Process-integrated self-regulation of the Wire and Arc Additive Manufacturing (WAAM) process to produce graded designed materials

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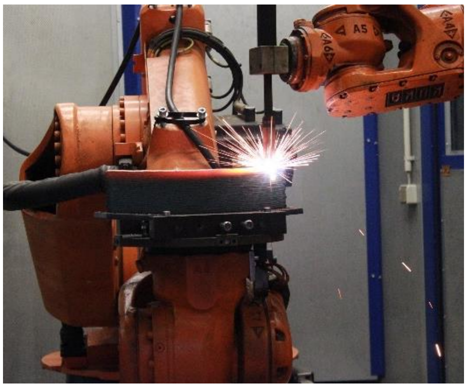
Motivation:

How can the WAAM printer learn the height offset from its own process data in order to generate fully automatic three-dimensional graded designed components? In the future, a process-dependent variable for working in the third dimension can be extracted from the arc process itself. The self-regulating process becomes intelligent! The traditional approach of slicing can be transferred by the development of a point-to-point control to the robot based WAAM technology in kind of a self-controlled process to vary the possibilities to produce special designed materials.

Objective of the PhD project:

Today, all applications of additive manufacturing systems work with static slicers, and always follow the same tree steps: slicing with a pre-defined height of the 3d-CAD model, path generation and printing. The control of an arc welding process is much more complex than a process with heated thermoplastics. Currently, the biggest obstacle in WAAM technology is the lack of material independence in process control. There are two strategies to increase process stability: determination of the optimal welding parameters or a control system that compensates for



WAAM process based on MIG welding technology

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process disturbances. The determination of welding parameters needs to be done for all metal alloys, wire diameters, and welding machines to provide for adequate welding parameters sets. The number of optimal welding parameters, n, increases exponentially with each new welding source, alloy and welding parameter set. Current control systems are only used for the metal-transfer into the arc by the welding machine. The path planning itself remains unaffected. Identifying welding parameter sets for each material is time-consuming and one needs extensive databases. External sensors for height measurement limit the working area and the spatial variability, i.e. welding is interrupted for measurement after each layer. Furthermore, changing the wire for height difference compensation leads to a loss of the optimum operating point. Consequently, the user cannot carry out a quick material change without the information on the material-dependent process parameters and height offset. Hence, there is still a considerable trial-and-error effort needed to fill databases with empirically obtained data. The objectives of this project can drastically reduce the effort of empirical data determination for the different materials (e.g. steels, Al, Cu alloys, etc.) and its properties. It will also account for varying wire diameters, gas compositions, and thus, make the WAAM process significantly more economical and variable. In essence, the machine will learn to control itself, which gains intelligence with respect to the materials application range. This in turn, will make the development of the robot-based WAAM considerably easier. Specifically, the intermediate step of "slicing" will be possibly become obsolete such that the robot code is generated directly from the CAD data file, and the component is assembled using path planning guided by the change of the arc information. This offers a huge field to development graded designed materials with WAAM.

The long term vision is to use this sort of system as a basis for a synergic height control of the WAAM process, i.e. the movement into the third dimension is no longer realized by a layer-by-layer application but by a spiral-shaped, continuously rising endless movement.

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