Laser Welding for Small and Medium Sized Enterprises

Introduction:

Lasers has been in commercial use for a number of years with the range of laser applications and types constantly being improved and developed. This paper looks at the application of Laser Welding to Products and Services in Small to Medium Enterprises (SME's) within the Australian market.

The paper starts with an overview of Laser types and a summary of Industry and Product Applications. It then looks at the Laser Welding System basic components and the requirements for a system. The basic SME characteristics are discussed with respect to laser systems. Advantages and disadvantages of Laser Welding Systems are examined. From the discussions in the paper, it can be surmised that Laser Welding Systems financially work with products and services in the high volume/value/quality category.

Background Information on Lasers:

A Laser is a piece of equipment that produces photons of energy for many different applications. The word Laser comes from the words "Light Amplification by Stimulated Emission of Radiation". Since the 1960's, when the first working lasers were demonstrated, the variations and applications of laser technology have propagated into many different industries. The focus of this paper is the application of laser technology to welding in Small to Medium Enterprises.

There are many different laser types and industrial process applications in which lasers can be used. The main industrial laser types and applications include:

- Nd:YAG: This Solid State laser produces photons at a wavelength of 1064 nm up to 10kW of Continuos Wave (CW) Power. They can be lamp or diode pumped, have a pulsed or CW output and be fibre coupled. These systems are generally used for Welding, Cutting, Heat Treatment and Drilling. Nd:YAG systems have been in wide commercial use for the last 15 to 20 years.

- CO2: A gas laser system producing photons at a wavelength of 10.6 um with powers up to 60kW. As the 10.6 um wavelength energy is absorbed by fibres, these lasers cannot utilise fibre coupling thus use mirrors and lenses to control laser characteristics. The main applications for CO2 lasers include Cladding, Cutting and Heat Treatment. The CO2 technology has been in commercial operation for over 20 years and is a mature product.

- Diode: Uses semiconductor (diodes) to produce photons with a wavelength between 808 and 980 nm – Low IR Range. Powers are up to tens of kW's. These lasers can be fibre coupled and are generally CW. These systems are reaching maturity and are used for Brazing, Cladding, Heat Treatment and Welding.

- Excimer: A gas laser system producing photons between 157 to 353 nm or UV range. Excimer systems are generally used for micromachining applications.

Some Applications and Examples of Laser Welding:

Laser Welding is used in the Aerospace, Automotive, Electronics, Medical and Many Other industries. Some applications for these industries include:

Aerospace: Welding of Turbine Components, Structural Components in Titanium, Steels and Aluminium.

Automotive: Welding small instrument packages (air bag initiators, fuel injectors), structural welding and body panel brazing.

Electronic: Welding small instrument packages (capacitor cans, battery cases, packages) in various materials.

3-Dimensional Laser Cutting with an Nd:YAG Fibre Delivered Laser System integrated with a robot.

Medical: Pacemaker and Implant case welding, Tool Welding.

Requirements for a Laser System Installation:

There are four main areas that need to be considered for a Laser Welding Installation. These include the laser itself, is the ancillary equipment (such as materials handling, chillers, power supplies, etc), safety equipment and the staffing requirements.

The first is the laser source equipment. The laser needs to be selected so that the photon characteristics (such as wavelength, beam quality, spot sizes, etc) match the materials and process requirements. Some materials that can be laser welded include Steels, Aluminium, Copper, Many different alloys, some dissimilar metals (eg Copper to Aluminium) Plastics, etc. The Diode and Nd:YAG systems are most commonly used for welding and cutting of three dimensional products.

Ancillary Equipment is required to support the work-piece and provide services to the laser source. A laser source requires power and cooling. Power is supplied via distribution boards and transformers. The cooling is usually supplied from a water chiller unit. Robots and X-Y Tables are used to move the optics or the work- to the correct location for welding. Materials handling equipment (Cranes, Hoists, and Conveyors) are used to move the work piece to and from the work area.

Due to the wavelength and power of the laser systems, Safety Enclosures are required. A typical laser welding system is classified as a Class 4 laser device and can potentially cause eye and skin injuries if they are not guarded. Therefore a laser welding system requires solid guarding as well as personal protective equipment for an operator. Safety Interlocks are required so as the laser becomes inoperative if the interlocks are open.

Staff Education is the final requirement for a welding laser system. As there are many parameters involved in laser welding (materials, process speeds, laser settings, optics and process gasses), a high level of education is required for engineering staff. An organisation considering laser welding would need to have access to technical knowledge of the process, laser safety requirements and materials handling.

What are Small to Medium Enterprises - SME's:

SME's can include engineering organisations that can include job shops, manufacturers, repair shops, toolmakers, etc. They can range from one to one hundred employees and are located in most major centres around Australia. They can produce their own products and/or provide services to other organisations.

The typical processes that can be found within SME's include the Welding Processes such as TIG, MIG, Electric Arc, and Oxy-Acetylene. Other processes include machining (drilling, milling, turning, grinding, polishing, etc), forming (bending, pressing, etc.), cutting (punching, guillotine, laser, plasma, water jet, etc.).

Corner Weld on a Stainless Steel Sink. Welded with a Fibre Coupled Diode Laser System.

There are two areas that affect an SME operation. The first is the costs of the products and services provided – the cost drivers. They include Capital cost of equipment, Labour, Materials, Consumables (power, water, gas, etc.), Maintenance and Overheads. The second area is the Productivity Drivers. Productivity is affected by Quality requirements, Process Speed, Process Complexity, Flexibility and Operator Educational Requirements.

Some Advantages of Laser Welding for SME's:

There are three main advantages for SME's utilising Laser Welding. They are the Laser as a Technology enabler, the product improvements achieved from laser welding and competitive advantages. These are discussed below.

The Technology Enabler allows an SME to perform processes including Intricate Cutting (eg 3 D Cutting), Fine Welding Detail, Can welding of Sealed Electronic Components, Dis-similar Materials Welding, Deep Keyhole Welding, Plastics Welding and Smaller Part Processing (Micron Level). Some of these processes cannot be achieved using any other process except laser.

Some Product improvements include Quality of the weld (achieve a more homogenous and consistent weld characteristics resulting in higher strength and durability), Minimised heat affected zones, Speed of welding operation and Reduction of Post Processing Operations (e.g. Grinding and Cleaning of Welds).

Some Competitive advantages from laser welding include improved Product Quality, faster Process Speeds, achievement of difficult product weld geometries and dis-similar materials. The Products most suited to laser welding include High Value (Low Volume) Components, High Volume Components and Products Not Able to be produced by any other Process.

Some Disadvantages of Lasers in SME's:

The main disadvantages of Laser Welding systems centre on mobility, flexibility and cost. Firstly, the Mobility of a laser welding system is limited. As a Laser Welding System is usually a fixed installation requiring guarding, chillers, materials handling systems, it is difficult to move to another site. However, some smaller compact systems are semi-mobile for on-site jobs and projects.

The second disadvantage is the flexibility of a Welding System to weld different parts and geometries. Generally High volume products result in a dedicated Laser facility. A dedicated laser facility can require substantial re-tooling costs for different products. These costs need to be added to product prices. Where as high quality (low volume) products require a facility that can accommodate a number of different products.

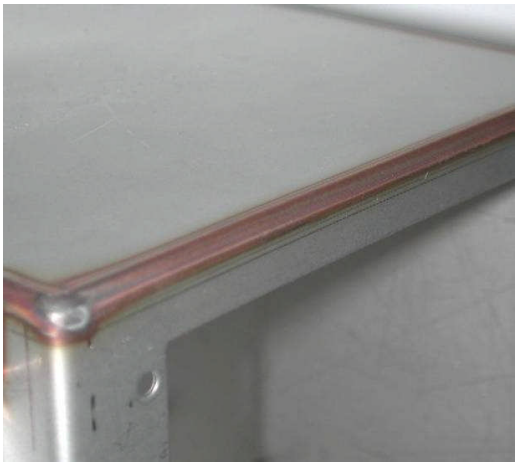
The final disadvantage is the Capital Cost of a Laser Welding System. The cost for a laser welding system can range from a few hundred thousand dollars to millions of dollars. This cost can be accommodated in the prices for a high volume and high value product environment. However, the capital cost is very difficult to justify if the product is outside the high volume/value/quality product category.

Summarising:

The discussions above can be summarised into three basic questions from an SME perspective and what is a typical laser installation. They are as follows:

Why would SME's consider Lasers? There are three reasons for using laser welding. The first is that laser welding can produce parts not possible by any other process. There are productivity improvements in weld quality and speed. Should consider for High Quality, High Volume and High Value Components.

What are the advantages (and disadvantages) of Lasers? The main advantages include technology enablement, productivity and competitiveness. The disadvantages include lack of Mobility, some lack of Flexibility compared to traditional MIG and TIG welding and Cost Justification.



Corner Weld on a Stainless Steel Cabinet. Welded with a Fibre Coupled Diode Laser System.

What criteria would laser welding (processing) fulfil? The best use of laser welding equipment is for high volume/value/quality components.

A Typical Laser Processing Installation includes a Laser System, Optics (beam delivery), Power Supply, Chilled Water Supply, Materials Handling System (Robot/X-Y Table/Gantry/Cranes/etc) and Guarding. In addition, staff training and/or access to technical knowledge is required.

Conclusion:

There are many potential applications for Laser Welding within Australia for SME's. To access these markets, the SME needs to determine if Laser Welding (Processing) is appropriate for the product and/or service and what are the benefits of a Laser System. The products would need to fit into the high volume/value/quality category so as the system can be justified from a business perspective. The main advantages include technology enablement, productivity and competitiveness. When balanced against the disadvantages, the justification should be favourable for products and services in the high volume/value/quality category.

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