PhD Position : 2025-2028 :

ENVIRONEMENTAL EVALUATION AND OPTIMIZATION OF ADDITIVE MANUFACTURING PROCESSES

Key Words: Additive Manufacturing, Environmental footprint, Laser Powder Bed Fusion, Gas atomization, Life Cycle Assessment.

Background:

Metal Additive Manufacturing (MAM) is growing rapidly thanks to a diversity of applications and functionalities, as well as gains in productivity and competitiveness [1]. The ICB/PMDM research team at the University of Technology of Belfort-Montbéliard (UTBM) has various metal additive manufacturing machines at its disposal, such as powder bed laser melting and cold spray deposition. Through its industrial collaborations, it targets various sectors such as: (a) aeronautics and space (b) prosthetics and medical tools (c) watchmaking. For each of these sectors, additive manufacturing is proving to be appropriate compared to traditional subtractive processes, particularly for (a) the production of complex geometric parts for weight reduction in structures, (b) the production of unique parts and (c) the optimization of material yields for expensive materials.

Although the economic viability of these processes has been demonstrated, their environmental impact over the entire product life cycle still needs to be refined and systematized. Gonçalves et al. [2] compared the costs and environmental impacts of metal additive manufacturing in the aerospace industry with subtractive manufacturing methods. They demonstrated a financial gain of 33%, with a reduction in environmental impacts of nearly 60%. Lyons et al. [3] demonstrated the significant benefits of additive manufacturing for knee prostheses made of Ta6V titanium alloy, with a material yield of 65% compared to 15% for subtractive processes. While the environmental sustainability of specific parts has been demonstrated, a systematic tool for evaluation and optimization is yet to be provided.

Figure 1 : fixing element for the aerospace industry [1] and knee prosthesis element [3]

This thesis project aims to address these needs. The Interreg COMPASS project (COMprehensive Production Assessment for Sustainable Systems) aims to provide decision-making tools for the various sectors involved in metal additive manufacturing. The consortium brings together private and public organizations from both sides of the French Swiss border in the Jura region. Members have complementary areas of expertise, including sustainable logistics and subtractive processes at the HE-Arc University of Applied Sciences and Arts in Neuchâtel (Switzerland); life cycle analysis at the CEDD design office in Belfort (France); the value chain of additive processes at UTBM (France); and the circular economy at Go-Circular (Switzerland). The project deliverables, such as systemic environmental impact assessment and optimization, will be directly addressed by the proposed thesis project.

PhD activity:

The work carried out in this thesis has two main objectives:

- Measure and systematize energy consumption and material efficiency data over the entire value chain of additive and subtractive processes.
- Optimize the processes of metal additive manufacturing. Developments in metal atomizers and laser melting machines will be required to minimize environmental impacts.

The candidate will work in a state-of-the-art research laboratory specializing in additive manufacturing (ICB/PMDM, https://icb.cnrs.fr; https://lermps.utbm.fr) and will interact with local private partners in northern Franche-Comté (CEDD, BV Proto), national partners in the aeronautics sector, and Swiss partners in the watchmaking sector. The results obtained will be promoted through scientific publications and international conferences. They will also support the development of continuing education and university courses offered by UTBM and HE-ARC by providing concrete case studies.

Candidate profile:

- Hold a master's degree or engineering degree with a specialization in metal manufacturing processes.
- Have an interest in environmental issues related to the production of high value-added metal parts. Be able to interact easily with different people.

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