

Popular science summary of the PhD thesis

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Title of the PhD thesis	Multi-Physics Simulation of Laser Welding for Battery Pack Manufacturing
PhD school/Department	Department of Civil and Mechanical Engineering

Science summary

Laser welding is a key manufacturing process in the production of modern electric vehicles, where it is used to connect battery tabs to busbars. These joints must be electrically efficient, mechanically strong, and free from defects such as pores, which can reduce both safety and performance. Laser welding offers a unique balance between high precision, controllable heat input, and the ability to join complex or delicate assemblies with minimal thermal damage.

The aim of my PhD research was to understand how different laser welding strategies affect the melt pool behavior, defect formation, and resulting microstructure when welding pure aluminum. Pure metals, such as aluminum used in battery connections, respond differently to laser heating compared to alloys, making it essential to study them in detail. My work combined experiments and numerical simulations to explore how laser parameters such as laser power, welding speed, angle, and wobbling pattern, influence the stability of the weld and the final joint properties.

In the first part of the work, I examined how changing the welding speed and power affected penetration depth and melt pool geometry. In the second part, I showed that simply tilting the laser beam at a small angle could significantly reduce the formation of internal pores by making the molten keyhole more stable. Finally, I investigated a wobbling laser path, in which the beam was moved in a controlled circular or ring-shaped pattern. This approach was intended to widen the weld and improve bonding at the joint interface.

At the end of PhD, the research also looked at the microscopic structure of the welds under different laser angles, revealing how grains in the solidified metal grow and orient.

The findings from this PhD not only provide new scientific knowledge about pure metal welding but also offer practical guidelines for industry. The work shows that by adjusting beam angles and movement patterns, manufacturers can improve weld quality without expensive hardware changes, a step toward faster, more efficient, and defect-free electric vehicle battery pack production.

Please email the summary to the PhD secretary at the department