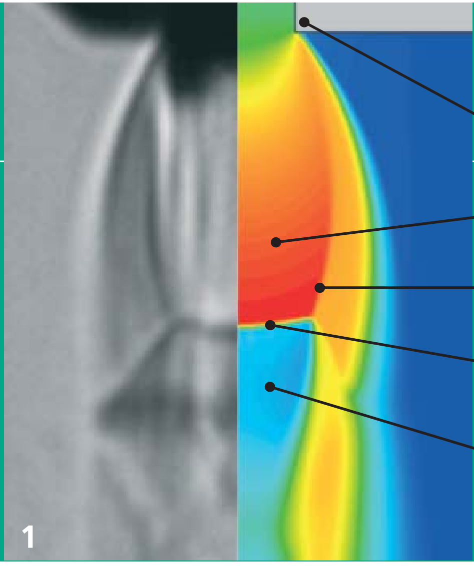


CFD SIMULATION FOR FLUIDIC COMPONENT OPTIMIZATION

THE TASK

Gases are used in many ways in laser materials processing. As primary gases, they blow out material in thermal cutting procedures, such as laser fusion cutting. In joining processes, shielding gases protect the process zone from the surrounding atmosphere. In cladding, gas functions as the carrier of the powder material. As secondary gases in a widest range of processing techniques, they have many other applications, including:

- shielding optical components,
- limiting disturbing influences from process emissions, in the form of vapor or smoke, which can impair both process reliability and processing quality due to interactions with incident laser beams,
- keeping the air in production compartments clean to fulfill the labor safety requirements.

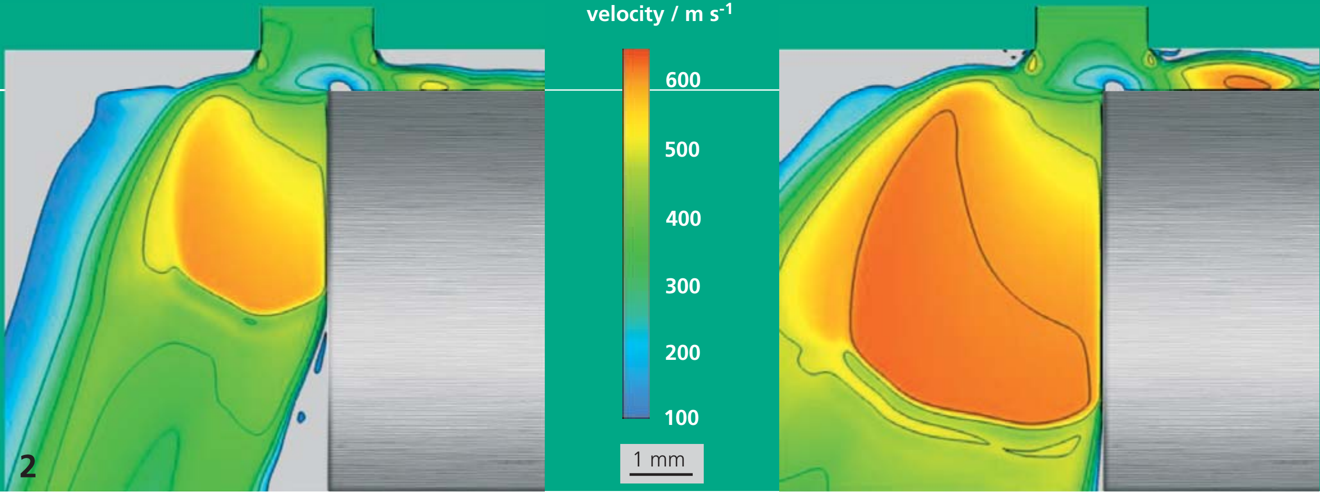
With reference to dimensioning, favorable design, and the configuration of the fluidic components to be used, several problems with practical relevance frequently emerge, which have to be solved to maintain both an optimum effect and economical gas application and consumption.

OUR SOLUTION

When examining how to utilize the primary and secondary gases for laser materials processing more efficiently, the spatial and sometimes even the temporal flow characteristics of the gases have to be characterized. For this purpose, at IWS, we have developed particular CFD models that make it possible to simulate gas flows under near-real conditions. These models were created at our customers' demand and in projects with public funding. Here, as a rule, excellent predictive accuracy, as well as a sound coincidence with the experimental results, was achieved (Fig. 1). In contrast to experimental testing methods, the gas flow can also be characterized in regions outside the visually observable range.

Parameterized models are the base for well-founded parameter studies and sensitivity analyses, which – together with statistical design and analysis of experiments – make it possible to identify the essential influencing factors, as well as relevant interactions.

As a result of these investigations, it is not only possible to immediately deduce specific recommendations aimed at constructive changes in the design of individual components, but also to identify optimal parameter settings under predefined conditions of application.



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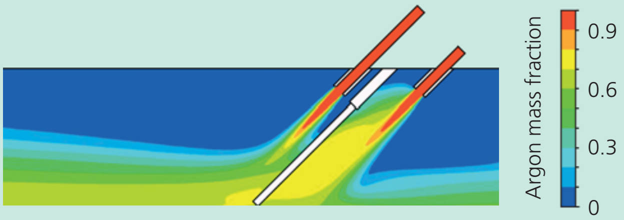
RESULTS

As varied as the ranges of application are the models that were and are being developed for gas flow simulation at the IWS. Current research topics are mainly focused on user problems arising from laser welding and laser cutting. Figure 3 illustrates a calculated shielding gas distribution (Argon) for narrow gap laser welding of multilayers with filler metal (wire). Based on the simulation results, one can analyze and assess different variants of shielding gas supply.

Simulation of shielding gas coverage in narrow gap laser welding



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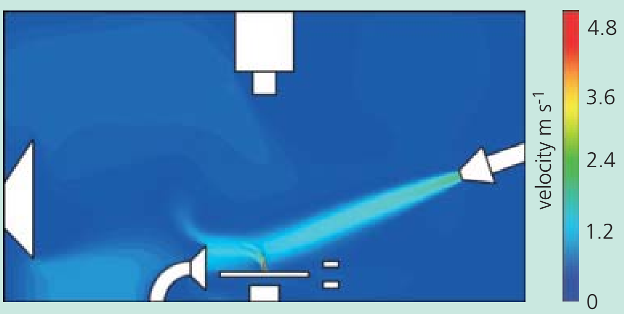
Global air flows were simulated for remote laser welding. Figure 4 shows the calculated velocity distribution in a model processing chamber with local and global inflow and outflow air components.

Air flow (calculated) in a processing chamber for remote laser welding



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The purpose of the project is to evaluate concepts of optimized air flow guidance, which, on the one hand, eliminate disturbing welding vapors in the laser beam path. On the other hand, they also guide the process emissions intentionally into the designated exhaust units to minimize the contamination both of workpieces and optical components. Flow characteristics of individual components were found to be a specific challenge and have usually to be analyzed separately in submodels.

In laser cutting, our customers are mostly interested in the analysis of nozzle concepts and flow characterization of entire processing heads. For laser fusion cutting, the efficiency of the cutting gas coupling into the cut kerf is analyzed as an objective criterion for an intended optimization, and the cutting gas flow within the kerf is examined (see Fig. 2).

1 *Comparison of experimental and numerical results for a free jet from a gas nozzle. Left: density distribution found in experiment (schlieren method). Right: calculated flow field.*

2 *Simulation of the cutting gas flow as a function of gas pressure in laser fusion cutting (left: 5 bar, right: 10 bar).*

CONTACT

Dr. Achim Mahrle

☎ *+49 351 83391-3407*

✉ *achim.mahrle@iws.fraunhofer.de*