Additive Manufacturing in Construction
2nd funding period: The Opportunity for Large Impact

AMC TRR 277

A06 Laser Powder Bed Fusion (LPBF) of Steel Elements for Construction – Basics of Design and Mechanical Resilience

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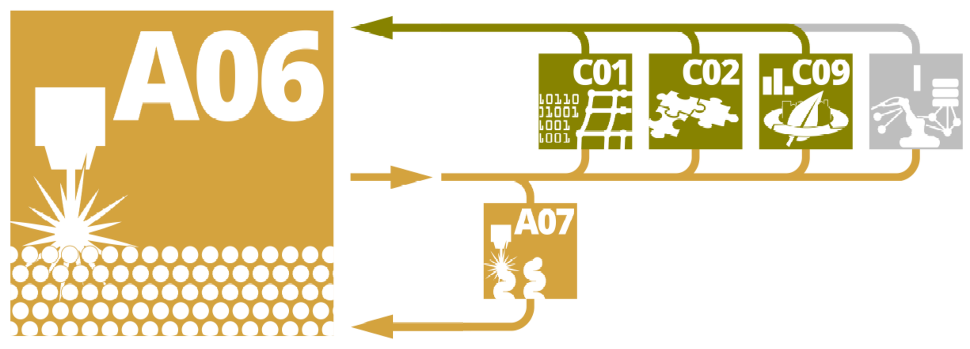
Project aims of 2nd funding period

- Applying an additional material providing a higher yield strength than 316L while maintaining a high elongation at fracture
- Increased reliability through fatigue life prediction
- Tailored part properties by including lattice structures
- Recommendations for a processing route that guarantees reliable mechanical properties and a low ecologic impact

Fig 1: Vision; section view of a shape-optimised steel node with tailored part properties, source C01

Key collaborations in 2nd funding period



- A07 - Exchange on testing of large-scale metal structures
- C01 - Development of a digital qualification method to predict fatigue life of steel parts manufactured by LPBF
- C02 - Investigation of the multi-scale optimisation of civil engineering structures
- C09 - Evaluation of the ecologic impacts of LPBF processing steps

Work programme

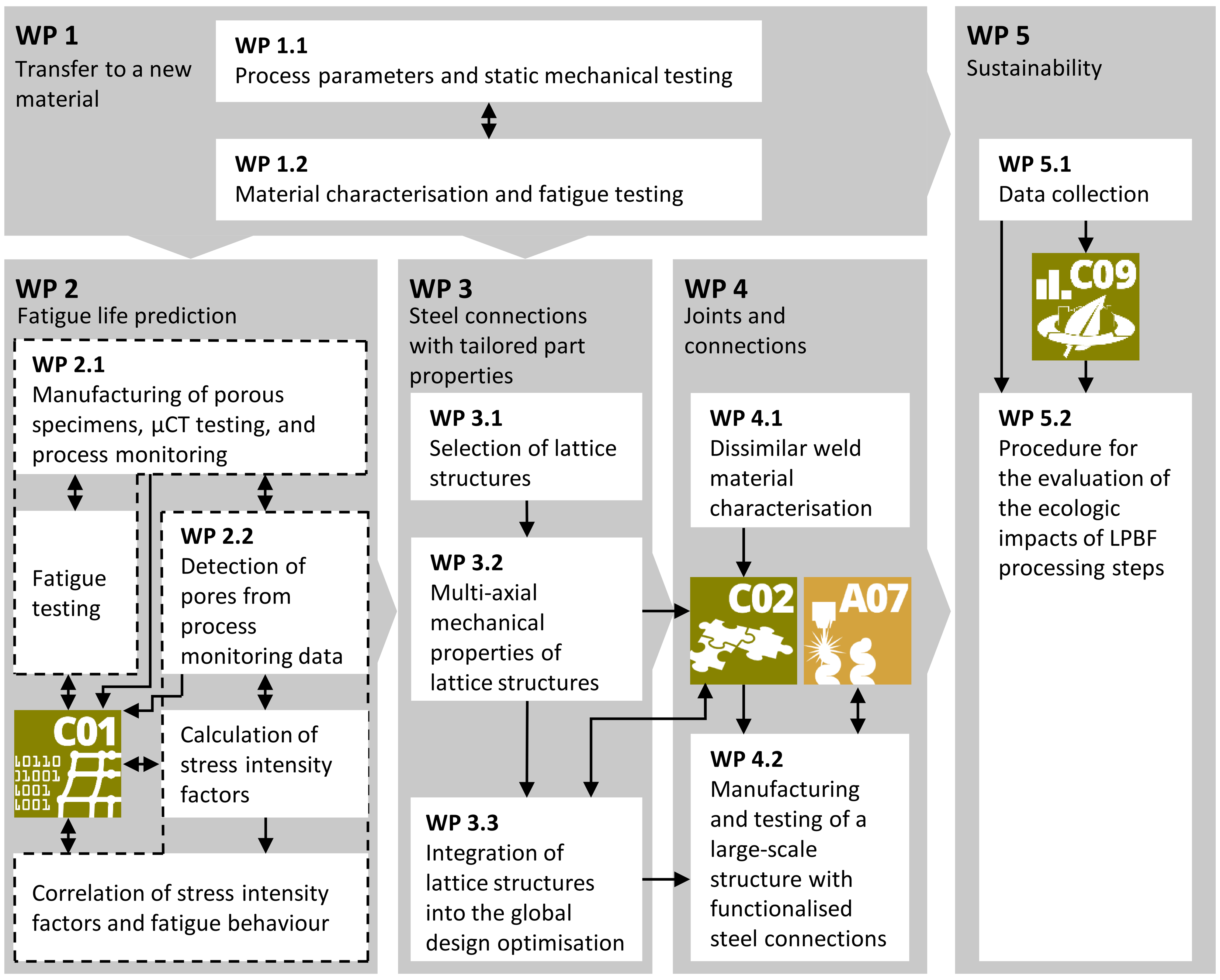


Fig 2 : Project flow chart, WP: work package

Methods – WP 3 to WP 5

Tailored part properties

- Inclusion of tailored lattice structures in LPBF parts
- Homogenised static material property model
- Integration into the design optimisation

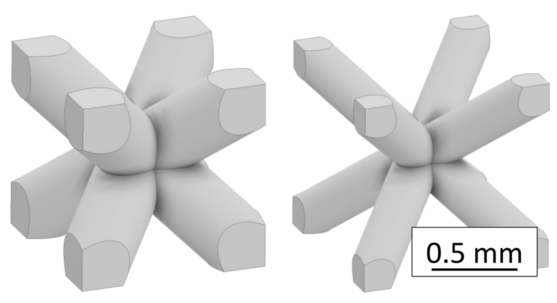


Fig 5 : Lattice structure cells with different design parameters

Joints and connections

- Joining and testing of local and global structures
- Including fusion zone properties into design optimisation

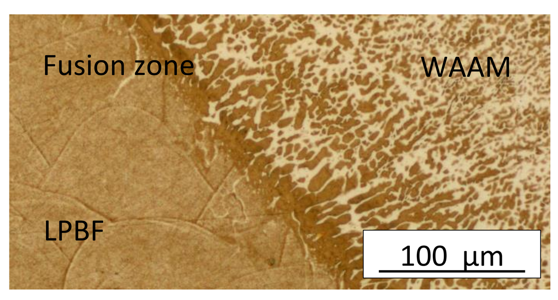


Fig 6 : Fusion zone of 316L manufactured by LPBF and Wire Arc Additive Manufacturing (WAAM)

Environmental sustainability

- Collecting comprehensive data for a life-cycle assessment
- Evaluation of the ecologic impacts of the LPBF processing steps

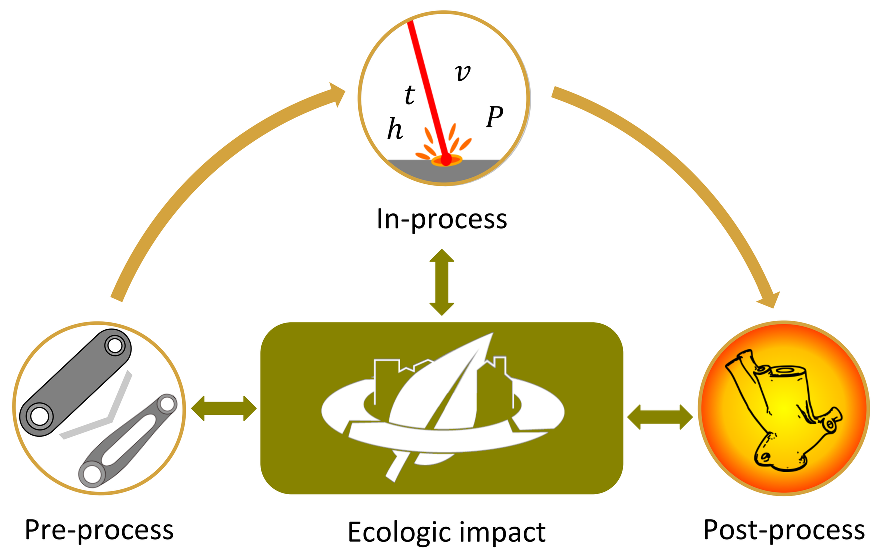


Fig 7 : Integration of environmental sustainability considerations into the LPBF processing route; v: =scanning velocity, t: layer thickness, h: hatch distance, P: laser power

Methods – WP 1 and WP 2

Transfer to a new material

- Static and dynamic material characterisation of a new manganese steel with higher strength and elongation at fracture than 316L
- Testing the transferability of results from the 1st funding period to the new material
- Providing a processing route for the new material

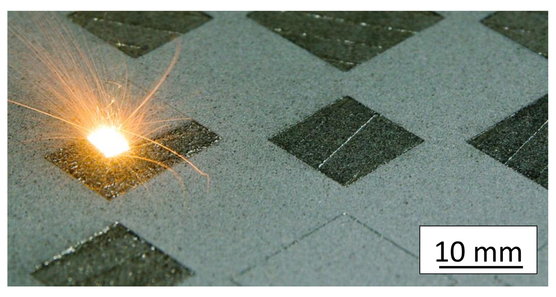


Fig 3 : LPBF process

Fatigue life prediction

- In-situ detection of pore formation during the manufacturing
- Methodology to obtain stress intensity factors for pores detected by process monitoring
- Calibration with mechanical simulations of µCT-scanned parts

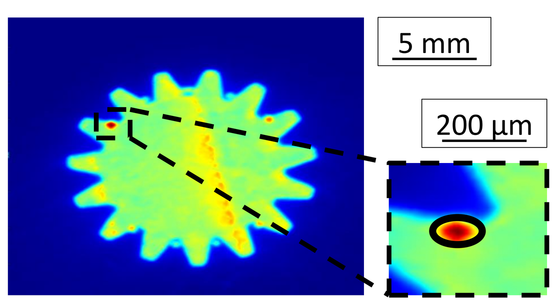


Fig 4 : Pore detection by optical tomography

Outlook 3rd funding period

- Further tailoring of LPBF parts to optimise the damping behaviour
- Process combination with directed energy deposition processes to increase the maximum scale of the manufactured parts
- Include environmental and ecological sustainability considerations (Life-Cycle Cost Analysis) in the digital design workflow of LPBF construction elements

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