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Where Discoveries Begin

Optimization of Solid-State Advanced Manufacturing Processes Using a Data-driven Approach

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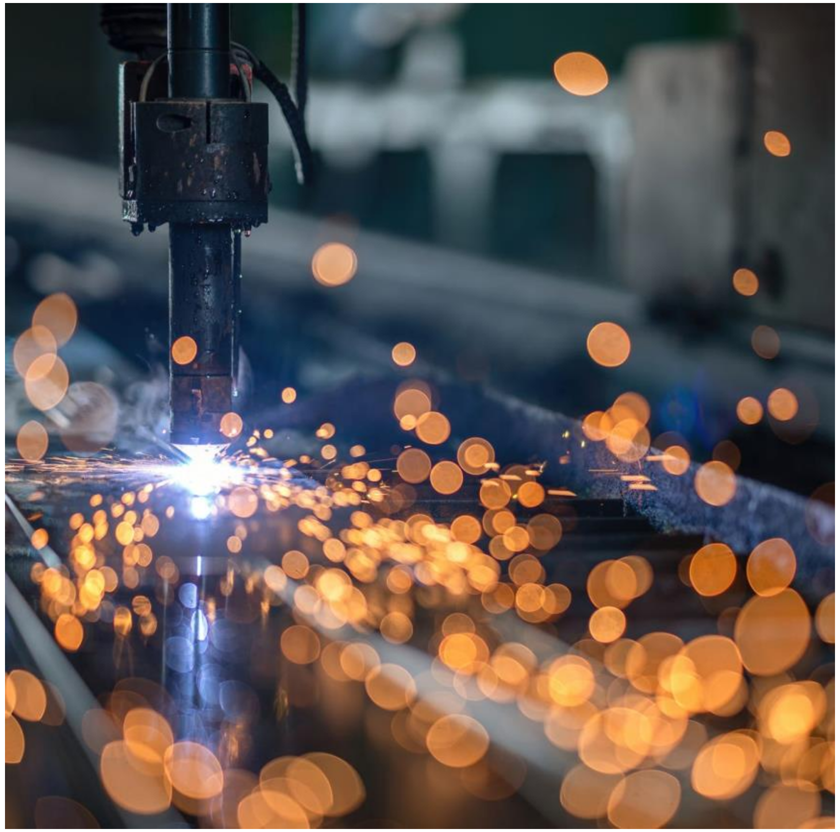
Beyond Melting: Solid → Liquid → Back Again

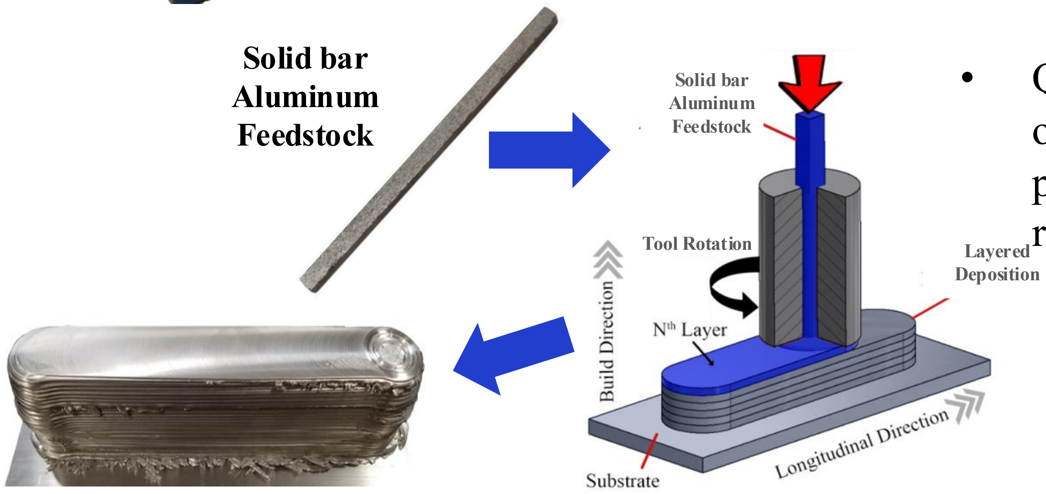
A Backbone of U.S. Manufacturing and Economic Strength

- ~25 % of liquid steel and ~40 % of liquid aluminum is lost due to quality issues, shape inefficiencies, and manufacturing defects (NIST Annual Report, 2024)
- Solid-state process uses ~42% less energy and produces ~31% fewer greenhouse gas emissions compared with conventional gas metal arc welding (GMAW) for aluminum joints (Shrivastava, 2015)
- Studies comparing friction stir processing with traditional aircraft joining methods show that FS can cut manufacturing cycle time by ~60% and reduce recurring assembly costs by ~20% versus conventional riveting and assembly processes. (Laan, 2016)



Friction Stir Manufacturing

Project Goals



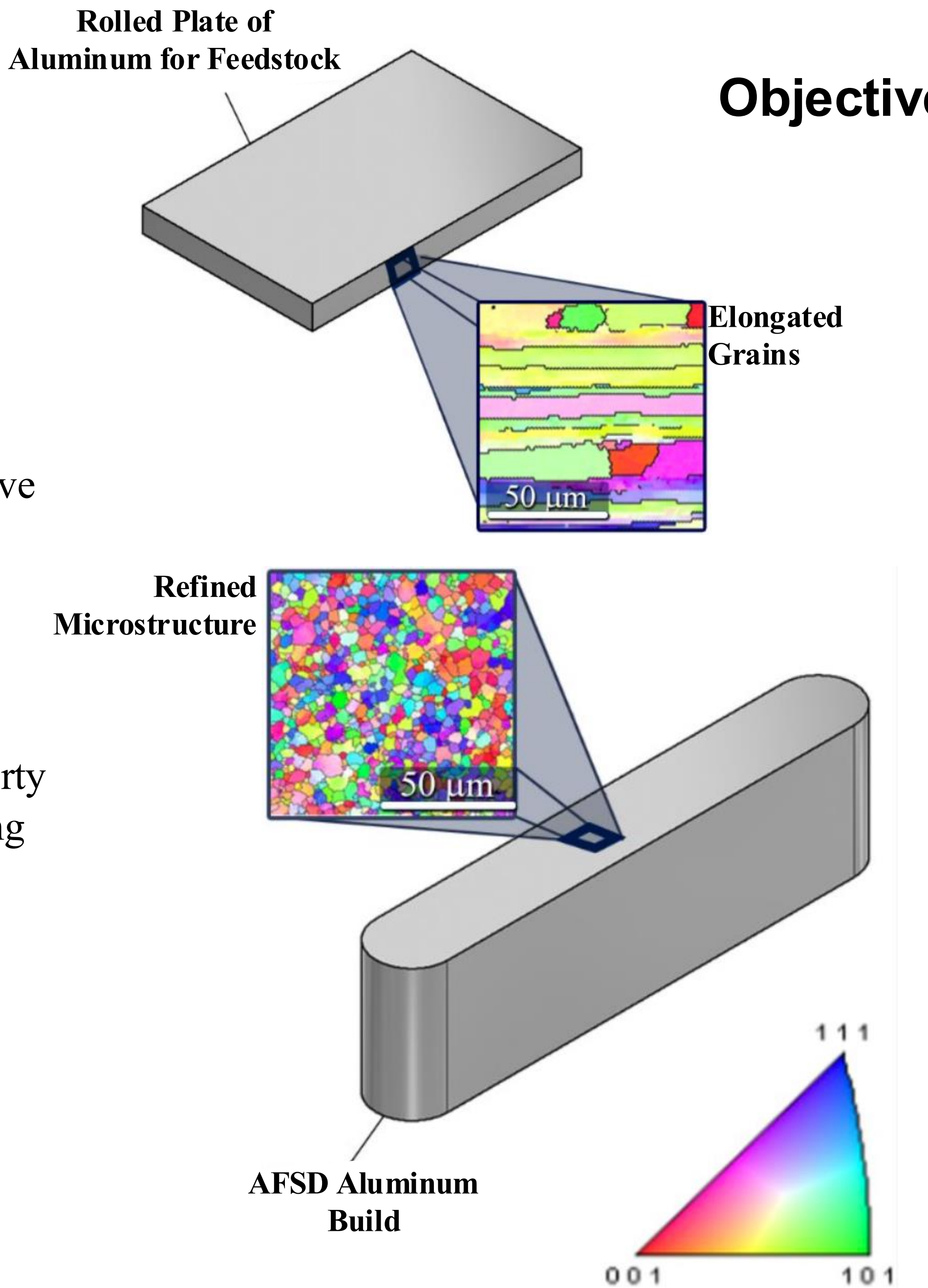
- Produce validated, transferable process knowledge and precompetitive technical outputs that enable industry partners to de risk proprietary R&D and accelerate commercialization of solid-state joining technologies

- Develop and demonstrate an integrated solid-state processing and framework that combines in situ sensing, physics-based modeling, and data analytics to enable real time process monitoring, prediction, and control.

- Quantify process structure property relationships for solid state joining of similar and dissimilar 2xxx to 7xxx series alloys, and identify processing windows that achieve target mechanical performance with reduced defects.

Objectives

- Develop and optimize solid-state processing techniques
- Investigate process parameters and control strategies to improve microstructural refinement
- Enhance understanding of solid-state process–structure–property relationships to inform industry adoption of new manufacturing techniques
- Integrate advanced sensing, modeling, and control tools (including data-driven and physics-informed approaches) to support industrial digital transformation



Our Technical Strengths & Research Approaches:

- Experimental Methods:
  - Process Parameter Experiments
  - Mechanical & Microstructural Testing
  - Tool Design and Material Studies

- Solid-State Additive Manufacturing:
  - Additive Friction Stir Deposition (AFSD)
  - Microstructure Characterization & Mechanical Testing

- Data-Driven & AI/ML Methods:
  - Machine Learning for Prediction & Optimization
  - AI-assisted Process Control

Lab Equipment:

- Extract spatiotemporal trajectory data to construct activity sequences and interaction graphs between workers, equipment, and workspace zones.
- Develop workflow efficiency metrics, including task duration, idle time, congestion level, and equipment utilization rate.
- Apply pattern recognition and statistical learning methods to detect bottlenecks, abnormal task sequences, and deviations from standard operating procedures.
- Implement safety analytics to quantify hazardous proximity events, unsafe posture or behavior patterns, and early indicators of imminent accidents.
- Develop a decision-support layer that converts visual analytics into actionable alerts and optimization recommendations for productivity improvement and risk mitigation.

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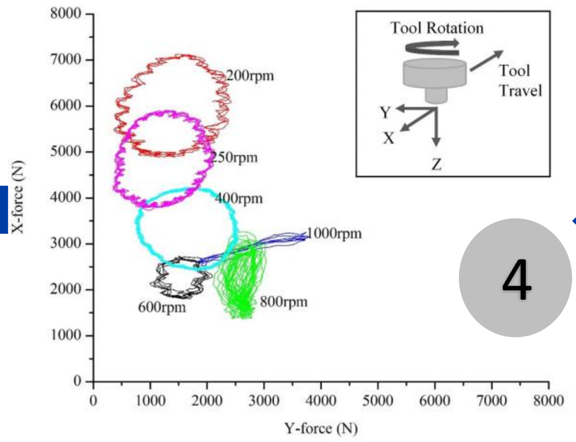
Pilot Study: Friction Stir Welding

1: Experimental data collection from FSW

2: Develop data-driven approach

3: Defect detection

4: Feedback control



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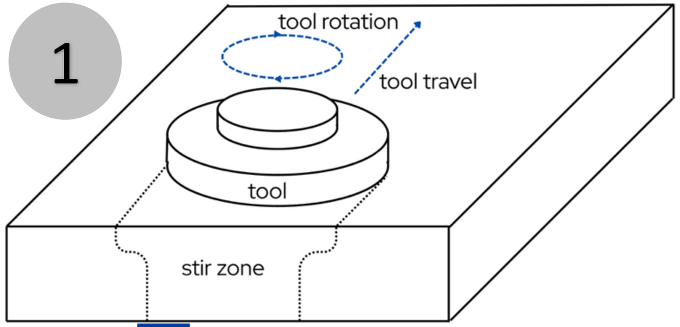
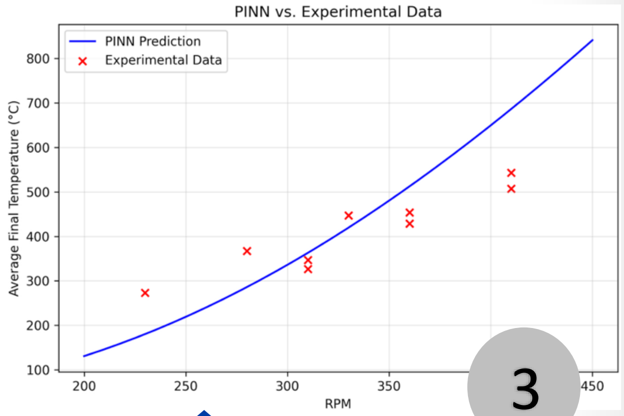
Process Parameter Optimization

1



FSW-PINN



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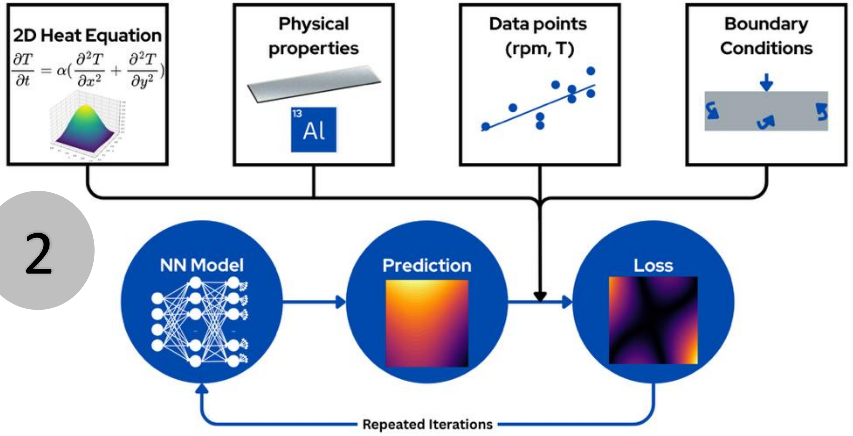
Experimental Data Acquisition

2



Defect Prediction via Physics-informed Neural Networks

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SMART Center
Smart Manufacturing using AI-based Revolutionary Technologies

Project Administration

Budget

Item	Year 1	Year 2	Total
Salaries and Stipends			
Faculty – J. Schneider	2,000	2,000	4,000
Faculty – D. Fonseca	2,000	2,000	4,000
Faculty – C. Chen	2,000	2,000	4,000
Graduate Research Assistant	31,200	31,200	62,400
Fringe Benefits			
Faculty and Staff (32%)	1,920	1,920	3,840
Student Research Assistants	1,664	1,664	3,328
Other Direct Costs			
Supplies, Software, and Equipment			
Travel	3,400	3,400	6,800
Total Direct Costs	44,184	44,184	88,368
Indirect Costs (10% Request)	4,420	4,420	8,840
Items Not Charged F&A			
GRA Tuition	11,380	11,380	22,760
Budget Totals	**$59,984**	**$59,984**	**$119,968**

Duration: 24 Months

Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8

- Q1. Stakeholder meeting to define scope
- Q1 - Q2. Experimental Data Acquisition
- Q3 – Q4. Physics-Based Model Training & Validation
- Q4. Feature Analysis & Defect Prediction
- Q5. Process Parameter Optimization
- Q6 – Q7. Closed-Loop Feedback Control
- Q8. Final Report and release for user testing

Questions?

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