



SIMULATION OF THE STABILITY OF A WATER-JET-GUIDED LASER BEAM

Task

Drilling and cutting with water-jet-guided laser radiation is an established manufacturing process. To better understand its physical limits and technical potential, research uses modern numerical tools such as OpenFOAM to develop reduced models and run simulations having short computation time. The reduced models are calibrated with experimental data and can correctly describe relevant properties. Moreover, they generate a large number of computational results to predict the geometric shape of the ablation, the dynamic stability of the water jet and the thermomechanical loading of the material. These powerful reduced models are applied to advance the manufacturing process and flexibly develop the product using a data-based »process map«.

Method

The so-called volume-of-fluid (VoF) method makes it possible to calculate the flow of multiphase interacting phases, i.e. the liquid phase of a water jet, which guides the laser radiation, and the gas phase surrounding the gas jet. By taking into account how compressible the outflowing vapor and the surrounding gas are, Fraunhofer ILT is able to analyze the stability and range of the light-guiding water jet in a spatially three-dimensional ablation cavity. The simulation is run with

- 1,2 *Simulation of an inclined borehole, side view (1) and top view (2).*
- 3 *Simulation of the flow of a water jet in a trepanning borehole.*

a parallelized OpenFOAMCode to reduce the computation time of the dynamic process. Automatic image processing is used to calculate the integrity of the water jet to then quantitatively characterize its degree of stability in the ablated cavity. In a multidimensional process map, the degree of stability is presented as a function of the parameters for the manufacturing process and the geometric characteristics of the ablation cavity.

Results

A simulation – using automatic post-processing to analyze water-jet stability – is organized into a spatial three-dimensional cavity as a tool chain. The virtual tools can be used to quantify stability of the water jet in the Laser MicroJet® (LMJ) process.

Applications

The dynamic simulation of a multiphase flow and its tools for analysis developed at Fraunhofer ILT are applied to evaluate the achievable quality of the LMJ process and improve its productivity. The virtual tool can be transferred to other manufacturing processes that have dominant ablation by melt removal.

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