TITLE

A welding apparatus and a method for welding

TECHNICAL FIELD

The present invention relates to a welding apparatus according to the preamble of claim 1 and to a welding method according to the preamble of claim 19. In particular the invention relates to a welding apparatus for performing twin wire welding where at least two consumable electrodes are connected to a single power source. The at least two consumable electrodes are connected to an output providing the same potential to said at least two consumable electrodes. The invention further relates to a twin wire welding method for such a twin wire welding apparatus.

BACKGROUND OF THE INVENTION

Welding methods and welding apparatuses are continuously being developed for achieving higher deposition rates at maintained or improved weld quality. One way of increasing deposition rates is to use a plurality of electrodes operating in a single welding process in a single weld puddle. Use of a plurality of welding electrodes in a single weld puddle requires that the electrodes are located in a close proximity to each other. Close arrangement of electrode will however lead to interaction between magnetic fields generated by each electrode. This may result in distorted weld results.

Two different approaches for using a plurality of welding electrodes in a single welding process are known, tandem and twin welding.

In tandem welding each electrode is powered via a separate power source. Tandem welding may be advantageous in many applications since the control of power supply to each electrode is facilitated. In tandem welding, the magnetic interference between electrodes may be reduced by supplying phase shifted welding currents to the electrodes. This may be accomplished

which ensures that both wires assumes the same potential. An example of this type of twin wire welding arrangement is disclosed in US5155330.

Even though twin welding methods where consumable electrodes are fed through a common electrically conductive contact element to ensure that both wires assumes the same potential has shown to be beneficial for both gas metal arc welding methods and to submerged arc welding methods, further improvements is desirable in order to improve weld quality as well as increasing the deposition rate in the welding process.

BRIEF DESCRIPTION OF THE INVENTION

An object of the invention is thus to provide a twin wire welding apparatus where the at least two consumable electrodes are connected to a single output providing the same potential, which twin wire welding apparatus enables improvement of weld quality and increase deposition rate. This object is achieved by a twin wire welding apparatus according to claim 1.

Another object of the invention is to provide a twin wire welding method where the at least two consumable electrodes are connected to a single output providing the same potential, which twin wire welding method enables improvement of weld quality and increase deposition rate. This object is achieved by a twin wire welding method according to claim 19.

The inventive twin wire welding apparatus includes a first contact tube for guiding a first consumable electrode toward a weld puddle and transferring welding current to the first consumable electrode, a second contact tube for guiding a second consumable electrode toward said weld puddle and transferring welding current to the second consumable electrode. The twin wire welding apparatus may include more than two contact tubes for enabling twin welding with more than two consumable electrodes. The first and second contact tubes may be formed in a single contact tip as two parallel lead-

throughs in the contact tip, where the consumable electrodes are forced through to enable contact between the power source and the consumable electrode. An arrangement of preferably parallel contact tubes may be arranged in a single contact tip or alternatively be arranged in separate contact tips. The arrangement with more than one contact tube in a single contact tip facilitates parallel arrangement of the consumable electrodes at a close distance, while the use of separate contact tips for housing the contact tubes facilitates arrangement of the contact tubes at an angle with respect to each other.

With separate contact tips is intended that the contact tips are not formed as a monolithic conducting structure containing all the contact tubes. Instead is provided a plurality of separate contact tips each housing a single contact tube. In the event separate contact tips are used, they will be electrically connected to enable all the consumable electrodes to assume the same potential when connected to a single power source. The electrical connection can be provided at the contact tips, at the power source or anywhere in between the contact tip and power source.

The single power source is connected to said first and second contact tubes. This may be achieved by a suitable conductor, such as a cable, connecting the power supply with the contact tube. Hence, welding current will be distributed from the power source to the respective consumable electrode via the contact tubes.

According to the invention, the twin wire welding apparatus further includes a feeding arrangement for feeding a cold wire into a weld puddle formed by arcs created by the first and second consumable electrodes.

The introduction of a cold wire into the weld puddle will enable cooling of the weld puddle to as to maintain the weld puddle at a desired temperature. Reduction of weld puddle temperature may lead to that alloy additives are vaporized to a lesser extent in a zone directly affected by the arcs from the

consumable electrodes. This may lead to improved control of the composition of the weld alloy, which may lead to improved welds. For the purpose of reducing the peak temperatures in the weld puddle as well as maintaining a relatively high deposition rate from the cold wire it is preferable to introduce the cold wire in the vicinity of the arc, preferably in the arc from at least one of the consumable wires. Furthermore, feeding of a cold wire into the weld puddle may lead to an increase in deposition rate above 20%, with a prospect to an increase of productivity of almost 50% with optimized welding parameters. The invention allows for higher deposition rates without increasing the welding speed. Expediently, the invention allows for retrofitting existing welding systems, particularly for welding of large workpieces such as pipe-mills.

According to the invention the feeding arrangement for said cold wire is arranged to feed said cold wire essentially orthogonally into said weld puddle. It has been discovered that oblique introduction of the cold electrode, that is when the cold wire is fed into the weld puddle at an angle with respect to a surface normal of the weld puddle, may lead to variations in the weld process with a deteriorated weld result. It is believed that variations in the height of the work piece has an influence of where the cold wire will enter the weld puddle in relation to an extension of the consumable electrode. Such a variation will have an effect on the melting rate of the cold wire and also of the peak temperature in the weld puddle. By arranging the cold wire so that it is introduced essentially orthogonally to the weld puddle, a more stable welding process is achieved. By orthogonally to the weld puddle is intended a normal to an upper surface of the weld puddle at quiescent undisturbed state. It is understood that the weld puddle will be exposed to oscillations during welding. However, the upper surface of the weld puddle at quiescent undisturbed state would essentially form a plane at the point of introduction of the cold wire into the weld puddle, which plane has to a vector from the tip of a consumable electrode to the closest point of the weld puddle as a normal.

According to a favourable embodiment of the invention, the electrically insulated duct can comprise an electrically insulated wire conduit in the contact device. The insulated wire conduit can be a ceramics tube arranged in the contact device. The ceramics tube can be inserted in the contact device or a part of the contact device can be treated, e.g. oxidized, to form an oxide of sufficient thickness for electrical insulation.

According to a favourable embodiment of the invention, the electrically insulated duct can comprise an electrically insulated portion in a wire straightening unit for straightening one or more of the consumable electrodes and the cold wire. The consumable electrodes and the cold wire can be manipulated in the same wire straightening device.

According to a favourable embodiment of the invention, an individual wire straightening unit can be provided for the cold wire separate from wire straightening units of the consumable electrodes of the electrode assembly. Advantageously, the cold wire can be manipulated independently from the consumable electrodes.

According to a favourable embodiment of the invention, the electrically insulated duct can comprise an electrically insulated portion in a wire feeder unit for feeding consumable electrodes and the cold wire towards a workpiece. The consumable electrodes and the cold wire can be manipulated in the same wire feeder device.

According to a favourable embodiment of the invention, an individual wire feeder unit can be provided for the cold wire separate from wire feeding units of the consumable electrodes of the electrode assembly. Advantageously, the cold wire can be manipulated independently from the consumable electrodes.

According to a favourable embodiment of the invention, an individual speed control unit can be provided for the cold wire separate from speed control unit

of the consumable electrodes of the electrode assembly. Advantageously, the cold wire can be manipulated independently from consumable electrodes.

Favourably, the cold wire can be fed independently from the consumable electrodes in the contact device. This allows for a comfortable control of the welding process. The cold wire electrode, can be fed with a different speed, particularly with a variable speed and/or with a different diameter, independent from the consumable electrodes in the contact device.

According to a favourable embodiment of the invention, the cold wire in the electrically insulated duct can be arranged in sequential order between a leading and a trailing consumable electrode with respect to a welding direction on a workpiece. The order of the cold wire can be used to adjust the welding deposition rate. Such a symmetric arrangement can yield very high deposition rates. The sequential order of the cold wire can be chosen depending on welding requirements.

According to a favourable embodiment of the invention, the cold wire in the electrically insulated duct can be arranged upstream of the consumable electrodes of the electrode assembly with respect to a welding direction on a workpiece. Depending on welding requirements the sequential order of the cold wire can be chosen. The outermost consumable electrodes can be tilted to a desired angle compared to the other electrodes. An asymmetric arrangement particularly allows adjusting such an angle in a straightforward manner.

According to a favourable embodiment of the invention, the cold wire in the electrically insulated duct can be arranged downstream of the other electrodes of the electrode assembly with respect to a welding direction on a workpiece. The sequential order of the cold wire can be chosen depending on welding requirements.

According to a favourable embodiment of the invention, a feeder unit and/or a straightening unit for the consumable electrodes can provide a feedthrough for guiding the cold wire through the feeder unit. Favourably, the cold wire can pass in the feedthrough through the wire straightening unit or the wire feeder unit without interacting with these units or the consumable electrodes. The cold wire can be manipulated independently from the consumable electrodes in the same contact device of the same welding head.

According to another aspect of the invention, a welding head assembly is proposed comprising at least two electric arc-welding welding heads, at least one of which comprises a contact device and a feeding portion, the contact device encompassing an electrode assembly, wherein the electrode assembly comprises at least two consumable continuously-fed wire electrodes arranged in a contact device. An electrically insulated duct is provided for electric insulation of at least one cold wire so that the cold wire is electrically insulated from the consumable electrodes of the electrode assembly. Favourably, such a welding head assembly is a powerful tool for very high deposition rates with reduced heat impact on workpieces. The welding quality can thus be improved.

According to a favourable embodiment of the invention, a first welding head can be arranged in sequential order before a second welding head so that the electrode assemblies of each welding head are aligned along a welding direction during a welding operation in sequential order. The welding head according to the invention allows for a large degree of freedom when designing such a welding head assembly.

According to a favourable embodiment of the invention, an order of the cold wire in each electrode assembly can be the same for each welding head with respect to the consumable electrodes in each electrode assembly. The welding head according to the invention allows for a large degree of freedom when designing such a welding head assembly.

According to a favourable embodiment of the invention, an order of the cold wire in one electrode assembly can be reversed with respect to an order of the cold wire in another electrode assembly of the welding head arrangement. The welding head according to the invention allows for a large degree of freedom when designing such a welding head assembly.

According to a favourable embodiment of the invention, each cold wire can be provided with a wire straightening unit and/or a wire feeder unit separate from wire straightening units and/or feeder units of the consumable electrodes of the electrode assemblies. The cold wires can be manipulated independently from the consumable electrodes and independently in each welding head thus giving a large degree of freedom in adapting welding parameters for particular welding requirements imposed by material and/or geometry and/or ambient conditions of the workpieces to be welded.

According to another aspect of the invention, an electric arc-welding contact device for an electric arc-welding head and/or a welding head assembly is proposed, comprising a device body and an electrically insulated portion for guiding cold wire in an electrically insulated way through the contact device and at least two ducts for at least two consumable electrodes which are in electrical contact with the device body. Favourably, a contact device is provided where one or more cold wires can be employed together with two or more consumable electrodes. The two or more consumable electrodes can be provided for being consumed in arcs during welding whereas the cold wires are not consumed by arcs but are intended to melt in the weld pool during welding. The cold wire can be used with various diameters chosen independently from the consumable electrodes in the contact device.

According to a favourable embodiment of the invention, the electrically insulated portion can comprise an electrically insulating tube. An electrically insulating tube can be easily inserted into the device body. Expediently, the tube can be made of ceramics which provides a superior electrical insulation as well as a good heat resistance.

According to a favourable embodiment of the invention, the device body can be composed of a main part and a removable part which can be attached to the main part. An arrangement of the consumable electrodes and the cold wire in a desired sequential order can be easily achieved or changed.

According to a favourable embodiment of the invention, a tip can provided at one end of the device body which has recesses for receiving the electrically insulating portion for cold wire and ducts for other electrodes. Favourably, the recesses for the consumable electrodes and the electrically insulating portion can be arranged in the grooves of the tip in a defined way and held securely during operation.

According to a favourable embodiment of the invention, the electrically insulating portion can be arranged in a symmetric position between ducts for the consumable electrodes. Favourably, the electrically insulated portion for guiding the cold wire can be arranged between two ducts of the consumable electrodes. Such a symmetric arrangement provides a high deposition rate during welding.

According to a favourable embodiment of the invention, the electrically insulating portion can be arranged in an eccentric position in relation to ducts for the consumable electrodes in the device body.

According to another aspect of the invention, an electric arc-welding system is provided for generating a weld pool in a workpiece, comprising at least one welding head or at least one welding head assembly according to anyone of the features described above. A highly versatile system can be provided which allows for easy adjustment of the welding parameters and conditions.

It is evident that more than two consumable electrodes and/or more than one cold wire may be used in a welding apparatus according to the invention. The

more than two consumable electrodes and/or the more than 1 cold wire can be arranged in the same welding head.

With cold wire is intended an elongated metal structure that is fed into the weld puddle. The cold wire may have any cross section, such as oval, circular, elliptic, rectangular, quadratic, triangular or any other suitable shape. The consumable electrode may in the same manner have any cross-section such as oval, circular, elliptic, rectangular, quadratic, triangular or any other suitable shape.

The invention also relates to a twin wire welding method comprising:
- guiding a first consumable electrode through a first contact tube toward a welding area,
- guiding a second consumable electrode through a first contact tube toward the welding area,
- transferring a welding current to the first and second consumable electrodes from a single power source connected to a first and second consumable electrodes via said first and second contact tubes to maintain a first and a second arc respectively for the generation of a weld puddle, wherein said single power source provides the same potential at said first and second contact tubes. According to the invention a cold wire is fed essentially orthogonally into said weld puddle.

In one embodiment of the invention the method includes directing a protective gas flow toward the weld area common for said first and second consumable electrodes wherein a weld puddle is maintained by said a first and a second arc respectively under the protective gas flow.

The method may also be applied in submerged arc welding.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention together with the above-mentioned and other objects and advantages may best be understood from the following detailed description of the embodiments, but not restricted to the embodiments, wherein is shown schematically:

Fig. 1 a twin wire welding apparatus according to the invention;
Fig1a a weld puddle with a coordinate system indicating a direction for feeding a cold wire into the weld puddle;
Fig. 2 a first view of an example embodiment of an arc-welding welding head according to the invention for submerged arc welding;
Fig. 3 the arc-welding welding head of Fig. 1 turned counterclockwise by 90°;
Fig. 4 a perspective view or the arc-welding head of Fig. 1;
Fig. 5a-5e various views of a contact device for two consumable electrodes and one cold wire with cut open views (Figs. 5a, 5e) and side views (Figs. 5b, 5d) and a front view (Fig. 5c);
Fig. 6 a side view of an example embodiment of an arc-welding welding head
Fig. 7a-7c an arrangement of a cold wire and a consumable electrode in a first electrode assembly comprising two electrodes (Fig. 7a), a second electrode assembly comprising two consumable electrodes with the cold wire being the central electrode (Fig. 7b), and a third electrode assembly comprising two consumable electrodes with the cold wire being at the outside of the electrode assembly (Fig. 7c); and
Fig. 8a-8c an arrangement of two arc-welding welding heads each comprising cold wire and a consumable electrode in a first electrode assembly comprising two electrodes in each welding head (Fig. 8a), a second electrode assembly comprising two consumable electrodes and a cold wire in each welding head, with the cold wire being the central electrode (Fig. 8b), and a third electrode assembly comprising two consumable electrodes and a cold wire in each welding head, with the cold wire being at the outside of the electrode assembly (Fig. 8c).

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

In the drawings, equal or similar elements are referred to by equal reference numerals. The drawings are merely schematic representations, not intended to portray specific parameters of the invention. Moreover, the drawings are intended to depict only typical embodiments of the invention and therefore should not be considered as limiting the scope of the invention.

Figure 1 shows a schematic drawing a twin wire welding apparatus 1 according to the invention. The twin wire welding apparatus includes a first contact tube 2 for guiding a first consumable electrode 4 toward a weld puddle 6. The first contact tube 2 is arranged in a contact tip 8 in a conventional manner. At the contact tube 2 welding current is transferred to the first consumable electrode 4. Further, a second contact tube 10 is arranged in the twin wire welding apparatus 1 for guiding a second consumable electrode 12 toward the weld puddle 6. The second contact tube 10 is arranged in a contact tip 14 in a conventional manner. The first and second contact tips may be arranged in a single body, which may be aggregated by parts, or in separate bodies. At the second contact tube 10, welding current is transferred to the second consumable electrode 12.

A single power source 16 is connected to a contact device 18 including the contact tips 8, 14 and housing the first and second contact tubes 2, 10. The contact device 18 may include separate contact devices 18a, 18b or a common contact device for both contact tips.The single power source 16 provides the same potential to the first and second consumable electrodes 4, 12. The power source may be of any conventional type operable for twin wire welding, such as a welding converter, a welding transformer, a rectifier, a thyristor controlled rectifier or an inverter.

The twin wire welding apparatus 1 further includes a feeding arrangement 20 for feeding a cold wire 22 into the weld puddle 6. The feeding arrangement

includes a tube 22, which is electrically insulated from the first and second contact tips. The cold wire is fed via the tube 22. When welding, an arc will be present at the first and second consumable electrodes 4, 12, but not at the cold wire 22. The cold wire is melted by introduction of the cold wire into the weld puddle 6. Suitably, the cold wire is not connected to any electrical power source and will therefore generally assume a ground potential. However, it may be possible to connect the cold wire to a power source for pre-heating the cold wire. However, the cold wire will not be connected to a power source for the purpose of generating an arc between the cold wire and the work piece. The tube 22, may be a metallic tube that is isolated from the first and second contact tips, or a ceramic tube as in the embodiment of a welding head as described below which is suitable for a twin welding apparatus according to the invention.

The feeding arrangement 20 for said cold wire is arranged to feed said cold wire 22 essentially orthogonally into said weld puddle. In figure 1A is shown a schematic drawing of a weld puddle 6 including a reference coordinate system 26. The reference coordinate system 26 indicates a welding direction x, which is the direction in which the welding head is moved relatively to a work piece 28 in which a weld seam is generated. The reference coordinate system 26 further includes a transverse direction y. The welding direction and the transverse direction form a plane xy which is coplanar with an upper surface 30 of the weld puddle. It is known that the weld puddle may be somewhat agitated during welding. The upper surface at a point of introduction 32 of the cold wire will is considered to be an upper surface 30 of the weld puddle at the point of introduction 32 at quiescent undisturbed state.

This upper surface 30 of the weld puddle at quiescent undisturbed state would form a plane xy at the point of introduction 32 of the cold wire into the weld puddle, which plane xy is normal to a vector 38 from the tip 34 of a consumable electrode to the closest point 36 of the weld puddle.
The reference coordinate system 26 includes a third direction z, which is orthogonal to the plane xy. It is here shown a vector c representing the

direction of introduction of the cold wire into the weld puddle. The vector c should be essentially orthogonal to the plane xy. A perfect co-alignment with the direction z is preferable, however some deviation of the direction of introduction from the direction z may be acceptable. The deviation from perfect alignment is indicated by an angle α. In embodiments of the invention the feeding arrangement is arranged to feed said cold wire into said weld puddle at an angle of less than 15º, preferably less than 5º, still preferably less than 2º with respect to a surface normal. This corresponds to a cone having an opening angle of less than 30º, preferably less than 10º, still preferably less than 4º.

In arc welding an arc is present between the tip of the electrode and the work piece. An arc 40 is shown in figure 1. The contact of the arc at the working piece will be moving in a random manner. However, normally it is assumed that the arc is present within a cone 42 from the tip of the consumable electrode 34 to the weld puddle. The opening angle β of the cone 42 may vary from welding case to welding case. However, a normal opening angle β is around 30º. For this reason it is preferable to locate the cold wire 22 such that it enters the weld puddle in an essentially orthogonal direction thereto at an axial distance D being less than L*cotan (β/2) from the consumable electrode measured at the tip 34 of the consumable electrode. Here L is the arc length, that is the distance from the electrode tip to the closes point 36 of the weld puddle.

It may be preferable to arrange the cold wire 22 in between two consumable wires. The consumable wires may preferably be mounted at an axial distance A being less than a cone diameter d measured at the surface 30 of the weld puddle 6. With this arrangement, the cold wire will be introduced in the outer parts e of the arc area defined by the cones 42 of both consumable electrodes, which has shown to be beneficial for the weld result.

The welding apparatus may include a contact tube spacing mechanism for adjusting a spacing between a respective tip of said first and second contact tubes. The welding apparatus may further include includes a contact tube inclination mechanism for adjusting an inclination between a respective length axis of said first and second contact tubes.

Figures 2 to 4 depict different views of an example embodiment of an electric arc-welding welding head 100 according to the invention for submerged arc welding which views are described in combination.

Along its longitudinal extension the electric arc-welding welding head 100 comprises a contact device 160 at its lower end which during welding is in close proximity to the workpiece to be welded. The contact device 160 holds the electrodes 172, 176 and a cold wire 174 (Figs. 3, 4) of the electrode assembly 170 of the welding head 100. The electrodes 172, 176 and the cold wire 174 exit the contact device 160 through an outlet 162 at the lower end of the contact device 160 which faces the workpiece during the welding operation. The electrodes 172, 176 and the cold wire 174 may be fed from respective reservoirs such as coils (not shown) towards the arc welding head 100.

The electrode assembly 170 comprises by way of example two fusible continuously-fed consumable wire electrodes 172, 176 and a cold wire 174 arranged in the contact device 160. The contact device 160 comprises an electrically insulating portion 166 for the cold wire 174. Only the cold wire 174 is shown along the welding head extension. The consumable electrodes 172, 176 are only shown in the contact device 160. The consumable electrodes 172, 176 are arranged as so called twin wires preferable being fed in parallel as a double wire electrode arrangement. The electrically insulating portion 166 is preferably an extra insulated wire conduit, for instance made of heat resistant material such as ceramics.

electrodes. Close to the contact device 160 a nozzle 116 for a flux hopper 114 (Figs. 2-4) is arranged, the nozzle 116 is fixed to a rod 116 arranged parallel to the longitudinal axis of the contact device 160.

Fig. 7a to 7c display arrangements of electrodes in electrode assemblies 170 with respect to a welding direction 20.

Fig. 7a shows a first variant of an electrode assembly 170 with an electrically insulated cold wire 174 and a non-insulated consumable electrode. This welding head must be combined with a further welding head to include at least two consumable electrodes as is suggested by the invention. A second variant of an electrode assembly 170 is shown in Fig. 7b comprising two consumable electrodes 172, 176 and a cold wire, with the cold wire 174 being the centrally located. A third variant of an electrode assembly 170 comprising two consumable electrodes 172, 176 and a cold wire, with the cold wire 174 being at the outside of the electrode assembly is displayed in Fig. 7c.

Figs. 8a to 8c show arrangements of a welding head assembly 200 comprising two arc-welding welding heads 100a, 100b. Each welding head 100a, 100b comprises an electrode assembly 170a, 170b with cold wire 174a, 174b and one or more consumable electrodes 172a, 172b. In a first variant of a welding head assembly 200 shown in Fig. 8a each welding head 100a, 100b comprises two electrodes 172a, 172b, and two cold wires 174a,174b in each welding head 100a, 100b. The cold wires 174a, 174b are the outermost electrodes in the welding head assembly 200.

A second variant is shown in Fig. 8b, where each welding head 100a, 100b comprises an electrode assembly 170a, 170b with three electrodes 172a, 176a, 172b, 176b, and two cold wires 174a, 174b, wherein the cold wire 174a, 174b is arranged in the middle between the two consumable electrodes 172a, 176a, 172b, 176b as central electrodes of each welding head 100a, 100b.

AMENDED CLAIMS

1) A twin wire welding apparatus (1) including a first contact tube (2) for guiding a first consumable electrode (4) toward a weld puddle (6) and transferring welding current to the first consumable electrode (4), a second contact tube (10) for guiding a second consumable electrode (12) toward said weld puddle (6) and transferring welding current to the second consumable electrode (12), and a single power source (16) connected to said first and second contact tubes (2,10) for providing the same potential to said two consumable electrodes (4,12), characterized in that in that said twin wire welding apparatus (1) further includes a feeding arrangement (20) for feeding a cold wire (22) into said weld puddle which is arranged to feed said cold wire (22) essentially in parallel with a feeding direction of said two consumable electrodes (4, 12).

2) A welding apparatus according to claim 1, characterized in that said feeding arrangement (20) is arranged to feed said cold wire (22) into said weld puddle at an angle of less than 5° with respect to a surface normal.

3) A welding apparatus according to claim 1, characterized said first and second contact tubes (2,10) are formed in separate contact tips (8,14).

4) A welding apparatus according to any of claims 1 - 3, characterized in that the first and second contact tubes (2,10) are connected to said single power source (16) via a first and second contact device (18a, 18b), which are separate for the first and second contact tube (2,10).

5) A welding apparatus according to any of the preceding claims, characterized in that said welding apparatus further includes a contact tube spacing mechanism for adjusting a spacing between a respective

tip of said first and second contact tubes.

6) A welding apparatus according to any of the preceding claims, characterized in that said welding apparatus further includes a contact tube inclination mechanism for adjusting an inclination between a respective length axis of said first and second contact tubes.

7) A welding apparatus according to any of the preceding claims, characterized in that an electrically insulated duct (180) is provided for electric insulation of said cold wire (174) to be electrically insulated from said first and second contact tubes (168a, 168b) in an electrode assembly housing said first and second contact tubes and said electrically insulated duct.

8) A welding apparatus according to claim 7, characterized in that the insulated wire duct (180) is a ceramics tube.

9) A welding apparatus according to claims 7 or 8, characterized in that the electrically insulated duct (180) comprises an electrically insulated portion (146) in a wire straightening unit (120, 140) for straightening one or more of the consumable electrodes and cold wire (172, 174, 176).

10) A welding apparatus according to any of claims 7 - 9, characterized in that an individual wire straightening unit (120) is provided for the cold wire (174) separate from wire straightening units (140) of the first and second consumable electrodes (172, 176) of the electrode assembly (170).

11) A welding apparatus according to any of claims 7 - 10, characterized in that the electrically insulated duct (180) comprises an electrically insulated portion (156) in a wire feeder unit (130, 150) for feeding one

or more electrodes (172, 176) and cold wires (174) towards a workpiece (10).

12)A welding apparatus according to any of claims 7 - 11, characterized in that an individual wire feeder unit (130) is provided for the cold wire (174) separate from wire feeding units (150) of the first and second consumable electrodes (172, 176).

13)A welding apparatus according to any preceding claim, characterized in that an individual speed control unit (132) is provided for the cold wire (174) separate from speed control unit (152) of the first and second consumable electrodes (172, 176).

14)A welding apparatus according to any preceding claim, characterized in that the cold wire (174) in the electrically insulated duct (180) is in sequential order arranged between the first and the second consumable electrodes with respect to a welding direction (20) on a workpiece (10).

15)A welding apparatus according to anyone of the claims 1 to 11, characterized in that said two consumable electrodes and said cold wire (174) are comprised in an electrode assembly, wherein said cold wire is located at the outside of the electrode assembly.

16)A welding apparatus according to any preceding claim, characterized in that a feeder unit (150) and/or a straightening unit (140) for the first and second consumable electrodes (172, 176) provides a feedthrough for guiding the cold wire (174) through the feeder unit (150).

17)A welding apparatus (1) according to any preceding claim, characterized in that said welding apparatus is a gas metal arc welding

apparatus including a gas cup for directing a protective gas flow toward a weld area common for said first and second electrodes

18) A twin wire welding method comprising:

- guiding a first consumable electrode through a first contact tube toward a welding area,
- guiding a second consumable electrode through a second contact tube toward the welding area,
- transferring a welding current to the first and second consumable electrodes from a single power source connected to the first and second consumable electrodes via said first and second contact tubes to maintain a first and a second arc respectively for the generation of a weld puddle, wherein said single power source provides the same potential at said first and second contact tubes, characterized in that a cold wire is fed essentially orthogonally into said weld puddle.

19)A method for welding according to claim 18, further comprising:

- directing a protective gas flow toward the weld area common for said first and second electrodes wherein a weld puddle is maintained by said a first and a second arc respectively under the protective gas flow.

TITLE

A welding apparatus and a method for welding

TECHNICAL FIELD

The present invention relates to a welding apparatus. In particular the invention relates to a welding apparatus for performing twin wire welding where at least two consumable electrodes are connected to a single power source. The at least two consumable electrodes are connected to an output providing the same potential to said at least two consumable electrodes. The invention further relates to a twin wire welding method for such a twin wire welding apparatus.

BACKGROUND OF THE INVENTION

Welding methods and welding apparatuses are continuously being developed for achieving higher deposition rates at maintained or improved weld quality. One way of increasing deposition rates is to use a plurality of electrodes operating in a single welding process in a single weld puddle. Use of a plurality of welding electrodes in a single weld puddle requires that the electrodes are located in a close proximity to each other. Close arrangement of electrode will however lead to interaction between magnetic fields generated by each electrode. This may result in distorted weld results.

Two different approaches for using a plurality of welding electrodes in a single welding process are known, tandem and twin welding.

In tandem welding each electrode is powered via a separate power source. Tandem welding may be advantageous in many applications since the control of power supply to each electrode is facilitated. In tandem welding, the magnetic interference between electrodes may be reduced by supplying phase shifted welding currents to the electrodes. This may be accomplished

which ensures that both wires assumes the same potential. An example of this type of twin wire welding arrangement is disclosed in US5155330.

Even though twin welding methods where consumable electrodes are fed through a common electrically conductive contact element to ensure that both wires assumes the same potential has shown to be beneficial for both gas metal arc welding methods and to submerged arc welding methods, further improvements is desirable in order to improve weld quality as well as increasing the deposition rate in the welding process.

BRIEF DESCRIPTION OF THE INVENTION

The invention is defined in the independent claims. Some optional features of the invention are defined in the dependent claims.

Implementation of the techniques disclosed herein may provide a twin wire welding apparatus where the at least two consumable electrodes are connected to a single output providing the same potential, which twin wire welding apparatus enables improvement of weld quality and increase deposition rate.

Implementation of the techniques disclosed herein may also provide a twin wire welding method where the at least two consumable electrodes are connected to a single output providing the same potential, which twin wire welding method enables improvement of weld quality and increase deposition rate.

One twin wire welding apparatus includes a first contact tube for guiding a first consumable electrode toward a weld puddle and transferring welding current to the first consumable electrode, a second contact tube for guiding a second consumable electrode toward said weld puddle and transferring welding current to the second consumable electrode. The twin wire welding apparatus may include more than two contact tubes for enabling twin welding with more than two consumable electrodes. The first and second contact tubes may be formed in a single contact tip as two parallel lead-

throughs in the contact tip, where the consumable electrodes are forced through to enable contact between the power source and the consumable electrode. An arrangement of preferably parallel contact tubes may be arranged in a single contact tip or alternatively be arranged in separate contact tips. The arrangement with more than one contact tube in a single contact tip facilitates parallel arrangement of the consumable electrodes at a close distance, while the use of separate contact tips for housing the contact tubes facilitates arrangement of the contact tubes at an angle with respect to each other.

With separate contact tips is intended that the contact tips are not formed as a monolithic conducting structure containing all the contact tubes. Instead is provided a plurality of separate contact tips each housing a single contact tube. In the event separate contact tips are used, they will be electrically connected to enable all the consumable electrodes to assume the same potential when connected to a single power source. The electrical connection can be provided at the contact tips, at the power source or anywhere in between the contact tip and power source.

The single power source is connected to said first and second contact tubes. This may be achieved by a suitable conductor, such as a cable, connecting the power supply with the contact tube. Hence, welding current will be distributed from the power source to the respective consumable electrode via the contact tubes.

Preferably, the twin wire welding apparatus further includes a feeding arrangement for feeding a cold wire into a weld puddle formed by arcs created by the first and second consumable electrodes.

The introduction of a cold wire into the weld puddle will enable cooling of the weld puddle to as to maintain the weld puddle at a desired temperature. Reduction of weld puddle temperature may lead to that alloy additives are vaporized to a lesser extent in a zone directly affected by the arcs from the

consumable electrodes. This may lead to improved control of the composition of the weld alloy, which may lead to improved welds. For the purpose of reducing the peak temperatures in the weld puddle as well as maintaining a relatively high deposition rate from the cold wire it is preferable to introduce the cold wire in the vicinity of the arc, preferably in the arc from at least one of the consumable wires. Furthermore, feeding of a cold wire into the weld puddle may lead to an increase in deposition rate above 20%, with a prospect to an increase of productivity of almost 50% with optimized welding parameters. Implementation of the exemplary techniques disclosed herein may allow for higher deposition rates without increasing the welding speed. Expediently, the implementation of the exemplary technique may allow for retrofitting existing welding systems, particularly for welding of large workpieces such as pipe-mills.

In one arrangement, the feeding arrangement for said cold wire is arranged to feed said cold wire essentially orthogonally into said weld puddle. It has been discovered that oblique introduction of the cold electrode, that is when the cold wire is fed into the weld puddle at an angle with respect to a surface normal of the weld puddle, may lead to variations in the weld process with a deteriorated weld result. It is believed that variations in the height of the work piece has an influence of where the cold wire will enter the weld puddle in relation to an extension of the consumable electrode. Such a variation will have an effect on the melting rate of the cold wire and also of the peak temperature in the weld puddle. By arranging the cold wire so that it is introduced essentially orthogonally to the weld puddle, a more stable welding process is achieved. By orthogonally to the weld puddle is intended a normal to an upper surface of the weld puddle at quiescent undisturbed state. It is understood that the weld puddle will be exposed to oscillations during welding. However, the upper surface of the weld puddle at quiescent undisturbed state would essentially form a plane at the point of introduction of the cold wire into the weld puddle, which plane has to a vector from the tip of a consumable electrode to the closest point of the weld puddle as a normal.

According to one arrangement, the electrically insulated duct can comprise an electrically insulated wire conduit in the contact device. The insulated wire conduit can be a ceramics tube arranged in the contact device. The ceramics tube can be inserted in the contact device or a part of the contact device can be treated, e.g. oxidized, to form an oxide of sufficient thickness for electrical insulation.

According to one arrangement, the electrically insulated duct can comprise an electrically insulated portion in a wire straightening unit for straightening one or more of the consumable electrodes and the cold wire. The consumable electrodes and the cold wire can be manipulated in the same wire straightening device.

According to one arrangement, an individual wire straightening unit can be provided for the cold wire separate from wire straightening units of the consumable electrodes of the electrode assembly. Advantageously, the cold wire can be manipulated independently from the consumable electrodes.

According to one arrangement, the electrically insulated duct can comprise an electrically insulated portion in a wire feeder unit for feeding consumable electrodes and the cold wire towards a workpiece. The consumable electrodes and the cold wire can be manipulated in the same wire feeder device.

According to one arrangement, an individual wire feeder unit can be provided for the cold wire separate from wire feeding units of the consumable electrodes of the electrode assembly. Advantageously, the cold wire can be manipulated independently from the consumable electrodes.

According to one arrangement, an individual speed control unit can be provided for the cold wire separate from speed control unit

of the consumable electrodes of the electrode assembly. Advantageously, the cold wire can be manipulated independently from consumable electrodes.

Favourably, the cold wire can be fed independently from the consumable electrodes in the contact device. This allows for a comfortable control of the welding process. The cold wire electrode, can be fed with a different speed, particularly with a variable speed and/or with a different diameter, independent from the consumable electrodes in the contact device.

According to one arrangement, the cold wire in the electrically insulated duct can be arranged in sequential order between a leading and a trailing consumable electrode with respect to a welding direction on a workpiece. The order of the cold wire can be used to adjust the welding deposition rate. Such a symmetric arrangement can yield very high deposition rates. The sequential order of the cold wire can be chosen depending on welding requirements.

According to one arrangement, the cold wire in the electrically insulated duct can be arranged upstream of the consumable electrodes of the electrode assembly with respect to a welding direction on a workpiece. Depending on welding requirements the sequential order of the cold wire can be chosen. The outermost consumable electrodes can be tilted to a desired angle compared to the other electrodes. An asymmetric arrangement particularly allows adjusting such an angle in a straightforward manner.

According to one arrangement, the cold wire in the electrically insulated duct can be arranged downstream of the other electrodes of the electrode assembly with respect to a welding direction on a workpiece. The sequential order of the cold wire can be chosen depending on welding requirements.

According to one arrangement, a feeder unit and/or a straightening unit for the consumable electrodes can provide a feedthrough for guiding the cold wire through the feeder unit. Favourably, the cold wire can pass in the feedthrough through the wire straightening unit or the wire feeder unit without interacting with these units or the consumable electrodes. The cold wire can be manipulated independently from the consumable electrodes in the same contact device of the same welding head.

In another arrangement, there is provided a welding head assembly comprising at least two electric arc-welding welding heads, at least one of which comprises a contact device and a feeding portion, the contact device encompassing an electrode assembly, wherein the electrode assembly comprises at least two consumable continuously-fed wire electrodes arranged in a contact device. An electrically insulated duct is provided for electric insulation of at least one cold wire so that the cold wire is electrically insulated from the consumable electrodes of the electrode assembly. Favourably, such a welding head assembly is a powerful tool for very high deposition rates with reduced heat impact on workpieces. The welding quality can thus be improved.

According to one arrangement, a first welding head can be arranged in sequential order before a second welding head so that the electrode assemblies of each welding head are aligned along a welding direction during a welding operation in sequential order. The welding head according to the invention allows for a large degree of freedom when designing such a welding head assembly.

According to one arrangement, an order of the cold wire in each electrode assembly can be the same for each welding head with respect to the consumable electrodes in each electrode assembly. The welding head allows for a large degree of freedom when designing such a welding head assembly.

According to one arrangement, an order of the cold wire in one electrode assembly can be reversed with respect to an order of the cold wire in another electrode assembly of the welding head arrangement. The welding head allows for a large degree of freedom when designing such a welding head assembly.

According to one arrangement, each cold wire can be provided with a wire straightening unit and/or a wire feeder unit separate from wire straightening units and/or feeder units of the consumable electrodes of the electrode assemblies. The cold wires can be manipulated independently from the consumable electrodes and independently in each welding head thus giving a large degree of freedom in adapting welding parameters for particular welding requirements imposed by material and/or geometry and/or ambient conditions of the workpieces to be welded.

In another arrangement, there is provided an electric arc-welding contact device for an electric arc-welding head and/or a welding head assembly is proposed, comprising a device body and an electrically insulated portion for guiding cold wire in an electrically insulated way through the contact device and at least two ducts for at least two consumable electrodes which are in electrical contact with the device body. Favourably, a contact device is provided where one or more cold wires can be employed together with two or more consumable electrodes. The two or more consumable electrodes can be provided for being consumed in arcs during welding whereas the cold wires are not consumed by arcs but are intended to melt in the weld pool during welding. The cold wire can be used with various diameters chosen independently from the consumable electrodes in the contact device.

According to one arrangement, the electrically insulated portion can comprise an electrically insulating tube. An electrically insulating tube can be easily inserted into the device body. Expediently, the tube can be made of ceramics which provides a superior electrical insulation as well as a good heat resistance.

According to one arrangement, the device body can be composed of a main part and a removable part which can be attached to the main part. An arrangement of the consumable electrodes and the cold wire in a desired sequential order can be easily achieved or changed.

According to one arrangement, a tip can provided at one end of the device body which has recesses for receiving the electrically insulating portion for cold wire and ducts for other electrodes. Favourably, the recesses for the consumable electrodes and the electrically insulating portion can be arranged in the grooves of the tip in a defined way and held securely during operation.

According to one arrangement, the electrically insulating portion can be arranged in a symmetric position between ducts for the consumable electrodes. Favourably, the electrically insulated portion for guiding the cold wire can be arranged between two ducts of the consumable electrodes. Such a symmetric arrangement provides a high deposition rate during welding.

According to one arrangement, the electrically insulating portion can be arranged in an eccentric position in relation to ducts for the consumable electrodes in the device body.

In another arrangement, an electric arc-welding system is provided for generating a weld pool in a workpiece, comprising at least one welding head or at least one welding head assembly according to anyone of the features described above. A highly versatile system can be provided which allows for easy adjustment of the welding parameters and conditions.

It is evident that more than two consumable electrodes and/or more than one cold wire may be used in a welding apparatus. The

more than two consumable electrodes and/or the more than 1 cold wire can be arranged in the same welding head.

With cold wire is intended an elongated metal structure that is fed into the weld puddle. The cold wire may have any cross section, such as oval, circular, elliptic, rectangular, quadratic, triangular or any other suitable shape. The consumable electrode may in the same manner have any cross-section such as oval, circular, elliptic, rectangular, quadratic, triangular or any other suitable shape.

An exemplary twin wire welding method comprises:

- guiding a first consumable electrode through a first contact tube toward a welding area,

- guiding a second consumable electrode through a first contact tube toward the welding area,

- transferring a welding current to the first and second consumable electrodes from a single power source connected to a first and second consumable electrodes via said first and second contact tubes to maintain a first and a second arc respectively for the generation of a weld puddle, wherein said single power source provides the same potential at said first and second contact tubes.

According to an exemplary technique a cold wire is fed essentially orthogonally into said weld puddle.

In one implementation the method includes directing a protective gas flow toward the weld area common for said first and second consumable electrodes wherein a weld puddle is maintained by said a first and a second arc respectively under the protective gas flow.

The method may also be applied in submerged arc welding.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention together with the above-mentioned and other objects and advantages may best be understood from the following detailed description of the embodiments, but not restricted to the embodiments, wherein is shown schematically:

Fig. 1 a twin wire welding apparatus;

Figl a a weld puddle with a coordinate system indicating a direction for feeding a cold wire into the weld puddle;

Fig. 2 a first view of an example embodiment of an arc-welding welding head for submerged arc welding;

Fig. 3 the arc-welding welding head of Fig. 1 turned counterclockwise by 90°;

Fig. 4 a perspective view or the arc-welding head of Fig. 1 ;

Fig. 5a-5e various views of a contact device for two consumable electrodes and one cold wire with cut open views (Figs. 5a, 5e) and side views (Figs. 5b, 5d) and a front view (Fig. 5c);

Fig. 6 a side view of an example embodiment of an arc-welding welding head

Fig. 7a-7c an arrangement of a cold wire and a consumable electrode in a first electrode assembly comprising two electrodes (Fig. 7a), a second electrode assembly comprising two consumable electrodes with the cold wire being the central electrode (Fig. 7b), and a third electrode assembly comprising two consumable electrodes with the cold wire being at the outside of the electrode assembly (Fig. 7c); and

Fig. 8a-8c an arrangement of two arc-welding welding heads each comprising cold wire and a consumable electrode in a first electrode assembly comprising two electrodes in each welding head (Fig. 8a), a second electrode assembly comprising two consumable electrodes and a cold wire in each welding head, with the cold wire being the central electrode (Fig. 8b), and a third electrode assembly comprising two consumable electrodes and a cold wire in each welding head, with the cold wire being at the outside of the electrode assembly (Fig. 8c).

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

In the drawings, equal or similar elements are referred to by equal reference numerals. The drawings are merely schematic representations, not intended to portray specific parameters of the invention. Moreover, the drawings are intended to depict only typical embodiments of the invention and therefore should not be considered as limiting the scope of the invention.

Figure 1 shows a schematic drawing a twin wire welding apparatus 1. The twin wire welding apparatus includes a first contact tube 2 for guiding a first consumable electrode 4 toward a weld puddle 6. The first contact tube 2 is arranged in a contact tip 8 in a conventional manner. At the contact tube 2 welding current is transferred to the first consumable electrode 4. Further, a second contact tube 10 is arranged in the twin wire welding apparatus 1 for guiding a second consumable electrode 12 toward the weld puddle 6. The second contact tube 10 is arranged in a contact tip 14 in a conventional manner. The first and second contact tips may be arranged in a single body, which may be aggregated by parts, or in separate bodies. At the second contact tube 10, welding current is transferred to the second consumable electrode 12.

A single power source 16 is connected to a contact device 18 including the contact tips 8, 14 and housing the first and second contact tubes 2, 10. The contact device 18 may include separate contact devices 18a, 18b or a common contact device for both contact tips. The single power source 16 provides the same potential to the first and second consumable electrodes 4, 12. The power source may be of any conventional type operable for twin wire welding, such as a welding converter, a welding transformer, a rectifier, a thyristor controlled rectifier or an inverter.

The twin wire welding apparatus 1 further includes a feeding arrangement 20 for feeding a cold wire 22 into the weld puddle 6. The feeding arrangement

includes a tube 22, which is electrically insulated from the first and second contact tips. The cold wire is fed via the tube 22. When welding, an arc will be present at the first and second consumable electrodes 4, 12, but not at the cold wire 22. The cold wire is melted by introduction of the cold wire into the weld puddle 6. Suitably, the cold wire is not connected to any electrical power source and will therefore generally assume a ground potential. However, it may be possible to connect the cold wire to a power source for pre-heating the cold wire. However, the cold wire will not be connected to a power source for the purpose of generating an arc between the cold wire and the work piece. The tube 22, may be a metallic tube that is isolated from the first and second contact tips, or a ceramic tube as in the example of a welding head as described below which is suitable for a twin welding apparatus.

The feeding arrangement 20 for said cold wire is arranged to feed said cold wire 22 essentially orthogonally into said weld puddle. In figure 1A is shown a schematic drawing of a weld puddle 6 including a reference coordinate system 26. The reference coordinate system 26 indicates a welding direction x, which is the direction in which the welding head is moved relatively to a work piece 28 in which a weld seam is generated. The reference coordinate system 26 further includes a transverse direction y. The welding direction and the transverse direction form a plane xy which is coplanar with an upper surface 30 of the weld puddle. It is known that the weld puddle may be somewhat agitated during welding. The upper surface at a point of introduction 32 of the cold wire will is considered to be an upper surface 30 of the weld puddle at the point of introduction 32 at quiescent undisturbed state.

This upper surface 30 of the weld puddle at quiescent undisturbed state would form a plane xy at the point of introduction 32 of the cold wire into the weld puddle, which plane xy is normal to a vector 38 from the tip 34 of a consumable electrode to the closest point 36 of the weld puddle.

The reference coordinate system 26 includes a third direction z, which is orthogonal to the plane xy. It is here shown a vector c representing the

direction of introduction of the cold wire into the weld puddle. The vector c should be essentially orthogonal to the plane xy. A perfect co-alignment with the direction z is preferable, however some deviation of the direction of introduction from the direction z may be acceptable. The deviation from perfect alignment is indicated by an angle α. In exemplary techniques disclosed herein, the feeding arrangement may be arranged to feed said cold wire into said weld puddle at an angle of less than 15°, preferably less than 5°, still preferably less than 2° with respect to a surface normal. This corresponds to a cone having an opening angle of less than 30°, preferably less than 10°, still preferably less than 4°.

In arc welding an arc is present between the tip of the electrode and the work piece. An arc 40 is shown in figure 1 . The contact of the arc at the working piece will be moving in a random manner. However, normally it is assumed that the arc is present within a cone 42 from the tip of the consumable electrode 34 to the weld puddle. The opening angle β of the cone 42 may vary from welding case to welding case. However, a normal opening angle β is around 30°. For this reason it is preferable to locate the cold wire 22 such that it enters the weld puddle in an essentially orthogonal direction thereto at an axial distance D being less than L*cotan (β/2) from the consumable electrode measured at the tip 34 of the consumable electrode. Here L is the arc length, that is the distance from the electrode tip to the closes point 36 of the weld puddle.

It may be preferable to arrange the cold wire 22 in between two consumable wires. The consumable wires may preferably be mounted at an axial distance A being less than a cone diameter d measured at the surface 30 of the weld puddle 6. With this arrangement, the cold wire will be introduced in the outer parts e of the arc area defined by the cones 42 of both consumable electrodes, which has shown to be beneficial for the weld result.

The welding apparatus may include a contact tube spacing mechanism for adjusting a spacing between a respective tip of said first and second contact tubes. The welding apparatus may further include includes a contact tube inclination mechanism for adjusting an inclination between a respective length axis of said first and second contact tubes.

Figures 2 to 4 depict different views of an example embodiment of an electric arc-welding welding head 100 for submerged arc welding which views are described in combination.

Along its longitudinal extension the electric arc-welding welding head 100 comprises a contact device 160 at its lower end which during welding is in close proximity to the workpiece to be welded. The contact device 160 holds the electrodes 172, 176 and a cold wire 174 (Figs. 3, 4) of the electrode assembly 170 of the welding head 100. The electrodes 172, 176 and the cold wire 174 exit the contact device 160 through an outlet 162 at the lower end of the contact device 160 which faces the workpiece during the welding operation. The electrodes 172, 176 and the cold wire 174 may be fed from respective reservoirs such as coils (not shown) towards the arc welding head 100.

The electrode assembly 170 comprises by way of example two fusible continuously-fed consumable wire electrodes 172, 176 and a cold wire 174 arranged in the contact device 160. The contact device 160 comprises an electrically insulating portion 166 for the cold wire 174. Only the cold wire 174 is shown along the welding head extension. The consumable electrodes 172, 176 are only shown in the contact device 160. The consumable electrodes 172, 176 are arranged as so called twin wires preferable being fed in parallel as a double wire electrode arrangement. The electrically insulating portion 166 is preferably an extra insulated wire conduit, for instance made of heat resistant material such as ceramics.

electrodes. Close to the contact device 160 a nozzle 1 16 for a flux hopper 1 14 (Figs. 2-4) is arranged, the nozzle 1 16 is fixed to a rod 1 16 arranged parallel to the longitudinal axis of the contact device 160.

Fig. 7a to 7c display arrangements of electrodes in electrode assemblies 170 with respect to a welding direction 20.

Fig. 7a shows a first variant of an electrode assembly 170 with an electrically insulated cold wire 174 and a non-insulated consumable electrode. This welding head must be combined with a further welding head to include at least two consumable electrodes. A second variant of an electrode assembly 170 is shown in Fig. 7b comprising two consumable electrodes 172, 176 and a cold wire, with the cold wire 174 being the centrally located. A third variant of an electrode assembly 170 comprising two consumable electrodes 172, 176 and a cold wire, with the cold wire 174 being at the outside of the electrode assembly is displayed in Fig. 7c.

Figs. 8a to 8c show arrangements of a welding head assembly 200 comprising two arc-welding welding heads 100a, 100b. Each welding head 100a, 100b comprises an electrode assembly 170a, 170b with cold wire 174a, 174b and one or more consumable electrodes 172a, 172b. In a first variant of a welding head assembly 200 shown in Fig. 8a each welding head 100a, 100b comprises two electrodes 172a, 172b, and two cold wires 174a, 174b in each welding head 100a, 100b. The cold wires 174a, 174b are the outermost electrodes in the welding head assembly 200.

A second variant is shown in Fig. 8b, where each welding head 100a, 100b comprises an electrode assembly 170a, 170b with three electrodes 172a, 176a, 172b, 176b, and two cold wires 174a, 174b, wherein the cold wire 174a, 174b is arranged in the middle between the two consumable electrodes 172a, 176a, 172b, 176b as central electrodes of each welding head 100a, 100b.

Amended Claims

1. A twin wire welding apparatus including a first contact tube for guiding a first consumable electrode toward a weld puddle and transferring welding current to the first consumable electrode, a second contact tube for guiding a second consumable electrode toward said weld puddle and transferring welding current to the second consumable electrode, and a single power source connected to said first and second contact tubes for providing the same potential to said two consumable electrodes, characterized in that in that said twin wire welding apparatus further includes a feeding arrangement for feeding a cold wire into said weld puddle which is arranged to feed said cold wire essentially in parallel with a feeding direction of said two consumable electrodes and wherein a feeder unit and/or a straightening unit for the first and second consumable electrodes provides a feedthrough for guiding the cold wire through the feeder unit.

2. A welding apparatus according to claim 1, characterized in that said feeding arrangement is arranged to feed said cold wire into said weld puddle at an angle of less than 5° with respect to a surface normal.

3. A welding apparatus according to claim 1, characterized said first and second contact tubes are formed in separate contact tips.

4. A welding apparatus according to any of claims 1 - 3, characterized in that the first and second contact tubes are connected to said single power source via a first and second contact device, which are separate for the first and second contact tube.

5. A welding apparatus according to any of the preceding claims, characterized in that said welding apparatus further includes a contact tube spacing mechanism for adjusting a spacing between a respective tip of said first and second contact tubes.

6. A welding apparatus according to any of the preceding claims, characterized in that said welding apparatus further includes a contact tube inclination mechanism for adjusting an inclination between a respective length axis of said first and second contact tubes.

7. A welding apparatus according to any of the preceding claims, characterized in that an electrically insulated duct is provided for electric insulation of said cold wire to be electrically insulated from said first and second contact tubes in an electrode assembly housing said first and second contact tubes and said electrically insulated duct.

8. A welding apparatus according to claim 7, characterized in that the insulated wire duct is a ceramics tube.

9. A welding apparatus according to claims 7 or 8, characterized in that the electrically insulated duct comprises an electrically insulated portion in a wire straightening unit for straightening one or more of the consumable electrodes and cold wire.

10. A welding apparatus according to any of claims 7 - 9, characterized in that an individual wire straightening unit is provided for the cold wire separate from wire straightening units of the first and second consumable electrodes of the electrode assembly.

11. A welding apparatus according to any of claims 7 - 10, characterized in that the electrically insulated duct comprises an electrically insulated portion in a wire feeder unit for feeding one or more electrodes and cold wires towards a workpiece.

12. A welding apparatus according to any of claims 7 - 11, characterized in that an individual wire feeder unit is provided for the cold wire separate from wire feeding units of the first and second consumable electrodes.

13. A welding apparatus according to any preceding claim, characterized in that an individual speed control unit is provided for the cold wire separate from speed control unit of the first and second consumable electrodes.

14. A welding apparatus according to any preceding claim, characterized in that the cold wire in the electrically insulated duct is in sequential order arranged between the first and the second consumable electrodes with respect to a welding direction on a workpiece.

15. A welding apparatus according to anyone of the claims 1 to 11, characterized in that said two consumable electrodes and said cold wire are comprised in an electrode assembly, wherein said cold wire is located at the outside of the electrode assembly.

16. A welding apparatus according to any preceding claim, characterized in that said welding apparatus is a gas metal arc welding apparatus including a gas cup for directing a protective gas flow toward a weld area common for said first and second electrodes

17. A twin wire welding method comprising:

guiding a first consumable electrode through a first contact tube toward a welding area,

guiding a second consumable electrode through a second contact tube toward the welding area,

transferring a welding current to the first and second consumable electrodes from a single power source connected to the first and second consumable electrodes via said first and second contact tubes to maintain a first and a second arc respectively for the generation of a weld puddle, wherein said single power source provides the same potential at said first and second contact tubes, characterized in that a cold wire is fed essentially orthogonally into said weld puddle, and wherein a feeder unit and/or a straightening unit for the first and second consumable electrodes provides a feedthrough for guiding the cold wire through the feeder unit.

18. A method for welding according to claim 18, further comprising:

directing a protective gas flow toward the weld area common for said first and second electrodes wherein a weld puddle is maintained by said a first and a second arc respectively under the protective gas flow.