USE OF ACOUSTIC RESONANCES IN LASER BEAM CUTTING – THE "CUTTING WHISTLE"

Task

Using high-speed video analyses of the melt film on the cutting front, research has identified acoustic resonances of the gas column in the cutting kerf for the first time. It was recognized that the cut edges produced have the lowest roughness depth precisely in the areas where the melt film exhibits high-frequency waves. By understanding of this positive effect, Fraunhofer ILT could develop an innovative approach to improve the cut edge quality by acoustic amplification of high-frequency melt waves. For this purpose, the institute should develop an acoustically tuned cutting nozzle design – a so-called "cutting whistle."

Method

The cutting whistle is based on a cavity-induced supersonic flow. The cavity formed at the nozzle exit side enables the generation of sharp high-frequency spectral peaks whose resonance frequency can be finely tuned as a function of the cavity length. The resonances are validated by Schlieren optics as well as by an optical microphone. Cuts are made on 6 mm thick stainless steel sheets using a disk laser at 6 kW output power to evaluate how the newly developed nozzle design influences the resulting cutting edge quality.

Results

The high-frequency oscillations of the nozzle flow are detectable in both the microphone measurements and the Schlieren recordings. In addition, a correlating stabilization of the melt flow can be detected on the basis of the diagnosed more uniform streak recordings. Accordingly, the institute produced high-quality cut edges with roughness depths and dross lengths of only 20 µm. In the future, it aims to specifically tune the acoustic resonances of the process gas flow to the kerf geometry.

Applications

The use of acoustic resonances in laser-beam fusion cutting is just one example of the potential that simulative, diagnostic and practical consideration of acoustic effects offers for improving laser material processing operations.

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1 An acoustically tuned cutting nozzle design to improve cutting edge quality.