First-time-right production with Bayesian process optimization

Industrial companies that use lasers in manufacturing are increasingly looking to integrate AI applications or process simulations into their own value chain and use them for fast, safe and optimized machine setup. Bayesian optimizers, Gaussian process regressors and reduced process models enable users to develop digital tools for fast, interactive process design and optimization.

Potential for time and cost savings

When companies introduce new processes into their manufacturing chains or use new materials, statistical test planning is usually carried out for design, optimization and error analysis. This procedure is generally time-consuming and costly. Since simulation, Bayesian optimization and smart system technology interact, process parameters can be determined quickly, automatically and less costly.

Bayesian optimizers are based on Gaussian process regressors and enable users to efficiently solve inverse tasks that occur, for example, in the search for optimal process parameters. The Gaussian process regressors can be constructed using data from simulations or experiments. The parameter sets to be investigated are determined by the Bayesian optimizer, which takes into account existing data and statistical uncertainties. This way, significantly fewer evaluations are required than with classic experimental design. By using smart system technology, companies can automatically calibrate models or create process regressors.

Realization and applications

Bayesian optimizers and Gaussian process regressors were developed at Fraunhofer ILT for two laser-based processes. The institute implemented an automated model calibration and a model-based Bayesian optimizer into a plant for structuring metals with ultrashort laser pulses. In the second system, a Bayesian process optimizer based on a "man in the loop" approach was developed for high-power laser material deposition (HIP-LMD), an approach that makes experiment-based design and optimization possible.

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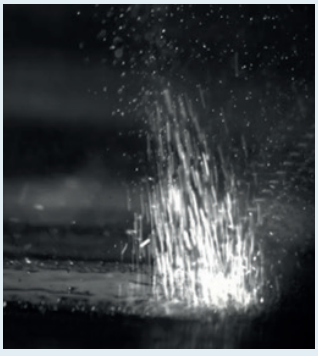

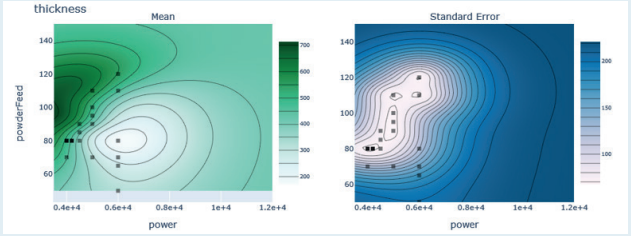

1 HIP-LMD process.
2 Determined parameters of a HIP-LMD process regressor.