Rail Flash-Butt Welding Technology†

FUJII Mitsuru[*1] NAKANOWATARI Hiroaki[*2] NARIAI Kiyoshi[*3]

Abstract:

New rail flash-butt welding technology with JFE feedback flashing rate control and direct current (DC) inverter type power supply system was developed. This welder also employed preheating system for continuous welding which had been adopted in overseas, achieving high efficiency and energy saving operation along with the reduction of weight and size of the machine. The welder has been delivered to East Japan Railway Company with successful operation. Outline of the development, delivered machines and applications at the construction site are introduced.

1. Introduction

Welding of railway rails is not easy, as rails have a unique profile and large cross section, and also have a high carbon content because wear resistance and damage resistance are priorities in this application. Four methods are used to join rails, namely, flash-butt welding, gas pressure welding, almino-thermic welding, and enclosed arc welding. Of these, flash-butt welding has the highest welding efficiency (welding time: approximately 1.5–4 min) among the rail welding methods used in Japan and other countries and is also an excellent method from the viewpoints of quality stability and control. **Figure 1** shows the principle of flash-butt welding.

In flash-butt welding, electric power is applied between the end faces of the rails being joined, the free rail is moved forward at low speed, and flash and arc are generated by the resistance heating and local heating caused by the contact of the rail ends. This contact electrification and flash generation is repeated a number of times until a melt layer is formed over the entire joint surface, and a weld joint is then obtained by rapidly advance and pressurization. The following reports a new flash-butt welding technology developed by JFE Rail Link and the results of its application in Japan.

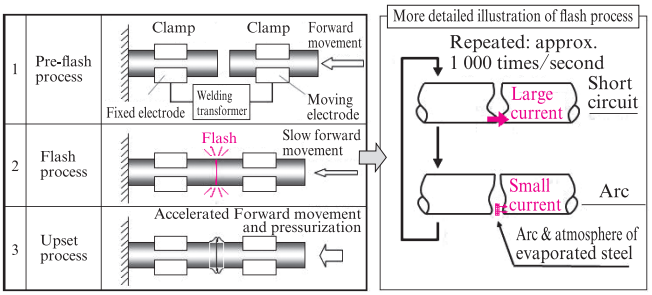

Fig. 1 Principle of the flash welding

2. JFE Rail Flash-Butt Welding Technology

Figure 2 shows the power supply systems used in flash-butt welding. Alternating current (AC) systems are mainly used as a mobile type in field welding, and welding is performed by a continuous flash-butt welding process using low electric power (**Fig. 3**(2)). Because low power is used in this type of system, the power supply is compact, but the welding time is long (2.5–4 min). A lightweight (Weight: 2.5–5 tons) welding machine with a simple structure is possible. On the other hand, direct current (DC) systems are used in shop welding, where large-scale power source equipment can be secured. The power supply equipment for flash-butt welders for shop use manufactured by foreign makers is all of this type. The preheated flash-butt welding method (Fig. 3(1)) is applied with this type of power system. With DC systems, the welding time is short (1.5–2 min), but since large electric power is necessary, the power supply equipment is large, and the welding machine is a large-

† Originally published in *JFE GIHO* No. 34 (Aug. 2014), p. 109–113

*1 General Manager, Engineering Dept., JFE Rail Link

*2 Staff, Engineering Sec., Engineering Dept., JFE Rail Link

*3 General Manager, Constraction Dept., JFE Rail Link

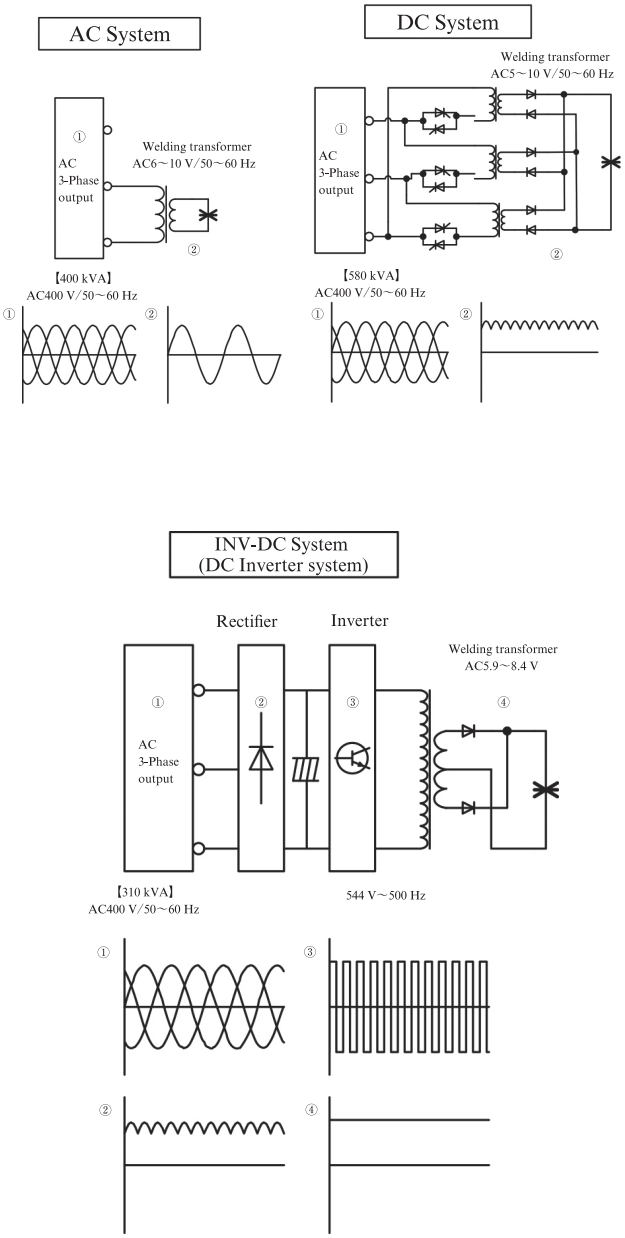

Fig. 2 Power supply system

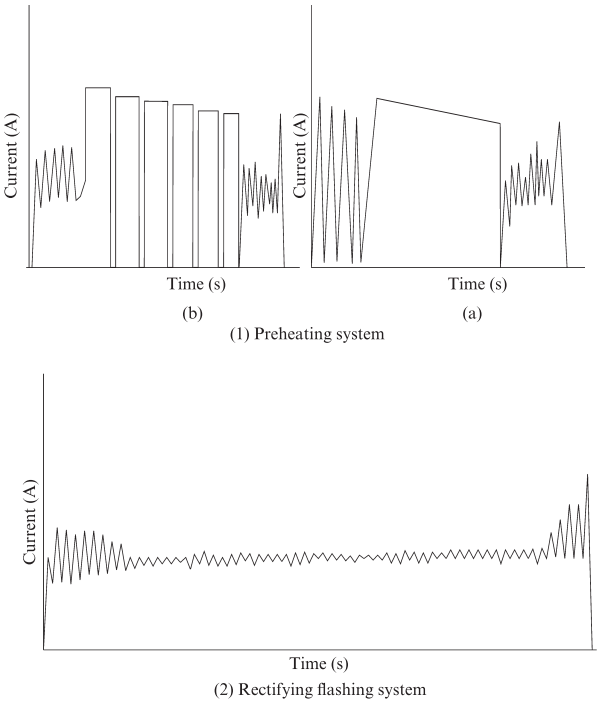

Fig. 3 Flash welding method

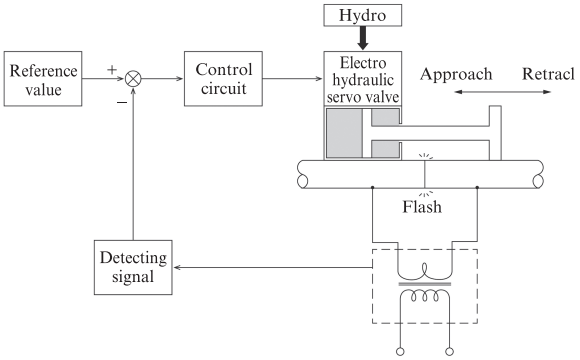

Fig. 4 Feedback flashing rate control

scale device (Weight: approx. 30 tons).

JFE Rail Link uses feedback flashing rate control (**Fig. 4**)[1] with the flash-butt welders. As a result, excessive peak power is eliminated, and an energy saving type welding machine with a low power capacity can be used. The flashing rate is controlled so that primary electric power is always equal to the setting value. If deviation electric power is detected, an electro hydraulic servo valve activates and the member being joined is immediately advanced or retracted, thereby maintaining a stable flashing rate. In this research, the authors developed a rail flash-butt welding technology which can realize high efficiency, power saving, compact size, and light weight by combining the advantages of feedback flashing rate control and the INV-DC system (DC inverter power supply system), together with the merits of the preheating welding process used in other countries in the conventional continuous flash-butt welding process.

3. Record of Application of JFE Rail Flash-Butt Welding Technology

3.1 Welder for Tokyo Rail Center, East Japan Railway Company

In 2013, the foreign-made rail flash-butt welding machine which had been introduced at Tokyo Rail Center of East Japan Railway Company in 1998 was due for renewal. As a successor welding machine, a flash-butt welder manufactured by JFE Rail Link was adopted. This welder was delivered in January 2014, and continuous-welding rail production was begun in February. The features of this welder are as follows:

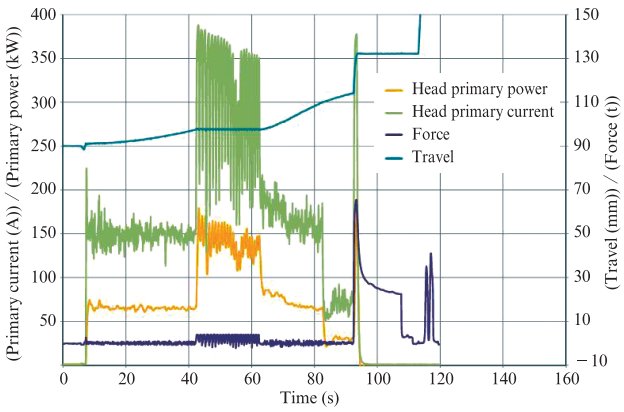

Fig. 5 Welding data of East Japan Railway Company

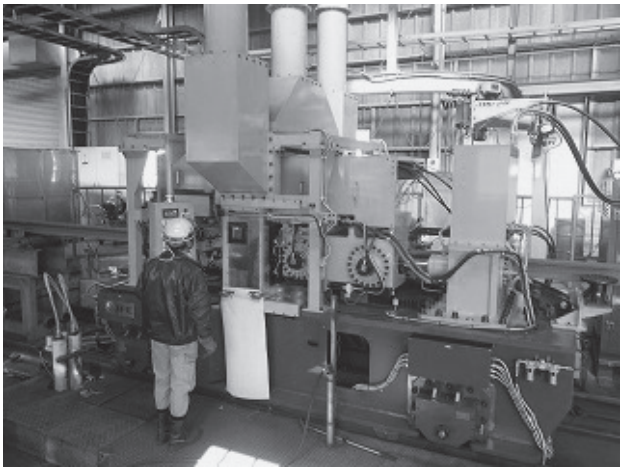

Photo 1 Welding machine of East Japan Railway Company

(1) Achieves high efficiency utilization of the welding power source and downsizing of the welding machine by adoption of the INV-DC (DC inverter) power supply system shown in Fig. 2 as the power supply system and adoption of feedback flashing rate control as the control method.

(2) Achieves the required efficiency (welding time: 1.5–2 min) by adding some preheating processes to the base process of continuous flash-butt welding used with mobile flash-butt welders, as shown in the welding data in **Fig. 5**.

This new welder has dimensions of 4.5W×1.8D×2.4H (m) and weight of 18 tons. In comparison with the welding machine before improvement, which had a maximum output of 310 kVA, the new welder realized a space saving of about 35%, weight reduction of about 40%, and reduction of electric power consumption of about 50%. **Photo 1** shows the welding machine.

3.2 Welder for Hamamatsu Rail Center, Central Japan Railway Company

In 1990, shortly after the breakup and privatization of Japan National Railways, a rail flash-butt welding machine manufactured was introduced at Hamamatsu Rail Center of Central Japan Railway Company. In this welding machine, a compact stationary-type flash-butt welding machine and small power capacity requirement were realized by adopting a continuous flash-butt welding process with an AC power supply. This equipment is operating stably, and is contributing to a compact production line and reduction of electric power costs at Hamamatsu Rail Center of Central Japan Railway Company. Average annual welding production is 3 000 joints (200 km). A cumulative total of 5 000 km of rails has been produced to date, supporting safe and stable operation of the Tokaido Shinkansen, which is the main artery of rail traffic in Japan. **Photo 2** shows the welding machine, and **Fig. 6** shows the welding data.

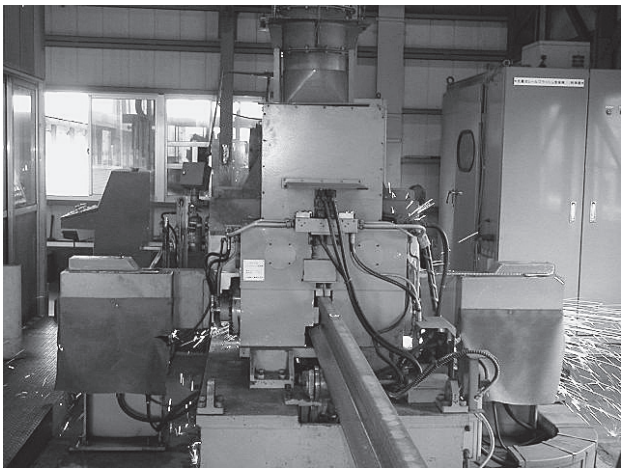

Photo 2 Welding machine of Central Japan Railway Company

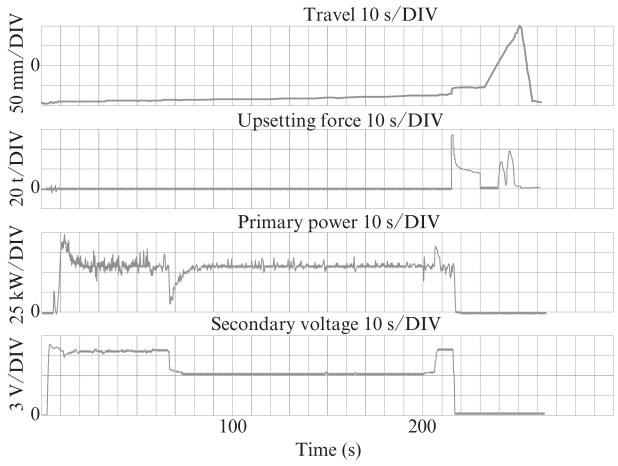

Fig. 6 Welding data of Central Japan Railway Company

3.3 Portable Flash-butt Welding Machines

In 1992, a welding machine (Weight: 1.9 tons) for field base welding construction by reducing the weight of the welding head was developed. The welding method and control were basically the same as those used in the

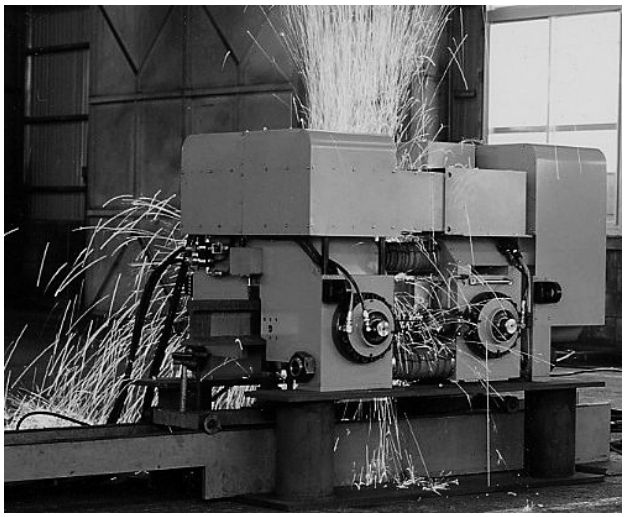

Photo 3 Portable flash welding machine

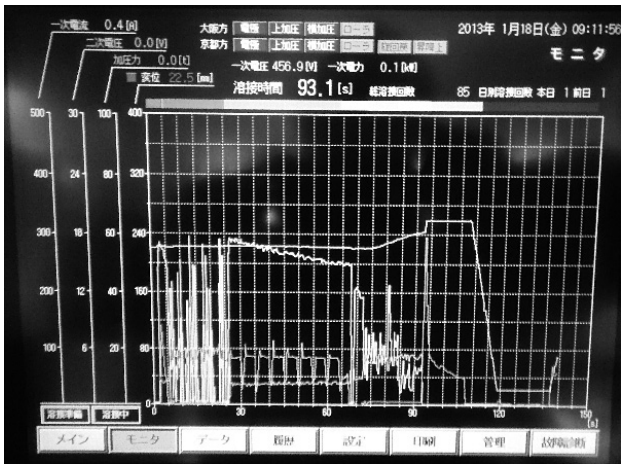

Photo 4 Picture of welding monitor

Photo 5 Picture of trouble diagnosis

Photo 6 Welding machine of West Japan Railway Company

stationary-type machine introduced by Hamamatsu Rail Center of Central Japan Railway Company. This welding machine has been supplied to line construction projects in various parts of Japan, beginning with Hokuetsu Hokusen Construction Project of 1993. In particular, in Hokuriku Shinkansen Construction Project, which began in July 1994, work was carried out in preparation for Olympic Winter Games held in Nagano in February 1998, and a high level of quality and construction at a rapid pace were required. Field welding was performed with this welding machine at a pace of more than 30 joints per day, contributing to the opening of the Nagano Shinkansen in December 1997. **Photo 3** shows the appearance of the portable flash-butt welding machine.

3.4 Improvement of Welder Control[2)] for West Japan Railway Company

Mukomachi Rail Center of West Japan Railway Company introduced various types of welding machines, beginning with a rail flash-butt welding machinery manufactured by a foreign maker in 1999, and welds an annual average of 5 000–6 000 joints, including conventional rail lines and Shinkansen lines. From 2009 to 2012, the center carried out improvement of its main welders and a partial changeover to domestically manufactured machines. JFE Rail Link, which was the only company in Japan with a record of deliveries of rail flash-butt welding machines, received the order for replacement of the control system of the flash-butt welder. In this replacement project, the following work was carried out for continuing use of the existing foreign-made welding machine: (1) analysis of the control program, (2) listing of component parts, and (3) selection of alternate parts, etc. Various new functions were also added to the control system, including a trouble diagnosis function for designating the part where trouble has occurred, and a monitor display which shows the welding part and welding parameters such as the welding heat input, etc. These improvements have enabled quick designation of the cause of trouble, and have also realized improved maintainability and a higher operat-

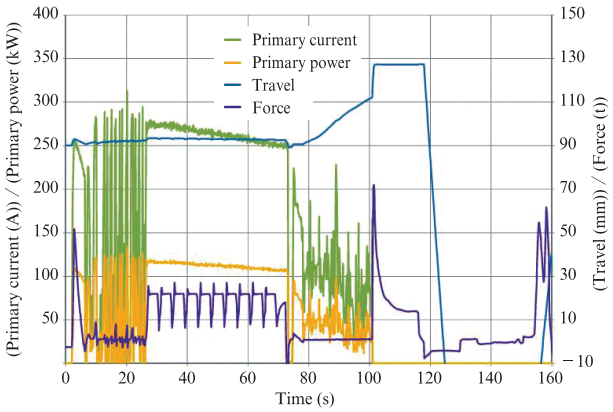

Fig. 7 Welding data of West Japan Railway Company

ing rate. **Photos 4–6** show the welding monitor screen of the control system, the trouble diagnosis screen, and the welding machine after renewal, respectively. **Figure 7** shows the welding data.

4. Conclusion

The rail flash-butt welding systems of JFE Rail Link and their record of application were introduced. In the future, the company is targeting sales of rail welding systems in Japan and other countries, beginning with stationary-type welding machines and also including portable machines, as well as application to field construction.

References

1) Fujii, Mitsuru et al. Computer Control Compact-type Flash Welding Equipment for Rails. 5th International Heavy Railway Conference. 1993-06-07.
2) Morita, Mitsugu et al. Japan society of Civil Engineers. 2013-09-05.