



Advantages of Laser Welding for Medical Device Fabrication

Traditionally, the most commonly used welding technology in medical device fabrication is gas shielded arc welding (GTAW), also known as tungsten inert gas welding (TIG welding). In many cases laser welding offers an attractive alternative that can be used to reduce production costs and improve results. Semi-automatic laser welding machines in particular offer a cost-effective solution in the production of medical devices.

Laser welding versus GTAW

In GTAW welding, two pieces of metal are first brought into contact or close together. A high voltage is built up between a tungsten electrode and the workpieces, creating an arc that melts the materials. This molten material flows together and then solidifies again to form the weld seam. Laser welding uses a focused, high-intensity laser spot to melt the material (instead of an electric arc).

Reduced Heat Input

The main advantage of laser welding is that the heat input into the component is much lower and easier to control than with GTAW welding. This reduces the size of the heat-affected zone (HAZ), which proves to be particularly advantageous in the manufacture of medical products where the material properties must not be changed. Specifically, it enables welding work to be carried out on an almost finished part without causing any significant cosmetic, functional or dimensional changes. This means that engravings, coatings or other surface treatments already present on the workpiece are not affected. Likewise, other sensitive parts, such as springs, magnets or plastic parts (handles etc.) are not damaged or altered during the welding process. The smaller HAZ also eliminates the pre- and post-processing steps that often have to be carried out with GTAW welding.

Furthermore, laser welding is particularly well-suited to small structures, which are often found in medical technology due to the trend towards miniaturization. Finally, the strict requirements for process control and documentation are more easily met with laser welding.



Figure 1: A 0.125" GTAW fillet weld using ER630 filler metal on an implant holder showing some discoloration due to the applied heat. However, GTAW is used here because these parts tend to be thicker and therefore require a deeper penetration weld.



Figure 2: A 1 mm LBW (laser beam weld) fillet weld on a funnel using 308L filler metal. This is a smaller weld joint compared to GTAW with essentially no heat affected zone, no discoloration, and no distortion.

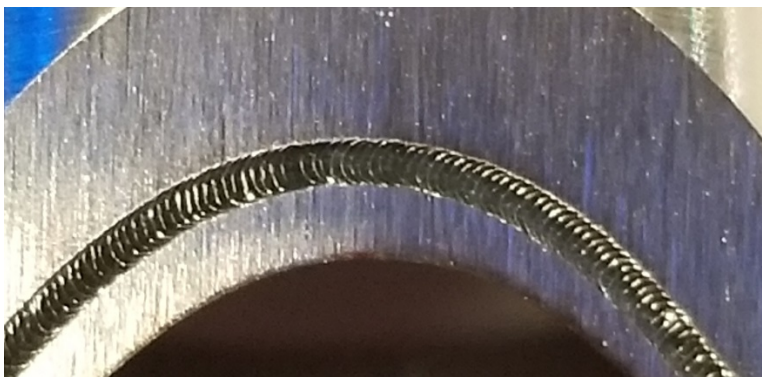


Figure 3: This is an autogenous LBW square groove weld on 17-4 stainless steel material funnel. The weld has no discoloration and little to no cleanup was required. This reduces production costs and waste and increases design flexibility.



Figure 4: The manual laser welding system Select from Coherent allows the adjustment of the laser pulse shape to optimize the welding results either with pre-programmed or newly programmed pulse shapes.

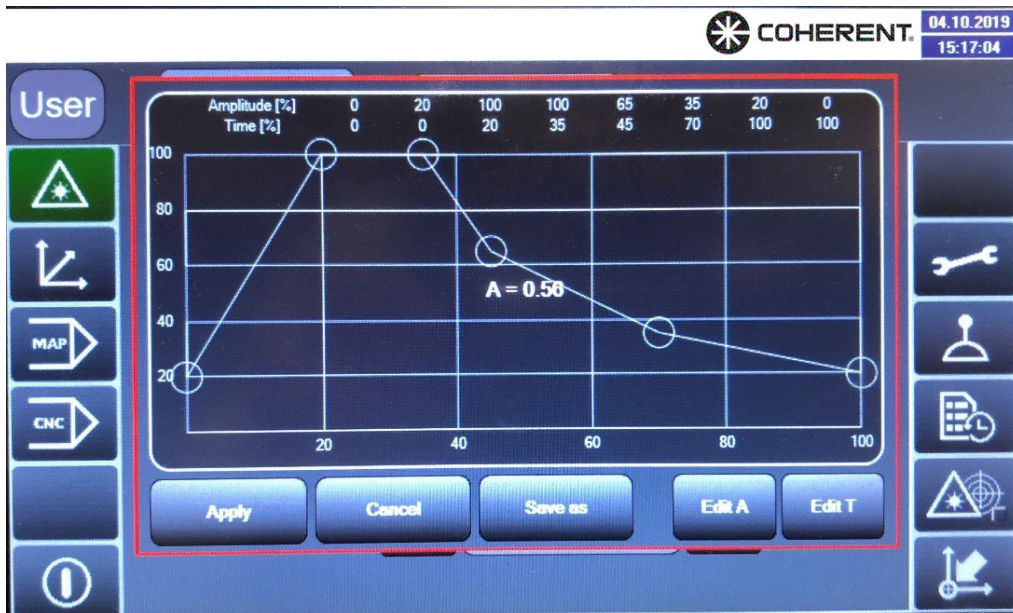


Figure 5: The Coherent Select Laser Welding Workstation control software allows customized pulse shapes to be defined.

Practical Laser Beam Welding

While there are clear technical advantages to laser beam welding (LBW), traditionally, it has only been available in the form of fully automated solutions, which typically carried a high price tag. This made them appropriate only for higher volume production. However, the introduction of

manual, or partially automated LBW systems over the past few years has now made this technology accessible and cost competitive with GTAW for the single piece or low quantity production environments often found in medical device manufacturing.



Figure 6: Select - the laser welding machine for a wide range of welding tasks

The Coherent Select Laser Welding Workstation is a standout example of this type of product. Based on either a pulsed solid-state (Nd:YAG) or fiber laser, it enables an operator to rapidly produce very high quality, precise laser welds.

This laser machine offers three distinct modes of operation. In manual mode, the operator's hand holds and positions the work piece while viewing it through a microscope, and then uses a foot pedal to initial laser welding as required. In this way, even complex contours can be easily laser welded. However, even though the operator hand holds the workpiece, the laser radiation is contained within a laser safe enclosure, so the system can be used in an open shop floor with no difficulty. Plus, the Select Laser Welding Workstation utilizes a flow-controlled exhaust system with HEPA filters so that no odors or particulates are introduced into the environment. The

advantages of manual mode are that it requires essentially no setup time and offers complete flexibility. This makes it particularly useful for producing “one-off” welds, or repair work.

The Select laser system can also be operated in joystick controlled mode. Here, the work piece is held in a fixture rather than being hand held, and moved by joystick in four high-precision axes (x, y, z, θ). Again, the laser is operator controlled by a button on the joystick. One useful feature of joystick-controlled operation is that a movement path can be memorized by the system. This level of semi-automation facilitates small batch processing.

A more fully automated CNC mode performs both automatic part movement and laser triggering. The system can be programmed through the touchscreen interface, or “taught” a path using the joystick. This allows a weld path to be run without operator attention, and repeated with high accuracy and repeatability. This mode of operation is most useful for short run, batch production applications.

Summary of Recommendations

Using a pulsed power laser for conduction mode LBW generally offers better results for welding thin materials (<.040"), or shallow penetration welds, and is cost competitive with GTAW. Conversely, GTAW is still faster, and therefore more economical for welding thicker materials that require filler metal. Determining the optimum welding approach for a specific task should always involve dialog with the fabricator, but for the engineer, the key takeaways to note are:

- It's possible to join different metals with LBW, but this is more difficult and requires more process development
- LBW enables welding close to other heat sensitive areas and components on a part
- Automated LBW systems, such as the Select laser welder, support various levels of automation which can save money and time, depending upon batch size

LBW can reduce or eliminate the need for ancillary processes, and thus lower production costs as compared to other welding methods. Thus, it is well worth it for engineers to understand the characteristics of LBW so that they can take maximum advantage of its potential during the design process.