# Abstract

The Laser Transmission Welding process (LTW) is widely used for joining thermoplastics in the industry and is examined in this work. A computer numerical control (CNC) machine was utilized and adjusted to fulfill the prerequisites for the welding procedure. The semiconductor laser parameters are continuous wave (CW) mode at 810 nm wavelength and 0.684 Watt as maximum power. The parameters of the other semiconductor laser are CW mode at 532 nm wavelength and 0.5 Watt. In this thesis, two polymers have been used transparent poly(methyl methacrylate) (PMMA) with two thicknesses (2 and 4) mm and opaque poly(methylmethacrylate) (PMMA) with thickness 2.57 mm. The laser transmission welding processes were carried out for overlap joints for PMMA sheets with varying welding speeds (5, 15, and 20) mm/min, three values for the clamping force (2, 6, and 10 N), and three different spot sizes of the laser beam (2, 2.5, 3 mm). Macrographs images have been done to measure the width of the pool. The Taguchi method is used to design the experiment and to optimize the impact of the process parameters on weld width and weld force. Additionally, the Gray relational analysis (GRA) based on the Taguchi technique is utilized for choosing the best process parameters which will give the best characteristics. The Taguchi optimization result demonstrates that, for welding speed, the maximum welding width is when the speed is slow. The laser diode has the largest width obtained in welding 2 mm and 2.5 mm. In the semiconductor laser (532 nm wavelength), the decrease precisely in the spot size leads to the wider width possible. It was found that, the strongest weld is at the lowest speed, the smallest spot size of the laser beam and the largest clamping force.

Grey relational analysis has been found to be an effective yet simple method for optimizing the multi-characteristic process. All experiments were performed based on the findings of Taguchi method. The GRA method shows that the best-combined response (the weld width and the weld force) with welding parameters (welding speed, laser spot size, and clamping force) for two wavelengths (810 and 532 mm), where the best experience among the experiments used was the first which has 3.7628 mm width and 500 N force.

A numerical model has been developed based on the finite element method to investigate the welding process of plastics. The finite element model has been built using Simufact welding program. The model provides an approximate solution for the weld width and the temperature distribution inside the welded parts. The model shows a good agreement with the experimental data where the lowest percentage error 3%.