PhD Position 2026

Wear-Resistance Optimization for Tool & Die Remanufacturing by Wire Laser Additive Manufacturing (WLAM)

PhD Position Summary: Remanufacturing damaged molds is of major interest for reducing production and maintenance costs, and its development can make our industries more competitive. Today, most studies on repair using additive manufacturing focus on restoring geometry. However, it is crucial to control the mechanical properties after repair, since molds/tools may be subjected to severe, repeated cyclic loading. The proposed project aims to develop a methodology to better understand the effect of DED-WLAM metal additive manufacturing parameters on the resulting properties and wear resistance, in order to achieve controlled and reliable repairs. In addition, multiphysics, multi-scale models developed in LAMIH will be used to analyze the complex interactions between thermal, mechanical, and metallurgical phenomena, with the goal of establishing a Process (manufacturing parameters)–Properties (mechanical, metallurgical)–Structure (wear) relationship.

Description of PhD: Remanufacturing damaged molds and tooling by metal additive manufacturing (AM) offers major advantages: (i) it is a more environmentally friendly solution that preserves natural resources and supports sustainable development, and (ii) it can significantly reduce maintenance costs for industry [CHE14]. Metal AM processes involve complex couplings between multiple physical phenomena (thermal, metallurgical, mechanical, fluid flow, etc.), which makes interpretation and control challenging.

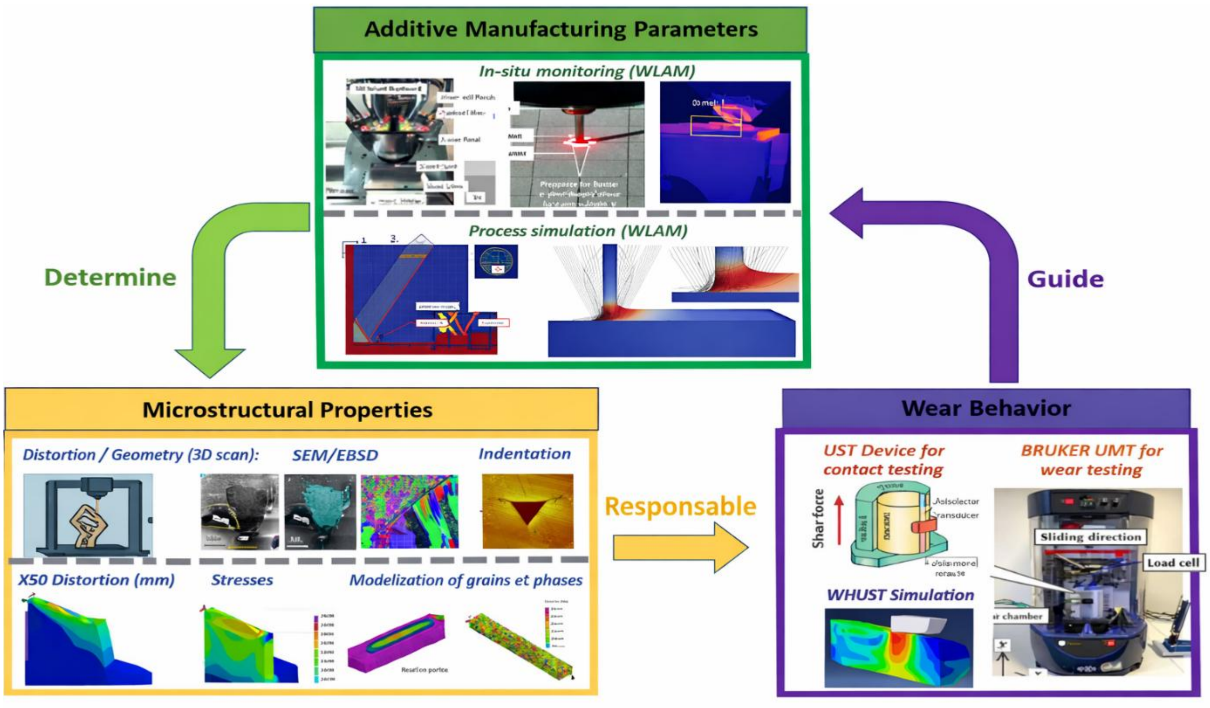
Today, the main criterion used to assess repair quality is often limited to restoring geometry [APR22]. This is insufficient to meet the mechanical requirements for repaired molds, which will be subjected to severe cyclic loading. Although studies have validated the feasibility of restoring molds by AM, controlling mechanical properties after repair remains very difficult and directly affects the service life of repaired molds [PRI21]. Many scientific barriers therefore remain to be overcome in order to master mechanical properties and improve wear resistance and durability. A major current challenge is to establish relationships between manufacturing parameters, AM melt-pool characteristics, and the resulting mechanical properties (wear), in connection with overall repair quality.

Many studies have investigated melt-pool characteristics (shape, temperature, stability) and reported strong inhomogeneity, which can lead to heterogeneous mechanical properties and the presence of defects such as porosity [Fite23].

This PhD aims to **control the mechanical and tribological performance** of repaired zones produced by DED-WLAM by combining experimental, characterization, and modeling approaches:

- **Experimental optimization of repair parameters**, supported by in-situ monitoring (e.g., high-speed and thermal imaging) to quantify melt-pool shape, temperature and stability.

- **Multi-scale mechanical characterization** (nano, micro, and component scales) coupled with **metallurgical analyses** to connect process conditions to microstructure, defects and local properties.
- **Functional validation through wear testing** of the repaired area on the **TRIBO LAB platform (LAMIH)** to assess repair quality under representative tribological conditions and relate local properties to lifetime.
- **Application the numerical models developed in LAMIH** to simulate the Remanufacturing process to improve understanding, predict the effect of parameters on performance, and guide optimization.



Candidate Profile :

- Master's degree (MSc/Engineering) in Materials/Manufacturing Engineering, Mechanical Engineering, Materials Science, or a related field.
- Strong interest in **hands-on experimental work**: setting up and running test campaigns, defining protocols, instrumenting the process, and acquiring data (e.g., thermal/high-speed cameras, sensors, data logging).
- Experience or strong motivation for **materials and mechanical characterization**: metallography and mechanical testing; interest in **tribology/wear testing** is a plus.
- Knowledge of numerical simulation of welding processes, heat transfer simulation, and residual stress analysis is highly valued.
- Practical mindset, autonomy, rigor, strong analytical and synthesis skills, and ability to work in a team

Host Laboratory: LAMIH, Université Polytechnique - Hauts de France, Valenciennes (59)
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