Civan Lasers

Application Note

Improving Al Die-Cast Welding Processes using Civan's Dynamic Beam Laser.

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Aluminum die-cast parts are a desirable solution for producing stronger and more efficient vehicles in the automotive industry. **However, joining these parts through laser welding has been a challenge due to the entrapped hydrogen gas in the material.**

Civan's OPA6 dynamic beam laser system provides meltpool control through beam shaping and tailored power distribution, reducing porosity and enhancing stability, enabling manufacturers to produce high-quality, high-strength aluminum die-cast parts more efficiently to meet industry demands.

Introduction.

The current trend in the automotive industry is to produce lighter, stronger, and more efficient vehicles, and aluminum die-cast parts have emerged as a prime candidate for achieving these goals. The die-casting process allows for intricate designs and shapes that would be difficult or impossible to achieve with other manufacturing methods. Additionally, the mechanical properties of aluminum die-cast parts, such as high impact strength, make them ideal for the demanding mechanical standards in the automotive industry.

The Challenge

A significant amount of hydrogen gas entrapped in the material due to the high temperatures and pressures involved.

However, the process of joining die-cast aluminum parts, particularly through laser welding, has proven to be a formidable task. The casting process usually involves a significant amount of hydrogen gas entrapped in the material due to the high temperatures and pressures involved, as well as processing additive materials. When welding, this gas expands, resulting in an excessive porosity and spatter, where the former can weaken the mechanical properties of the material and reduce its overall strength. Furthermore, the excessive porosity can also promote keyhole instability and collapse. Various techniques, such as magnetic fields, laser-wobble processes and dual beam welding (via DOE) to name a few, have been employed to mitigate porosity with limited success since controlling the meltpool dynamics during welding remains a challenge.

Melt Pool Control & Tailored Power Distribution.

A novel laser system that provides significant meltpool control.

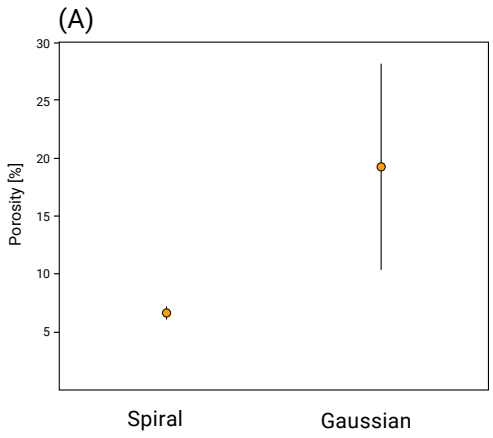
Civan's OPA6 dynamic beam laser, is a novel laser system that provides significant meltpool control through beam shaping and tailored power distribution. This innovative technology can effectively reduce porosity and enhance overall stability, resulting in a considerable reduction in process time. With this system, manufacturers can produce high-quality, high-strength aluminum die-cast parts at a faster pace and with greater efficiency, meeting the demands of the automotive industry in the coming years.

Experiment.

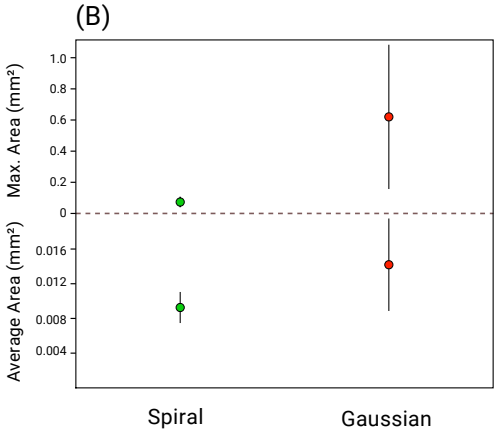
The experiments were conducted using Civan's OPA6 dynamic beam laser and display a comparison between a gaussian and spiral beam shapes according to the parameters at table 1:

Beam shape	Power [kW]	Feed-rate [mm/s]	Frequency [kHz]	Spot Size [µm]	Alloy gas content [cm3]
Gaussian	6	150	NA	570	15
Spiral	6	150	1000	570	15

Table 1: Comaprison experiment of Gaussian and spiral beam shapes.

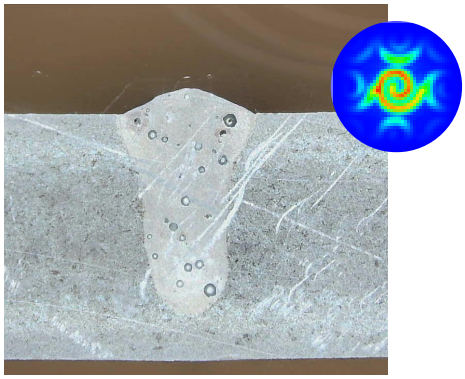


(A) Porosity percentage for Spiral and Gaussian beam shapes.

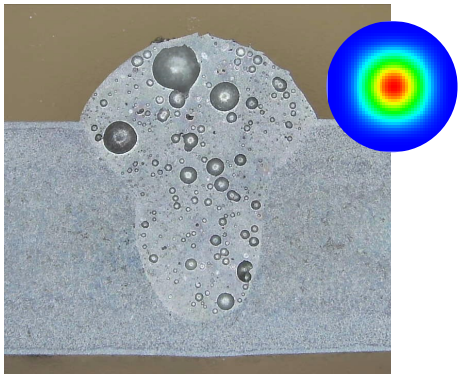


(B) Up - Maximum area of pores Down - Average area of pores.

The mechanical properties of a workpiece are affected by porosity, which is determined not only by its volumetric percentage but also by the size of the pores, as increased pressure within the pores can intensify the mechanical stresses exerted on the workpiece. Figure 2 displays the results in terms of porosity percentage, average pore size and maximal pore size. the data was acquired from five sections per parameter set. In addition, typical sections and the power distribution of the beam shape is also displayed:



Spiral beam shape and a representative cross-section.



Gaussian beam shape and a representative cross-section.

The findings indicate a significant enhancement in the aforementioned parameters with the use of a spiral dynamic beam shape. Additionally, the minimal deviation observed in the percentage of pores, average pore area, and maximum pore size highlights the dynamic stirring ability to promote process stability by reducing gas porosity and preserving keyhole stability, which is influenced by the dynamic condition of the molten pool.

Welding of such parts requires additional flexibility in terms of process and beam parameters.

Die-casted parts rarely display simple part geometry in practice, and they typically involve several factors that significantly affect the process stability. Some of these factors include gaps between the part assembly, variations in part thickness, and the combination of welding layouts, among others. These added complexities increase the welding difficulty and often lead to welding instability and a higher incidence of defects. As a result, welding such parts requires additional flexibility in terms of process and beam parameters.

This laser system allows for greater flexibility in terms of optimizing welding parameters and adapting to the specific requirements of a given application.

The OPA6 dynamic beam laser is a unique system that enables optimization and parameter tuning to enhance the adaptability of welding processes and concepts to meet the demands of actual applications. This laser system allows for greater flexibility in terms of optimizing welding parameters and adapting to the specific requirements of a given application. Figure 2 display sections from experiments conducted on prototype parts and commercially available parts that were not designed for laser welding:

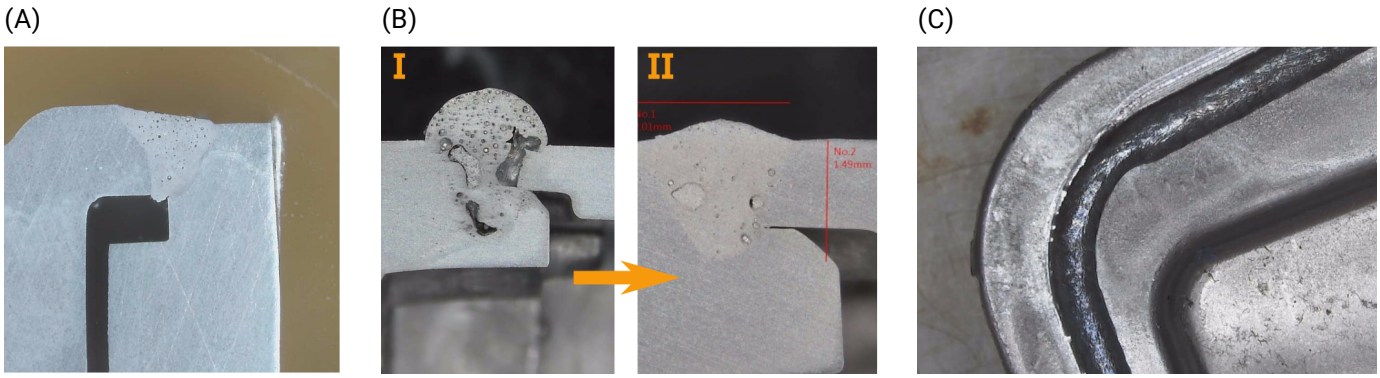


Figure 2. Welding examples from industrial applications.
(A) A high quality weld is demonstrated, with low porosity (1.4%) despite combining parts with asymmetry and gaps.
(B)Shows an example of improved welding quality in parts that combine different parts geometry and welding layout.
(C)At top-view of the weld seam that demonstrates smooth surface with no irregularities or blowholes.

Tailored to each specific welding task and alloy type and combination to meet the desired requirements.

By customizing the welding process using beam shaping, we are able to demonstrate the ability to weld quickly and accurately while minimizing porosity and maintaining a smooth and clean weld bead surface. These outcomes are achieved through a combination of factors, including the beam shape profile, path strategy, and optimized beam frequency, all of which are tailored to each specific welding task and alloy type and combination to meet the desired requirements.

Conclusions.

The utilization of Civan's OPA6 laser in experiments has resulted in a remarkable enhancement in the welding quality of die-cast aluminum alloys.

These outcomes indicate that controlling the melt pool via dynamic beam shaping is a highly beneficial approach for die-cast welding applications, aimed at improving both welding stability and integrity while reducing the overall welding process time.

Civan Lasers OPA6 Weld.

Dynamic Beam Lasers.

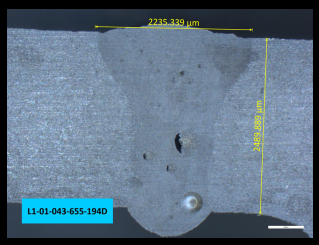
Civan's Dynamic Beam Laser enables manufacturers to quickly tailor the welding process to the application. With the ability to control beam shape, beam sequence, shape frequency, and focal depth at MHz speeds without any moving parts.

Civan's disruptive DBL technology facilitates rapid process optimization, eliminating unwanted joining defects such as pores, cracks, and humping. Civan's lasers not only improve joint quality but also offer increased power, increased feed rates, and more efficient production of new, complex, products made of dissimilar materials.

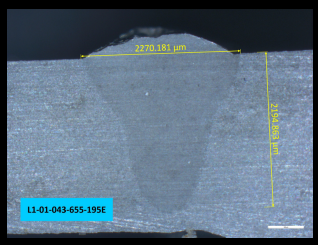
Civan's Dynamic Beam Lasers for AI Die Cast Applications.

Civan's Dynamic Beam Lasers enable the elimination of entrapped-gas-induced porosity by supreme control over keyhole dynamics and melt pool stirring.

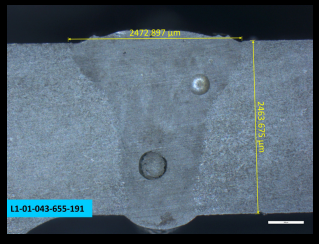
- **Unlimited Beam Shapes**
- **Shape Frequency**
- **Shape Sequence**
- **Focus Steering**



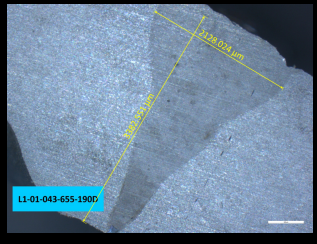
1.8% Porosity



0% Porosity



1.2% Porosity



0% Porosity

About Civan Lasers.

Established in 2008, Civan is a Jerusalem-based manufacturer of fiber lasers based on coherent beam combining (CBC) technology. With 180 employees, Civan is the only company to master CBC.

The company's unique dynamic beam laser technology lets manufacturers make more complex parts from a wider range of materials, more quickly, more efficiently, and with better process control than existing production methods.

Milestones.

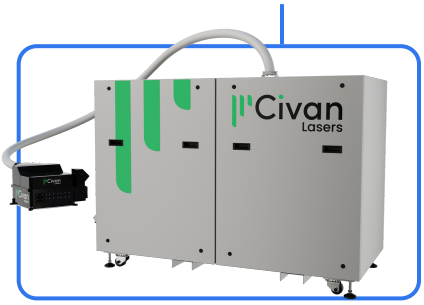
2008
Establishment

2012
1kW

2016
5kW

2018
14Kw

2021
100kW



+75 Over 75 patents.

200 Employees worldwide.

50K Sqt. Facility of Labs and Production.

JLM Located at Jerulsaem, Israel.

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