Spatter behavior in laser beam welding process

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1 Description of process

The group of production technology at Ilmenau University of Technology investigates the spatter behaviour of/in the laser beam welding process. Spatter is the formation of metal droplets that leave the melt pool as the result of the flow conditions in the capillary and in the melt pool. It is known that the spatter formation depends strongly on the welding speed, but the industry requires high welding speed to increase output. The escaping droplets cause lack of material in the weld seam this leading to reduction of their mechanical properties. Furthermore, the droplets deposit on the work piece reducing the surface quality. The spatter can also deposit on the protective window of the laser optic which then needs to be replaced causing downtime that has to be avoided.

Hence, the task of the group is to understand the physical mechanisms of spattering and how it can be reduced.

The research group observes the formation of the capillary as well as the melt pool behavior around the capillary using a high-speed camera. Due to the high demands in terms of high frames rates and short shutter times, an external lighting source is needed. Here the group uses Cavitar's CAVILUX HF illumination laser for lighting the area of interest. The reason for choosing CAVILUX HF lies in its ability to produce high qualitative and homogeneous illumination to the melt pool. The robust design of the CAVILUX system enables also easy handling. Furthermore, an integrated green laser pointer in the illumination laser unit permits a simple alignment of the focusing optic in relation to the area of interest. The involved operators welcome the comfort of easy configuration of the laser parameters and the simple synchronization of the lighting with the used Photron SAX 2 high-speed camera.

For observing the spatter behavior, the best illumination results were achieved using the transmitting light setup. Therefore, the optic of the illumination system was placed on the opposite side of the high-speed camera using the same angle of incidence like the camera.

Video/Image 1 shows the formation of the capillary and the melt pool. Moreover, the development of a column of material on the back side of the capillary can be observed. The column increases in vertical direction with further time steps and disintegrates into several droplets. The droplets leave the melt pool resulting in the lack of material and reduction of mechanical properties of the weld.

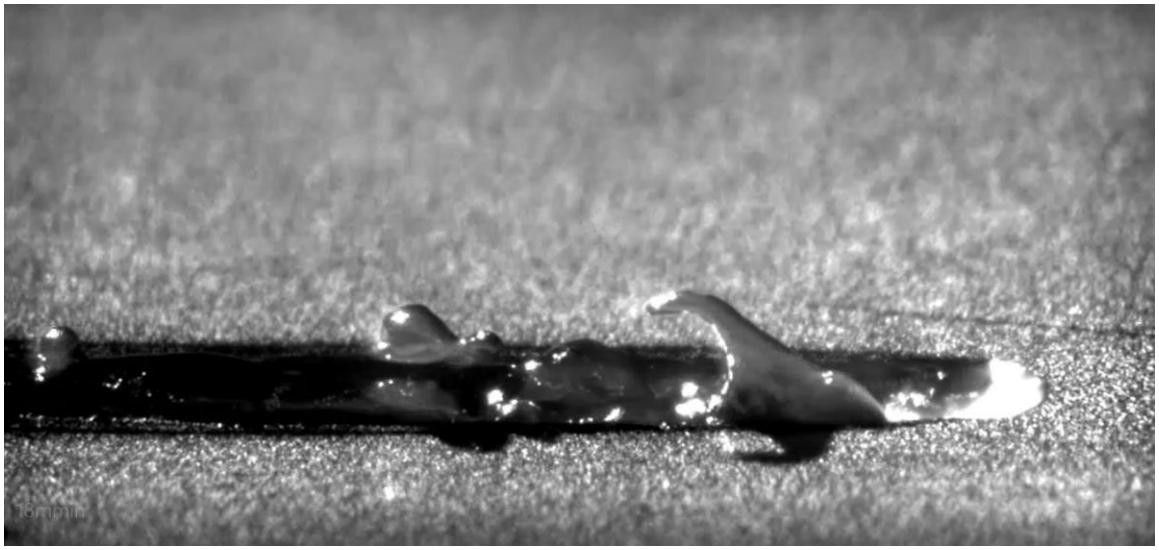

Image 1: Formation of capillary in melt pool of laser welding. Captured at 20.000 fps.

Video/image 2 shows the influence of the superimposed diode laser on melt pool behavior using the same welding speed. It is clearly visible that the size of the melt pool is increased, whereby the dynamics of the melt flow is reduced. Particularly the last mentioned effect leads to a distinctive decrease of spattering.

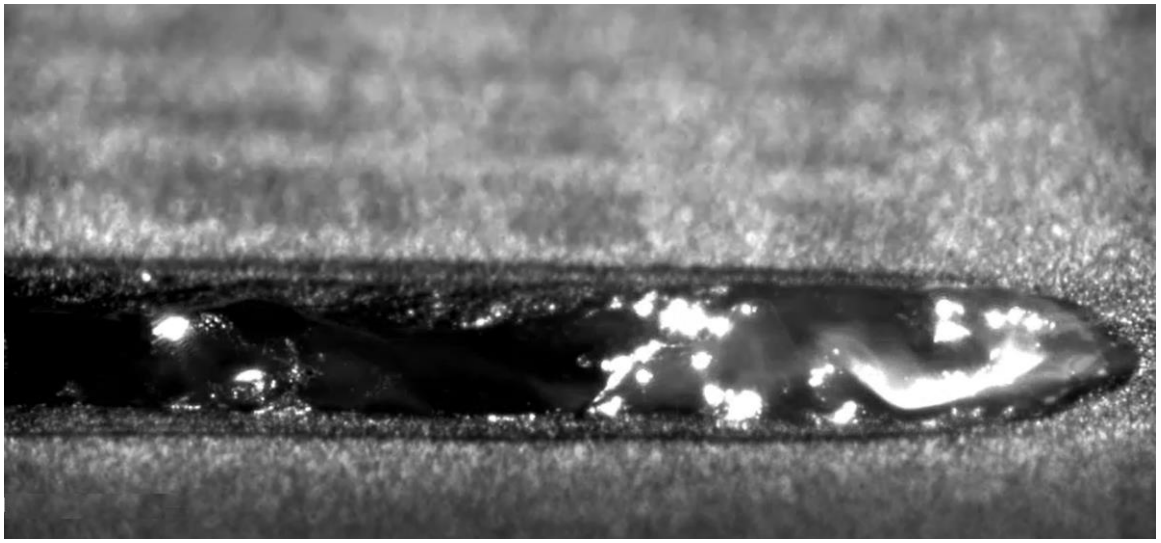

Image 2: Influence of superimposed diode laser on melt pool. Captured at 20.000 fps.

The use of the CAVILUX illumination system in combination with the high-speed camera enables the possibility to visualize the impact of the superimposed laser spots on the weld pool behavior and hence, the formation of spatter. The observations are necessary in order to extend the knowledge of spatter formation and their reduction.

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Imaging technology

Camera: Photron SAX 2
Objective: Navitar 12 x zoom
Illumination: Cavitar Ltd’s CAVILUX HF

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