

Introduction of Products

Twister Hybrid THB Series

Tetsuya Kabata

In 2000, the Sheet Metal Komatsu Business Unit (KBU) of Komatsu Industries Corp. launched “Twister” (fine plasma cutter) and has made a series of improvements since then. “Twister” has grown as a pillar of the Sheet Metal KBU through technical excellence unrivaled by its competitors.

Aimed at further expanding the market, the KBU developed “Twister Hybrid” fully utilizing the strengths of “Twister” and the new product has made a successful market entry. The principal features of the new product are described below.

Key Words: World’s first, Twister Hybrid THB, Compound machine, Runaway hit, Hybrid machining, High productivity, High precision, Low cost, Plasma, Laser

1. Introduction

The “Twister” has grown as a runaway hit product in productivity, cost and cutting quality in processing medium-thickness and thick mild steel plates. For example, thermal cutting is generally used as a method to cut arms, booms and other components of construction machinery from steel plates. Thermal cutting is roughly classified into gas cutting, plasma arc cutting and laser beam cutting. These cutting methods utilize the oxidation reaction. The cutting principles and characteristics of these methods are summarized

in **Fig. 1**.

In the past, laser beam cutting has mainly been used due to its high cutting accuracy, environmental friendliness and setup performance, while laser beam cutting has problems such as high cost and low productivity. The low-cost, high-productivity features of the Twister have been highly evaluated, and a large number of Twisters have been installed in plants of various industries, especially for cutting components for construction machinery.

This product is a plasma arc cutter and its product name, “Twister,” was given to represent cutting quality more similar to that of laser beam cutting and very high productivity and to eliminate the reputation on the market that plasma arc cutting is fast, but low in precision.

Designed to expand the market of the Twister further and to achieve higher productivity, lower cost and higher precision, the “Twister Hybrid” has been developed and put on the market as a compound machine that merges plasma arc and laser beam for the first time in the world (**Fig. 2**).

Comparison of thermal cutting of mild steel 6mm or more in thickness

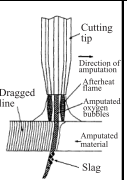
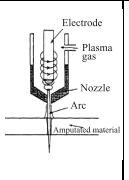
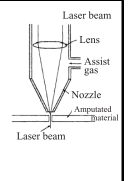
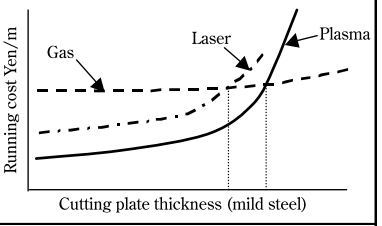
	Gas cutting	Plasma cutting	Laser cutting
Principle			
Cutting accuracy	0.5~1mm	0.2~0.8mm	0.05~0.2mm
Plate thickness for cutting	~1m	~40mm	~25mm
Impact of heat	Large	Minor	Minor
Speed of cutting medium thickness plate	Slow	Fast	Slow
Speed of cutting thin thickness plate	Slow	Fast	Fast
Unmonitored operation	Not feasible → Feasible		
Running cost			
Initial cost	Low → High		

Fig. 1 Thermal cutting methods



Fig. 2 Full view of the Twister Hybrid (THB6082)

2. Development Background

- (1) Higher precision in drilling and unattended operation during the night
- (2) Expanded business area of the Twister
Expansion in business areas applying Komatsu's unique core technology Twister
- (3) Stronger ties with Trumpf of Germany, an alliance partner
Trumpf: World's largest manufacturer of sheet metal working machines

3. Selling Points

“High productivity,” “High precision” and “Low cost”

Excellence is demonstrated in cutting medium-thickness to thick plates (SS400: 4.5 to 25 tons) compared with high-output 6-kW laser beam machines (Fig. 3).

The combination of the Twister and the laser function allows hybrid cutting such as using the Twister and laser beam for different uses, drilling by a laser beam and machining external peripheries by the Twister. The user can flexibly choose the machining method in accordance with the required product precision and shape.

Evaluation	Item	Twister*60kW	Trump Laser 3.2kW	Twister Hybrid*	Laser 6kW	
Productivity	Medium thickness plate productivity	○	△	○	○	t9~t19mm
	Thick thickness plate productivity	○	×	○	△	t19~t36mm
Accuracy	High precision cutting	○	○	○	○	Especially quality of drilled holes
Cost	Running cost	○	○	○	△	Gas, electricity, consumables
Stability	Cutting stability	○	○	○	○	Short term stability
	Long term stability	○	○	○	△	Long term stability
Labor saving	Unmonitored operation	×	○	○	○	Ability to operate at night
Recovery of investment	Evaluation of recovery of investment	○	○	○	○	
Overall evaluation	Overall evaluation	○	○	○	△	

◎Best suited ○Suited △Not suitable ×Not applicable

Fig. 3 Comparison of performance

4. Configuration and Features

4.1 Configuration

(1) Cutting machine size and configuration

The cutting machine size can be selected by combining a machining width of 2.5 m or 3.1 m and a standard machining length of 6.2 m or 12.4 m. The machining length can be set freely in accordance with the user specifications. The machine is driven by a rack and pinion and a linear guide. The rapid feed speed is high, 25 m/min in Axis X (lengthwise) and 50 m/min in Axis Y (widthwise).

The structure is of the cantilever type, and the cantilever frame is equipped with a control panel and laser oscillator and moves freely. Generally, machines of this size are of the gantry type, driven by both side drive. The cantilever frame that is disadvantageous in terms of rigidity is used, taking advantage of good workability and curbing deterioration in accuracy caused by aging. As explained below, this disadvantage was solved by minute structural analysis.

The cantilever frame is equipped with a laser beam head and Twister head that are controlled completely independently.

The Twister head stands by at the tip of the frame during laser beam machining, while the laser beam head stands by on the base of the frame during machining by the Twister. This construction protects the heads from sputtering and other interference caused during machining by the respective heads. These heads can be switched by programming, and there is almost no time lag caused by head changing.

(2) Twister and laser

The Twister is powered by a 60-kW high-output power source manufactured by Komatsu and can cut up to 36 mm of mild steel. The Twister corrects tapering of the cut surfaces by Komatsu's unique high velocity twist gas system. A unique control sequence and gas control system are used to achieve high speed and high precision that are greatly improved compared with those of conventional plasma arc machines. The Twister was developed by the Corporate Research Division as “Fine Plasma” about 15 years ago and is now refined as the Twister incorporating many improvements.

The laser oscillator is a high performance 3.2-kW CO2 laser manufactured by Trumpf of Germany, capable of cutting 16 mm of mild steel. Komatsu sells Trumpf's laser beam machines in Japan. Trumpf of Germany is the largest manufacturer in the world of sheet metal working machines and industrial laser oscillators. The laser oscillator emits a single mode beam close to the ideal Gaussian mode, and the beam quality of the laser oscillators is very high (Fig. 4).

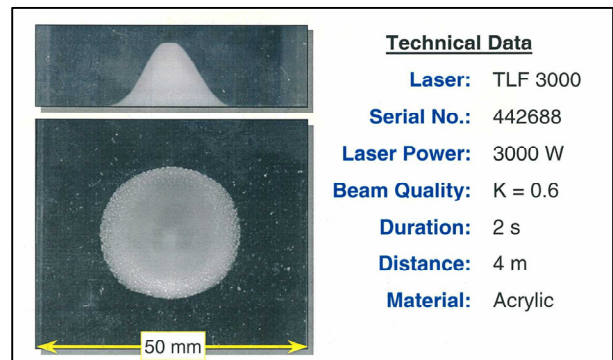


Fig. 4 Laser single beam mode

4.2 Features

(1) High-speed machining and cutting of thick plates

The 60-kW high-power Twister power source features a machining speed about twice that of 6-kW-class laser beam machining. Compared with the 25-mm-thick mild steel that can be cut by a 6-kW laser machine, the Twister Hybrid can cut thick plates up to 36 mm.

The high performance 3.2-kW single mode laser oscillator cuts plates at a speed equal to that of conventional 4-kW-class laser beam cutting machines (Fig. 5).

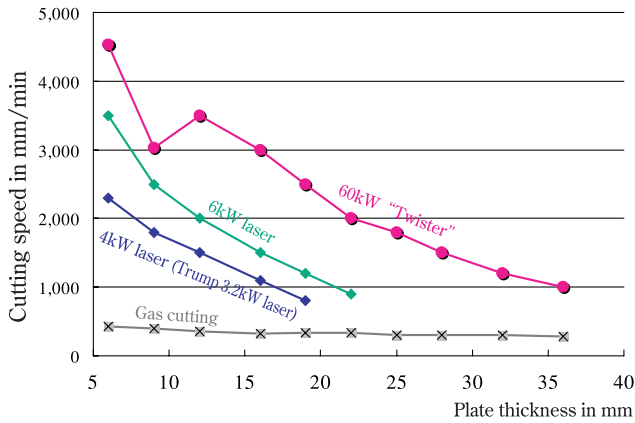


Fig. 5 Comparison of cutting speed

(2) Hybrid machining

Machining by the Twister alone has had precision problems in drilling small holes. These problems have been solved by machining small holes by laser beam machining and machining external peripheries by low-cost, fast Twister machining, achieving high-productivity, high-precision, low-cost production. Hybrid machining can be used in the thickness range of 6 to 16 mm at a better efficiency than ever achieved in the past. Hybrid machining cuts production time by 20% and running costs by 20% compared with 6-kW laser beam machines (Fig. 6).

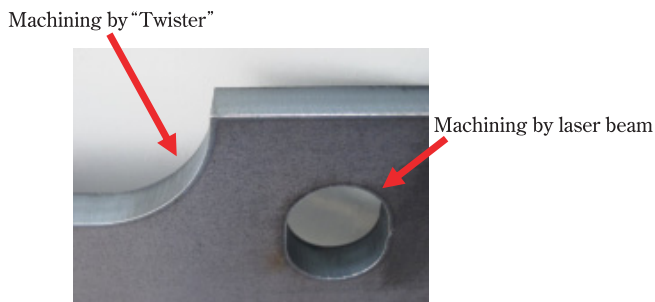


Fig. 6 Example of cutting by “Twister Hybrid”

(3) High-rigidity cantilever frame

As mentioned above, a cantilever frame that is reputed to be disadvantageous when installed in large machines is used. Cutting errors by misalignment of the optical path of the laser beam due to deflection, cutting errors due to deflection deformation during acceleration or deceleration and other risks have been a consideration with this system. However, these risks have been solved through thorough FEM structural analysis (Fig. 7).

The cantilever construction tends to cause dynamic inaccuracies due to an imbalance of the center of gravity of the drive. This problem could be solved by moving the center of gravity of the moving parts including the cantilever frame to the center of the rack and pinion drive, resulting in accomplishing a drive with very good balance (Fig. 8).

(4) Use of adaptive optics (AO)

The laser beam features a uniform wavelength and a

coherent light. Nevertheless, the laser beam diffuses, and the beam diameter expands in accordance with the distance from the laser oscillator. Laser beam cutting is performed by reflecting a laser beam onto the machining point by a mirror, and the laser beam is concentrated on the machining point by a lens. Cutting is performed by the oxidation reaction of the laser power and the oxygen gas that is used as an assist gas.

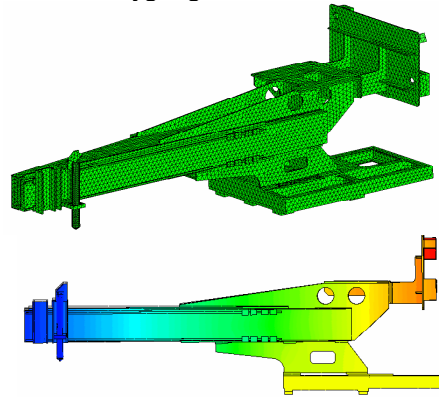


Fig. 7 FEM analysis of cantilever frame

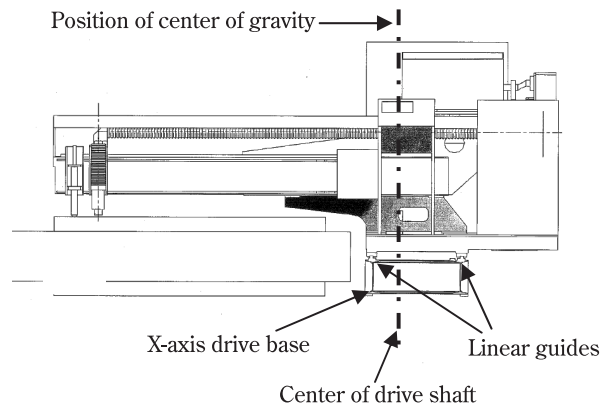


Fig. 8 Position of center of gravity of cantilever frame moving parts

However, the focal position fluctuates if the diameter of the beam emitted into the lens, and the cutting characteristics vary in accordance with the machining position. The distance from the laser oscillator to the machining point (optical path length) varies a maximum of 3.2 mm with this system. The spread angle of a laser beam is a maximum of 2 mrad, and the beam diameter difference between the minimum and maximum beams is about 6 mm. In the past, these variations have been corrected using the mechanical technique of adding two movable mirrors so that the optical path length always becomes constant. This technique ineffectively uses more mirrors and makes adjustment of the optical path difficult, sometimes causing errors in cutting caused by misalignment of the optical path due to aging.

This system employs “AO,” which is an adaptive mirror with a variable radius of curvature. This is an advanced mirror whose variable radius of curvature can be controlled to vary freely by controlling the pressure of the compressed air

supplied to the mirrors. This AO has enabled the diameter of a laser beam emitted into the lens to always be constant by variably controlling the air pressure through the position information of the machining point. As a result, stable machining can be performed in any position (Fig. 9).

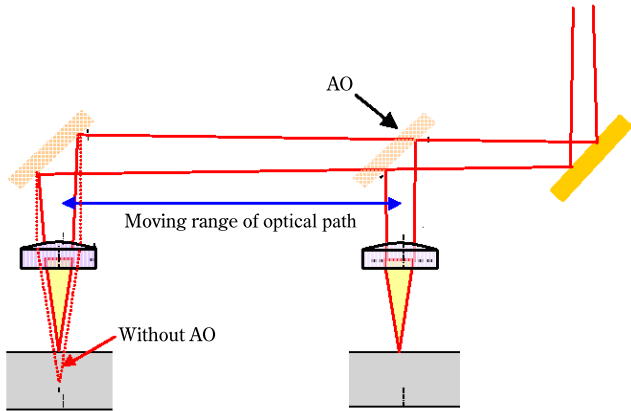


Fig. 9 Effect of AO

(5) Clean work environment

Molten metals in thermal cutting become fine iron oxide when the metals are cut and fine iron oxide flies up as fumes, deteriorating the work environment. This problem has been solved by a push-pull dust collector system. In the past, fumes were collected through a dust collector by suctioning the fumes through a fume inlet port built in the machining table. This system employs a push-pull dust collector system for efficient dust collection by producing optimum airflow inside the table by actively feeding controlled air through the side opposite the air intake side, instead of merely suctioning air (Fig. 10).

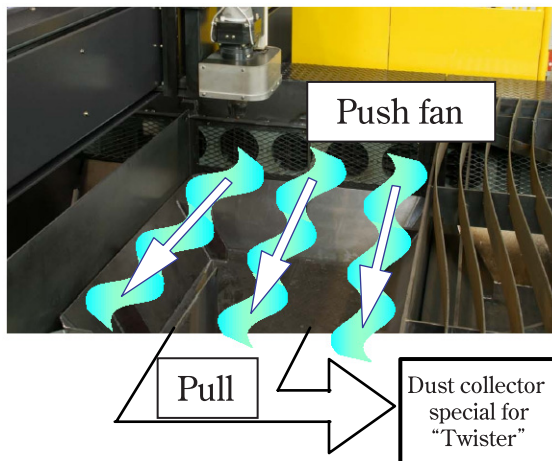


Fig. 10 Push-pull dust collector system

(6) Enhanced safety

Because a large frame moves at high speed, the operator working on the table is exposed to risk of crash or nipping when the operator is working on the table. To prevent this danger, photoelectric safety sensors are installed before and

after the cantilever frame to instantaneously stop the table when a sensor beam is shielded. Tape switches of the contact type are installed in other areas to ensure high safety for the system (Fig. 11).

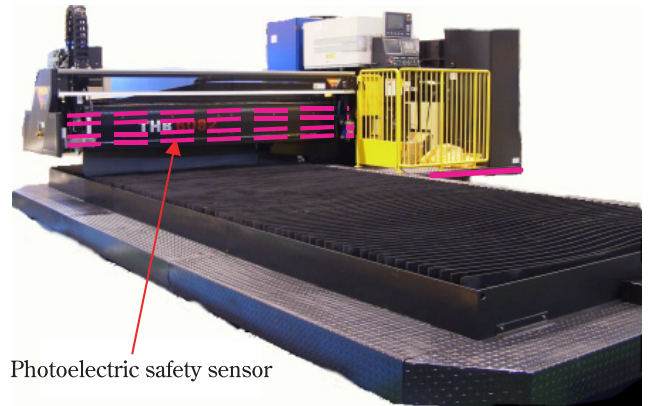


Fig. 11 Photoelectric safety sensor

5. Conclusion

The development of the Twister Hybrid THB has been accomplished through the runaway hit of the Twister, which was further enhanced. This is the world's first compound cutting machine that could be developed on schedule in spite of obstacles.

The first machine is already operating very smoothly in the compounds of a user 24 hours per day. The user has said, "It works 200%."

The Twister Hybrid based on this new concept will undoubtedly renovate the manufacturing processes of users.

Introduction of the writer



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Entered Komatsu in 1991. Currently belongs to Sheet Metal Komatsu Business Unit (KBU), Komatsu Industries Corp.

[A few words from the writer]

A compound plasma arc-laser beam cutting machine has been developed for the first time in the world. A series of risks were encountered in the development process. The development period was six months in designing and developing the new machine, and the schedule was very tight. The new machine could be developed efficiently on schedule through structural analysis, minute FMEA and other techniques. QCD could also be accomplished. This could be achieved by developers heading towards the same goal. The development department will team up with the sales and marketing department to expand sales in the future.