Investigation of Dynamic Thermal and Deformation Behavior for AA6061-T6 Alloy in Laser Forming for Automotive Manufacturing

Yang Fei[1], Yin Tang[1], Shuai Wang[1] Walter Perrie[1] , Geoff Dearden[1] , Stuart Paul Edwardson[1]

1- Laser Group, Department of Engineering, University of Liverpool

Corresponding author: sgyfei2@liverpool.ac.uk

Laser forming (LF) is an advanced, non-contact metal forming technology known for its flexibility and customizability. LF relies on the non-uniform temperature field generated by a defocused laser beam to produce localized thermal stresses, thereby facilitating deformation in a component. When the thermal stress exceeds the material's yield strength, it leads to plastic deformation of the component. In this study, experimental investigations and finite element simulations using COMSOL 6.0 were conducted to analysis the dynamic thermal field and deformation behavior of AA6061-T6 aluminium alloy components during the laser forming process. The experimental work comprised two key parts: first, the impact of component geometry on the dynamic thermal field and deformation behavior was explored; second, the effect of inclined laser beams applied to pre-bent components was studied. Finite element simulations were employed to validate the experimental results and provide deeper understandings into the mechanisms of thermal distribution and deformation. The findings indicate that, under consistent laser parameters, smaller aluminium alloy components exhibit greater difficulty in achieving the desired forming outcomes. Additionally, the size and shape of pre-bent components significantly affect the thermal field and final deformation. The study demonstrates that laser forming holds significant potential for enhancing process consistency, precision, and repeatability, especially in industries such as automotive and aerospace, where high accuracy and material efficiency are critical. This research provides valuable experimental data and theoretical analysis that contribute to the optimization of laser forming parameters and its reliable application in industrial manufacturing.