

METHOD AND APPARATUS FOR CONTROLLING A
PENETRATION BEAD IN ONE-SIDE WELDING

The present invention relates to a method of controlling a penetration bead in one-side welding which is capable of always ensuring an excellent penetration bead shape irrespective of variations in the conditions of a groove, and also relates to an apparatus for performing the method.

Automatic one-side welding is a welding method so designed that, in the butt-welding of base metals, a sufficient weld penetration is provided by welding the workpieces from their surface side without turning them over, and also such that welding is effected efficiently and economically. Thus, this welding method is widely used for example in the backing-strip welding of large steel plates such as shipbuilding steel products.

In automatic one-side welding, the conditions in the welding groove of the workpieces, i.e. the groove shape, the root gap, etc., must always be constant for the production of an excellent penetration bead.

However, there is a disadvantage that the end faces of the workpieces tend to become nonuniform due, for example, to the occurrence of thermal deformation during their cutting and therefore the groove conditions are not always constant, thus causing nonuniformity in the penetration beads after the welding.

It is the primary object of the present invention to provide a method and apparatus for controlling a penetration bead in one-side welding which overcome the foregoing deficiencies of the conventional automatic one-side welding methods and are capable of making uniform the width of a penetration bead even if the groove conditions are not constant.

To accomplish the above object, in accordance with the invention, there is thus provided a method of controll-

ing a penetration bead in one-side welding which ensures a uniform penetration bead width through the following steps:

- 5 (a) an inorganic material is arranged on a metal plate;
- (b) the inorganic material is held in close contact with the back of the workpieces by means of the metal plate;
- 10 (c) a signal generator for generating an electric signal which is different in frequency, current and voltage characteristics from a welding power source is connected to the workpieces and the metal plate;
- 15 (d) the step of one-side welding is effected while applying an electric signal from the signal generator across the workpieces and the metal plate;
- 20 (e) during one-side welding, either one or both of the voltage and current generated between the workpieces and the metal plate by the electric signal are detected to obtain an electric impedance at and around the generation point of the arc during the welding step;
- 25 (f) such welding parameters as the welding current, arc voltage, welding speed or wire extension is controlled so as to maintain the electric impedance constant.

Also, penetration bead control apparatus for one-side welding according to the invention includes a welding
30 power source, a signal generator, a signal detector, a band-pass filter, a converter, a filter, reference signal setting means, a comparator and an integrator.

The signal generator is connected to the workpieces and a metal plate placed in close contact with the back
35 of the workpieces through an inorganic material, and an electric signal which is different in frequency, current and voltage characteristics from the welding power source

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is applied across the workpieces and the metal plate.

The band-pass filter passes the detection signal from the signal generator only for the desired frequency.

5 The converter converts the ac signal passed through the band-pass filter to a dc signal. The filter eliminates the noise included in the dc signal generated from the converter.

10 The reference signal setting means establishes a reference signal predetermined in accordance with the desired penetration bead width.

The comparator compares the dc signal generated from the filter and the reference signal generated from the reference signal setting means and generates the resulting difference signal.

15 The integrator integrates the difference signal generated from the comparator and applies its output signal to the welding power source.

20 The welding power source controls the welding parameter in such a manner that the output signal from the integrator is reduced to zero and the width of a penetration width during the one-side welding is made uniform.

25 In one embodiment of the present invention, a method and apparatus are provided in which a 200 Hz frequency oscillator of a constant-current characteristic is used as a signal generator and during the welding the ac voltage between the workpieces and a metal plate is detected, converted to a dc voltage and then compared with a reference voltage thereby controlling the width of a penetration bead to become uniform.

30 In accordance with the invention, by utilizing the fact that there is an excellent correlation between a penetration bead width and a signal voltage or current produced across the workpieces and a metal plate by an electric signal applied from a signal generator across
35 the workpieces and the metal plate during welding, the welding parameter is controlled in such a manner that the signal voltage or current across the workpieces and

the metal plate is maintained constant and the penetration bead width is made uniform thereby ensuring a uniform penetration bead shape irrespective of variations in the groove conditions. Further, it is possible easily to ensure a uniform penetration bead width by an on-line operation and therefore it is possible considerably to increase the efficiency of the welding operation of large steel plates.

The above and other objects, features and advantages of the invention will become more clear from the following description taken in conjunction with the accompanying drawing, in which:

Fig. 1 is a schematic diagram for explaining the principle of one-side welding by the submerged arc welding technique, employing two electrodes to complete the welding in a single pass, that is, an embodiment of the invention;

Fig. 2 is a characteristic diagram showing the relation between the detection voltage across the workpieces and the backing copper plate and the penetration bead width; and

Fig. 3 is a block diagram showing a penetration bead control apparatus according to the invention.

Referring now to Fig. 1, numeral 1 designates workpieces, 2 a backing flux consisting of an inorganic material and held in close contact with the back of the workpieces 1 by a backing copper plate 3, 4A and 4B electrodes, 5A and 5B welding power sources each having a frequency of 50 Hz or 60 Hz, and 12 a signal generator. The signal generator comprises a frequency oscillator having a constant-current characteristic and a frequency of 200 Hz differing from the welding sources 5A and 5B. Numeral 6 designates a voltage detector for detecting the voltage between the workpieces 1 and the backing copper plate 3.

In the illustrated one-side welding, during the starting period of the welding where no penetration bead is formed, the electric impedance between the workpieces 1 and the backing copper plate 3 is extremely high so

that even if an electric signal is applied across the workpieces 1 and the backing copper plate 3 from the signal generator 12, practically no signal current flows and thus the no-load voltage of the frequency oscillator is
5 detected as a signal voltage.

After welding has started, if a satisfactory penetration bead is formed, the signal current from the frequency oscillator flows. Because it is considered that, where the penetration bead is formed satisfactorily, a
10 keyhole is formed in each workpiece 1 just below the arc generation point, the arcs reach the backing copper plate 3 through the keyholes and therefore an electric conduction state is established between the workpieces 1 and the backing copper plate 3. Another cause is the fact that
15 the backing flux 2 is heated by the welding heat input and a part of it forms a molten slag thus decreasing the electric resistance.

The inventors of the present application have obtained the characteristic shown in Fig. 2 by connecting
20 the signal generator 12 comprising a frequency oscillator having a frequency of 200 Hz and a constant-current characteristic to the workpieces 1 and the backing copper plate 3 and examining the relation between the electric conduction state between the workpieces 1 and the backing copper plate 3

1 and the penetration bead width in the condition where the
penetration bead was formed. In the characteristic diagram
of Fig. 2, the abscissa represents the penetration bead
width (mm) and the ordinate represents the detection voltage
5 V (volt) detected by the voltage detector 6.

While, in Fig. 2, the ordinate represents the detection
voltage V, if I represents the current, the electric
impedance Z in the electric conduction state is expressed as
follows:

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$$Z = V/I$$

In the present embodiment, the signal generator 12 comprises
a frequency oscillator of a constant-current characteristic
so that the current I is constant and there holds $Z = K \cdot V$
or $V = K' \cdot Z$ (where K and K' are constants). As a result,
15 when the constant current is supplied, the detection
voltage V is directly proportional to the electric impedance
Z and thus it represents the electric impedance Z.

As will be seen from Fig. 2, there is an excellent
correlation between the detection voltage V across the base
20 metals 1 and the backing copper plate 3 and the penetration
bead width.

Consequently, by controlling the welding parameter so
that the detection voltage V or the electric impedance Z
is maintained constant, it is possible to obtain a given
25 penetration bead width.

Fig. 3 is a block diagram showing an example of a
control apparatus for controlling the welding parameter
such that the detection voltage V is maintained constant as
mentioned previously. As shown in Fig. 3, the detection

voltage V between the workpieces 1 and the backing copper plate 3 detected by the voltage detector 6 is passed through a band-pass filter 13 which passes only the output frequency of the frequency oscillator and thus the ac signal of 200 Hz is applied to a converter 7 which in turn converts it to a dc signal. The voltage signal generated from the converter 7 is passed through a filter 8 for noise elimination and then applied to a comparator 9. The voltage signal applied to the comparator 9 is compared with a reference voltage signal preset in reference voltage setting means 10 in correspondence to a given penetration bead width on the basis of the correlation between the penetration bead width and the voltage across the workpieces 1 and the backing copper plate 3. The comparator 9 applies the difference signal between the voltage signals to the welding power source 5A through an integrator 11. The welding power source 5A controls the welding current in such a manner that the applied difference signal is reduced to zero. In other words, the welding current is controlled so that the voltage signal between the workpieces 1 and the backing copper plate 3 and the reference voltage signal 10 always become equal to each other.

By thus controlling so as to always maintain constant the voltage V generated between the workpieces 1 and the backing copper plate 3 by the electric signal from the signal generator 12, it is possible to effect one-side welding with a penetration bead of a given width corresponding to the voltage V thus making it possible easily to control the penetration bead width.

While, in this embodiment, the signal generator 12 comprises a 200 Hz frequency oscillator of a constant-current characteristic, any desired frequency may be used provided that it is distinguishable from the frequency of the welding power source and also the signal may be a dc signal. Of course, the signal generator need not

be of a constant-current characteristic provided that an electric impedance is provided between the workpieces 1 and the backing copper plate 3.

5 Further, while, in this embodiment, the welding current to the electrode 4A is controlled, it is needless to say that any other welding parameter than the welding current can be used provided that it is effective in the formation of a penetration bead. For example, any one of the arc voltage, the welding speed, the wire extension, 10 etc., or any combination thereof may be used for the control of the penetration bead width.

Still further, the invention can be applied to other welding methods besides the submerged arc welding, i.e., gas-shielded arc welding employing a consumable 15 electrode.

CLAIMS:

1. A one-side welding method for welding a pair of workpieces from one surface side thereof by arranging an inorganic material on a metal plate and attaching said metal plate to the back of said workpieces through said inorganic material, the method being characterised by a penetration bead control method comprising the steps of:

- 10 (a) connecting to said workpieces and said metal plate a signal generator for generating an electric signal which is different in frequency, current and voltage characteristics from the welding power source;
- (b) effecting one-side welding of said workpieces while applying the electric signal from said signal generator across said workpieces and said metal plate;
- 15 (c) detecting either one or both of a voltage and current generated between said workpieces and said metal plate by said electric signal during said one-side welding to obtain an electric impedance at and around a point of generation of an arc during said welding;
- 20 (d) controlling a welding parameter (such as a welding current, arc voltage, welding speed or wire extension) so as to maintain said electric impedance constant.

25 2. A penetration bead control apparatus for use in one-side welding for welding a pair of workpieces from one surface side thereof by arranging an inorganic material on a metal plate and attaching said metal plate to the back of said workpieces through said inorganic material, said apparatus comprising:

30 a signal generator connected to said workpieces and said metal plate to apply across said workpieces and said metal plate an electric signal different in frequency, current and voltage characteristics from a welding power source;

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a signal detector connected to said workpieces and said metal plate to detect either one or both of a voltage and current generated between said workpieces and said metal plate by the electric signal from said signal generator during welding;

a band-pass filter for passing only a detection signal of a predetermined frequency detected by said signal detector;

a converter for converting an ac signal passed through said band-pass filter to a dc signal;

a filter for eliminating noise in the dc signal generated from said converter;

reference signal setting means for setting a reference signal predetermined in accordance with a desired penetration bead width;

a comparator for comparing the dc signal generated from said filter and the reference signal generated from said reference signal setting means to generate a difference signal;

an integrator for integrating the difference signal generated from said comparator; and

said welding power source for receiving an output signal from said integrator to control a welding parameter (such as a welding current, arc voltage, welding speed or wire extension) and thereby to reduce said integrator output signal to zero.

3. A penetration bead control apparatus according to claim 2, wherein said welding power source comprises a power source having a frequency of 50 Hz or 60 Hz, and wherein said signal generator comprises a frequency oscillator having a frequency of 200 Hz and a constant-current characteristic.

