

ARC STARTING METHOD OF MULTIPLE-ELECTRODE ONE-SIDE WELDING
EQUIPMENT AND THE MULTIPLE-ELECTRODE ONE-SIDE WELDING
EQUIPMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an arc starting method of multiple-electrode one-side welding equipment used in arc welding for joining large plates in, for example, a plate joining process in a ship-body block manufacturing line at a shipyard; and the multiple-electrode one-side welding equipment that starts arc welding by the arc starting method.

2. Description of the Related Art

In, for example, arc welding for joining large plates at a shipyard, a one-side arc welding using multiple electrodes is primarily used as a high efficiency welding method. In recent years, in the shipbuilding industry, for the purpose of making more efficient a welding operation, a welding process is being automated. In particular, there is a strong demand for automating an arc starting operation.

Hitherto, arc starting methods discussed in, for example, Japanese Unexamined Patent Application Publication Nos. 4-309471 and 8-52573 have been used as arc starting methods.

Japanese Unexamined Patent Application Publication No.

4-309471 discusses an arc starting method of three-electrode one-side welding equipment. More specifically, it discusses what is called a running starting method. In the running start method, arcs are generated using a first electrode and a second electrode. Immediately after this, a welding carriage to which the first electrode and the second electrode are mounted starts to move, so that an arc to be generated using a third electrode is generated at molten pools formed on weld materials using the first and second electrodes.

Japanese Unexamined Patent Application Publication No. 8-52573 discusses an arc starting method of four-electrode one-side welding equipment using an arc generation auxiliary material. More specifically, it discusses a stationary starting method. In the stationary starting method, while using an arc generation auxiliary material, at least a third electrode is caused to precedingly singly generate an arc or both the third electrode and a fourth electrode are caused to precedingly simultaneously generate arcs. Immediately after this, remaining electrodes are caused to generate arcs, and a welding carriage starts to move.

However, in the arc starting method discussed in Japanese Unexamined Patent Application Publication No. 4-309471, when the distance between the second and third electrodes is relatively large, the molten pools that are

formed using the first and second electrodes are partially solidified. Therefore, when a wire, serving as the third electrode, is fed at an ordinary speed, the wire collides with the partially solidified molten pool prior to the generation of the arc. Therefore, the welding carriage to which the first to third electrodes are mounted stops moving, as a result of which the arc cannot be generated using the third electrode.

In addition, since an arc generation auxiliary material is not used even at the first and second electrodes, it takes time to generate arcs. Further, wires that are fed as the first and second electrodes collide with weld materials, causing the welding carriage to stop moving. As a result, the arcs cannot be generated even using the first and second electrodes. Still further, the collision of the wires causes, for example, the wires, that is, the welding carriage to which the electrodes are mounted to be lifted up. As a result, a large load is applied to the welding equipment. Therefore, the method discussed in Japanese Unexamined Patent Application Publication No. 4-309471 is not a satisfactory method as an automated arc starting method.

In the arc starting method discussed in Japanese Unexamined Patent Application Publication No. 8-52573, arc generation auxiliary materials are used. However, the

auxiliary materials are set at the third electrode and the following electrodes (serving as trailed electrodes), but an auxiliary material is not set at the first electrode, serving as a leading electrode. Therefore, the time it takes to generate an arc using the first electrode (serving as a leading electrode) cannot be reduced. Consequently, the collision of the wire (serving as the first electrode) with a weld material cannot be prevented, as a result of which the arc cannot be generated using the first electrode.

In an actual welding operation, an arc generation auxiliary material needs to be set not only at the third electrode but also at a fourth electrode. Therefore, a larger amount of arc generation auxiliary material is used, which is uneconomical, and work efficiency is also reduced. Further, in order to eliminate any portion that is not welded at a welding starting portion, a tab plate is provided on an extension line of a welding line. Since, when the welding is started, arcs are generated using all of the electrodes, the tab plate becomes long, which is not economical. Consequently, the method discussed in Japanese Unexamined Patent Application Publication No. 8-52573 is not a satisfactory method as an automated arc starting method.

SUMMARY OF THE INVENTION

Accordingly, the present invention is conceived in

overcoming such problems, and has as its object the provision of an arc starting method of multiple-electrode one-side welding equipment and the provision of the multiple-electrode one-side welding equipment. The method and equipment allow an arc starting operation to be automated to reliably generate arcs using respective electrodes, are economical because the amount of arc generation auxiliary material used is reduced, and provide excellent work efficiency.

According to an aspect of the present invention, there is provided an arc starting method of multiple-electrode one-side welding equipment for performing arc welding on weld materials using two or more electrodes mounted to a welding carriage, the electrodes being wires that are fed. The method includes a first process of setting an arc generation auxiliary material at a first electrode serving as a leading electrode among the two or more electrodes; a second process of causing the first electrode to generate an arc at the weld materials and causing the welding carriage to move immediately thereafter; and a third process of controlling wire feeding in three stages including a first stage, a second stage, and a third stage. In the first stage, a second electrode serving as a trailed electrode of the first electrode among the two or more electrodes is caused to generate an arc at a partially solidified molten

pool formed on the weld materials using the first electrode, and the wire serving as the second electrode is fed at a slow-down speed that is lower than an ordinary speed before the arc is generated until the wire serving as the second electrode comes into contact with the partially solidified molten pool. In the second stage, the feeding of the wire serving as the second electrode is stopped from immediately after the wire serving as the second electrode comes into contact with the partially solidified molten pool to when the arc is generated. In the third stage, after the arc is generated, the wire serving as the second electrode is fed at the ordinary speed that varies in accordance with a variation in a voltage value of the wire serving as the second electrode.

The arc starting method may be such that three or more of the electrodes are used, and may further include a fourth process of causing a third electrode and/or a following electrode or following electrodes serving as trailed electrodes of the second electrode among the three or more electrodes to generate arcs at partially solidified molten pools formed on the weld materials using respective preceding electrodes of the third electrode and the following electrode or the following electrodes, and controlling feeding of the wires serving as the third electrode and the following electrode or the following

electrodes in the three stages including the first to third stages.

According to the above-described procedure, the first process in which an arc generation auxiliary material is set at the first electrode is performed. Therefore, in the second process, it is possible to reduce the time required to generate the arc using the first electrode, and to prevent collision of the wire, which is fed as the first electrode, with the weld materials. In addition, in the second process, since the arc generation auxiliary material is only set at the first electrode, the amount of auxiliary material used is reduced and work efficiency is increased. Since, when welding is started, the arc is generated only using the first electrode serving as a leading electrode, a tab plate provided at a welding starting portion can be shortened. In the third process and the fourth process, the wire feeding speeds of the second electrode and the following electrode or electrodes are controlled in three stages, that is, each wire feeding is controlled by the first stage in which the wire is fed at the slow-speed that is lower than the ordinary speed until the arc is generated and by the second stage in which each feeding is stopped when the wire comes into contact with the partially solidified molten pool. Therefore, it is possible to prevent the wires from colliding with the partially

solidified molten pools. Consequently, the arcs are generated even at the partially solidified molten pools.

According to another aspect of the present invention, there is provided multiple-electrode one-side welding equipment for performing arc welding on weld materials. The welding equipment includes a plurality of electrodes; an electrode power supply section that supplies power to the electrodes; a wire feeding section that feeds wires serving as the electrodes; a welding carriage to which the electrodes are mounted; carriage moving means for moving the welding carriage along a welding line of the weld materials; and a controller including a welding power supply processing section that controls the power supplied to the electrodes, a wire feeding processing section that controls feeding speeds of the wires, and a carriage movement processing section that controls movement of the welding carriage. The wire feeding processing section performs the control in three stages including a first stage, a second stage, and a third stage. In the first stage, the wire feeding processing section causes a next one of the electrodes in relation to a leading one of the electrodes to generate an arc at a partially solidified molten pool formed on the weld materials using the leading one of the electrodes, and causes the wire serving as the next one of the electrodes in relation to the leading one of the electrodes to be fed at a

slow-down speed that is lower than an ordinary speed before the arc is generated until the wire serving as the next one of the electrodes comes into contact with the partially solidified molten pool. In the second stage, the wire feeding processing section causes the feeding of the wire serving as the next one of the electrodes to be stopped from immediately after the wire serving as the next one of the electrodes comes into contact with the partially solidified molten pool to when the arc is generated. In the third stage, after the arc is generated, the wire feeding processing section causes the wire serving as the next one of the electrodes to be fed at the ordinary speed that varies in accordance with a variation in a voltage value of the wire serving as the next one of the electrodes.

According to this structure, the welding equipment includes a controller including a welding power supply processing section that controls the power supplied to the electrodes, a wire feeding processing section that controls the feeding speeds of the wires serving as the electrodes, and a carriage movement processing section that controls the movement of the welding carriage. In addition, the wire feeding processing section controls the feeding of the wires serving as the next electrodes in relation to the leading one of the electrodes (that is, the second electrode and the following electrode or electrodes) in three stages.

Therefore, it is possible to reduce the amount of arc generation auxiliary material used, to increase work efficiency, and to prevent collision of the wires serving as the electrodes, so that arcs are generated even at the partially solidified molten pools.

The arc starting method of multiple-electrode one-side welding equipment and the multiple-electrode one-side welding equipment according to the present invention allow an arc starting operation to be automated to reliably generate arcs using the respective electrodes, are economical because the amount of arc generation auxiliary material used is reduced, and provide excellent in work efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flowchart of the steps of an arc starting method of multiple-electrode one-side welding equipment according to the present invention;

Fig. 2 is a time chart of the arc starting method of the multiple-electrode one-side welding equipment according to the present invention;

Fig. 3 is a perspective view of the structure of the multiple-electrode one-side welding equipment according to the present invention; and

Fig. 4 is a block diagram of a controller in the

multiple-electrode one-side welding equipment according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An arc starting method of multiple-electrode one-side welding equipment and the multiple-electrode one-side welding equipment that starts arc welding by the arc starting method according to the present invention will be described with reference to the drawings.

First, multiple-electrode one-side welding equipment 1 will be described with reference to Figs. 3 and 4, and, if necessary, with reference to Fig. 2.

As shown in Fig. 3, the multiple-electrode one-side welding equipment (may hereunder also be called "welding equipment") 1 performs arc welding of weld materials W using a plurality of electrodes 2 (that is, a first electrode 2a, a second electrode 2b, and a third electrode 2c) mounted to a welding carriage 4, with the electrodes 2 being wires that are fed. During the welding, a controller 9 controls carriage moving means 5 to move the welding carriage 4 along a welding line (that is, a groove line) V of the weld materials W that abut against each other. In addition, the controller 9 controls wire feeding sections 3 to control feeding speeds of the wires serving as the electrodes 2.

The welding equipment 1 is, in particular, multiple-

electrode one-side submerged arc welding equipment. The multiple-electrode one-side submerged arc welding equipment performs arc welding from a front side of the welding line V using flux supplied from flux supplying sections 7 and the plurality of electrodes (wires) 2 at the same time by pressing a backing flux (scattered from a back side of the welding line V of the weld materials W that abut against each other onto, for example, a copper plate (not shown)) towards the back side of the welding line V by a push-up mechanism such as an air hose.

The welding equipment 1 includes the plurality of electrodes 2, electrode power supply sections 10, the wire feeding sections 3, the welding carriage 4, the carriage moving means 5, and the controller 9. Each structural component of the welding equipment 1 will hereunder be described taking as an example the case in which the number of electrodes 2 of the welding equipment 1 is three.

Electrodes

The electrodes 2 are mounted to the welding carriage 4 and extend downward in series towards the weld materials W. By moving the welding carriage 4, the electrodes 2 move along the welding line V of the weld materials W that abut against each other. The electrodes 2 are wires that are fed from the wire feeding sections 3 (described later). By supplying power to the wires from the electrode power supply

sections 10, an arc discharge is generated between the weld materials W and the electrodes 2, to weld the weld materials W along the welding line V. More specifically, the electrodes 2 include the first electrode 2a, the second electrode 2b, and the third electrode 2c.

Electrode Power Supply Sections

The electrode power supply sections 10 supply power to the wires serving as the electrodes. In the welding equipment 1, the electrode power supply sections 10 are provided in correspondence with the plurality of the electrodes 2. More specifically, the electrode power supply sections 10 include an electrode power supply section 10a (for the first electrode) that supplies power to the first electrode 2a, an electrode power supply section 10b (for the second electrode) that supplies power to the second electrode 2b, and an electrode power supply section 10c (for the third electrode) that supplies power to the third electrode 2c.

Wire Feeding Sections

The wire feeding sections 3 feed the wires serving as the electrodes 2. In the welding equipment 1, the wire feeding sections 3 are provided in correspondence with the plurality of electrodes 2. More specifically, the wire feeding sections 3 include a wire feeding section 3a (for the first electrode) that feeds the wire serving as the

first electrode 2a, a wire feeding section 3b (for the second electrode) that feeds the wire serving as the second electrode 2b, and a wire feeding section 3c (for the third electrode) that feeds the wire serving as the third electrode 2c.

Welding Carriage

The welding carriage 4 has the electrodes 2 mounted thereto, and moves along the welding line V. The welding carriage 4 includes a supporting base 4a that supports the electrodes 2, a front supporting arm 4b and a back supporting arm 4c that extend downward from the supporting base 4a, and a bridging member 4d horizontally bridging the front supporting arm 4b and the back supporting arm 4c. At the welding carriage 4, the flux supplying sections 7 that scatter and supply flux to the welding line are supported by the supporting base 4a. A flux collector 8 that collects any residual flux after the welding may be supported at the back supporting arm 4c.

Carriage Moving Means

The carriage moving means 5 moves along a movement rail 11 (installed along a longitudinal direction of the welding line V) in an installation direction XL while the welding carriage 4 is suspended from the carriage moving means 5, so that the welding carriage 5 moves along the welding line V. The carriage moving means 5 includes a suspension member 5a

that is suspended so as to be movable in a transverse direction YL orthogonal to the installation direction XL of the movement rail 11, a motor 5b that drives the suspension member 5a so as to move in the installation direction XL of the movement rail 11, and a position detector 5c, such as an encoder, that detects a driving amount of the motor 5b. The driving amount of the motor 5b detected by the position detector 5c is transmitted to a storage section 9A, and is stored as position coordinates of the electrodes 2 in the installation direction XL.

Controller

The controller 9 controls the power supplied to the electrodes 2, the feeding speeds of the wires serving as the electrodes 2, and the movement of the welding carriage 4. The controller 9 includes the storage section 9A, a welding power supply processing section 9B, a wire feeding processing section 9C, and a carriage movement processing section 9D.

The storage section 9A stores voltage values of the electrode power supply sections 10, more specifically, for example, initial voltage values that are supplied to the electrodes 2 when the welding equipment 1 is started, arc generation voltage values used in determining arc generation, and wire contact voltage values used in determining contact of the wires with partially solidified molten pools. The

storage section 9A also stores the wire feeding speeds of the wire feeding sections 3, more specifically, for example, an ordinary speed after arc generation (that is, during welding) and a slow-down speed before the arc generation that is lower than the ordinary speed. The storage section 9A further stores, for example, the movement speed of the welding carriage 4. The storage section 9A still further stores, for example, electrode position coordinates and molten pool position coordinates. The molten pool position coordinates correspond to, for example, the distance between the first electrode and the second electrode and the distance between the first electrode and the third electrode.

The initial voltage values, the arc generation voltage values, and the wire contact voltage values are previously input to the storage section 9A, and are transmitted to the welding power supply processing section 9B, the wire feeding processing section 9C, and the carriage movement processing section 9D. The ordinary speed and the slow-down speed of the wires are previously input to the storage section 9A, and are transmitted to the wire feeding processing section 9C. Further, the movement speed of the welding carriage 4, the electrode position coordinates of the electrodes 2, and the molten pool position coordinates are previously input to the storage section 9A, and are transmitted to the welding power supply processing section 9B and the carriage movement

processing section 9D. The electrode position coordinates of the electrodes 2 are rewritten on the basis of the driving amount of the motor 5b that is detected by the position detector 5c and that is transmitted from the carriage moving means 5.

The welding power supply processing section 9B controls the power supplied to the electrodes 2, that is, an on-off state of each electrode power supply section 10 (see Fig. 2). More specifically, on the basis of the electrode position coordinates and the molten pool position coordinates transmitted from the storage section 9A, the welding power supply processing section 9B transmits the initial voltage values transmitted from the storage section 9A to the electrode power supply sections 10, so that the electrode power supply sections 10 are switched from an off state to an on state. When the electrode position coordinates of the first electrode 2a serving as a leading electrode correspond to those at a starting time of the welding equipment 1, that is, when they are zero, the electrode power supply section 10a for the first electrode 2a is turned on. When the electrode position coordinates of the respective second and third electrodes 2b and 2c (serving as trailed electrodes) reach the molten pool position coordinates of molten pools formed using respective preceding electrodes, that is, the first electrode 2a and the second electrode 2b, respectively,

the electrode power supply sections 10b and 10c for the second electrode and the following electrode are switched from the off state to the on state. The welding power supply processing section 9B transmits electrode voltage values at the electrodes 2 after starting the welding equipment 1 to the wire feeding processing section 9C.

The wire feeding processing section 9C controls the feeding speeds of the wires serving as the electrodes 2, that is, the feeding speeds of the wire feeding sections 3, to generate an arc using a next electrode at a partially solidified molten pool formed on the weld materials using a leading electrode. More specifically, an arc is generated using the second electrode 2b at the partially solidified molten pool formed on the weld materials using the first electrode 2a, and an arc is generated using the third electrode 2c at the partially solidified molten pool formed using the second electrode 2b (see Fig. 2). In addition, in controlling the feeding speeds in the wire feeding processing section 9C, a determination is made by comparing the electrode voltage values transmitted from the welding power supply processing section 9B, the initial voltage values, the wire contact voltage value, and the arc generation voltage values transmitted from the storage section 9A with each other, wire feeding speeds transmitted from the storage section 9A are selected, and the selected

wire feeding speeds are transmitted to the wire feeding sections 3, so that the feeding speeds of the wire feeding sections 3 are controlled. The wire feeding processing section 9C transmits to the wire feeding sections 3 the slow-down speed when the electrode voltage values are equal to the initial voltage values, a feed stop command when the electrode voltage values are equal to the wire contact voltage values, and the ordinary speed when the electrode voltage values are equal to the arc generation voltage values.

Here, although the slow-down speed depends upon, for example, the thicknesses of the weld materials W, it is 1/10 to 1/2 of the ordinary speed. The ordinary speed is the speed used when the weld materials W are being welded. Although the ordinary speed depends upon, for example, the thicknesses of the weld materials W, it is 0.5 to 3 m/min. The ordinary speed varies in accordance with the voltage value so that the voltage value at the electrode power supply section 10b (for the second electrode), that is, the voltage value of the wire serving as the second electrode 2b becomes constant. More specifically, when the voltage value increases, the feeding speed increases.

The carriage movement processing section 9D controls the movement of the welding carriage 4, that is, an on-off state of the carriage moving means 5 (see Fig. 2). More

specifically, the carriage movement processing section 9D makes a determination by comparing the electrode voltage value of the first electrode 2a transmitted from the welding power supply processing section 9B and the arc generation voltage value of the first electrode 2a transmitted from the storage section 9A with each other. If the electrode voltage value is equal to the arc generation voltage value, the movement speed transmitted from the storage section 9A is transmitted to the carriage moving means 5, so that the carriage moving means 5 is controlled from the off state to the on state. At the carriage moving means 5', on the basis of the transmitted movement speed, the motor 5b is driven to move the welding carriage 4.

In the controller 9, the storage section 9A may be formed of a recording medium such as ROM, RAM, or HDD (hard disc). The welding power supply processing section 9B, the wire feeding processing section 9C, and the carriage movement processing section 9D may each be formed of a processing/operational device such as a microcomputer or a personal computer.

In addition to the above-described structural components, the multiple-electrode one-side welding equipment may include a slider 6 that controls displacement of the electrodes 2 in the transverse direction YL from the welding line V. The slider 6 moves the welding carriage 4

in the transverse direction YL, and includes a slider table 6a and a slider driving section 6b. The slider table 6a is mounted to the supporting base 4a of the welding carriage 4. The slider driving section 6b includes a motor that moves the slider table 6a in the transverse direction YL, and a position detector, such as an encoder, that detects a driving amount of the motor. The driving amount of the motor detected by the position detector is transmitted to the storage section 9A, and is stored as the position coordinates of the electrodes 2 in the transverse direction YL. The multiple-electrode one-side welding equipment may include four or more of the electrodes 2 (not shown).

Arc Starting Method of the Multiple-Electrode One-side Welding Equipment

Next, the arc starting method of the multiple-electrode one-side welding equipment according to the present invention will be described with reference to Figs. 1 and 2.

The arc starting method of the multiple-electrode one-side welding equipment according to the present invention includes the following first to fourth processes. The processes will hereunder be described taking as an example the case in which the multiple-electrode one-side welding equipment includes three electrodes. Each structural component of the multiple-electrode one-side welding equipment will be described with reference to Figs. 3 and 4.

First Process: Step S1

In the first process, Step S1 is performed to set an arc generation auxiliary material at the first electrode 2a serving as a leading electrode. The arc generation auxiliary material may be either manually or automatically set. Setting the arc generation auxiliary material causes an arc to be reliably generated using the first electrode 2a.

If, in Step S1, the arc generation auxiliary material is manually set, the following are performed. That is, for example, steel wool is used as the arc generation auxiliary material. After ripping, for example, the steel wool by a required degree, the ripped steel wool is pressed by a certain amount, and its shape is adjusted. Then, the steel wool is interposed between the first electrode 2a and the weld materials W. Thereafter, a weld start button of the welding equipment 1 is pressed, to start the welding equipment 1.

If, in Step S1, the arc generation auxiliary material is automatically set, the following are performed. That is, for example, a cut wire or iron powder is used as the arc generation auxiliary material. When the power supply of the welding equipment 1 is turned on, the arc generation auxiliary material is supplied between the first electrode 2a and the weld materials W from an arc generation auxiliary material supplying section (not shown) provided near the

first electrode 2a. The supply amount of the arc generation auxiliary material is controlled by the controller 9.

Second Process: Steps S2 to S5

In the second process, the first electrode 2a is caused to generate an arc at the weld materials W, and the welding carriage 4 is moved immediately thereafter. More specifically, in the second process, a Step S2 in which the power supply of the first electrode 2a is turned on, a Step S3 in which feeding of the wire (first electrode 2a) is started, a Step S4 in which it is determined whether or not the arc is generated at the first electrode 2a, and a Step S5 in which the welding carriage 4 starts to move are performed.

In the Step S2, when the power supply of the welding equipment 1 is turned on in the Step S1, the initial voltage is applied to the first electrode 2a by the electrode power supply section 10a (for the first electrode). Here, the initial voltage value of the first electrode 2a is previously stored in the storage section 9A, and is transmitted to the electrode power supply section 10a (for the first electrode) from the welding power supply processing section 9B.

In the Step S3, after the initial voltage has been applied to the first electrode 2a in the Step S2, the wire supplying section 3a (for the first electrode) feeds the

wire serving as the first electrode 2a at a predetermined speed. Here, the wire feeding speed is previously stored in the storage section 9A, and is transmitted to the wire feeding section 3a (for the first electrode) from the wire feeding processing section 9C.

The wire serving as the first electrode 2a is fed at the ordinary speed from the beginning, and is not fed at the slow-down speed at which the second electrode 2b and the third electrode 2c (described later) are fed. This is because, since, in the first process, the arc generation auxiliary material is set near the first electrode 2a, the time it takes to generate the arc is short and the wire does not collide with the weld materials W even if the wire is fed at the ordinary speed. However, similarly to the second electrode 2b and the third electrode 2c, the wire feeding speed of the first electrode 2a may be controlled to the slow-down speed, stoppage, and the ordinary speed in that order. Here, the slow-down speed and the ordinary speed will hereunder be described. The ordinary speed means the speed of the wires that are fed when the weld materials W are being welded.

In the Step S4, it is determined whether or not an arc is generated using the first electrode 2a. If it is determined that an arc is generated (Yes), the process proceeds to the next step. If it is determined that an arc

is not generated (No), the determination of whether or not an arc is generated using the first electrode 2a is repeated. More specifically, the determination is performed by transmitting the electrode voltage value of the first electrode 2a in the electrode power supply section 10a (for the first electrode) and the arc generation voltage value previously stored in the storage section 9A to the carriage movement processing section 9D, and by comparing the electrode voltage value and the arc generation voltage value with each other at the carriage movement processing section 9D. Then, if the electrode voltage value is equal to the arc generation voltage value, it is determined that an arc is generated using the first electrode 2a (Yes). Here, although the arc generation voltage value depends upon, for example, the thicknesses of the weld materials W, it is in the range of from 20 to 60 V. This determination is not limited to the use of the voltage value. The determination may be performed using characteristic values that can be used to determine whether or not an arc is generated, such as an electric current value.

In Step S5, the carriage moving means 5 moves the welding carriage 4 at a predetermined movement speed along the welding line V. Here, the movement speed of the welding carriage 4 is previously stored in the storage section 9A, and is transmitted to the carriage moving means 5 from the

carriage movement processing section 9D.

Third Process: Steps S6 to S12

In the third process, at the second electrode 2b serving as a trailed electrode of the first electrode 2a, an arc is generated at a partially solidified molten pool formed on the welding materials W using the first electrode 2a.

More specifically, in the third process, a Step S6 in which the position of the second electrode 2b is determined, a Step S7 in which the power supply of the second electrode 2b is turned on, a Step S8 in which feeding of the wire serving as the second electrode 2b is started, a Step S9 in which it is determined whether or not the wire has come into contact with the weld materials W, that is, the molten pool, a Step S10 in which the feeding of the wire serving as the second electrode 2b is stopped, a Step S11 in which it is determined whether or not an arc is generated using the second electrode 2b, and a Step S12 in which feeding of the wire serving as the second electrode 2b is started are performed.

In the Step S6, it is determined whether or not the second electrode 2b has reached the position of the partially solidified molten pool formed using the first electrode 2a. If it is determined that the second electrode 2b has reached this position (Yes), the process proceeds to

the next step. In contrast, if it is determined that the second electrode 2b has not reached this position (No), the determination of the position of the second electrode 2b is repeated. More specifically, the determination is performed by transmitting the electrode position coordinates, stored in the storage section 9A, and the molten pool position coordinates, previously stored in the storage section 9A, to the wire feeding processing section 9C, and by comparing them with each other at the wire feeding processing section 9C. The electrode position coordinates in the storage section 9A are rewritten on the basis of the driving amount of the motor 5b detected by the position detector 5c, that is, the movement amount of the welding carriage 4. Then, if the electrode position coordinates are equal to the molten pool position coordinates, it is determined that the second electrode 2b has reached the position of the partially solidified molten pool formed using the first electrode 2a (Yes).

In the Step S7, the electrode power supply section 10b (for the second electrode) applies the initial voltage to the second electrode 2b. The initial voltage value of the second electrode 2b is previously stored in the storage section 9A, and is transmitted to the electrode power supply section 10b (for the second electrode) from the welding power supply processing section 9B.

In the Step S8, the wire feeding section 3b (for the second electrode) feeds the wire serving as the second electrode 2b at a feeding speed that is lower than the ordinary speed, so that it feeds the wire at the slow-down speed. Although the slow-down speed depends upon, for example, the thicknesses of the weld materials W, it is 1/10 to 1/2 of the ordinary speed. The ordinary speed is used when welding the weld materials W. Although the ordinary speed depends upon, for example, the thicknesses of the weld materials W, it is 0.5 to 3 m/min. Here, the slow-down speed of the wire is previously stored in the storage section 9A, and is transmitted to the wire feeding section 3b (for the second electrode) from the wire feeding processing section 9C.

In the Step S9, it is determined whether or not the wire whose feeding has been started in the previous Step S8 has come into contact with the partially solidified molten pool formed using the first electrode 2a. If it is determined that the wire has come into contact with the molten pool (Yes), the process proceeds to the next step. In contrast, if it is determined that the wire has not come into contact with the molten pool (No), the determination of whether the second electrode 2b has come into contact with the molten pool is repeated. More specifically, the determination is performed by transmitting the electrode

voltage value of the second electrode 2b in the electrode power supply section 10b (for the second electrode) and the wire contact voltage value previously stored in the storage section 9A to the wire feeding processing section 9C, and by comparing the electrode voltage value and the wire contact voltage value with each other at the wire feeding processing section 9C. Then, if the electrode voltage value is equal to the wire contact voltage value, it is determined that the second electrode 2b has come into contact with the molten pool (Yes). Here, since the wire contacts the partially solidified molten pool, the wire contact voltage value is 0 V.

In the Step S10, the wire feeding section 3b (for the second electrode) stops feeding the wire serving as the second electrode 2b. Here, the wire feeding stop command is transmitted to the wire feeding section 3b (for the second electrode) from the wire feeding processing section 9C.

In the Step S11, it is determined whether or not an arc is generated using the second electrode 2b. If it is determined that an arc is generated using the second electrode 2b (Yes), the process proceeds to the next step. In contrast, if it is determined that an arc is not generated using the second electrode 2b (No), the determination of whether or not an arc is generated using the second electrode 2b is repeated. More specifically, the

determination is performed by transmitting the electrode voltage value of the second electrode 2b in the electrode power supply section 10b (for the second electrode) and the arc generation voltage value previously stored in the storage section 9A to the wire feeding processing section 9C, and by comparing the electrode voltage value and the arc generation voltage value with each other at the wire feeding processing section 9C. Here, although the arc generation voltage value depends upon, for example, the thicknesses of the weld materials W, it is from 20 to 60 V. This determination is not limited to the use of the voltage value. The determination may be performed using characteristic values that can be used to determine whether or not an arc is generated, such as an electric current value.

In the Step S12, the wire feeding section 3b (for the second electrode) feeds the wire serving as the second electrode 2b at the ordinary speed. The ordinary speed varies in accordance with a variation in the voltage value so that the voltage value at the electrode power supply section 10b (for the second electrode), that is, the voltage value of the wire serving as the second electrode 2b becomes constant. More specifically, when the voltage value increases, the feeding speed decreases. Here, the ordinary speed of the wire is previously stored in the storage section 9A, and is transmitted to the wire feeding section

3b (for the second electrode) from the wire feeding processing section 9C.

By performing the aforementioned Steps S6 to S12, the feeding speed of the wire that is fed is controlled in the following three stages. By this, an arc is reliably generated using the second electrode 2b even at the partially solidified molten pool.

First Stage

Before an arc is generated until a wire comes into contact with the weld materials W, that is, a partially solidified molten pool, the wire is fed at the slow-down speed.

Second Stage

From immediately after the wire comes into contact with the molten pool to when an arc is generated, the feeding of the wire is stopped.

Third Stage

After the arc is generated, the wire is fed at the ordinary speed that varies in accordance with the variation of the voltage value of the wire.

Fourth Process: Steps S13 to S19

In the fourth process, at the third electrode 2c serving as a trailed electrode of the second electrode 2b, an arc is generated at a partially solidified molten pool formed on the welding materials W using the second electrode

2b.

More specifically, in the fourth process, a Step S13 in which the position of the third electrode 2c is determined, a Step S14 in which the power supply of the third electrode 2c is turned on, a Step S15 in which feeding of the wire serving as the third electrode 2c is started, a Step S16 in which it is determined whether or not the wire has come into contact with the molten pool, a Step S17 in which the feeding of the wire serving as the third electrode 2c is stopped, a Step S18 in which it is determined whether or not an arc is generated using the third electrode 2c, and a Step S19 in which feeding of the wire serving as the third electrode 2c is started are performed.

The Steps S13 to S19 perform on the third electrode 2c the operations that are performed on the second electrode 2b in the Steps S6 to S12. Therefore, the description thereof will be omitted. In the Steps S13 to S19, the electrode power supply section is the electrode power supply section 10c (for the third electrode), the wire feeding section is the wire feeding section 3c (for the third electrode), and the molten pool is formed using the second electrode 2b.

By performing the aforementioned Steps S6 to S19, the feeding speed of the wire that is fed is controlled in the above-described three stages. By this, an arc is reliably generated using the third electrode 2c even on the partially

solidified molten pool.

Although, in the foregoing description, the arc starting method of the welding equipment including three electrodes is described, the above-described arc starting method can be used even in welding equipment including four or more electrodes. More specifically, after the Steps S13 to S19 in the fourth process, the same operations performed in Steps S13 to S19 are performed on a fourth electrode and following electrodes (not shown).

WHAT IS CLAIMED IS:

1. An arc starting method of multiple-electrode one-side welding equipment for performing arc welding on weld materials using two or more electrodes mounted to a welding carriage, the electrodes being wires that are fed, the method comprising:

a first process of setting an arc generation auxiliary material at a first electrode serving as a leading electrode among the two or more electrodes;

a second process of causing the first electrode to generate an arc at the weld materials and causing the welding carriage to move immediately thereafter; and

a third process of controlling wire feeding in three stages including a first stage, a second stage, and a third stage,

wherein, in the first stage, a second electrode serving as a trailed electrode of the first electrode among the two or more electrodes is caused to generate an arc at a partially solidified molten pool formed on the weld materials using the first electrode, and the wire serving as the second electrode is fed at a slow-down speed that is lower than an ordinary speed before the arc is generated until the wire serving as the second electrode comes into contact with the partially solidified molten pool,

wherein, in the second stage, the feeding of the wire serving as the second electrode is stopped from immediately after the wire serving as the second electrode comes into contact with the partially solidified molten pool to when the arc is generated, and

wherein, in the third stage, after the arc is generated, the wire serving as the second electrode is fed at the ordinary speed that varies in accordance with a variation in a voltage value of the wire serving as the second electrode.

2. The arc starting method according to Claim 1, wherein three or more of the electrodes are used, and

wherein the arc starting method further comprises a fourth process of causing a third electrode and/or a following electrode or following electrodes serving as trailed electrodes of the second electrode among the three or more electrodes to generate arcs at partially solidified molten pools formed on the weld materials using respective preceding electrodes of the third electrode and the following electrode or the following electrodes, and of controlling feeding of the wires serving as the third electrode and the following electrode or the following electrodes in the three stages including the first to third stages.

3. Multiple-electrode one-side welding equipment for performing arc welding on weld materials, comprising:

a plurality of electrodes;

an electrode power supply section that supplies power to the electrodes;

a wire feeding section that feeds wires serving as the electrodes;

a welding carriage to which the electrodes are mounted; carriage moving means for moving the welding carriage along a welding line of the weld materials; and

a controller including a welding power supply processing section that controls the power supplied to the electrodes, a wire feeding processing section that controls feeding speeds of the wires, and a carriage movement processing section that controls movement of the welding carriage,

wherein the wire feeding processing section performs the control in three stages including a first stage, a second stage, and a third stage,

wherein, in the first stage, the wire feeding processing section causes a next one of the electrodes in relation to a leading one of the electrodes to generate an arc at a partially solidified molten pool formed on the weld materials using the leading one of the electrodes, and causes the wire serving as the next one of the electrodes in

relation to the leading one of the electrodes to be fed at a slow-down speed that is lower than an ordinary speed before the arc is generated until the wire serving as the next one of the electrodes comes into contact with the partially solidified molten pool,

wherein, in the second stage, the wire feeding processing section causes the feeding of the wire serving as the next one of the electrodes to be stopped from immediately after the wire serving as the next one of the electrodes comes into contact with the partially solidified molten pool to when the arc is generated, and

wherein, in the third stage, after the arc is generated, the wire feeding processing section causes the wire serving as the next one of the electrodes to be fed at the ordinary speed that varies in accordance with a variation in a voltage value of the wire serving as the next one of the electrodes.