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PROCESS MONITORING FOR ADDITIVE MANUFACTURING PROCESSES

THE TASK

Minor deviations in a technological parameter significantly affect the additive manufacturing process result. Not only key parameters, such as laser power or buildup strategy, are varied; the users also aim to monitor the manufacturing process as a whole. The task is to offer new tools able to predict the resultant component quality in-situ.

Buildup defects are cumulative and continuing due to the process-specific layered structure, whereas the boundary conditions are ever-changing. These variations must be reliably detected and controlled. In additive manufacturing with difficult-to-use materials, such as titanium aluminides or nickel-based super alloys, the range of adjustable process parameters is extremely narrow, so that the process can only be performed reliably by using suitable process control systems.

Laser-based additive manufacturing faces special requirements; for many process parameters, adequate data acquisition must be adapted for these conditions or newly developed altogether. Measurement of the thermal load and scattered radiation in the vicinity of the processing zone is extremely challenging.

OUR SOLUTION

Many measuring tasks can be performed by temperature acquisition systems. Camera-based systems can record temperature gradients on the component surface, as well as geometric process parameters, rather than only temperature and are thus superior to measurements by pyrometer or temperature sensors. These systems are also convenient because they measure indirectly, making process feedback unnecessary.

Functions to record states are provided by integrated sensor elements (see Fig. 3). Detailed monitoring makes the equipment more reliable, assesses the state of the equipment, and enables quality assurance. The objective is to detect a faulty process state without having directly affected it.

RESULTS

Using cameras in conjunction with powerful image processing systems to record, process variables can be captured by means of customized software tools (Fig. 1). The controlling functions for higher process reliability are based on feedback to the process.

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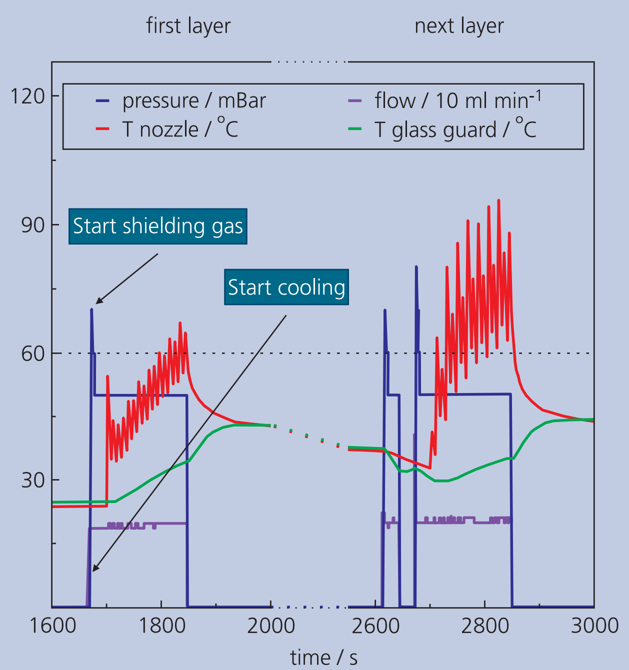
An image processing system based on data acquired by a camera can make induction-based laser powder buildup welding significantly more reliable. The systems developed at the Fraunhofer IWS measure and control component temperature and geometry features as well. The part temperature necessary for defect-free manufacturing is adjusted by automated adaptation of the inductively-coupled power. Thanks to the image processing system, even crack-prone alloys can be processed. The measured values are immediately fed back to the additive manufacturing system and adjusted. Stable process conditions and thus uniform manufacturing results are achieved even if environmental conditions change (Fig. 2).

The information gained from the process zone is extended by the data about the state of the laser head for purposes of documentation and saved in a standardized data format. The equipment state is monitored in-situ in parallel to parameter control in the process. Adequate setting of the process limits makes it possible to recognize critical states and switch off the systems in time to avoid damage.

Finally, these measuring devices also validate the process models developed at the Fraunhofer IWS and enhance the process knowledge.

Monitoring of state variables in the laser powder buildup welding process



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1 *Geometry of a turbine blade made of titanium aluminides in comparison; left – built up without and right – built up with process control*

2 *Image processing tool to control laser powder buildup welding (hybrid process)*

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