E. Optimization Of An Laser+GMAW Hybrid Welding Process

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Introduction

Hybrid Laser Arc Welding is a combination of laser beam welding with another welding process. In this work, Laser Beam Welding was combined with Gas Metal Arc Welding. This hybridization yields more than a serial combination of the two processes but instead results in a synergistic process that eliminates the disadvantages and while retaining the advantages of each individual process.

The hybrid process was applied to produce tee-joints (Fig 1). The goals of the hybrid process implementation on these components was to reduce distortion by reducing heat input while increasing productivity and decreasing equipment complexity by completing the weld from one side of the joint.

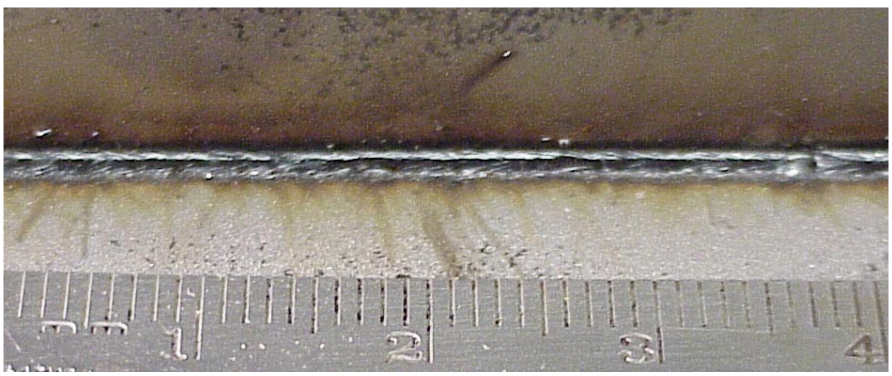

Figure 1 Backside of typical STT-HLAW weld on 0.109 inch Tee-joint configuration.

Procedure

A short circuit transfer variant of the GMAW process was adopted to reduce spatter, smoke and volume of GMAW arc plasma while using helium shielding gas. The combined process parameters were systematically varied according to experimental designs to determine their effects on the final weld shape and quality. The DOE consisted of a screening run (SR) followed by an optimization experiment was a 16 trial two-level design which put the parameters at either a high or low value. A quadratic equation could be produced to relate the parameters to response variables and 3D surface plots were created to show the optimized values for parameters and their effect on the process.

Results and Discussion

Seven process variables were included in the screening run: web vertical position, laser+GMAW horizontal position, web angle, GMAW horizontal position, travel speed, laser+GMAW angle and laser-to-GMAW spacing. After the screening DOE welds were scored, the results were analyzed statistically to narrow down the list of parameters to be included in the subsequent optimization DOE. Those variables retained were GMAW horizontal position, laser+GMAW horizontal position, travel speed and web angle.

The results of the optimization experiments provided optimal parameters for each of the four variable and revealed their affect on the weld size and quality. GMA Torch Horizontal position had the single greatest effect on the weld quaity value. Travel speed was the second most important parameter. At low travel speeds, there was more energy getting to the backside and more weld metal was being deposited on the front, both creating better weld quality. Positive settings of web angle opened the gap, providing a larger tolerance for "hitting" the joint with the filler wire, the effectively deeper vee groove allows metal to reach the backside more readily and produces a wider back bead. In the negative direction, the effective "double-Vee" groove design creates a thinner section for the laser to penetrate by moving the bottom away from the pipe. When the laser and GMA torch were perfectly aligned with the groove, this double-V groove was associated with relatively high weld scores. However, unless the GMA torch horizontal settings positioned the filler wire was positioned behind the keyhole, the backside bead tended to be small due to under fill in the backside. Laser & GMA Torch Horizontal had the smallest effect of the four variables, a possible explanation being that the groove and the pipe produce a good light trap for the laser beam and that the offset value (+/- 0.5 mm) was small compared to the joint opening (1.6 mm). The optimized parameter values determined from the designed experiments are summarized in Table 1.

Table 1. Optimized parameter values

Travel Speed	25.6 in/min
Laser + GMA Torch Horiz	0.5mm
GMA Torch Horiz.	0.075mm
Web Angle	5 Degrees

Conclusions

Hybrid Laser Arc Welding was applied to tee joint fabrication by one-sided welding. Short circuit GMAW practically eliminated spatter created by the helium shielding gas, filler metal addition and heat input were reduced. This combination with the CO2 laser improved results significantly. Designed experiments revealedthe most important process varibles to be GMAW horizontal position, laser+GMAW horizontal position, travel speed and web angle. The results of the optimization experiments provided optimal parameters for each of the four variable and revealed their affect on the weld size and quality.