ABSTRACT: An arc spray gun is provided for melting the ends of two electrically isolated metal wires in an electric arc struck between their ends and spraying the molten metal onto a work piece to be coated, for example, and includes a pair of hollow electrodes connected to a source of electric current, two pairs of wire feed rollers for feeding a metal wire through each of the electrodes, an air jet nozzle positioned adjacent the ends of the electrodes and connected to a source of compressed air and the ends of the electrodes being fixedly secured relative to each other and the air jet nozzle to insure proper contact of the wires for arc formation and uniform atomization of the molten metal. A plenum chamber surrounding the electrodes and the air jet nozzle, and connected to a source of compressed air is also provided. The chamber has a spray opening and is adapted to feed a stream of annular air about the electrodes and the air jet nozzle which flows out through the spray opening resulting in control of the spray pattern and coating metallurgy.
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ELECTRIC ARC METAL SPRAY GUN

This invention relates to an improved arc spray gun for melting the ends of two metal wires in an electric arc and spraying molten metal onto a workpiece to be coated. More particularly, the invention relates to an improved arc spray gun which provides reliable, mutual contact of the two metalizing wires for proper arc formation, uniform atomization of the molten metal, a controlled spray pattern for the molten metal and improved metal coatings such as those obtained with a wire flame spray gun such as that shown and described in U.S. Pat. No. 3,148,818.

BACKGROUND

Electric arc metal spray guns are well known in the art. However, several problems have arisen from the use of such guns. For instance, long electrodes are used to insure proper wire contact. These electrodes are usually supported only at the rear end and because of their long, unsupported length, they occasionally get knocked out of line which results in inefficient arcing or a complete failure to obtain arcing. Also, in prior art guns, the spraying air is directed directly at the arc in the form of a narrow jet of air or a blast of air which completely surrounds the wires such as air forced through a converging conical nozzle with the arcing wires positioned in the nozzle throat. Both of these arrangements are undesirable since they disturb the arc between the wires and interfere with uniform melting of the wires. This results in nonuniform and poor quality coatings.

Another problem associated with arc spray guns resides in rapid wearing of the electrodes which are generally made from a soft, highly conductive metal such as copper or aluminium. To overcome the problem, hard metal bushings of low conductivity (such as steel) have been used at the front ends of the electrodes. However, this has resulted in welding of the wires to the bushings because of poor current distribution along the electrodes and current concentration in the area of the bushings.

A third problem met with arc spray guns involves explosive starts. When an arc gun is shut down the two metal wires end up touching each other. When the gun is started up again, a first explosion takes place because the wires are in contact and a second explosion takes place when the arc is reestablished.

SUMMARY

The present invention overcomes the problems encountered with prior arc spray guns and provides an improved arc spray gun for melting the ends of two metal wires in an electric arc and spraying molten metal which comprises a pair of hollow electrodes connected to a source of electric current, so means for feeding a metal wire through each of the electrodes, an air jet nozzle positioned adjacent the ends of the electrodes, and connected to a source of compressed air, and the ends of the electrodes being fixedly secured relative to each other and to the air jet nozzle to insure proper contact for arc formation and uniform atomization of the molten metal. In a preferred embodiment the air jet nozzle comprises two air jets parallel to each other and to the longitudinal axis of the gun which are positioned above and below the point of contact and arcing between the metal wires. In another embodiment the electrodes and the air jet nozzle are enclosed in a chamber connected to a source of compressed air and having a spray opening. This chamber is adapted to feed annular air about the electrodes and the air jet nozzle which flows out through the spray opening.

THE DRAWINGS

FIG. 1 is a side view, partially in vertical section, of a spray gun of this invention.

FIG. 2 is a top view, partially in horizontal section, of the spray gun of FIG. 1.

FIG. 3 is a front view on an enlarged scale, partially broken away, of the spray gun of FIG. 1.

FIG. 4 is a side view, partially in vertical section, of an insulated drive shaft used in the spray gun of FIG. 1.

FIG. 5 is a vertical sectional view on an enlarged scale of an electrode tip used in the spray gun of FIG. 1.

FIG. 6 is an exploded perspective view showing the mounting and drive of one pair of wire feed wheels of the spray gun of FIG. 1.

DESCRIPTION

The invention will now be described in detail with reference to the embodiments shown in the accompanying drawings which are provided by way of illustration and not limitation.

As shown in FIGS. 1, 2 and 3, the spray gun of this invention includes a gun body indicated generally by reference numeral 1 which is compressed of a drive housing block 7, block 6 forward of an mounted to block 7, a lower handle 24 and an upper circular handle 21; a mounting post 3; an electrode housing 4 and a spray shield 5. An air turbine 24 is mounted on gun body 1 by means of plate 25 and has a turbine wheel 34 which rotates on a shaft extending through block 7 and terminating at cap 29 (FIG. 1). For convenience, switch housing 88 is mounted on the gun body 1, for controlling the flow of current and compressed air to the spray gun. If desired, the switch means may be detached from the gun for remote control.

The wires to be melted in the arc are initially fed through the gun from the rear through a pair of rear wire guide tubes one of which is shown in FIGS. 1 by reference number 26. Rear wire guide tube 26 may progressively decrease in diameter as shown in FIG. 1 or may be constant in diameter. Surrounding the rear wire guide tubes are covers 27 and 27 onto which are screwed wire intake sleeves 28 and 28 (FIG. 1 and FIG. 2), both of which are made from a suitable insulating material such as rubber or a polymeric material. Forward of the rear wire guide tubes are forward wire guide tubes 22, 23 and 22', 23'.

As shown in FIG. 2, mounted in housing 4 are a pair of electrodes 12 and 12' which are secured at their rear ends by electrode clamps 11 and 11'. The forward tubes 22, 22' and 23' are positioned to guide wire into the rear electrodes 12 and 12'. The clamps carry electrical connector posts 9 and 9' each having a pair of connectors 10 and 10' for making the necessary electrical hook up (FIGS. 1 and 3). Mounted between and in the same horizontal plane as electrodes 12 and 12' is air tube 14 in communication at its back end with passages 20 and 21 in block 6 and terminating at its front end in air jet nozzle 15. Chamber 8 in housing 4 surrounds the electrodes 12 and 12' and air jet nozzle 15 and terminates at its forward end at cap 21 having spray opening 21' therein (FIG. 3). As shown more clearly in FIG. 3, air jet nozzle 15 is provided with two semi-circular fins on each side thereof in which the tips of electrodes 12 and 12' rest and are fixedly secured therein by eccentric cams 16 and 16' which rotate about cam screws 17 and 17', respectively (FIG. 2).

Located in the front tips of electrodes 12 and 12' are hard metal annular bushings, one of which is shown in section in FIG. 5 by reference numeral 18. It is positioned well back from the exit end of the electrode, with the remaining space to the front tip of the electrode filled with an annular spacer of high-conductivity metal, 19.

Means for feeding wire through each of the electrodes 12 and 12' are located in block 7. Positioned between each of the rear and forward wire guide tubes (FIG. 1) is a pair of wire feed rollers, one pair being shown in FIG. 1 by reference numerals 30 and 31. A gear 32 is connected along side of roller 30 and a corresponding gear 33 is connected along side of roller 31. As shown in FIG. 4, roller 30 and corresponding roller 30' are connected to a common drive shaft 80 which is driven by a suitable drive such as an electric motor or a gas turbine, for example. The gears 32 and 33 (FIG. 1) mesh so that in effect gear 33 is driven by gear 32 which in turn drives roller 31. Thus, both pairs of wire feed rollers may be considered to be positively driven.

As shown in FIG. 6, the drive is provided by means of a turbine wheel 34. This turbine wheel is driven by a jet of gas directed thereagainst from a nozzle which is fed from a suita-
ble gas passage connected at 70 to the passage 71 (FIGS. 2 and 3). Connected to the turbine wheel 34 through a shaft 36 which drives worm gear 37 which, in turn, drives worm 38 driving worm gear 35, and thus, rollers 30 and 31' and gears 32 and 32', through the connecting shaft 80 (FIGS. 1 and 6).

The rollers 30 and 30', 31 and 31' are of the conventional and well-known construction being preferably provided with gripping teeth as shown in FIG. 6. Shaft 80 is mounted in suitable fixed bearings in block 7. Rollers 31 and 31' and gears 33 and 33' are each rotatably mounted on shafts 39 and 39', respectively, which are secured in the housing or shells 40 and 40'. The shafts 40 and 40' are pivotally connected to block 7 by means of pivot pins 41 and 41'. When the housings 40 and 40' pivot in a counterclockwise direction, the rollers 31 and 31' are moved toward rollers 30 and 30', and when the housings 40 and 40' are pivoted in a counterclockwise direction, the rollers 31 and 31' move away from the rollers 30 and 30'. The teeth of the gears 32 and 32', 33 and 33' are of such size and pitch that the same may remain meshed over a given adjustment of the distances between the rollers 30 and 31 and 30' and 31'. If desired, adjustable set screws (not shown) may be provided on the forward portions of housings 40 and 40' to contact the upper forward portion of block 7 to limit the degree of pivoting of housings 40 and 40' in a counterclockwise direction.

Referring to FIG. 1, mounted on block 7 behind housing 40 is a pneumatic piston and cylinder arrangement which consists of a piston 43 mounted in cylinder 44 which is screwed onto collar 55 which is in turn screwed to the end of block 45. A piston rod 46 terminating a s a plunger 47 extends through a correspondence bore in block 45. A central portion of the rod 46 between the O-ring seals 48 and 49 has a reduced diameter, and the lateral bore 50 and axial bore 51 (shown in phantom) connect this segment of reduced diameter to the space 50 and 51 of means of the O-ring seals 48 and 49, with the cylinder space 52. A coil spring 53 urges the piston to its retracted position and an adjustment screw 54 limits its rearward travel as urged by spring 53. The space in front on the piston is vented by means of a hole 73. Block 45 is secured to block 7 by means of screws 74 (FIG. 2) and the pivot pin 41 extends through the forward portion of block 7.

Block 45 is provided with a gas flow passage in communication with a similar passage in block 7 (not shown) which is connected to a source of compressed air having suitable valve means for feeding compressed air into the space around rod 46 between O-rings 48 and 49. A suitable valve arrangement for admitting air under pressure through the passages in blocks 7 and 45 and into the space around rod 46 between O-rings 48 and 49 is disclosed in U.S. Pat. No. 3,148,818 issued Sept. 15, 1964.

As is clear from FIG. 2, two pneumatic piston cylinder arrangements, as shown in FIG. 1, are employed in the gun of this invention.

Referring to FIGS. 1, 2, 3 and 4 a source of compressed air is connected at 60 to feed air under pressure through passage 61 into tube 14 and out through parallel air jets 64 in air jet nozzle 15. This is more clearly shown in FIG. 3. Air under pressure also flows from passage 61 through passage 62 out through orifice 63 into chamber 8 for supplying annular air which surrounds electrodes 12 and 12' and nozzle 15 and which flows out through spray opening 21'. Air jets 64 are parallel to each other, and, for purposes of describing the gun, air jets 64 are also parallel to the longitudinal axis of the gun and for purposes of describing the spraying operation, air jets 64 are parallel to the direction of spray. It should also be noted that air jets 64 are positioned above and below a horizontal line drawn through the centers of electrodes 12 and 12' (FIG. 3).

FIG. 4 shows an embodiment of the present invention wherein rollers 30 and 30' and gears 32 and 32' are mounted on a common drive shaft 80 which is driven by worm gear 35. Because electrical current has a tendency to flow back through the wires W and W' during operation of the gun, it is essential that the rollers 30 and 30' and gears 32 and 32' be electrically insulated from each other. A particularly suitable arrangement for accomplishing this is shown in FIG. 4. The shaft 80 is shown threaded at one end and is provided with an insulated threaded adapter 83 at the other end. The adapter 83 facilitates mounting of the shaft 80 in block 7. Surrounding the threaded end of shaft 80 and the threaded end of adapter 83 are insulating caps 82 and 82' which are made from a suitable insulating material such as rubber or a polymeric material. The caps 82 and 82' may be made separately and screwed onto the threaded end of shaft 80 and the threaded end of adapter 83 or they may be molded in place. Threaded over, or molded to insulating caps 82 and 82' are screwed rollers 30 and 30' and gears 32 and 32'.

For safety purposes, the various exterior metal parts may be electrically grounded, as for example the pneumatic actuating devices which are grounded by metal straps 67 attached by a screw 68 in block 45 as is shown in FIGS. 1 and 2.

Block 7 is provided with a continuous metallic electrically insulating material such as a thermosetting or thermoplastic resin. A preferred material for block 7 is a laminated phenolic resin, the use of which minimizes electrical leakage hazards. To prevent overheating of the components mounted in block 7 when the block is made from a poor conductor of heat, it is desirable to provide means for expediting heat away from block 7. This may be accomplished by fabricating the turbine mounting plate 25, shown in FIGS. 2 and 3, from a heat conducting material such as aluminum. To increase heat dissipation by plate 25, one or more aluminum inserts connected to plate 25 and extending into block 7 may be employed.

In operation, metal wires are threaded through the rear guide tubes 26 and 26', which is spaced of rollers 30 and 30' and 30', 31, forward guide tubes 22, 22, and 22', spray molten metal generated by the arc toward the workpiece 54 and 54' on which are screwed rollers 30 and 30' and gears 32 and 32'.
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5 the point of wire contact and arcing, molten metal generated by the arc is effectively sprayed to the workpiece to be coated without disturbing or distorting the arc. Stated in different terms, this means that no molten metal from the periphery of the arc without disturbing or disturbing same. The arc is believed to frequently operate intermittently at high frequency. Apparently the arc is started, melts off the wire faster than it is fed and then extinguishes (or at least diminishes in current flow) and then restarts immediately. The restarting does not necessarily require physical contact of the wire ends since this happens so rapidly that ionized gas still exists adjacent the wire ends. All of this takes place so rapidly that the arc appears to be continuously arcing.

Another, important feature is the annular air stream flowing from chamber 5 around the electrodes 12 and 12' and the air jet nozzle which are in contact in the same horizontal plane. This annular air stream is forced to flow out around this assembly and thus does not disturb or distort the arc. In addition, it is believed that this annular air in combination with the parallel air jets 64 beneficially affects the metallurgy of the metal being sprayed which results in improved metal coatings which approach the quality of metal coatings heretofore only obtainable with wire flame spray guns such as that shown in the aforementioned U.S. Pat. No. 3,148,918. This annular air also promotes uniform, controlled spray pattern, helps tailor the fineness of the molten metal being sprayed and cools the electrodes.

The air bushings described above (FIG. 5) in the electrodes 12 and 12' are another important aspect of this invention. The positioning of the bushing back from the electrode tip and surrounded by high-conductivity metal, front and back, permits uniform current distribution around the bushing, eliminating high current flow through the bushing itself and thereby preventing welding of the spray wire to the bushing.

An additional means for further protection against welding at the bushing involves coating the bushing with a suitable insulating material to isolate it electrically. It is preferably insulated by flame-spraying with ceramic material to coat the outside surfaces. Metal oxides are preferred. An alumina-titania ceramic containing from 10 to 50 percent by weight titania has been found to be especially suitable.

Throughout the foregoing specification and in the appended claims, the term “air” has been used in describing construction and operation of the arc gun of this invention. While air is the most commonly used gas in metal arc spraying, the term itself has been used herein in a descriptive sense and is to be construed as including other suitable gases such as nitrogen, argon, helium and the like.

The present invention has been described in detail with reference to the specific embodiments shown herein. However, as will be apparent to those skilled in the art, various changes and modifications can be made without departing from the spirit and scope of this invention.

What is claimed is:
1. Arc spray gun for melting the ends of two electrically isolated metal wires in an electric arc struck between their ends and spraying molten metal, comprising:
   a. a pair of hollow electrodes connected to a source of current;
   b. means for feeding a metal wire through each of said electrodes;
   c. an air jet nozzle positioned adjacent the ends of said electrodes and connected to a source of compressed air; and
   d. a chamber enclosing said electrodes and said air jet nozzle having a spray opening and being connected to a source of compressed air, said chamber being adapted to feed annular air about said electrodes and said air jet nozzle which flows out through said spray opening without disturbing said arc and
   e. means for fixedly securing the ends of said electrodes relative to each other and said air jet nozzle to insure proper contact for arc formation and uniform atomization of the molten metal.
2. Arc spray gun of claim 1 wherein said air jet nozzle is provided with two seats in which the ends of said electrodes are fixedly secure.
3. Arc spray gun of claim 2 wherein said electrode ends are fixedly secured in said seats by eccentric cams.
4. Arc spray gun of claim 1 wherein air jet nozzle comprises two air jets parallel to each other and to the longitudinal axis of said gun and positioned above and below the point of contact and arcing between said metal wires.
5. Arc spray gun of claim 1 wherein said means for feeding metal wire through each of said electrodes comprises two pairs of wire feed rollers, one roller from each pair being connected to a common drive shaft and electrically insulated from each other.
6. Arc spray gun of claim 5 wherein the other rollers from each pair are each positioned in a housing pivotally mounted for pivoting each roller toward and away from the other roller connected to the common drive shaft, and wherein pneumatic piston cylinders are provided each having a plunger for actuation contact with said housings to pivot the rollers positioned therein in the direction moving them toward the rollers connected to the common drive shaft.
7. Arc spray gun of claim 5 wherein said common drive shaft is gear driven by an air turbine.
8. Arc spray gun of claim 1 which includes switch means for said source of current adapted to supply current to said electrodes after wire feeding stops for a period of time sufficient to melt the ends of said wires so that they are not touching.
9. Arc spray gun for melting the ends of two metal wires in an electric arc struck between the wire ends and spraying molten metal comprising:
   a. a pair of hollow electrodes connected to a source of current;
   b. wire feed roller means for feeding metal wire through each of said electrodes;
   c. an air jet nozzle positioned in the same horizontal plane as and adjacent to the ends of said electrodes and connected to a source of compressed air, said nozzle having two air jets parallel to each other and to the longitudinal axis of said gun and positioned above and below a horizontal line drawn through the centers of said electrodes;
   d. a chamber enclosing said electrodes and said air jet nozzle having a spray opening and being connected to a source of compressed air, said chamber being adapted to feed annular air about said electrodes and said air jet nozzle which flows out through said spray opening; and
   e. means for fixedly securing the ends of said electrodes against said air jet nozzle to insure proper contact of the wires for arc formation.
10. Process for spraying molten metal in a controlled spray pattern which comprises:
   a. feeding and melting the ends of two metal wires in an electric arc struck between the wire ends;
   b. spraying the molten metal without disturbing the arc with two air jets parallel to each other and parallel to the direction of spray and positioned above and below the point of contact and arcing between said metal wires.
11. Process of claim 10 wherein annular air under pressure surrounds said metal wires and said air jets and flows in the direction of spray without disturbing said arc whereby said molten metal is sprayed in a controlled pattern.
12. Process of claim 10 wherein the current causing the electric arc continues to flow after wire feeding stops for a period of time sufficient to melt the ends of said wires so that they are not touching.

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