Introduction of Product

Flexible Tandem Welding System

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As the demand for construction machinery increases, the improvement of productivity and quality of sheet metal welded components comes to be more strongly required. Komatsu succeeded in developing a epoch-making torch structure and welding conditions control technology that overcome the disadvantages of conventional tandem welding system as well as developing and marketing the "flexible tandem welding system" that employs these new technologies to meet such severe requirements. This report introduces the new system.

Key Words: *Tandem Welding, Flexible Tandem Welding.*

1. Introduction

The demand for construction machinery is expanding worldwide, and parts production and body assembly shops are increasing production and come to suffer capacity shortage. In such circumstances, it is an urgent matter for sheet metal welding shop to improve the productivity of welding robot.

In order to meet the demand for high throughput, high quality and short lead time, Komatsu Engineering Corp. developed the "Flexible Tandem Welding System" together with Komatsu Ltd., aiming at improving welding productivity to a large extent, and began to introduce it from May of the last year.

Prior to the market introduction, Komatsu Engineering applied for 4 patents by itself and 1 patent together with Komatsu, Ltd.

This report describes the welding technology that was developed by introducing epoch-making improvements to conventional tandem welding methods as well as its systematization and sample application to construction machinery.

2. What Is Tandem Welding?

It is the welding technology featured by that two independent electrodes (early electrode and delayed electrode) are arranged parallel to weld line and that welding is performed by controlling them individually under separate welding conditions (current and voltage) while keeping the distance between the early and delayed electrodes at constant (**Fig. 1**).

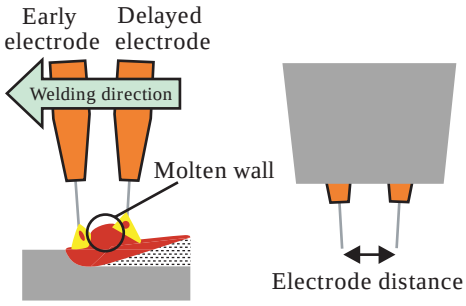

Fig. 1 Tandem Welding Condition and Electrode Distance

3. Conventional Tandem Welding

Komatsu's initial type and general tandem torches are of one-nozzle two-wire system (**Fig. 2**). With this torch structure, it is impossible to perform terminal welding at corners or avoid interference with bracket, etc. In addition, the monoblock torch is unsuitable for welding with a single torch.

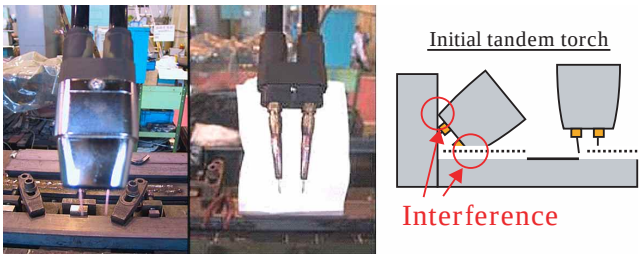

Fig. 2 Initial Tandem Torch and Welding Motion

4. Flexible Tandem Welding System

We developed the flexible tandem welding system that overcame the shortcomings of conventional tandem welding torch and has the following advantages.

(1) High-speed welding (almost double), high welding rate (productivity: 1.3 times)

(2) Flexible torch structure

2 types:①Changer system ② Slide system

(3) High quality tandem welding - Weld defect free, improved appearance

These features are described in detail below.

4.1 Advantages of the flexible tandem welding system

(1) High-speed welding and high welding rate

With this technology, the high-speed and high welding rate welding that best matches the wall thickness of object part is possible by optimally setting the large-current welding conditions (twice the current of single electrode, or 700 A) and the distance between electrodes.

・Medium thickness plate (large frame, etc.)

→ High welding rate and high-speed welding

・Thin plate (tank, exterior , etc.)

→ Mainly high-speed welding

For high-speed welding, the welding speed of approx. twice that of conventional single-electrode welding is possible (**Table 1**); for high welding rate , approximately 1.3 times higher productivity was achieved in welding medium thickness plates (cycle time ratio per product).

Table 1 Comparison of single and Tandem Welding Conditions

Horizontal fillet welding (leg length 8 mm) MAG		Early electrode		Delayed electrode		Speed
		Current	Voltage	Current	Voltage	
Wire 1.2mm	Komatsu single welding conditions	320	32.5			35
	Tandem welding conditions	350	26	300	31	70
Wire 1.4mm	Komatsu single welding conditions	390	32.5			35
	Tandem welding conditions	380	30	325	30	70

(2) Flexible torch structure

With conventional monoblock torch, it is impossible to weld starting/end points or narrow portion, so that welding coverage inevitably decreases. To solve this problem, we developed two types of flexible torch structures that assure almost the same coverage as single-electrode welding. Their advantages are described below.

①Changer system (**Fig. 3**)

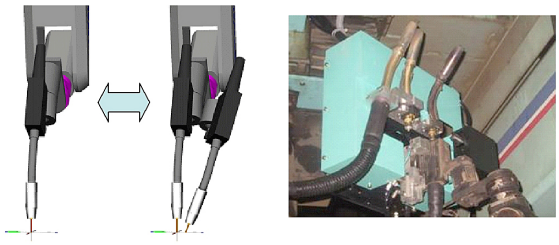

Fig. 3 Changer System

<Advantages>

・With the torch changer, the high speed and high welding rate of tandem welding and the welding of starting/end points or narrow portion can both be achieved.

This system is effective especially for the welded parts that requires the welding of narrow portion, corners and end portion, such as construction equipment parts.

・The currently used single-electrode welding programs can be used as they are. What we have to do is only add or modify the program for tandem welding adapted portions.

②Slide system (**Fig. 4**)

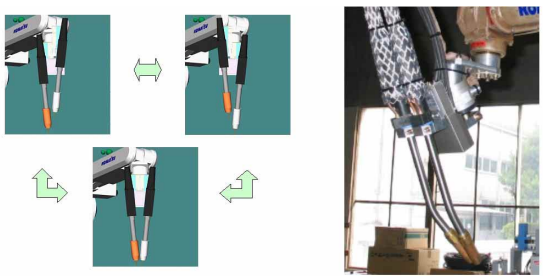

Fig. 4 Slide System

<Advantages>

・With the slide mechanism, starting/end points and corners can be welded without stopping arc during welding operation only by changing over between Tandem and Single modes, which greatly reduces the touchup welding on the downstream process (**Fig. 5**).

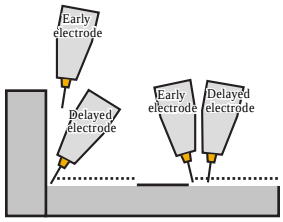

Fig. 5 Slide Tandem Torch

This system is effective especially for the high-speed, high welding rate welding of the parts having continuous weld line (tank, steel frame column, etc.)

・Due to the design concept that allows using two pieces of commercially available welding torch, both initial cost and the running cost including consumables can be reduced.

(3) High-quality tandem welding

We improved the weld quality (internal defect (**Fig. 6**) and appearance) of tandem welding and established the tandem welding conditions for reducing spatter by developing the tandem welding conditions control interface in which our welding and other know-how's are incorporated.

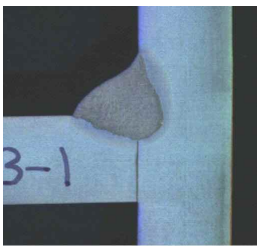

Fig. 6 Macroscopic Structure of Cross Section (Leg length 8 mm)

Concerning the welding know-how, the welding conditions that give the early and delayed electrodes of tandem welding system independently a separate role was set. For the early electrode, the welding condition was set that reduces welding voltage to give importance to amount of merging , where due to the reduced voltage, spatters are absorbed in molten weld. Thus the generation of spatter can be reduced. For the delayed electrode, the welding condition was set that puts in order the weld bead of end point by adjusting voltage.

For the system that controls the welding conditions of early and delayed electrodes as explained above, the tandem welding interface that has the welding condition database for the delayed electrode with respect to the early electrode was developed (**Fig. 7**).

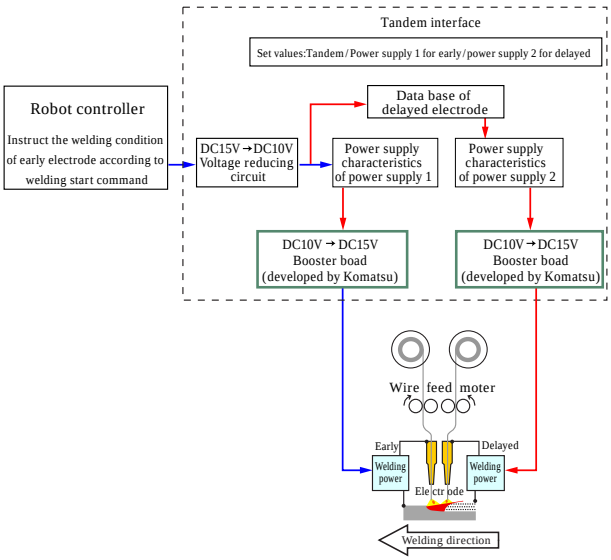

Fig. 7 Control Flow of Tandem Welding Interface

4.2 Supply List to 3 Plants of Komatsu Ltd.

Total 9 systems were supplied to 3 sheet metal welding factories (Awazu, Moka, Osaka) of Komatsu, Ltd. in a short period from May of the last year to January of this year, as shown in **Table 2**. The changer system that allows using the welding programs of existing robots as they are was employed and adapted by modifying existing systems.

Table 2 Supply List of Tandem Welding System

No.	Object work	Plant	No. of systems	System
1	PC78, PC128 boom	Awazu	2	Changer
2	PC300 - PC400 boom	Osaka	2	Changer
3	PC1250 - boom	Osaka	2	Changer
4	WA rear frame	Moka	1	Changer
5	WA side frame	Awazu	1	Slide
6	Motor grader front face	Moka	1	Changer

4.3 Sample application to the boom welding of construction machinery - Changer system

A sample application to the welding of the boom of hydraulic excavator is described below.

More than twice the welding speed of single-electrode welding was achieved for tandem welding adapted weld lines, and the number of weld layers could be reduced due to almost doubled welding rate . Thus productivity (cycle time ratio per product) was increased to 1.3 times, and high quality welding was achieved (**Fig. 8, Fig. 9**).

Adopting the remodeling of existing system by means of the "changer system", the application of tandem welding was gradually expanded while using the welding programs of existing single-electrode welding system as they are and changing over between single and tandem torches.

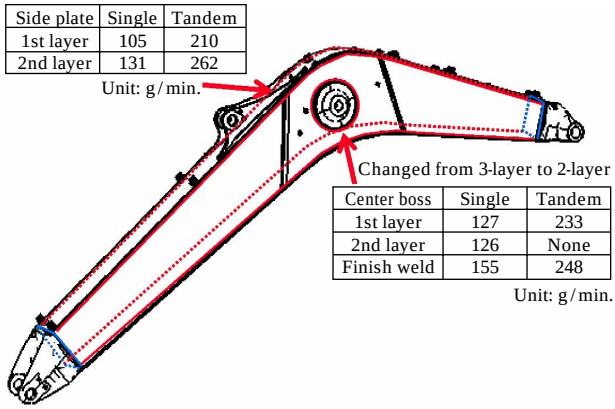

Fig. 8 Tandem Welding Adapted Weld Line

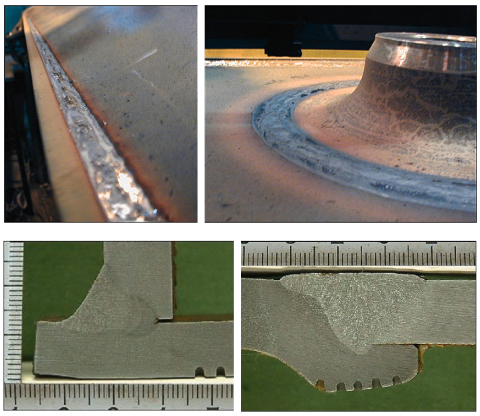

Fig. 9 Quality of Tandem Welding

5. Expanding the Application to Thin Plates

Above explanation is mainly for the welding of medium thickness plates. The result of our investigation on the application of tandem welding to thin plates (wall thickness 4.5 mm) of tank, etc. is described below.

According to the result of above explained experiments, we investigated the problems of tandem welding, and it was pointed out as a problem how to adapt to the welding of parts having a small radius of curvature. It is impossible to weld a part having a small radius of curvature with tandem electrode, and tandem welding requires the radius of 3 to 4 times the electrode distance. On the other hand, the radius of curvature of thin plate is mostly small and therefore requires being welded with a single electrode. In changing over between single and tandem welding modes, it is possible to perform welding without interruption if changeover is made in the order of “Single - Tandem - Single”. On the other hand, if changeover is made in the order of “Tandem - Single - Tandem”, there arises a part where welding is interrupted when changing over from Single to Tandem mode. Thus it is necessary to devise the mode changeover. By adjusting welding conditions, electrode distance and torch motion, we succeeded in eliminating incomplete merging and uneven bead. In addition, for complicated motion, we simplified programs using the delayed electrode welding condition holding function of the interface (**Fig. 10**).

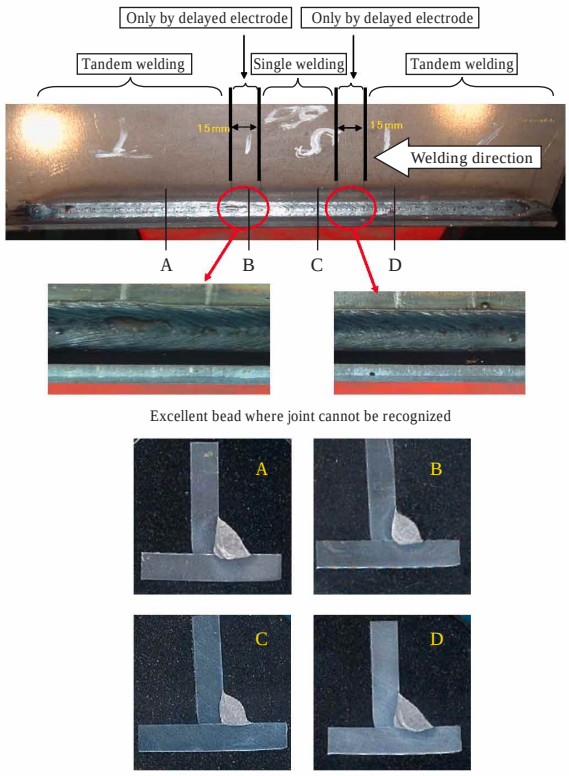

Fig. 10 Tandem Welding of Thin Plate (Welding Speed: 100 cm/min.)

6. Patents Applied for

For ① Changer System and ② Slide System related to flexible tandem welding, we applied for total 5 patents (**Table 3**).

Table 3 Patents Applied for

No.	Title	Application No.
1	Welding method and the mechanism and structure of welding torch	2004−029710
2	Welding head equipped with multiple torches and welding method	2003−315600
3	Method and mechanism to change the head of welding torch	2004−244287
4	Welding method using multiple torches	2003−297539
5	Welding method using compound welding head and parallel torch	2003−109295

No. 3 was applied for together with Komatsu Awazu Plant

7. Conclusion

While conventional tandem welding systems use two-electrode fixed type welding torch, Komatsu Engineering Corp. developed epoch-making mechanisms of slide type and changer type as well as the high-speed, high welding rate and high quality welding conditions control technology, and applied them to the welding of construction machinery and steel parts, contributing to greatly improving productivity.

In the future, we will further challenge the development and introduction of new tandem welding system aiming at doubling the cycle time ratio, software, sens**ing technology to improve net welding time, as well a**s the high-efficiency high quality welding that can cover from thin plates of tank, etc. to ultra-thick plates of ship, bridge, etc.

Introduction of the writers

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[A few words from the writers]

Based on the experience of use in Komatsu, we would like to expand the application of the “Flexible Tandem Welding System” to affiliated companies as well as develop new system based on their experience.