New Fiber 2D Laser Processing System GX Series

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1. Introduction

2D laser processing systems have established their positions as essential machine tools at manufacturing sites thanks to dramatic technical progress and expansion of the market. In recent years, in the markets of processing systems for cutting metal plates in Japan, China, the U.S., and major powers in Europe, the number of laser processing systems installed each year has significantly exceeded that of turret punch presses. Meanwhile, as the population of workers continues to decrease, the manufacturing industry is being forced to automate processing processes, reduce running costs, and improve productivity. Therefore, fiber laser processing systems with high productivity and lower running costs have been gaining attention.

2. Product Specifications and Concepts

To satisfy such market needs, Mitsubishi Electric Corporation has developed new 2D fiber laser processing system GX series (hereafter, "GX"), a solution for high-dimensional automation (Table 1). This paper describes the concepts of the GX, which include: (1) high processing stability and reliability, (2) high-speed processing and low running cost, and (3) complete automation and labor-saving.

Table 1 Main ML3015GX specifications

Item		ML3015GX
Travel method		Photon scanning
Stroke (mm)	x-axis	3100
	y-axis	1550
	z-axis	120
Fast feed speed (m/min)	x- and y-axes	Combined 170
Positioning accuracy (mm)		0.05/500 (x- and y-axes)
Repeatability (mm)		±0.01 (x- and y-axes)

2.1 High processing stability and reliability

2.1.1 Processing diagnosis function by AI

Laser processing of metal plates is performed while spraying assist gas. Skilled workers can roughly predict whether the processing is proper or defective by listening to the sound of the gas flow during cutting and by observing the flow of molten metal. Accordingly, we considered that it should be possible to judge whether processing is proper or defective by sensing and analyzing the sound and light generated during processing without observing the processed surface.

To realize such a function, we collected a large amount of data during proper processing and various types of improper cutting operations and then made AI learn from it. Based on the learned data, the AI then judges data on sound and light generated during processing to determine the processing status (Fig. 1).

If the AI judges that the processing is defective, the nozzle monitor function, which is described later, is executed to identify what caused the defect. If the processing nozzle has a problem, it is replaced in order to continue the operation; if the nozzle has no problem, the processing conditions are automatically changed to more stable ones to correct the processing defect. If the defect still remains even after the conditions were changed, the system stops due to an error because it may not be possible to automatically eliminate the cause of the defect. Executing these functions can prevent users from wasting raw materials.

2.1.2 Nozzle monitoring function

One cause of processing defects is deformation of the processing nozzle due to heat during processing and collision with the raw material. The shape of the hole of a processing nozzle significantly affects the flow of assist gas, and so deformation of the hole may affect processing adversely. Deformation of small-diameter processing nozzles in particular is known to have a large influence, and even slight deformation of such nozzles affects the processing. In actual working environments, when a processing defect is found, the operator removes the processing nozzle and examines the hole shape visually to check whether it is proper or defective. We decided to use a camera to do this in place of operators.

For this function, we collected a large number of photographs of proper and defective nozzles and made AI learn from them to be able to make judgments, similar to the processing diagnosis function. Even for a processing nozzle for which a defect is hard to identify by visual check as shown in Fig. 2, the function can judge whether it is defective. This function can quickly eliminate processing defects caused by defective processing nozzles.

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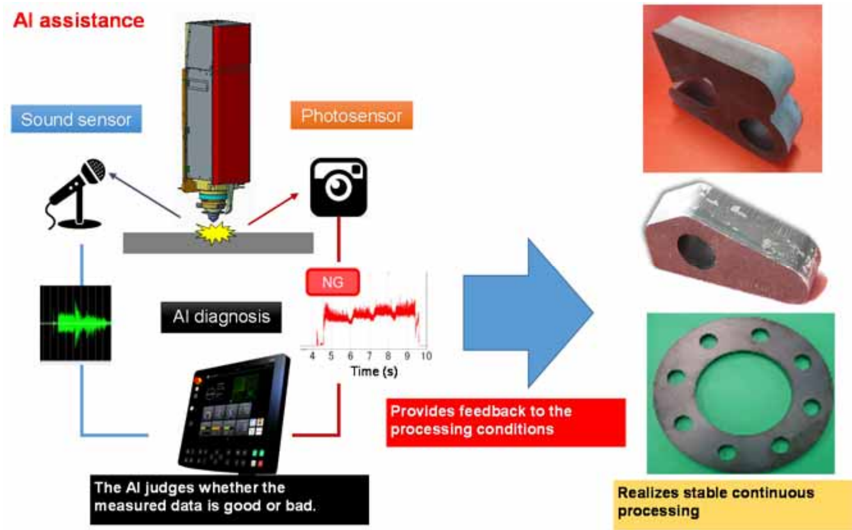


Fig. 1 Processing diagnosis function

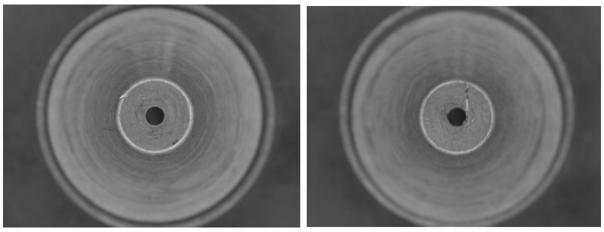


Fig. 2 Proper and defective processing nozzles

2.2 High-speed processing and low running costs

2.2.1 High-speed high-accuracy processing

Since the wavelength of fiber laser is shorter than that of carbon dioxide gas laser, it is strongly absorbed by metals and also has excellent light-harvesting characteristics. Therefore, fiber laser is optimum for cutting thin plates at high speed. To maximize its performance, Mitsubishi Electric has developed processing systems with higher rigidity and a lighter driving unit, thus increasing the fast feed speed of the x- and y-axes to 1.2 times and the acceleration to 1.3 times. Compared to the conventional processing systems, the new type reduces the takt time for thin benchmark shapes by 10% (Fig. 3) and improves the roundness of small-hole processing by 33% (Fig. 4), achieving high-speed high-accuracy processing.

2.2.2 Low running costs

As the output of fiber laser processing systems has increased, nitrogen has been more frequently used as the processing gas. Compared to the processing method involving chemical reactions (e.g., oxidation combustion reactions), when nitrogen is used, the processing rate is not restricted by such reactions and the productivity may be increased as the output of the oscillator is higher. However, the amount of nitrogen gas consumed during processing tended to increase, making it difficult to improve the productivity while reducing the running cost. For GX, the processing gas flow was visualized (Fig. 5) to clarify processing phenomena and a new AGR-eco technology that reduces the consumption of nitrogen gas was developed; AGR-eco can reduce nitrogen gas consumption for 9-mm mild steel by up to 90% (Fig. 6).

2.3 Complete automation and labor-saving

Faced with labor shortages at production sites and increased use of fiber laser processing systems for production, there is a strong need to boost productivity by laser processing of metal plates through automation, including the manufacturing processes before and after metal plate laser processing. The steps of metal plate laser processing consist of supply of materials, laser cutting, discharge of the cut materials, and taking out and sorting of cut parts from the discharged materials. To reduce the labor required for sorting after laser cutting, global demand for automatic sorters is expected to increase rapidly. To satisfy such market need, we added automatic sorting systems to our lineup (Table 2). These systems completely automate the metal plate laser cutting processes from the supply of materials to the sorting of cut parts, thereby saving labor for such operations.

The four arms of this system automatically select the optimum tool based on the target items to be sorted. This function allows the sorting of parts having various shapes for which the raw material varies. In addition, a technology for controlling the four arms separately has made it possible to sort picked-up parts into any orientation (Fig. 7).

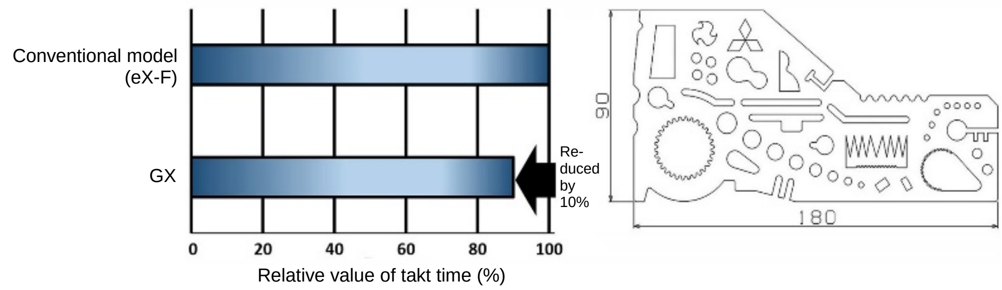


Fig. 3 Reduced takt time

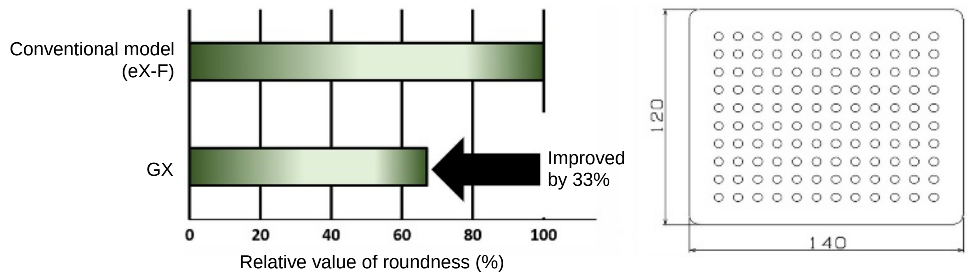


Fig. 4 Improved roundness

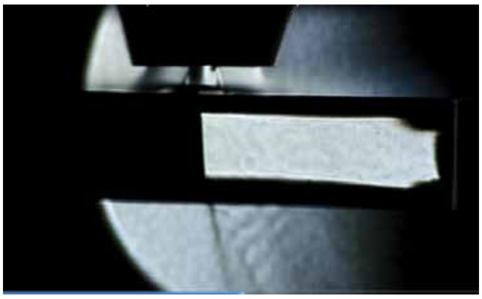


Fig. 5 Technology for visualizing processing gas

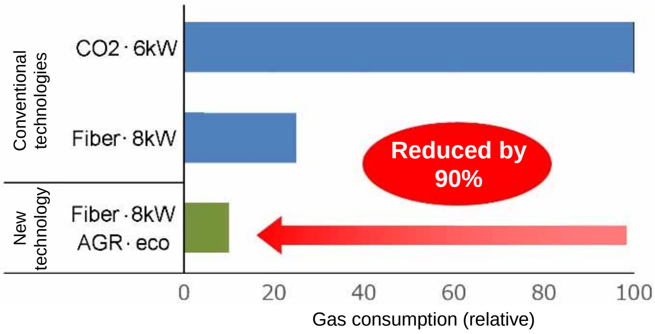


Fig. 6 Reduction of nitrogen gas consumption

Table 2 Specifications of automatic sorting system

Item	Automatic sorting system	
	Standard type	Lightweight type
Method of picking up products	Independent-control arm x 4	
Thickness of target plates	Up to 25 mm	Up to 9 mm
Transportable weight	2,000 kg	1,000 kg
Rotational placement	Possible	
Loading and unloading function	Provided	

Fig. 7 An automatic sorting system picking up products

3. Examples of Latest Processing

When the fiber laser was first put on the market, it was used for high-speed cutting and micromachining of thin plates and processing of highly reflective materials, to leverage its characteristic of high convergence thanks to the wavelength used (Fig. 8). Meanwhile, the recent increases in oscillator output and advances in processing technologies have improved the processing performance for medium-thick to thick plates. Thus, the fiber laser is highly regarded as a processing method also for medium-thick to thick plates. This section introduces such latest processing technologies.

3.1 Increased maximum processible thickness

In laser processing, the optimum diameter of the beam spot and beam profile vary depending on the raw material and thickness of the targets. Generally, such beam characteristics can be changed by replacing the processing lens. However, in the case of lens replacement, the variable ranges of lenses are discrete, making it impossible to select a beam that is optimum for all raw materials and thicknesses. The GX is equipped

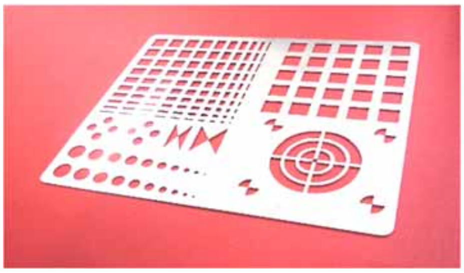


Fig. 8 Example processing by fiber laser

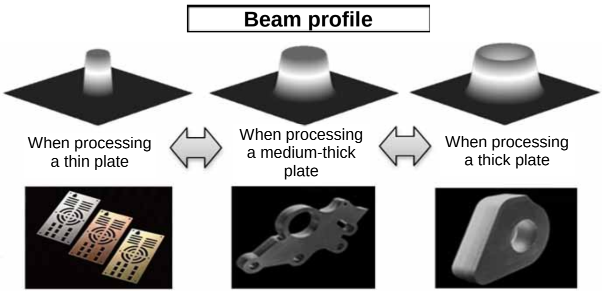


Fig. 9 Example beam profiles for various types of raw materials and thickness

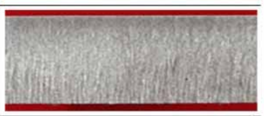
Material	Thick-ness	Processed sample	Cut section
Mild steel SS400	32 mm		
Stainless steel SUS304	30 mm		
Aluminum alloy A5052	30 mm		

Fig. 10 Processing quality at the maximum cuttable thickness

	Conventional technology	New technology
Cut section		
Roughness of the cut section Rz (μm)	240	35

Fig. 11 Example processing by fiber laser

with our unique processing head with a variable optical system. By changing the beam spot diameter and beam profile continuously, it is possible to use the optimum values for each type of raw material and thickness (Fig. 9).

Figure 10 shows example cutting at the maximum cuttable thickness for different raw materials by GX. The maximum thickness that the GX can cut effectively is 32 mm for mild steel, 30 mm for stainless steel, and 30 mm for aluminum alloys.

3.2 Technologies for improving the processing stability for thick mild steel plates

Cutting technologies using fiber laser have been rapidly advancing and the quality and stability of processing have been approaching those of the CO_2 laser. However, when processing thick mild steel plates with the thickness of 16 mm or more with oxygen, variations in material quality may cause abnormal combustion, which may make stable processing impossible. To solve this problem, a new beam oscillation method and new type of nozzle were developed for the GX to reduce the influence of variations in material quality. This development has made it possible to stably process mild steel plates for which the material quality significantly varies. Figure 11 shows examples of processing.

4. Conclusion

This paper described the concepts of the GX series of new fiber 2D laser processing systems and the latest technologies applied to the GX. Processing technologies for fiber laser processing systems have been dramatically advancing and technological innovation will continue. We will steadily improve the performance of our products as a comprehensive laser processing system manufacturer to satisfy increasingly sophisticated and diversifying user needs, in response to various needs at many production sites.

References

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(2) N. Miyamoto, et al.: Cutting-edge Technology with Fiber Laser Processing Machine, Mitsubishi Denki Giho, 89, No. 4, 251–254 (2015)