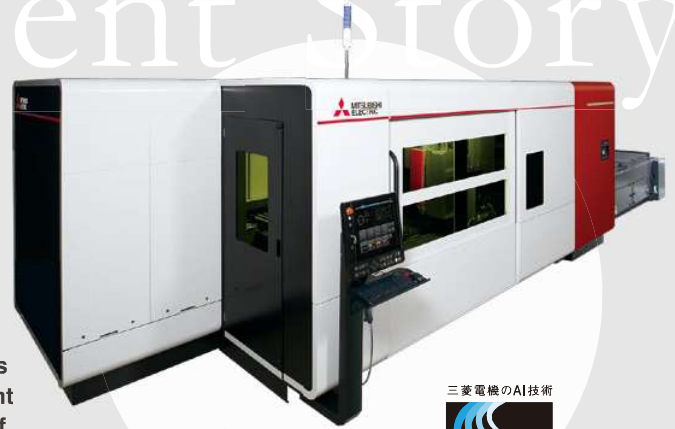


2D Fiber Laser Processing Machines

GX-F Series

The new GX-F Series 2D fiber laser processing machines released in April 2019 have been exhaustively redesigned as special-purpose EDMs in the pursuit of high speed, excellent reliability and lower operating cost. Having an abundance of new functions, these models powerfully contribute to increasing users' productivity.



Based on the key concept of “non-stop processing machines” and the development motto of “All Mitsubishi Electric”

The world of laser processing machines is transitioning to fiber lasers. Since the era of carbon-dioxide gas (CO₂) lasers, the former mainstream method, we have adhered to the philosophy of “All Mitsubishi Electric”. In this respect, the models in the GX-F Series are fiber laser processing machines that symbolize a major step forward for Mitsubishi Electric.

The previous series, eX-F, was developed based on the eX Series of CO₂ laser processing machines, and unlike the new special-purpose fiber laser processing machines, was therefore not rebuilt from the ground up. Takeshi Kitagawa, head of the GX-F Series development project and member of the Laser Processing Machine Design Section, Laser Systems Department, commented that this time the new series was designed from the drawing board in terms of both structure and functions, in order to develop a special-purpose fiber laser platform. To increase speed, enhance reliability, and lower the running cost fiber laser processing, the company took an “All Mitsubishi Electric” approach in the development and design phases.

Users expect laser processing machines to achieve better productivity through continuous operation. With “non-stop processing machine” as the key concept, the specifications for the new series were decided and development work completed accordingly.

The formal decision to begin development of the new series as a successor to the eX-F Series was made in 2017. The three elements incorporated in this project in order to realize a “non-stop processing machine” were Mitsubishi Electric's new fiber laser oscillator,

AGR-eco, and AI assist.

Since joining Mitsubishi Electric in 2005, Kitagawa has worked consistently on designing the mechanical components of laser processing machines. Naturally he was involved in the design of the predecessor series, eX-F Series, and was also involved in designing CO₂ lasers. With Kitagawa in a central role, a team was formed from members of the Laser Processing Machine Design Section, No. 1 Development Section, Laser Applications Technology Section.

In fact, there had been one piece missing from the fiber laser processing machines developed based on the CO₂ laser machines manufactured to date that prevented us from being able to label them “All Mitsubishi Electric”. While our CO₂ lasers had incorporated Mitsubishi Electric-made oscillators, the fiber laser oscillators were made by another manufacturer.

In order to find that missing piece, Hiroaki Kurokawa, who worked in the No. 1 Development Section with Kitagawa, and was in his 10th year with Mitsubishi Electric, proceeded with the development of a new Mitsubishi Electric-made fiber laser oscillator in 2016, immediately after the release of eX-F Series. While having used the other company's oscillator to date, Kurokawa identified the areas requiring improvement in order to help increase user productivity, and incorporated these in product development.

Kurokawa commented, “There are difficulties in terms of service when we use oscillators made by other manufacturers on the machines. When a problem occurs, we had to rely on the oscillator

manufacturer for support to a certain extent, and that meant it would take time to find a solution. Additionally, when processing copper, which is a reflective material, the laser beam returns to the oscillator, and can damage internal components. So, we had to put constraints on the user, asking them not to process materials not covered under warranty by the oscillator manufacturer.” Against this backdrop, by replacing the conventional fiber laser oscillator with a Mitsubishi Electric-made oscillator having our quality standards and adding a function to block laser beam reflection, the processing of copper is now also possible. Kurokawa spoke confidently, “Now we are in charge of the oscillator, so we can flexibly respond to customers' requests and support expanding their work scope.”

The second of the three elements is the new function, “AGR-eco.” Takanori Miyazaki, with Mitsubishi Electric since 2006 and in the same Processing Technology Section, has experience in developing machining technologies for the eX-F Series and CO₂ laser processing machines. Miyazaki lead development of the AGR-eco for the GX-F Series. AGR is an abbreviation for “Advanced Gas Reduction,” and is a function to effectively reduce nitrogen gas consumption.

Miyazaki commented, “The fact that fiber laser processing uses nitrogen gas to enable high-speed processing is a major advantage. However, no matter how fast a machine processes parts, it won't be beneficial to our customers' productivity if it means increasing running cost. I've actually heard from some sources that they are hesitant to purchase fiber laser processing machines due to the increase



Takeshi Kitagawa

Manager
Laser Processing Machine
Design Section
Laser Systems Department
Nagoya Works, Mitsubishi
Electric Corporation



Hiroaki Kurokawa

Manager
No. 1 Development Section
Laser Systems Department
Nagoya Works, Mitsubishi
Electric Corporation



Takanori Miyazaki

Manager
Laser Applications Technology
Section
Laser Systems Department
Nagoya Works, Mitsubishi
Electric Corporation



Terufumi Fukuoka

Manager
Laser Processing Machine
Design Section
Laser Systems Department
Nagoya Works, Mitsubishi
Electric Corporation



Automatic replacement of a defective nozzle. Accommodating up to 21 nozzles, this technology supports prolonged continuous processing.

Mitsubishi Electric Maisart AI Technology Supports Phases Monitored by the Five Human Senses

in cost associated. AGR-eco achieves a low running cost through processing condition development that leverages the high-quality beam, oscillator control, independent gas flow control, and Mitsubishi Electric's original zoom head. Now that the oscillator is also made in-house, we can control it as we please, and that is producing good results."

Other company's laser processing machines perform processing with the nozzle firmly adhered to the workpiece and incorporate a configuration to reduce nitrogen gas consumption. However, that configuration results in the workpiece being damaged by the nozzle. Another potential issue is rapid wear of the nozzle, thus resulting in a higher replacement frequency. Meanwhile, as Miyazaki attested, "We liaised with the Advanced Technology R&D Center to simulate gas flow and test a newly designed nozzle configuration," which resulted in the GX-F Series having up to 90% less gas consumption per unit of time compared to conventional CO₂ laser processing machines. Even compared to the eX-F Series, a reduction of 76% was accomplished. Moreover, through innovative thinking regarding the nozzle, cutting face quality has been enhanced.

The third and final element was introducing a new AI assist function. Terufumi Fukuoka, who works with Kitagawa in the Laser Processing Machine Design Section, said, "This model is the world's first laser processing machine capable of automatically adjusting processing conditions using AI. A significant portion of laser processing still relies on human intuition. That's because,

in a lot of cases, an operator must stand in front of the machine and monitor changes in light and sound to judge whether processing is going smoothly or if a problem is occurring. When we considered whether or not we could replace that portion with AI, we were motivated to develop an AI assist."

If there is still a phase where processing work must be monitored using a human's five senses, the operator must be present the entire time the machine is in operation. If processing is around-the-clock, this means user companies would have a heavier burden in terms of human resources. If it were possible to automatically adjust processing conditions by sensing light and sound conditions during operation, and determining the quality of processing using "Maisart," a Mitsubishi Electric AI technology, it would be another step closer to a "non-stop processing machine" through AI assist. However, collecting data in response to various machining conditions was still not an easy task. The development team repeated processing under a variety of conditions to see a workpiece's final results when a particular sound was heard, etc., and gathered information with the help of the Advanced Technology R&D Center to facilitate AI learning and improve the technology.

Fukuoka, who joined Mitsubishi Electric in 2006 at the same time as Miyazaki, has been involved with oscillator control and other technologies in the Laser Manufacturing Department and affiliated with the Advanced Technology R&D Center since he entered the company. He claimed that the data learning process applied this time made a significant contribution to the capabilities of his former workplace.

Following basic research, full-scale data collection began in June 2018. From then until immediately prior to release in April 2019, Fukuoka constantly collected data on a truly diverse range of light and sound conditions. He commented, "There's still a long way to go before we can say it is perfect, but by making improvements in the AI, it is getting smarter and smarter. I believe, in this development phase, we were able to lay the foundation for a framework enabling various functions to be achieved with AI in the future. The aim of ultimately creating a "non-stop processing machine" is to be able to continue work by handling any issue that arises in processing conditions without having to

stop the machine."

In addition to this assist function, the GX-F Series is equipped with a function to determine the nozzle condition via AI, and if deemed necessary, automatically replace the nozzle using the nozzle changer. The nozzle changer itself was also provided on eX-F Series; however, this time the number of slots for nozzle replacement have been increased from five to nine, making it possible to hold up to 21 nozzles. This function facilitates higher productivity for users by automating nozzle replacement work.

The appeal points of the GX-F Series go beyond the abovementioned three elements. Through pursuing high-speed processing with a processing machine as the basis, the development team reviewed structural rigidity from CAE analysis results and devised a design that suppresses vibration to the maximum possible extent.

As Kitagawa revealed with his statement, "It didn't really go as we'd hoped," the team had to repeat the cycle of building prototypes, performing verifications, and feeding the results back into development. A total of three processing machine main unit prototypes were built, with the first being completed at the end of 2017, and then finetuned for completion through repeated verification and improvement.

The GX-F Series was released in April 2019. By introducing an oscillator developed in-house, this machine has truly become "All Mitsubishi Electric," and the oscillator warranty period has been extended from the conventional three years to five years when the machine is used in Japan. This strongly supports higher user productivity in terms of the warranty aspect, too.

Kitagawa commented, "It's hard to be highly evaluated by customers even if we push the quality aspect. But, by actually using the product, they gain real appreciation for the reliability of Mitsubishi Electric processing machines and the company's high-quality service. In that sense, I think the notion that 'Mitsubishi Electric equals quality' has firmly taken root amongst our customers."

All four members of the development team shared the sentiment that they wished to muster the strength of "All Mitsubishi Electric" while sincerely listening to users' voices requesting that the company create and provide products of even higher quality.



New Mitsubishi Electric-made fiber laser oscillator achieves both high reliability and productivity. With a mechanism to isolate laser beam reflection, this device makes it possible to process copper, which was not possible using conventional models.