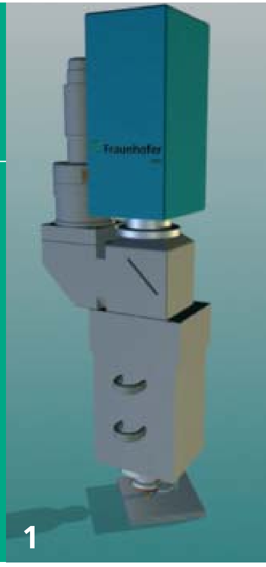

1

TEMPERATURE-BASED PROCESS MONITORING FOR LASER CUTTING

THE TASK

End users are focusing more and more on process monitoring and control sensors for laser cutting. The desired functionality ranges from simple quality assurance systems to smart solutions with online optimization of the cutting parameters. The sensors currently commercially available are mostly limited to the control of individual cutting parameters or monitoring of individual incidents. These systems are not capable of providing a general assessment of the process state or the current cutting quality or, if they are, only to a low extent. Furthermore, these systems have always to be calibrated to the nominal cutting quality or the requested parameter.

To create acceptable solutions for process automation in industry, we need a system that is able to reliably distinguish the greatly varying cutting processes and states. The system should be able to detect both unacceptable parts and continuously diminishing cutting qualities.

Consequently, we strive for a sensor system that depicts a correlation between characteristic measured values and the cutting result in the cutting process. The system should not only "digitally" classify as "ok/not ok", but also detect further graduations that indicate the process state more clearly. Ideally, the analysis system can also intervene in the cutting process and adjust the nominal cutting quality via suitable controlling parameters.

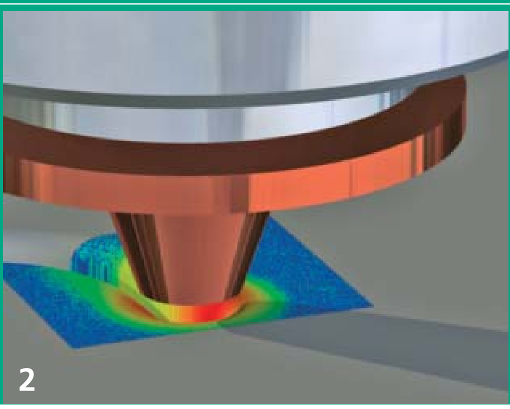
OUR SOLUTION

Basically, laser cutting is a thermal process connected with emissions in the electromagnetic spectrum. It could be verified by various optical measuring methods that these emissions correlate with the current process state both in a quantitative – as to be seen in laser density – and a qualitative way, observed for the assignment to spectral ranges.

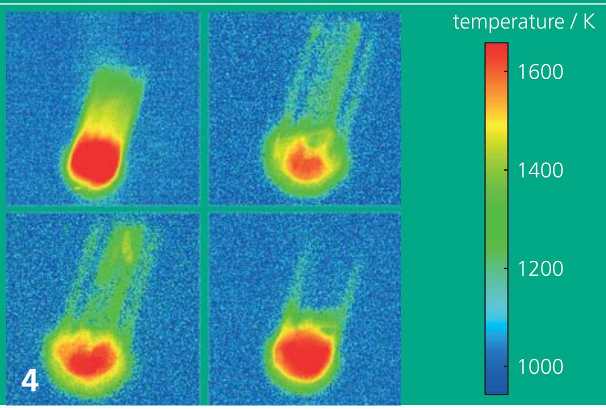
What is state of the art for other thermal techniques, such as laser hardening, can also be applied to laser cutting: the cutting process can be characterized by means of the thermally induced emissions.

This characterization was implemented at the IWS Dresden by means of the camera-based temperature recording system "E-MAqS" and the controlling system "LompocPro". The measuring and control system originally developed for power-controlled temperature guidance in laser hardening, is successfully in use in build-up laser welding, laser soldering, induction hardening and other specific heat treatment techniques.

The system is designed for demanding industrial measurement tasks and makes available surface temperature values at a lower measurement threshold of 600 °C and a frequency of max. 200 Hz.



2

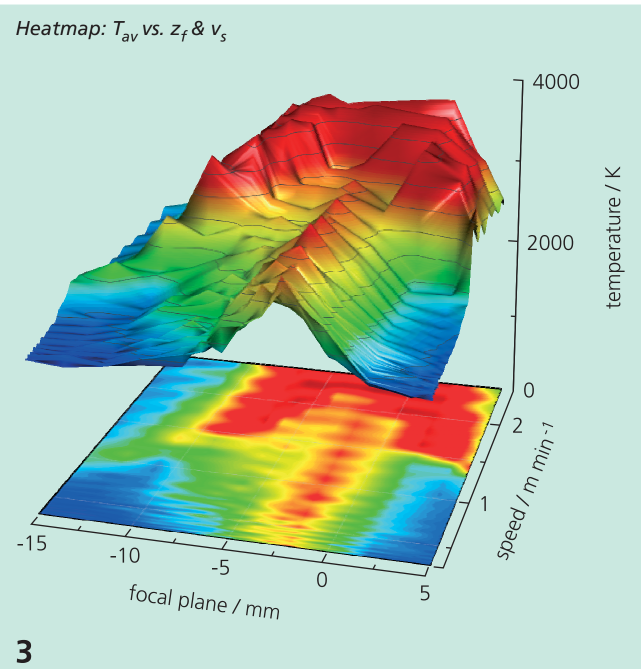


4

RESULTS

The examinations were run on commercially available hardware, equipped with an E-MAqS system of Fraunhofer IWS. A 5 kW solid state laser was used as the beam source, and standard optical components modified specifically for the coaxial coupling of the E-MAqS system into the laser beam, were used for cutting. The signal curves were correlated with the cutting results achieved to evaluate the process characteristics. The results shown in Figures 3 and 4 depict fusion cutting of CrNi steels.

The cutting process can be evaluated and characterized by means of various parameters. Since the measurement is spatially and temporally resolved, the melt pool temperature at discrete positions and the melt pool size or spatial and temporal temperature gradients can be considered. Analysis of the gradients simplifies the measuring methodology, because it is not necessary to exactly know the emissivity of the cast.



3

The melt pool characteristics depend on many factors, with various effects. The melt pool characteristics are strongly influenced by the sheet metal thickness, the laser power, and the resultant cutting clearance geometry.

The mulitdimensional correlation between the maximal temperature and the speed and focal plane as the two cutting parameters ($T_{max} = f(v_S, z_f)$) is shown as an example in Figure 4.

Current research is aimed above all at designing purposeful analysis strategies, which can be based spatially and temporally. Various effects can only be detected in the cutting process. Thus, a clear increase in the melt pool temperature indicates an imminent breakdown of the process. Other goals are online characterization of the resultant edge roughness and burr formation and the validation of the measurement system for additional cutting techniques.

The "E-MAqS" temperature measurement system is suitable for monitoring flame cutting processes, since here spatially based signal analysis plays a role in detecting instabilities in the cutting process. Under certain conditions, for instance, so-called "self-burning" or "side-burning" effects may occur, which can be detected by means of "E-MAqS" and compensated with the help of the "LompocPro" complementary control.

1 Cutting head with E-MAqS

2 Measuring position (sketch)

4 Snapshots

CONTACT

Dipl.-Ing. Thomas Pinder

☎ *+49 351 83391-3202*

✉ *thomas.pinder@iws.fraunhofer.de*