Technical Information

BRANSON

Design Guide for Laser Welding

EMERSON
Industrial Automation

Laser welding is one of Branson's "Clean Joining Technologies."

This bulletin provides guidelines to aid the designer during the initial concept and design of a new product. All joint designs should be used as guidelines only, since the specifics of your application may require variations. If you have questions or need assistance in designing your parts, contact your local Branson representative.

TTIr Welding

Branson Contour Laser assembly systems use a process called Through Transmission Infrared welding (TTIr). The process passes laser radiation through one plastic component (transmissive component), and the energy is absorbed by the mating component (absorptive component). This absorption results in the heating and melting of the interface, and with the application of a controlled clamp force the parts are joined. (figure 1)

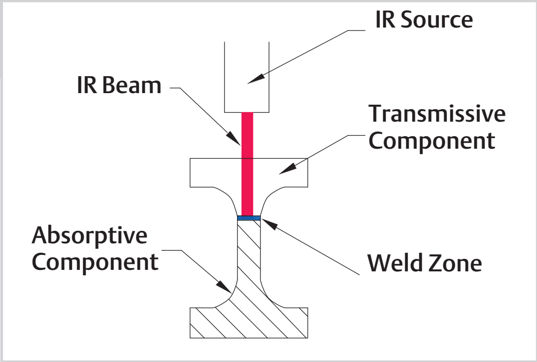


Figure 1. TTr Welding

Process Advantages

The Laser welding method has certain clear-cut advantages over other methods for welding plastics.

- **Weld quality –** Because the process is nonintrusive, the parts typically exhibit excellent cosmetic properties. The heating/melting of the parts is very localized, occurring only at the weld interface.
- **Minimal flash and no particulate –** Since the process can be easily controlled by varying the power of the laser source, it is possible to accurately control the power dissipation within the weld, resulting in less flash. There is also no frictional motion between the parts and therefore no particulate generated.
- **Part design flexibility –** This method allows for 3-D joint configurations.
- **Gentle to sensitive assemblies –** Since there is little movement of the parts, no excitation or vibration, sensitive electronic and mechanical assemblies can be welded without damage. The only requirement is the ability to apply a clamping force to the two parts being welded.
- **Pre-assembled parts can be welded –** For some applications it is critical to allow internal components to be held in place during the welding process without becoming dislodged. This method allows for parts to be placed into the welder in the same position and orientation as the final, assembled position.
- **Ability to weld materials that are not easily welded with other technologies –** Some of the Materials that have been welded successfully to date include acrylonitrile butadiene styrene, acrylics, cyclic olefin copolymer, elastomers, PBT, polyamide, polycarbonate, polyoxymethylene, polypropylene, poly-styrene, thermoplastic polyurethane, high-density polyethylene, low-density polyethylene, and polysulphone. This method is also effective with some dissimilar material combinations.
- **Fast and flexible –** Ideal for high volume applications; a typical weld cycle time ranges between 1 and 5 seconds.

Process Methods

Branson offers multiple methods for laser welding of plastic components. Each method has certain advantages and selection of the appropriate method will depend on the configuration of the parts to be welded as well as the desired cycle rate of the process. The major breakthrough in Branson Laser technology is the ability to illuminate the entire welding surface simultaneously as compared to other techniques that rely on scanning of the weld joint.

The patented **Simultaneous Through Transmission Infrared (STTIr)** method is widely used when an entire discrete weld path or area must be welded to produce a defined collapse or melt-down at the joint interface. With this method, the complete weld path or area is illuminated simultaneously, not intermittently as with some tracing methods. This method generally produces the fastest laser weld cycle times. The simultaneous illumination allows for the use of a much lower power density than typical laser trace welding. This virtually eliminates material degradation or flare ups often experienced in trace welding. (figure 1)

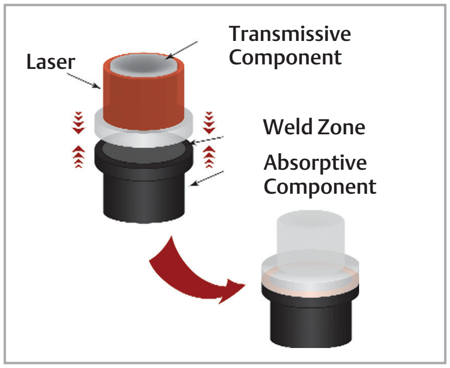
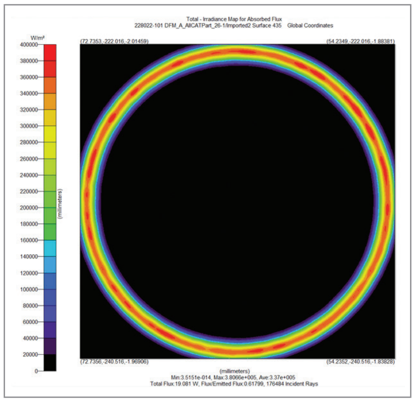


Figure 2. STTIr Welding

Wide Beam Scan welding is another method which is used when welding of larger surface areas is desired. With this method, a curtain of laser light is projected down onto the clamped part set. The part set is then traversed through the laser beam and the weld is produced. This method is used when limited collapse and minimal flash are required as when welding thin films to rigid components.

Material Considerations



As described above, to successfully complete a laser weld, the assembly must consist of one part that transmits the laser light and another part that absorbs the laser light. For transmitting parts, the best welding results are obtained when the material transmission rate is 15% or higher. Some applications have been successfully laser welded with a material transmission rate as low as 15%, but this may result in higher process sensitivity. For absorbing parts, black or darker colored materials (colored with carbon black) are usually very good absorbers.

When combined with high transmission rate materials, black or dark colored parts will usually produce the fastest laser welds. Many shades of gray and beige have also been found to be good absorbers, as well.

It is also possible to laser weld two parts that are both optically clear by adding an absorptive interface between the two parts. This can be accomplished by various methods such as:

- Dispensing a laser absorbent ink at the interface
- Hot stamping an absorptive film
- Placing a die cut film or absorptive component in the weld joint
- Using a two-shot molding technique with absorptive resin in selected areas
- Laser etching the surface to create an absorptive surface
- Molding one of the components with an absorptive dye into the resin

The use of fillers, such as glass fiber, must also be taken into account when designing parts for laser welding. The addition of a filler to a resin generally decreases the transmission rate of the material by diffusing or absorbing the laser light as it passes through the part. If the filler content is too high and the transmission thickness is excessive, it may not be possible to generate enough heat at the weld interface to create a weld.

If you have questions about materials or would like to have your specific materials tested for laser feasibility, contact your local Branson representative.

Part Design Considerations

When designing parts for laser welding, there are a few important requirements to keep in mind.

1. Initially, *the parts should be designed so that the area above the weld joint is completely accessible by the laser tooling.* The laser tooling generally actuates on the parts in a direction nearly perpendicular to the weld
joint face (except for tapered joints). The laser tooling will contact the parts above the weld joint in order to provide clamping force to the parts and to project the laser light to the joint.
2. The part design should also take into account *the need for adequate clamping of the weld joint*. A good part design will insure that the entire length of the weld joint can be supported below the joint as well as allowing the laser tooling to clamp
the parts above the joint.
3. It is also important when designing parts for laser welding to *maintain a consistent transmission thickness in the transmitting part.* This becomes increasingly important as the transmission rate of the material decreases. In lower transmitting materials as the thickness increases, the amount of laser light that reaches the joint decreases.
4. Another area of concern is occlusions in the transmission area of a transmitting part. *It is recommended to avoid designing any passages (flow paths, ports, voids, etc.) into the transmission area directly above the weld joint.* These features can also create shadows or cold spots in the weld area. **If an occlusion or passage is unavoidable a rectangular or square shaped feature will allow for more uniform transmission than a circular one.**

Joint Design Considerations

PRIMARY FACTORS INFLUENCING JOINT DESIGN

All of the following basic questions must be answered prior to the design stage to gain a total understanding of what the weld joint must do:

- What type of material(s) is to be used? Does it contain filler?
- Does the transmitting part transmit enough laser energy to promote a laser weld?
- Does the absorbing part absorb enough laser energy to promote a laser weld?
- What is the overall part size and configuration including tolerances?
- What are the final requirements of the part?
  - Is a structural weld required? If so, what load forces does the part need to resist?
  - Is a leak-tight seal required? If so, to what pressure requirement?
  - Does the assembly require a visually attractive appearance?
  - Is visible flash objectionable inside and/or outside of the joint?
  - Any other requirements?

KEY DESIGN CONSIDERATIONS

The following points need to be addressed when designing parts for laser welding:

- For maximum strength, the weld bead or tongue width should be equal to the nominal wall thickness for unfilled materials, and at least 1.25X the nominal wall thickness for filled materials.
- The transmission thickness (distance from outside surface of transmitting part to weld interface) should be limited to 2.5mm for filled materials. For unfilled materials, this thickness can be greater based on the transmission rate of the material.
- Because the laser welding process is based on heat transfer between parts, intimate contact of the parts is very important. The parts should have minimal warp and should mate together well. The weld bead surfaces should be smooth and free of voids. It is recommended to avoid positioning ejector pins, gates, or vents directly on weld interface surfaces.

JOINT DESIGN

Figure 1 shows a properly designed **skirt joint** which is used when external flash is not acceptable and internal flash is tolerable. This design provides adequate clamping area on each side of the weld bead. The flash trapping leg should be designed to allow for maximum collapse plus a small amount of clearance.

Figure 2 shows an improperly designed **skirt joint** where the edge margin on the inner side of the weld is too small. This situation results in tooling sections which are too thin and can be easily damaged. The inner tooling margin should be designed to be 1mm minimum.

Figure 3, a **tongue and groove** design, is an ideal laser welding joint when inner and outer flash containment are necessary. The inner tooling margin should also be designed to be 1mm minimum. The flash trapping legs should be designed to allow for maximum collapse plus a small amount of clearance.

Figure 4 shows a **tapered joint design** (with flash containment) which works well when there is no straight transmission path from the top surface to the weld joint. If parts having square or rectangular perimeter parts are used, the corners must be radiused. With this design, laser light is projected radially inward around the perimeter of the part to the joint interface.

Figure 5 shows a full section **tapered joint** (without flash containment).

Figure 6 shows a **simple butt joint** with a small offset to the inside of the part. This design can be used when flash containment is not required.

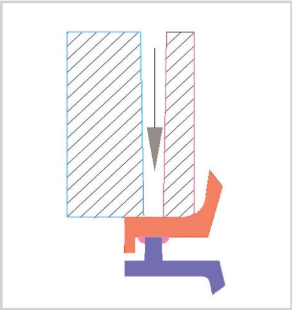


Figure 1. Skirt Joint

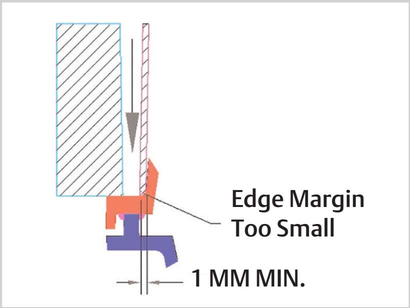


Figure 2. Minimum Tool Margin

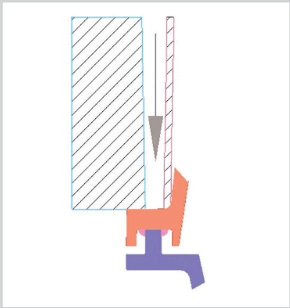


Figure 3. Tongue and Groove

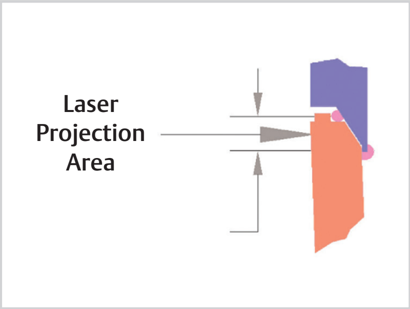


Figure 4. Tapered Joint with Flash Containment

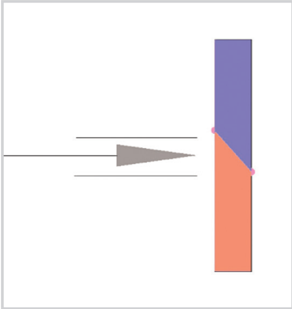


Figure 5. Tapered Joint with Full Section

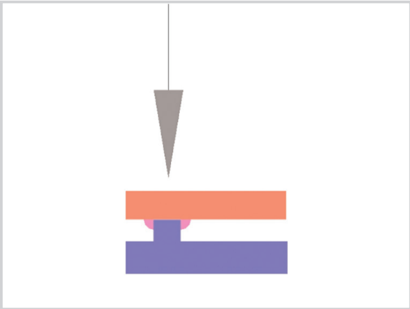


Figure 6. Simple Butt Joint

Laser Design Guide

Figure 7 shows an **edge butt joint.** This design is also used when flash containment is not required or with the use of external flash traps designed into the tooling. With this design, it is important to maintain a minimum radius on the outside of the transmitting part. If this area is radiused, it will cause the laser light to be rejected at the outer edge and will result in a cold spot in the weld.

Figure 8 shows a poorly designed **butt joint** with a long transmission thickness. This design will result in higher transmission losses. With a low transmitting material, it may not be possible to achieve a weld with this design.

Figure 9 shows a **double v joint**. This design is used with long walls that are asymmetrical and complex profiles. Joint design provides post weld part alignment.

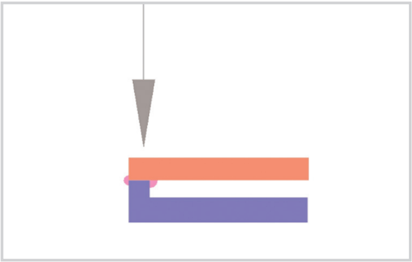


Figure 7. Edge Butt Joint - No Flash Containment

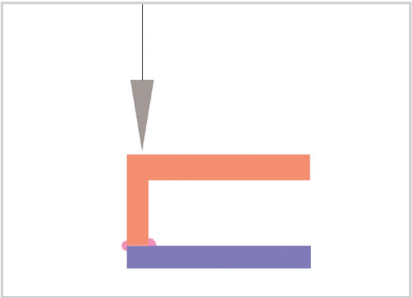


Figure 8. High Transmission Losses

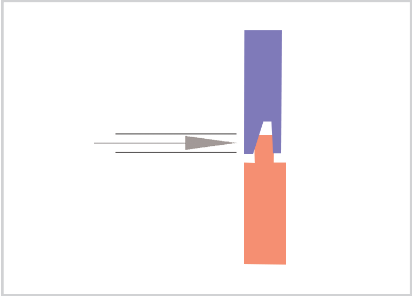


Figure 9. Double V Joint

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