Fine Welding With Lasers

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The need for micro joining metallic alloys for surgical instruments, implants and advanced medical devices is driving a rapid increase in the implementation of laser welding technology in research, development and volume production. This article discusses the advantages of this welding method and the types of lasers used in the process.

Image: iStockphoto

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Benefits of laser welding

Laser welding offers a fast, repeatable solution with consistently high quality. It is easy to automate and offers strong joints that can be applied to the hermetic seam sealing of implantable devices or fixing together parts by spot welding. Often, a company will introduce laser welding for one component and then find that more products can be improved by changing the design to suit laser joining. These changes can mean optimising the joint interface for laser welding to ensure the fit up and penetration as well as access for the laser beam are considered; or the laser weld can replace screws, rivets or other fasteners. New designs are then developed around the inhouse laser welding capability.

Laser welding allows the joining of miniature parts. For example, it is possible to join two wires of 50 microns or less in diameter using the fine spot available in a laser welding system. The low heat input and small heat affected zone allow miniature parts such as wires, thin foils and spring coils to be joined accurately and permanently with low heat input and hence virtually zero distortion of the welded parts. Figure 1 shows an example of fine wire welding.

Compared with tungsten inert gas (TIG) or plasma welding, the heat input and location of the laser weld are more controlled and the noncontact nature of the process makes for less maintenance and avoids the issue of tool wear.

Choice of laser

Choosing the right laser for the application can seem daunting. The majority of laser welding applications, however, are best suited to the pulsed YAG laser, which is available from under 20 W of average power up to 500 W for high speed and deeper penetration welding. The pulsed YAG laser is capable of high pulse energies for spot welding. It can be used for hermetic sealing by overlapping the pulses by 80% or more to achieve a smooth and even seam weld on the component. For welding metals, the YAG laser is normally preferred →

Figure 1: Fine stainless steel wires of 0.25 mm diameter joined by laser welding.

over the CO_2 laser, which is more commonly used for deep penetration welding (automotive and heavy industrial applications), or in laser cutting of sheet metal. The CO_2 laser typically has a higher heat input and creates more distortion than the YAG laser in fine welding applications.

Newer to the market is the fibre laser, which has a wavelength similar to the YAG laser and offers a high beam quality output. It can be focused to a fine spot of less than 15 microns for fine joining applications. The laser is limited in peak power, thus it is not capable of deep penetration welding except where the average power is higher; but the stability of welding low pulse energies offers advantages. When extremely fine welds with small spot size of less than 100 microns in diameter are required, it is necessary for the laser to run with a stable average power output or in pulsed mode with repeatable pulse energy from each pulse.

Materials suitable for laser welding

As a general rule, if the metallurgy of materials allows them to be welded, then a laser can weld them. In the medical device manufacturing industry, it is most common to use biocompatible metallic alloys. Stainless steel, titanium, cobalt chrome, platinum and shape memory alloys such as Nitinol are all suitable for laser welding. Titanium and platinum are examples of materials that are considered challenging to weld, but these materials can be welded with ease using lasers. In the case of titanium, the most important factor is shielding the weld from the oxygen and nitrogen present in air. Depending on the component, this can be achieved with a gas nozzle directing argon, which is the most commonly used shielding gas for titanium welding; or immersing the component in a dry glove box atmosphere of pure argon. An example of a titanium implant that is regularly laser welded is the pacemaker as shown in Figure 2.

Figure 2: Titanium pacemaker, hermetically welded by laser.

Laser system solutions

There are a variety of system solutions for welding, depending on the scale and geometry of the components to be welded. In the case of extremely fine components where the laser spot must be positioned accurately and the repeatability of fixturing is challenging, it is possible to use manual laser welding under a microscope. If the process is to be automated, then a vision system with pattern recognition can compensate for any error in the component positioning. Modern turnkey solutions with computer numerical control and an integrated "all-in-one" enclosure allow the implementation of affordable laser welding in smaller companies.

Future trends

The trend in laser welding systems is to improve the repeatability from pulse to pulse with the use of closed loop power control in real time. Other enhancements are to make the operator interface and the "networkability" of systems more straightforward so that the ease of use can be improved, whether the laser is "stand alone" or part of a centrally controlled production cell. Laser welding is not a new phenomenon and the knowledge base continues to expand and move the process increasingly into mainstream manufacturing. The laser welder is often the part of the production process that needs the least maintenance and has the highest uptime on the shop floor. mdt

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