

**EXPERIMENTAL INVESTIGATION, MODELLING AND
OPTIMIZATION OF LASER BEAM WELDING OF POLYMERS
AND TITANIUM BASED ALLOYS**

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Abstract

The increasing application of lightweight, advanced, and smart materials in automotive and aerospace industries has created a demand for precise and sustainable joining technologies that reduce vehicle weight and greenhouse gas emissions. Laser beam welding has emerged as a superior joining method due to its high precision, controlled heat input, minimal distortion, reduced heat-affected zone (HAZ), and improved productivity. However, its full potential is restricted by challenges related to material incompatibility and differences in thermal and optical properties. A major limitation is the difficulty in welding different combinations of engineering materials due to varying degrees of incompatibility. Although polymers and titanium alloys are fundamentally different, they share common challenges in laser beam welding, including thermal management, absorption characteristics, and process control.

This research investigates the laser weldability of thermoplastic polymers and titanium-based alloys using two laser sources. A low-power diode laser (10 W) was used for laser transmission welding of polymethyl methacrylate, polycarbonate, and polypropylene copolymer, while a high-power fiber laser (500 W) was employed for welding Nitinol and titanium superalloys. The study focuses on analyzing the influence of process parameters on weld quality and developing optimization strategies to minimize defects. Response Surface Methodology (RSM) and ANOVA were used to evaluate the effects of process parameters. Results showed that incompatible polymer combinations could be successfully joined using white or black ink as a compatibilizer or absorber. Beam wobbling improved weld quality by homogenizing heat distribution, reducing porosity, and enhancing interfacial bonding. Microstructural analysis revealed refined grains and increased microhardness in fusion zones due to controlled solidification. Optimized parameters resulted in enhanced weld strength and minimal defect formation.

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