Improvements in Laser Processing of Hot-Forming Materials with 3D-5axis Laser Machines

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Abstract. At present, the use of Hot-forming 3D five-axis laser cutting in automotive body parts is very mature. With the maturity of Hot-forming industry technology and the continuous cost reduction requirements from auto OEMs to Hot forming parts suppliers, automotive Hot-forming parts Suppliers' requirements for 3D laser cutting machine tools are also changing. With the development of the Hot-forming market, customer groups and customer needs are also changing. From the earliest customer requirements for high efficiency, high cut quality, precision cutting, long-term operation stability; up to now, customers have put forward different demand directions for the lower investment cost of laser machine tools and higher machine tool efficiency. The results of this research are based on the needs of different customers in the existing Hot-forming market, and new technological innovations have been developed for 3D laser cutting machine tools: one is the latest two-in-one fiber laser applied to the cutting of 3D Hot-forming materials. At the same laser power, the cutting efficiency of the entire machine tool for a single part can be improved; the other is how to reduce investment costs on the premise of meeting the needs of some customers.

Keywords: Laser processing · 3D five-axis laser cutting · Hot stamping

1 Introduction

The application of 3D laser cutting to the production of automotive hot forming parts has a history of development for many years; around 2006, the production mode of 3D laser cutting machine cutting automotive hot forming was officially introduced into the Chinese market and has been in China so far. In the past 17 years of development, as the development of hot forming technology has become more and more mature, the cost of thermoformed parts is lower, and the proportion of thermoformed parts in auto body parts is getting higher and higher. 3D laser cutting is an important part of the hot forming production process. Hot forming manufacturers have higher and higher requirements for 3D laser cutting machine tools. Machine tool cost and production output are the two topics they are most concerned about.

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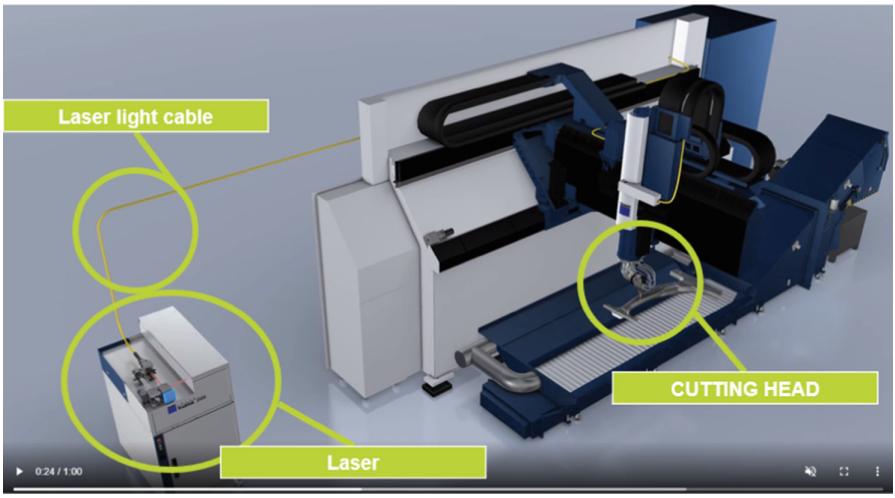

Fig. 1. Mainly components of the 3D 5-axis laser machine tool.

This introduction needs to involve the main components of the three-dimensional laser machine tool, so there are the following descriptions of the main components of the machine tool. Easy for readers to understand. 3D laser cutting machine mainly includes several important components: machine body, laser light source, laser fiber optic cable, cutting head.

(1) Machine body: The main structural support of the machine tool and the motion unit.
(2) Laser light source: A unit that generates laser light, usually a solid-state laser.
(3) Cutting head: Focus the laser on the surface of the part material for laser production and processing.
(4) Laser cable: The transmission tool of the laser, which is used to transmit the laser generated by the laser light source to the position of the laser cutting head (Fig. 1).

2 Analysis of the Laser Cutting Process for Special Laser Beam Quality

The latest laser technology is Bright Line Speed 2-in-1 fiber technology for hot forming 3D cutting. The two-in-one fiber optic cable is reasonably matched to use two diameters of laser beams (inner core laser beam and outer ring laser beam), and the beam quality of the laser source output laser for cutting can be changed by the combination of the inner core and outer ring diameters of laser beams. After reaching a laser beam ratio that is most suitable for 3D laser cutting, it can effectively improve the cutting speed of the machine system and ensure the cutting quality of laser processing parts with complex part shapes (Fig. 2).

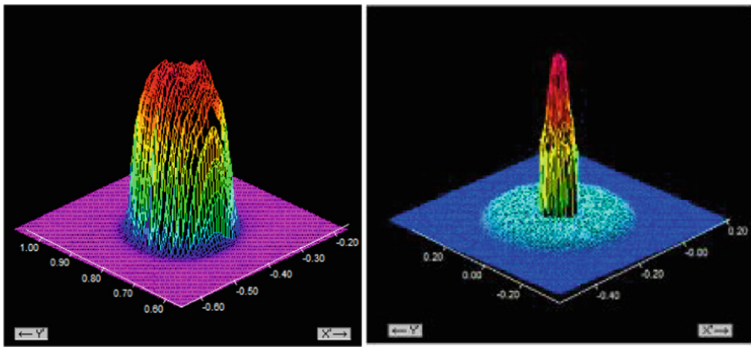

Fig. 2. Power distribution of the beam cross section. Right side is a normal single laser source beam in φ100 μm, left side is beam quality with 2 in 1 laser light cable.

There is a single fiber diameter for hot forming 3D cutting machines in the market. By using a two-in-one fiber, the cutting speed of parts can be increased while keep using the same laser power, and the production efficiency of machine be effectively improved.

We used the TRMMPF 3D machine tool-TruLaser Cell 8030 to do two kinds of cutting for test comparison: one is cutting flat plate, and the other is hot forming 3D stamping parts.

2.1 The Cutting Test Data on 2D Sheet Metal Material

A 2D cut works is cutting on Laser machine as Fig. 3 (Tables 1 and 2).

Conclusion 1:

(1) When use 3 kw laser power, Bright Line Speed function can improve > 30% cutting speed performance in 2 mm material thickness, and ~50% speed increase in 1 mm material.
(2) 3 kw laser power with Bright Line speed beam quality construction, cutting speed a little higher than 4 kw normal laser beam when part material thickness < 2 mm.

2.2 The Cutting Test Data on 3D Hot Forming Material

With Bright line speed function and higher laser beam quality, the new laser beam shape only needs smaller cut nozzle, it can help the machine only need less cut gas assumption with same cut quality in same thickness. Here is a cut test comparison as Table 4 (Figs. 4, 5 and Table 3).

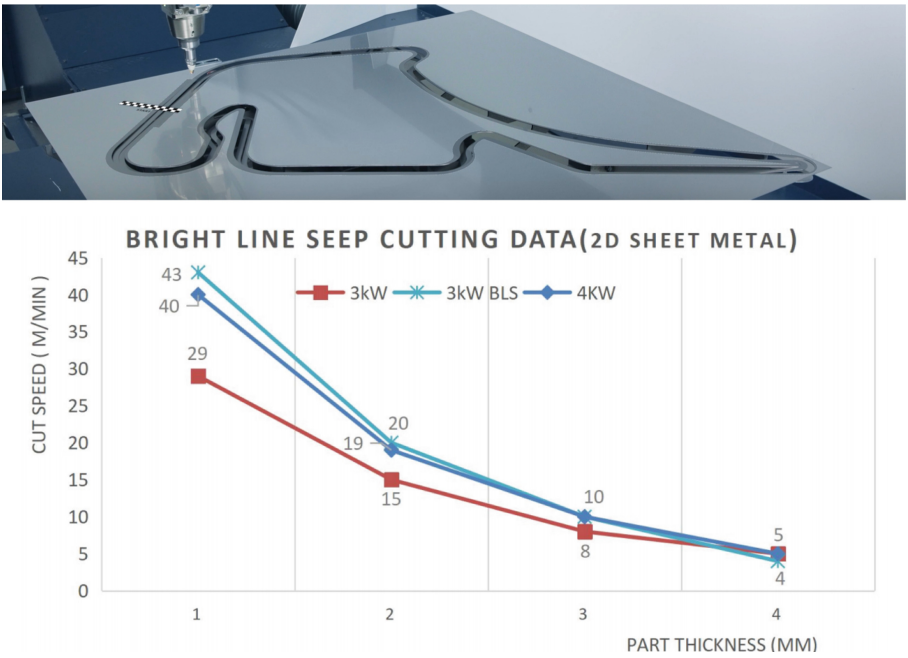

Fig. 3. 2D cut test on TRMMPF TruLaser Cell 8030 machine system.

Table 1. Cutting data of the Bright Line Speed function used on a 2D sheet metal for time comparison. Test machine TruLaser Cell 8030.

Sheet thickness [mm]	1 mm	2 mm	3 mm	4 mm
3 KW normal Laser beam_100 µm	29	15	8	5
3 KW With BLS [mm/min]	43	20	10	5
Cut speed higher in Percentage	48%	33%	25%	0%

Table 2. Cutting data of the 3 kw BLS function and 4 kw Normal laser test on a 2D sheet metal for cut speed comparison. Test machine TruLaser Cell 8030

Sheet thickness [mm]	1 mm	2 mm	3 mm	4 mm
3 KW With BLS [mm/min]	43	20	10	5
4 KW with normal laser beam_100µm	40	19	15	5

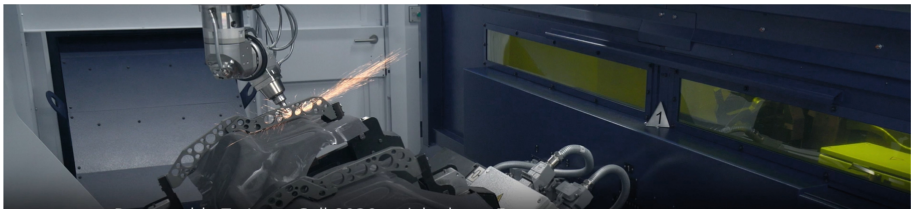

Fig. 4. 3D cut test on TRMMPF TruLaser Cell 8030 machine system.

Table 3. Cutting data of the 3 kw BLS function and 4 kw Normal laser test on a 2D sheet metal for cut speed comparison. Test machine TruLaser Cell 8030.

Laser power [kW]	3 kw	3 kw
		
Part description	Few reorientations B/C Many straight stretches	Many reorientations B/C Few straight stretches
Sheet thickness [mm]	1.2 mm & 1.5 mm	1.5 mm
Nμmber of inner contours	30	20
With Bright Line cutting time (single part)	~45 s	~37 s
Without BLS cutting time (single part)	~49 s	~40 s
Cut time higher in Percentage	~8 %	~7.5 %

Table 4. Cutting data of gas consumption comparison.

Cutting gas consumption comparison [m^3/m]		
Sheet thickness [mm]	1 mm	2 mm
3 KW normal Laser beam_100 μm	0.17	0.65
3 KW With BLS	0.1	0.27
Gas consμmption in percentage	58%	41.5%

Conclusion 2:

When use 3 kw laser power, Bright Line Speed function can improve ~8% cutting time performance for hot forming part in 1.5 mm. When use 3 kw laser power, Bright Line Speed function can help customer save ~50% gas consumption cost.

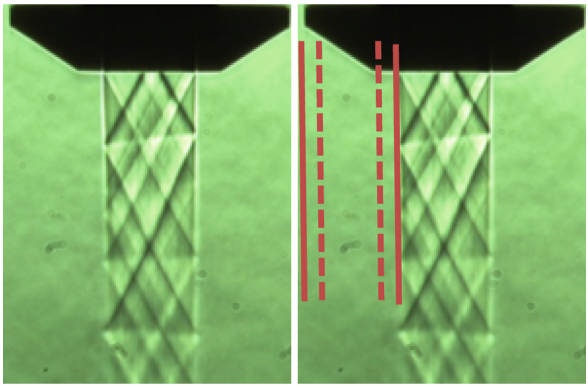

Fig. 5. Standard X-Blast cut nozzle (left) and the X-Blast nozzle changes with Bright Line speed function gas consumption cross section view(right).

3 Conclusion and Outlook

The Bright Line speed function with special beam shaping can help hot forming customer use 3D 5-axis laser machine in below benefits:

(1) When use 3 kw laser power, Bright Line Speed function can improve >30% cutting speed performance in 2 mm material thickness, and ~50% speed increase in 1 mm material.
(2) 3 kw laser power with Bright line speed beam quality construction, cutting speed a little higher than 4 kw normal laser beam when part material thickness <2 mm.
(3) When use 3 kw laser power, Bright Line Speed function can improve ~8% cutting time performance for hot forming part in 1.5 mm.
(4) When use 3 kw laser power, Bright Line Speed function can help customer save ~50% gas consumption cost.

With hot forming customers are getting cost pressure due to competitive market situation in China. In a near future, 3D laser machine technology development must be focus on machine production running cost and performance improvement. And Hot forming automotive industry market will use percentage more and more high.

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