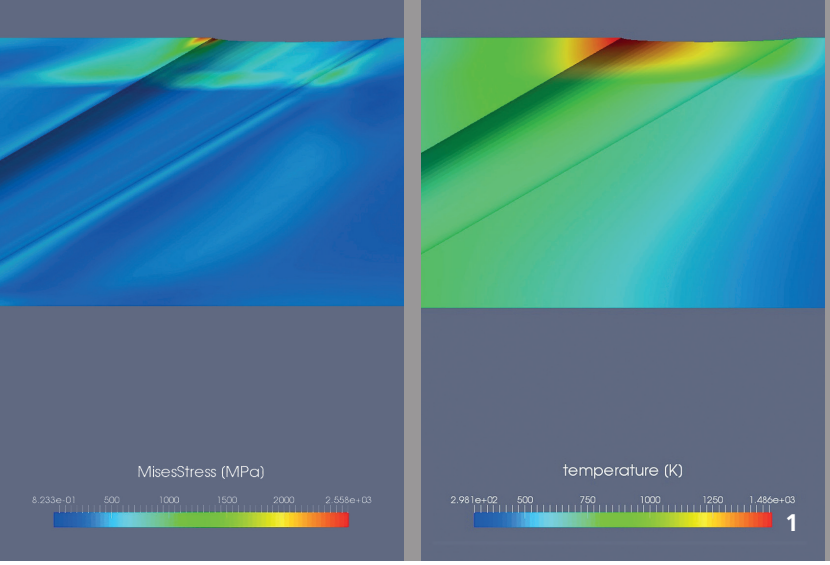

DELAMINATION AND EJECTION OF MELT FOR LASER DRILLING OF MULTILAYER SYSTEMS

Task

Highly stressed components of today's gas turbines are manufactured out of thermal barrier coating systems. These consist of a high-temperature-resistant base material, a primer layer and a ceramic thermal barrier coating. In the film cooling, a cooling fluid flows through the introduced cooling holes and then forms a cooling film on the side acted upon by the hot gas component. If the cooling channels are produced by laser drilling, delamination cracks can occur between the layer components. Furthermore, a pronounced melt ejection at the hole entry can damage the optical system. In this context, the project aims to identify suitable process settings to optimize the drilling process.

Method

With the aid of reduced models, fast process simulations have been developed which allow users to analyze large areas of the parameter space and to create process maps for process setting on this basis.

Results

To describe delamination cracks, Fraunhofer ILT first simulated the thermo-mechanical behavior of the multi-layer system as the drill hole formed (Fig. 1). Based on this, it developed a reduced model that provides a substitute criterion for the formation of cracks. Furthermore, the institute developed a model for the melt ejection at the drill hole entrance. In particular, three different modes of melt ejection could be identified and experimentally confirmed (Fig. 2).

Applications

In addition to applications in laser drilling, the developed models can also be used in other manufacturing processes. The substitute criterion for delamination cracks can be transferred, for example, to the cracking of additively manufactured components. The melt ejection model may be expanded, for example, to describe the dynamic properties of the absorber layer in »laser-induced forward transfer« (LIFT), a process for the site-selective transfer of biomaterials and cells.

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1 Thermomechanical properties: stress distribution (left) and temperature distribution (right).

2 Three different melt ejection modes.

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