

Development of an Accelerated Digital Tool for Part-Scale Simulation of Additive Manufacturing Processes (FAST-AM)

Keywords: Additive Manufacturing, part scale modeling, accelerated digital tool

Supervision:

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Partners of project:

The FAST-AM project is under the framework of the SINO-FRENCH INSTITUTE OF COMPUTING TECHNOLOGY FOR ADVANCED MATERIALS (CTAM).

General context of the project:

During the PhD and postdoctoral research of Joël KEUMO TEMATIO [1], a finite element software package was fully developed. Named AM-MULTI [2], it is dedicated to the thermomechanical analysis of the Directed Energy Deposition (DED) additive manufacturing process and incorporates several model reduction techniques [3]. The developed numerical methods have demonstrated significant reductions in computational time for relatively simple DED structures. However, further improvements in efficiency and validation on industrial-scale components are still required.

Post-doctoral objectives:

Part of the work consists in implementing selected model reduction techniques within the CimLib numerical platform, while continuously advancing AM-MULTI through the integration of more sophisticated reduction strategies and the development of an optimization module at CEMEF.

Profile sought:

The candidate should hold a PhD degree, or be close to completing a PhD, in numerical methods, particularly in computational mechanics, high-performance computing, or a closely related field. The candidate is expected to demonstrate a strong interest in the numerical modeling of additive manufacturing processes and in model reduction techniques.

The Key point of the subject:

The overall objective of FAST-AM is to accelerate the numerical modeling of the additive manufacturing process by developing advanced model reduction techniques and applying them to the design of complex industrial parts.

As illustrated in Fig. 1, the model reduction strategy combines the Inherent Strain Rate (ISR) method and Proper Orthogonal Decomposition (POD). These techniques have been applied to Directed Energy Deposition (DED) simulations for a simple structure with varying curvatures, achieving a speedup of

approximately $100\times$ [3]. To further decrease computational cost, an additional reduction step based on hyper-reduction methods is proposed.

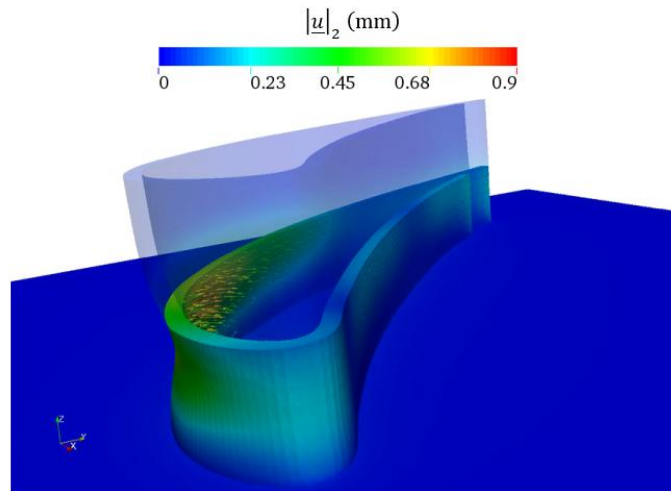


Figure 1: Distortion prediction in the DED process using the ISR-POD simulation approach, achieving a speedup of approximately $100\times$ [3].

Three main tasks are planned in this project:

1. **Implementation of model reduction techniques within CimLib library:** Reproduce the part model simplification methods developed in AM-MULTI within the CimLib numerical platform, including the ISR approach and its coupling with POD-based model reduction. Validation will be performed on both simple and complex structures within the additive manufacturing (AM) framework.
2. **Development of hyper-reduction and optimization tools:** Complete the development of hyper-reduction methods in AM-MULTI and implement an optimization module to identify optimal process parameters.
3. **Fast residual stress prediction module:** Develop a dedicated module for the rapid prediction of residual stresses under specified constraints.

Finally, an integrated platform for fast additive manufacturing (AM) modeling and optimization will be implemented. By combining physics-based high-fidelity modeling with data-driven prediction, the system will enable high-accuracy simulation, rapid prediction, automated optimization, and real-time process control, providing a digital twin solution tailored to the needs of the AM industry.

Bibliography references:


- [1] J. Keumo Tematio, Simulation numérique du procédé de fabrication additive DED : résolution thermomécanique incrémentale complète et modèles réduits de type "inherent strain", PhD thesis, MINES Paris – PSL, 2022.
- [2] J. Keumo Tematio, Y. Zhang, M. Bellet. Am multi. A fast numerical modeling tool for Additive manufacturing process at part scale, hal-04396479 v1.
- [2] J. Keumo Tematio, D. Ryckelynck, M. Bellet, Y. Zhang. Construction of Data Sequence for Model Order Reduction in Thermomechanical Modeling of DED Additive Manufacturing. International Journal for Numerical Methods in Engineering, 2025, 126 (4), e70005.

Overview of CEMEF and of your future research team:

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The doctoral project will be supervised by scientists from the research teams 2MS.

The research field of the 2MS team focuses on numerical method development and its application on AM process.

Type de contrat	CDD	 Online application https://www.cemef.minesparis.psl.eu/post-doctorat/ Application deadline : 30/04/2026
Working time	Full time	
Duration	2 years	
Salary	Approximately 35 k€ gross per year (before income tax)	
Location	CEMEF Mines Paris 1 rue Claude Daunesse 06904 Sophia Antipolis, France	
Starting date	June 1 st , 26	