A02

Particle-Bed 3D Printing by Selective Cement Paste Intrusion (SPI) - Particle Surface Functionalisation, Particle Synthesis and Integration of WAAM Reinforcement

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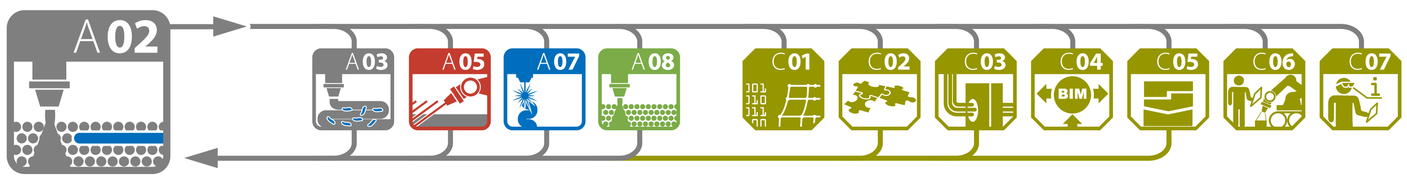
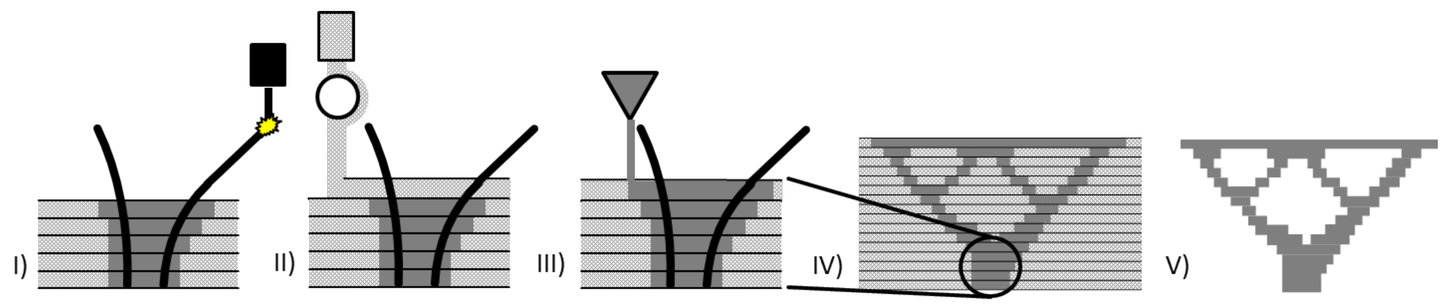
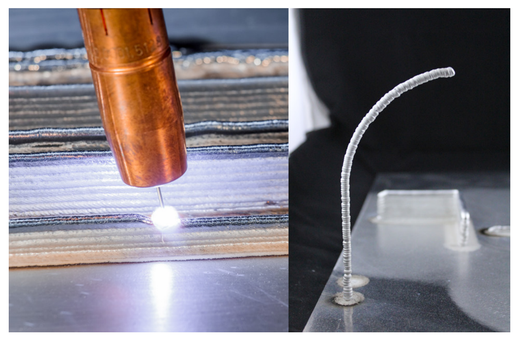
Summary



Selective paste intrusion (SPI) is a particle-bed based additive manufacturing technology in which aggregates are spread in thin layers and bond by cement paste. To qualify SPI for structural concrete elements, the inclusion of reinforcement is mandatory. The innovation introduced here is that reinforcement will be implemented in the SPI process using Wire and Arc Additive Manufacturing (WAAM) simultaneously. Different active and passive cooling strategies, e.g. particle surface functionalisation and the synthesis of new particles, will be developed to deal with the high temperatures during WAAM.



Production cycle of SPI with WAAM reinforcement: I) Application of the WAAM reinforcement, II) Spreading of the next aggregate layer, III) Intrusion of the cement paste in the target layer, Repeating of I-III until the object is finished (IV), Excavation of the object. For production without reinforcement same procedure without I)



Left: WAAM in progress. Right: 3D-printed overhanging structure produced by WAAM

Preliminary Work

Selective paste intrusion SPI:

- Fundamental research regarding strength (> 70 MPa), durability and shape accuracy
- Rheological behaviour of cement paste in dependency of increased temperature

Tailoring of particles:

- Surface functionalisation to control bulk powder properties and material stability
- Development of innovative grinding machines

Wire and Arc Additive Manufacturing WAAM:

- Simulation and thermal monitoring as well as fabrication of metal structures with various additive manufacturing methods
- WAAM of titanium parts

Thermal development in the particle-bed:

- Manufacturing of steel bar and measurement of temperature development in the particle-bed

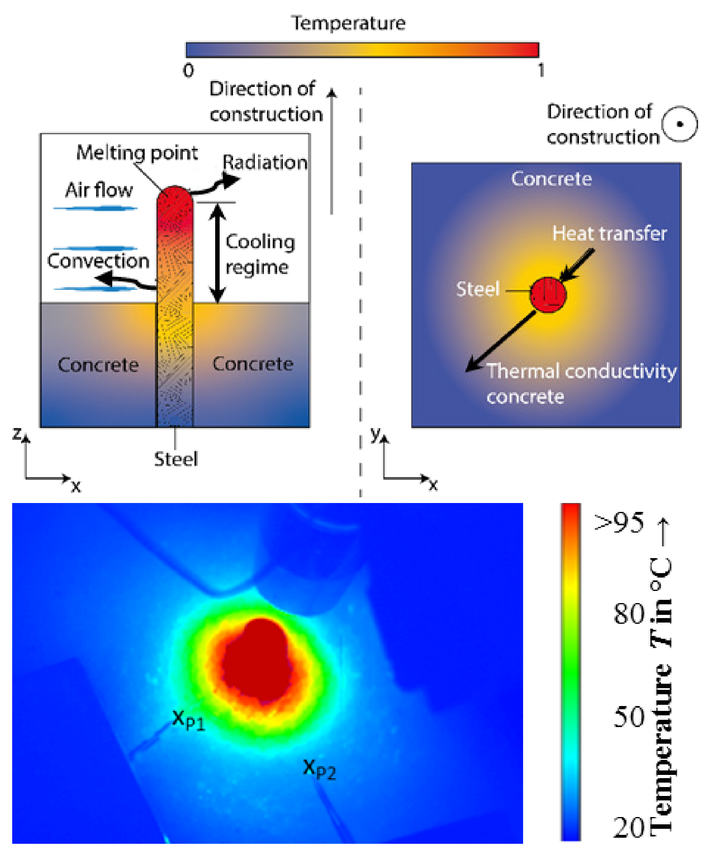
  Result:

  Temperatures ≤ 105 °C in the particle-bed at a distance of 25 mm between welding point and the particle-bed surface

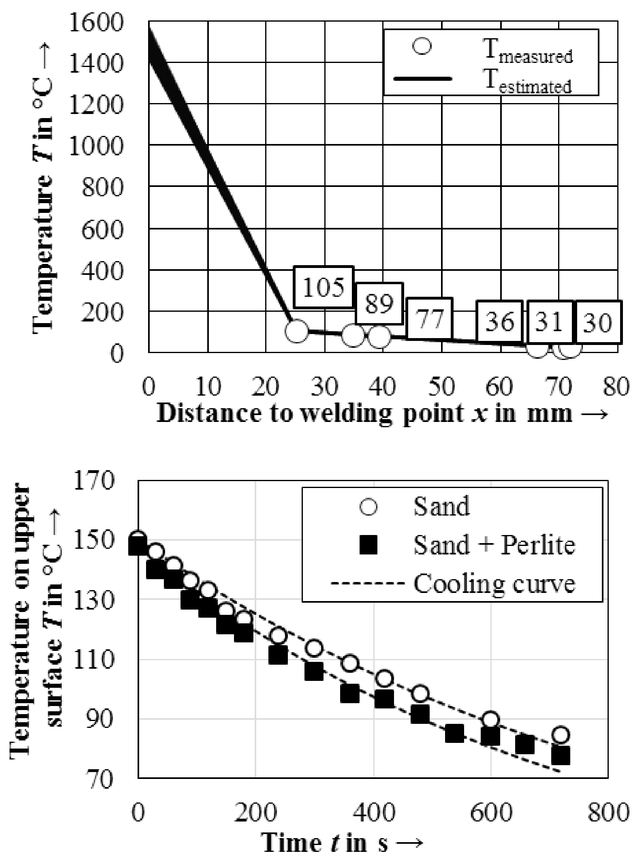
- Functionalisation of aggregates in the particle-bed

  Result:

  Functionalised particles assisted to cool down the particle-bed



Top: Temperature profile at the metal - concrete interaction. Bottom: Heat propagation in the particle-bed with emissivity equal to 0.4



Top: Temperature field along a WAAM 3D printed steel bar
Bottom: Cooling rate in sample particle-beds

Research Questions

Therefore the two main objectives of A02 are:

1. Minimize the heat transfer and propagation into the particle-bed
2. Adapt the particles and cement paste to withstand the remaining thermal load

For this aim, three approaches will simultaneously be pursued in the project:

a. Suitable cooling strategies for the reinforcement fabricated by WAAM
b. Development of coated and new synthesized particles
c. Storage of water in particles of the particle-bed or the paste