Static and Dynamic Laser Beam Shaping for E-Mobility Applications: Physical and Practical Impacts via Computational Fluid Dynamics Simulation

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Laser precision welding has become a standard technique for various applications in electric vehicle production. However, challenges such as reduced weld quality and defects at higher production speeds persist. One industry solution to these challenges is laser beam shaping. In this presentation, we explore the effects of both well-established static and innovative dynamic laser beam shaping techniques on the welding process for e-mobility applications. Using advanced computational fluid dynamics (CFD) simulations, we examine how the laser beam's intensity distribution influences melt pool behavior and fusion zone formation. The model incorporates complex physical phenomena, including surface tension, multiple beam reflections, phase transitions between solid, liquid, and vapor states, as well as, thermal expansion, and Marangoni flows. The high level of detail in the simulation helps explain why certain beam shapes outperform others in addressing current laser welding challenges. Furthermore, this model provides insights into designing future laser beam shapes optimized for precision welding applications in e-mobility by e.g. minimizing porosity, intermetallic formation, or ensuring airtightness of the fusion zone.