHY THIS ROLE

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- **Constitutive modeling is the centre of my work.** Deriving material descriptions from first principles within a finite deformation framework, implementing them at solver level, and proving them against experiment is what my doctorate was built to do.
- **Material science meets mechanical engineering.** I sit on exactly that boundary: I run the microstructural characterization, I write the constitutive theory, and I run the component simulation, so nothing is lost in translation between the three.
- **Bottom up validation.** I build validation upward from single element and coupon response to component behaviour, comparing against highly instrumented tests, and I state plainly where the predictions stop holding rather than reporting only the cases that matched.
- **Experiments I designed myself.** Because I define the test matrices and run the measurement, the models are calibrated against data whose noise and limits I understand firsthand, and my subroutine and workflow development has been built for handover to collaborators rather than left as personal research scripts.

## EDUCATION

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**Ph.D., Mechanical & Mechatronics Engineering** — University of Waterloo | 2026

*Thesis:* Crystal plasticity based damage modeling for strain rate and temperature dependent failure in advanced high strength steels. Advisor: Prof. Kaan Inal.

**M.Sc., MERGE Technologies for Resource Efficiency** — Technische Universität Chemnitz | 2021

**B.Eng., Mechanical Engineering** — Gujarat Technological University | 2017

## PUBLICATIONS & RECOGNITION

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- S. Dayani, W. Muhammad, A. Brahme, F. Hekmat, T. Sabiston, K. Inal. Thermodynamically consistent damage evolution model coupled with rate dependent crystal plasticity: application to high strength low alloy steel at various strain rates. *International Journal of Plasticity*, 186, 104255, 2025. DOI: [10.1016/j.ijplas.2025.104255](https://doi.org/10.1016/j.ijplas.2025.104255).
- Two additional first author papers under review or submitted (dual phase steel; quenching and partitioning steel).
- Invited oral presentation, International Conference on Plasticity, Damage & Fracture (ICPDF 2026), Geelong, Australia, January 2026.
- Oravas Memorial Scholarship, University of Waterloo (2025); Teaching Assistant, ME219 Mechanics of Deformable Solids (Fall 2024).

## LANGUAGES

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English (fluent), German (working), Hindi, Gujarati.