Dynamic Beam Shaping and its new Potentials in Laser Welding

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The intensity distribution of the laser beam determines the amount of energy, which is locally absorbed by the material and thus influences all other process characteristics during laser material processing. As a result, it has a significant impact on both the process's stability and the quality of the welds produced. Recent laser beam sources and beam shaping technologies enable the variation of intensity distribution to optimize laser material processing. Stabilization of welding and cutting processes has recently been demonstrated using multi-core fibres, diffractive optical elements (DOE), superposition of multiple laser beams, or fast spatial oscillation of the laser beam via scanner optics [1]. The most recent beam shaping technology for coherent beam combining allows for the flexible generation of a wide range of intensity distributions, as well as their dynamic modulation at frequencies of several MHz [2,3,4]. High-speed X-ray imaging captures the effect of static and dynamic beam shaping on the shape of the keyhole and how it changes during laser welding [4]. The results show that specific beam shaping strategies and dynamic beam shaping at high frequencies >10kHz stabilize the keyhole while reducing spatter and pore formation [5]. Furthermore, the geometry of the keyhole influences the characteristics of the fluid flow in the melt pool during welding [6]. This enables the development of beam shaping strategies, which optimize the melt flow in order to significantly improve process efficiency and weld seam quality [6].

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