

PATENT SPECIFICATION

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(54) PLASMA-ARC CUTTING METHODS AND PLASMA-ARC CUTTING MACHINES

(71) We, NAOYOSHI HOSODA of 2-20-18 Denenchofu, Ota-ku, Tokyo, Japan and TAKESHI HOSODA, 2-22-7 Wakabayashi, Setagaya-ku, Tokyo, Japan, both Japanese citizens, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to plasma-arc cutting methods, and to plasma-arc cutting machines for use in the performance of such methods.

A conventional plasma-arc cutting machine includes a nozzle that in operation of the machine is maintained spaced from the surface of the metal workpiece to be cut. The electrode of the machine is arranged at a fixed position with respect to the nozzle, the distance between the electrode and the metal workpiece being dependent directly on the distance between the end of the nozzle and the surface of the workpiece. The distance between the electrode and such surface should be maintained within a certain range so as to obtain a stable plasma-arc. Consequently, it requires a great deal of skill to operate a conventional plasma-arc cutting machine. Also the operator must watch the end of the nozzle in order to maintain its proper distance from the workpiece, and because of the intense light generated by the arc, it is necessary for him to wear a very dark eye shield.

Furthermore, it is known that the diameter of the opening cut in the workpiece is about twice as large as the diameter of the nozzle when the optimum distance between the nozzle and the workpiece is maintained. However, if the diameter of the nozzle is made smaller so as to reduce the diameter of the opening cut in the workpiece, at a certain point there results a series arc which is generated via the nozzle. Accordingly, it is impossible to make the diameter of the cut opening as small as one wishes, by reducing the diameter of the nozzle.

It is one object of the present invention to provide a plasma-arc cutting method free

from one more of the above-mentioned disadvantages.

According to one aspect of the present invention there is provided a plasma-arc cutting method wherein a metal workpiece is cut by an arc that extends from an electrode within a nozzle, and wherein the end of the nozzle is contacted with the workpiece and maintained in such contact during cutting.

According to another aspect of the present invention a plasma-arc cutting method comprises contacting the end of a nozzle with a metal workpiece and spacing an electrode located within the nozzle away from the workpiece; striking an arc from the electrode to the workpiece through the nozzle end; increasing the distance between the electrode and the workpiece after the arc has been struck; and maintaining the nozzle end in contact with the workpiece during cutting of the workpiece by the arc.

The nozzle for use in the method may have its end which contacts the workpiece grooved to enable escape of gas from the nozzle when contacting the workpiece.

It is another object of the present invention to provide a plasma-arc cutting machine that may be used for performance of the method, and in this respect there is provided a plasma-arc cutting machine comprising an electrode located within a nozzle and an electrical device arranged to respond to the condition in which an electrical circuit is completed between the nozzle and a workpiece to be cut when the end of the nozzle is brought into contact with the workpiece to apply voltage between the electrode and such workpiece so as to strike an arc therebetween.

A method of plasma-arc cutting, and a plasma-arc cutting machine together with a nozzle for use in the performance of the method, all in accordance with the present invention, will now be described, by way of example, with reference to the accompanying drawing in which:-

Figure 1 is a sectional view of the nozzle of a conventional plasma-arc cutting machine;

Figure 2 is a sectional view of the nozzle of the plasma-arc cutting machine used in per-

formance of the method according to the present invention;

Figure 3 is a schematic view of a plasma-arc and an associated wall member, to which reference is made by way of explanation; and

Figure 4 provides a schematic representation of the electric circuit of a control arrangement that may be used for the plasma-arc cutting machine of Figure 2.

Referring to the drawing, Figure 1 shows the essential part of a conventional plasma-arc cutting machine. As the cutting machine 1 is operated, the nozzle end 2 is separated by a certain gap L from the surface 4 of a metal workpiece 3 which is to be cut.

The distance L' between the electrode and the workpiece 3 depends on the distance L between the nozzle end 2 and the workpiece 3. This distance L' between the electrode and the workpiece 3 should be maintained within a certain range so as to obtain a stable plasma-arc 5. Accordingly, it requires a great deal of skill to operate such a plasma-arc cutting machine.

When an operator uses this cutting machine, he watches the nozzle end 2 in order to maintain the proper distance L between the nozzle end 2 and the surface 4 of the workpiece 3. Thus, because the intense light generated by the arc 5 inevitably shines into his eyes, he requires an eye shield.

Furthermore, it is known that the diameter D of the opening 6 cut in the workpiece 3 is about twice as large as the diameter D' of the nozzle when the optimum distance between the nozzle 2 and the metal workpiece 3 is maintained. However, as explained above, the size of the opening 6 cannot arbitrarily be reduced by reducing the size of the nozzle D' , since at a certain point a serious arcing problem occurs.

Figure 2 shows the essential part of a plasma-arc cutting machine 11 of the present invention, corresponding to the part illustrated in Figure 1 of the prior-art machine.

Referring to Figure 2, the end 14 of the metal nozzle 13 is in this case contacted with a surface 16 of the metal workpiece 15. The cathode electrode 17 is then brought towards the workpiece 15 while a flow of argon gas is maintained through the nozzle 13. This results in the striking of an arc 12 between the electrode 17 and a first anode point 18. Nitrogen gas is now added to the flow of argon gas - the gas flow speed itself may be changed - and the electrode 17 is moved away from the surface 16 to establish the proper electrode distance 1 for cutting. The nozzle 13 is then moved along the metal surface 16, keeping it in contact therewith, thereby cutting the workpiece along the track followed by the nozzle.

Radially-extending escape grooves 19 of an inverted U-section are provided in the nozzle end 14 for venting the gas from the

nozzle 13 while the end 14 is maintained in contact with the workpiece.

During the cutting of the workpiece 15, the range of motion of the anode point 18 formed on the workpiece 15 does not expand beyond the nozzle diameter d and no transfer of the anode point 18 to the nozzle 13 occurs. This is an engineering fact, and is not fully understood, but is believed to be a consequence of the thermal pinch effect of the nozzle 13. It can be illustrated in another way as shown in Figure 3.

Figure 3 shows a representative part of the side wall 33 of the electrically-conductive nozzle 13 and a cathode electrode 37. The side wall 33 is in electrical contact with the metal workpiece 35, and is at a fairly large radial distance r_1 from the cathode 37. It is found that the anode point 38 formed on the workpiece 35 by the arc 32 wanders, and the arc 32 spreads out like a shower, as shown by the dotted lines in Figure 3.

Now, if the nozzle 13 is changed for a smaller one - that is, one which has a smaller internal radius r_2 - as indicated by the two dotted lines in Fig. 3, and the electrical contact of the nozzle 13 with the workpiece 35 is maintained, it is found that the anode point 38 does not transfer to the wall member 33. Instead, the arc shower 32 is contracted, as shown by the two-dotted lines in Fig. 3. However, if the electrical contact of the nozzle 13 and the workpiece 35 is broken, so that they are electrically isolated from one another, a series arc is generated via the wall member 33 between the cathode 37 and the workpiece 35.

With the method described above with reference to Figure 2, nitrogen gas is mixed into the stream of argon gas while the workpiece 15 is being cut. This enhances migration of the anode point 13 through the thickness of the workpiece 15 around the cavity being cut. Accordingly thick metal workpieces may be cut readily.

Since the nozzle end 14 contacts the metal workpiece 15 and surrounds the anode point 18, the anode point 18 cannot wander outwardly on the workpiece beyond the nozzle. Hence an opening having a diameter d' almost the same as the nozzle diameter d , is obtained. The cutting width is thus reduced by half compared with that of a conventional process. In other words, the cutting efficiency increases, and therefore the temperature rise of the workpiece is lower. Distortion of the workpiece caused by heat when cutting is thus also much reduced - consequently thin metal workpieces may be readily cut and even those which heretofore it has been difficult to cut using a plasma arc.

In Figure 4 there is shown a control arrangement for the plasma-arc cutting machine of the present invention. The control arrangement includes a relay device 20

which is actuated by the contacting of the nozzle 13 with the workpiece. Actuation of the relay device 20 causes the contacts 21 to close and establish thereby a connection to the cathode electrode 17 by which voltage is applied from an electric current source 22 between the cathode electrode 17 and the workpiece 15. This causes the arc 18 to be struck, so that the plasma-arc cutting is started.

The relay device 20 may be further arranged to actuate a control device (not shown) which automatically adjusts appropriately the time for generating the arc and which also automatically withdraws the electrode 17 so as to increase the distance between the electrode 17 and the workpiece 15 appropriately for the cutting operation.

From the above description it will be readily understood that according to the present invention there is provided a plasma-arc cutting machine which is easily operated without emission of intense light, which requires little skill, which makes a cut of reduced width and accordingly is of greater practical efficiency, and which minimises the temperature rise of the workpiece so as more readily to process thin base metal. In view of the abovementioned facts, a small-size pencil-type plasma-arc cutting machine can readily be provided. Further, since it is easy to maintain the distance between the electrode and the workpiece, this method may be conveniently applied to an automatic plasma-arc cutting machine which is numerically controlled by computer.

WHAT WE CLAIM IS:-

1. A plasma-arc cutting method in which a metal workpiece is cut by an arc that extends from an electrode within a nozzle, and wherein the end of the nozzle is contacted with the workpiece and maintained in such contact during cutting.

2. A plasma-arc cutting method comprising:- contacting the end of a nozzle with a metal workpiece and spacing an electrode located within the nozzle away from the workpiece; striking an arc from the electrode to the workpiece through the nozzle end; increasing the distance between the electrode and the workpiece after the arc has been struck; and maintaining the nozzle end in contact with the workpiece during cutting of the workpiece by the arc.

3. A plasma-arc cutting method accord-

ing to Claim 1 or Claim 2 wherein argon is caused to flow through the nozzle when the arc is being struck, whereas a mixture of argon and nitrogen is caused to flow there-through while the workpiece is being cut.

4. A plasma-arc cutting method according to any one of the preceding claims, wherein the arc is struck by application of voltage from an electric current source by means of a device that is arranged to be actuated by the contacting of the nozzle with the workpiece.

5. A plasma arc cutting method according to any one of the preceding claims, wherein said nozzle end is grooved to enable escape of gas from the nozzle when said end is contacting the workpiece.

6. A plasma-arc cutting method substantially as hereinbefore described with reference to Figure 2 of the accompanying drawing.

7. A plasma-arc cutting method according to Claim 6 and utilizing an arrangement substantially as hereinbefore described with reference to Figure 4 of the accompanying drawing.

8. A plasma-arc cutting machine comprising an electrode located within a nozzle and an electrical device arranged to respond to the condition in which an electrical circuit is completed between the nozzle and a workpiece to be cut when the end of the nozzle is brought into contact with the workpiece, to apply voltage between the electrode and such workpiece so as to strike an arc there-between.

9. A plasma-arc cutting machine according to Claim 8, wherein the end of the nozzle for contacting the workpiece is grooved to enable escape of gas from the nozzle when said end is contacting the workpiece.

10. A plasma-arc cutting machine substantially as hereinbefore described with reference to Figure 2 of the accompanying drawing.

11. A plasma-arc cutting machine substantially as hereinbefore described with reference to Figures 2 and 4 of the accompanying drawing.

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